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MONETARY POLICY SHOCKS AND INDUSTRIAL OUTPUT IN BRICS COUNTRIES

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Abstract

This study employs a Panel Structural Vector Autoregressive model ($P-SVAR$) to investigate how monetary policy shocks affect industrial output in BRICS countries using monthly data for the period 1994:1 to 2013:12. A nine variable $P-SVAR$ with short-run restrictions among the variables is constructed for the analysis. The study finds that variations in the exchange rate have the largest impact on industrial output in the BRICS countries. It is also observed that inflation rates significantly increase industrial output, peaking after about eleven months. This reveals that monetary authorities should be cautious when formulating policies aimed at reducing the rate of inflation because of the spillover effect on industrial output. Further analysis reveals that interest rates have a marginal effect on exchange rates, while money supply makes a relatively large contribution to exchange rate fluctuations. Again, it is observed that changes in money supply exert a very large impact on variations in the rate of inflation. Thus, money supply plays an important role in curbing inflation. The study also analyses variations in interest rates, money supply and inflation and concludes that monetary authorities in the BRICS countries adjust interest rates, and not money supply, in response to inflation expectations.

Keywords: Monetary policy shocks; industrial output; Panel SVAR
JEL Code: E5, E52, E58, L6

1. Introduction

Does monetary policy play a significant role in explaining variations in industrial output, prices and real gross domestic product (GDP)? If yes, what is the process through which this occurs? The effective management of any economy depends on a clear understanding of the shocks that impact the economy, their effects on macroeconomic variables, and the process through which the policy action taken by policymakers in response to the shocks that impact the economy. While this has been extensively studied on different groups of countries such as the European Union (see Peersman and Smets, 2001; Peersman, 2004; Angeloni *et al.*, 2003; Fountas and Papagapitos, 2001), the Organisation of Economic Cooperation and Development

(OECD) countries (see Dedola and Lippi, 2000; Britton and Whitley, 1995), the G-7 Countries (see Corsetti *et al*., 2008; Kim and Roubini, 2000) and European countries (see Favero et al., 1999 and Giuliodori, 2005), there is no similar study that we are aware of on Brazil, Russia, India, China and South Africa, a group of emerging market economies (EMEs) with similar interests, generally referred to as the BRICS. The primary objective of this study, therefore, is to investigate how monetary policy shocks in the BRICS countries affect the growth of industrial output. Accordingly, the study aims at examining (i) whether monetary policy shocks lead to significant effects on industrial output in the BRICS countries; (ii) the process through which operating tools of monetary policy affect monetary policy goals; and (iii) the impact of foreign interest rates on industrial output.

Monetary authorities in the BRICS countries aim at achieving full-employment equilibrium, rapid industrial growth, price stability and external balance. Changes in monetary policy targeted at influencing policy goals are propagated through a transmission process commonly called the monetary policy transmission mechanism. There are, however, divergent views on how this process works.

Some empirical studies argue in favour of the traditional Keynesian framework, which holds that the transmission process occurs through interest rates (see Smets and Wouters, 2002; Angolani et al., 2003; Loayza and Schmidt-Hebbel, 2002; Boivin et al., 2010). Ncube and Ndou (2011), Zhensheng (2002), Hall (2001) and Bayangos (2010) advocate the credit channel of monetary transmission while Adolfson (2001) and Acosta-Ormaechea and Coble (2011) have highlighted the exchange rate channel. In addition, Kabundi and Ngwenya (2011) show both the direct and exchange rate channels of monetary policy transmission, while Mishkin (2001), Elbourne (2008), Disyatat and Vongsinsirikul (2003), Alfaro et al. (2003) and Borio and Zhu (2012) reveal that the monetary policy pass-through effects on the real economy occur through asset prices and lending rates. Against a background of these divergent views, it is clear that the nature of the monetary transmission mechanism in the BRICS countries can only be determined empirically. This study, therefore, contributes to the literature by attempting to analyse how industrial output, GDP and prices in BRICS countries respond to monetary policy shocks, and it investigates how the transmission process operates.

Following this introduction, the rest of the paper is structured in five sections. Section 2 is a brief overview of the BRICS countries. A discussion of the various mechanisms through which monetary policy affects economic activity is presented in Section 3, followed by an outline of the methodology used to investigate how monetary policy shocks affect industrial output in the BRICS countries in Section 4. Section 5 is a discussion of study results. A summary and conclusion conclude the paper in Section 6.

2. A brief overview of the brics countries

The BRICS countries are a group of five large developing economies that are distinguished by their demographic and economic potential deemed capable of surpassing the economies of the group of seven richest countries (G7-Countries, namely, Canada, France, Germany, Great Britain, Italy, Japan, and the United States of America) by 2050. The group was created in 2008 with an initial four members (Brazil, Russia, India and China, known as BRIC) as conceived in 2001 by an

American multinational investment banking firm, Goldman Sachs. On 21 September 2010, the BRIC Foreign Ministers at their meeting in New York agreed that their scope must be expanded to Africa and that either Nigeria or South Africa should be invited. South Africa was invited to attend the third BRIC Summit in Sanya on 14 April 2011 (see Vieira and Alden, 2011) and subsequently joined the group, consequently changing the acronym to BRICS. The sole aim of these EMEs is partnering for integration and industrialisation (Chun, 2014). The grouping further aims to create room for alternative sources of development funds that will increase their trade with one another and diversify their economies towards developing domestic and international markets. According to Indien (2012), the BRICS countries account for around 25% of the global GDP, hence making this grouping of countries a potentially powerful future market grouping.

The resources they each possess equally position them for greater market performance. Brazil has one of the fastest developing agriculture sectors; Russia is the largest producer of oil and gas and it is also one of the largest producers of military hardware; India is the second largest telecommunications producer; China is the largest producer of manufactured goods; and South Africa is one of the mineral-rich countries in the world (gold, diamonds, iron ore, platinum, manganese, chromium, copper, uranium, silver, beryllium, and titanium, among others). These resources when taken together provide the infrastructural development needs of the economic grouping, enabling them to empower consumer spending, accelerate development and sustain economic growth. According to the IMF (2012), countries of the group contributed an estimated 56% of world GDP growth in 2012.

