CBN Journal of Applied Statistics Vol. 15 No. 1 (June 2024) 117-151

The effectiveness of monetary policy transmission in Nigeria: Evidence from the Monetary Policy Rate and the Cash Reserve Ratio

Abdulrahman Abdullahi Nadani[1,2] **and Auwal Isah**[3]

This paper investigates the effectiveness of the Monetary Policy Rate (MPR) and Cash Reserve Ratio (CRR) as policy instruments in Nigeria. A structural VAR model is employed to simulate two distinct models measuring shocks from the MPR and the CRR using monthly data from January 2006 to December 2023. Findings show that contractionary monetary policy impulses using MPR and the CRR contract output and credit to the private sector, inflation remains largely positive in the two models, known as the "price puzzle", but the puzzle is more persistent in the MPR equation. Moreover, shock to MPR strongly influences short-term interest rates (treasury bill rate) only within 3 months. This is similar to the impact of CRR on banks' reserves which remains positive for the latter part of the horizon. Thus, the study concludes that the MPR exhibits a rapid wide-ranging impact on the selected variables, offering a balanced method for controlling credit growth, interest rates, and liquidity. However, supportive channels may be needed to counteract inflationary trends. Finally, the study recommends improved focus on supply-side limitations, clear communication between expectations and policy measures, deeper financial markets and alternate funding sources.

Keywords: Cash reserve ratio, monetary policy rate, structural VAR
JEL Classification: E52, E58
DOI: 10.33429/Cjas.15124.5/8

1. Introduction

Central banks across the globe monitor and analyse how effective is the transmission mechanisms of monetary policy in their respective economies. This helps the central banks make informed decisions on how to adjust interest rates and liquidity levels to ensure financial stability in the economy. The timing and magnitude of these adjustments are crucial, as they determine how quickly and effectively the central bank's actions will impact the economy. Thus, a deep understanding of the transmission

[1]Department of Economics and Development Studies, Federal University of Kashere, Gombe.
[2]Corresponding author: nadaniabdul@gmail.com
[3]Department of Monetary Policy, Central Bank of Nigeria

process allows central banks to anticipate and mitigate any potential negative effects or unintended consequences of their policy decisions. In addition, study of this nature becomes important as several arguments have been raised in the literature questioning the effectiveness of monetary policy transmission channels in Nigeria. In fact, studies show that the interest rate channel of the Central Bank of Nigeria (CBN) has been weak over time (Yusuf, *et al.,* 2022). This prompts other effective channels such as the use of cash reserve ratio (CRR) to be intensified. Albeit empirical studies have been lacking to establish the extent and degree of how such alternative tools can influence prices, especially in the current inflationary challenge that Nigeria faces.

Moreover, there is broad agreement on the use of short-term interest rates to impact monetary policy in developed countries with more advanced financial systems. A number of empirical studies indicate that developed countries find that the short-term interest rate works well as a tool for affecting growth and reining in inflation (Egea & Hierro, 2019; Dale, & Haldane, 1995; Boivin, *et al.,* 2010; Bernanke, & Blinder, 1992; Boivin, *et al.,* 2008). In contrast, developing countries which are subject to poor regulatory systems and weak financial markets in the transmission of monetary policy (Davoodi, *et al*., 2013), often use the interest rate and the macroprudential measure of cash reserve requirement[4] to curb credit growth and anchor the stability of the financial sector (see Primus, 2018). For instance, in Nigeria, the monetary policy rate (MPR) and the CRR and are two significant monetary policy tools used by the CBN.

Since the minimum rediscount rate (MRR) was replaced by the monetary policy rate (MPR) in 2006 as the nominal anchor for other interest rates, the CBN, in line with other objectives, has simultaneously used the MPR and CRR to set its objective for monetary policy and determine the trajectory of other rates. In Nigeria, the CRR is considered as an alternative tool for transmitting monetary policy and has been established to be essential for effectively managing the Nigerian economy (Yusuf, *et al.,* 2022). In addition, its ability to complement the MPR, directly impact banking sector liquidity, stabilize financial markets, allow targeted interventions, mitigate external shocks, and enhance monetary policy transmission makes it a valuable instrument for the CBN. By incorporating the CRR into the broader monetary policy framework, the CBN can achieve a more balanced and effective approach to maintaining economic

[4] It has been observed that, in contrast to developed countries, cash reserve requirements are typically larger in developing countries.

stability and promoting sustainable growth.

Similarly, while the MPR primarily influences borrowing costs through the market lending rate, which transmits to credit accessibility by the real sector and subsequently affects economic activities and general prices, this renders the MPR channel indirect. Meanwhile, the CRR directly affects the banks' reserves with the CBN, this directly affects the amount of funds banks can lend which affects credit creation to the private sector, and by default, economic activities, and inflation. Also, by requiring banks to hold a certain percentage of deposits as reserves with the CBN, the CRR can control liquidity more effectively and can be used in tandem with the MPR to achieve monetary policy objectives. This dual approach allows for a more nuanced and flexible monetary policy that can address multiple economic issues simultaneously.

This is evident from the time of the global financial crisis that originated in the United States and spread to the rest of the world, when the MPR and CRR were lowered to all-time lows of 6 percent and 1 percent, respectively, to address issues related to non-performing loans, a strain on the exchange rate, and banking sector liquidity. After the banking sector stabilised and a liquidity glut reappeared, significant fiscal expansion and monetary put significant strain on inflation, the exchange rate, and external reserves. The CBN increased the MPR by 600 basis points and tightened the CRR from 1.00 to 2.00, 4.00, and 8.00 percent in order to mitigate these threats (CBN, 2011). However, with the creation of the Treasury Single Account (TSA) and the imperative to halt diminishing growth in the midst of higher inflation, the MPR stayed at 13 percent while the CRR dropped from 30 percent to 20 percent to address the liquidity stance of the banking sector (CBN, 2015).

Considering that there have been concerns about the effectiveness of direct policy instruments (Kelilume, 2014), this study investigates the effectiveness of monetary policy in Nigeria using both direct and indirect policy tools of the cash reserve ratio and monetary policy rate, respectively. Nevertheless, various studies have discussed the transmission mechanisms of monetary policy in Nigeria (Chuku, 2009; Ndweke 2013; Fasanya *et al*., 2013; Hasssan, 2015; Apanisile, *et al.,* 2022; Didigu, *et al.,* 2022; Omowonuola and Temidayo 2022). However, these studies focused on the indirect instruments by looking at whether the interest rate, money supply, external reserve, credit, or exchange rate is the most important tool for monetary policy, as

well as the effectiveness of these conduits in the transmission processes.

Furthermore, developing economies are often more susceptible to external shocks, such as fluctuations in commodity prices or global financial crises. Specifically in Nigeria, the effectiveness of traditional interest rate channel may be limited due to structural issues in the financial system (Kelilume, 2014; Yusuf, *et al.,* 2022), such as high levels of informal lending or underdeveloped financial markets.

Overall, it is important to evaluate alternate tools in transmitting monetary policy to the real sector of the Nigerian economy beyond just the traditional interest rate channel – the MPR for the case of Nigeria. To support this argument, our interrogation of the historical data shows that adjustments in the CRR have been used effectively to manage liquidity and achieve monetary policy objectives during various economic conditions in Nigeria (as in Didigu, *et al.,* 2022; Omowonuola & Temidayo 2022). For instance, the CBN's adjustments of the CRR during the global financial crisis and subsequent economic recovery periods demonstrate the CRR's practical utility as a policy tool. Against the above backdrop and in addition to the use of MPR to analyse monetary policy transmission as found in most studies, therefore, this paper extends the scope to include the CRR as an alternative tool in the analysis. The aim is to provide a more holistic approach to the understanding of monetary policy transmission in Nigeria and study of this nature would guide the CBN in its choice of policy decisions especially on the effective tool to employ or deploy to address the current inflationary pressure in the country.

The rest of the study is structured as follows: the literature review is presented in Section 2; the data and methodology are discussed in Section 3. The empirical findings and analysis are presented in Section 4, while the conclusion is presented in Section 5.

2.0 Literature Review

2.1 Theoretical Literature

This section reviews two theories of monetary policy transmission channels namely, the liquidity preference theory and the reserve requirement. According to the liquidity preference theory, the interest rate is one factor that influences the amount of money people decide to keep. The interest rate represents the opportunity cost of saving money, or what you give up by keeping cash or liquid assets, which are not subject to interest rates. As per Keynes' the liquidity preference theory, the equilib-

rium between the supply and demand of money determines the interest rate which is written as:

$$M_d = M_s \tag{1}$$

Keynes stated that the money was demanded for three reasons: (i) the transaction, (ii) the precautionary motive (iii) the speculative drive. Consequently, the triple categorization of motivations has been a cornerstone of monetary economics. The following equation represents the demand for money:

$$M_d = \alpha_1(Y) + \alpha_2(i) \tag{2}$$

where M_d represents the money demand. $\alpha_1\ (Y)$, which represents transactions and precautionary motives and both of which rise as income increases. The second factor influencing demand for money is $\alpha_2(i)$, which stands for speculative demand. This demand is a decreasing function of interest rate (i); that is, as interest rate (i) rises, the speculative demand for money decreases. Thus, the rate of interest determines the speculative demand for money. Keynes believed that the monetary authority would exogenously determine the money supply (M), ensuring:

$$M_s = M^{'} \tag{3}$$

Where M_s is the money supply and $M^{'}$ is given by the central bank.

The money market is in equilibrium when:

$$M_d = M_s \text{ which is } \alpha_1(Y) + \alpha_2(i) = M_s \tag{4}$$

The basic justification for reserve requirements is that they strengthen the monetary authority's capacity to regulate the money supply and, in turn, enable it to carry out its mandate of upholding sustainable financial conditions. Since demand for base money is largely determined by reserve requirements, an increased reserve requirement will help stabilise the money multiplier and enhance projections of the liquidity of commercial banks required for open market operations. As illustrated by (Froyen & Kopecky, 1983) Banks' demands for excess reserves (ε^r) as well as required reserves αM combine to create the demand for reserve money or base money (D^r):

$$D^r = \alpha M + \varepsilon^r \tag{5}$$

It is believed that the demand for excess reserve is given as follows:

$$\varepsilon^r = \beta_1 M - \beta_2(i) + u_1 \tag{6}$$

Where i is the interest rate and u_1 is the disturbance error term. Subsequently, the supply of base money or supply of reserve by the monetary authority is given as:

$$S^r = \delta + u_2 \tag{7}$$

Where δ stands for the intentional policy changes made by the monetary authority.

u_1 is the error in the central bank's decision-making process or fluctuations in the country's account balances with the bank which could disrupt the supply of reserve. The short-term demand for money by commercial bank and a random disturbance shock given as:

$$M = -b + u_3 \tag{8}$$

At equilibrium, the demand for excess reserve is equal to the supply of excess reserve or base money $D^r = S^r$ which is exemplified as:

$$M = \frac{1}{B}\{b(\delta + u_2 - u_1) + \beta_2 u_3\} \tag{9}$$

$$i = \frac{1}{B}\{-(\delta + u_2 - u_1) + (\delta + a_1)u_3\} \tag{10}$$

And $B = b(\alpha + a_1) + a_2$.

