STATISTICAL ANALYSIS OF THE INTERRELATIONSHIP AMONG SOME MONETARY POLICY INDICATORS IN NIGERIA

[1]Ikughur, Jonathan Atsua, [2]Nwaosu, Sylvester Chigozie and [3]Amara, Ngozika Gloria
1&2. Department of Statistics, Joseph Sarwuan Tarka University Makurdi, Nigeria
3. Federal Capital Territory Administration, Transportation Secretariat, Garki Area 11, Abuja, Nigeria.
[1]ikughur.ja@uam.edu.ng; [2]sylvesternwaosu88@gmail.com; [3]ngozikaelijah@gmail.com

Abstract
In this study, the interrelationship among Nigeria's monetary policy indicators namely, inflation rate, foreign exchange rate, money supply and treasury bill rate in Nigeria is investigated using the Augumented Dickey Fuller (ADF) test, Co-integration and Vector Autoregressive Regression (VAR) modelling and Granger causality test criteria. Annual data on inflation, exchange rate, treasury bill rate and money supply for the period 1981-2022 was collected from the National Bureau of Statistics and Central Bank of Nigeria (cbn.gov.ng). ADF unit root tests suggested that the variables are all non-stationary at level but stationary at first difference while the Johansen co-integration test suggested absence of co-integration among the variable. The Vector Autoregressive (VAR) model showed that inflation and foreign exchange rates are only influenced by their lag 1 values while money supply is visibly influenced by lag 1 values of inflation, exchange rate, money supply and treasury bill rate with exchange rate and treasury bill rates exerting significant negative impact on money supply. Similarly, treasury bill rate is positively and significantly influenced by inflation rate and lag1 values of treasury bill rate while money supply has significant negative impact on current treasury bill rate. These results opens up avenue for monetary policy operators to introduce measures for tuning the economic indicators to ensure stability.

Keywords: Monetary Policy Indicators, Interrelationship, Co-integration, Short-run

Introduction

Monetary policy is the use of money supply or interest rates to achieve macroeconomic goals in a country. Ajie *et al.* (2007) stated that macroeconomic policy has been the main tool for achieving output stabilization in the short run and a diversified self-sustaining economic growth in the long run. It rests on the relationship between rate of interest in an economy, that is the price at which money can be borrowed, and the total supply of money. The process also uses variety of tools to control one or more of these, to influence outcomes like economic growth, inflation, exchange rates with other currencies and unemployment (Blanchard, 2000; Wyplosz & Burda, 1997).

According to Central bank of Nigeria (CBN, 2006), the objectives of monetary policy may vary from country to country but there are two main views: to achieve price stability and to achieve other macroeconomic objectives. It is also seen as the general process by which the government through the central bank, or monetary authority of a country control the supply of money, availability of money, and cost of money or rate of interest in order to attain objectives set towards the growth and stability of the economy.

The Central Bank of Nigeria (CBN) derives its mandate from the CBN Act of 1958 and its subsequent amendments in section one of the CBN Decree No. 24 of 1991 which stipulates that the bank shall Issue legal tender currency in Nigeria; maintain external reserves to safeguard the international value of the legal tender currency; promote monetary stability and a sound financial system in Nigeria, and Act as banker and financial adviser to the Federal Government (CBN, 2006). Ayodeji and Oluwole (2018) and Ajie *et al.* (2007 stated that macroeconomic policy is the main tool for achieving output stabilization in the short run and a diversified self-sustaining economic growth in the long run.

There are several monetary policy indicators or variables, namely money supply, inflation, investment, Treasury bill rate and so on usually targeted at to stimulate economic growth and stability. It is necessary to identify how each variable relates with other variables in a developing economy like that of Nigeria so as to understand the joint effects of these variables on each other in order to provide signals useful in guiding managers of the economy as it relates to monetary policy.

The intention of this study is to determine the link among the monetary policy indicators namely, inflation rate, exchange rate, money supply and treasury bill rates. Danjuma *et al.* (2012), examined the impact of monetary policy on inflation rate in Nigeria over the period 1980 to 2010 with the aim of measuring the effectiveness of monetary policy in Nigeria. Using the least squares technique, Granger causality, they found that liquidity ratio and interest rate were the leading monetary policy instruments in combating inflation in Nigeria while cash reserve ratio, broad money supply and exchange rate were described as being Impotent in effective monetary policy decision in Nigeria.

Philip *et al.* (2014) examined the effectiveness of monetary policy in reducing inflation in Nigeria, for the period 1970 to 2012 by employing the co-integration and Error Correction Technique of econometric analysis. The test of both the Unit root and co-integration revealed that there was a long run relationship between the variables while the Granger Causality test revealed a uni-directional relationship between monetary policy and inflation rate. However, the VECM test revealed that Inflation rate, Gross Domestic Product (GDP) and exchange rate were negatively related, and positively related to broad money supply (M2) and domestic credit.

Fabian and Charles (2014) investigated the determinants of inflation rate in Nigeria using a monthly data from January 2007 to August 2014. The ordinary least square (OLS) was used in the study and result showed that inflation, exchange rate and money supply influenced inflation, while annual Treasury bill rate and monetary policy rate though rightly signed did not influence inflation in Nigeria within the period under investigation.

Tule *et al*. (2015) examined the relationship between money supply and inflation as it affect the conduct of monetary policy in Nigeria. They used the Vector Auto regressive (VAR) model. Results from these estimates showed that the coefficients of money supply were positive and significant at 1, 5, and 10 per cent, respectively in the inflation equation for the full sample period, suggesting that money supply bears a long run positive relationship with inflation.

