

Monetary Policy and the Real Sector: A Structural VAR Approach for Nigeria

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Abstract This study attempt to investigate the effect of monetary policy on the real sector, by employing the structural vector autoregressive (SVAR) framework. It used a set of policy and non-policy macroeconomic variables based on monthly data spanning the period 2006 and 2019. The empirical results based on structural impulse response functions reveal that MPR as a policy tool provides significant results as it is effective in stabilizing price levels, increasing output marginally, and improving the nominal exchange rate conditions. Despite the innovations in the policy rate in the period covered, shocks to the nominal exchange rate have been a major challenge, it affects domestic economic activity complicating the effort of the monetary authority. Given the importance of international trade and investment in the process of economic growth, this study recommends a stern exchange rate policy action that will have good implications for output growth and complement monetary policy actions in Nigeria.

Keywords Monetary Policy, Real Sector, Structural VAR Models

1. Introduction

Several factors influence the supply of money, some of which are within the control of the central bank while others are outside its control. The need to regulate money supply is based on the knowledge that there is a relatively stable relationship between the quantity of money supply and economic activity and that if the supply of money is not limited to what is required to support productive activities, it will result in undesirable effects in the real sector (CBN 2011). The specific actions were taken by the Monetary Authority (Central Banks) to regulate the money supply in the economy to achieve predetermine macroeconomic objectives are Monetary policy actions. The Monetary Authority deploys various monetary policy instruments (direct and indirect) through the Central Bank of Nigeria to achieve its objectives. One of the major Monetary policy instruments currently used is the Discount rate (Monetary policy rate) which was introduced to replace the Minimum Rediscount Rate (MRR), in 2006 to achieve stable aggregate prices.

Monetary policy is one of the macroeconomic management tools used to influence outcomes in the real economy to its desired direction. The basic goals of monetary policy are the promotion of stable prices, sustainable output, and employment. It is expected to affect

the real economy through movements in interest rates which would alter the cost of capital and investment in the productive sector. (CBNOP 2014).

The Central Bank of Nigeria seeks to achieve price stability through the management of the money supply. The money supply is the aggregate stock currency and other liquid instruments in a country's economy on the date measured. Money aggregate comprises currency in circulation and close substitutes, such as bank deposits, and is informative for aggregate spending and inflation. It thus goes beyond those assets that are generally accepted means of payment to include instruments that function mainly as a store of value. (ECB 2011).

In Nigeria, according to (Salihu et al 2018) the definition of money supply includes those financial assets which are highly liquid; Nigeria introduced M3 in 2009 when it included a new financial instrument in its national definition of broad money i.e. securities issued by the CBN and held by money holding sector. Excess money supply (or liquidity) may arise when the amount of broad money is higher than the level required to sustain non-inflationary output growth in the economy (CBN Monetary policy framework 2011). Hence the need to regulate the money supply to achieve the desired level of economic growth.

Economic growth is an important macro-economic objective because it enables increased living standards, improved tax revenues, and helps to create new jobs. (Ufoeze, et al 2018). It is the increase in the number of goods and services available in a given country at a particular period. An economy can be classified into four distinct inter-related sectors- real, external, fiscal/government, and

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financial sectors. The real sector - agriculture, industry, and services - is strategic as it encompasses the production and distribution of tangible goods and services required to satisfy aggregate demand in the economy. Its performance can be used to measure the effectiveness of macroeconomic policies. A vibrant real sector drives economic growth as its impact positively on the production and distribution of goods and services which raise the welfare of the citizenry. The real sector creates more linkages in the economy than any other sector. (Anyanwu 2010).

The Nigerian government has adopted various monetary policies through the Central Bank of Nigeria over years to achieve economic growth and despite the increasing emphasis on manipulation of monetary policy in Nigeria, the problem surrounding its economic growth persists. These perceived problems are being claimed to have caused a fast decline in the economic growth of Nigeria (Nwoko et al 2016). Hence the need to examine the effect of monetary policy actions on the real sector.

2. Theoretical Foundation and Empirical Review

Monetary policy theories have been dominated by diverse beliefs. There is no consensus among economists as to whether monetary policy will bring about economic stabilization. This disagreement divided the economy into different schools of thought (Nwoko, et al. 2016). They are, the Classical view of the monetary policy which is based on the quantity theory of money, the Keynesian view (the indirect relationship between money and price), and the Monetarist view (a modern variant of classical macroeconomist) have been the center of monetary policy analysis.

2.1. Theoretical Foundation

2.1.1. The Classical view on Monetary Policy

The Classical view of monetary policy is based on the quantity theory of money (QTM), it is given by the expression $MV = PY$ and was developed by an American Economist Irving Fisher. M denotes the supply of money which the Central Bank controls indirectly with the use of base money; V denotes the velocity of circulation that is, the average number of times currency is spent on final goods and services over a given period usually a year; P denotes the price level GDP (Inflation). The classicists believe that given the equation of exchange {(which states that the current market value of all final goods and services (nominal GDP) must equal the supply of money multiplied by the average number of times currency is used in the transaction in a given year (Gholamrezapour and Gang 2018)} and stability in the velocity of money plus the assumption that economy operates at full employment, the change in money supply will only affect price without any effect on real demand, investment and output. (Nwoko, et al 2016).

The classical believes the economy is always at or near the natural level of real GDP so that Y in the equation of exchange can be regarded as fixed (Gholamrezapour and Gang 2018). Therefore, if V and Y are constant, then there is a proportional relationship between M & P .

2.1.2. The Keynesian View on Monetary Policy

On the other hand, Keynesians believe an indirect relationship between output and money supply. The Keynesian believe that monetary policy works by influencing investment decisions through the interest rate. They believe that change in the money supply has effects on total expenditure and output level through the changes in the interest rate and thus mechanism works indirectly. (Chaudhry et al 2012). The variations in the money supply could lead to an increase or decrease in interest rates. A decrease in interest rate will affect aggregate investment and enhance aggregate income and output. This is based on the belief that the interest rate is the key determinant of investment in the market economy. Expansionary monetary policy increases the supply of loanable funds available through the banking system, causing interest rates to fall. (Nwoko et al 2016).

2.1.3. The Monetarist View of Monetary Policy

Monetarist is a school of thought led by Milton Friedman. This school of thought is a modern variant of classical macroeconomics. They developed a subtler and relevant version of the quantity theory of money (Gholamrezapour and Gang 2018). The monetarists base their views on money supply as the key factor affecting the wellbeing of the economy. They believe that an increase in the money supply will lead to an increase in nominal demand, and where there is excess capacity, they believe that output will be increased.

