Chapter

Exchange Rate Volatility and Monetary Policy Shocks

Ghalam Peter Eze and Tonprebofa Waikumo Okotori

Abstract

The study investigated the influence of innovations in monetary policy on the rate of exchange volatility in Nigeria. The research adopted vector error correction model as well as impulse response function and forecast error variance decomposition function in the estimation using two models derived in the study. Monthly data between the periods 2009 and 2019 were adopted for the research. Our findings show that in the long run; all the monetary policy variables have a significant long run correlation with volatility in the exchange rate; but that money supply and the rate of exchange seem to have significant short run impact on volatility in the exchange rate, the other variables such as liquidity ratio or monetary policy rate did not show a significant short run relationship with the volatility in the exchange rate. Further findings on the volatility impulse response and the forecast error variance decomposition suggest a significant link between volatility in the exchange rate and money supply though the link was much more pronounced. The use of monthly data shows that the managed exchange rate regime by the CBN seems to have the desired effect in exchange rate volatility and thus having a critical impact on inflationary spikes.

Keywords: exchange rate volatility, monetary policy, central Bank of Nigeria, exchange rate regime, vector error correction model, impulse response function, forecast error variance decomposition

1. Introduction

1.1 Background of study

Exchange rate and price instability seems to have a negative effect on producers economic well-being, on upcoming investors as well as the situation of current consumers alike as it results in unpredictability, which has a negative impact on commitments that are of longer run; that reduces the chances of attaining self-reliant growth in output, income, and employment. The foregoing has led both the monetary and fiscal authority to develop policies or moves that aim at the attainment of the exchange rate and price stability. One of the key goals of the monetary authority in Nigeria (Central Bank of Nigeria (CBN)) is the attainment of price and stability of the rate of exchange. The CBN's policy on the rate of exchange regime over the years can be placed in two categories, (1) The Pre-SAP (1960–1986) period, (2) Post SAP (1986–present). The pre SAP period was characterized by: direct foreign exchange control, in that the authorities simply maintained overvalued exchange rates. These policies led to the fall in the value of the naira as it made imports cheaper. It also led to a weak balance of payments position

subsequently. The Post SAP period was characterized by free float exchange rate, which also led to the steep depreciation of the naira.

Emefiele [1] observed that for the Nigeria economy, a depressed GDP growth, which having grown by nearly 7% in previous years culminated in the 2016 recession, rising inflation, did rise to the level of 18.7% by the end of January, 2017 from 9.6% a year earlier, depreciation of the foreign exchange from N155/1 US dollar as at June, 2014 to a peak of N525/1 US dollar in February, 2017. There seems to be a nexus linking shocks from monetary policy to exchange rate volatility for an economy such as Nigeria that is import-dependent [2]. Thus, maintaining an effective and stable exchange rate is a realistic proposition for the Nigerian economy. Exchange rate regimes differ from country to country, and the level of financial development is the basis for whatever policy position a country might adopt. The important attention given to price stability is said to be derived from "new developments in monetary theories and empirical evidence which show that sustainable growth can only be achieved when the price level is stable" [3].

Liberalization of the financial system in Nigeria is still ongoing; hence the anticipated impact of these monetary policy variables in dictating trends in the financial markets such as the foreign exchange market raises a query about their empirically verified effects on the various financial markets. The most pressing issue is the identification of: (a) monetary authority's policy tools and their actual effect on the naira rate of exchange to the US Dollar, (b) the aggregate impact of these tools on the Naira exchange rate, and (c) determining if financial liberalization undertaken in Nigeria has yielded the anticipated results. The main targeted goal this research sought to attain is to ascertain the extent of the volatility of the rate of exchange due to monetary policy shocks. Amato et al. [4] observed that based on "the implications of exchange rates for monetary policy, several questions are particularly relevant these are; what is the appropriate response of volatility in the exchange rate to broad money supply, treasury bills rate, statutory liquidity ratio, exchange rate and the external reserve changes"?

The theoretical postulations of Mundell-Fleming known as the impossible trilemma states that every country has three policy options, and these are: (i) unfettered mobility of capital, (ii) rate of exchange that is fixed, and (iii) ability to embark on monetary policy that can be considered independent. That any country's monetary authority can only apply two of the three policy options simultaneously at any point in time. What is revealed from the Nigerian experience is that in its adopted regime on the rate of exchange, the Central Bank of Nigeria has taken a middle ground approach as regards its regime on the rate of exchange by using a managed float exchange rate regime, thus making the exchange a monetary policy tool. The CBN has also allowed the operation of three different exchange rates in Nigeria. The foregoing was though not factored into the policy prescriptions of Mundell-Fleming.

The rest of the study is subdivided into: 2—review of relevant literature; 3—methodology, 4—data presentation, analysis, and discussion; 5—summary.

2. Review of relevant literature

2.1 Conceptual framework

2.1.1 Exchange rate volatility

The rate of exchange refers to that rate at which the currency of one country is converted to another currency from a different country. There is volatility in the exchange rate when the rate of such exchange rate change happens rather randomly

or in rapidity. Ozturk [5] defined exchange rate volatility as being associated with exchange rate movements that are unexpected. Exchange rate volatility has been a serious concern for those in the academia, policymakers, and participants in the financial markets for all economies across board in the world [6]. The volatility of the exchange rate has inflationary tendencies; hence the attempts by the central banks to watch exchange rate volatility.

2.1.2 Monetary policy

Monetary policy is the pathway through which the Central Bank of Nigeria or the monetary authority in any country decides on amount of supply of money for that given country. It has been the "fundamental instrument over the years in attaining macroeconomic stability and as a prerequisite to attaining sustainable output growth" [7, 8]. Mathai [9] saw monetary policy as the regulating amount of the supply of money in a country's economy in order to attain an optimal mix of output and inflation goal realization. Jimoh [10] observed that it is generally believed that an exchange rate is an important variable that has a significant impact on the overall outcome of macroeconomic performance as it concerns internal and external balances. But Pattnaik et al. noted that a specific regime of the rate of exchange cannot be one solution fit it all remedy for the world, noting the real scenario can change at any time. Exchange rates can thus serve as "automatic stabilizers" for the macroeconomy in any nation [11].

2.2 Exchange rate regimes

2.2.1 The free float rate of exchange regime

The rate of exchange regime that is free floating depends on market forces in the determination of the exchange rate. Alade [12] opined that in a rate of exchange regime that is free float, "the monetary authority does not intervene in the foreign exchange market and that monetary policy is therefore independent of the exchange rate regime and can be used to steer the domestic economy". Okoli et al. [13] did observe that the "high level of exchange rate volatility in the world market, particularly the Naira/Dollar exchange rate especially in the recent past is not only alarming but economically threatening".