Due to variations in the demand for surplus reserves and broad money, it can be demonstrated that the variance of M decreases with increasing reserve requirement (δ). Increased reserve requirements make it such that changes in the demand for excess reserves can better buffer disruptions to the demand for broad money and reduce the impact of disruptions and interventions in the reserve money market. Presumably, the monetary authority's only goal is to regulate the overall monetary aggregate, and it cannot act to counteract every disturbance.

Equation (9) shows that as α increases, the marginal gain in monetary control decreases quickly. Moreover, equation (10) shows that the magnitude of reserve requirements affects the variability of the interest rate. A higher reserve requirement ratio α increases the sensitivity of the interest rate to errors in demand for broad money while decreasing variance caused by disturbances in the market for reserve money.

2.2 Conducts of monetary policy

In conducting monetary policy, a central bank acts, either directly on its statutory authority or indirectly leveraging on its impact on the money market as the issuer of cash reserve requirement. The phrase "direct" implies a link between policy objective and instruments (e.g., lending limits). Direct policy instruments work by regulating prices (policy rates) or quantities (volume of lending) whereas, indirect policy instruments work via the money market by altering the existing reserves. Both with the objective to enhance efficiency. The policy rates, credit limits and direct lending (lending based on request of the central bank contrary to commercial purpose) are the major direct policy instruments. Whereas the indirect policy instruments include; cash reserve requirement, open market operations (OMO), and central bank credit

facilities (Alexander *et al*., 1995). In this case, the policy rates or interest rates and the cash reserve requirement are only discussed here because of their relevance to the research objectives.

Policy rate: The policy rate, commonly known as the monetary policy rate (MPR) in Nigeria, is the charge levied by the Central Bank of Nigeria (CBN) on short-term loans issued to financial institutions. Banks can borrow money from each other to guarantee that they have sufficient liquidity to meet their urgent obligations, or they can lend money when they have extra. The short-term interest rate is at the core of the Keynesian IS-LM model, which was developed by Hicks (1937). A contractionary monetary policy leads to a decrease in money supply and a fall in investment. Rising policy rate contracts aggregate demand which leads to a decline in the money supply. This reduces individual's real money, and leads to a cash shortage in the hand of individuals. Policy rates are expected to rise as individuals reduce their bond holdings in order to enhance their cash balances, raising the cost of capital and, in turn, causing a fall in investment spending, aggregate demand and output, and vice versa. The following is schematically shown below:

Contractionary Monetary Policy=> Policy Rate↑=> Investment↓=> Output↓

Cash reserve requirement: The minimal amount of deposits that banks must retain as reserves with the CBN is known as reserve requirements. This portion of the reserve cannot be utilized to extend loans or acquire securities. As a result, greater reserve requirements lower the money multiplier for a said monetary base, M2 declines as reserve requirements rise. Increase in reserve requirements act as a levy on commercial banks deposits. As commercial banking becomes costlier the difference between lending and deposit rates rises. If the interbank rate is stabilized by the CBN the lending rates is expected to rise while the deposit rates fall. As the quantity of reserve requirement rises, so does the interest rate. Commercial banks must attract additional deposits so as to meet the reserve requirement without lowering the amount of loans. The lending rates however, increases as marginal funding cost rises.

Furthermore, for reserve requirements to be effective, certain requisites must be made: Firstly, customers deposits cannot be replaced easily. Otherwise, financial institutions would mitigate the high reserve requirement with other source of funding. Secondly, businesses cannot simply replace loans from banking institutions with other form of finance. If bank borrowing could be replaced, a rise in reserve would

result in a reduction in bank loans which would be offset by other forms of liabilities, such as capital market finance, keeping investment and private assets unchanged Kashyap and Stein (2000).

2.3 Empirical Literature

Several studies have examined the significance of interest rate and cash reserve requirement in the transmission of monetary policy across different countries and using various approaches. From a global standpoint, Alper, *et al.,* (2018) evaluated the influence of reserve requirements on credit issuance and banking sector liquidity in the Turkish economy using panel data. As per their analyses, increased reserve requirements reduce liquidity and credit issuance in the banking industry. Also, Primus, (2018) assessed the efficiency of policy tools in three Caribbean countries. According to the research, an increase in the policy rate and cash reserve ratio has a significant effect on lending rates, whereas a rise in the CRR diminishes private sector lending and relieves exchange rate pressure.

Glocker and Towbin (2012) used a VAR model for the macroeconomic variables in Brazil and found that discretionary rise in reserve requirements reduced domestic lending, whereas other macroeconomic aggregates had substantially different effects. The findings also imply that reserve requirements can help achieve financial stability, while not being a replacement for interest rate policy in terms of price stability.

Using a vector autoregression model, Aleem (2010) investigates how monetary policy is transmitted in India and the impact of an unexpected tightening of monetary policy on the real sector. The VAR model's findings imply that the overnight call money rate is temporarily impacted by an unexpected monetary policy shock. Following the addition of the exogenous foreign variables, the price puzzle disappeared.

Herrera, *et al.* (2010) investigate the effects of reserve requirements on real interest rates and interest rate pass-through in Columbia. Reserve requirements appear to be important long-term drivers of business credit rate of interest, and they have helped to improve policy-to-deposit and borrowing rates pass-through.

Tovar, *et al*. (2012) investigate how reserve requirements and other macroprudential policy tools affect lending to private sector in Latin American countries of Brazil, Chile, Mexico, Peru, and Colombia. The data is analyzed using two approaches, an event analysis and a dynamic panel data vector autoregression (panel data VAR) which indicated that reserve requirements and other macroprudential measures caused

a significant and temporary stall in the expansion of bank lending to the private sector.

Federico, *et al.* (2014) studied the cyclical features of reserve requirements in 52 economies using quarterly data. The findings show that approximately two thirds of developing countries have used RR policy as a macroeconomic stabilisation tool, compared to just one third of industrial countries (and non since 2004). The latter conclusion illustrates the necessity for many emerging markets to protect their currencies by raising interest rates during difficult periods, rather than lowering or raising them during times of prosperity to avoid additional currency appreciation.

On data from US banks, Okamoto, (2011) utilised an autoregressive integrated moving average (ARIMA) approach with two different sets of equations: in the first equation, the lending quantity is used as the dependent variable, while in the second, the policy rate is used. The first equation revealed that an increase in the reserve requirement is related to a reduction in lending quantity, while the second equation revealed that an increase in the 30-year mortgage rate is attributed to a reduction in bank credit.

Research on the influence of adjustments in minimum capital requirements on bank credit in the United Kingdom have also been conducted. Bridges et *al.,* (2014), for example, employed panel data from 1990 to 2011. The findings revealed that a 1% rise in bank capital results in a 2.0% drop in credit expansion. Using the vector autoregressive (VAR) methodology, Noss and Toffano, (2014) discovered that increasing macro prudential capital requirements by 1.0% through an economic boom could perhaps cut credit creation by roughly 4.5%.

Mésonnier and Monks (2014) examined the lending behavior of euro area banks that were subject to the External Balance Assessment (EBA) 2011/12 Capital Review using a monthly dataset of bank balance sheets. Since having to account for an unusual transitional cushion against sovereign debt risk, significant European banking firms were requisite to reach an increased Tier 1 capital ratio by June 2012. According to the results, banks that had to boost their capital ratio by 1% of risk-weighted assets had yearly credit creation of 1.2% to 1.6% points lower than banks that did not have to raise their capital ratio.

For Nigeria, Apanisile, *et al.,* (2022) investigates the efficacy of the monetary policy transmission mechanism in Nigeria by estimating a sticky-price DSGE model using

the Bayesian estimation approach and quarterly data from 2000:1 to 2019:4 to estimate the two main categories of monetary policy frameworks; monetary aggregate and implicit inflation targeting, respectively. According to the findings the monetary policy transmission channels are successful in conveying policy impulses to the economy.

Didigu, *et al.,* (2022) used autoregressive distributed lag (ARDL) and quarterly data covering the period 2007Q1 to 2021Q4 to examine the effect of monetary policy rate on the stability of the Nigerian banking industry. The findings indicate that monetary policy rate in Nigeria and the stability of the banking industry are related over the long term. Moreover, it is discovered that the cash reserve ratio, liquidity ratio, and monetary policy rate all improve the stability of the banking industry.

Using a structural VAR, Omowonuola, & Temidayo, (2022) examined how Nigeria's various monetary policy conduits responded to a number of macroeconomic variables between 1986 and 2017.The results showed that each conduit of monetary policy had a negligible impact on output, with the interest rate channel having the most effect. In another study, Hassan (2015) used a VAR technique applying monthly data from 2001M01 to 2014M12 to examine the mechanism of monetary policy transmission in Nigeria. The results show that the credit and exchange rate channels are the most efficient mechanisms for transmission, whereas the interest rate and asset price channels are ineffective.

Utilising sign restriction and monthly data from 2007 to 2020, Yusuf *et al.,* (2022) used a structural vector autoregressive (SVAR) model to examine the effectiveness of the monetary policy rate in the transmission of monetary policy in Nigeria. The MPR's failure to stimulate output or stabilise prices is made clear by the impulse response functions. Furthermore, it was discovered that exchange rate innovations had a greater significance in explaining changes in the price level based on the results of the variance decomposition. As per the study's findings, external sector shocks tend to reduce the efficacy of the policy rate in maintaining price stability.