The Monetarists acknowledge that the economy may not always be operating at the full employment level of real GDP. Thus, in the short-run, monetarists argue that expansionary monetary policies may increase the level of real GDP by increasing aggregate demand. However, in the long-run, when the economy is operating at the full employment level, they argue that the quantity theory remains a good approximation of the link between the supply of money, price level, and the real GDP. Also, the long-run expansionary monetary policy only leads to inflation and does not affect the level of real GDP (Gholamrezapour and Gang 2018). Monetarism concludes that monetary expansions influence the real variables such as output and employment in the short-run, while the nominal variables such as nominal national income, interest rates, and prices are influenced in the long-run (Chaudhry et al 2012). The Keynesians believe that fiscal policy influences on economic activity while monetarists believe that monetary policy impacts on economic activity greatly than fiscal policy.

2.2. Monetary Aggregate

Monetary aggregate is the measure of the amount of

money in circulation within an economic sector. It is used to measure the money supply in an economy. According to Walter J 1989 monetary aggregates are measures of the nation's money stock and the most narrowly defined monetary aggregate. It takes into account one narrow aggregate (M1) and three broad ones (M2, M3, and M4). M1 is banknotes and coins in circulation and demand deposits with issuers of money that is, the greatest liquidity held by residents, M2 is M1 plus deposits with banks and other issuers with a residual term of up to five years, shares in debt funds and payables under repurchase agreements (repos) while M3 adds government securities held directly by resident money holders and issued by the federal government or the Mexican Bank Savings Protection Institute (IPAB) to M2. Finally, M4 has been redefined to include non-resident holdings of all the instruments included in M3 (Morales 2018). Monetary aggregation relied on three categories of aggregates based on the assumption of weak separability among a given set of monetary assets. These are the simple or weighted sum, the variable elasticity of substitution, and the Divisia aggregates (Salihu et al 2018).

Current Compositions of Monetary Aggregates in Nigeria

a) Narrow money is made up of currencies, (that are paper notes and coins in circulation) and demand deposits. It is often denoted by M1. It is regarded as a liquid component of the money supply. Narrow money consists of currency outside banks (COB) plus demand deposits.

$$M1_t = CoB_t + DD_t \quad (1)$$

Where $M1$ = Narrow Money, CoB = Currency Outside Bank, DD = Demand Deposit

b) Broad money is a broader measure of money supply, in terms of its composition and refers to the total value of money in the economy, in addition to the components of narrow money; broad money includes the savings and time deposits with the deposit money banks.

Thus, Broad Money from the liability side of the monetary survey

$$M2_t = M1_t + QM_t \quad (2)$$

$$\{CoB_t + DD_t\} + \{SD_t + TD_t + FCD_t\}$$

$$M2_t = CoB_t + DD_t + SD_t + TD_t + FCD_t \quad (3)$$

Where $M2$ = Broad Money, $M1$ = Narrow Money, QM = Quasi-Money, SD = Savings Deposit, TD = Time Deposit, FCD = Foreign currency Deposit

On the assets side, $M2_t$ is the combination of the net foreign assets and net domestic assets.

$$M2_t = NFA_t + NDA_t \quad (4)$$

Net foreign asset (NFA) = Foreign Assets – Foreign liabilities

Net domestic assets (NDA) = Net domestic credit (NDC) + other asset net (OAN)

$$M2_t = NFA_t + NDC_t + OAN_t \quad (5)$$

CBN 2012

The broad definition of money supply in Nigeria includes

$M3$ that is $M2$ plus securities issued by CBN and held by the money holding sectors.

$$M3_t = M2_t + OBMH_t \quad (6)$$

Where $M2$ is money supply, $OBMH$ is OMO Bills issued by CBN and held by money-holding sectors

c) Reserve Money (RM) also known as Base Money, Monetary Base, High-powered money, and central bank money is the main component on the liability side of the CBN balance sheet. It consists of currency in circulation and other depository corporations (ODCs) deposits with CBN. It is used to influence credit and monetary developments in the system.

Mathematically, it is represented as:

$$RM_t = CIC_t + DD_t \quad (7)$$

Where CIC is currency in circulation, DD is ODCs deposit with CBN.

The RM identity is given as:

$$RM_t = NFA_t + NDA_t \quad (8)$$

Where NFA is Net Foreign Assets and NDA is Net Domestic Assets of the CBN

Note;

$$NDA_t = NCG_t + CPS_t + CODC_t + OAN_t \quad (9)$$

Where NCG is Net Claims on Central Government, CPS is Claims on Private Sector, $CODC$ is Claims on ODCs and OAN is Other Assets Net of the CBN (Salihu et al 2018).

2.3. Monetary Policy Actions

Monetary Policy is the deliberate use of monetary instruments (direct and indirect) at the disposal of monetary authorities such as the central bank to achieve macroeconomic stability (Gholamrezapour and Gang 2018). Governments try to control the money supply because most governments believe that their rate of growth affects the rate of inflation. Hence monetary policy comprises those government actions designed to influence the behavior of the monetary sector (Gholamrezapour and Gang 2018). It is the tool for executing the mandate of monetary and price stability. Monetary policy is essentially a program of action undertaken by the monetary authorities, generally the central bank, to control and regulate the supply of money with the public and the flow of credit to achieve predetermined macroeconomic goals (Dwivedi, 2005 as sighted in Okafor et al 2015).

Monetary policy can be neutral, expansionary, or contractionary. Monetary authority engages in expansionary (accommodating) or contractionary (tight) monetary policy, to either increase or decrease the money supply (M) and neutral monetary policy in other to leave the money supply unchanged. If an economy is operating above potential, the monetary authority deploys tight monetary policy to bring the economy back to potential and if an economy is operating below potential, the monetary authority deploys expansionary policy to stimulate economic growth. According to ECB 2011, an economy is said to be at

potential when its level of output can be achieved using available production factors without creating inflationary pressures.

Potential output can be described as an estimate of “full-employment” gross domestic product, or the level of GDP attainable when the economy is operating at a high rate of resource use. Rather than being a technical ceiling on production, potential GDP is a measure of the economy’s maximum sustainable output, in which the intensity of resource use is neither adding to nor subtracting from inflationary pressure. (CBO 2004). Potential output measures the medium-to-long-term level of sustainable real output in the economy (ECB 2011).

The main objectives of monetary policy remain to achieve internal and external balances and the promotion of non-inflationary growth in output. Although Monetary policy is designed to achieve price stability and sustainable economic growth (CBNOP 2014), it gives an absolute priority to price stability (Bojan and Ivan, 2013). The targets of monetary policy are the operational target, the intermediate target, and the ultimate targets. The Central Bank of Nigeria manipulates the operating target (reserve money) over which it has substantial direct control to influence the intermediate target (broad money supply) which has an impact on the ultimate objective of monetary policy, i.e., inflation and output. (CBN 2011). Monetary policy instruments are used to manipulate the operating target (reserve money) in order to influence the intermediate target (broad money supply).

