Application of Bayesian Vector Autoregressive in Modeling Nigerian Narrow Money and Quasi-Money

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ABSTRACT

This study examines the application of Bayesian Vector Autoregressive model in modeling Nigerian narrow money and quasi money as a guide for monetary policy, using monthly data from 2015 - 2022. The objectives include to; model and estimates the interaction between Nigerian narrow money and quasi money, determine the direction of causality, significance of the causality among the variables, and determine the fractions in each variable explained by the changes in the other variables. The data used for the study were narrow money and quasi money, extracted from the Central Bank of Nigeria online statistics bulletin. The model used in the study is Bayesian Vector Autoregressive models. The results of the descriptive statistics revealed that all the series are statistically significant at the 5 percent level of significance. Augmented Dickey Fuller (ADF) and Phillip Perron (PP) test were used to test for stationarity of the variables under investigation. The results of Johansen Cointegration test showed that there is no cointegration or long-run equilibrium relationship between narrow money and quasi money at a 0.05 significance level. The Adjusted R-square value indicates that 97.7% variation in future narrow money values is explained by first and second per-determined value of narrow money itself and quasi money. Th narrow money has a significant effect on quasi money during the studied period. The result of VAR model stability test (AR root circle) satisfied the stability condition, with all characteristic root lying inside the circle. The result of the impulse response function revealed that narrow money responded positively to quasi money. It was found that narrow money granger caused quasi money. This suggests that changes in the money supply have potential effect on economic activity through the narrow-money market, which may have implications for monetary policy decision. Therefore, it was recommended that there should be adequate monetary policy development measures to capture both short-run and long-run relationship between the study variables, including structural reforms to address issues related to shocks from one variable to the other.

Key Words: *Model, Narrow Money & Quasi-Money*

INTRODUCTION

1.1` Background to the Study

The importance of money in an economy has been a matter of interest to the government, policymakers, and economists. This is because money serves as a key driver of economic activity, so changes in the amount of money supply can have a significant effect on a wide range of macroeconomic indicators (Ifionu, 2015). Nigeria, like many other countries, follows a monetary policy framework to manage its economy and ensure the stability of the financial system and promote economic growth. The apex bank of Nigeria, known as the Central Bank of Nigeria (CBN), is responsible for formulating, implementing, and regulating monetary policies in the country (Oluwafemi, 2012). One important aspect of monetary policy is the management of money supply in the economy. According to Umeora (2010), money supply refers to the total amount of physical currency in circulation (including coins and notes) in an economy at a particular point in time. The study of Nigerian narrow money and quasi money is essential for the formulation of monetary policy because it provides insights into the overall liquidity in the economy. The central bank uses these measures to assess the level of money supply, the velocity of money circulation, and the availability of funds for lending and investment activities.

Therefore, it is necessary to investigate the interaction between narrow money and quasi money in Nigeria economy using the VAR model. This is because VAR model is useful in identifying the cordial relationship among the variables under investigation. Although, the Bayesian vector autoregression (BVAR) model in the context of this study estimate the model parameters as random variables with assigned prior probabilities instead of treating them as fixed values.

Several studies have investigated the use of VAR model in modeling microeconomic variables and some of the studies include Yeshiwas & Tegegne, (2021) investigation on the impact of broad money supply on economic growth of Ethiopia, Ayo (2006) studied on the empirical characteristics of money in Nigeria; Abdur Rauf, & Abdulkareem, (2019) studied on Monetary Policy and Money Supply in Nigeria: A Comparative Analysis: 1993-2018; Ebele (2015) investigation on microeconomic variables and money supply, providing evidence from Nigeria; Salihu, Yaaba, and Hamman (2018) studied on Money supply and inflation dynamics in Nigeria, Yan-liang (2012) use of co-integration and granger causality techniques to Chinese data from 1998 to 2007 to determine the relationship between money supply, the level of economic activity, and changes in the general price level; Chizoba (2022) investigation on the impact of monetary policy on banking sector stability in Nigeria, utilizing quarterly data for the period 2007Q1 to 2021Q4; Ahad (2015) adopted a combination of Baver-Hanck and Johansen cointegration approaches to estimates a money demand function; Odior (2013) studied on the supply of money in Nigeria using a time-series generalized method of moment (GMM) model and Yeshiwas(2021)investigation of the impact of money supply on Real GDP of Ethiopia using Vector Autoregressive model and a causality test to check the short causality between the study variables.

However, none of the studies reviewed so far uses Bayesian VAR in Modeling Nigeria's Narrow Money and Quasi Money to ascertain the assumption of a prior likelihood distribution of the coefficients of the model. The interaction between Nigerian narrow money and quasi-money, determine the direction of causality, significance of the causality and the infractions in each variable that is explained by the changes in the other variables were not determined.

METHODOLOGY

3.1 Model Specification

In line with objectives for this study, the models adopted for the study is the Bayesian Vector Autoregressive (BVAR) Model. However, the unrestricted Vector Autoregressive (VAR) Model is estimated as a preliminary model for lagged length estimation. In a univariate autoregression, a stationary time-series variable y_t can often be modelled as depending on its own lagged values:

$$Y_t = a_0 + a_1Y_{t-1} + a_2Y_{t-2} + \ldots\ldots + a_{k-1}Y_{k-1} + \mathcal{E}_t \quad (3.1)$$

When multiple time series is analyzed, the normal extension to the autoregressive model is the Vector Autoregressive or VAR, in which a vector of variables is modelled as depending on their own lags and the lags of every other variable in the vector. Vector autoregressive model is a multivariate time series model . The structure is that each variable is a linear function of past lags of itself and lags of the other variables. The model adopted in this study is the Vector Auto-regressive (VAR) which could be specified as thus:

$$X_t = a_0 + a_1Y_{t-1} + a_2X_{t-1} + \mathcal{E}_{1t} \quad (3.2)$$
$$Y_t = b_0 + b_1Y_{t-1} + b_2X_{t-1} + \mathcal{E}_{2t} \quad (3.3)$$

Where X_t *and* Y_t represents Narrow money and Quasi money respectively. While the apriori expectation: $a_0, b_0 > 0$, these represent the intercept a_1, *and* b_1= Short-run dynamic coefficients of the model's adjustment long-run equilibrium, $\mathcal{E}_{i.t}$ = Errors, impulses, shocks or innovations. Each variable is a linear function of the lag 1 values for all variables in the set. In a VAR (2) model, the lag 2 values for all variables are added to the right sides of the equations. Generally, for a VAR (p) model, the first p lags of each variable in the system would be used as regression predictors for each variable.

