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Monetary Policy and Economic Activity in the BRICS

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Abstract

This paper provides time-series and panel evidence on the monetary policy transmission for five key emerging market economies: Brazil, Russia, India, China and South Africa (BRICS). The analysis is based on a Bayesian vector auto-regression (VAR) model that includes seven key variables. Instead of the conventional Choleski decomposition as used in the literature, Bayesian methodology has been used to identify the monetary policy (positive interest rate) shock along with using the more recent sign restrictions approach. Finally, to summarise the response for this group of key emerging market economies, we carry out a panel VAR exercise, which provides further robustness of our finding that contractionary monetary policy has a negative effect on output. These results are robust to changes in the specification, the methodology and sub-sample time horizon.
Keywords: monetary policy, emerging markets, BVAR, sign restrictions.
JEL classification: E37, E52.

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"Over the next 50 years,… the BRICs economies … could become a much larger force in the world economy." (Goldman Sachs, 2003)

According to the Law on the People's Bank of China, *"the aim of monetary policies shall be to maintain the stability of the currency and thereby promote economic growth"*.

1. Introduction

Can monetary policy exert a powerful influence in emerging market economies? Is there a scope for monetary authority in controlling inflation? How effective is it in reviving output? Can it be part of the cause in generating a currency or financial crisis in these countries?

Historically double-digit inflation has been a major threat to economic growth in many developing countries, but the monetary authority in these countries continues to maintain a pro-growth monetary policy stance, as these economies have a large negative output gap or excess productive capacity.[1] Emerging markets have substantial excess capacity with regards to labour, and thereby require higher public investment on infrastructure to create conditions for sustained growth.

Given that these economies are growing below their potential level of output, monetary policy may help stimulating private investment via monetary easing, rather than playing a stabilising role. As a result, understanding the role that monetary policy can play in the five key emerging countries - namely, Brazil, Russia, India, China and South Africa, the so called BRICS – is crucial.

So we set up a VAR model with seven key macroeconomic variables - the interest rate (that is, the policy rate); a set of macroeconomic variables that adjust to the shock with a lag (GDP, inflation, and the commodity price); and a set of variables that react contemporaneously to the policy shock (the growth rate of the monetary

1 Large negative output gap or excess capacity means low inflation, but relatively high inflation rates of 10% in low and middle-income countries partly reflects limited use of available resources and in part due to the occurrence of high inflation crises (Bruno and Easterly, 1998), while high-income countries have annual inflation of 3% mainly due to their policy towards containing inflation.

aggregate, the exchange rate, and the equity price index) - aimed at identifying the macroeconomic effects of unexpected variation in monetary policy.

The broad concerns of monetary policy in these countries have been to monitor money growth so as to maintain price stability and to ensure adequate credit expansion to promote economic growth (Mallick, 2006). Consequently, the inclusion of both money growth and interest rate in the model is justified by the need of monitoring the effect of interest rate policy on the liquidity conditions of the banking and financial system.

Comparing two monetary policy rules - the money supply (quantity) rule and interest rate (price) rule - for China in a dynamic stochastic general equilibrium model, Zhang (2009) finds that the price rule is likely to be more effective in macroeconomic management, in line with the government's intention of liberalizing interest rates and making a more active use of that instrument. Our results also suggest that the interest rate did not respond aggressively to inflation in China. The same story can be found in the case of Russia, where monetary aggregates were the key factor determining inflation and the Bank of Russia used monetary aggregates as the main policy instrument (Esanov *et al.*, 2005).

The need to include commodity prices in the VAR is explained by the fact that while India and China are net commodity importers, Russia and, to a lesser extent, Brazil and South Africa depend on commodity exports. In addition, it has been argued that one can eradicate the price puzzle by the inclusion of a forward looking variable - namely, the commodity price index -, which acts as an information variable (Leeper *et al.*, 1996).

The effectiveness of monetary policy and its transmission would depend on the exchange rate regime that is in place. While China follows a fixed peg making its monetary policy to lose its ability to influence economic activity, India monitors multiple indicators as its monetary policy framework with a managed floating exchange rate regime. On the other hand, Russia manages its exchange rate indicator in the absence of any pre-announced monetary and exchange rate regime, whereas Brazil and South Africa currently adopt an inflation targeting framework with a floating exchange rate regime.

Given the previous empirical work on macroeconomic fluctuations mainly being confined to the advanced economies, this paper contributes to studying the sources of economic fluctuations and providing time-series and panel evidence on the monetary policy transmission for the major emerging market countries.