2.2.2 The fixed rate of exchange regime

In the fixed exchange rate regime, the exchange rate of the local currency is pegged to the amount of another country's currency or a basket of currencies or the Special Drawing Right (SDR). The monetary authority adjusts this peg in the scenario where misalignment becomes a threat to the economy. Fixed exchange rates are to "promote certainty and orderliness in foreign exchange markets and of course in international trade transactions" [13, 14]. Alade [12] opined that the fixed rate of exchange regime can achieve stability and the ability of the local currency to compete when the peg is credible, though noting that "the regime is prone to currency crises if the country is open to international capital market (free capital mobility) because of the limited shock absorptiveness capacity".

2.2.3 Managed float rate of exchange regime

In the managed float exchange rate regime, there is active intervention from the monetary authority in the market that deals on exchange of the domestic currency

with foreign currencies, and this is not subject to any preannounced path for the policy as regards the adopted rate of exchange regime. Under the managed float exchange rate regime, the monetary policy is said to be relatively independent. Monetary policy here serves to move the economy in the desired direction; hence exchange rate can be used as an instrument of monetary policy. Alade [12] observed that the limited flexibility of managed float "permits partial absorption of adverse shocks and that it can also maintain stability and competitiveness if the regime is credible, as it is less vulnerable to currency crises". But in practice, "no exchange rate is 'clean or pure float,' that is a situation where the exchange rate is left completely to be determined by the market forces of demand and supply"; yet the existing regime is a managed float, in which a country's monetary authorities get involved the dynamics in country's foreign exchange market in an attempt to accomplish very important economic objectives [15, 16]. According to Heipertz [17], "exchange rate is adjusted by the central bank like the use of the interest rate as an operating instrument."

2.3 Theoretical review

The exchange rate channel is certainly effective in a given economy with a shallow money market, as well as a deep market for foreign. Overall, random changes in the rate of exchange were observed for Nigeria, specifically in all the years for the period 1980–1990 [2].

2.3.1 Purchasing power parity (PPP)

Mordi [18] opined that the purchasing power parity (PPP) presupposes "those exchange rates between two currencies at a given period are equal if the ratio of the level of price in a certain amount of products produced" and flowing in two countries and the rate of exchange among those two countries are equal. Adeoye and Saibu [2] observed that purchasing power parity hypothesis is the most useful reason proffered as regards the stability in the long term as well as persistence of the rate of exchange in bilateral relations and that testing for PPP in the long term; this is useful for a lot of purposes: following many monetary models [19], that this rests on the reliability of the PP theory in the long run, in addition to a lot of models that describe the macroeconomy by adopting the PPP to express the nexus to foreign and local development; mostly when examining market economy such as Nigeria. Adenekan et al. [20] did observe that the "PPP theory was criticized for not considering the impact of international capital movements, and suffers from the choice of an appropriate price index used in price calculations." There is thus the need for theoretical postulations that can be all encompassing in application.

2.3.2 Mundell-Fleming theory

The Mundell–Fleming model is also called the IS-LM-BOP model (or IS-LM-BP) model based on the independent research of Mundell [21] and Fleming [22]. Though the Mundell-Fleming model is an offshoot of the IS-LM model, the original IS-LM model expresses the situation in a closed economy (autarky), this model expresses the situation that exists in an economy that is not closed, but small and open. The impossible trilemma of this theoretical model is the premise for the position that in an economy that is open, a country cannot follow the path of: a fixed rate of exchange, free mobility of capital, and the application of monetary policy that is independent

simultaneously. The operation of a managed float was not specifically captured at the beginning of this model, yet managed float is an imperfect free float or fixed exchange rate regime. The model states that two and not three of the trilemma can be operated simultaneously at any point in time.

Aizenman [23] observed that the financial crises of 1990 have "induced emerging markets to converge to the trilemma's middle ground—managed exchange-rate flexibility, restricted financial integration, and an effective but less prominent monetary independence" and that the crisis of flight of capital has led to financial stability becoming an additional goal in the operation of the trilemma's targeted goals. Hence, the present scenario goes beyond the textbook description unveiled by the trilemma. This encapsulates the theoretical foundations of our present study.

2.4 Empirical review

Ndung'u [24] assessed if the rate of exchange of Kenyan currency is influenced by the monetary authority's policy moves and whether the observed impact transient or consistent. The findings of this research reveal that the rate of exchange in nominal terms for the period 1970–1994 was impacted upon by income increase in real terms, the inflation rate, expansion in the supply of money, the circular movements in the volatility in the real rate of exchange, the cointegrating vectors, and the shocks. A similar research by Ubok-Udom [25] did study the nexus linking the total GDP growth rate in annual terms, GDP attributable to the non-oil sector, and the variations in the rate of exchange spanning 1991–1995. The results of this study further indicate that the rates of growth for total GDP and GDP from non-oil sources seem to reduce or rise with drops or spikes in the rate of exchange in nominal terms. Pattnaik et al. disclosed that the study shows that monetary policy has been useful achieving sustained factors in the exchange rate market revealing the pass-through via the exchange rate to the local inflation rate.

Similar studies such as Adebiyi [26] investigated the influence of the monetary authority's involvement in Nigeria's currency exchange market. The research did not focus on the link that connects shocks from monetary authority's policy moves and changes in the rate of exchange but looked at whether these involvements of the local monetary authority in the foreign exchange market are sterilized or not. The research by An and Sun [27] investigated the linkage between monetary policy, the monetary authority's intrusion into the foreign exchange market, and the rate of exchange for Japan in the form of a unifying model. The results from the study firstly lend support to the hypothesis referred to as "leaning-against-the –wind" as well as the hypothesis referred to as "signaling," though the presence of the "signaling" postulation happens to be rather minimal. Another finding is that the impact of intervention is not effective, possibly even a negative effect. Lastly, normal monetary policy seems to exert a major impact on both the rate of exchange and interventions in foreign exchange.

Cagliarini and Mckibbin [28] used the G-Cubed model for analyzing several sectors in an economy for a cross-country data; examining the possible impact of three shocks on US monetary policy, risk premia, and productivity to determine major relative price movement for the period 2002–2008. A very important summary of the study experimental exercise was done by this study, and it shows that monetary authority's policy moves seem to impact prices in relative terms for as much four years due to the fact that a non-permanent in real interest rates varies across sectors. Asad et al. [29] studied the influence of rate of exchange(in real and effective terms) on inflation on the economy of Pakistan by utilizing secondary data on GDP (in real and nominal terms), effective real rate of exchange, prices, and the supply of money that covered 1973–2007. The results from their study show that the exchange rate (in real terms) has a significant influence on the rate of inflation as

regards the economy of Pakistan; the nexus between the effective real rate of exchange and inflation was found to be positive and strong.