The instruments deployed by Central banks depend on the level of development of the economy, especially the financial sector. These policy instruments could be direct or indirect (CBN 2011) both the direct and indirect policy instruments have the same objectives, of channeling funds from surplus to deficit sectors, to extend the frontiers of growth and development. (CBNOP 2014).

The Central Bank of Nigeria in 1993 abandoned the direct control regime as a natural reaction to the liberalization of the financial sector to adopt the direct control regime through the use of market-driven instruments such as Open Market Operations (OMO). OMO is the most important and flexible tool of monetary policy is open market operations. It is the buying and selling of government securities in the open market (primary or secondary) to expand or contract the amount of money in the banking system. OMO enables the central bank to influence the cost and availability of reserves and bring about desired changes in bank credit and money supply.

Reserve Requirements, an indirect instrument is also used by the central bank to influence the level of bank reserves and hence, their ability to grant loans. It can either be lowered/ raised to increase/reduce the capacity of banks to grant loans and thereby influencing money supply in the economy. The two major tools used to achieve the desired level of the reserve are the Cash reserve ratio (CRR) and the liquidity ratio (LR).

The third monetary policy instrument currently used by the Central Bank of Nigeria is the Discount Window Operations. This instrument enables the DMBs to borrow reserves against collaterals in form of government or other acceptable securities. The central bank operates this facility in accordance with its role as lender of last resort and transactions are conducted in form of short term (usually overnight) loans. The central bank lends to financially sound DMBs at the policy rate (MPR) which sets the floor for the interest rate regime in the money market (the nominal anchor rate) and thereby affects the supply of credit, the supply of savings (which affects the supply of reserves and monetary aggregate) and the supply of investment (which affects employment and GDP). (CBN 2011).

The Bank introduced the Monetary Policy Rate (MPR) to replace the Minimum Rediscount Rate (MRR), in 2006, as a new Monetary Policy Implementation framework. The new framework was designed to achieve stable aggregate prices, including the exchange rate of the domestic currency through stability in short-term interest rates. The MRR represents the minimum interest rate banks can borrow from the CBN while the MPR is a short-term interest rate at which banks can predictably borrow from the apex bank. The MPR serves as an indicative rate for transactions in the money market. (CBNOP 2014).

2.4. The Real Sector

The real sector of an economy is the sector that produces goods and services to meet the consumption demand of an economy. (Oduyemi 2013). Economic activity is commonly broken down into three sectors: The primary sector, which involves; agriculture, forestry, and fishing, the secondary sector is also known as the industry and it includes manufacturing, processing, or transforming goods, and finally, the tertiary sector (Services) i.e. providing information or services to consumers, such as in IT, tourism, or banking. (Statista 2020).

According to USTIC 2017, Nigerian services industries are expected to drive future growth. The sector has shown impressive gains in recent times see Figure (1) Services accounted for over 50% of Nigeria’s gross domestic product (GDP) in 2019. Nigeria is one of the most open services markets in Africa, receiving an overall score of 27.1 (virtually open) on the Services Trade Restrictions Index (STRI) published by the World Bank even though it’s faced with infrastructure and ease of doing business challenges.

According to A.T. Kearney’s 2015 as sighted in USTIC 2017 African Retail Development Index, Nigeria is the fourth most attractive investment market for retailers in Sub-Saharan Africa (SSA), largely based on its volume of consumers and its growing middle class. Nigeria has attracted a wide range of foreign investors (South Africa’s Shoprite, the continent’s largest supermarket chain, and U.S.-based KFC) and it’s becoming an important market for luxury goods retailers (e.g., Porsche, Hugo Boss). Homegrown online retailing has also begun to take hold,

with Jumia.com and others (which offer services similar to Amazon.com) leading the way. The telecom industry also

accounts for a considerable amount of Foreign Direct Investment FDI.

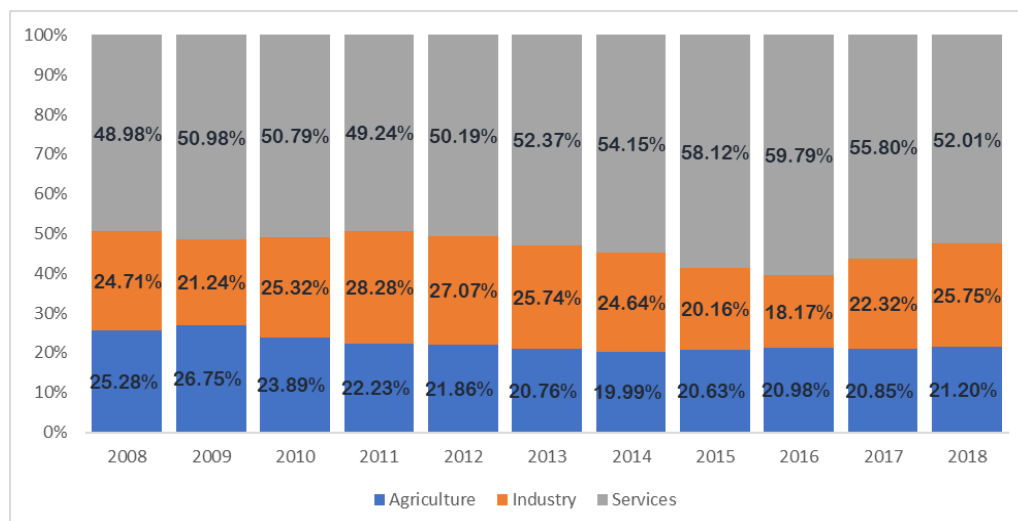


Figure 1. Source: Statista 2020

2.5. Review of Empirical Literature

Monetary policy can play a major role in alleviating economic growth. Many empirical studies have been conducted to review the impact of this policy on economic growth. Ufoeze et al 2018, investigated the effect of monetary policy on economic growth in Nigeria from 1986 – 2016 using the Ordinary Least Squared technique. The study employed GDP as the dependent variables against the explanatory monetary policy variables: monetary policy rate, money supply, exchange rate, lending rate, and investment. They find that monetary policy rate, interest rate, and investment have an insignificant positive effect on economic growth in Nigeria, Money supply however has a significant positive effect on growth in Nigeria, and the Exchange rate has a significant negative effect on GDP in Nigeria. The study concluded that monetary policy can be effectively used to control the Nigerian economy and thus a veritable tool for price stability and improve output. Using the cointegration and error correction model Obamuyi, and Olorunfemi, 2011 examined the implications of financial reform and interest rate behavior on economic growth in Nigeria from 1970-2006. The results demonstrate that financial reform and interest rates have a significant impact on economic growth in Nigeria. The results imply that the behavior of interest rate is important for economic growth given the empirical nexus between interest rates and investment, and investment and growth.