The study by Abeng *et al*. (2018) on the relationship between money supply and inflation showed that, while money supply has positive and statistically significant impact on inflation during periods of low economic growth while the impact is negative and statistically significant in a regime of "high economic growth". In the same vein, Batarseh (2021) investigated the relationship between the money supply (M1) and inflation in the Jordanian economy during the period of 1980–2019 using statistical test namely, Augmented Dickey-Fuller (ADF) test, Johansen's Cointegration test and the Granger Causality. The study showed that there was no causal link between the money supply M1 and inflation in the long term. The results of Granger Causality showed a unidirectional causality running from the money supply M1 to inflation in the short term, suggesting that money supply causes inflation, not vice versa; this means that the money supply M1 can explain the changes that occur in the consumer price index (CPI) in the Jordanian economy.

In their study, Nguyena *et al.* (2022) examined the relationship between money supply and inflation in Vietnam in the period of 2005-2021 using data on money supply and inflation rate and the linear regression modeling approach. The results support the view that money supply growth and past inflation are among the factors affecting inflation in Vietnam.

Treasury bills are financial instruments issued by the Federal Government of Nigeria and they serve as short-term debt securities, allowing the government to raise funds while providing a secure investment avenue for individuals, joint applicants, businesses, and corporates. According to Junesuh (2014), the rationale for issuing out treasury bills by governments through their central banks is to resolve temporarily insufficient budget, and as one of open market operations (OMO) forms for monetary policy. This enables central banks raise short-term fund for governments and absorb surplus liquidity from financial markets simultaneously.

Exchange Rate on the other hand is the rate at which the currency of one country is being exchanged for that of another country or the relative price that indicates the price of one currency in terms of another currency. In Nigeria, Otori (2023) reported on how Forex impact trade noting that because the economy have been in a slump due to inflation rate, among others , and also, the unsettling exchange rate which he sees as a major issue affecting Nigeria's economy because of the weak naira in relation s to Forex as Naira weakening can no longer be controlled. This has caused increase in exchange expenses and prices which in turn, limits production capacity. The fast increasing prices in marketplace is seen to be induces by the fast increasing rate of foreign exchange rate.

The Central Bank of Nigeria defines money supply as comprising narrow and broad money and while narrow money (M1) includes currency in circulation with non-bank public and demand deposits or current accounts in the banks, the broad money (M2) includes narrow money plus savings and time deposits, as well as foreign denominated deposits. Basically, broad money measures the total volume of money supply in the economy. The importance of regulating money supply is based on the knowledge that there is a stable relationship between the quantity of money supply and economic activity and that if its supply is not limited to what is required to support productive activities, it will result in undesirable effects such as high prices or inflation (CBN, 2006).

In Nigeria, several empirical evidence on the subject matter are also documented in literature. For example, Onwachukwu (2014) conducted a study on the impact of monetary policy on inflation control in Nigeria. The study was based on annual time series data from 1970 to 2010 and employed the method of Ordinary Least Squares (OLS) to estimate the model results, the study found that bank rate, deposit with the central bank, liquidity ratio, and broad money supply were statistically significant in explaining changes in inflation. However, exchange rate did not account for significant changes in inflation in Nigeria. The study recommended the need to check the excess reserves of commercial banks, which will help in keeping money supply at a low level.

Okotori (2019) evaluated the dynamics monetary policy and inflation in Nigeria using monthly data from 2009-2017 to estimate the model parameters. The Augmented Dickey-Fuller (ADF) unit root test, Johansen Cointegration test and Error Correction model (ECM) were adopted. The study conclusion that money supply, exchange rate, monetary policy rate, treasury bills rate, reserve requirement and liquidity ratio have significant and effective impact on the inflation rate.

Ogunmuyiwa (2020) examined empirically the impact of monetary and fiscal policy management on the problem of inflation in Nigeria. Monthly data from January 2010 to October 2016 on inflation rate, interest rate, exchange rate, narrow money, broad money, government capital expenditure and government recurrent expenditure and fitted into the regression model. Autoregressive Distributed Lag (ARDL) having ascertained the stationarity status of the series using the Augmented Dickey-Fuller (ADF) test. The results showed that broad money supply (M2) and Capital Expenditure (CE) were significant and were positively related (short and long run) to inflation in Nigeria. Exchange rate was significant and positively related to inflation in the long run. The study also revealed that Nigerian inflationary situation is driven by monetary and fiscal policies in the long run. Narrow money has no significant impact on inflation problem both in the short and long run in Nigeria The study concluded that monetary and fiscal policies have positive impact on inflation in Nigeria and recommended that monetary and fiscal policies should be harnessed, coordinated and sustained with the help of Central Bank of Nigeria in order to combat the problem of inflation in Nigeria.

From the reviewed empirical literature, it is interesting to know that several authors used different variables and statistical methodologies to investigate the effect of monetary policy on inflation. This study takes a holistic approach to investigate the relationship between the monetary policy variables and the joint effects on each other using statistical techniques prescribed for time series econometric modelling.

Methods

Source of Data: This study makes use of annual secondary time series data on Exchange rate, Inflation rate, Money Supply and Treasury bill rate obtained from National Bureau of Statistics and Central Bank of Nigeria (CBN) bulletin for the period 1981 to 2022.