Similarly, Bayesian Vector Autoregressive (BVAR) model was propounded by Thomas Bayes in the 18th century was also used in the study. The model describes the relationship between the conditional probabilities of two random events. Assuming a random event *x* and *y*, P(x) denote the probability of event *x*, also called the prior probability of event *x*. P(y) represents the probability of event B occurring, also called the prior probability of event *y*. $P(x|y)$ represents the probability of event *x* occurring under the condition that event *y* occurs, also called the posterior probability of event *x*. Similarly, $P(y|x)$ represents the probability of event *y* occurring under the condition that event *x* occurs. It is also called the posterior probability of event *y*. The relationship is as follows:

$$P\left(\frac{x}{y}\right) = \frac{P(y)\,P(y|x)}{P(X)} \quad (3.4)$$

The formula above is well-known Bayes theorem. It is sometimes called the standard likelihood, and could also be expressed as: $P_p = L_l \times P_{p.}$

Where P_p is the posterior probability, L_l is the likelihood function, and $P_{p.}$ is the prior probability.

The Bayesian VAR models has three distinct priors: Independent Normal-Wishart prior, the Minnesota prior and the SSVS prior.
From the VAR model with p lag written as

$$y'_t = \mu' + \sum_{i=1}^{p} y'_{1-t}\Theta_i + \varepsilon_\tau' \quad (3.5)$$

for t = 1, …, T, where μ is n x 1 vector of an intercept term; Θ_i are n x n matrices of coefficients for I = 1, …, p; ε_t are n x 1 independent $N_n(0, \sum)$ errors; and the covariance matrix ∑ is an n x n positive definite matrix.
The VAR model in equation (3.4) can be written in matrix form as follows:

$$Y = X\Theta + \varepsilon \quad (3.6)$$

Where the T x n matrix Y is defined as Y = $(y_1; . . . ; y_T)'$; the T x (1 + np) matrix X is defined as X = $(x_1, …, x_T)'$; the (1 + np) X 1 vector is defined as $x_1 = (1, y'_{t-1}, …, y'_{t-p})'$, the (1 + np) X n matrix Θ is defined as $\Phi = (\mu', \Theta'_I, … \Theta'_p)'$; and the ε is a T x n matrix with $\varepsilon = (\varepsilon_1, …, \varepsilon_T)'$. Based on the VAR model in equation (3.5), the three priors are described briefly in the following subsections.

3.2 Model Estimation Technique (BVAR)

The VAR model in (3.14) with the independent Normal-Wishart prior

$$vec(\Phi) \sim MN\,(vec(\Phi_0), V_0) \quad (3.6)$$

$$\Sigma \sim IW(\Sigma_0, v_0) \quad (3.7)$$

Where MN refers to a multivariate normal with $vec(\Phi_0)$ and convenience-variance matrix V_0: IW refers to an inverted Wishart distribution wit parameters Σ_0 and degrees of freedom, v_0. Unlike the natural conjugate priors, prior for Φ in equation (3.15) and Σ in equation (3,16) are independently specified. With the joint prior and the likelihood, the conditional posterior densities of $vec(\Phi)$ and Σ are derived as thus:

$$vec(\Phi)|\Sigma, Y \sim MN\,(vec(\Phi_*), V_*) \quad (3.8)$$

$$\Sigma|\Phi, Y \sim IW(\Sigma_* V_*) \quad (3.9)$$

$$V_* = [V_0^{-1} + \Sigma \otimes (XX)]^{-1} \; and \; vec\,(B_\star) = V_*[V_0^{-1}\, vec\,(\Phi_0) + (\Sigma \otimes I_k)^{-1}\, vec\,(X'Y)],$$

$\Sigma_* = (Y - X\Phi)'(Y - X\Phi) + \Sigma_0$, and $v_* = T + v_0$. Given these conditional posterior specifications above, the Gibbs sampler generates sample draws. It is important to note that, with zero prior mean $\Phi_0 = 0$ and large prior variance V_0 in equation (3.5), the posterior mean for Φ is almost the same with the Maximum likelihood estimator. Also, following Litterman (1986) proposed method known as Minnesota prior which shrinkage the prior for a Bayesian VAR model with random walk components. For a VAR model with *p*-the lag in equation (3.13), the Minnesota prior for the coefficient suggests that the significance of the lagged variables is shrinking with the lag period, in order that the previous is tighter around 0 with lag duration such that $\Theta_i \sim N\left(\overline{\Theta}_{i,} V(\Theta_i)\right)$ where the expected values of Θ_i is defined as $\Theta_1 = I_n$ and $\overline{\Theta}_2 = \cdots = \overline{\Theta}_p = 0_n$, and the variance of Θ_1 is given as:

$$V(\Theta_i) = \frac{\lambda^2}{i^2}\begin{bmatrix} 1 & \theta\hat{\sigma}_1^2/\hat{\sigma}_1^2 & \cdots & \theta\hat{\sigma}_1^2/\hat{\sigma}_1^2 \\ \theta\hat{\sigma}_2^2/\hat{\sigma}_1^2 & 1 & \cdots & \theta\hat{\sigma}_1^2/\hat{\sigma}_n^2 \\ \vdots & \vdots & \ddots & \vdots \\ \theta\hat{\sigma}_n^2/\hat{\sigma}_1^2 & \theta\hat{\sigma}_n^2/\hat{\sigma}_2^2 & \cdots & 1 \end{bmatrix}$$

Where $0 < \theta < 1, and\ \Sigma = diag\ (\hat{\sigma}_1^2, \dots, \hat{\sigma}_n^2)$.