The BRICS countries have large populations (total number of inhabitants) and domestic markets compared to G7 countries. Presently, the BRICS population is at over 3-billion. According to De Klerk (2011), the inclusion of South Africa as Africa’s representative in BRICS resulted in the grouping's world presence increasing to 31.9% of global land mass and 56% of the global population. The BRICS countries have opened up their respective economies without following the full market liberalisation policies of John Williamson (the Washington consensus), and in so doing providing a successful alternative to this model of economic reform for other emerging market economies to emulate.

Wilson and Purushothaman (2003, 2006) predicted that by 2025, the BRICS countries would account for over half the size of the G6 economies (France, West Germany, Italy, Japan, the United Kingdom and the United States) and in less than 40 years, they (the BRICS) would be larger than the G6-economies in United States (US) dollar terms. Trade in the BRICS countries taken together has been growing faster than in the G7 countries. While the economy of China is growing faster than envisaged, the other four members of the group are growing at a rate that Goldman Sachs predicted in the first of their long-range projections of the BRICS’ economic fate in the first half of the twenty-first century. The inflation rate has been projected relatively lower for 2016-2020 as follows: Brazil 4.8%, Russia 5%, India 6%, China 3.4% and South Africa 4.8%.

3. Channels of monetary transmission mechanism

The monetary policy transmission mechanism is a process through which changes in monetary policy instruments generate the desired end result of price stability and real output growth. According to Ireland (2005), channels of monetary transmission operate through the effects that monetary policy has on interest rates, exchange rates, equity and real estate prices, bank lending, and firm balance sheets. These in turn affect the decisions of firms, households, financial institutions and investors which alter the price level and economic activities. However, as pointed Kokores (2015), the global financial crisis reveals the shortcomings of modern macroeconomic analysis to adequately model the role of financial intermediaries as key factors in the workings of the monetary transmission mechanism. Therefore, the channels of monetary policy transmission can be generalised into the following five groups.

3.1 The Interest Rate Channel

An increase in the rate is transmitted to other short-term money-market rates and consequently leads to a higher cost of borrowing, and hence a fall in private investment and consumption (see Mollentze, 1997). This in turn changes the expectation of the future interest rate as the long-term interest rate depends in part on market expectations of the future course of the short-term interest rates.

3.2 The Money Effect Channel

The central bank controls money growth to stimulate output and control prices. An increase in money supply would cause interest rates to fall. The money effect channel of monetary policy transmission downplays the role of interest rates and liquid asset adjustment in the transmission mechanism, reducing the process to a direct link between changes in aggregate money supply and absorption (Bolnick, 1991).

3.3 The Exchange Rate Channel

Bhuiyan (2008) argues that monetary policy shocks are transmitted to real output through the exchange rate channel. As a result, monetary policy affects exchange rates, which in turn affect net exports and output in the economy. Expansionary monetary policy leads to a fall in interest rates, making domestic funds attracted to foreign currency deposits, thus leading to a depreciation of the exchange rate. The fall in the exchange rate makes domestic goods cheaper compared to foreign goods, thus resulting to an increase in net exports leading to an increase in output, while an increase in the value of domestic currency makes domestic goods more expensive relative to foreign goods, thereby causing a fall in net exports and hence in aggregate output (Mishkin, 1995).

3.4 The Credit Channel

This is a bank-lending channel of monetary transmission through which funds are made available to borrowers for investment. It works through the effects of bank lending on economic activities. According to Mishkin (1995), contractionary monetary policy will lead to a fall in bank deposits, which subsequently affects the capacity of banks to extend loans to investors. This in turn adversely affects investment and consequently results in a fall in total output. Conversely, the central

bank can reduce the reserve requirement of commercial banks to enable them to increase their lending capacity to customers/investors. Nevertheless, there exist other broad credit channel on how it influences the economy (see Kokores, 2015).

3.5 The Asset Price Channel

An expansionary monetary policy stance can also increase the financial and physical asset prices of a firm. According to Dabla-Norris and Floerkemeier (2006), expansionary monetary policy can increase the net worth of firms and hence the value of collateral, company cash flow, and a firm's creditworthiness. An increase in money supply (expansionary monetary policy) leads to a fall in interest rates, hence, an increase in the prices of stocks and securities. Such an increase leads to an increase in financial wealth, lifetime income, consumption, and hence output.

4. Reseach Methodology

Following Prasad and Espinoza (2012), Ciccarelli *et al.* (2013) and Davoodi *et al.* (2013) who carried out a panel analyses on Gulf Cooperation Council (GCC) countries, the euro area and East Africa, respectively, this study pooled cross-sectional data together and employed a panel data estimation owing to the distinctive characteristics of the BRICS' economies (fiscal and monetary union), such as: (i) Similar monetary policy regime shifts and that they have drifted towards inflation targeting/floating exchange rate system (Mallick and Sousa, 2012), (ii) establishment of the BRICS Development Bank to foster greater financial and developmental cooperation among the member countries and promote their monetary union (Griffith-Jones, 2014), (iii) BRICS countries are prone to the same external shocks due to the influence of the US dollar on their economy as goods exports and imports in the first quarter of 2009 are priced in US dollars (Havlik, 2009), (iv) all BRICS member countries are EMEs with a per capita income lower than the average per capita income in the G7 countries (Calderón and Yeyati, 2009) and, (v) adoption of countercyclical monetary and fiscal policies as against the previous procyclical or acyclical (Coulibaly, 2012) that resulted to policy bias.

4.1 Research Techniques

Again, this study follows Prasad and Espinoza (2012), Ciccarelli *et al.* (2013) and Davoodi *et al.* (2013) and uses Panel Vector Autoregressive ($P-VAR$) analyses of monetary policy transmission mechanisms in the GCC countries, Euro area and East Africa to formulate a Panel Structural Vector Autoregressive ($P-SVAR$) model for the BRICS countries. The $P-SVAR$ is employed to capture dynamic behaviour of the variables in the model and to provide more efficient estimation of the parameters. $P-SVAR$ have the same structure as $P-VAR$ models, in the sense that all variables are assumed to be endogenous and interdependent, except for those identified as exogenous. The $P-SVAR$ is built with the same logic applied in the standard $P-VAR$ except for the structural restrictions, which are imposed on the former, making it a different and much more powerful tool for addressing macroeconomic policy. The $P-SVAR$ methodology suggests the imposition of restrictions on the contemporaneous structural parameters only for reasonable economic structures to be derived. The traditional restrictions are denoted by "$f_{21}-f_{98}$" and "0" (see equation

6) for the contemporaneous and sluggish lagged relationships, respectively. This $P-SVAR$ is employed because it is further suited to capture both static and dynamic interdependencies by treating the links across units in an unrestricted manner, and can account for cross-sectional dynamic heterogeneities.