Pre-Estimation Tests: The choice of econometric techniques is based on the nature of relationship that exists between time-series variables. The first concern in the analysis of time series data is to test for unit root or stationarity using the Augmented Dickey Fuller (ADF) test.

Augmented Dickey-Fuller unit root test

Let $\{Y_t\}$ be a given time series, the ADF unit root test is used to test whether the given time series contains a unit root or whether the given series is stationary or not, Dickey and Fuller (1979). The Augmented Dickey-Fuller (ADF) unit root test constructs a parametric correction for higher-order correlation by assuming that the series follows an AR(p) process:

$$y_t = \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + \cdots + \varphi_p y_{t-p} + \varepsilon_t \quad (1)$$

where $\varepsilon_t \sim iid(0, \sigma^2)$.The hypothesis, is Ho: $\psi^* = 0$, that the given time series does not contain unit root test against Hi: $\psi^* < 0$, that is, the time series contains unit root test) where $\varphi^* = \varphi - 1$. If the hypothesis is rejected against the alternative $\psi^* < 0$, then Y_t, contains a unit root. To test the null hypothesis, the ADF test is evaluated using the t-statistic:

$$t_{\varphi^*} = \varphi^* SE(\varphi^*) \quad (2)$$

This can be compared against the critical values at the conventional test sizes while ψ^* is the estimate of ψ, and $SE(\psi^*)$ is the coefficient standard error. An important result obtained by Fuller is that the asymptotic distribution of the t-ratio for is independent of the number of lagged first differences included in the ADF regression. When the variables are integrated of the same order, then Johansen Co- integration test will be conducted to check if there is long run relationship among the study variables.

Johansen Cointegration test: To investigate the long-run stable relationship among inflation rate, exchange rate, money supply and treasury bills rate in Nigeria, we employ Johansen cointegration testing procedure. Two or more non-stationary series, I(1), are said to be cointegrated if their linear combination gives a stationary series, I(0). Johansen (1991, 1995) developed a methodology for testing for cointegration as follows:

Let $(Y_t = y_{1t}, y_{2t}, \ldots, y_{nt})$ denote an (n x 1) vector of non-stationary I(1) time series variables. The basic Vector Autoregressive Model of order p, denoted VAR(p) is defined as

$$y_t = \alpha + \varphi_1 \Delta y_{t-1} + \varphi_2 \Delta y_{t-2} + \cdots + \varphi_p \Delta y_{t-p} + Bx_t + \varepsilon_t \qquad (3)$$

where α is an (n x 1) vector of intercept, ϕ_i (i = 1,2,...,p): is (nxn) coefficient matrices, X_t = d-vector of deterministic variables, ε_t : is an (n x 1) vector of unobservable error term with zero mean (white noise).

The VAR model is represented as

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + Bx_t + \varepsilon_t \qquad (4)$$

where $\Pi = \sum_{i=1}^{p} \varphi_i - 1$ and $\Gamma_i = \sum_{j=i+1}^{p} \varphi_j$

Granger's representation theorem asserts that if *the* coefficient matrix Π has reduced rank $r > k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' Y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. Johansen cointegration test computes two statistics, trace statistic and maximum eigenvalue statistic namely, the trace test and maximum eigenvalue test statistics which are used in this study. The trace statistic for the null hypothesis of r cointegrating relations is computed as:

$$LR_{tr}(r/k) = -T \sum_{i=r+1}^{p} \log(1 - \lambda_i) \qquad (5)$$

The maximum eigenvalue test statistic is computed as:

$$LR_{Max}(r/r+1) = -T \log(1 - \lambda_i) = LR_{tr}(r/k) - LR_{tr}(r+1/k) \qquad (6)$$

where λ_i is the ith largest eigenvalue of the Π matrix in Equation (5), $r = 0,1,2, \ldots, k-1$.

In testing for cointegration, the five deterministic trend cases as summarized by Johansen (1995) are:

(i) The level data Y_t have no deterministic trends and the cointegrating equations do not have intercepts:

$$H_2 \text{ (r)}: \Pi Y_{t-1} + BX_t = \propto \beta' Y_{t-1} \qquad (7)$$

(ii) The level data have no deterministic trends and the cointegrating equations have Intercepts:

$H^*(r){:}\Pi Y_{t-1} + BX_t = \propto (\beta' Y_{t-1} + \rho_0)$ (8)

(iii) The level data Y_t have linear trends but the cointegrating equations have only intercepts:

$H_1(r){:}\Pi Y_{t-1} + B\boldsymbol{X}_t = \propto (\beta' \boldsymbol{Y}_{t-1} + \propto \perp \gamma_0$ (9)

(iv) The level data Y_t and the cointegrating equations have linear trends

$H^*(r){:}\Pi \boldsymbol{Y}_{t-1} + B\boldsymbol{X}_t = \propto (\beta' \boldsymbol{Y}_{t-1} + \rho_0 + \rho_1 t) + \propto \perp \gamma_0$ (10)

(v) The level data Y, have quadratic trends and the cointegrating equations have linear trends.

$H(r){:}\Pi \boldsymbol{Y}_{t-1} + B\boldsymbol{X}_t = \propto (\beta' \boldsymbol{Y}_{t-1} + \rho_0 + \rho_1 t) + \propto \perp (\gamma_0 + \gamma_1 t$ (11)

When the study variables are cointegrated, then the vector error correction model (VECM) is estimated otherwise, the VAR model is estimated.