The focus on this set of countries is due to three main reasons. First, many of these countries have adopted inflation targeting as the institutional setting for monetary policymaking.[2] For instance, Brazil (in 1999) and South Africa (in 2000) switched their monetary policy to a framework anchored on a numerical objective for inflation. Second, the downward trend of inflation in many emerging countries associated with a greater confidence in macroeconomic policies has enhanced the scope for monetary policy as an effective tool for managing demand. Third, fiscal consolidation has reduced pressure for monetizing public sector deficits and allowed more independence for the central bank (Ortiz, 2002).

Instead of the conventional Choleski decomposition, we identify the monetary policy shock using modern estimation techniques, namely, the Bayesian Structural Vector Auto-Regressive (B-SVAR) and the sign-restrictions VAR. The panel VAR technique is also applied in the same spirit as Ahmed (2003), which was done for Latin American countries.

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[2] Gonçalves and Salles (2008) show that developing countries that adopted the inflation targeting regime have also experienced a greater fall of both growth volatility and inflation.

Using high-frequency (quarterly) data for the period 1990:1-2008:4, we show that a monetary policy contraction: (i) has a negative effect on output; (ii) leads to a quick fall in the commodity price, but the aggregate price level exhibits strong persistence; (iii) produces a small liquidity effect; (iv) has a strong and negative impact on equity markets; and (v) generates an appreciation of domestic currency. These results are robust to changes in the specification, the methodology and sub-sample time horizon.

The rest of the paper is organized as follows. Section 2 reviews the existing literature on the role of monetary policy in explaining macroeconomic fluctuations in emerging markets. Section 3 presents the estimation methodologies and Section 4 describes the data. Section 5 discusses the empirical results. Finally, Section 6 concludes with the main findings of the paper and the policy implications.

2. A Brief Review of the Literature

2.1. The Conduct of Monetary Policy in the BRICS

This Sub-Section provides a brief review of the conduct of monetary policy in Brazil, Russia, India, China and South Africa.

Brazil

Although the central bank of Brazil is not formally independent, it is perceived as enjoying *de facto* autonomy from the government.

The introduction of the Real Plan in July 1994 associated with a very tight monetary policy managed to bring inflation down quickly, but also led to a sharp appreciation of the nominal exchange rate in the weeks following the monetary reform. The impact of this appreciation on imports has put pressure on domestic producers of tradable goods to accelerate the fall of inflation rate and has discouraged speculative movements. As a result, deposit interest rates were kept over 50% for several months after the monetary reform.

Brazil had two very distinct monetary policy regimes after price stabilisation: (i) a soft peg from early 1995 to December 1998, characterized by stable real exchange rates and volatile interest rates; and (ii) following the January 1999 floating of the Real, an inflation target from July 1999 onwards, where interest rates were lower and more stable, at the expenses of greater exchange rate volatility (Lopes, 2004).

The new monetary framework has been fundamental to enhance transparency and to guide medium to long-term expectations, therefore, preventing transitory inflation surges to develop into permanent increases of inflation (Fachada, 2001).

Russia

The dissolution of the Soviet Union at the end of 1991 did not immediately lead to the establishment of a truly, independent and effective Russian monetary authority, as, until mid 1993, some of the former republics kept using the ruble, and central banks of those republics conducted their own credit policy (Esanov *et al*., 2005). This took place in 1993, but even then the scope of the policy was limited by the need to finance a huge budget deficit. In 1995, the Russian economy started to stabilize and a new law on the Bank of Russia provided some degree of legal independence, allowing it to adopt a tighter monetary policy and to introduce a pegged exchange rate regime with a crawling band against the US dollar.

In 2000, the main objective of the Bank of Russia was to reduce inflation to 18 percent and to achieve an annual growth rate of GDP of 1.5 percent. An increasing pressure on monetary policy was placed in the Bank of Russia, given its reluctance to permit a real appreciation of the ruble and the strength of the balance of payments.

More recently, the Bank of Russia has placed more weight on the exchange rate stability, while accepting the inflationary consequences of such a decision. The greater part of budget revenues from oil and gas production has been “frozen” in Central Bank accounts in order to sterilize petrodollar expansion of the money supply (Fetisov, 2009). This “sterilization policy” has caused underfunding of investments in infrastructure, high technology, and manufacturing. Therefore, the main problem for Russia’s Central Bank is to find a way to exponentially increase bank funding of socioeconomic and scientific-technical development without a sharp rise in inflation.

India

The basic objectives of the Reserve Bank of India - that is, maintaining a reasonable price stability and ensuring adequate expansion of credit to assist economic growth (Rangarajan, 1998) - have remained unchanged during the past two decades, but the underlying operating framework for monetary policy has undergone a significant transformation. Apart from these two main goals, it has also been engaged in maintaining orderly conditions in the foreign exchange market to curb destabilizing and self-fulfiling speculative activities (Reddy, 1999)

From the mid eighties, the broad money, M_3, emerged as the nominal anchor based on the premise of a stable relationship between money, output and prices.