Using the vector autoregression (VAR) model, Ndekwu (2013) investigates how changes in the interest rate impact the structure of interest rates, credit, aggregate demand, output and, ultimately, changes in the inflation rate. Of all the channels, it is discovered that the credit channel acts as a fulcrum in the process of transferring monetary policy to the actual economy. Nonetheless, the real economy did not seem

to have been much impacted by interest rate or exchange rate channels between 1981 and 2008. In a different study, the effect of monetary policy on economic growth in Nigeria was investigated by Fasanya, *et al.*, (2013) using time-series data spanning the years 1975 to 2010 using the Error Correction Model (ECM). The variables exhibit a long-term relationship. The study also demonstrates the importance of the exchange rate, foreign reserve, and inflation rate as monetary policy tools that propel Nigeria's gross domestic product (GDP).

Chuku (2009) used a structural VAR model to estimate the impact of monetary policy. Three policy tools were used in the study: the real effective exchange rate (REER), the minimum rediscount rate (MRR), and broad money supply (M2). The It was demonstrated that the real exchange rate and MRR, had short-lived and equal effects on output, whereas the broad money supply (M2) had moderate effects on prices and output that adjusted extremely quickly.

The empirical research revealed that numerous studies have been conducted on Nigeria, looking into various monetary policy transmission mechanisms (Chuku, 2009; Ndweke 2013; Fasanya, *et al.* 2013; Hasssan, 2015; Apanisile, *et al.,* 2022; Didigu, *et al.,* 2022; Omowonuola, and Temidayo ,2022; Yusuf, *et. al.,* 2022). But these studies looked at whether the interest rate, money supply, the credit, inflation, external reserve or the exchange rate is the most important tool for monetary policy, as well as the effectiveness of these conduits in the transmission processes. Nevertheless, this study extends the scope to include the cash reserve ratio. Also, unlike Didigu *et. al.* (2022), this study differs by using a structural VAR model and a longer time period (2006M01 to 2023M12) which includes significant economic downturns.

3. Data and Methodology

3.1 Data

The variables employed in this study include the real GDP (RGDP) and inflation rate (INF); MPR, CRR; treasury bill rate (TBR); banks reserve (BKR); credit to the private sector (CPS); and real exchange rate (EXR). The frequency of the variables is monthly, starting in January 2006 and ending in December 2023. Since monthly RGDP is unavailable, annual RGDP is sliced into monthly dataset using Eviews 12. The selection of 2006 was done to accommodate the CBN's implementation of the new monetary policy framework, the Monetary Policy Rate (MPR) which substituted the Minimum Rediscount Rate (MRR) as the nominal anchor for other market rates.

In addition, the data has been updated up to 2023 to accommodate the recent aggressive monetary policy actions taken by the CBN to address the current inflationary pressure in the economy. Thus, we feel that extending the data will allow the study to capture the recent monetary policy events in the Nigeria economy. The variables are transformed into logarithm form so as to avoid measurement error, except for MPR, CRR, INF, TBR. Also, a lag length criterion is carried out to determine the optimal lag of the structural VAR model. The data were obtained from the CBN Data Statistics

3.2 Model Specification

A structural VAR introduced in Lütkepohl *et. al.* (2006) is proposed to investigate the effect of MPR and CRR in Nigeria. The VAR model is supported by its excellent forecasting capabilities and its utilisation of economic theory to identify contemporaneous relationships between the variables. Identifying assumptions are necessary for structural VARs to understand correlations as causal relationships (Bernanke, 1986; Blanchard and Watson, 1986; Sims, 1986). The model is specified as follows:

$$Ay_t = B_1^* y_{t-1} + \ldots + B_p^* y_{t-p} + \varepsilon_t \tag{11}$$

Where invertible $(K \times K)$ matrix A models the relationship amongst economic variables in y_t, $\varepsilon_t = (\varepsilon_{1t}, \ldots, \varepsilon_{kt})$ k-dimensional structural innovations that is have a zero mean and a white noise process with a covariance matrix $\sum_\varepsilon$; $y_t = (y_{1t}, \ldots, y_{kt})$ is a vector of k-observable endogenous variables, and $A \wedge B^*$ are structural coefficient matrices.

The fundamental objective from equation 11 is to learn about the parameters where $y_t isann \times 1$ vector of endogenous variables in the system which represents the transmission variables in the SVAR system. Thus, because the study assesses two transmission channels of monetary policy in terms of the interest rate channel (MPR) and an alternative tool (CRR), the two models based on MPR and CRR with their respective interactive endogenous variables are presented in equation (12) and (13) below:

$$y_t = (MPR, TBR, CPS, GDP, INF) \tag{12}$$

$$y_t = (CRR, BKR, CPS, GDP, INF) \tag{13}$$

In SVAR model, structural shocks are the key variables. The shocks are associ-

ated with an economic meaning such as a monetary shock. Moreover, the shocks are decomposed into orthogonal components such that the shocks or structural innovations, denoted by u_t, are assumed to be related to the model residuals by linear relations $\varepsilon_t = \Psi\varepsilon_t$, where Ψ is a $(K \times K)$ matrix with ε_t $(0, I_k)$. The model's reduced form is derived by multiplying equation 11 by the inverse of A: Where $B_j = A^{-1}B_j^*(j = 1,2,\ldots p)$ The reduced VAR is obtained:

$$y_t = B_1 y_{t-1} + \ldots + B_p y_{t-p} + u_t \tag{14}$$

$$u_t = A^{-1}\Psi\varepsilon_t$$

Where the variables in y_t include MPR as the monetary policy rate; TBR is the three months treasury bills rate proxy for short-term interest rate; CPS is credit to the real private sector; GDP represents real GDP proxy for aggregate demand; INF in year-on-year inflation rate proxy for general prices; CRR is cash reserve ratio proxy for alternative monetary policy tool; and BKR is banks reserve which represents commercial banks sterilised deposits with the CBN that is significantly determined by the CRR. Recalling equations (12) and (13) of the estimation, inflation is placed as the fifth variable in the SVAR model, the *INF* is placed as the fifth enables us to generate structural responses of inflation to monetary policy shock and CRR shock. Specifically, the ordering of the variables follows the recursive ordering. Thus, for equation (12) to hold, a monetary policy shock takes the leading diagonal as in equation (15) below, such that a shock to MPR leads to an increase in short-term interest rate which increases the cost of borrowing, this contracts access to credit by the real sector and by implication, lowers output. Hence, inflation is expected to decelerate contemporaneously. Thus, all the endogenous variables respond to monetary policy shock. The reduced form errors linear combination of structural innovations u_t in the MPR equation is given below;

$$\begin{pmatrix} u_t^{MPR} \\ u_t^{TBR} \\ u_t^{CPS} \\ u_t^{GDP} \\ u_t^{INF} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 \end{bmatrix} \begin{pmatrix} \varepsilon_t^{MPR} \\ \varepsilon_t^{TBR} \\ \varepsilon_t^{CPS} \\ \varepsilon_t^{GDP} \\ \varepsilon_t^{INF} \end{pmatrix} \tag{15}$$

In the second estimation in equation (13), the *CRR* equation is introduced to the

SVAR model as a tool for monetary policy which is placed as the leading diagonal because CRR is the major driver of banks reserves. Based on monetary theory, we can say a contractionary monetary policy leads to a rise in CRR by a central bank which decreases banks reserves. This reduces the ability of banks to create credit which in turns contracts credit to the private sector, this leads to a reduction in output and subsequently, prices moderated. The reduced form errors linear combination of structural innovations u_t in the CRR equation is given below;

$$\begin{pmatrix} u_t^{CRR} \\ u_t^{BKR} \\ u_t^{CPS} \\ u_t^{GDP} \\ u_t^{INF} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 \end{bmatrix} \begin{pmatrix} \varepsilon_t^{CRR} \\ \varepsilon_t^{BKR} \\ \varepsilon_t^{CPS} \\ \varepsilon_t^{GDP} \\ \varepsilon_t^{INF} \end{pmatrix} \tag{16}$$

Overall, the variables are selected based on what is observed in previous empirical works by (Primus, 2018), (Glocker & Towbin, 2012), (Rapu, *et al.,* 2016), and (Tovar, *et al.,* 2012) in order to capture the relationship between the real sector and banking industry, respectively.

4. Results and Discussion

4.1 Descriptive Statistics

Table 1 presents the descriptive statistics of the variables. The monetary policy rate has an average of 11.88 percent with a minimum of 6 percent and a maximum of 18.7 percent. The lowest monetary policy rate was observed between July 2009 to September 2010 while the highest was observed from March 2023 to December 2023. The standard deviation of the MPR is about 2.89 percent indicating low dispersion between the average and the median. This showed that the MPR did not diverge from its mean over the study period. The cash reserve ratio has an average mean of 15.8 percent with a minimum and maximum of 1 percent and 32.5 percent, respectively. The standard deviation value of 10.79 percent indicates the dispersion is higher than the monetary policy rate. Inflation has an average mean of 12.7 percent with a maximum and minimum of 28.9 percent and 3 percent, respectively, with a standard deviation of 4.7 percent demonstrating a stable inflation over the study period. The treasury bill rate has an average mean of 7.8 percent and a standard

deviation of 4.04 percent. The standard deviation of the treasury bill rate is low but higher than that of the MPR. The treasury bill rate has a maximum and minimum of 15 percent and 0.03 percent, respectively. The bank reserve indicated an average mean value of N 4367724 billion and a standard deviation of N4614573 billion which suggest that bank reserve spread "over a wider range of values". Furthermore, the minimum bank reserve between the study period is N96786.01 billion whereas the maximum is N21082215 billion. This demonstrates that bank reserve has risen from N97686.01 billion to N 21082215 billion.

Table 1: Descriptive Statistics

	MPR	CRR	INF	TBR	BKR	CPS	RGDP
Mean	11.88542	15.86111	12.75176	7.883287	4367724.	19593569	4.203561
Median	12.00000	20.00000	12.10000	8.295000	3267528.	18323040	3.96229
Maximum	18.75000	32.50000	28.92000	15.00000	21082215	44786870	11.25891
Minimum	6.000000	1.000000	3.000000	0.030000	96786.01	1113896	-1.794254
Std. Dev.	2.895547	10.79283	4.720237	4.042671	4614573.	1277586	3.293687
Skewness	-0.156258	-0.058117	0.791923	-0.140266	1.294997	1.072157	0.043832
Kurtosis	3.336576	1.517008	3.959333	1.893274	4.010429	4.253122	2.686938
Jarque-Bera	1.898550	19.91499	30.86001	11.73187	69.56134	55.51557	0.951238
Prob.	0.387022	0.000047	0.000000	0.002834	0.000000	0.000000	0.621500
Sum	2567.250	3426.000	2754.380	1702.790	9.43E+08	4.23E+09	907.9692
Sum Sq. Dev.	1802.602	25044.33	4790.337	3513.789	4.58E+15	3.51E+16	2332.400
Observations	216	216	216	216	216	216	216

Note: MPR, CRR, INF, TBR, BKR, CPS, RGDP indicate monetary policy rate, cash reserve ratio, inflation, treasury bill rate, bank reserve, credit to private sector, and real GDP, respectively.