While various studies have used $P-VARs$ and VARs/SVARs to study the monetary transmission process in different groups of countries and individual countries, respectively, there is no study that we are aware of that has used a $P-SVAR$ to study a bloc of countries worldwide. This study, therefore, contributes to the literature by employing a $P-SVAR$ to study the relationship between monetary policy shocks and industrial performance in the BRICS. Mallick and Sousa (2009) use a sign restriction VAR to determine output growth in the BRICS countries, while Ivrendi and Yildirim (2013) carry out their study on the Brazil, Russia, India, China and Turkey ($BRICS\_T$) economies using an $SVAR$. In addition, Assenmacher-Wesche and Gerlach (2008) carried out a study on OECD countries using a $P-VAR$; Mehrara and Mohaghegh (2011) use a $P-VAR$ to analyse oil-exporting countries; Sousa and Zaghini (2007) use an $SVAR$ for each of the G5 countries; Canova and Ciccarelli (2004) studied G7 countries using a panel VAR; and Love and Zicchino (2006) carry out a study in 36 countries using a panel VAR. All these studies have served as a guide upon which this study built the $P-SVAR$.

The analyses and interpretation of the real effects of monetary policy shocks on industrial output and the process of its impact on the economy as well as the impact of external shocks on macroeconomics variables are carried out using the generalised impulse response functions of the $P-SVAR$ in levels to avoid loss of information that is usually associated with differenced data. $P-SVAR,$ however, may not perform the same tasks as dynamic simultaneous equation models. They, nonetheless, have the further advantage of avoiding some of the difficulties that characterise the traditional $SVAR$ approach and are well suited for structural analyses, thereby making inferences more reliable.

4.2 Model Specification and Set-up of the Panel SVAR

The $P-SVAR$ in this study is estimated using eight endogenous variables, namely, real GDP, industrial output (IP), imports (IMP), exports (EXP), exchange rate (EX), inflation rate (IF), interest rate (IN) and money supply (MS), and one exogenous variable, namely, the international interest rate as proxied by the federal funds Rate (FFR). The exogenous variable is included to capture the open economy status of the BRICS countries as well the international flow of funds as investors will always be willing to invest in a economy with higher expected returns.
Suppose the BRICS countries can be represented by the following structural panel equation:

$$BY_{it} = K_{io} + A_1Y_{it-1} + A_2Y_{it-2} + \cdots + A_pY_{it-p} + \Pi X_t + H\varepsilon_{it} \quad (1)$$

where B is an invertible $(k \times k)$ matrix describing the contemporaneous relationship among the variables; Y_{it} is a $(k \times 1)$ vector of endogenous variables such that $Y_{it} = Y_{1t,}\, Y_{2t,} \ldots Y_{nt}$. K_{io} is a $(k \times 1)$ vector of constants representing country-specific intercept terms; A_i is a $(k \times k)$ matrix of coefficients of lagged endogenous variables (for every $i = 1 \ldots p$); Π and X_t are vectors of coefficients and the

exogenous variable, respectively, capturing external shocks; H is a $(k \times k)$ matrix whose non-zero diagonal elements allow for direct effects of some shocks on more than one endogenous variable in the system; and ε_{it} is a vector of uncorrelated error terms (white-noise structural disturbances).

The $P-SVAR$ presented in equation (1) cannot be estimated directly due to the feedback inherent in the $SVAR$ process (see Enders, 2004). The structure of the system incorporates feedback, which makes it difficult to estimate because the endogenous variables are allowed to affect each other in the current and past realisation time path of BY_{it}. Nonetheless, the information in the system can be estimated and recovered by estimating a reduced-form $SVAR$ implicit in the equations (see Ngalawa and Viegi, 2011). Pre-multiplying equation (1) by an inverse of B gives:

$$Y_{it} = B^{-1}K_{io} + B^{-1}A_1Y_{it-1} + B^{-1}A_2Y_{it-2} + \cdots B^{-1}A_pY_{it-p} + B^{-1}\Pi X_t + B^{-1}H\varepsilon_{it} \qquad (2)$$

One can denote

$$B^{-1}K_{io} = C_i,\ B^{-1}A_1 \ldots\ldots B^{-1}A_p = D_i \ldots\ldots D_p,\ B^{-1}\Pi = \alpha \text{ and } B^{-1}H\varepsilon_{it} = \mu_{it}. \qquad (3)$$

Hence, equation (3) becomes:

$$Y_{it} = C_i + D_1Y_{it-1} + D_2Y_{it-2} + \cdots \ldots\ldots\ldots + D_pY_{it-p} + \alpha X_t + \mu_{it} \qquad (4)$$

The difference between equations (1) and (4) is that the first is called a $P-SVAR$ or primitive system where all variables have contemporaneous effects on each other while the second is called a reduced form $P-SVAR$ or a $P-SVAR$ in standard form in which all the right-hand side variables are predetermined at time *t* and no variable has a direct contemporaneous (immediate) effect on another in the model. In addition, the error term (μ_{it}) is a composite of shocks in Y_{it} (Enders, 2004). Equation (4) can be rewritten in short form as:

$$Y_{it} = C_i + B(L)Y_{it} + G(L)X_t + \mu_{it} \qquad (5)$$

where Y_{it} and X_t are $nx1$ vectors of variables given by

$$Y_{it} = (GDP, IP, IMP, EXP, EX, IF, IN, MS) \qquad (5.1)$$

$$X_t = (FFR) \qquad (5.2)$$

Equation (5.1) is a vector of the $BRICS$ countries' endogenous variables used in the study; and equation (5.2) represents the vector of the exogenous variable that controls for external shocks. C_i is vector of constants representing country intercept terms. $B(L)$ and $G(L)$ are matrices of polynomial lags that capture the relationship between the endogenous variables and their lags. $\mu_{it} = B^{-1}H\varepsilon_{it}$ is a vector of random disturbances, which can also be rewritten as $B\mu_{it} = H\varepsilon_{it}$.