Also, due to the problem of over-parameterization in VAR, George *et al.* (2008) suggested the Bayesian **Stochastic Search Variable Selection (SSVS) Prior** method in a Var. This method was put forward by George et al. (2008) and Goerge and McCulloch (1997), which restricts the parameters of the model by using a hierarchical prior on the parameters. **Stochastic Search Variable Selection** defines the prior for the VAR coefficient Φ for each element in Φ. Let Φ_j be each element in Φ, then the prior for ϕ_j is a hierarchical prior with combination of two normal distributions and different variance conditional on an unknown dummy variable γ_j that takes 0 or 1: $\phi_j\, |\gamma_j \sim (1-\gamma_j)\, N\, \left(0, \tau_{0_j}^2\right) + \gamma_j N\, \left(0, \tau_{0_j}^2\right)$
Where $\tau_{0_j}^2$ is small and, $\tau_{0_j}^2 < \tau_{0_j}^2$. This means that if $\gamma_j = 0$, that is, the element ϕ_j is restricted to be close to 0 as $\phi_j\, |\gamma_j \sim N\, \left(0, \tau_{0_j}^2\right)$, the prior for $\phi_j\, |\gamma_j$ is virtually zero small variance, on the other hand, if $\gamma_j = 1$, that is, the element ϕ_j is unrestricted as $\phi_j\, |\gamma_j \sim N\, \left(0, \tau_{0_j}^2\right)$, the prior is almost non-informative with larger variance. The priors on γ_j are assumed to be independent Bernoulli $p_i \epsilon (0,1)$ random variables as follows:

$$P(\gamma_j = 1) = p_j$$

$$P(\gamma_j = 0) = 1 - p_j$$

Where p_j is the prior parameter and $p_j = 0.5$ for a natural default choice.

3.3 Source of Data for the Study

This study used secondary data sourced from the Central Bank of Nigeria's website www.cbn.org.ng. The data was on Nigerian narrow money and quasi-money and it spanned for a period of 8years (2015 - 2022).

3.4 Model Estimation Procedure (VAR)

The procedure used in estimating parameters of the Bayesian VAR model is as follows: Firstly, the time series plot for the variables were investigated for the purpose of visualization, to the movement, trends, seasonal patterns, and variation in the variables over successive time intervals. Also, the summary descriptive statistics are usually used to determine whether a dataset is normally distributed. This is tested using Jarque-Bera test statistics. In another development, the unit root test for stationarity was conducted using both Augmented Dickey-Fuller (ADF) and Philip Perron Test (PPT). The importance of Lag length determination was demonstrated by Braun and Mittnik (1993) who show that estimates of a VAR (Vector Autoregression) whose lag length differs from the actual lag length are inconsistent. According to Tuaneh (2018), VAR Lag Length Order is selected using various model selection criteria, such as Schwarz Information Criterion (SIC), Gideon Schwarz Bayesian Information Criterion (SBIC), Final Prediction Error (FPE), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQ). However, the study adopted the Akaike information criterion because it chooses the value of the length that minimizes the model selection criteria (Lϋtkehpohl 2005). Similarly, co-integration analysis was conducted to determine the long-term correlation between two or more non-stationary time series or for a specific period. According to Sayed (2008), the concept of co-integration between variables was developed by Granger and Engle in 1987. They explained the presence of a long-run relationship between two or more variables. When testing for co-integration, there are several underlying assumptions, and these include: all variables are considered non-stationary; they are all integrated of the same order. If they are not integrated to the same order, then we will proceed with cointegration analysis using multi-cointegration. However, Sayed (2008) further explained that there exists a long-run relationship among variables, including Engle-Granger's residual-based test, Johansen-Juselius (JJ) test, and Philip-Ouliaris test. However, Johansen test overcomes the limitation of providing incorrect test result for more than two time series compared to the Engle-Granger method; therefore, it is most preferred method (Sayed, 2018). The Johansen test can be seen as a multivariate generalization of the augmented Dickey-Fuller test. The generalization involves the examination of linear combination for unit roots. This approach is preferred over other methods due to its robust properties in trace statistics when dealing with skewed and kurtosis in the residuals of the series (Wassell and Saunders, 2000). Granger Causality and the impulse response functions (IRFs) of the studied variables in the system were investigated to determine their dynamic behaviors. This was done to show how one variable react to sudden changes in another variable. Also, to trace the impact of one-unit or one-standard deviation shock to an endogenous variable on all the other endogenous variable in a VAR model while keeping all other variables and shocks constant.

RESULTS

4.1 Pre-estimation Results

This section contains the result for the study. The series for this study were transformed using logarithm. The purpose of transformation is to deal with skewness of the variables under investigation. there is need to convert them into a series that is more approximately normal to avoid biased estimation.

4.1.1: Time Plots of the Variables under investigation.