In April 1998, the Reserve Bank of India formally adopted a multiple indicator approach whereby interest rates or rates of return in different financial markets along with data on capital flows, currency, credit, exchange rate, fiscal position, inflation, output, trade are used for policy purposes. The switchover provided necessary flexibility to respond to changes in domestic and international economic environment and financial market conditions more effectively.

According to Reddy (2007), the most important factors that shaped the changes in monetary policy framework in India during the nineties were: (i) the delinking of budget deficit from its automatic monetization; (ii) the deregulation of interest rates; and (iii) the development of the financial markets.

With the enactment of the Fiscal Responsibility and Budget Management Act in 2003 and later amendments, the Reserve Bank has almost withdrawn from participating in the primary issues of Central Government securities from April 2006.

China

Compared with advanced economies, China's monetary policy appears to be more complicated. First, the Law of People's Bank of China states that the objective of monetary policy is to maintain price stability *and* to promote economic growth. The People's Bank of China has also implicitly the mandate of maximizing employment, achieving balance of payments equilibrium, and maintaining the stability of the Chinese financial system (given its role as the lender of last resort). Second, China's monetary authority usually applies instruments of both quantity and price in nature in view of imperfect monetary policy transmission mechanism (He and Pauwels, 2008), wich is paramount relative to advanced economies which typically employ one instrument (money supply in the earlier periods, and short-term interest rate in recent times).

Since the beginning of the nineties, the policy implementation framework has evolved from relying on quantity-based instruments into a mixture of both quantity and price-based instruments. In addition, the People's Bank of China does not have an obvious operational target that can be used as a main indicator of its policy stance.

Consequently, short-term interbank interest rates may not necessarily be a good measure because of the segmentation of credit markets (Liu and Zhang, 2007).

South Africa

Since the sixties, there have been three broad monetary policy regimes in South Africa. The first regime operated until the early eighties and was a liquid asset ratio-based system with quantitative controls on interest rates and credit. The second one encompassed a range of reforms towards a cash reserves-based system using pre-announced monetary target ranges for broad money, M_3, and a redefinition of the role of the discount rate (Aron and Muellbauer, 2002). The usefulness of these targets was severely diminished by the financial liberalisation process and the openness of capital accounts. As a result, in the nineties, they were supplemented by an diverse set of indicators, such as asset prices, balance of payments, credit growth, exchange rate, fiscal stance, output gap, and wage settlements (Stals, 1997). Finally, the third regime came into place with the adoption of an inflation targeting regime in 2000, which aimed at enhancing accountability, predictability, and transparency (Aaron and Muellbauer, 2007).

Nowadays, interest rate policy is determined by a Monetary Policy Committee (MPC). After consultation with the South Africa Reserve Bank, the target range for inflation is set by the National Treasury. The current inflation target corresponds to a rate of increase in the overall consumer price index, excluding the mortgage interest cost, of between 3 and 6% per year.

2.2. A Review of the VAR Evidence in the Emerging Market Economies

The conduct of monetary policy in emerging market economies confronts different challenges from those of advanced countries. The past monetary policy experience of many emerging market countries has seen extreme episodes of monetary instability, swinging from very high inflation to financial instability (Mishkin, 2000).

More recently, the favourable environment in terms of macroeconomic stability in emerging markets has led to the need to identify the likely impact of unexpected variation in monetary policy and then design appropriate long-run strategies for the conduct of economic policy. In large developed economies, changes in monetary policy affect real economic activity in the short run but only prices in the long run. In emerging and transition economies, the real effects of monetary policy in the short run remain an important question to be investigated.

Although monetary aggregates have been traditionally used in these countries as a framework for monetary policy, Nelson (2003) comments that models where the only effect of monetary policy is via a short-term interest rate can be consistent with the quantity theory of money. Laxton and Pesenti (2003) also find that inflation forecast based rules perform better than conventional Taylor rules in small open emerging economies.

The extension of the conventional VAR approach to emerging markets poses, however, important conceptual and methodological challenges. First, uncertainty about the access to international capital markets may lead to a large weight of balance-of-payments equilibrium in the central bank's reaction function, therefore, reflecting the role of adjustments in the exchange rate. Second, public finances may influence the behaviour of the monetary authority, in particular, in the context of unsustainable public debt, and lead to inflationary bias. Third, monetary policy may direct credit to strategic sectors when financial markets are underdeveloped. Consequently, monetary authority may react to indicators that are typically neglected in the analysis for developed countries.