With regard to the credit to private sector, the average mean is N19593569 billion with a maximum and minimum of N 44786870 billion and N1113896 billion, respectively, with a standard deviation of about 1277586. For the real GDP, Table 1 demonstrates that the variable grew by 4.20 percent annually with a maximum and minimum of about 11.26 percent and -1.79 percent, respectively, with a standard deviation of 3.4 percent.

The analysis of skewness showed that the distribution for the monetary policy rate, cash reserve ratio, and treasury bill rate negatively skewed whereas inflation, bank reserve, credit to private sector and real GDP are positively skewed. For the kurtosis, all the variables are leptokurtic with the exception of the cash reserve ratio, treasury bill rate and the real GDP are considered platykurtic.

4.2 Pre-estimation Results

Table 2 presents the unit root test results based on the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The intent of selecting two unit root test is to enable comparability and robustness of the outcomes. The PP unit root test has higher reliability than the ADF due to its resilience to both serial correlation and heteroskedasticity (Elliot, *et al.,* 1996).

Table 2: Unit Root Test

Variables	Levels		First Difference	
	ADF	**PP**	**ADF**	**PP**
MPR	-1.9219	-2.2933	-8.8157***	-14.7169***
CRR	-2.7937	-2.7442	-14.7109***	-14.9136***
INF	-1.9403	-1.3284	-8.1565***	-12.0701***
TBR	-2.5962	-2.4387	-18.9964***	-10.6888***
LBKR	-2.3182	-4.2397	-12.800***	-26.5783***
LCPS	-2.6899	-2.9693	-10.3222***	-21.0908***
LRGDP	-2.4228	-2.5193	-14.5353***	-14.5354***

Note: Based on the properties of the data, tests are carried out with intercept and trend. The maximum lag is equal to 14, which was chosen using Scharz information criteria (SIC) for ADF test and Newey-West Bandwidth for PP test. Mackinnon (1996) critical values are given as -3.4627; -2.8756; 2.5743. Asteriks, ****(**) *. indicates that a variable is statistically significant at 1%, (5%) and 10% levels, respectively.

From the ADF and PP tests presented in Table 2, it is evident that the variables are not stationary at level. However, at first difference all variables are stationary at 1% significance level and integrated at order one [i.e. I(1)]. This is as a result of the computed ADF and PP tests exceeding their respective critical values.

4.3 VAR Lag Order Selection Criteria

Before estimating the structural VAR model, it is necessary to select an appropriate lag. The lag period is determined by the lowest value of the test statistics, implying that the lower the value of test statistics, the better the model, and vice versa.

In estimating the monetary policy shock, Table 3 shows the Schwarz information criterion (SC) chose a lag of 1 contrary to the other lag selection criteria. Hence, lag 1 is selected as the optimum lag length for the MPR model.

Table 3: Lag Selection Criteria for MPR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-13.70258	NA	0.2627621	12.85288	12.93152	12.8846
1	815.7026	4249.344	4.45e-10	-7.343015	-6.871149*	-7.152339
2	877.4699	117.1846*	3.16e-10*	-7.68663*	-6.821547	-7.337062

*Indicates lag order selected by the criterion

Correspondingly, Table 4 demonstrated the lag selection for the CRR model. Similarly, the Schwarz information criterion (SC) chose a lag of 1 as the optimum lag in estimating the CRR shock while the LR, FPE, AIC, HQ chose a lag of 2. Thus, lag 1 is used as the optimum lag in estimating the CRR shock.

Table 4: Lag Selection Criteria for CRR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-800.7522	NA	0.001282	7.53094	7.609038	7.562174
1	1137.217	3767.266	2.21e-11	-10.34782	-9.875952*	-10.15714
2	1180.130	81.41630*	1.87e-11*	-10.51524*	-9.650151	-10.1656*

*Indicates lag order selected by the criterion

4.2 Estimation Results

4.2.1 Shock to Monetary Policy Rate (MPR)

In this section, the impulse response function, and the variance decomposition of one standard deviation shock to the monetary policy rate are discussed. Also note that a shock to monetary policy rate means contractionary policy stance by the CBN. Figure 1 shows the impulse response with sturdy lines and dotted lines representing the 95 percent confidence interval over a 12-month horizon. In this model, TBR responds positively and almost immediately to a structural monetary policy shock from month 1 to month 2, it then becomes stable from month 3 to month 4 and begins to marginally decline for the rest of horizon (as in Primus, 2018 for Barbados & Onyukwu *et al.,* 2011 for Nigeria). This suggest that the impact of MPR in influencing TBR is positively significant and transitory - within a quarter, while subsequently market condition plays vital role. The initial positive response of TBR to structural shock to MPR could suggest strong expectation anchoring of using MPR as a signal rate by the CBN.

Furthermore, CPS response is positively significant to a structural shock to the MPR from month 1 to month 2, and subsequently decreases for the rest of the 12-months horizon. This explains the lag of two months for a contractionary monetary policy to effectively affect credit to the private sector. Similarly, a contractionary monetary

policy shock to aggregate output is negatively insignificant with about 2 months lag as well. For instance, a shock to the MPR increases output from month 1 to month 2, output then consistently declines for the rest of the 12-months horizon. The response is more significant towards the end of the period. The first two lags are the puzzle identified in the impulse response analysis, this is noticeable in the literature suggesting the nature of the Nigerian economy (see Yusuf *et al,* 2022). Most importantly is the response of inflation to shock to MPR. This study establishes a positively significant "price puzzle" between monetary policy and inflation as initially argued by (Sims, 1992). Similar studies include that of (Aleem, 2010) for India and (Hassan, 2015) for Nigeria. They also found that contractionary monetary policy is not fully efficient in bringing prices down. The positive response of inflation from the monetary policy shock is frequently referred to in the literature as the 'price puzzle' (Sims, 1992). The magnitude of the response of inflation to shock to MPR is persistent especially towards the end of the horizon. Given the CBN's goal of keeping prices stable, the decline in output and persistent inflation may be due to long transmission lags. In the short run, inflation could stay strong amid prior expectations and sticky pricing, whereas outputs fall more swiftly as firms minimise production in reaction to increasing loan rates and low liquidity. According to a different perspective, increased MPR raises borrowing costs, which businesses may then pass on to customers by hiking prices, even while output falls, keeping inflation positive. Additionally, if the economy is also experiencing supply-side constraints, raising the MPR may result in decreased output but not inflation, since supply-side bottlenecks, may be the source of inflationary pressures. Finally, fiscal stimulus or fiscal policy may be expansionary keeping inflationary pressures high even as contractionary monetary policy contract output.

The variance decomposition shown in Figure 3 makes it possible to determine the proportion of variation in each endogenous variable that results from shocks to the baseline variable. According to the findings, variations in RGDP primarily accounts for the effects of its shocks (97 percent), 1.07 percent of bank reserves, 0.5 percent of exchange rate and 0.8 percent of inflation. This showed that the magnitude of the bank reserve exchange rate and the inflation rate affect the growth of RGDP to a lesser extent. Fluctuation in inflation contributes to about 98 percent of its variations, 0.05 percent of the monetary policy rate, 0.14 percent of the RGDP, and 1.2 percent of the bank reserve.

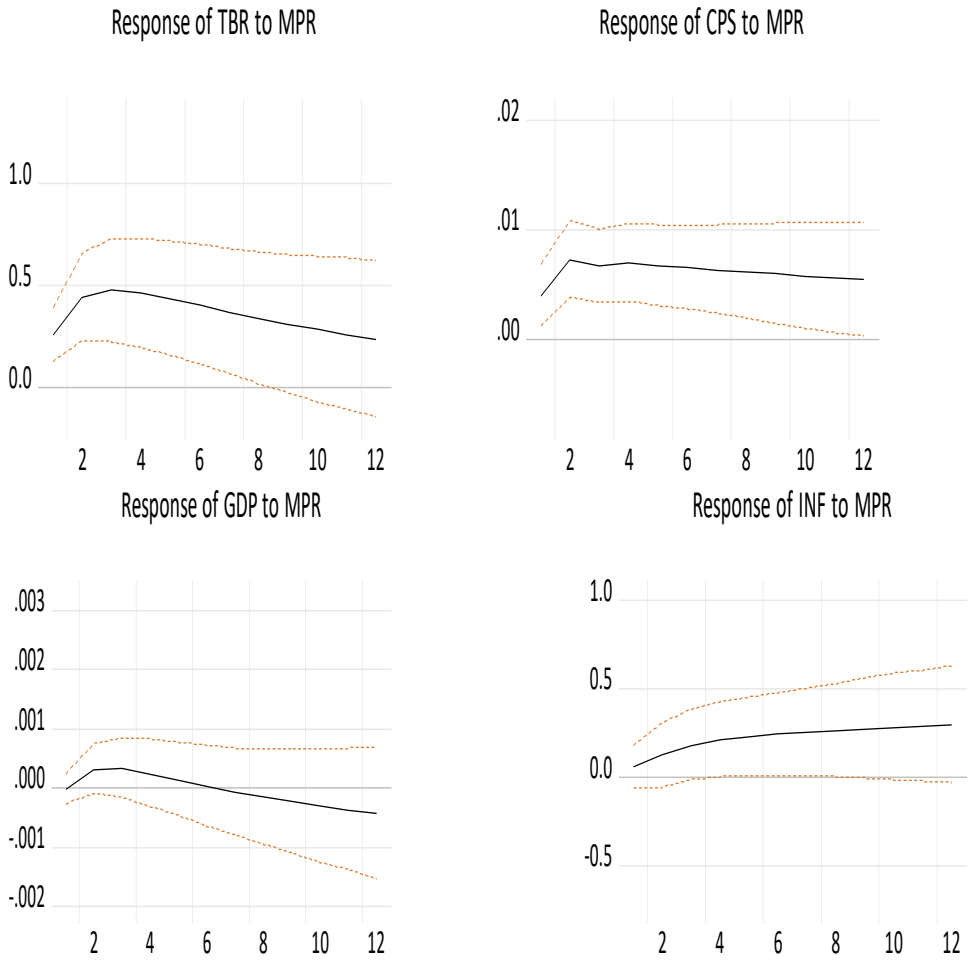


Figure 1: Impulse Response Functions of a shock to the MPR (± 2 Analytical Asymptotic S.E.s)

The bank reserve accounts for approximately 98 percent of its stock, 0.36 percent of the credit to the private sector, 0.17 percent of inflation and 0.36 percent of the monetary policy rate. The treasury bill rate is influenced by its own shock (89 percent), 9.2 percent of the policy rate, and 0.3 percent of the bank reserve and 1.08 percent of exchange rate. The contribution of the policy rate to the treasury bill rate demonstrates the peak effect on the impulse response function in the second month. Fluctuation in the credit to private sector is mostly influenced by 96 percent (its innovation), inflation (0.8 percent), monetary policy rate (2.2 percent), bank reserve (0.18 percent), and, to a lesser extent, the treasury bill rate (0.02 percent). This is similar to the finding of (Primus, 2018) for Jamaica.