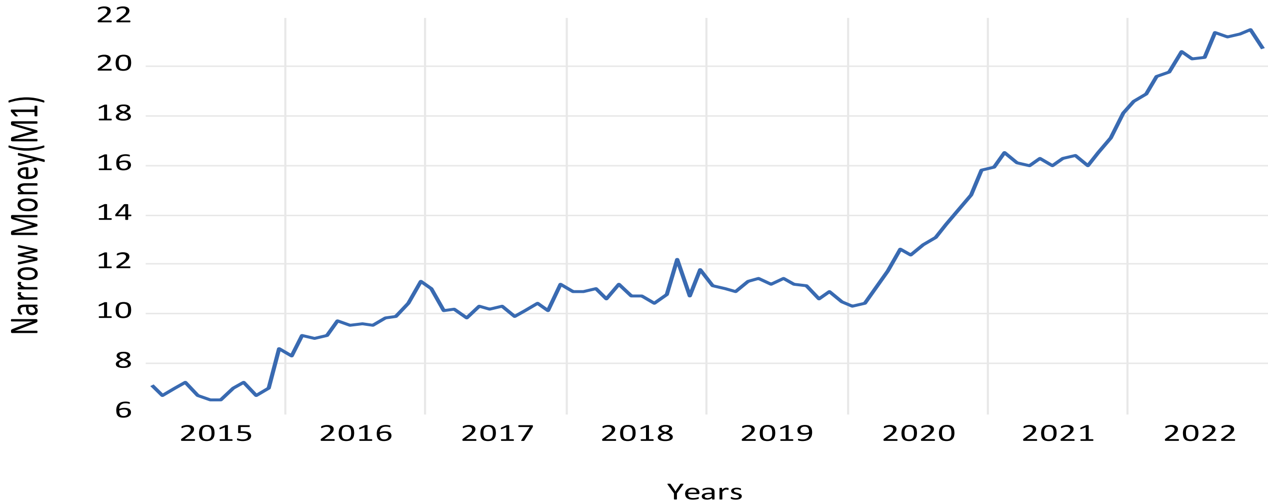


Figure 4.1, Plot on the raw series Nigeria Narrow money (M1)

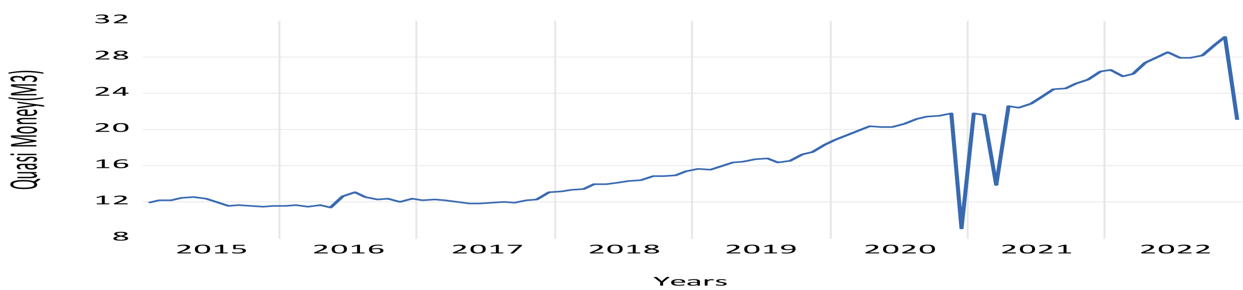


Figure 4.2: Time Plot on the raw series on Quasi Money at Level (M3)

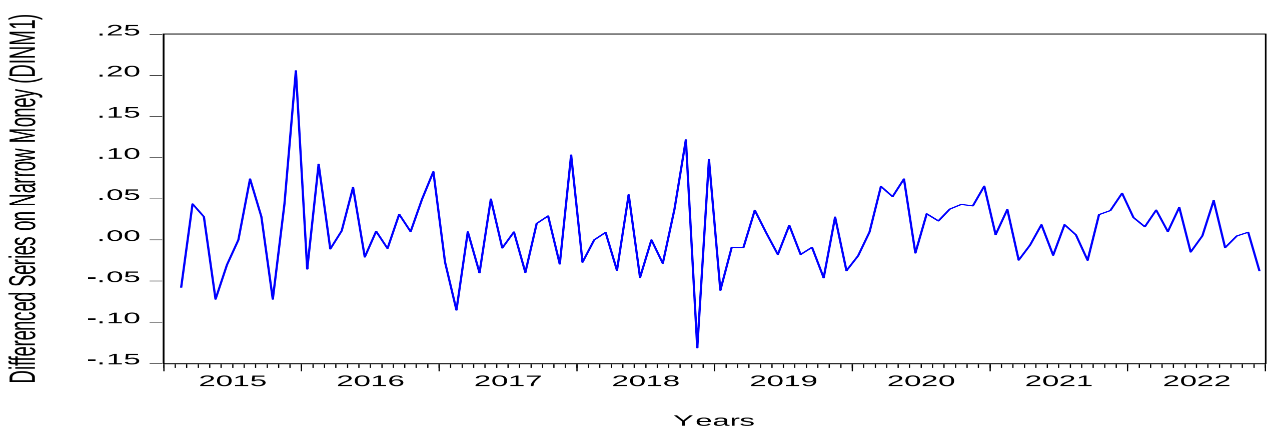


Figure 4.3: Time Plot on the Differenced Series on Narrow money (DINM1)