The VAR Model: The first order VAR Model for economic time series that exhibit short run or long-run dynamics.

$$\begin{pmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \\ y_{4t} \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \end{pmatrix} + \begin{pmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \\ \beta_{41} & \beta_{42} & \beta_{43} & \beta_{44} \end{pmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \\ y_{4t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{pmatrix} \qquad (12)$$

Which can be summarized as

$$\mathrm{Y}_t = C + \Pi_1 Y_{t-1} + \mathrm{E}_t; t = 1,2,\dots,T \qquad (13)$$

Pairwise Granger Causality Test: The directions of causality between these variables is investigated using the pairwise Granger Causality test categorized into three namely; unidirectional causality, bidirectional causality and no causality.

Let *X* and *Y* be two independent series, X is said to be Granger-caused by Y if Y helps in the prediction of *X* it if and only if the coefficients on the lagged Y's are statistically significant. If Y granger causes X and X in turn Granger causes Y, then the causality is two-way or bidirectional.

Consider the regressions of the form:

$$\left.\begin{aligned} \mathrm{y}_t &= \textstyle\sum_{j=1}^{m} a_j y_{t-j} + \sum_{j=1}^{m} \beta_i x_{t-i} + \varepsilon_{1t} \\ \mathrm{x}_t &= \textstyle\sum_{j=1}^{m} \gamma_j y_{t-j} + \sum_{j=1}^{m} \varphi_i x_{t-i} + \varepsilon_{2t} \end{aligned}\right\} \qquad (16)$$

where a_j, γ_j are the coefficients of lagged y; β_i and φ_i are the coefficients of the lagged x.

For each equation in (16), the hypothesis is that Y does not Granger cause X in the first regression and that X does not Granger cause Y in the second regression. In each case, a rejection of H, implies there is Granger causality.

Results

In this Section, the researchers presented results of data analysis.

Specifically, the section presents results of time plotsof the study variables,unitroottest result, and VAR model and the associated model testing criteria.

Time Plots of the Variables: The time plots on Figure 1 shows that LOGINF series appears to wanders and reverts to its stable mean over the time while the LOGBR, LOGEXC and LOGMS appears to wander away not reverting to its stable mean level.