Equations (4) and (5) share the same features as both are reduced form $P-SVARs$ derived from the primitive $P-SVAR$ system of equations (1) where all variables have contemporaneous effects on each other and are assumed to describe the BRICS economies. To recover the information in the structural equation, we impose restrictions in matrices B and H in the system of equations (6).

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ f_{21} & 1 & f_{23} & f_{24} & f_{25} & 0 & 0 & 0 & 0 \\ f_{31} & f_{32} & 1 & 0 & 0 & f_{36} & 0 & f_{38} & 0 \\ f_{41} & f_{42} & 0 & 1 & 0 & 0 & 0 & 0 & f_{49} \\ f_{51} & f_{52} & 0 & f_{54} & 1 & f_{56} & 0 & 0 & f_{59} \\ f_{61} & f_{62} & 0 & 0 & 0 & 1 & f_{67} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & f_{78} & 0 \\ f_{81} & 0 & 0 & 0 & 0 & 0 & 0 & 1 & f_{89} \\ f_{91} & f_{92} & f_{93} & f_{94} & f_{95} & f_{96} & f_{97} & f_{98} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{FFR} \\ \mu_{it}^{logGDP} \\ \mu_{it}^{logIP} \\ \mu_{it}^{logIMP} \\ \mu_{it}^{logEXP} \\ \mu_{it}^{logIF} \\ \mu_{it}^{IN} \\ \mu_{it}^{logMS} \\ \mu_{it}^{dlogEX} \end{bmatrix} =$$

$$\begin{bmatrix} b_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_7 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_8 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_9 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{FFR} \\ \varepsilon_{it}^{logGDP} \\ \varepsilon_{it}^{logIP} \\ \varepsilon_{it}^{logIMP} \\ \varepsilon_{it}^{logEXP} \\ \varepsilon_{it}^{logIF} \\ \varepsilon_{it}^{IN} \\ \varepsilon_{it}^{logMS} \\ \varepsilon_{it}^{logEX} \end{bmatrix} \quad (6)$$

The first matrix on the left-hand side of the system of equations (6) is the B matrix, which pertains to the non-recursive restrictions in the model, while the first matrix on the right-hand side shows the H-matrix, also known as the diagonal matrix. The terms

$$\mu_t^{FFR},\ \mu_{it}^{logGDP},\ \mu_{it}^{logIP},\ \mu_{it}^{logIMP},\ \mu_{it}^{logEXP},\ \mu_{it}^{logIF},\ \mu_{it}^{IN},\ \mu_{it}^{logMS}\ and\ \mu_{it}^{logEX}$$

are residuals in the reduced-form disturbances to both the foreign and the domestic variables and further represent unexpected movements (given information in the system) of each variable; and

$$\varepsilon_t^{FFR},\ \varepsilon_{it}^{logGDP},\ \varepsilon_{it}^{logIP},\ \varepsilon_{it}^{logIMP},\ \varepsilon_{it}^{logEXP},\ \varepsilon_{it}^{logIF},\ \varepsilon_{it}^{IN},\ \varepsilon_{it}^{logMS}\ and\ \mu_{it}^{logEX}$$

are the structural shocks associated with the respective equations.

For the scheme to be exactly (just) identified, this study follows the method introduced by Amisano and Giannini (1997) in which the $P-SVAR$ needs $2n^2 - n(n+1)/2$ or 117 restrictions on the B and H matrices collectively (where n is the number of variables). Since H is assumed to be a diagonal matrix, 72 exclusion restrictions are imposed on it whereas 45 restrictions are required to be imposed on the B matrix for the system to be exactly identified. Since our non-recursive $P-SVAR$ imposes 42 zero restrictions on B, the system is over-identified and 30 free parameters in the B matrix and 9 in the H matrix have to be estimated (see system of equations 6).

The way variables influence each other is based on economic theory and also depends on their position in the identification scheme. The domestic variables are deemed not to affect the international variables and the transmission of international shocks to the domestic economy can be very rapid (Berkelmans, 2005). The non-zero coefficients (f_{kj}) in the matrices indicate that variable j affects variable k instantaneously. For example, row 1 measures the external pressure on the economy that is captured by international interest rates. This is proxied by the federal funds rate (FFR) as the United States acts as a leader in setting monetary policy (see Grilli and Roubini, 1996,

and Elbourne, 2008) and also as the most industrialised economy in the world (See Reinhart and Rogoff, 2008). The second and third equations represent real GDP and industrial output. Based on macroeconomic accounting identity that GDP is a function of IP, IMP and EXP, therefore, the real GDP responds instantaneously to $FFR, IP, IMP\ and\ EXP$ only, while f_{31} f_{32}, f_{36} and f_{39} indicate that industrial output responds contemporaneously to FFR, GDP, IF and EX. The fourth and fifth equations characterise the domestic and international goods market of imports and exports. Imports respond contemporaneously to FFR, GDP and money supply only, while exports respond contemporaneously to only FFR , GDP, imports, inflation rate and exchange rate.

In the sixth and seventh equations, f_{61}, f_{62} and f_{67} indicate that the inflation rate responds contemporaneously to FFR, GDP and IN while, f_{78} shows a contemporaneous relationship of the interest rate to money supply. Rows 8 and 9 of the matrix represent money supply and exchange rate. f_{81} and f_{89} allow for contemporaneous relationships between money supply on the one hand, and FFR and EX on the other, while exchange rate (row 9) is assumed to respond instantaneously to all the variables (see Elbourne and de Haan, 2006).

4.3 Data and Data Sources

Monthly time series data covering a period of 20 years from 1994:1 to 2013:12 for the five emerging economies in the BRICS are employed in this study. The study period and cut-off dates are dictated by data availability and efforts to stay current. The data are obtained from the individual countries' central bank's statistical bulletins, World Bank's World Development Indicators (WDI), International Monetary Fund's (IMF) International Financial Statistics (IFS) and the statistics offices of each country. The choice of the domestic variables (with the exception of money supply) is in line with Ibrahim and Amin (2005) while the incorporation of the international interest rate (the federal funds rate) as an external variable is consistent with studies by Maturu (2007) and Elbourne (2008). In addition, this study borrows from Bhuiyan (2008) and Afandi (2005) who use a $SVAR$ model with 9-variables (one variable for the external sector and eight variables for the domestic sector). The model in this study is a large $P-SVAR$ capable of capturing all the key macroeconomics interactions in the BRICS countries. Other large $SVARs$ similar to this study are by Sattler *et al*. (2007), which uses 11-variables, and by Dungey and Fry (2009), which employs 12-variables. All variables are expressed in logarithms except the federal funds rate and domestic interest rates.