In the same vein, Moyo, C. & Le Roux, P. 2018, examined the impact of interest rate reforms on economic growth through savings and investments in SADC countries for the period 1990-2015 using the Pooled Mean Group (PMG) estimation technique. The authors used three specifications for the analysis; the first one determines the influence of interest rate reforms on savings, the second one analyses the effect of savings on investments while the third one

examines whether investments have a positive impact on economic growth. They concluded that interest rate reforms have a positive impact on economic growth through savings and investments. Jelilov 2016 however, discovered that interest rate has a slight impact on growth while examining the impact of interest rate on economic growth in Nigeria from 1990 to 2013.

However, Obansa et al 2013 discovered that the Exchange rate had a stronger impact on Economic growth than the Interest rate. Using the vector autoregression (VAR) technique, the study examined the relationship that exists among the Exchange rate, Interest rate, and economic growth in the Nigerian economy from 1970 to 2010, with specific emphasis on the Impulse Response factor and the Forecast Error Variance Decomposition. The period of their study was fractured into two prominent distinctions of the economic era- the regulation era and the deregulation era.

Adofu and Salami 2017 examined the effects of monetary policy shocks on some selected macroeconomic variables in Nigeria, from 1983 to 2015 using the structural vector autoregressive technique to model. They concluded that interest rate-shock has a negative impact on real GDP and money supply. Similarly, Mardy and Pahlaj 2015 examined whether monetary policy has any impact on the economic growth in Cambodia using quarterly time-series data from 2000 to 2012. The study applied a multiple regression model to examine the impact of money supply and the interest rate on GDP growth in Cambodia. The results show that the money supply has a positive impact on GDP growth, but the strength of impact is relatively weak, while a change in interest rate over the study period did not affect economic growth, meaning that there is no significant effect of interest rate on GDP growth. Monorith 2019, also finds a similar result for Cambodia. The author studied the significance of monetary policy in the contribution to the economic growth of Cambodia from 2000-2018. The empirical results

illustrate that money supply (which represents the monetary policy), inflation, and exchange rate revealed a positive relationship with GDP while interest rate, is confirmed negatively insignificant with GDP.

Finally, Twinoburyo and Odhiambo 2018 took a comprehensive view of the theoretical evolution of the relationship and the respective recent empirical findings and discovered that the majority of findings support the relevancy of monetary policy in supporting economic growth, mainly in financially developed economies with fairly independent central banks. Based on their study, they realized that the relationship tends to be weaker in developing economies with structural weaknesses and underdeveloped financial markets that are weakly integrated into global markets. They concluded that monetary policy matters for growth both in the short-run and long-run despite the prevailing ambiguous relationship and recommended an intensive financial development measure for developing countries as well as structural reforms to address supply-side deficiencies.

3. Methodology

3.1. Data Description

This study used six domestic variables (real gross domestic product (RGDP), inflation rate (INF), the nominal exchange rate (NER), monetary policy rate (MPR), Prime Lending rate (LR), and monetary aggregate (MA)). All data were sourced from the CBN website. The sample period covers started from the year 2006 {when the Bank introduced the Monetary Policy Rate (MPR) to replace the Minimum Rediscount Rate (MRR) as a new Monetary Policy Implementation framework} to 2019. Though the data were not monthly all through, the annual and quarterly data were transformed into monthly data using Eviews to allow for stable estimations and analyses. Real GDP and money supply are in log form while nominal exchange rate, inflate rate, and monetary policy rate, prime lending rate were entered in their natural form.

The two nonpolicy variables included in this study are the Real GDP and the Inflation rate. Real GDP can be used to measure the level of economic activity while the inflation rate {the most well-known indicator of the inflation rate is the consumer price index (CPI)} measures the level of goods and services bought by both households and firms. This study assumes that RGDP and the inflation rate are the two major pillars for the reals sector. The essence of incorporating the RGDP and the inflation rate is to determine how the policy rate influences growth in the real sector.