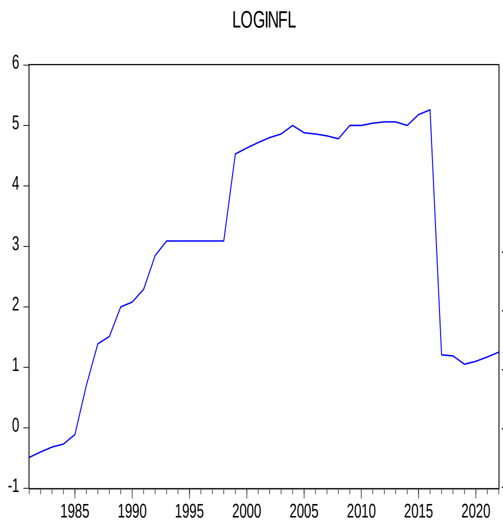

Figure 1a: Time Plot of LOGINFL Series

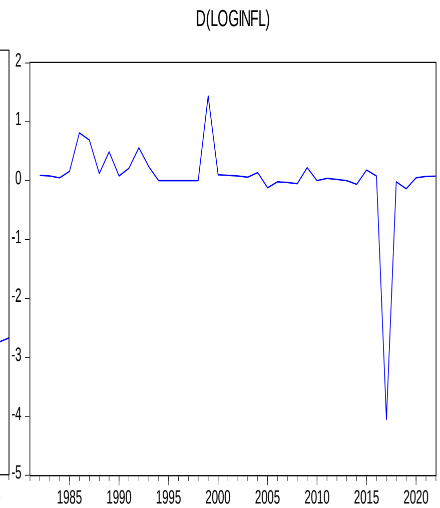

Figure 1b: Time Plot of LOGINFL Series at first difference

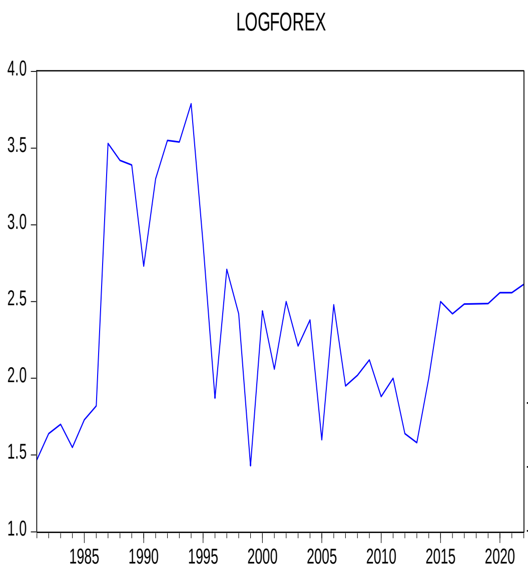

Figure 2a: Time Plot of LOGFOREX Series

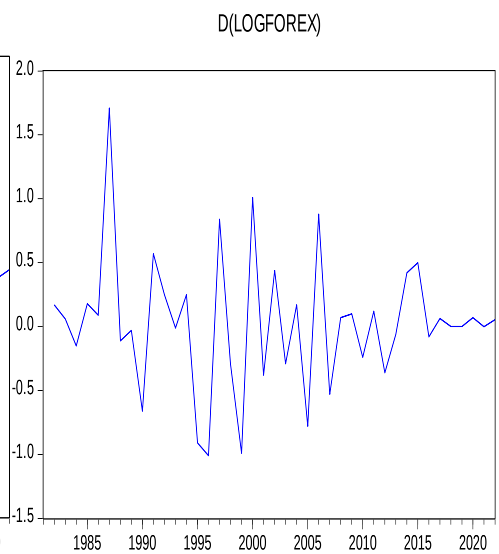

Figure 2b: Time Plot of LOGFOREX Series at first difference

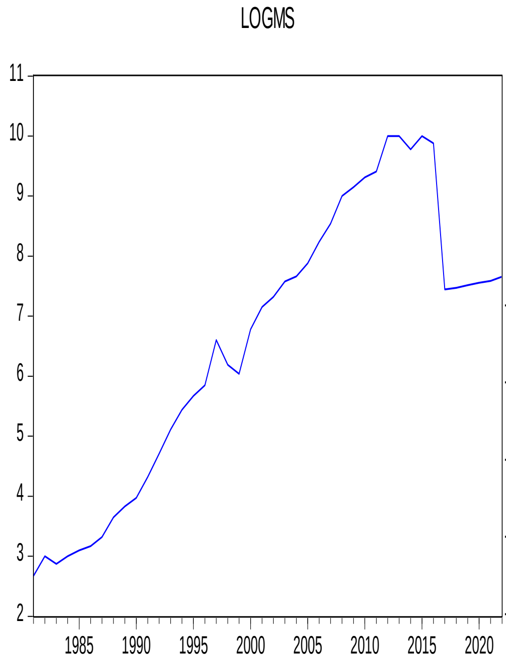

Figure 3a: Time Plot of LOGMS Series

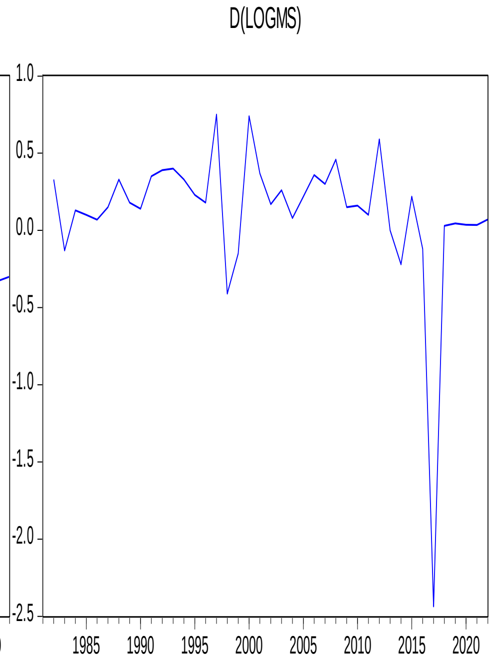

Figure 3b: Time Plot of LOGMS Series at first difference

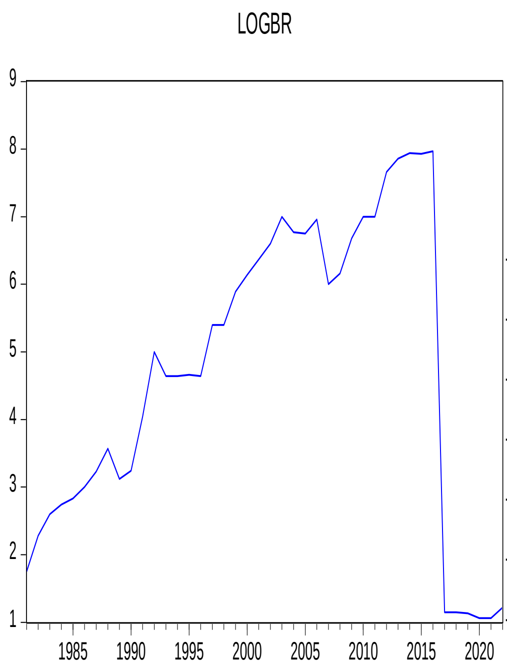

Figure 4a: Time Plot of LOGBR Series

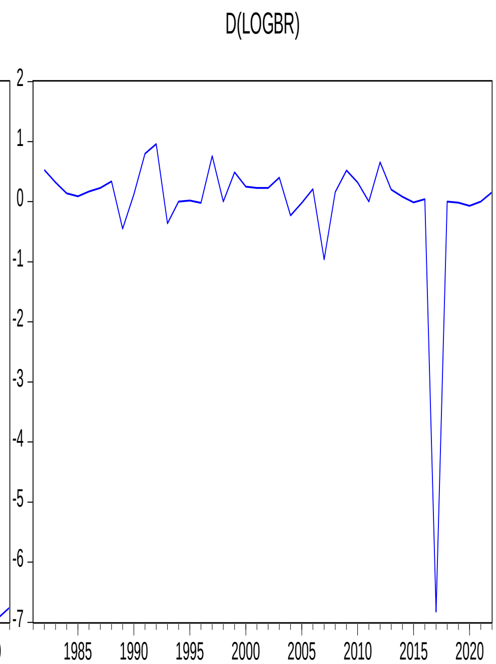

Figure 4b: Time Plot of LOGBR Series at first difference

Table 1: Summary of Augmented Dickey Fuller Unit Root Test for the Variables

	Level		First Difference		
Variables	ADF t-Statistic	p-value	ADF t-Statistic	p-value	**Remark**
LOGINF	-0.7967	0.9575	-6.4771	0.0000	I(1)
LOGEXC	-3.0796	0.1262	-8.3121	0.0000	I(1)
LOGMS	-0.3703	0.9855	-5.7978	0.0001	I(1)
LOGBR	-1.1456	0.9083	-6.3915	0.0000	I(1)