4.4 Non-stationarity and Unit Root Test

This study follows the existing literature of Vonnák (2005), Ibrahim and Amin (2005), Uhlig (2005), Peersman and Smets (2005), Fève and Guay (2006) and Elbourne (2008), among others, that have specifically estimates $SVARs$ and $VARs$ in levels. The studies have argued that this approach will prevent efficiency loss or loss of vital information about the data sets that are usually associated with a differenced $SVARs$ and $VARs$. The procedure also has an advantage of producing consistent parameter estimates irrespective of whether the time series are integrated or not, making it produce a more robust result than a cointegrated $SVAR$ or VAR model (Afandi, 2005). More so, Berkelmans (2005) argues that the inclusion of lagged lengths of the variables in the SVARs or $VARs$ will enable the residual to be

stationary even with $I(1)$. Recent studies on the impact of monetary policy on economic activities have also followed this same procedure (see, among others, Sharifi-Renani, 2010; Mordi and Adebiyi, 2010; Farzanegan, 2011; Ncube and Ndou, 2011; Ngalawa and Viegi, 2011).

4.5 Definition of Variables

The federal funds rate (FFR) is the United States of America (hereafter the US) short-term interest rate at which depository institutions in the country borrow from and lend to each other their central bank balances, usually overnight. The variable is included to control for the stance of the global economy that is likely to affect the performance of the BRICS economies as "the FFR is a good indicator of monetary policy action" (Bernanke and Blinder, 1992). In addition, the FFR is a good indicator of the global business cycle that serves as an important driver of domestic business activities through which the FFR affects the economy. Several studies have followed this line of thought (see Kuttner and Mosser, 2002; Elbourne and De Haan, 2006; Elbourne, 2008; Afandi, 2005; Maturu, 2007).

Real Gross Domestic Product (GDP) is the value of economic output produced at constant national prices for each country annually at 2005 base year for all the countries. This variable is included to examine the impact of monetary policy on total output of the economy in line with Berkelmans (2005) and Dungey and Pagan (2000). On the other hand, industrial output (IP) is the contribution of the industrial sector's output to GDP. This is used to further examine how monetary policy shocks affect industrial sector performance in the BRICS countries as the sector provides a locus for stimulating the growth of the economy and achieving specific outcomes such as employment creation and economic growth. In our study, the role industry plays in stimulating the economy is further elaborated in line with Elbourne and De Haan (2006). Furthermore, GDP and industrial production are both included to assess the validity of the view that the stabilisation of output and inflation can be left to monetary policy to achieve Pareto optimality (see Mishkin, 1995 and Erceg, *et al*., 2000).

The GDP and industrial production (output) data are only available in quarterly frequency, and not in monthly frequency. To obtain the monthly frequency data for the two variables, we interpolated the quarterly data. The interpolation of low frequency to high frequency data is a standard approach in the literature (See Ngalawa and Viegi, 2011; Cheng, 2006; Borys *et al*., 2009 and Davoodi *et al*., 2013).

Imports (IMP) are the total value of goods and services imported for each country while exports (EXP) are the total value of goods and services exported. The inclusion of both variables is in line with Dungey and Fry (2009) to determine the trade relationship among the BRICS countries and assess the extent of interaction between business cycles and the process through which it stimulates the economy. The exchange rate (EX), on the other hand, is the price of each country's currency expressed in another country's currency. The US dollar exchange rate is used as the benchmark in this study due to its wider acceptability and the fact that it is the most traded on the foreign exchange market (Ibrahim and Amin, 2005). This variable will assist in investigating how variations in the value of the US dollar affect selected variables in the BRICS (see Bacchetta and Van Wincoop, 2000 among others). The consumer price index (CPI) is used as a proxy for the price level for each country

across different consumption goods and services. It also serves as a control variable that has a link to monetary policy decisions especially with the interest rates through which economic stability is achieved. The interest rate (IN) is the average monthly real REPO rate set by the central bank of each individual country as a monetary policy indicator (see Agung, 1998; Disyatat and Vongsinsirikul, 2003; Bernanke and Blinder, 1992; Iturriaga, 2000) and will allow us to assess the process through which it is used to counter inflation and manage the movement of intermediate targets of monetary policy. Money supply (MS) is the entire stock of currency and other liquid instruments in each country at a particular time. $M2$ is employed in this study (in line with Ngalawa and Viegi, 2011) for all the BRICS countries except for India where $M3$ is used due to the non-availability of $M2$. The money supply enables this study to determine and assess the process through which the monetary authorities employ operating tools of monetary policy to achieve their targets.

5. Estimation and Results

5.1 Lag length test

Since the data series are monthly, the study tests for various lag lengths using different lag selection criteria to allow for adjustments in the model and the attainment of well-behaved residuals. The standard Akaike Information Criteria (AIC), Final Prediction Error (FPE) and Sequential Modified LR test suggested an optimal 4-lag length while the Schwarz Information Criterion (SC) selected 2-lags and the Hannan-Quinn information criterion (HQ) chose 3-lags for the $P-SVAR$. We decided to choose the more general model suggested by the AIC, FPE and Sequential Modified LR tests. The choice of the 4-lags by this study offers accurate and more robust dynamics without necessarily shortening the estimation sample too much, which would compromise the degrees of confidence. This lag length also allows for no serial correlation in the residuals. The study is also further guided by previous studies by Sharifi-Renani (2010) and Elbourne (2008) that use 4-lags in their study.