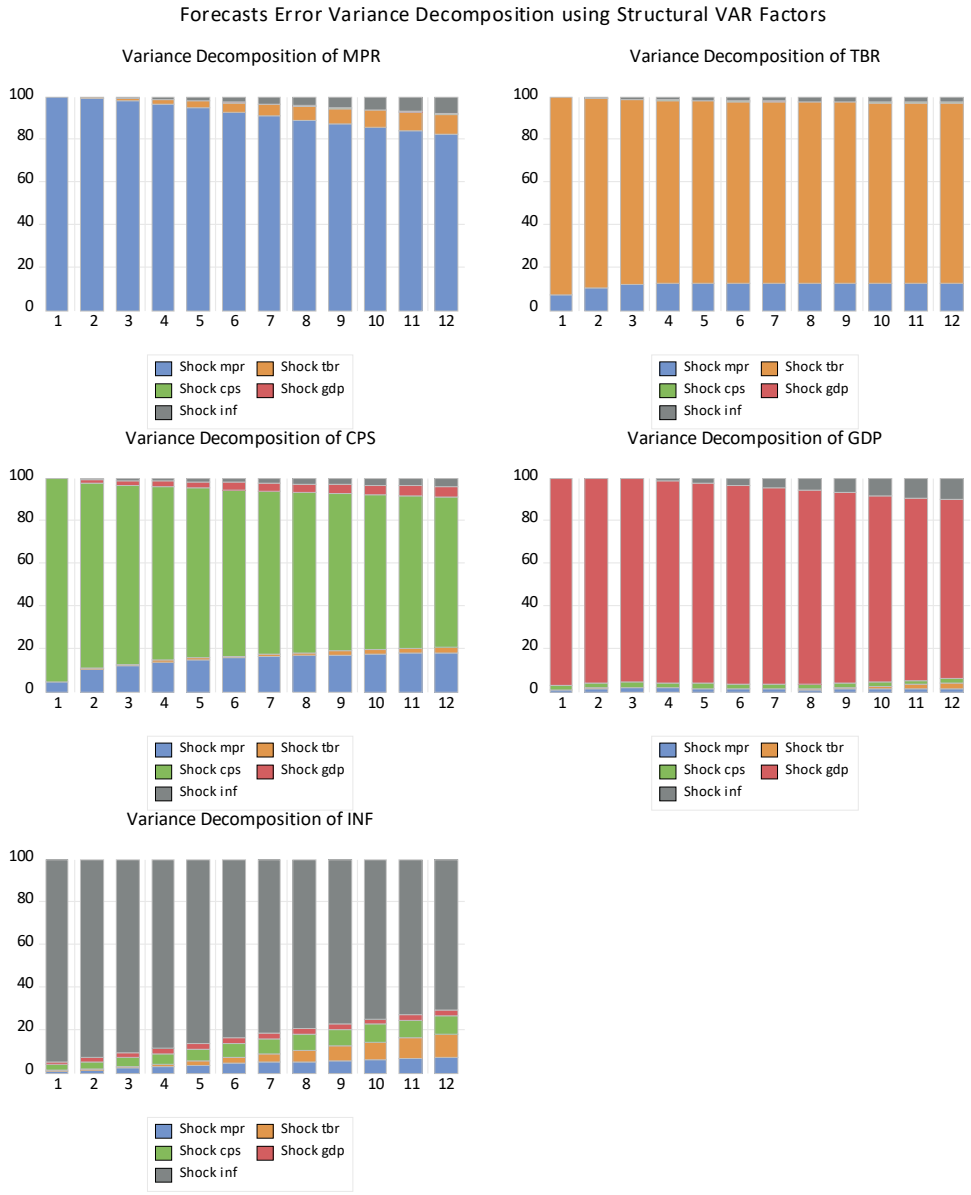


Figure 2: Variance Decomposition of a shock to the MPR

4.2.2 Shock to the CRR

Figure 3 presents the impulse response function of one standard deviation structural shock to the cash reserve requirement and responses of the transmission variables. for instance, the banks' reserve responds to a structural shock to CRR instantaneously but negatively insignificant over the short-horizon; it declines consistently but marginally up to the 12th month period. This may suggest that deposits balances

of banks increase over the reviewed period thus, reduces the impact of CRR on BKR. Moreso, the impact of CRR shock to CPS is negative but only within 3 months. Subsequently, CPS reverses positively up to the 12^{th} month. This also suggests that while CRR is raised by the CBN, it only hinders or reduce the banks' ability to create more credit to the private sector in the short-run. Further implying that balances of banks increase with higher proportion that the increase in CRR after a quarter. Meanwhile, the result shows that raising CRR could constraints credit to the private sector by banks with higher intensity than raising MPR, except simultaneous raising of CRR and MPR.

In addition, a contractionary monetary policy using CRR contracts output almost immediately but marginally with higher intensity from month 6 to month 12. Though it is insignificant, it is implausible especially as one of the main objectives of CBN when raising CRR is to address inflationary pressure. In addition, output responds faster with higher degree to a CRR shock than shock to MPR. Inflation remains steady between month 1 to month 2 to a structural shock to CRR. It then accelerates marginally up to 12^{th} month suggesting the presence of price puzzle even in the case of CRR shock. This is the case in most developing economies with a high level of informal sector and shallow financial markets. A possible explanation for this is that when CRR rises, the decrease in credit to the private sector instantly affects business operations and spending, reducing output. However, sticky prices, lingering cost-push variables, or prior inflationary forces frequently cause inflation to react slowly, keeping inflation positive.

Furthermore, the price puzzle is more present and persistent in the MPR model than in the CRR model. Hence, the monetary policy rate triggers an immediate surge in treasury bills, suggesting reliable oversight over short-term interest rates. Even while private sector credit first rises before falling, this immediate response enables policymakers to precisely control the timing and breadth of measures in regulating credit and economic activity within a short-horizon.

Despite the fact that inflation is positive and insignificant, the monetary policy rate has an impact on growth, and treasury bills. Its broad influence, indicates that it is more thorough than the cash reserve ratio, which mainly affects bank reserves and credit. Although both the monetary policy rate and the cash reserve ratio contract output, the monetary policy's greater market influence renders it a robust option

for macroeconomic stability, notwithstanding inflationary trends. In conclusion, the most efficient means of monetary policy transmission in Nigeria is the monetary policy rate, which exhibits a rapid and wide-ranging impact on all the variables. Although it offers a well-balanced method for controlling credit growth, interest rates, and liquidity, it might require supplementary policies to counteract the inflationary consequence.

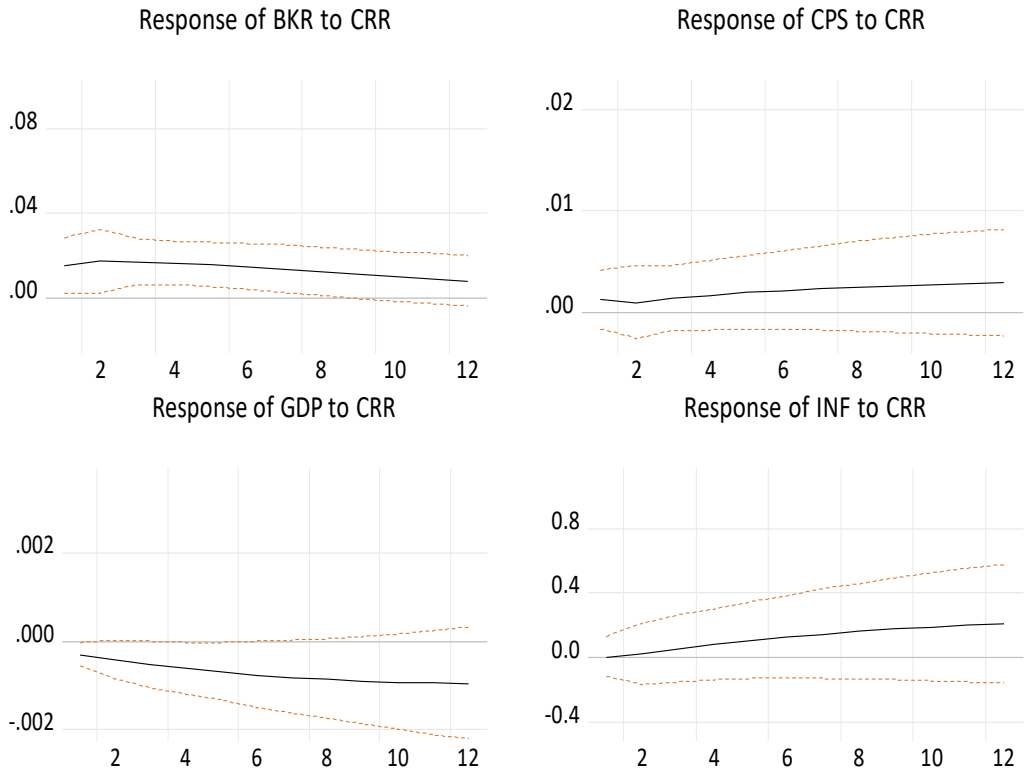


Figure 3: Impulse Response Function of a Structural shock to CRR (± 2 Analytical Asymptotic S.E.s)

The variance decompositions of a shock to the corresponding CRR are shown in Figure 4. On a closer look, it can be demonstrated that the outcomes are often comparable to the baseline scenario of a policy rate shock. The RGDP and bank reserve account for about 96 percent and 97 percent variations of their own shocks, respectively. Fluctuations in inflation are ascribed to approximately 0.12 percent fluctuations in the cash reserve requirement during the third month. Conversely, the policy rate and the RGDP account for 0.03 to 0.17 percent of inflation, respectively, as the baseline shock. Also, changes in the Treasury bill rate are similar under the two

scenarios (88 percent) of its own innovations; however, the policy shock (9.16 percent) is attributed to a bigger fluctuation in the treasury bill rate as opposed to the reserve requirement (0.83 percent). In addition, the credit to the private sector can be explained by the MPR (2.2 percent) as opposed to the baseline scenario of 0.3 percent.