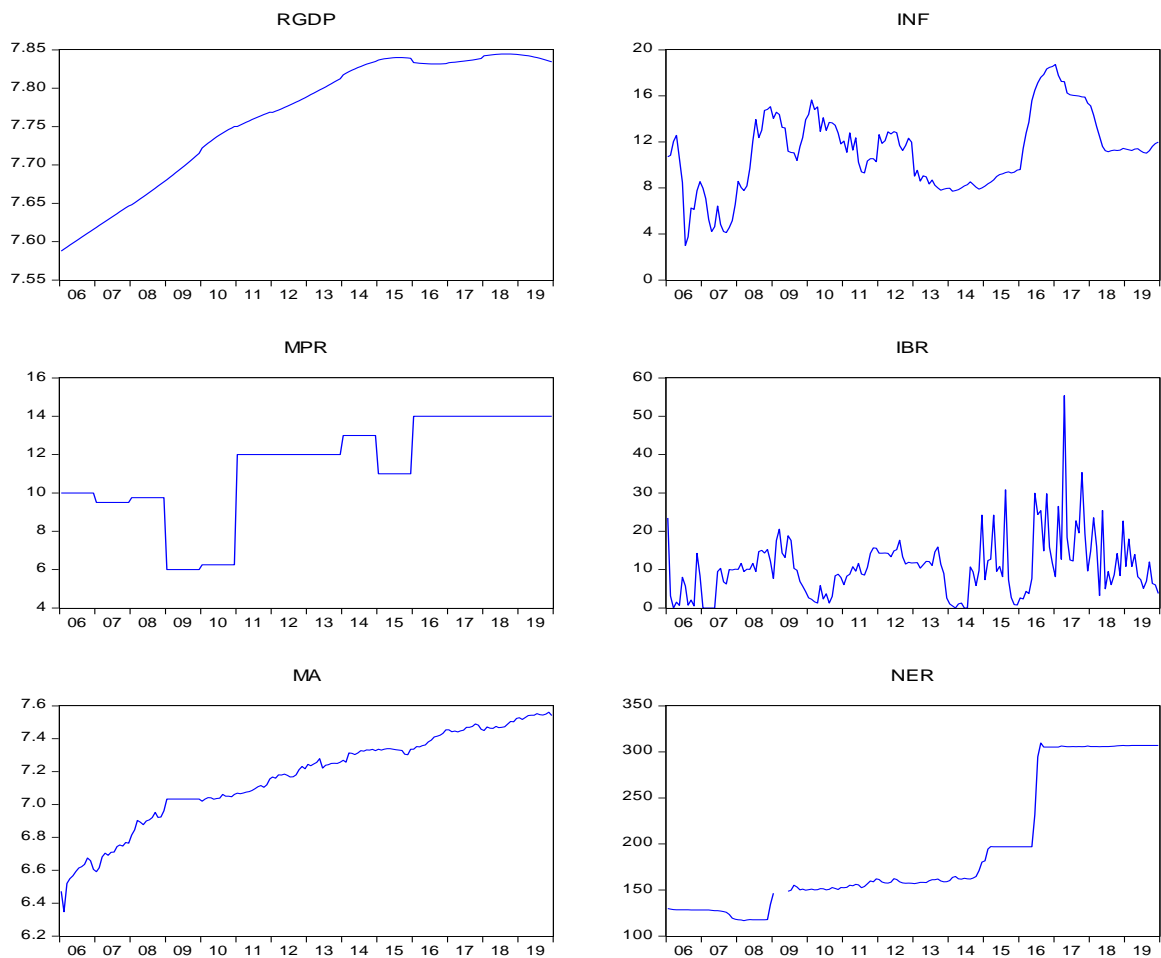


Figure 2

Policy variables include Monetary Policy Rate, the Prime lending rate, the Monetary aggregate, and the Nominal exchange rate. The policy variables are stabilization tools for Central Banks. The official rate of the Central Bank of Nigeria (MPR) serves as an anchor rate, it is the benchmark against which other lending rates are pegged and it's used to moderate inflation through the money supply. This study used the M2 from 2006 - 2008 and M3 afterward and also included the nominal exchange rate to capture the interplay between monetary policy and foreign exchange transactions. The average exchange rate of the Nigerian currency (naira per us dollar) was used, hence, an increase in its numerical value means currency depreciation i.e. a fall in the value of a currency.

3.2. Research Methodology

a) The General VAR model

VAR is a natural extension of the univariate autoregressive model to dynamic multivariate time series. According to Stock and Watson as sighted in Sebastian 2019 VARs are often employed as forecasting and policy tools.

$$y_t = (y_1, y_2 \dots y_{nt}) \quad (10)$$

VAR(p) model:

$$X_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t \quad (11)$$

where:

Where X_t is a $n \times 1$ column vector the endogenous variables, c is a $n \times 1$ vector of constants, the A_i 's are $n \times n$ coefficient matrices (for every $i = 1 \dots, p$) and u_t is a $n \times 1$ vector of error terms. Adufo and Salami 2017).

b) Structural VAR model

To assess the effectiveness of monetary policy in Nigeria, this study employs the structural Vector Autoregressive (SVAR) model with a non-recursive identification structure (Keating 1992). Although there are recent improvements in the VAR methodology, the SVAR is theoretically suitable and offers the benefit of identifying monetary policy as well as other shocks, the use of SVAR in the analysis of monetary policy effects have produced relatively better and robust results (CBNOP 2014). SVAR models are not only consistent but they also provide valid results. (Cushman and Zha 1997 as sighted in Nizamani 2016).

Assume that the Nigerian economy is represented by the following structural form

$$Ax_t = C(L)x_{t-1} + Dz_t \quad (12)$$

where x_t is a vector of endogenous variables and z_t is a vector of exogenous variables. The elements of the square matrix, A , are the structural parameters on the contemporaneous endogenous variables and $C(L)$ is a k th degree matrix polynomial in the lag operator L . The matrix D measures the contemporaneous response of endogenous variables to the exogenous variable.

A reduced-form of equation (12) is;

$$x_t = A^{-1}C(L)x_{t-1} + A^{-1}Dz_t \quad (13)$$

where $z_t = \varepsilon_t$

equation (13) can be re-written as

$$\Delta x = \beta(L) \Delta x_{t-1} + e_t \quad (14)$$

where $\beta(L) = A^{-1}C(L)$ and $e_t = A^{-1}D\varepsilon_t$.

The structural shocks, ε_t could be derived from the estimated residuals,

that is,

$$\varepsilon_t = D^{-1}Ae_t \quad (15)$$

Because the coefficients in A and D are unknown, identification of structural parameters is achieved by imposing theoretical restrictions to reduce the number of unknown structural parameters to be less than or equal to the number of estimated parameters of the variance-covariance matrix of the VAR residuals. Specifically, the covariance matrix for the residuals, Σ_e from either equation (14) is;

$$\Sigma_e = E[e_t e_t'] = A^{-1} D E[\varepsilon_t \varepsilon_t'] D A^{-1} = A^{-1} D \Sigma_D A^{-1} \quad (16)$$

where E is the unconditional expectations operator, and Σ_e is the covariance matrix for the shocks.

b) Impulse Response Function: According to Sani and Alli (2018) the Structural Impulse Response Functions (SIRF) will help us to show the dynamic response of current and future values of each variable to a one-unit change in the current value of one structural shock while assuming that other shocks are equal to zero. Impulse response analysis attempts to answer the question of what the effect of a shock is on current or future values of the variables in the model (Sebastian 2019).

c) Forecast Error Variance Decomposition: FEVD shows the proportion of movements in the endogenous variables of a VAR model that occurs due to its shocks versus shocks to other variables in the model. It determines how much of the forecast error variance of a given variable is explained by innovations to each explanatory variable in the model (Adofu and Salami 2017). The results of an SVAR model are usually presented using either or combination of both IRF and FEVD. This study used both the Impulse Response Function and the Forecast Error Variance Decomposition to analyze the statistical significance of the variables.

3.3. Identification of Structural VAR

In this model, variables are *RGDP*, *INF*, *MPR*, *LR*, *MA*, *NER*. The domestic variable comprises two blocks: The nonpolicy block with two variables *RGDP*, *INF*, and the policy blocks with four variables *MPR*, *LR*, *MA*, *NER*. This study followed the idea of Salihu et al 2018 by not introducing foreign variables in the model, as against previous studies (Vinayagathan 2013, Arwatchanakarna 2017)

$$AY_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & a_{34} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ 0 & 0 & a_{63} & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} RGDP \\ INF \\ MPR \\ LR \\ MA \\ NER \end{bmatrix} \quad (17)$$

In this study, the author imposes the restrictions on the contemporaneous relationship among the variables based on the works of Vinayagathan 2013 and CBNOP 2014 but modifies it in some aspects.

The first two equations relate to real GDP and price level, which represent the goods market equilibrium of the domestic economy, we assume that MPR, LR, MA, and NER do not affect the output and price contemporaneously, they are assumed to affect with a lag. If there is an unexpected change in the monetary policy, it is assumed that the real sector does not change its prices immediately.

In this study, both MPR and LR were used as interest rate variables. The MPR is the official monetary policy stance of the CBN and it is an anchor rate for the money markets. It is used to gauge the effectiveness of the monetary policy on the real sector of the Nigerian economy. Since MPR affects the market with a lag, the LR was included to augment the official rate. In other words, the MPR is unaffected by innovations from other variables except for the Prime lending rate and itself.