From an empirical perspective, there is very limited research in the literature on identifying monetary shocks in emerging markets, given current efforts to understand the workings of these emerging economies, in terms of the impulses - real and monetary - and propagation mechanisms that drive the cycle. Agénor *et al.* (2000) documents the main stylized features of macroeconomic fluctuations for twelve developing countries, pointing to many similarities between macroeconomic fluctuations in developing and industrial countries (procyclical real wages, countercyclical variation in government expenditures) and some important differences (countercyclical variation in the velocity of monetary aggregates). Hoffmaister and Roldôs (2001) use a structural VAR approach in the spirit of Blanchard and Quah (1989) for Brazil and Korea, and show that domestic shocks are the main source of GDP fluctuations, while external shocks explain a small fraction of movements in output. Notably, while, in Korea, the most important domestic shocks are those associated with supply factors, in Brazil, domestic demand factors are important. Ahmed (2003) argues that the absence of common business cycles undermines any case for fixed exchange rates, and also emphasizes the limited role of external shocks in driving output fluctuations in key Latin American countries.

On a country level basis, the existing evidence on the macroeconomic impact of monetary policy is also almost inexistent. For Brazil, Rabanal and Schwartz, (2001) and Minella (2003) find that the consideration of the monetary aggregate and the exchange rate as endogenous variables typically understates the responsiveness of economic activity to monetary shocks and often displays a price puzzle. For Argentina, Hsing (2004) shows that that output responds negatively to a shock to the real interest rate, while Gabrielli *et al.* (2004) find a weak correlation between money and prices during the currency board regime. For Chile, Bravo *et al.* (2003) suggest that the effect of monetary policy on prices and economic activity is small. For Peru, Quispe Misaico (2001) show that the response of economic activity to a monetary shock is small. For Mexico, Del Negro and Obiols-Homs (2001) find a small role for monetary policy in explaining macroeconomic fluctuations.

In a recent work, Devereux *et al.* (2006) compare alternative monetary policies for an emerging market economy that experiences external shocks to interest rates and the terms of trade. They argue that financial frictions magnify volatility and the degree of exchange rate pass-through is critical for the assessment of monetary rules. Burdekin and Siklos (2008) model post-1990 Chinese monetary policy with an augmented McCallum-type rule considering China's emphasis on targeting the rate of money supply growth, and find that the People's Bank policy appears responsive to the output gap as well as to external pressures. Similar long-run evidence between the link between money growth and inflation was found for several Latin American countries (Feliz and Welch, 1997). Even in a key emerging market economy such as South Africa, there is supporting evidence for the thesis that monetary policy has been used more consistently to dampen the cycle of economic activity since the early nineties (du Plessis, 2006).

In this paper, we aim at understanding the effects of monetary policy shocks in emerging market economies while improving and extending the existing literature in several directions. First, we consider the conduct of monetary policy in five key emerging countries (Brazil, Russia, India, China and South Africa). While being among the biggest and fastest growing emerging markets, these countries represent about 40% of the world's population, encompass over 25% of the world's land coverage, and hold a combined GDP (PPP) of more than 15 trillion dollars. According to Goldman Sachs

(2003), Brazil and Russia will dominate the supply of raw materials, while China and India will be influential players in the supply of manufactured goods and services. Second, we look not only at the impact of monetary policy in terms of output and inflation – which is central in forecasting future changes in the monetary authority's policy instruments, in extracting information about long-term price stability and in identifying the linkages between the real and nominal sides of the economy – but also for the monetary growth rate, the exchange rate and the stock price. This, therefore, allows one: (i) to determine the nature of monetary policy decisions in terms of provision of liquidity; (ii) to understand the likely effect of monetary policy in explaining the current account imbalances; and (iii) to assess whether the actions of monetary authority can be detrimental for financial markets stability (Lopes, 2004). Third, we identify monetary policy shocks using modern estimation techniques and different schemes, which provide the basis for accounting for the uncertainty about the impulse-response functions. Finally, we use data at high frequency - that is, quarterly data - and for a longer time period (namely, 1990:1-2008:4), being, therefore, able to obtain more precise estimates.