But Dickson [30] did study to examine the influence of volatility in the real rate of exchange on Nigeria's growth in output by adopting annual data from 1970 to 2009. The results of the study did reveal that the nexus between economic growth and rate of exchange volatility was positive in the short run; but in the long run, the relationship for both variables is negative. Adeoye and Saibu [2] analyzed that monetary policy shocks influence via movements in the policy instruments on volatility in the rate of exchange in Nigeria. Specifically the study focused on the relationship between volatility in the rate of exchange and shocks due to monetary policy in Nigeria. The short-run dynamics reveals that changes in monetary policy instruments correlate to the variations in the rate of exchange via process that is self-correcting without the involvement of the CBN. Furthermore, the findings from the test for causality that link the volatility in the rate of exchange and the monetary authority's policy tools indicate significant nexus between as regards historical values of the rate of exchange and monetary policy variables. It was observed that shifts in past values of policy tools result in changes in exchange rate volatility.

Nwachukwu et al. [31] modeled the long-run nexus that linked "the Bureau De Change rate of exchange and Nigeria's external reserves in a threshold vector error correction model (TVECM)" econometric methodology by utilizing daily data that spanned from 2014 to 2015. The study concluded that "the adjustment mechanism between the two variables flow from external reserves to BDC exchange rate." Ayomitunde et al. [32] examined the nexus that exists linking monetary authority's policy instruments and the rate of exchange rate Nigeria. The study adopted the Autoregressive Distributed Lag (ARDL) model to achieve the focused goal of the study. The results show that there was a negative nexus linking the Treasury bill rate, cash reserve requirement to the rate of exchange. On the other hand, the policy rate and money supply (broad) have a nexus with the exchange rate that is positive for Nigeria.

Miyajima [33] did carry out a study that was premised on an answer to the question "does the South African rand's relatively large volatility affect inflation?" The derived results indicate that when the volatility in the rate of exchange spikes, it leads to an increase in core inflation, though that impact is limited for the economy of the country under study.

The Nigeria experience shows that some research studies have been carried out on the nexus linking volatility in the rate of exchange and the actions of the Central Bank's stabilizing actions. The study is an attempt to determine the interventions in the markets for the buying and selling of foreign currency by the monetary authority; whether such intervention is sterilized or not sterilized has had the moderating impact on exchange rate volatility. The Nigerian experience from a few studies in the area of the interrelationship between exchange rate volatility and macroeconomic policies of the CBN have been carried out; yet the use of monthly data was not common in all these studies. This study did apply monthly data to reveal that nexus in a more timely manner.

3. Methodology

3.1 Study design

The study utilizes an ex-post facto research design, the events have already taken place before the analysis, and hence there is no way the data can be manipulated. The "ex post facto design in its application is causal comparative and used when the

researcher aims to establish relationship between the independent and dependent variables with a view to establishing the causal link between them" [34, 35].

3.2 Population of study

The dataset is monthly time series data for Nigeria on the rate of exchange, money supply (M2), policy rate (nominal anchor), reserve requirement, treasury bills rate, and external reserve. These form the population of study.

3.3 Sample

The study sample is secondary data, retrieved after the occurrence of the event; hence the ability of the researcher to influence it is not possible. The sample period covered 2009–2019. The sample period covered over 48,180 days.

3.4 Sources of data

The data was extracted from the CBN's statistical bulletin, CBN website, World Bank, and IMF databases.

3.5 Model development and variable description

The research employs vector error correction (VEC) methodology to study the magnitude of the effect and the response to the impulse function of the rate of exchange concerning stock prices. This is done after determining the variables are cointegrated. Vector error correction model (VECM) is used to capture the evolution and the interdependencies between multiple time series, generalizing the univariate AR models. There is a symmetrical treatment of all the variables adopted for the VECM in the study via the addition in every one of the given equation in determining process on the bases of its lags as well as the lags of all other variables.

3.6 Model specification

Chen [36] did note that volatility in the rate of exchange volatility might be either for the description of a regime that is tranquil regime, and this rests how descriptive the adopted policy tools are (e.g. interest rate) utilized as a tool of stabilization instruments as follows:

Model 1

$$\begin{aligned} \text{Erv} &= f\ (\text{MPR}, \text{M2}) \\ \text{Erv} &= \text{MPR} + \text{M2} + \text{u}_\text{t} \end{aligned} \tag{1}$$

Model 2

$$\begin{aligned} \text{Erv} &= f\ (\text{TBR}, \text{LQR}, \text{EXR}) \\ \text{Erv} &= \text{TBR}_\text{t} + \text{LQR} + \text{EXR} + \text{u}_\text{t} \end{aligned} \tag{2}$$

3.7 Method of data analysis

Experience has shown in Nigeria that the monetary authority uses either the quantitative or qualitative measures of stabilizing the macroeconomic activities. But

most often, money supply, interest rate, and inflation are the major quantitative measures employed by the Central Bank in maintaining a close watch of monetary balances in Nigeria. However, the exchange rate deepening experienced in the past prompted the monetary authority to strengthen the stock of money reserves to decelerate exchange rate volatility and watch the overall economy performance closely in terms of productivity. Based on the above argument, the empirical model for analyzing the effect of monetary policy shocks on generated exchange rate volatility series in Nigeria by considering the most employed monetary tools in formulating the error correction model is as follows:

Model 1

$$Erv_t = d_0 + d_1MPR_t + d_2M2_t + +u_t \quad (3)$$

Model 2

$$Erv_t = d_0 + d_1TBR_t + d_2LQR_t + d_3EXR + u_t \quad (4)$$

Here erv represents volatility in the rate of exchange, which is generated from the nominal rate of exchange of Nigeria's domestic currency the naira as measured in value against the US dollar by adopting the approach trough the standard deviation; mpr is the proxy for the nominal rate of interest, the monetary policy rate, which is the rate at which the Central Bank lends to the bank; ms is the broad money supply; tbr is the treasury bills rate; rsq is the reserve requirement; lqr is the liquidity ratio; and u represents the error term, and it describes the Markov models depiction transition from one regime to another. The dynamics linking monetary policy to volatility in the rate exchange for the Nigeria economy in the short run via the error correction mechanism model is investigated.

Since estimated regression results do not provide an answer to which variables cause changes in the other while ignoring the impact interaction. In terms of data requirement and sources, the paper uses a time-series data on the nominal exchange rate of naira vis-a-vis US dollar, minimum policy rate as a proxy for the interest rate, money supply, inflation rate, reserve requirement.