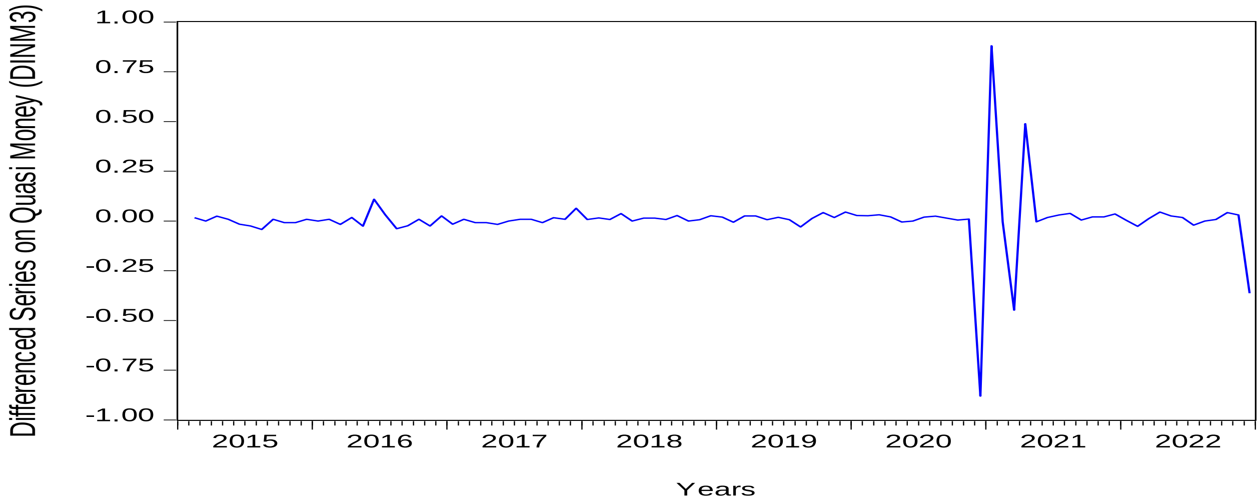


Figure 4.4: Time Plot on the Differenced Series on Quasi money (DINM3)

4.1.2: Descriptive Test for Normality

Descriptive test for normality provides basic information about the variables and highlights potential relationship between them. the result of the descriptive test for normality is shown in Table 4.1 below.

Table 4.1 Descriptive Statistics on Narrow and Quasi Money

Statistics	Narrow Money (INM1)	Quasi Money (INM3)
Mean	2.460182	2.784847
Median	2.397895	2.697994
Maximum	3.068053	3.407842
Minimum	1.871802	2.197225
Std. Dev.	0.315690	0.315096
Skewness	0.233786	0.443197
Kurtosis	2.472841	1.846927
Jarque-Bera	1.986077	8.461087
Probability	0.370449	0.014544
Sum	236.1775	267.3453
Sum Sq. Dev.	9.467731	9.432111
Observations	96	96

The results were all tested at 1%, 5%, and 10% level of significance respectively

4.1.3 Unit Test

The unit test is performed to determine the stationary level of the variables under investigations and the results is shown in Table 4.2 below.

Variable (s)	Stat. Level	Augmented Dickey Fuller Test (ADFT)					Phillip Perron Test (PPT)				
		1%	5%	10%	ADFTS	Remarks	1%	5%	10%	PPTS	Remarks
INM1	1(0)	-3.50	-2.89	-2.58	-0.461	Not Stationary	-3.51	-2.89	-2.58	-0.471	Not Stationary
	1(1)	-3.50	-2.89	-2.58	-12.18	Stationary	-3.50	-2.89	-2.58	-12.17	Stationary

INM3	1(0)	-3.50	-2.89	-2.58	-0.300	Not Stationary	-3.50	-2.89	-2.58	-1.958	Not Stationary
	1(1)	-3.50	-2.89	-2.58	-14.91	Stationary	-3.50	-2.89	-2.58	-20.06	Stationary

Table 4.2: Unit Root Test using Augmented Dickey Fuller and Phillip Perron Test
The results were tested at 1%, 5%, and 10% level of significance respectively.

4.1.4 Cointegration Test Result

Cointegration Test is conducted to determine the presence of a long-run relationship among the study variables. This is done using Johannsen cointegration test which make use of trace and maximum eigen value statistics and results is shown in Table 4.3 below.

Table 4.3: Cointegration Test Result

Hypothesized Unrestricted Cointegration Rank Trace and Max Eigenvalue Test

	Trace				Max Eigen value		
No. of CE(s)	Statistics	Crit. value	Prob	Statistics	Crit.value	Prob	
None	0.070004	6.794889	15.49471	0.6016	6.749503	14.26460	0.5192
At most 1	0.000488	0.045387	3.841466	0.8313	0.045387	3.841466	0.8313

Trace test and max eigenvalue indicates no cointegration at the 0.05 level

4.1.5 VAR Lag Length Order Selection

Table 4.4 contains the result for the lag order selection to ascertain the VAR lag length before estimation.

Table 4.4: VAR Lag Length Estimation.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	22.03612	NA	0.002174	-0.455366	-0.399063	-0.432683
1	196.6262	337.2764	4.50e-05	-4.332414	-4.163505	-4.264365
2	204.4485	14.75567	4.13e-05	-4.419284	-4.137769	-4.305869
3	219.8015	28.26340*	3.19e-05*	-4.677306*	-4.283184*	-4.518524*
4	220.9664	2.091511	3.41e-05	-4.612872	-4.106144	-4.408724
5	221.3778	0.720083	3.70e-05	-4.531314	-3.911980	-4.281800
6	224.3457	5.058825	3.79e-05	-4.507856	-3.775916	-4.212976
7	225.2661	1.527102	4.08e-05	-4.437867	-3.593320	-4.097620
8	225.6585	0.633226	4.44e-05	-4.355876	-3.398723	-3.970263
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						

FPE: Final prediction error				
AIC: Akaike information criterion				
SC: Schwarz information criterion				
HQ: Hannan-Quinn information criterion				

The result in Table 4.4 is used to determine the lag length of the model in shown in equation (4.1) and (4.2) below.