3. Estimation Methodology

3.1. The B-SVAR Framework

We estimate the following Structural VAR (SVAR)

$$\underbrace{\Gamma(\boldsymbol{L})}_{n\times n}\underbrace{\boldsymbol{X}_t}_{n\times 1} = \Gamma_0 \boldsymbol{X}_t + \Gamma_1 \boldsymbol{X}_{t-1} + ... = \boldsymbol{c} + \boldsymbol{\varepsilon}_t \qquad (1)$$

$$v_t = \Gamma_0^{-1} \boldsymbol{\varepsilon}_{\mathrm{t}} \ , \qquad (2)$$

where $\varepsilon_t \mid X_s, s < t \sim \mathrm{N}(\underline{0}, \Lambda)$, $\Gamma(L)$ is a matrix valued polynomial in positive powers of the lag operator L, n is the number of variables in the system, ε_t are the fundamental economic shocks that span the space of innovations to X_t, and v_t is the VAR innovation.

Monetary policy can be characterized as

$$\boldsymbol{i}_t = \boldsymbol{f}(\Omega_t) + \varepsilon_t^i \tag{3}$$

where, i_t is the Central Bank rate, f is a linear function, Ω_t is the information set, and ε_t^i is the interest rate shock.

We consider a recursive identification scheme and assume that the variables in X_t can be separated into 3 groups: (i) a subset of n_1 variables, X_{1t}, which do not respond contemporaneously to the monetary policy shock; (ii) a subset of n_2 variables, X_{2t}, that respond contemporaneously to it; and (iii) the policy instrument in the form of the Central Bank rate, i_t.

The recursive assumptions can be summarized by $\boldsymbol{X}_t = [\boldsymbol{X}_{1t}, \boldsymbol{i}_t, \boldsymbol{X}_{2t}]'$ and

$$\Gamma_0 = \begin{bmatrix} \underbrace{\gamma_{11}}_{n_1 \times n_1} & \underbrace{0}_{n_1 \times 1} & \underbrace{0}_{n_1 \times n_2} \\ \underbrace{\gamma_{21}}_{1 \times n_1} & \underbrace{\gamma_{22}}_{1 \times 1} & \underbrace{0}_{1 \times n_2} \\ \underbrace{\gamma_{31}}_{n_2 \times n_1} & \underbrace{\gamma_{32}}_{n_2 \times 1} & \underbrace{\gamma_{33}}_{n_2 \times n_2} \end{bmatrix}. \text{[3]} \tag{4}$$

Finally, the impulse-response function to a one standard-deviation shock under the normalization of $\Lambda = \boldsymbol{I}$ is given by:

$$\boldsymbol{B}(\boldsymbol{L})^{-1}\Gamma_0^{-1}, \tag{5}$$

3 While this approach does not deliver a correct identification of the other shocks in the system, one can get consistent impulse-responses to a monetary policy shock (Christiano et al, 1999).

We use a Monte Carlo Markov-Chain (MCMC) algorithm to assess uncertainty about its distribution (Sims and Zha, 1999). We construct probability intervals by drawing from the Normal-Inverse-Wishart posterior distribution of *B(L)* and *Σ*

$$\beta|_{\Sigma} \sim \mathrm{N}(\hat{\beta}, \Sigma \otimes (X'X)^{-1}) \qquad (6)$$

$$\Sigma^{-1} \sim \mathrm{Wishart}((T\hat{\Sigma})^{-1}, T-m) \qquad (7)$$

where *β* is the vector of regression coefficients in the VAR system, *Σ* is the covariance matrix of the residuals, the variables with a hat are the corresponding maximum-likelihood estimates, *X* is the matrix of regressors, *T* is the sample size and *m* is the number of estimated parameters per equation (Zellner, 1971; Schervish, 1995; Bauwens *et al.*, 1999).

3.2. The Sign Restrictions Approach

In this section, we describe our method in estimating the effects of monetary shocks by means of sign restrictions, following Uhlig (2005). Unlike the traditional VAR approach, in order to completely identify the system, Uhlig (2005) proposed imposing sign restrictions on the impulse response functions. Identification via sign restrictions is relevant in this context, as our objective is to investigate the effect of shocks due to surprise movements in interest rates. We use the reduced-form of a vector autoregressive (VAR) model of order *p* with the following standard representation:

$$Y_t = B(L)Y_{t-1} + u_t \qquad (8)$$

where the vector *Y* includes the endogenous variables, *B(L)* is a lag polynomial of order *p*, and the covariance matrix of the vector of reduced-form residuals *u* is denoted as Σ. Identification in the structural VAR literature amounts to providing enough restrictions to uniquely solve for the following decomposition of the $n \times n$ estimated covariance matrix of the reduced-form VAR residuals Σ. The identification approach here is to represent the one-step ahead prediction errors into economically meaningful or fundamental shocks that there are n fundamental shocks which are mutually orthogonal and normalised to be of variance one, $\Sigma = E[u_t, u_t^{'}] = AE[\varepsilon_t \varepsilon_t^{'}]A^{'} = AA^{'}$, where this equation can be described as the Cholesky decomposition of Σ.