Key: LOGINF = Log of Inflation; LOGEXC = Log of Exchange Rate; LOGMS = Log of Money Supply and LOGBR = Log of Treasury Bill Rate

Table 1 presents the summary of ADF unit root test result for the study variables. The ADF test results for LOGINF has t = -0.7967 (p = 0.9575) which does not rejects the null hypothesis of unit root in the series at level of the variable. However, after first difference, t = -6.4771 (p =0.0000) indicating that LOGINF is stationary after the first difference denoted by I(1). Similarly, the ADF unit root test result for LOGEXC (t= -3.0796, p=0.1262), LOGMS (t= -0.3703, p=0.9855) and LOGBR (t=-1.1456, p=0.9083) provided evidence for accepting the hypothesis of unit root in LOGEXC, LOGMS and LOGBR at the level of the variables which make the series non-stationary. However, the ADF unit root test results at first difference showed that DLOGEXC (t=-8.3121, p=0.0000), DLOGMS (t=--5.7978,p=0.0001) and DLOGBR (t=-6.3915,p=0.0000) are stationary after the first difference as the null hypothesis of unit root is rejected.

Table 2 represents the pairwise granger causality test for the study variables. Here, it is noticeable that the hypothesis that LOGINF does not granger cause LOGEXC is not rejected at 5% level as p > 0.05. Similarly, LOGEXC does not granger causes LOGINF as p >0.05. The hypothesis that LOGEXC does not granger cause LOGMS is also not rejected at 5% levels. This is same with LOGMS, LOGBR and LOGEXC as they do not granger cause each other at 5% level of significance. This results shows no directional link between these variables and it is reasonable to conclude in the context of Nigeria's economy, the expectation regarding the relationship among these variables is not realized. This also raises concern on how well the monetary policy indicators are managed within the economy.

Table 2: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGINF does not Granger Cause LOGEXC	40	1.17500	0.3207
LOGEXC does not Granger Cause LOGINF		0.02709	0.9733
LOGMS does not Granger Cause LOGEXC	40	1.01925	0.3713
LOGEXC does not Granger Cause LOGMS		0.28386	0.7546
LOGBR does not Granger Cause LOGEXC	40	0.66009	0.5231
LOGEXC does not Granger Cause LOGBR		0.26814	0.7664
LOGMS does not Granger Cause LOGINF	40	0.96347	0.3915
LOGINF does not Granger Cause LOGMS		0.84306	0.4389
LOGBR does not Granger Cause LOGINF	40	0.04460	0.9564
LOGINF does not Granger Cause LOGBR		0.17597	0.8394
LOGBR does not Granger Cause LOGMS	40	0.58947	0.5600
LOGMS does not Granger Cause LOGBR		0.77620	0.4679

Table 3 shows clearly that there is no co-integration among the variables. Consequently, the short run dynamic of the model become of interest and it is appropriate to fit the vector auto-regressive (VAR) model to express the relationship among the monetary policy indicators.

Table 3: Johansen Co-integration Test for the Series

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.324546	35.05314	47.85613	0.4452
At most 1	0.254690	19.35831	29.79707	0.4674
At most 2	0.143317	7.600111	15.49471	0.5091
At most 3	0.034699	1.412628	3.841466	0.2346

Trace test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The lag length determined for the model based on the Akaike Information Criteria (AIC) amongst others is shown on Table 4. The result shows specifying the model with Lag 1 with provide a model with minimum error as it has AIC = 5.2026 which is the smallest when compared with other lags.

Table 4: Lag Length for the Model

VAR Lag Order Selection Criteria

Endogenous variables: LOGINF LOGEXC LOGMS LOGBR

Exogenous variables: C

Date: 08/02/24   Time: 15:17

Sample: 1981 2022

Included observations: 39

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-222.5206	NA	1.303402	11.61644	11.78706	11.67766
1	-75.48202	256.3750*	0.001582*	4.896514*	5.749622*	5.202602*
2	-71.02005	6.864568	0.002940	5.488207	7.023803	6.039166
3	-59.75946	15.01411	0.004029	5.731255	7.949337	6.527083

* indicates lag order selected by the criterion

The VAR Models are presented on Table 5 for the study variables with the functional relationships expressed as models 1 to 4.

Model 1: When LOGINF is being explained.Here, inflation at lag 1, that is, LOGINF(-1) has significant coefficient with $p < 0.05$. This means that the immediate past value of inflation has significant impact on the current inflation in Nigeria if all other factors are held constant while other variables are not significant. Thus, the current inflation will increase by approximately 1.2 units given a unit increase in the past values of inflation. The model does not contain serial correlation as the Durbin Watson statistic, D = 2.12. However, the inflation model has 0.87 as the coefficient of determination indicating an 87% goodness of fit. By this result.

Model 2: When LOGEXC is being explained. From the result, only log exchange rate at lag 1, that is LOGEXC(-1) is seen to have significant impact on current exchange rate at 5% level ($p < 0.05$). It shows that LOGEXC will increase by about 0.53 for every unit of the previous exchange rate. This model does not contain serial correlation as the Durbin Watson statistic, D = 2.06 and the coefficient of determination of 0.477 (or ≅ 48) which indicates the existence of other intervening variables not considered in this study.