4.2 Bayesian Vector Autoregressive (BVAR) Model Estimation

$$Inm1_t = \underset{(0.041)}{0.032} + \underset{(0.045)}{0.733}\, Inm1_{t-1} + \underset{(0.041)}{0.183}\, Inm1_{t-2} + \underset{(0.022)}{0.053}\, Inm3_{t-1} + \underset{(0.015)}{0.015}\, Inm3_{t-2} \quad (4.1)$$

$R^2 = 0.978, AdjR^2 = 0.977$

$$Inm3_t = \underset{(0.444)}{0.404} + \underset{(0.130)}{0.355}\, Inm1_{t-1} + \underset{(0.119)}{0.127}\, Inm1_{t-2} + \underset{(0.065)}{0.324}\, Inm3_{t-1} + \underset{(0.044)}{0.108}\, Inm3_{t-2} \quad (4.2)$$

$R^2 = 0.813, AdjR^2 = 0.805$

Note: INM1 represents **Narrow Money**, INM3 represents **Quasi Money**

The result obtained in model (4.1) shows that the overall statistically significant positive coefficient of narrow money at first and second lags imply that the effect of a unit increase in first and second per-determined value of narrow money may result to increase in current values of narrow money by 73.3% and 18.37% respectively while other factors remain constant. Also, unit increase in first and second per-determined value of quasi money may result to increase in current narrow money by 5.3% and 1.5% respectively while other factors remain constant. This shows that quasi money has a significant dynamic relationship with narrow money during the studied period. The Adjusted R-square value for this model is 0.977, indicating that 97.7% of the variation in the future narrow money observation is explained by first and second per-determined value of narrow money itself and quasi money. Similarly, in the model in equation (4.2), the coefficient of narrow money at first and second lags are positive but not statistically significant while quasi money at first lag is not Also statistically significant. However, quasi money at first lag is statistically significant at 5 percent level of significance. This imply that the effect of a unit increase in the second per-determined value of quasi money may result to increase in current values of quasi money by 10.8% while other factors remain constant. This shows that quasi money has a significant dynamic relationship with itself during the studied period. The Adjusted R-square value for this model is 0.805, indicating that 80.5% of the variation in the future quasi money observation is explained by its second per-determined value.

4.3 Post Estimation Test

Post-estimation test, particularly the VAR Model Stability Test (AR Root Circle), Normality of the residuals, heteroscedasticity test , impulse response function and granger causality test were conducted on the Vector Autoregressive (VAR) Model, and the results are summarized in Table 4.4, 4.5, 4.6, 4.7 and 4,8 respectively as shown below. The VAR Model Stability Test (AR Root Circle) is conducted to determine the stability of the estimated model. Model Stability is confirmed if all the points fall inside AR Root Circle. The result is further ascertained in Table 4.4 and figure 4.5 below.

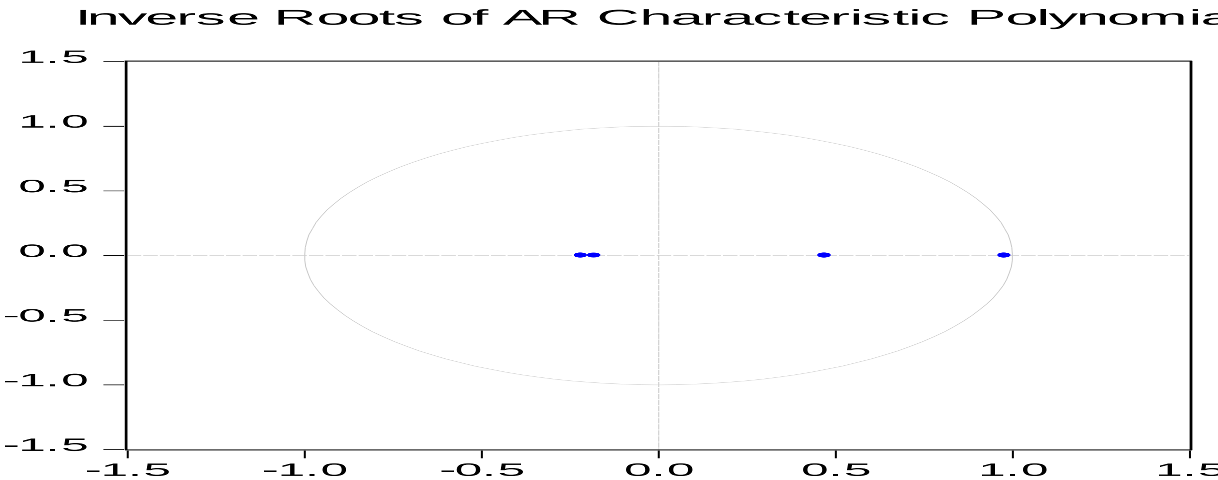


Figure 4.5: Dynamic Stability.

According to Halkos and Tsilika (2012), the necessary and sufficient condition for VAR stability is that all characteristic root lie inside the circle.

Table 4.5: VAR Model Stability Test: Inverse Root of AR Characteristic Polynomial (Endogenous Variables: In INM1 INM3. Exogeneous Variables C)

Root	Modulus
0.980101	0.980101
0.471846	0.471846
-0.215798	0.215798
-0.179136	0.179136
No root lies outside the unit circle.	
VAR satisfies the stability condition.	

Similarly, the residual normality test is performed to verify whether the residuals obtained from the model estimation are normally distributed, as part of the condition to assess model adequacy. **Also,** diagnostic test was conducted to verify whether the residuals obtained from the model estimation exhibit heteroscedasticity. The result is shown in **Table 4.6 below.**