After having estimated the reduced form VAR model, in the first step, we randomly draw from the posterior distributions of the matrix of reduced form VAR coefficients, the variance covariance matrix of the error term, Σ. The usual structural VAR approach assumes that the error terms, u_t, are related to structural macroeconomic shocks, ε_t, via a matrix A, hence $u_t = A\varepsilon_t$. This defines a one-to-one mapping from the vector of orthogonal structural shocks ε to the reduced-form residuals u, $u=A\varepsilon$. The j^{th}-column of the identifying matrix A, a_j, is called an impulse vector, as it maps the innovation to the j^{th} structural shock ε_j into the contemporaneous, impact responses of all the n variables. With the structural impulse vector a_j in hand, the set of all structural impulse responses of the n variables up to the horizon k can then be computed using the estimated coefficient matrix $B(L)$ of the reduced-form VAR.[4] Thus the sign restriction approach amounts to simultaneously estimating the coefficients of the reduced-form VAR and the impulse vector.

Uhlig (2005) identification method searches over the space of possible impulse vectors, $A_i\varepsilon^i$ to find those impulse responses that agree with standard theory. The aim is to identify an impulse vector, a, where $a \in \Re^n$, if there is some matrix A, such that $AA^{'} = \Sigma$, where $A = [a_1, ..., a_n]$, so that a is a column vector of A. As a result, a, is an impulse vector if and only if there is an n-dimensional vector α of unit length so that

4 See Dedola and Neri (2007) for more details.

$a = A'\alpha$ and, hence, $\Sigma = AA' = \sum_{i=1}^{n} a_i a_i'$. Once the impulse vector *a* has been appropriated, the impulse response is calculated as $\varepsilon_a(k) = \sum_{i=1}^{n} \alpha_i \varepsilon_i(k)$, where $\varepsilon_i(k) \in \Re^n$ is the vector response at horizon k to the i^{th} shock in a Cholesky decomposition of Σ (Uhlig, 2005). This way, we obtain a range of impulse responses that are compatible with the sign restrictions.

3.3. A PVAR Assessment

We also use a panel-data vector autoregression (PVAR) methodology, which: (i) relies on the traditional vector autoregression (VAR) approach, and, therefore, treats all variables in the system as endogenous; (ii) combines it with the panel-data approach - consequently, allowing for unobserved individual heterogeneity; and (iii) increases the efficiency of statistical inference, avoiding the potential bias coming from a small number of degrees of freedom of the country level VAR.[5]

We specify a first-order VAR model as follows:

$$\mathrm{Y}_{\mathrm{i,t}} = \Gamma_0 + \Gamma(\boldsymbol{L})\boldsymbol{Y}_{\mathrm{i,t}} + \nu_{\mathrm{i}} + \boldsymbol{d}_{\boldsymbol{c,t}} + \boldsymbol{\varepsilon}_{\boldsymbol{i,t}} \quad \mathrm{i} = 1, ..., \mathrm{N} \quad \mathrm{t} = 1,...,\mathrm{T}_{\mathrm{i}} \qquad (9)$$

where $Y_{i,t}$ is a vector of endogenous variables, Γ_0 is a vector of constants, Γ(L) is a matrix polynomial in the lag operator, v_i is a matrix of country-specific fixed effects, and $\varepsilon_{\mathrm{i,t}}$ is a vector of error terms.[6] Our model also allows for country-specific time dummies, $d_{c,t}$, which capture aggregate, country-specific macro shocks. These dummies

5 Gavin and Theodorou (2005) show that this approach uncovers common dynamic relationship, despite disregarding cross-country differences.

6 The disturbances, $\varepsilon_{i,t}$, have zero mean and a country-specific variance, σ_i.

are eliminated by subtracting the means of each variable calculated for each country-year.[7]

Given that the correlation between the fixed effects and the regressors (due to the lags of the dependent variables) implies that the mean-differencing procedure creates biased coefficients (Nickell, 1981; Holtz-Eakin *et al.*, 1988; Pesaran and Smith, 1995), we use a two-stage procedure in which: 1) we forward mean-difference the data (the 'Helmert procedure'), thereby removing only the mean of all future observations available for each country-year (Arellano and Bover, 1995); and 2) we estimate the system by GMM using the lags of the regressors as instruments (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998). In our model, the number of regressors is equal to the number of instruments.

Another issue that deserves attention refers to the impulse-response functions. Given that the variance-covariance matrix of the error terms may not be diagonal, one needs to decompose the residuals so that they become orthogonal.[8] We follow the usual Choleski decomposition of variance-covariance matrix of residuals, in that after adopting the abovementioned ordering, any potential correlation between the residuals of two elements is allocated to the variable that comes first.