5.2 The Impulse Response Analyses

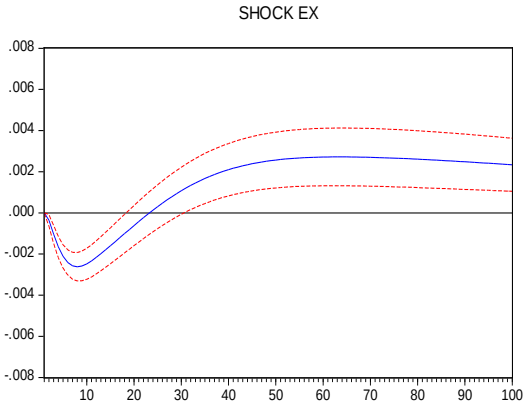
5.2.1 Industrial Output to Monetary Policy Shocks

Figure 1 presents the impulse responses of industrial output to a one standard deviation shock in monetary variables (exchange rate, interest rate and money supply) and the rate of inflation. The Figure shows that an exchange rate shock (depreciation/devaluation) initially reduces industrial output, bottoming out after seven months and thereafter increasing significantly over a relatively long period of time, peaking after about five years. The rise in industrial output following a decline in the value of the local currency is in line with economic theory, which states that an exchange rate depreciation/ devaluation boosts exports and output growth (see Haddad and Pancaro, 2010).

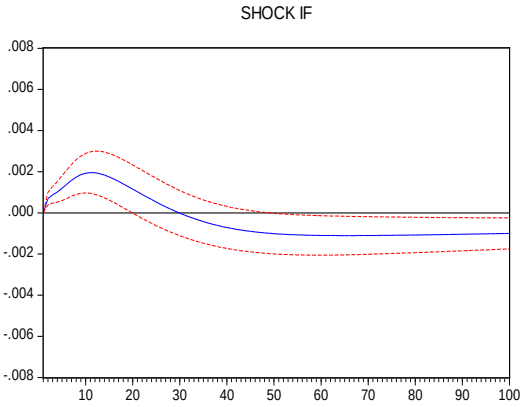
Figure 1

Impulse responses of industrial production to exchange rate, interest rate, money supply and inflation shocks

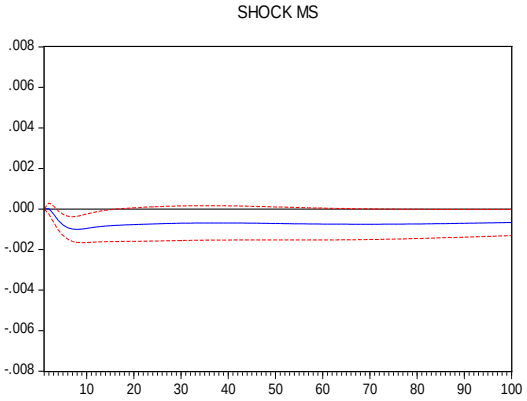
Response of IP to EX shock



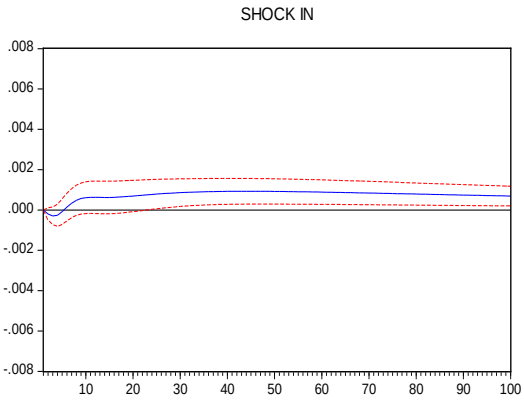
Response of IP to IF shock



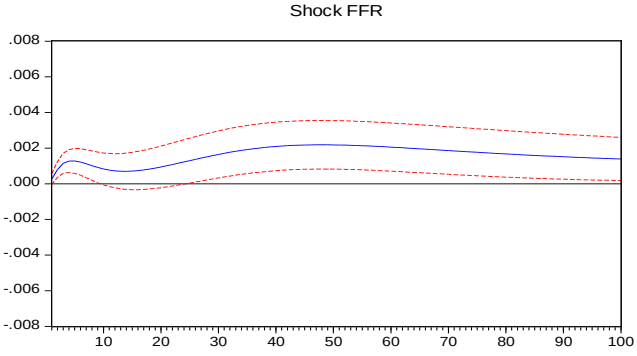
Response of IP to MS shock



Response of IP to IN shock



Response of IP to FFR shock



The initial decline in industrial output (following an exchange rate shock) may be explained by the high local currency costs of imported intermediate inputs, which cannot be offset by high local currency revenue from the export of final goods because the period is not long enough for the firms to produce more output by, for example, increasing plant size.

Figure 1 also shows that a positive inflation shock significantly increases industrial output, peaking after about 11 months and declining thereafter. The initial increase in industrial output caused by an inflation shock may be a result of information asymmetry in the economy. If producers observe only their prices and not the general price level, then they will not know whether a change in the price of their goods reflects a change in the goods relative price or a change in the aggregate price level (see Aoki, 2001). Therefore, they will attribute part of the price change to an increase in the price level and part of it to an increase in relative prices. Thus, they will respond by increasing output, to some extent, as a rational response to their belief that probably relative prices have increased. When they eventually realise that the rise in their prices is a result of an increase in the general price level, they will reduce production to its original level and industrial output reverts to equilibrium. Figure 1 shows that this occurs after about two years.

It is also observed in Figure 1 that industrial output does not respond significantly to a positive interest rate shock (representing monetary tightening) until after about two years when it starts increasing, albeit marginally, a response that remains persistent after eight years. The initial non-response can be a result of structural rigidities in the BRICS countries industrial sector. The increase in industrial output observed after two years is, nonetheless, surprising. A possible explanation for this occurrence is that following a rise in the expected rate of return (reflected by the increase in real interest rates), the BRICS countries start attracting capital inflows that trickle to the industrial sector, the impact of which starts showing-up after two years. The persistent response that follows is consistent with the findings of Lopes (2004) in a study of monetary policy and external vulnerability in Brazil. In addition, a monetary policy shock characterised by an unexpected increase in money supply, causes industrial output to initially decrease, bottoming out after seven months. Thereafter, industrial output remains generally constant. This outcome may be due to some slight differences in the monetary policy regime shifts and frameworks in each country (see Mallick and Sousa, 2012).