Table 4.6: Post Estimation

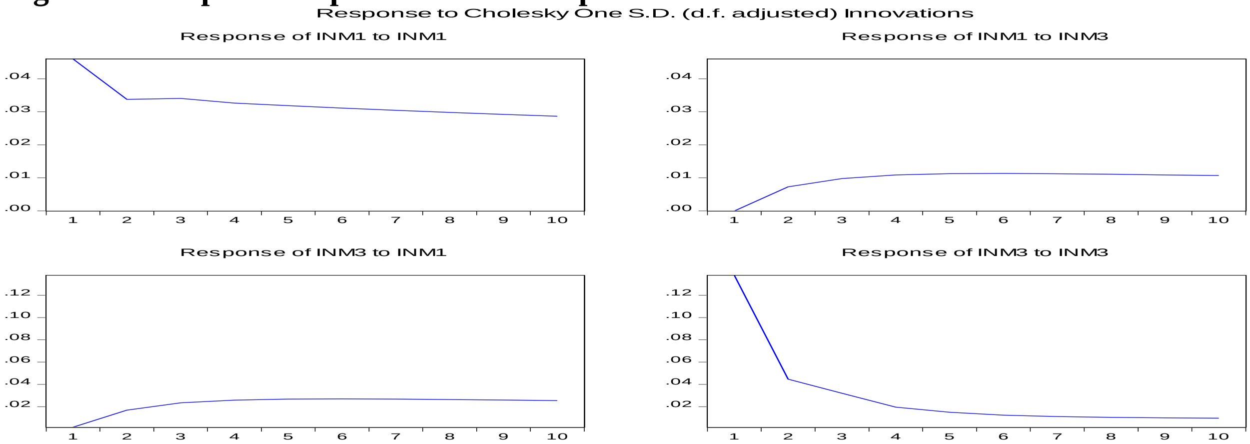
Diagnostic Test	Test Statistics	Df	Prob. Value (p-value)	Remarks
VAR Residual Normality Test	Orthogonalization: Cholesky (Lutkepohl)	2 2 2	123.8426 (0.0000) 811.7625 (0.0000) 935.6051 (0.0000)	Multivariate residual is not normal
VAR Residual Heteroscedasticity Test	Chi-square	24	36.95209 (0.0442)	Heteroscedastic

Also, **Impulse Response** is estimated to check how variance of each variable under investigations responds to shocks, and the result is shown in Table 4.7 below with its corresponding graphs in Figure 4.6 respectively.

Table 4.7: Impulse Response Results

Response of INM1:		
Period	INM1	INM3
1	0.045962	0.000000
2	0.033764	0.007297
3	0.034062	0.009785
4	0.032631	0.010870
5	0.031861	0.011275
6	0.031124	0.011335
7	0.030465	0.011246
8	0.029839	0.011087
9	0.029236	0.010896
10	0.028649	0.010694
Response of INM3:		
Period	INM1	INM3
1	0.001513	0.137841
2	0.016816	0.044680
3	0.023443	0.031990
4	0.025804	0.019606
5	0.026816	0.014920
6	0.026944	0.012343
7	0.026736	0.011073
8	0.026355	0.010359
9	0.025902	0.009922
10	0.025421	0.009615
Cholesky Ordering: INM1 INM3		

Figure 4.6: Impulse Response Results Graph



In another development, the granger causality test was conducted. This is done to check the causation and direction of causality among variables under investigation in response to shocks. The results obtained from the estimation of Granger Causality Test are shown in Table 4.8.

Table 4.8: Granger Causality Test Results

Null Hypothesis:	Obs	F-Statistic	Prob.
INM3 does not Granger Cause INM1	94	1.37717	0.2576
INM1 Granger Cause INM3		3.47913	0.0351

5.1 DISCUSSION

The time plots are shown in Figure 4.1 and 4.2, with raw data plotted using Time (years) on the horizontal axis and Narrow money (M1) and Quasi money (M3) on the vertical axis. These plots illustrate the direction and movement or trend of the variable under investigation, revealing trends, fluctuations, and intercepts in the series. Upon visual examination, it becomes evidence that there is a need to detrend the series to eliminate these trends, fluctuations, and intercepts to avoid biased estimation. Also, figures 4.3 and 4.4 are time plots for the differenced natural logarithm variables, with time (years) on the horizontal axis and the natural logarithm-transformed data on narrow money and quasi-money on the vertical axis. This clearly indicates that all the series were detrended. The variables vary within a zero (0) mean, showing that it is stationery and provide evidence of clustering volatility with constant variance.

Table 4.1 contains the results for descriptive statistics for the natural logarithm transformation of the data on Nigerian narrow money and quasi money. This was done to determine whether the distribution of the series follows the normal distribution assumption. The results show that the skewness statistics include: INM1 (0.234) and INM3 (0.443), with corresponding kurtosis as INM1 (2.473) and INM3 (1.847). These values are statistically Significant and suggest that all the series are skewed to the right. The Jarque-bera test statistics are all statistically significant, and the probability value of INM3 (0.015) indicates that it is not normally distributed and is statistically significant, while INM1 (0.370) is normally distributed.

Table 4.2 shows the results for the unit root test. Since most time series are inherently non-stationary, and may lead to spurious or biased estimation. However, to assess stationarity, we adopted the Augmented Dickey Fuller and Phillip Perron unit root tests. The results in Table 4.2 for the unit root test indicate that at the level, all the variables exhibit a unit root (non-stationary) with significance level greater than 5%. At the first difference, all variables exhibit no unit root (stationary) as the p-value is less than 5%, leading to the rejection of the null hypothesis.

Table 4.3 contains the results for cointegration using trace and maximum-eigenvalue test of the Johansen Cointegration Test. According to Johansen, cointegration exist if two variables have a long -run equilibrium relationship between them. The results obtained from the λtrace and λmax statistics respectively indicate no cointegration at the significance level of 0.05. therefore, the hypothesis of no cointegration is accepted since the calculated probabilities of trace and maximum-Eigenvalue were not significant.