4. Data and Summary Statistics

We use data for the BRICS (Brazil, Russia, India, China and South Africa). The sample covers the period 1990:1-2008:3 for which data is available at quarterly frequency and the main sources of the data are as follows:

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7 We neglect the international linkages between the countries. In fact, our aim is not to investigate the international transmission of the different shocks to the system. An approach to deal with this issue is the Global Vector Autoregression (GVAR) methodology by Pesaran et al. (2004) and Dees et al. (2006).

8 One should, however, note that the orthogonalised shocks can be interpreted as reduced form but not as structural shocks. This can be achieved by imposing short-run restrictions (Leeper and Zha, 2003; Sims and Zha, 2006a, 2006b), long-run restrictions (Blanchard and Quah, 1989; Beaudry and Portier, 2006) or sign restrictions (Mountford and Uhlig, 2009; Canova and Pappa, 2007), and estimating the VAR at the country level.

- Raw materials: *Real Commodity Price Index* ($COMMODITY_{i,t}$). Used as a proxy for changes in the global demand and to control for the price puzzle and provided by Haver Analytics.
- Real GDP: *GDP* ($GDP_{i,t}$). Used as a proxy for economic activity and business cycle and provided by Haver Analytics.
- Inflation rate: *Inflation Rate* ($INFLATION_{i,t}$). Computed from the GDP deflator and provided by Haver Analytics.
- Interest rate: *Nominal Central Bank Rate* ($CBRATE_{i,t}$). Used as the monetary policy instrument and obtained from Haver Analytics.
- M_2: *Real Growth Rate of* M_2 ($M2\_GR_{i,t}$). Obtained from Haver Analytics.
- Exchange Rate: *Real Exchange Rate versus the U.S. Dollar* ($EXCRATE_{i,t}$). Obtained from Haver Analytics.
- Equity Price: *Real Stock Price Index* ($EQUITY_{i,t}$). Obtained from Haver Analytics (Brazil, China, India) and Global Financial Database (Russia and South Africa).

Data are also transformed in several ways for the econometric analysis. First, all variables are expressed in logs and deflated using the GDP deflator with the obvious exception of the policy instrument. Second, data on real GDP and the corresponding deflator for China are annual, and, therefore, interpolated to quarterly frequency using a cubic conversion method.

Table A.1 in the Appendix provides a detailed description of the variables and data sources used in the analysis, while Tables A.2 to A.5 also present a range of descriptive statistics. Table A.6 summarizes the panel unit root tests of Levin *et al.*

(2002), and Im *et al.* (2003) and shows that the log differences (year-on-year) of all key variables are stationary.

5. Empirical Results

5.1. The B-SVAR Framework

In the recursive identification scheme, we include the growth rate of M_2, the exchange rate and the equity price in the set of variables that react contemporaneously to the monetary policy shock (X_{2t}). Similarly, the GDP, the inflation rate and the commodity price are allowed to react to monetary policy only with a lag (being, therefore, included in X_{1t}).

We start by analyzing the impact of changes in the interest rate in Brazil.[9] We identify the monetary policy shock by imposing the recursive assumptions defined in (4) and estimate the Bayesian Structural VAR (B-SVAR) represented by (1) and (2).

Figure 1 plots the impulse-response functions to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

The results suggest that after a contractionary monetary policy, GDP falls, the trough (of -0.2%) is reached after 4 quarters, and the negative effect persists for about 8 quarters. These findings are in line with Hoffmaister and Roldôs (2001) who also show that domestic shocks are important and Lopes (2004) who emphasizes that a rise in interest rates can have persistent effects. The price of raw materials also substantially decreases and the reaction is quick. In addition, the price level exhibits a high

9 Céspedes et al. (2005) discuss different approaches taken in the literature to evaluate the stance of monetary policy.

persistence and is roughly unaffected, despite a very small price puzzle in the first quarters, similar to results in Rabanal and Schwartz (2003) and Minella (2003).

The response of the growth rate of M_2 also quickly falls, but the liquidity effect disappears after 2 quarters, which, therefore, suggests that tracking monetary aggregates may be useful (Albuquerque and Gouvêa, 2001).[10] Finally, the exchange rate appreciates for about 8 quarters, while the stock price index immediately falls (by around -6%) after the shock

The strategy for estimating the parameters of the model focuses on the portion of fluctuations in the data that is caused by a monetary policy shock. It is, therefore, natural to ask how large that component is. With this question in mind, Figure 2 displays the percentage of variance of the *k*-step-ahead forecast error due to an interest rate shock. Notice that while policy shocks account for only a small fraction of inflation they are important determinants of the price of raw materials. On the other hand, monetary policy shocks are responsible for a substantial fraction of the variation of GDP (about 15% of the variation 12 quarters ahead). A similar conclusion can be drawn with respect to the stock price: monetary policy shocks explain about 25% of the variation in the equity market 12 quarters ahead.