Finally, the spillover effect of a 1 percent increase in world interest rate (as proxied by FFR) is also reflected in a positive, significant reaction of the industrial output (IP). This reaction shows that an unanticipated shock from the external sector can subsequently decrease industrial production over a given period of time. This decrease might not be unconnected with the desire of investors to move funds to an economy with higher returns. The impulse response shows that global shocks can have an impact of increasing and decreasing industrial sector growth and transmits across EMEs with more contractionary effects (Di Giovanni and Shambaugh, 2008). This impact is in line with Berkelmans' (2005) findings that the transmission of international shocks to domestic variables can be so rapid and has a significant impact on real GDP and also transmits to industrial output.

The foregoing discussion reveals that the exchange rate is an important determinant of industrial output. Inflation also leads to a positive industrial output response within a relatively short period of time. The impact of money supply and interest rate shocks, however, are marginal. These results are similar to Bhattacharya et al.'s (2011) study on monetary policy transmission mechanisms in EMEs.

5.3 Variance Decomposition

5.3.1 Variance Decomposition of Industrial Sector Performance (IP)

Table 1 presents the variance decomposition of industrial output. The Table reveals that the contribution of interest rate shocks to variations in industrial output is very small, ranging from 0.41 percent after one year, to 0.81 percent, 1.34 percent, 1.78 percent and 2.10 percent after two, three, four and five years, in that order. Similarly, a very small proportion of the variations in industrial output is attributed to money supply shocks. Table 1 shows that after one, two, three, four and five years, money supply shocks account for 1.47 percent, 1.60 percent, 1.67 percent, 1.77 percent and 1.89 percent of the variations in industrial output. The contribution of GDP shocks, which may be reflecting industrial output itself, is highest among the shocks that result in fluctuations in industrial output. Table 1 reveals that GDP growth accounts for 67.02 percent, 50.62 percent, 43.08 percent, 37.99 percent and 34.33 percent of the variations in industrial output in the first to the fifth years, respectively.

The contribution of international interest rates (proxied by the FFR) to variations in industrial output in the BRICS increases from 2.13 percent at the end of a year to 4.19 percent and 9.12 percent after three and five years, respectively. Imports and exports shocks explain a moderate proportion of the variations in industrial output.

Table 1: Variance Decomposition of IP

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock EX	Shock IF	Shock IN	Shock MS
12	0.02	2.13	67.02	3.42	5.67	4.52	10.13	5.19	0.41	1.47
24	0.03	2.09	50.62	13.05	8.39	10.95	7.14	5.29	0.81	1.60
36	0.03	4.19	43.08	16.60	8.18	14.01	6.78	4.09	1.34	1.69
48	0.03	7.00	37.99	16.05	7.21	14.67	9.60	3.88	1.78	1.77
60	0.04	9.12	34.33	14.64	6.34	14.33	13.10	4.11	2.10	1.89

The shock on imports account for 5.67 percent, 8.39 percent, 8.18 percent, 7.21 percent and 6.32 percent after the first, second, third, fourth and fifth years, respectively. The shock on exports, on the other hand, accounts for 4.52 percent, 10.95 percent, 14.01 percent, 14.67 percent and 14.33 percent of the variations in industrial sector output after one, two, three, four and five years, in that order.

To understand the role of monetary authorities in influencing industrial output we further investigate the contribution of the operating tools of monetary policy to intermediate monetary policy targets and relate the same to the foregoing discussion, with industrial output as a monetary policy goal. Table 2 presents variance decomposition of exchange rates, which has been observed to have a preponderant effect on industrial output.

Table 2: Variance Decomposition of Exchange Rates

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock EX	Shock IF	Shock IN	Shock MS
12	0.17	1.05	2.94	6.17	0.81	3.07	75.89	3.48	0.46	6.08
24	0.23	1.29	4.98	7.54	1.34	5.56	67.09	5.46	0.75	5.96
36	0.26	1.39	6.57	8.21	1.98	7.02	62.41	6.34	0.69	5.34
48	0.28	1.58	7.44	8.52	2.40	7.91	59.76	6.70	0.64	5.00
60	0.28	1.79	7.83	8.56	2.59	8.37	58.51	6.80	0.62	4.88

The Table shows that interest rate shocks have a marginal effect on exchange rates, accounting for less than one percent of exchange rate fluctuations throughout the period under analysis (up to five years). Money supply, on the other hand, makes a relatively larger contribution to exchange rate fluctuations. The Table reveals that a money supply shock accounts for 6.08 percent of the variations in exchange rates after one year. This contribution declines to 5.96 percent, 5.34 percent, 5.00 percent and 4.88 percent at the end of the second, third, fourth and fifth years, respectively. We can safely conclude, therefore, that the effect of changes in money supply is more pronounced than the effect of interest rates on industrial output. While the direct effect is marginal in both cases, as observed in Table 1, the transmission process operating from money supply shocks to industrial output through exchange rates is pronounced (see Table 2). It is further observed in Table 2 that inflation and money supply have a comparable effect on exchange rate fluctuations. After about one year, inflation accounts for 3.48 percent of the fluctuations in exchange rates, which increases to 5.46 percent, 6.34 percent, 6.70 percent and 6.80 percent after the second, third, fourth and fifth years. These fluctuations reveal that any policy aimed at fighting inflation by reducing money supply is likely to depress industrial production through an appreciation of the local currency. If the monetary authorities care about both inflation and industrial output, they face a dilemma of deciding the optimal rate of inflation that does not reduce industrial output excessively.

Table 3, on the order hand, shows the contributions of all variables in the model to variations in the rate of inflation. The Table shows that most of the fluctuations in inflation are explained by exchange rate shocks. It is observed that 18.43 percent of the fluctuations in inflation rates are explained by exchange rate shocks after one year. This increases to 30.79 percent, 37.70 percent, 41.35 percent and 42.56 percent after two, three, four and five years, respectively, and shows that any policy by the monetary authorities to weaken the domestic currency with a view to increase industrial output will have inflationary effects.

Table 3 also reveals that changes in money supply exert a large impact on variations in the rate of inflation, which weakens over time. After one year, money supply accounts for 28.6 percent of inflation rate variations. This impact declines to 25.02 percent after two years, 21.22 percent after three years, 17.84 percent after four years, and 15.52 percent after five years. Thus, while money supply shocks have a sizeable

effect on the fluctuations in exchange rates, which in turn spur industrial output, they also have inflationary effects.