4. Presentation of data/results

4.1 Empirical analysis

This section elaborates on the empirical results and the analysis.

4.1.1 Unit root tests

The test for unit root reveals information on the stationarity properties of variables. The variables were tested at levels and their first differences. The results are given in **Tables 1** and **2** respectively.

The unit root test result for the variables at level are shown in **Table 1**, the ADF test statistic for exchange rate ($t = 0.29$, $p > 0.05$) is insignificant at the 5% level. From the foregoing, a unit root at the 5% significance level for the null hypothesis cannot be rejected. The rate of exchange is thus not stationary at level. Similarly, liquidity ratio ($t = -1.79$, $p > 0.05$), monetary policy rate ($t = -1.55$, $p > 0.05$), money supply ($t = -2.46$, $p > 0.05$), and Treasury bill rate ($t = -2.41$, $p > 0.05$) are nonstationary at levels. These variables were all tested determine their stationarity at their first differences.

Variable	ADF statistic	5% Critical value	Remarks
EXR	0.29	−2.89	Nonstationary
LQR	−1.79	−2.89	Nonstationary
MPR	−1.55	−2.89	Nonstationary
MS	−2.46	−2.89	Nonstationary
TBR	−2.41	−2.89	Nonstationary

Source: Results Extract from Eviews 11.0.

Table 1.
(augmented dickey-fuller unit root tests at levels (augmented Dickey-Fuller regression has an intercept as an addition, but not a linear trend).

Variable	ADF statistic	5% Critical value	Order of integration	Remarks
D (EXR)	−17.18	−2.89	I(1)	Stationary
D (LQR)	−11.15	−2.89	I(1)	Stationary
D (MPR)	−11.04	−2.89	I(1)	Stationary
D (MS)	−3.89	−2.89	I(1)	Stationary
D (TBR)	−16.64	−2.89	I(1)	Stationary

Note: Note: D denotes first difference of the variable.
Source: Results Extract from E views 11.0.

Table 2.
(augmented dickey-fuller unit root tests at first differences (augmented Dickey-Fuller regressions include an intercept but not a linear trend).

The results for the unit root test at first difference are given in **Table 2**; the findings indicate that at the 5% level of significance both the independent and dependent variables are all significant at first difference. This is because the ADF test statistics are all greater than the 5% critical values in absolute terms. Thus, we fail to accept the null hypothesis of a unit root at the 5% level.

4.1.2 Cointegration tests

Following the establishment of the time-series data's properties, the study carried out the multivariate Johansen cointegration test. The test was conducted for the two sets of the VEC models. The findings from the tests for exchange rate volatility, monetary policy rate, and money supply are reported in **Tables 3** and **4**, and those of exchange rate volatility, treasury bill rate, liquidity ratio, and exchange rate are presented in **Tables 5** and **6**.

As shown in **Tables 3** and **4**, the cointegration test based on the trace and maximum eigen statistics indicate that there is one cointegrating equation among exchange rate volatility, monetary policy rate, and money supply within significance level of the 5% level. The findings indicate that there exists a long run relationship among: exchange rate volatility, monetary policy rate, and money supply. Similarly, from **Tables 5** and **6**, the cointegration test based on the trace and maximum eigen statistics indicates that there is one cointegrating equation among exchange rate volatility, Treasury bill rate, liquidity ratio, and exchange rate at the 5% level. This shows that exchange rate volatility, Treasury bill rate, liquidity ratio, and exchange rate have a common long-run trend.

Hypothesized No. of CE(s)	Eigenvalue	T race statistic	0.05 critical value	Probability**
None*	0.186630	33.73461	29.79707	0.0167
At most 1	0.080373	9.979107	15.49471	0.2823
At most 2	0.002983	0.343533	3.841465	0.5578

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level.
**denotes rejection of the hypothesis at the 0.05 level.*
***MacKinnon-Haug-Michelis [37] p-values.*
Source: Results Extract from Eviews 11.0.

Table 3.
Unrestricted cointegration rank test (trace).

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen statistic	0.05 critical value	Probability**
None*	0.186630	23.75550	21.13162	0.0209
At most 1	0.080373	9.635573	14.26460	0.2370
At most 2	0.002983	0.343533	3.841465	0.5578

Max-Eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level.
**denotes rejection of the hypothesis at the 0.05 level.*
***MacKinnon-Haug-Michelis [37] p-values.*
Source: Results Extract from Eviews11.0.

Table 4.
Unrestricted cointegration rank test (maximum eigenvalue).

Hypothesized No. of CE(s)	Eigenvalue	T race statistic	0.05 critical value	Probability**
None*	0.233281	56.64510	47.85613	0.0060
At most 1	0.151818	26.09708	29.79707	0.1258
At most 2	0.046361	7.161141	15.49471	0.5590
At most 3	0.014692	1.702127	3.841465	0.1920

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level.
**denotes rejection of the hypothesis at the 0.05 level.*
***MacKinnon-Haug-Michelis [37] p-values.*
Source: Results Extract from Eviews11.0.

Table 5.
Unrestricted cointegration rank test (trace).

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen statistic	0.05 critical value	Probability**
None*	0.233281	30.54803	27.58434	0.0202
At most 1	0.151818	18.93593	21.13162	0.0987
At most 2	0.046361	5.459013	14.26460	0.6831
At most 3	0.014692	1.702127	3.841465	0.1920

Max-Eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level.
**denotes rejection of the hypothesis at the 0.05 level.*
***MacKinnon-Haug-Michelis [37] p-values.*
Source: Results Extract from Eviews11.0.

Table 6.
Unrestricted cointegration rank test (maximum eigenvalue).

4.1.3 Analysis of the estimated vector error correction models

The results of the first estimated VEC model are reported in **Table 7**.

The coefficient of determination (R^2) for exchange rate volatility short-run equation is approximately 0.26. This indicates that the regressors in the equation account for about 26% of the systematic variations in volatility of the rate of exchange on the short-run basis. Similarly, the adjusted R^2 shows all the independent variables in the first model account for about 21% of the systematic variations in exchange rate volatility in the short run. Thus, the overall goodness of fit of the exchange rate volatility short-run model is low.

From the exchange rate volatility short-run equation, its one-month previous volatility rate has a negative significant effect on its current rate, but its two-month previous volatility rate has an insignificant impact on its current rate in the short term. The two previous values of monetary policy rate have no significant effects on exchange rate volatility in the short run. However, the one-month lagged value of money supply has a negative significant effect on exchange rate volatility in the short run. The foregoing leads to a rejection of the acceptance of the null hypothesis that the monetary policy rate has no significant effect on the volatility in the exchange rate in Nigeria, whereas the null hypothesis on money supply not having a significant nexus with the volatility in the exchange rate is rejected as money supply has a significant impact on exchange rate volatility in Nigeria.