The fourth and the fifth row relate to money supply and money demand, representing the money market equilibrium. The LR, which is also the money supply equation, is affected contemporaneously by real output, price level, monetary policy rate, and its innovation. The prime lending rate is the interest rate at which a commercial bank lends to its borrowers. An increase in MPR results in a rise in the prime lending rate. The inclusion of the LR in the equation tells us that the policymaker is reacting indirectly through the

interest rate channel. In line with the commonly stated money demand equation in macroeconomics $M^d = f(P, Y, i)$, the money demand equation in row five is affected by innovations from the real output, price, MPR, Prime lending rate, and structural shocks from itself.

The sixth row is the Nominal exchange rate, it represents the uncovered interest rate parity. The nominal exchange rate is affected contemporaneously by shocks from MPR and itself. This study assumes that interest rate is a key determinant of the nominal exchange rate, any movements in the policy rate will engender shocks that will affect portfolio flows and cause currency appreciation or depreciation.

4. Discussion of Result and Findings

4.1. Unit Root Test, Optimal Lag, and Stability Test

The study adopted Augmented Dickey-Fuller (ADF) based on Akaike Information Criterion (AIC) and Phillips-Perron (PP) tests to determine the level of stationarity of the data. Aside RGDP that is neither returned I (0) nor I(1) by ADF(AIC), the two techniques return the variables as I(1) stationary *Table 1*. The author chose two-lags as an optimal lag based on the AIC lag-length selection criteria *Table 2*, 24 lags for the Impulse response function, and variance decomposition. A stability test was also undertaken as part of the diagnostic tests, to ascertain the reliability of the VAR model, the estimated VARs exhibited stability since all roots lie inside the unit circles.

Table 1. Unit Roots Test Result

Variable	Augmented Dickey Fuller (ADF)		Phillips-Perron Unit Roots	
	Level	1 st Diff	Level	1 st Diff
RGDP	0.152584	-3.445680**	0.948412	-8.054174***
INF	-3.187944*	-7.548904***	-2.228611	-11.00821***
MPR	-2.483355	-12.79562***	-2.562004	-12.79562***
LR	-4.207784***	-8.990673***	-3.166048*	-16.38180***
MA	-3.773451**	-4.527651***	-2.958101	-16.97800***
NER	-1.911763	-5.934146***	-1.936263	-6.127737***

Note: *, ** and *** denote statistical significance at 10%, 5% and 1%.

Table 2. Optimal Lag Result

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1126.44	NA	0.178341	15.30320	15.42471	15.35257
1	363.3404	2838.630	5.24e-10	-4.34244	-3.491877*	-3.99686
2	437.2462	134.8282	3.15e-10*	-4.854679*	-3.27507	-4.212886*
3	472.6049	61.63882*	3.19e-10	-4.84601	-2.53735	-3.90801
4	493.9418	35.46530	3.94e-10	-4.64786	-1.61015	-3.41365
5	516.0207	34.90852	4.84e-10	-4.45974	-0.69297	-2.92931
6	540.5366	36.77395	5.81e-10	-4.30455	0.191269	-2.47791
7	569.7748	41.48655	6.61e-10	-4.21317	1.011698	-2.09032
8	594.5535	33.14988	8.11e-10	-4.06153	1.892388	-1.64247

Note * indicates lag order selected by the criterion

Table 3. Stability Test

Root	Modulus
0.998202	0.998202
0.986904	0.986904
0.922796 - 0.018870i	0.922989
0.922796 + 0.018870i	0.922989
0.826818 - 0.044434i	0.828011
0.826818 + 0.044434i	0.828011
0.614273	0.614273
0.433659	0.433659
-0.423073	0.423073
-0.195354	0.195354
0.143788	0.143788
-0.022143	0.022143

No root lies outside the unit circle.
VAR satisfies the stability condition.

4.2. Impulse Response Function

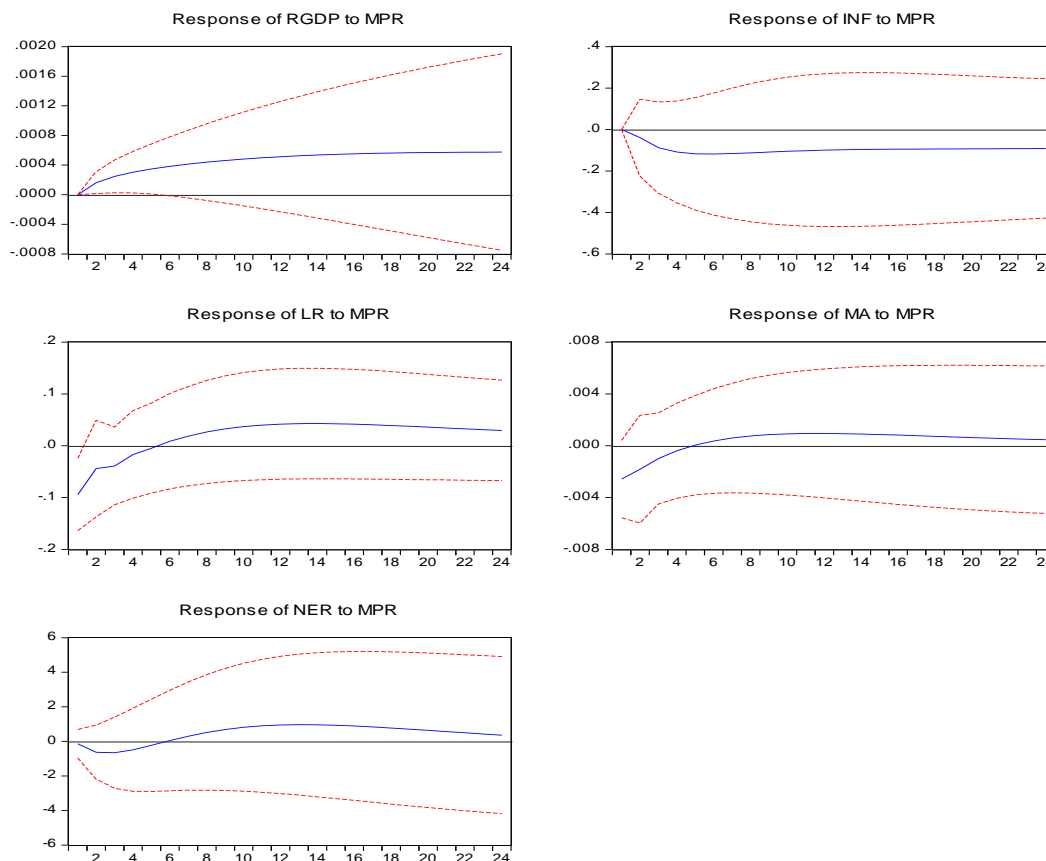
This section reports the impulse response function used to understand the dynamic responses of domestic variables to a structural one-standard-deviation shocks.