Model 3: When LOGMS is being explained. Results showed that money supply is visibly influenced by lag 1 values each of inflation, exchange rate, money supply and treasury bill rate as they all have significant coefficients at 5% level. While LOGINF(-1) and LOGMS(-1) have significant positive impact on money supply, LOGEXC(-1) and LOGBR(-1) all have negative impact on LOGMS. Thus, LOGINFL(-1) and LOGMS(-1) would each increase money supply by 0.49 and 0.80 units respectively for every unit of inflation rate and every unit of money supply. LOGEXC(-1) and LOGBR(-1) all have negative impact on LOGMS which indicates that an unit increase in each of them will decrease money supply by 0.24 and 0.30 units respectively. The model does not contain serial correlation as the Durbin Watson statistic, D = 1.98 and the coefficient of determination of 0.97 (97%) indicates that it does provide a good fit.

Model 4: When LOGBR is being explained. The results showed that Treasury bill rate (LOGBR) is positively and significantly influenced by lag 1 values of log of inflation rate (LOGINF) and lag1 values of LOGBR itself. A unit increase in LOGINF(-1) will increase LOGBR by 0.72 units while a unit increase in LOGBR(-1) will increase LOGBR by 0.49 units if all things are held constant. It is worthy of note that exchange rate at lag 1 does not significantly impact on current treasury bill rate while LOGMS(-1) have negative impact on current LOGBR. The model does not contain serial correlation as the Durbin Watson statistic, D = 2.07 and the coefficient of determination of 0.79 (79%) which indicates that the model does provide a good fit.

Table 5: The VAR Models for the Variables

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	**1.217218**	**0.227967**	**5.339449**	**0.0000**
C(2)	-0.168179	0.197063	-0.853425	0.3948
C(3)	-0.162622	0.091380	-1.779618	0.0772
C(4)	-0.151468	0.155489	-0.974141	0.3316
C(5)	1.572634	0.871063	1.805419	0.0731
C(6)	0.192001	0.158135	1.214164	0.2267
C(7)	**0.529992**	**0.136698**	**3.877112**	**0.0002**
C(8)	-0.095101	0.063388	-1.500295	0.1357
C(9)	-0.126259	0.107859	-1.170601	0.2437

C(10)	**1.784988**	**0.604233**	**2.954136**	**0.0037**
C(11)	**0.491591**	**0.133283**	**3.688335**	**0.0003**
C(12)	**-0.241541**	**0.115214**	**-2.096448**	**0.0378**
C(13)	**0.796747**	**0.053426**	**14.91305**	**0.0000**
C(14)	**-0.298368**	**0.090908**	**-3.282095**	**0.0013**
C(15)	**1.966681**	**0.509273**	**3.861741**	**0.0002**
C(16)	**0.716762**	**0.355217**	**2.017813**	**0.0455**
C(17)	-0.539398	0.307063	-1.756635	0.0811
C(18)	**-0.312438**	**0.142388**	**-2.194265**	**0.0298**
C(19)	**0.490704**	**0.242283**	**2.025339**	**0.0447**
C(20)	**3.581077**	**1.357288**	**2.638407**	**0.0092**

Determinant residual covariance 0.000556

Equation: LOGINF = C(1)*LOGINF(-1) + C(2)*LOGEXC(-1) + C(3)

*LOGMS(-1) + C(4)*LOGBR(-1) + C(5)

Observations: 41

R-squared	0.877241	Mean dependent var	3.066267
Adjusted R-squared	0.863601	S.D. dependent var	1.886016
S.E. of regression	0.696547	Sum squared resid	17.46640
Durbin-Watson stat	2.118978		

Equation: LOGEXC = C(6)*LOGINF(-1) + C(7)*LOGEXC(-1) + C(8)

*LOGMS(-1) + C(9)*LOGBR(-1) + C(10)

Observations: 41

R-squared	0.477756	Mean dependent var	2.389384

Adjusted R-squared	0.419729	S.D. dependent var	0.634294
S.E. of regression	0.483176	Sum squared resid	8.404541
Durbin-Watson stat	2.063989		

Equation: LOGMS = C(11)*LOGINF(-1) + C(12)*LOGEXC(-1) + C(13)

*LOGMS(-1) + C(14)*LOGBR(-1) + C(15)

Observations: 41

R-squared	0.971762	Mean dependent var	6.652526
Adjusted R-squared	0.968625	S.D. dependent var	2.299098
S.E. of regression	0.407241	Sum squared resid	5.970437
Durbin-Watson stat	1.976618		

Equation: LOGBR = C(16)*LOGINF(-1) + C(17)*LOGEXC(-1) + C(18)

*LOGMS(-1) + C(19)*LOGBR(-1) + C(20)

Observations: 41

R-squared	0.791931	Mean dependent var	4.791987
Adjusted R-squared	0.768813	S.D. dependent var	2.257307
S.E. of regression	1.085358	Sum squared resid	42.40804
Durbin-Watson stat	2.077170		

The result here does not agree with findings in Hassain and Islam (2013) who examined the determinants of inflation rate using ordinary least square method and data from 1990 to 2010 in Bangledesh showed that money supply, one year lagged value of interest rate positively and significantly affect inflation rate and Onwachukwu (2014) who posited that bank rate, deposit with the central bank, liquidity ratio, and broad money supply were statistically significant in explaining changes in inflation . However, the study agrees with findings by Odusanya and Atanda (2010) who showed that lagged 1 value of inflation rate exerted positive influence on inflation rate. Similarly, findings here do not support the findings by Okotori (2019) who had shown that money supply, exchange rate, monetary policy rate, treasury bills rate, etc have significant and effective impact on the inflation rate in the long run. The postulation that inflation rate affects money supply is supported by works of Abeng (2015), Bataresh (2021).