The results of the second estimated VEC model are reported in **Table 8**.

The coefficient of determination (R^2) for exchange rate volatility short-run equation is approximately 0.26. This indicates that the regressors in the equation account for about 26% of the systematic variations in exchange rate volatility in the short term. Similarly, the adjusted R^2accounts for about 21% systematic variations in exchange rate volatility in the short run. Thus, the overall goodness of fit of the exchange rate volatility short-run model is low.

From the exchange rate volatility short-run equation, its one-month previous volatility rate has a negative significant effect on its current rate, but its two-month previous volatility rate has an insignificant impact on its current rate in the short term. The two previous values of monetary policy rate have no significant effects on exchange rate volatility in the short run. However, the one-month lagged value of money supply has a negative significant effect on exchange rate volatility in the short run.

The results of the second estimated VEC model are reported in **Table 9**.

The coefficient of determination (R^2) for exchange rate volatility short-run equation is approximately 0.92. This indicates that the regressors in the equation account for about 92% of the systematic variations in exchange rate volatility in the short term. Similarly, the adjusted R^2 indicates that all the independent variables in the second model account for about 91% systematic variations in exchange rate volatility in the short run. The F-statistic ($F = 139.33$, $p < 0.05$) indicates the overall exchange rate volatility short-run model is significant at the 5% level.

From the exchange rate volatility short-run equation, its one-month previous volatility rate has a negative significant effect on its current rate while its two-month previous volatility rate has a positive significant impact on its current rate in the short term.

The two previous values of Treasury bill rate have no significant effect on exchange rate volatility in the short run. Also, the two lagged values of liquidity ratio have no significant effect on exchange rate volatility in the short run. However, the two lagged values of exchange rate have positive significant effects on

Cointegrating Eq:	CointEq1		
EXRV(−1)	1.000000		
MPR(−1)	−7817.859		
	(1584.61)		
	[−4.93362]		
MS(−1)	−1723.057		
	(784.802)		
	[−2.19553]		
C	119340.6		
Error Correction:	D(EXRV)	D(MPR)	D(MS)
CointEq1	−0.058246	2.23E-05	2.25E-06
	(0.02723)	(7.7E-06)	(3.3E-06)
	[−2.13889]	[2.87772]	[0.68702]
D(EXRV(−1))	−0.407297	−1.31E-05	9.58E-06
	(0.09440)	(2.7E-05)	(1.1E-05)
	[−4.31465]	[−0.48875]	[0.84535]
D(EXRV(−2))	0.018987	−4.17E-07	1.98E-05
	(0.09219)	(2.6E-05)	(1.1E-05)
	[0.20596]	[−0.01593]	[1.78598]
D(MPR(−1))	−271.3121	−0.145712	−0.039322
	(323.488)	(0.09193)	(0.03883)
	[−0.83871]	[−1.58495]	[−1.01274]
D(MPR(−2))	−228.4871	−0.225357	−0.013785
	(317.403)	(0.09021)	(0.03810)
	[−0.71986]	[−2.49827]	[−0.36183]
D(MS(−1))	−1777.983	0.497631	0.398358
	(762.661)	(0.21675)	(0.09154)
	[−2.33129]	[2.29592]	[4.35169]
D(MS(−2))	59.68383	−0.018873	0.321481
	(827.667)	(0.23522)	(0.09934)
	[0.07211]	[−0.08023]	[3.23605]
C	212.6540	0.109331	−0.051629
	(402.479)	(0.11438)	(0.04831)
	[0.52836]	[0.95583]	[−1.06872]
R-squared	0.260032	0.203020	0.371578
Adj. R-squared	0.212511	0.151838	0.331220
F-statistic	5.471951	3.966619	9.207182

Source: Extract from Eviews 11.0.
Notes: Standard errors are in ()and t-statistics are in [].

Table 7.
Estimated VEC model 1.

Cointegrating Eq:	**CointEq1**		
EXRV(−1)	1.000000		
MPR(−1)	−7817.859		
	(1584.61)		
	[−4.93362]		
MS(−1)	−1723.057		
	(784.802)		
	[−2.19553]		
C	119340.6		
Error Correction:	D(EXRV)	D(MPR)	D(MS)
CointEq1	−0.058246	2.23E-05	2.25E-06
	(0.02723)	(7.7E-06)	(3.3E-06)
	[−2.13889]	[2.87772]	[0.68702]
D(EXRV(−1))	−0.407297	−1.31E-05	9.58E-06
	(0.09440)	(2.7E-05)	(1.1E-05)
	[−4.31465]	[−0.48875]	[0.84535]
D(EXRV(−2))	0.018987	−4.17E-07	1.98E-05
	(0.09219)	(2.6E-05)	(1.1E-05)
	[0.20596]	[−0.01593]	[1.78598]
D(MPR(−1))	−271.3121	−0.145712	−0.039322
	(323.488)	(0.09193)	(0.03883)
	[−0.83871]	[−1.58495]	[−1.01274]
D(MPR(−2))	−228.4871	−0.225357	−0.013785
	(317.403)	(0.09021)	(0.03810)
	[−0.71986]	[−2.49827]	[−0.36183]
D(MS(−1))	−1777.983	0.497631	0.398358
	(762.661)	(0.21675)	(0.09154)
	[−2.33129]	[2.29592]	[4.35169]
D(MS(−2))	59.68383	−0.018873	0.321481
	(827.667)	(0.23522)	(0.09934)
	[0.07211]	[−0.08023]	[3.23605]
C	212.6540	0.109331	−0.051629
	(402.479)	(0.11438)	(0.04831)
	[0.52836]	[0.95583]	[−1.06872]
R-squared	0.260032	0.203020	0.371578
Adj. R-squared	0.212511	0.151838	0.331220
F-statistic	5.471951	3.966619	9.207182

Source: Extract from Eviews 11.0.

Table 8.
Estimated VEC model 2.