Figure 3 shows the response of domestic variables to the innovation in interest rate shocks. The interest rate shock is neither a contractionary or accommodative shock, it's a change in policy framework to achieve stable aggregate prices. The first row of Figure 3 contains the response from

the output and inflation rate. The domestic output responds positively to the interest rate shock, though the positive response is not statistically significant while the price level reduced significantly throughout the horizon. The innovations to the interest rate significantly reduce and stabilize the domestic price level.

Figure 4 shows the estimated impulse responses of each economic variable to positive money growth shocks. The positive money shock on output produces the expected results as the output level increased to its pick at period ten. Although, the response of the output level is not statistically significant. Innovations in monetary aggregates caused a statistically significant inflationary pressure over the first eight periods, and then gradually decline. The shock to monetary aggregate reduced the MPR; this is in line with the money demand theory which states that as money demand increases and interest rate decreases. However, the response is short-lived, declining for only a few months, and then gradually moves towards its pre-shock values. The positive response of LR in the first quarter followed by a negative response creates a puzzle while the impact on the nominal exchange rate is positive as NER appreciates.

Figure 5 shows the responses of economic variables to a nominal exchange rate shock. Positive NER shocks represent domestic currency depreciation. The output declines throughout the period. The positive response of the price level in the first few periods followed by a negative response implies a price puzzle.

**Figure 3.** Impulse Response to an Interest rate shock (MPR)

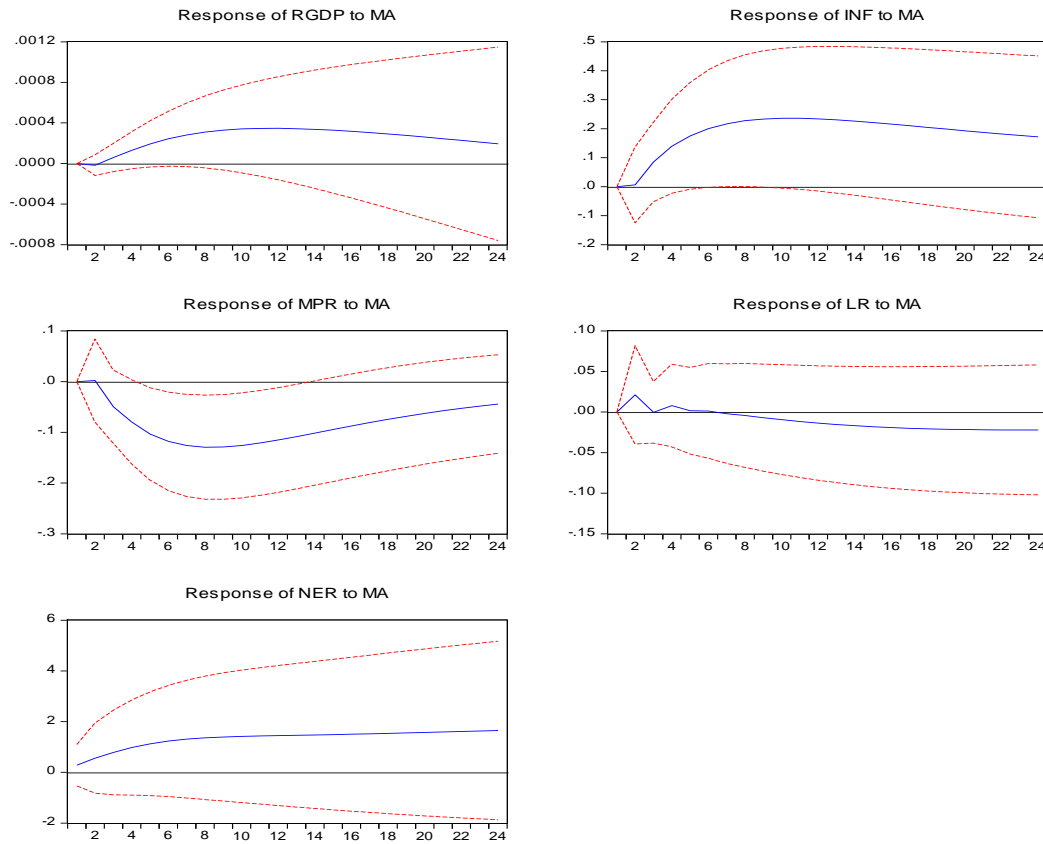


Figure 4. Impulse Response to a positive money growth shock (Monetary Aggregate)

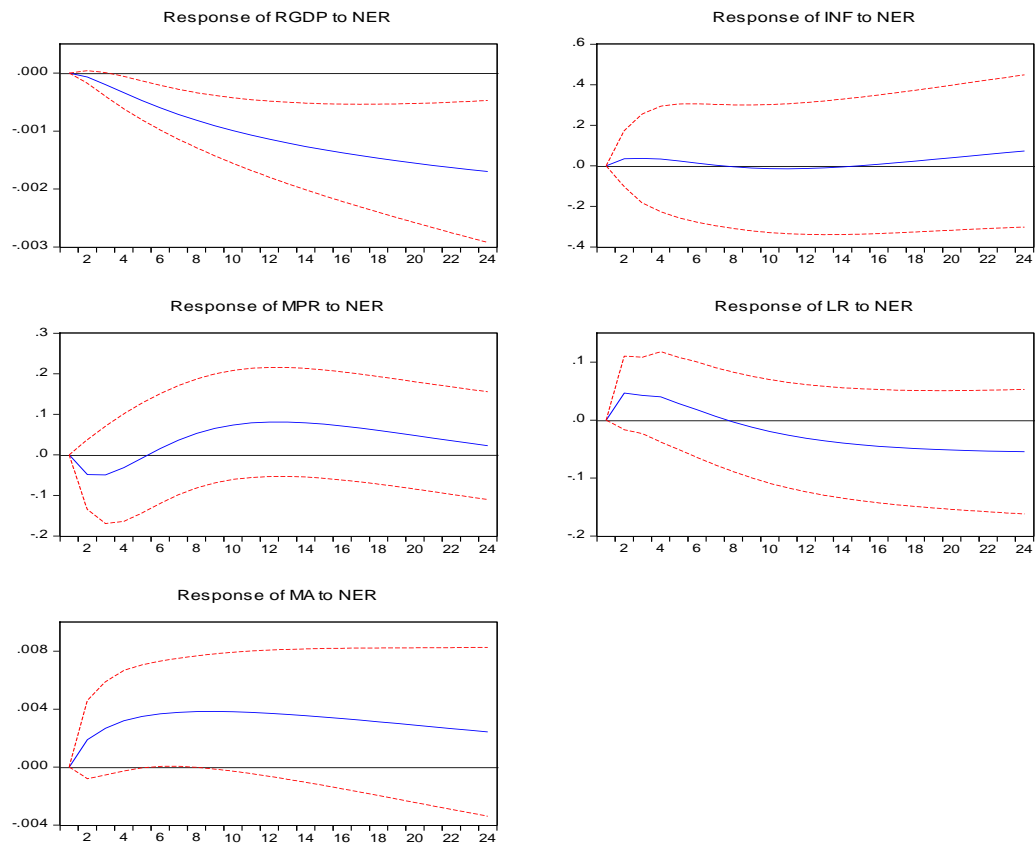


Figure 5. Impulse Response to a nominal exchange rate shock

4.3. Variance Decomposition

Variance decomposition is also a useful tool in investigating interactions among economic variables over the impulse response period. *Table 4* presents the proportion of variations in major economic variables that can be explained by shocks to other economic variables. The decomposition values for the 1st, 5th, 10th, 20th, and 24th periods into the future are displayed in that table.