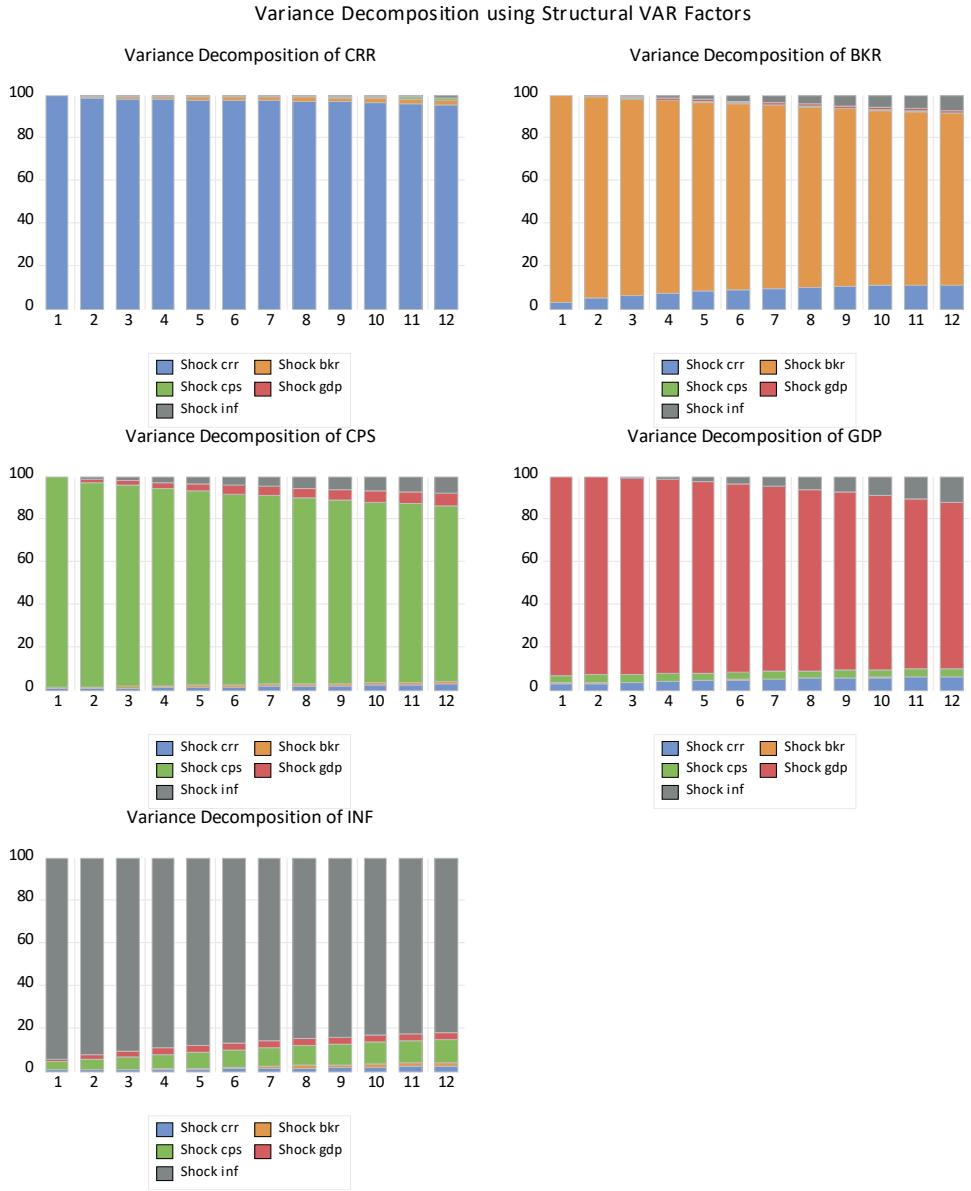


Figure 4: Variance Decomposition a CRR shock

4.4 Diagnostic Tests

A few diagnostic tests were carried out to determine the soundness of the timeseries data. Appendix 1A presents the causal relationship using the Granger Causality test before estimating the MPR model. The relationship is centred on the null hypothesis that a variable does not granger causes the other variable. Appendix 1A demonstrates that the TBR granger causes MPR at 5% significance level. Similarly, whilst the LCPS and RGDP granger causes MPR at 5% significance level, INF granger causes MPR at 10% significance level.

In addition, the group χ^2 test statistic further corroborates the significance of the variables to MPR. Overall, the block exogeneity results validate the endogeneity of TBR, LCPS, RGDP and INF thus, supporting the suitability of the VAR model. The Wald test further indicate MPR granger causing RGDP and INF at 5% and 10% significance level, respectively. Furthermore, The AR roots test depicted in Appendix B1 indicate the inverse roots of the polynomial are within the unit circle and have a moduli less than one. Appendix C1 showed the portmanteau autocorrelation fail to reject the null hypothesis of no autocorrelation.

Similarly, Appendix D1 also showed the absence of no serial correlation by failing to reject the null hypothesis. Appendix E1 result show that the variables are not distributed normally. (Juselius, 2006) states that this is not a major issue since, if the excess Kurtosis is the source, the residuals in the VAR do not need to be regularly distributed. The majority of the variables in this study exhibit excess kurtosis, surpassing the value of 3 in all VAR models, which is actually the situation with the VAR model. The heteroscedasticity test in Appendix F1 demonstrate that the model is homoscedastic.

Appendix G1 presents the correlogram of the MPR model which gives a meaningful autocorrelation. Although some residuals autocorrelations are beyond the $\pm 2/\sqrt{T}$ bounds, it does not give rise to concerns.

Appendix A2 illustrates the causal relationship using the Granger Causality test of the CRR model. The Wald test indicated only RGDP granger causes MPR, however, the All statistic is statistically significant at 10% level. The Table further demonstrates the significance of the variables to granger cause BKR with the exception of CPS. In addition, whilst INF granger causes RGDP, CPS granger causes INF at 10% significance level. Appendix C2 and Appendix D2 fail to reject the null hypothe-

ses of no autocorrelation. The AR roots test depicted in Appendix B2 demonstrates the inverse roots of the polynomial are within the unit circle and have a moduli less than one. In addition, Appendix E2 indicates that the variables are not normally distributed. However, as the MPR model, the variables suffer from excess kurtosis. Additionally, Sun *et al.,* (2008) state that even in cases where the residuals are not normally distributed, the VAR models can be suitable as long as there are no issues with autocorrelation or heteroscedasticity. Also, Appendix F2 further indicate that the variables are homoscedastic while Appendix G2 presents a meaningful correlogram of the CRR model.

5.0 Conclusion and Policy Recommendations

This paper investigates the effectiveness of the MPR and CRR as policy instruments in Nigeria by employing a structural VAR model. Findings show that contractionary monetary policy impulses using MPR and CRR contracts output and credit whereas inflation remains largely positive in the two models, respectively. This signifies the presence of price puzzle as argued by (Sims, 1982), although, the puzzle is more persistent in the MPR equation. Moreover, shock to MPR strongly influences treasury bills, suggesting that it serves as a stable instrument for signaling change and controlling liquidity. Furthermore, even though private sector credit has a positive initial response before fading off, the steady change over time provides a defined way to affect credit flow.

The cash reserve ratio, on the other hand, has a more limited insignificant influence and mainly affects bank reserves and private sector lending in the short term. It has a negative effect on output and has an inflationary price puzzle effect that is comparable to the MPR.

Therefore, the study recommends improved interaction between fiscal and monetary policies to increase the efficiency of the transmission mechanisms. This is due to the possibility that expansionary fiscal policy could counteract the effects of a contractionary monetary action. Also, inflationary trends can be lowered without monetary tightening by addressing supply-side constraints. In addition, effective communication from the CBN can help simplify the price puzzle by bringing together expectations with policy measures. Furthermore, consumers might be less impacted by modifications to bank lending due to CRR shifts if deeper financial markets and alternative funding sources like corporate bonds and equity markets are developed.

This would eliminate the need for direct credit and facilitate the CBN to concentrate on controlling inflation via interest rate measures.

The study has some significant limitations, first, although interpolating annual output data into monthly series yields higher frequency, doing so runs the danger of introducing errors and giving the appearance of exactitude. Consequently, the study's conclusions about the efficiency of these channels and the precision of their effects on output and inflation may be impacted. Secondly, the price puzzle phenomena raise the possibility that the model does not adequately account for all the fundamental causes of inflation in Nigeria. Thirdly, the study does not specifically take into consideration external factors that might affect the results.

References

Alexander, M. W. E., Enoch, M. C., & Baliño, M. T. J. (1995). *The Adoption of Indirect Instruments of Monetary Policy*. International monetary fund.

Aleem, A. (2010). Transmission mechanism of monetary policy in India. *Journal of Asian Economics*, 21(2), 186–197. http://doi.org/10.1016/j.asieco.2009.10.001

Alper, K., Binici, M., Demiralp, S., Kara, H., & Özlü, P. (2018). Reserve requirements, liquidity risk, and bank lending behavior. *Journal of Money, Credit and Banking*, *50*(4), 817-827.

Apanisile, T. O., & Akinlo, A. E. (2022). Effectiveness of monetary policy transmission mechanism in an implicit inflation targeting regime: the case of Nigeria. *African Journal of Economic Review*, *10*(4), 85-109.

Bernanke, Ben S & Blinder, Alan S, (1992). The federal funds rate and the channels of monetary transmission,, *American Economic Association*, 82(4), pages 901-921. https://ideas.repec.org/s/aea/aecrev.html

Bernanke, Ben S (1986). alternative explanations of the money-income correlation, carnegie rochester conference series on *public policy* (Autumn), pp. 49-100.

Bernanke, B. and Blinder, A. (1988). Credit, money and aggregate demand, *NBER* Working Paper No. 2534.