Cointegrating Eq:	**CointEq1**			
EXRV(−1)	1.000000			
TBR(−1)	1549.282			
	(1397.79)			
	[1.10838]			
LQR(−1)	−2231.369			
	(505.274)			
	[−4.41616]			
EXR(−1)	−213.4598			
	(86.0715)			
	[−2.48003]			
C	109208.8			
Error Correction:	**D(EXRV)**	**D(TBR)**	**D(LQR)**	**D(EXR)**
CointEq1	−0.010650	1.15E-05	4.67E-05	2.24E-05
	(0.00673)	(4.6E-06)	(1.7E-05)	(6.2E-05)
	[−1.58296]	[2.51205]	[2.70826]	[0.36361]
D(EXRV(−1))	−0.385805	−4.52E-05	0.000422	−0.002019
	(0.08789)	(6.0E-05)	(0.00023)	(0.00080)
	[−4.38984]	[−0.75693]	[1.87360]	[−2.51091]
D(EXRV(−2))	0.059607	1.05E-06	−7.54E-08	−0.000309
	(0.03030)	(2.1E-05)	(7.8E-05)	(0.00028)
	[1.96705]	[0.05102]	[−0.00097]	[−1.11294]
D(TBR(−1))	38.35665	−0.561259	−0.380656	−0.203570
	(147.432)	(0.10007)	(0.37770)	(1.34903)
	[0.26017]	[−5.60869]	[−1.00783]	[−0.15090]
D(TBR(−2))	40.87102	−0.210251	−0.382622	−0.232701
	(146.478)	(0.09942)	(0.37525)	(1.34030)
	[0.27903]	[−2.11474]	[−1.01963]	[−0.17362]
D(LQR(−1))	−20.11324	−0.021162	0.021844	0.056033
	(37.9020)	(0.02573)	(0.09710)	(0.34681)
	[−0.53066]	[−0.82260]	[0.22497]	[0.16157]
D(LQR(−2))	−22.85686	0.006525	0.031133	0.104535
	(37.2871)	(0.02531)	(0.09552)	(0.34118)
	[−0.61300]	[0.25780]	[0.32592]	[0.30639]
D(EXR(−1))	319.5856	0.001760	0.019157	−0.424650
	(10.4040)	(0.00706)	(0.02665)	(0.09520)
	[30.7176]	[0.24918]	[0.71874]	[−4.46070]
D(EXR(−2))	132.7066	0.014933	−0.149753	0.638002
	(29.8317)	(0.02025)	(0.07642)	(0.27296)
	[4.44852]	[0.73749]	[−1.95949]	[2.33731]
C	−401.4474	0.206492	0.398258	2.063144

Cointegrating Eq:	**CointEq1**			
	(138.532)	(0.09403)	(0.35490)	(1.26759)
	[−2.89787]	[2.19605]	[1.12217]	[1.62761]
R-squared	0.921381	0.239291	0.097537	0.242732
Adj. R-squared	0.914768	0.175306	0.021629	0.179037
F-statistic	139.3325	3.739801	1.284933	3.810822

Source: Extract from Eviews 11.0.
Notes: Standard errors are in ()and t-statistics are in [].

Table 9.
Estimated VEC model 2.

exchange rate volatility in the short run. The results lead to the acceptance of null hypothesis that the treasury bills rate and the liquidity ratio have no significant nexus with the volatility in the exchange rate in the, but the impact of exchange rate on exchange rate volatility is significant in the short run, thus rejection of the null hypothesis concerning this nexus.

4.1.4 Impulse response functions

The results of the Impulse Response Functions (IRFs) of the first VEC model in graphical form are reported in the **Figure 1**.

The impulse response function of exchange rate volatility in the VEC model to a shock in itself shows that exchange rate volatility reacted positively to its innovations all through the five months of forecast. Similarly, it responded positively to innovations in monetary policy rate throughout the five months of forecast. However, exchange rate volatility responded negatively to a shock in money supply all through the five months of forecast.