The result suggests that real GDP accounted for its variance from its innovations with about 85 percent in the fifth year, although it shows a gradual decline to about 32% in the long term, apart from its shocks, output variation is also explained by the NER and MPR. However, in later periods, nominal exchange rate and LR increasingly contributed to variations of real GDP with about 34% and 23%, respectively.

Table 4. Variance decomposition

FEV of RGDP:							
Period	S.E.	RGDP	INF	MPR	LR	MA	NER
1	0.000764	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000
5	0.002645	85.09640	0.530436	4.291400	3.819286	0.827628	5.434847
10	0.004596	60.46782	1.968647	5.938759	11.59443	2.446767	17.58357
20	0.008311	36.67365	2.689564	6.091903	20.85053	2.196314	31.49803
24	0.009727	32.21232	2.434667	5.838982	23.24599	1.807826	34.46022
FEV of INF:							
Period	S.E.	RGDP	INF	MPR	LR	MA	NER
1	0.973860	0.977237	99.02276	0.000000	0.000000	0.000000	0.000000
5	2.241982	5.662043	92.38686	0.690748	0.033215	1.141917	0.085217
10	2.859623	7.285532	87.30311	1.191849	0.408223	3.752418	0.058864
20	3.348278	7.836615	79.47235	1.692488	3.962357	6.957980	0.078207
24	3.457505	7.817244	76.48704	1.872244	6.019197	7.603963	0.200312
FEV of MPR:							
Period	S.E.	RGDP	INF	MPR	LR	MA	NER
1	0.607807	8.459283	0.368431	91.17229	0.000000	0.000000	0.000000
5	1.124236	8.960745	0.362706	87.36707	1.304503	1.539233	0.465740
10	1.314255	7.231251	1.800074	82.07640	2.039914	5.699804	1.152561
20	1.427088	6.269740	3.625765	75.60393	1.975769	9.110736	3.414061
24	1.442532	6.264155	3.728055	74.71261	2.332440	9.415430	3.547312
FEV of LR:							
Period	S.E.	RGDP	INF	MPR	LR	MA	NER
1	0.447459	0.235552	0.517326	4.436024	94.81110	0.000000	0.000000
5	0.696002	0.224959	1.304407	2.617238	94.42196	0.105375	1.326061
10	0.852845	0.491946	4.408966	2.230301	91.76860	0.092090	1.008096
20	0.992305	0.678618	7.020666	3.306747	85.99936	0.400846	2.593768
24	1.021297	0.642958	7.006099	3.511933	84.72128	0.564440	3.553292
FEV of MA							
Period	S.E.	RGDP	INF	MPR	LR	MA	NER
1	0.018992	0.002560	0.186974	1.833970	0.125930	97.85057	0.000000
5	0.030720	0.062766	2.295744	1.169229	3.895836	89.05219	3.524237
10	0.038601	0.268035	8.695460	0.918462	10.18782	72.87689	7.053326
20	0.049095	0.514872	17.13822	0.853325	18.24375	54.12563	9.124198
24	0.051964	0.504888	18.92066	0.802152	20.03413	50.58670	9.151471
FEV of NER:							
Period	S.E.	RGDP	INF	MPR	LR	MA	NER
1	5.225817	0.582955	0.317383	0.070526	1.507321	0.289057	97.23276
5	18.57221	3.898889	4.724681	0.330604	1.180934	0.934277	88.93062
10	27.47340	8.020339	12.82728	0.350771	0.702699	1.623650	76.47526
20	37.05298	10.96865	21.75029	0.732879	3.984095	2.530467	60.03362
24	39.56067	11.08269	22.92801	0.698638	6.098400	2.890552	56.30171

The variance of price level was caused largely by its innovations and real GDP with about 92% and 5% respectively in period five. Although the contributions of most of the variables increased over time, the contributions of real GDP, monetary aggregate, and the lending rate increased the most to about 7.8%, 7.6%, and 6% respectively in period 24.

Compared to other shocks, monetary aggregate shocks seem to explain much of the MPR variation while price level seems to explain much of lending rate variation.

Although as expected, the inflation rate is best explained by its innovations and real GDP, however, monetary aggregated contributes more to variations in price level than real GDP. This is in line with the ultimate goal of monetary policy – Price stability.

5. Conclusions

This study attempts to investigate the effect of monetary policy rate on the real sector in Nigeria by employing a Structural VAR model using policy and non-policy domestic variables. The focal point of this study is to examine the effectiveness of the Monetary Policy Rate (MPR) introduced as a replacement of Minimum Rediscounting Rate (MRR) in ensuring price stability in the real sector of the economy.

The empirical results based on structural impulse response functions reveal that MPR as a policy tool provides significant results. There is substantial evidence that the shock is effective in reducing and stabilizing the price level and increasing output marginally. In the case of the nominal exchange rate, the policy rate shock is found to be effective in the medium to long run. The result suggests that innovations to policy rate are effective in stabilizing price levels, increasing output marginally, and improving the nominal exchange rate conditions. This study supports the idea of Ufoeze et al 2018 that interest rate shocks have a positive but insignificant effect on economic growth in Nigeria, as against Adofu and Salami 2017's opinion that interest rate-shock has a negative impact on real GDP.

Furthermore, result of the findings reveal that changes in output level are more influenced by shocks to nominal exchange rate than shocks to MPR through the Prime lending rate - Obansa et al 2013 also find a similar result - while changes in the price level are influenced by shocks to real GDP, monetary aggregate and MPR through the lending rate respectively. Although as expected, the inflation rate is best explained by its innovations and real GDP, however, monetary policy actions contribute more to variations in price level than real GDP.

Empirical findings of both the impulse response and the variance decomposition reveal that shocks to the nominal exchange rate can greatly influence the efforts of the monetary authority in ensuring stable economic growth.

Given the importance of international trade and investment in the process of economic growth, this study recommends a stern exchange rate policy action that will

have good implications for output growth and complement monetary policy actions in Nigeria.

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