Boivin, J., Giannoni, M. P., & Mojon, B. (2008). How has the euro changed the monetary transmission mechanism? *NBER macroeconomics annual*, *23*(1), 77-126.

Boivin, J., Kiley, M. T., & Mishkin, F. S. (2010). How has the monetary transmission mechanism evolved over time? In *Handbook of monetary economics* (Vol. 3, pp. 369-422). Elsevier.

Blanchard, Olivier Jean. and Mark W. Watson (1986). Are business cycles all alike? In Robert J. Gordon, ed., The American Business Cycle (University of Chicago Press).

Bridges, J., D. Gregory, M. Nielsen, S. Pezzini, A. Radia & M. Spaltro (2014). The impact of capital requirements on bank lending, *Bank of England* Working Paper No. 486 BP (2019) Statistical Review of World Energy

Central Bank of Nigeria. (2011). Conducts of Monetary Policy. Retrieved November 21, 2023, from https://www.cbn.gov.ng/monetarypolicy/conduct.asp

Central Bank of Nigeria. (2015). Conducts of Monetary Policy. Retrieved November 22, 2023, from https://www.cbn.gov.ng/monetarypolicy/conduct.asp

Chuku, C. A. (2009). Measuring the effects of monetary policy innovations in Nigeria: A structural vector autoregressive (SVAR) approach. *African Journal of Accounting, Economics, Finance and Banking Research*, *5*(5).

Dale, S., & Haldane, A. G. (1995). Interest rates and the channels of monetary transmission: Some sectoral estimates. *European Economic Review*, *39*(9), 1611-1626.

Davoodi, M. H. R., Dixit, M. S., & Pinter, G. (2013). *Monetary transmission mechanism in the East African Community: An empirical investigation*. International Monetary Fund.

Egea, F. B., & Hierro, L. Á. (2019). Transmission of monetary policy in the US and EU in times of expansion and crisis. *Journal of Policy Modeling*, *41*(4), 763-783.

Elliott, G., Rothenberg, T. J., & Stock, J. H. (1996). Efficient Tests for an Autoregressive Unit Root. *Econometrica*, *64*(4), 813-836.

Froyen, R. T., & Kopecky, K. J. (1983). A note on reserve requirements and monetary control with a flexible deposit rate. *Journal of Banking & Finance*, *7*(1), 101-109.

Dickey, D. A. & Fuller, W. A. (1979). Estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association* 74, 427–431.

Didigu, C. E., Joshua, N. J., Okon, J. I., Eze, A. O., Gopar, J. Y., Oraemesi, C. N. & Ette, V. E. (2022). Monetary Policy and Banking Sector Stability in Nigeria. *Central Bank of Nigeria Journal of Applied Statistics*, *13*(1), 1-26.

Federico, P., Vegh, C. A., & Vuletin, G. (2014). *Reserve requirement policy over the business cycle* (No. w20612). National Bureau of economic research.

Fasanya, I. O., Onakoya, A. B., & Agboluaje, M. A. (2013). Does monetary policy influence economic growth in Nigeria. *Asian Economic and Financial Review*, *3*(5), 635-646.

Glocker, C., and P. Towbin (2012). "The Macroeconomic Effects of Reserve Requirements", VII Annual Seminar on Risk, Financial Stability and Banking, 9 – 10 August, 2012.

Herrera, H. V., Betancourt, Y. R., Varela, C., & Rodríguez, N. (2010). Effects of reserve requirements in an inflation targeting regime: the case of Colombia. *Bank of Israel Rony Hizkiyahu*, *133*.

Hassan, A. (2015). Transmission mechanism of monetary policy in Nigeria: Evidence from VAR approach (Master's thesis, Eastern Mediterranean University (EMU)-Doğu Ak deniz Üniversitesi (DAÜ)).

Hicks, J. R. (1937). Mr. Keynes and the classics; a suggested interpretation. *Econometrica: journal of the Econometric Society*, 147-159.

Juselius, K. (2006). *The cointegrated VAR model: methodology and applications*. Oxford University Press, USA.

Kashyap, A. and J. Stein (2000) What do a million observations on banks say about the transmission of monetary policy? *American Economic Review*, 90(3), 407-428.

Kelilume, I. (2014). Effects of the monetary policy rate on interest rates in Nigeria. *The International Journal of Business and Finance Research*, *8*(1), 45-55.

Lütkepohl, H., Krätzig, M., & Boreiko, D. (2006). VAR analysis in JMulTi. *JMul'Ti Documentation Downloads*.

Mésonnier, J. S., & Monks, A. (2014). Did the EBA capital exercise cause a credit crunch in the euro area? *Banque de France* Working Paper No. 491

Ndekwu, E. C. (2013). An analysis of the monetary policy transmission mechanism and the real economy in Nigeria. *Central Bank of Nigeria Occasional paper* NO. 43.

Noss, J. and P. Toffano (2014). Estimating the Impact of Changes in Aggregate Bank Capital Requirements during an Upswing, Working Paper No. 494

Ogbulu, O. M., & Torbira, L. L. (2012). Monetary policy and the transmission mechanism: Evidence from Nigeria. *International Journal of Economics and Finance*, *4*(11), 122-133.

Okamoto, G. W. (2011). *The effect of bank reserve requirements on lending volume and interest rates faced by borrowers*. Georgetown University.

Onyukwu, O., Nwosu, E. O., & Diejomaoh, I. (2011). Monetary Policy and Output-inflation Volatility Interaction in Nigeria: Evidence from Bivariate GARCH-M Model. *IISTE Journal of Economics and Sustainable Development*, *2*(6), 46-64.

Omowonuola, O. O., & Temidayo, A. (2022). Further insights on monetary transmission mechanism in Nigeria. *Journal of Economics and International Finance*, *14*(2), 11-22.

Primus, K. (2018). The effectiveness of monetary policy in small open economies. *Journal of Policy Modeling*, *40*(5), 903-933.

Rapu, S., Sanni, G., Penzin, D., Nkang, N., Golit, P., Okafor, H., & Ibi, E. (2016). Does Cash Reserve Requirement (CRR) influence Bank lending in Nigeria? *Central Bank Of Nigeria*, *54*(4), 70.

Sims, Christopher A (1986). Are Forecasting Models Usable for Policy Analysis *Federal Reserve Bank of Minneapolis Quarterly Review* Winter, pp. 2 16.

Sims, C. A. (1992). Interpreting the macroeconomic time series facts: The effects of monetary policy. *European Economic Review*, 36(5), 975-1000.

Sun, Y., Phillips, P. C., & Jin, S. (2008). Optimal bandwidth selection in heteroskedasticity–autocorrelation robust testing. *Econometrica*, *76*(1), 175-194.

Tovar Mora, C. E., Garcia-Escribano, M., & Vera Martin, M. (2012). Credit growth and the effectiveness of reserve requirements and other macroprudential instruments in Latin America.

Yusuf, B., Afiemo, O., & Isah, A. (2022). Assessment of interest rate channel Effectiveness in the transmission of Monetary Policy in Nigeria. *Applied Journal of Economics, Management and Social Sciences*, *3*(5), 27-42.

APPENDICES

Appendix A: VAR Granger Causality Wald Test (Block Exogeneity)

Appendix A1

	Dependent Variables				
	MPR	TBR	LCPS	RGDP	INF
MPR does not granger cause	-	3.09	13.35**	10.75**	5.74*
TBR does not granger cause	7.60**	-	2.40	1.28	{ 7.80*
LCPS does not granger cause	7.90**	0.21	-	2.36	7.99*
RGDP does not granger cause	10.28**	0.01	10.66**	-	5.56*
INF does not granger cause	4.72*	3.28	3.68	9.95**	-
All does not granger cause	21.14**	7.11	49.16***	28.56***	16.61**

Note: This indicates the χ^2 test statistic with 2 degrees of freedom except for "All" which have 8 degrees of freedom. Asteriks, ****(**) *. indicates that a variable is statistically significant at 1%, (5%) and 10% levels, respectively.

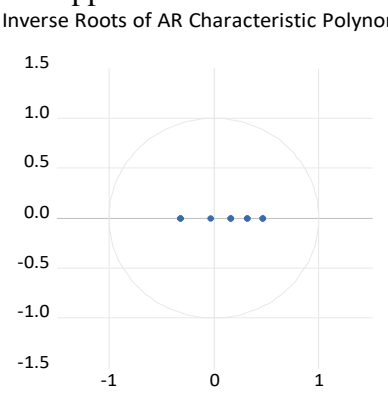
Appendix A2

	Dependent Variables				
	CRR	BKR	LCPS	RGDP	INF
CRR does not granger cause	-	6.90**	0.76	1.61	2.50
BKR does not granger cause	2.81	-	0.37	1.79	3.64
LCPS does not granger cause	3.00	4.38	-	2.23	5.71**
RGDP does not granger cause	5.12**	8.62**	7.56**	-	1.37
INF does not granger cause	2.85	8.56**	5.38*	9.19**	-
All does not granger cause	17.91**	28.01***	36.49***	15.82**	12.60

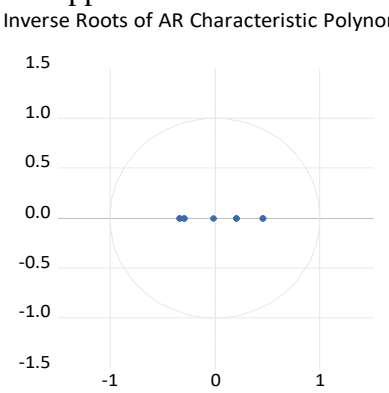
Note: This indicates the χ^2 test statistic with 2 degrees of freedom except for "All" which have 8 degrees of freedom. Asteriks, ****(**) *. indicates that a variable is statistically significant at 1%, (5%) and 10% levels, respectively.