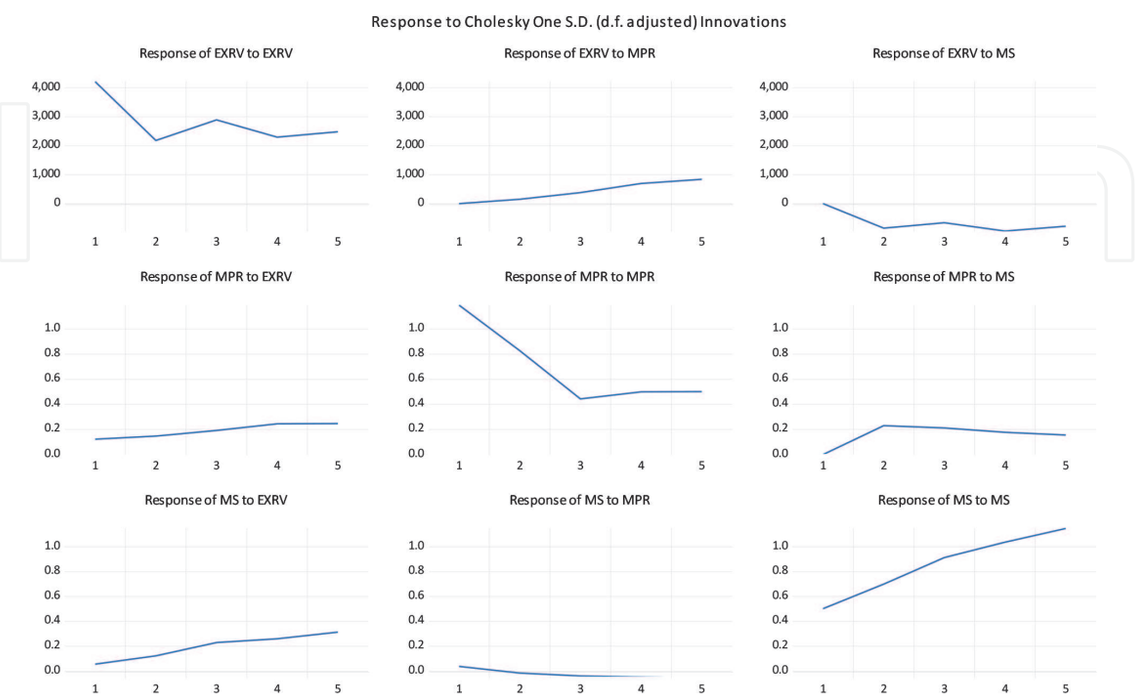

Figure 1.
Impulse response functions. Source: Results extract from E-views 11.0

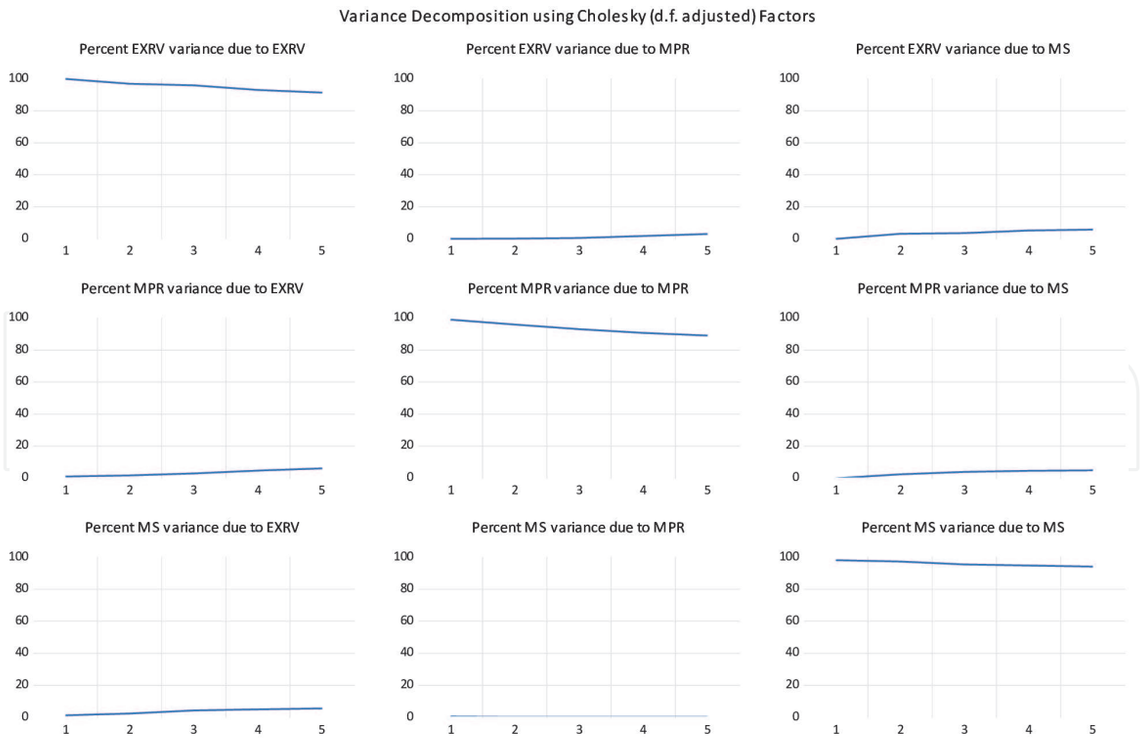

Figure 2.
Forecast error decomposition functions. Source: Results extract from E-views 11.0.

4.1.5 Forecast error variance decomposition functions

The estimation of a VAR model firstly requires the explicit choice of lag length in the equations of the model. In this study, graphs of the forecast error variance decomposition functions are presented in **Figure 2**.

As shown in **Figure 2**, it can be observed from the variance decomposition of exchange rate volatility that own shocks contributed most [100%] to its variations in the first month of forecast but declined marginally to 91% in the fifth month of forecast. The proportions of variations in exchange rate volatility, due to shocks in monetary policy rate and money supply, are minimal throughout the five months of forecast. The two variables accounted for less than 6% in the entire periods of forecast. Hence, the variance decomposition of exchange rate volatility shows that own shocks predominantly determined variations in its variations throughout the months of forecast. Monetary policy rate and money supply accounted for less than an average of 6% variations in exchange rate volatility all through the five months of forecast. The proportions of variations in exchange rate volatility due to money supply shocks are marginally higher than those of monetary policy rate during the periods.

4.1.6 Impulse response functions

The results of the Impulse Response Functions (IRFs) of the second VEC model in graphical form are reported in the **Figure 3**.

The impulse response function of exchange rate volatility in the VEC model to a shock in itself shows that exchange rate volatility reacted positively to its innovations all through the five months of forecast. However, it responded negatively to innovations in treasury bill rate throughout the 5 months of forecast. With respect to a shock in liquidity ratio, exchange rate volatility responded positively all through the 5 months of forecast. Similarly, exchange rate volatility responded positively to shocks in exchange rate within the 5 months of forecast.

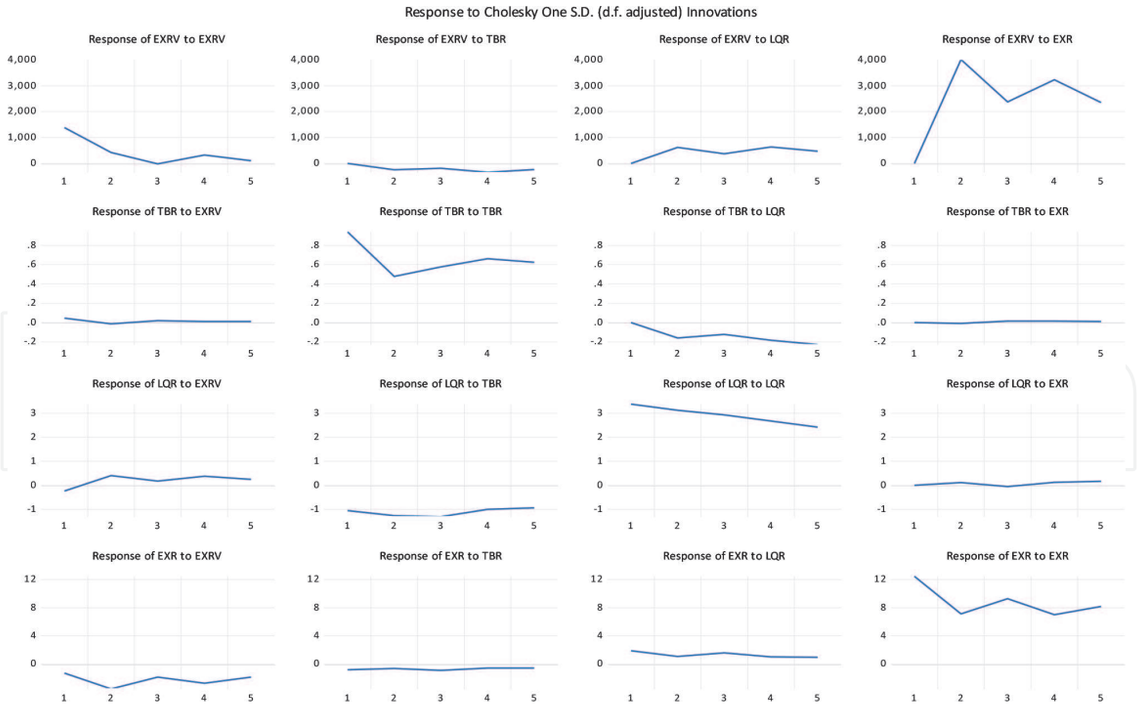

Figure 3.
Impulse response functions. Source: Results extract from E-views 11.0.

4.1.7 Forecast error variance decomposition functions

The graphs of the forecast error variance decomposition functions are presented in **Figure 4**.