Tests for Basic Assumption of Goodness of Fit of the VAR Model

The basic assumptions of VAR model are that the model must satisfy assumption of linearity, no serial correlation and the error covariance must be constant. The model presented here are basically linear and of is testing for presence of serial correlation and that of heteroskedasticity and normality of residuals.

Table 6: VAR Residual Serial Correlation Test

Lags	LM-Stat	Prob
1	8.619211	0.9283
2	11.41864	0.7829
3	15.09023	0.5180
4	6.102654	0.9869
5	8.786340	0.9220
6	10.98821	0.8102
7	15.90432	0.4597
8	32.40845	0.0088
9	19.14168	0.2614
10	18.22623	0.3108
11	16.10694	0.4455
12	22.83215	0.1183

Table 7: VAR Reidual Heteroskedasticity Test

Joint test:

Chi-sq	df	Prob.
98.17258	80	0.0819

Individual components:

Dependent	R-squared	F(8,32)	Prob.	Chi-sq(8)	Prob.
res1*res1	0.220673	1.132635	0.3689	9.047599	0.3383
res2*res2	0.305406	1.758758	0.1228	12.52164	0.1294
res3*res3	0.260827	1.411457	0.2296	10.69393	0.2197
res4*res4	0.244993	1.297965	0.2796	10.04472	0.2619
res2*res1	0.134560	0.621927	0.7530	5.516964	0.7012
res3*res1	0.255769	1.374672	0.2449	10.48651	0.2325
res3*res2	0.134647	0.622393	0.7526	5.520538	0.7008
res4*res1	0.235695	1.233510	0.3120	9.663478	0.2894
res4*res2	0.034119	0.141298	0.9965	1.398890	0.9943
res4*res3	0.251272	1.342396	0.2590	10.30216	0.2445

Tables 6 and 7 for serial correlation and test of heteroskedasticity respectively show the VAR residual serial correlation LM test and the VAR residual heteroskedasticity test. Here, the hypothesis of no serial correlation in the residuals is not rejected as $p > 0.05$ in all cases. Similarly, the residuals are jointly homoscedastic as the assumption as all p-values are all greater than 5% level of significance.

Figure 5 further confirms that all the root of the characteristic polynomials associated with the VAR model fall inside the unit root.

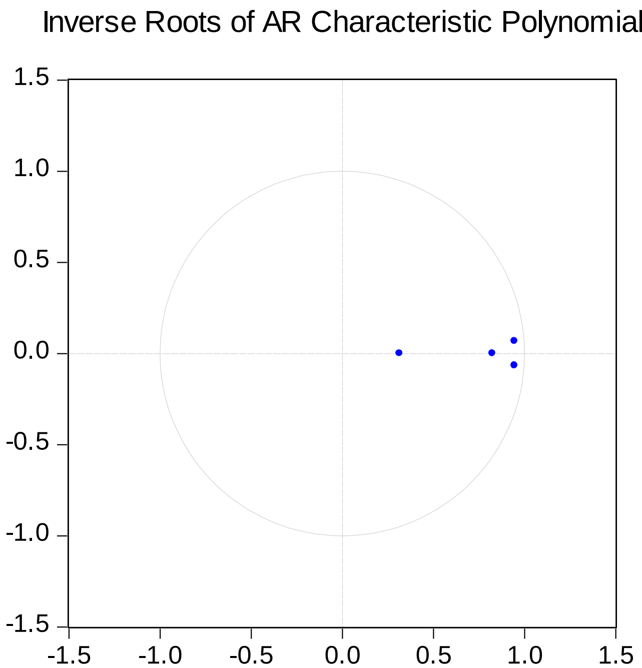

Figure 5: Inverse Root of AR Characteristic Polynomial

Conclusion

From the result in this study, it is noticeable that Inflation rate, treasury bill rate, money supply and exchange rate in Nigeria for the samples data are non-stationary but become stationary after first difference. By the Granger causality test results, there is no evidence that the variables granger causes each other. Similarly, no long run relationship among the variables is established as evidenced by result of the Johansen Co-integration test outcomes. In the short run, money supply is influenced by lag 1 values of inflation, money supply, treasury bill rate and exchange rate. Lag 1 values of exchange rate is the only variable influencing current inflation and this is similar with inflation rate which is also influenced by its lag 1 values. It is also evidence in the model that lag 1 of inflation rate will increase current treasury bill rate while lag 1 of money supply will have negative impact on current treasury bill rate. The short run impact of these variables on inflation and exchange rates is not significant for the sampled data. Money supply and treasury bill rates appear to be a critical indicator of interest requiring regulation for economic stability. Treasury bill rate is another indicator of interest demanding attention

It is, therefore, necessary for the monetary policy regulators in Nigeria to revisit the operations of these monetary policy indicators so that the purpose of minimizing inflation among others can be effectively achieved and to fulfil the expectations inherent in relationship among the indicators. This could be achieved via the control of flow of money in circulation, stabilizing foreign exchange rate and interest rates in order to curb inflation in the country.

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