Table 3: Variance Decomposition of Inflation

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock EX	Shock IF	Shock IN	Shock MS
12	0.04	3.64	9.99	2.74	27.63	4.84	18.43	1.65	2.44	28.60
24	0.05	2.39	11.38	2.98	18.67	3.41	30.79	2.18	3.15	25.02
36	0.06	2.25	9.27	4.72	14.10	3.17	37.70	3.73	3.78	21.22
48	0.07	3.57	7.93	5.28	11.18	3.32	41.35	5.54	3.95	17.84
60	0.08	5.27	7.50	5.41	9.37	3.66	42.56	6.67	3.99	15.52

How is monetary policy conducted in the BRICS countries? Table 4 presents the variance decomposition of interest rates. It is observed in the Table that inflation accounts for most of the fluctuations in interest rates in the BRICS countries, indicating that monetary authorities primarily adjust interest rates in response to inflation expectations. It is estimated that 66.10 percent of the fluctuations in interest rates are explained by inflation rate shocks after one year. The contribution of inflation rate shocks to interest rate fluctuations declines to 58.55 percent, 56.44 percent, 55.50 percent and 55.02 percent after two, three, four and five years, respectively. We further observe that exchange rate shocks are the second most important factor that explain variations in interest rates. Table 4 shows that exchange rate shocks account for 17.47 percent of the fluctuations in interest rates after a year, 18.86 percent after two years, 18.87 percent after three years, 18.67 percent after four years and 18.51 years after five years, suggesting that monetary authorities in the BRICS countries also adjust interest rates to influence exchange rates, probably through capital flows as an intermediate target.

Table 4: Variance Decomposition of Interest Rates

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock EX	Shock IF	Shock IN	Shock MS
12	6.29	0.02	0.00	3.65	5.71	3.01	17.47	66.10	3.16	0.84
24	6.81	0.08	0.07	7.61	5.64	5.01	18.86	58.55	2.88	1.27
36	6.94	0.42	0.41	8.36	5.59	5.74	18.87	56.44	2.78	1.35
48	7.00	0.76	0.80	8.46	5.57	6.11	18.67	55.50	2.73	1.35
60	7.03	0.98	1.05	8.47	5.57	6.30	18.51	55.02	2.72	1.34

Table 5 shows the variance decomposition of money supply. The Table reveals that the variations in money supply explained by inflation rate shocks are very small. It is observed that after one year, inflation rate shocks explain only 4.44 percent of the variations in money supply. This decreases to 3.18 percent after two years and 2.12 percent after three years before increasing slightly to 2.28 percent after four years and 2.75 percent after five years. This result, therefore, indicates that monetary authorities do not use money supply as a primary operating tool of monetary policy in the fight against inflation. As shown in Table 5, however, monetary authorities adjust money supply primarily in response to industrial output fluctuations. The Table reveals that industrial output shocks account for 1.60 percent of the fluctuations in money supply after one year, which increases to 19.55 percent after two years, 32.95 percent after three years, and 33.48 percent after four years. This increase reveals that the monetary authorities' adjustment of money supply is highly likely to be a response to an industrial output shock rather than an inflation rate shock.

Table 5: Variance Decomposition of Money Supply

Period	S.E	Shock FFR	Shock GDP	Shock IP	Shock IMP	Shock EXP	Shock EX	Shock IF	Shock IN	Shock MS
12	0.05	4.50	8.46	1.60	73.74	1.47	1.89	4.44	3.16	0.70
24	0.07	2.89	20.97	19.55	43.67	3.86	1.21	3.18	2.31	2.32
36	0.09	2.74	20.33	32.95	26.64	9.42	1.16	2.12	2.33	2.25
48	0.12	5.94	19.20	33.48	18.19	13.09	3.30	2.28	2.56	1.93
60	0.14	9.54	18.61	29.88	13.47	14.63	6.51	2.75	2.78	1.78

6. Conclusion

This paper employs a $P-SVAR$ to investigate how monetary policy shocks in the BRICS countries affect industrial output and inflation. The study finds that an exchange rate shock (depreciation/devaluation) has the largest impact on industrial output. The shock initially reduces industrial output and later increases it significantly over a relatively long period of time. The impact of a positive inflation shock on industrial output, on the other hand, is not as pronounced in comparison to the effect of an exchange rate shock. It is, nonetheless, observed that an inflation rate shock significantly increases industrial output, peaking after about eleven month and declining thereafter. The study also finds that industrial output does not respond significantly to a positive interest rate shock (representing monetary tightening) until after about two years when it starts increasing, albeit by a very small margin. The direct impact of a monetary policy shock on industrial output is also observed to be relatively small, while the global shock largely impacts on industrial output in the BRICS countries.

Further analysis reveals that interest rate shocks have a marginal effect on exchange rates, while money supply makes a relatively larger contribution to exchange rate

fluctuations. It is argued, therefore, that the effect of changes in money supply on industrial output is more pronounced than the effect of interest rates. While the direct effect is marginal for both variables, the transmission process that starts with changes in money supply through exchange rate fluctuations to industrial output is relatively large, revealing that any policy aimed at reducing money supply in order to ease inflationary pressures will tend to depress industrial output. If the monetary authorities care about both inflation and industrial output, they face a dilemma as they have to decide on the optimal rate of inflation that does not reduce industrial output excessively.

The study also finds that a large part of the fluctuations in inflation rates are explained by exchange rate shocks, which reveals that any policy by the monetary authorities to weaken the domestic currency with the view of increasing industrial output will have inflationary effects. We also find that changes in money supply exert a large impact on variations in the rate of inflation, which weakens further over time. Thus, while money supply shocks have a sizeable effect on the fluctuations in exchange rates, which in turn spur industrial output, they also have inflationary effects.

The study observes that inflation accounts for most of the fluctuations in interest rates in the BRICS countries, indicating that monetary authorities primarily adjust interest rates in response to inflation expectations. After inflation rate shocks, exchange rate shocks are the second most important factor that explain variations in interest rates suggesting that monetary authorities in the BRICS grouping probably adjust interest rates to influence capital flows, which in turn affects exchange rates.

Variations in money supply explained by inflation rate shocks are very small, suggesting that monetary authorities do not use money supply as an instrument target in the fight against inflation. It is observed, however, that industrial output shocks account for a relatively large proportion of the variations in money supply after one year. This reveals that the monetary authorities' adjustment of money supply is highly likely to be a response to an industrial output shock rather than an inflation rate shock.

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