As shown in **Figure 4**, it can be observed from the variance decomposition of exchange rate volatility that own shocks contributed most [100%] to its variations in the first month of forecast but declined drastically in the other months. The proportions of variations in exchange rate volatility, due to shocks in treasury bill

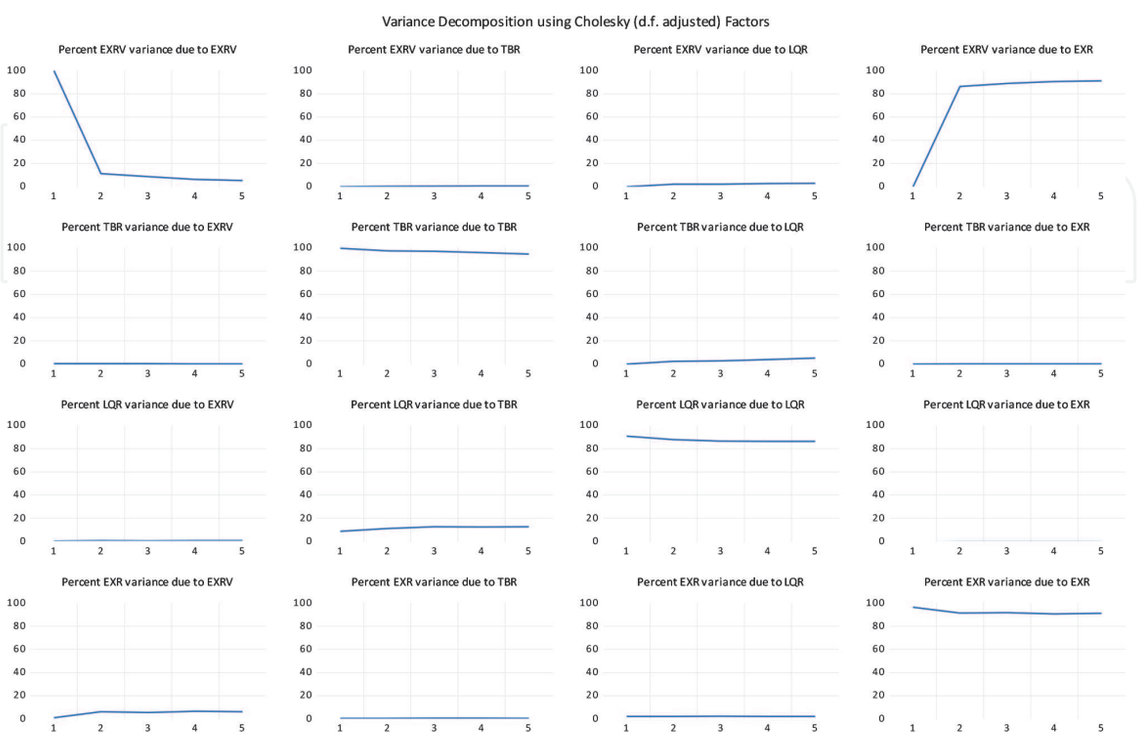

Figure 4.
Forecast error decomposition functions. Source: Results extract from E-views 11.0.

rate and liquidity ratio, are minimal throughout the 5 months of forecast. As revealed in the top panel of **Figure 4**, the variance decomposition function for exchange rate volatility due to own shock (top left corner) is the transpose of that due to exchange rate shock (top right corner). Thus, the percent exchange rate volatility variance due to a shock in exchange rate is minimum [0%] in the first month of forecast. However, in all other months of forecast, it rose drastically to an average of 90% ranging between 86% and 91%. To this end, the variance decomposition of exchange rate volatility shows that own shocks predominantly determined variations in the first month of forecast while exchange rate mainly accounted for volatility in exchange rate in the other periods. Treasury bill rate and liquidity ratio accounted for less than an average of 3% all through the five months of forecast.

5. Summary

The first model shows that the monetary policy rate did not have a significant relationship with volatility in the exchange rate not even with a two-month lagged period, but the money supply had a negative and significant short run nexus with the volatility in the exchange rate. Though, the monetary policy rate was not significant; yet the impulse response functions exchange rate volatility responded negatively to innovation in the MPR from what is revealed by **Figure 1**. The forecast error decomposition reveals that own shocks account for 100% of variation in the first month falling to only 91% in the fifth month; there were minimal variations for monetary policy rate and money supply for five months. The two variations account for less than 6% in the entire forecast period. Though, MS was marginally higher than MPR.

In the second model, the Treasury bill rate's two lagged values were not significant in the short run. The liquidity ratio's two lagged values of the liquidity ratio nexus with the volatility of the exchange rate were not significant in the short run. Exchange rate volatility responded negatively to innovations in Treasury bill rate throughout the 5 months of forecast. But a shock to liquidity ratio and exchange rate volatility responded positively all through the five months of forecasting exchange rate volatility and responded positively to shocks in exchange rate within the months of the forecast as shown in **Figure 3**. Shocks predominately determine variations in its variations, in the first month of forecast, while exchange rate and liquidity ratio accounted for less than average of 3% all through the five months of forecast as in **Figure 4**.

6. Conclusion

In the long run, monetary policy instruments tend to have significant long run nexus with the volatility in the exchange rate; yet looking at the critical short-run dynamics, we find that only the exchange rate and money supply that have significant short-run impact on volatility in the exchange rate. The nexus for money supply is negative as in a priori expectation; yet exchange rate had a negative but significant impact on the volatility in the exchange rate.

The study seems to justify the CBN's managed float exchange rate regime a well as reliance on monetary targeting as this tends to stabilize the volatility in the exchange rate, due to its inflationary impact (volatility in the exchange rate). The Mundell-Fleming trilemma never envisaged the existence of managed float exchange rate regime, and this has produced and unexpected reality as it exists in Nigeria. The impact on deposit money banks as a result of an unmitigated fall in the

rate of exchange and the attendant inflationary spiral is something that should be of serious concern to the CBN and other regulatory institution. Inflation and exchange depreciation will impact negatively on the assets of DMBs and the ability of stable and useful global players; hence the ability of the CBN's managed float exchange rate regime to mitigate such volatility happens to be a great relief.

6.1 Recommendation

The fact that money supply and the exchange rate are dominant sources that introduce volatility in the exchange rate makes these instruments very important to Nigeria's monetary authority. The CBN should focus on this important nexus as the current experience of dwindling revenues from crude oil exports diminishes the possibility of other instruments of stability geared toward curtail instability that flows from instability due to exchange rate volatility.

Classification

JEL: D53, E44, E52, E58, G15

Author details

Gbalam Peter Eze[1] and Tonprebofa Waikumo Okotori[2*]

1 Department of Banking and Finance, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

2 Faculty of Management Sciences, Department of Banking and Finance, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria

*Address all correspondence to: tonprebofa@gmail.com

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