Appendix B: Inverse Roots of AR Characteristic Polynomial

Appendix B1



Appendix B2



Appendix C: VAR Residual Portmanteau autocorrelation test

Appendix C1

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob	df
1	40.59144	--	40.78211	--	--
2	77.00146	--	77.53552	--	--
3	106.0105	0.1063	106.9570	0.1015	25

df is the degrees of freedom for (approximate) χ^2 distribution

Appendix C2

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob	df
1	48.11259	--	48.33847	--	--
2	82.29793	--	82.84632	--	--
3	114.1498	0.2560	115.1511	0.2109	25

Appendix D: Autocorrelation LM test (Edgeworth expansion)

Appendix D1

Lags	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	145.2179	25	0.0000	6.322773	(25, 7.22.2)	0.0000
2	39.75001	25	0.0309	1.608252	(25, 7.22.2)	0.0310
3	30.83798	25	0.1944	1.240063	(25, 7.22.2)	0.1945

*Edgeworth expansion corrected likelihood ratio statistic

Appendix D2

Lags	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	141.8674	25	0.0000	6.162346	(25, 7.22.2)	0.0000
2	40.00919	25	0.0291	1.619026	(25, 7.22.2)	0.0291
3	35.11457	25	0.0862	1.416186	(25, 7.22.2)	0.0862

*Edgeworth expansion corrected likelihood ratio statistic

Appendix E: VAR Residual Normality Test for the MPR model

Appendix E1

Component	Skewness	χ^2	df	Prob.
1	-1.294269	59.74637	1	0.0000
2	0.175981	1.104569	1	0.2933
3	1.011445	36.48775	1	0.0000
4	-1.053046	39.55101	1	0.0000
5	-0.702397	17.59656	1	0.0000
Joint		154.4863	5	0.0000
Component	Skewness	χ^2	df	Prob.
1	18.45691	2130.335	1	0.0000
2	6.422554	104.4487	1	0.0000
3	11.17459	595.8469	1	0.0000
4	24.40278	4084.536	1	0.0000
5	7.690865	196.2043	1	0.0000
Joint		7111.32	5	0.0000
	Component		df	Prob.
	1	2190.082	2	0.0000
	2	105.5533	2	0.0000
	3	632.3346	2	0.0000
	4	4124.088	2	0.0000
	5	213.8008	2	0.0000
	Joint	7265.858	10	0.0000

Appendix E2

Component	Skewness	χ^2	df	Prob.
1	3.837623	525.2755	1	0.0000
2	-0.174695	1.088482	1	0.2968
3	0.787487	22.11817	1	0.0000
4	-0.755964	20.38286	1	0.0000
5	-0.397831	5.644947	1	0.0000
Joint		574.5100	5	0.0175
Component	Skewness	χ^2	df	Prob.
1	37.51773	10.623.98	1	0.0000
2	6.805969	129.1615	1	0.0000
3	12.2873	768.3415	1	0.0000
4	23.35290	3693.645	1	0.0000
5	6.0979	85.32096	1	0.0000
Joint		1500.45	5	0.0000
	Component	Jarque-Bera	df	Prob.
	1	11149.25	2	0.0000
	2	130.2500	2	0.0000
	3	790.4597	2	0.0000
	4	3714.028	2	0.0000
	5	90.97400	2	0.0000
	Joint	15874.96	10	0.0000

Appendix F: White Heteroscedasticity Test (with cross terms)

Appendix F2

Joint test	χ^2	df	Prob.
	1561.294	915	0.6808

Individual components

Dependent	R-squared	F (61, 152)	Prob.	Chi-sq(61)	Prob.
res1*res1	0.333237	1.245361	0.1430	71.31269	0.1723
res2*res2	0.299223	1.063968	0.3743	64.03367	0.3706
res3*res3	0.845113	13.59603	0.0000	180.8541	0.0000
res4*res4	0.197145	0.611876	0.9850	42.18909	0.9683
res5*res5	0.744700	7.268500	0.0000	159.3658	0.0000

Appendix F2

Joint test

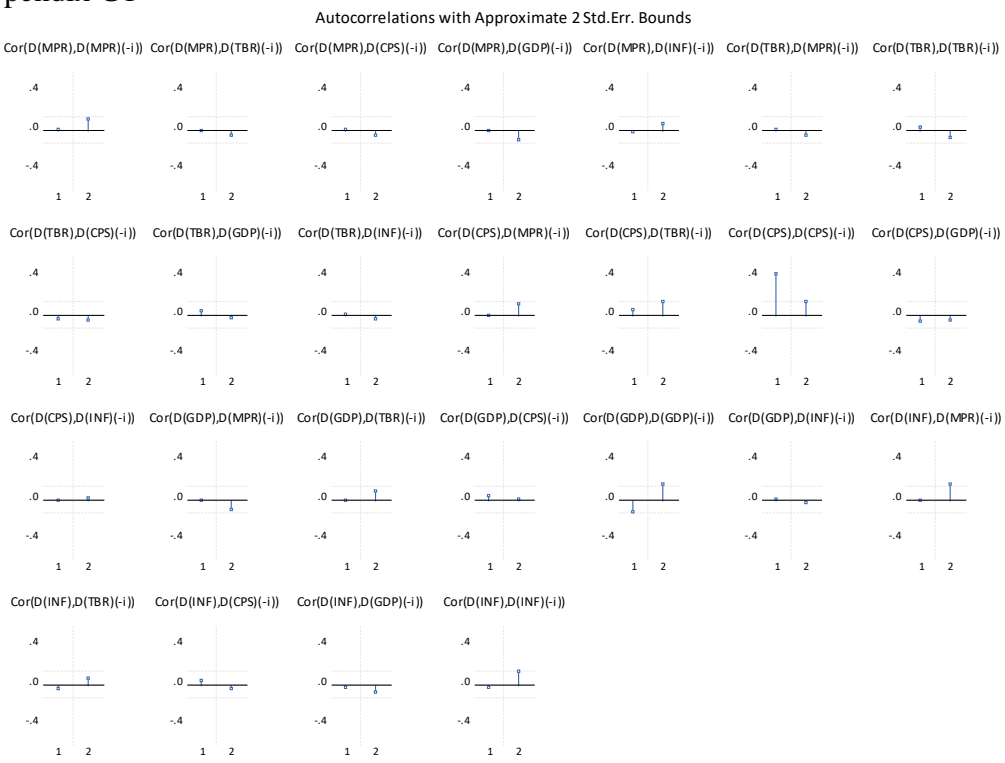
χ^2	df	Prob.
558.9551	00	0.4016

Individual components

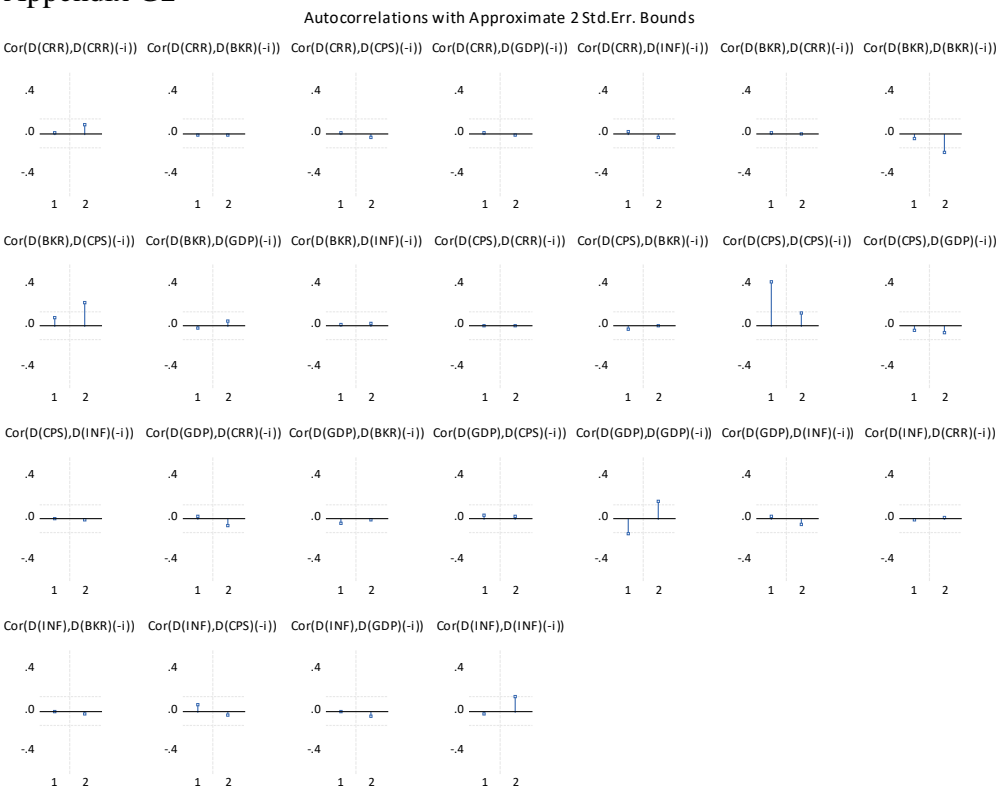
Dependent	R-squared	F (61, 152)	Prob.	Chi-sq(61)	Prob.
res1*res1	0.065160	0.672625	0.8501	13.9443	0.8333
res2*res2	0.285090	3.848212	0.0000	61.00937	0.0000
res3*res3	0.643637	17.42913	0.0000	137.7383	0.0000
res4*res4	0.090146	0.956102	0.5174	19.29133	0.5030
res5*res5	0.264451	3.469457	0.0000	56.59257	0.0000

Appendix G: Residual Correlogram

Appendix G1



Appendix G2


Autocorrelations with Approximate 2 Std.Err. Bounds
Cor(D(CRR),D(CRR)(-i))
Cor(D(CRR),D(BKR)(-i))
Cor(D(CRR),D(CPS)(-i))
Cor(D(CRR),D(GDP)(-i))
Cor(D(CRR),D(INF)(-i))
Cor(D(BKR),D(CRR)(-i))
Cor(D(BKR),D(BKR)(-i))
Cor(D(BKR),D(CPS)(-i))
Cor(D(BKR),D(GDP)(-i))
Cor(D(BKR),D(INF)(-i))
Cor(D(CPS),D(CRR)(-i))
Cor(D(CPS),D(BKR)(-i))
Cor(D(CPS),D(CPS)(-i))
Cor(D(CPS),D(GDP)(-i))
Cor(D(CPS),D(INF)(-i))
Cor(D(GDP),D(CRR)(-i))
Cor(D(GDP),D(BKR)(-i))
Cor(D(GDP),D(CPS)(-i))
Cor(D(GDP),D(GDP)(-i))
Cor(D(GDP),D(INF)(-i))
Cor(D(INF),D(CRR)(-i))
Cor(D(INF),D(BKR)(-i))
Cor(D(INF),D(CPS)(-i))
Cor(D(INF),D(GDP)(-i))
Cor(D(INF),D(INF)(-i))
.4
.0
-.4
1
2