Table 4.4 contains the VAR Lag Order Selection Criteria for the model specification. To ensure that the model adequately captures the dynamic relationship between NM1 and NM3, the lag order is selected using statistical information criteria. The results obtained in Table 4.4 from VAR lag order selection are as follows: Final Prediction Error (FPE): 3.19e-05*, Akaike Information Criteria (AIC): -4.677306*, Schwartz Information Criteria (SC): -4.283184*, were respectively selected for lag 3. Other criteria include the Likelihood Ratio (LR): 28.26340* for lag 3, and Hanna Quinn Information Criteria (HQ): -4.518524* for lag 3. AIC and HQ were selected to evaluate the goodness of fit and the parameter estimates in the model. However, an AIC value of -4.419284* for lag 2 was selected among others because it indicates a better-fitted model and provides a simpler and more parsimonious representation that still captures the essential dynamics of the variables. Hence, the VAR model in first difference indicates a loss of 1 lag. Consequently, the VAR analysis is performed at lag 2. The results of the Bayesian vector autoregressive model captured evidence of an interaction between narrow money and quasi money in Nigeria such that narrow money has a significant dynamic relationship with quasi money during the studied period. The Adjusted R-square value for this model is 0.977, indicating that 97.7% of the variation in the future narrow money observation is explained by first and second per-determined value of narrow money itself and quasi money. Similarly, in the model in equation (4.2), the coefficient of narrow money at first and second lags are positive but not statistically significant while quasi money at first lag is not Also statistically significant. However, quasi money at first lag is statistically significant at 5 percent level of significance. This shows that quasi money has a significant dynamic relationship with itself during the studied period. The Adjusted R-square value for this model is 0.805, indicating that 80.5% of the variation in the future quasi money observation is explained by its second per-determined value. **Also,** post-estimation test was conducted on Vector Autoregressive (VAR) models, including VAR Model Stability Test (AR Root Circle) in Figure 4.6, the test for the normality of the residuals, heteroscedasticity, Impulse Response Results (Table 4.7), and Impulse Response Results (Graph) in Figure. 4.6. Also, Figure 4.5 is the graph of the inverse roots of the characteristics AR polynomial. It satisfies the stability condition of the diagnostic test. The graph shows that all roots lie inside the unit root circle, and the detailed results show that all moduli were less than one but greater than zero. The inverse roots of a characteristic polynomial satisfy the stability condition (of the diagnostic test) since no root lies outside the unit root circle. Therefore, the estimated VAR is stable. This is in line with Salihu, Yaaba, and Hamman (2018) studied on money supply, output, and inflation dynamics in Nigeria: the case of new Higher-order monetary aggregates. In Salihu, Yaaba, and Hamman (2018), it was found that quasi money satisfies the F-M dual criteria. It was confirmed that there is high persistent positive response of the level of economic activities resulting from a positive shock to quasi money.

Table 4.6 contains the results of the diagnostic test, which includes test for normality and heteroscedasticity. The test for normality of residuals was conducted using the joint Jarque-bera test. The results revealed that the p-values of Jarque-bera (21.85833, 913.7467) are less than 5%, confirming the rejection of the null hypothesis of normality and acceptance of the alternative hypothesis. This indicates that residuals are not normally distributed. Additionally, there is evidence of residual heteroscedasticity in the narrow money and quasi-money components. The post estimation test for heteroscedasticity, revealed that the p-value of chi-square (36.95209) is less than 5% level of significance, confirming the presence of heteroscedasticity.

Table 4.7 displays the results obtained from the impulse response analysis, which was conducted to examine the dynamic response of one variable to a shock in another variable. The results indicate that increased in period of narrow money to corresponding effect on quasi money. This findings is in line with Salihu, Yaaba, and Hamman (2018) studied on money supply, output, and inflation dynamics in Nigeria: the case of new Higher-order monetary aggregates. In Salihu, Yaaba, and Hamman (2018), it was found that quasi money satisfies the F-M dual criteria. It was confirmed that there is high persistent positive response of the level of economic activities resulting from a positive shock to quasi money. In Figure 4.6, the response of narrow money to quasi money and vice versa remains almost constant throughout the period, while the response of narrow money to itself experience a shock and exceeds 0.5. Also, Table 4.8 contains the results of the granger causality test statistics. This test was conducted to confirm the potential causal relationship between the variables under investigation. The summary of the results shows that narrow money granger causes quasi money based on statistical significance. (quasi-money (F-Statistic = 1.37717, probability value (PV) = 0.2576 > 0.05)); narrow money (F-Statistic = 3.47913, probability value (PV) =0.0351 < 0.05), respectively). The results also reveal that narrow money has a positive and significant effect on quasi-money. The response to the question determines the direction of causality, the significance of the causality, and hence summarizes the causal channel among the study variables. The response is: narrow money provides information that helps predict quasi money. there is potential evidence that narrow money granger causes quasi money. On the other hand, there is insufficient evidence to conclude that quasi money does not granger cause narrow money. The results in this result is synonymous to Abdurrauf, & Abdulkareem, (2019) findings in their studied on monetary policy and money supply in Nigeria: A Comparative Analysis: 1993-2018. In Abdurrauf, & Abdulkareem, (2019), it was revealed that in the short run, all the variables had the correct negative signs, but only CRR was significant.

6.1 Conclusion

From the results obtained, the study concludes that there is no co-integrating or long-run relationship between Nigerian narrow and quasi money. Th narrow money has a significant effect on quasi money during the studied period. The adjusted R-square value indicates that 97.7% variation in future narrow money values is explained by first and second per-determined value of narrow money itself and quasi money. This shows that narrow money has effect on quasi money such that when there is an increase in narrow money, banks have more reserves to lend out, which in turn lead to increase in credit availability. Similarly, it was found that narrow money granger-caused quasi money. The causal channels described here also suggest that there is one directional (unidirectional) relationship between narrow and quasi money, i.e. from narrow money to quasi money. The implication is that narrow money has the propensity to influence monetary policy decision.

6.2 Recommendations

Based on the findings derived from the study, the following recommendations are made:

1. Adequate monetary policy development measures should be implemented to capture both short-run and long-run relationships between quasi and narrow money. This should also include their lag structure and other structural reforms to address issues related to shocks arising from one variable to the other.
2. Monetary policy tools formulated to target both quasi and narrow money as part of their monetary policy objectives. This will enhance the dynamic interaction between the two variables.

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