10 Albuquerque and Gouvêa (2001) note that unsuccessful macroeconomic stabilization programs were characterized by excessive liquidity.

Figure 1: Impulse-response functions to a monetary policy contraction using Christiano *et al.* (2005) identification and data for Brazil.

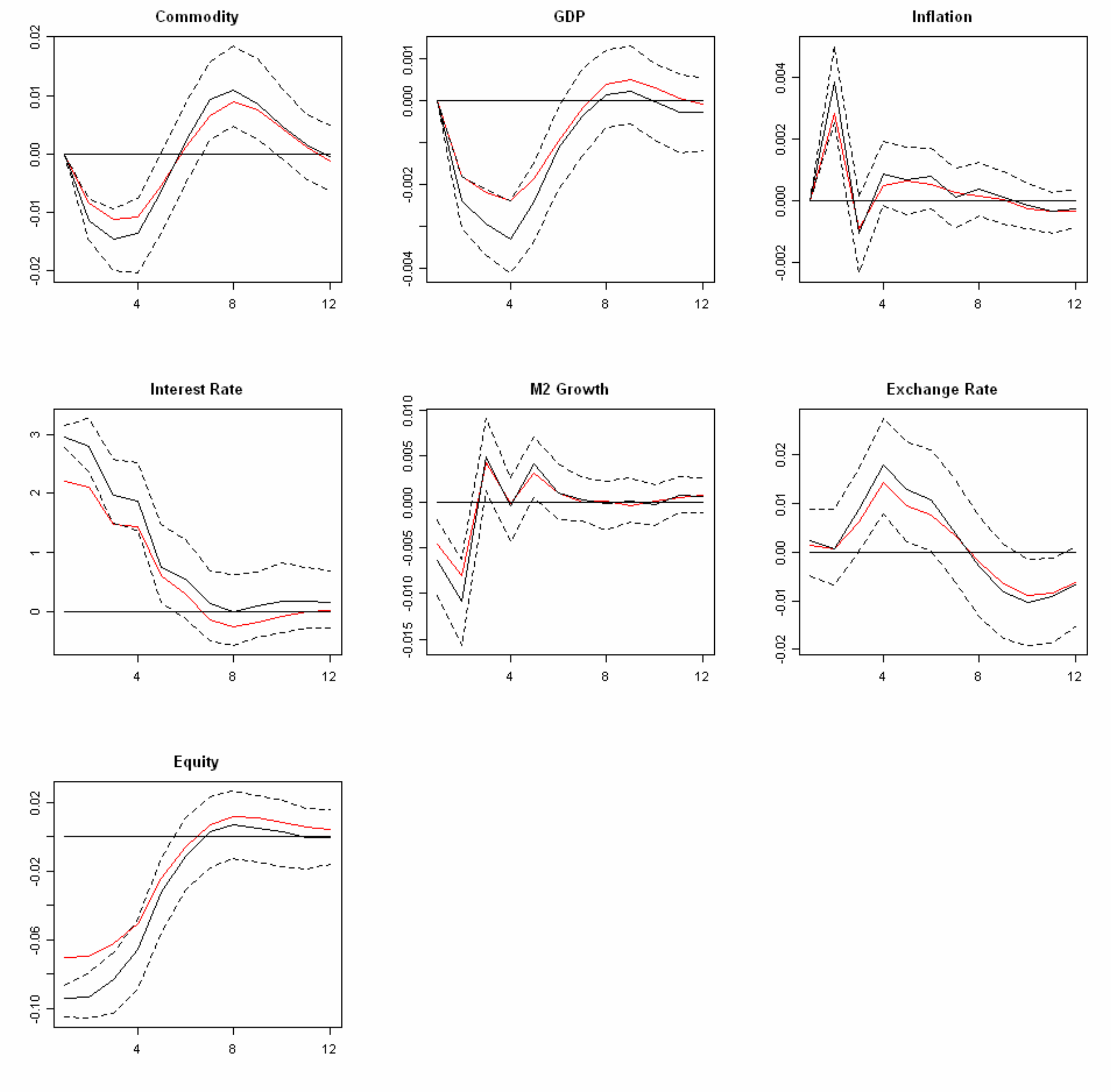
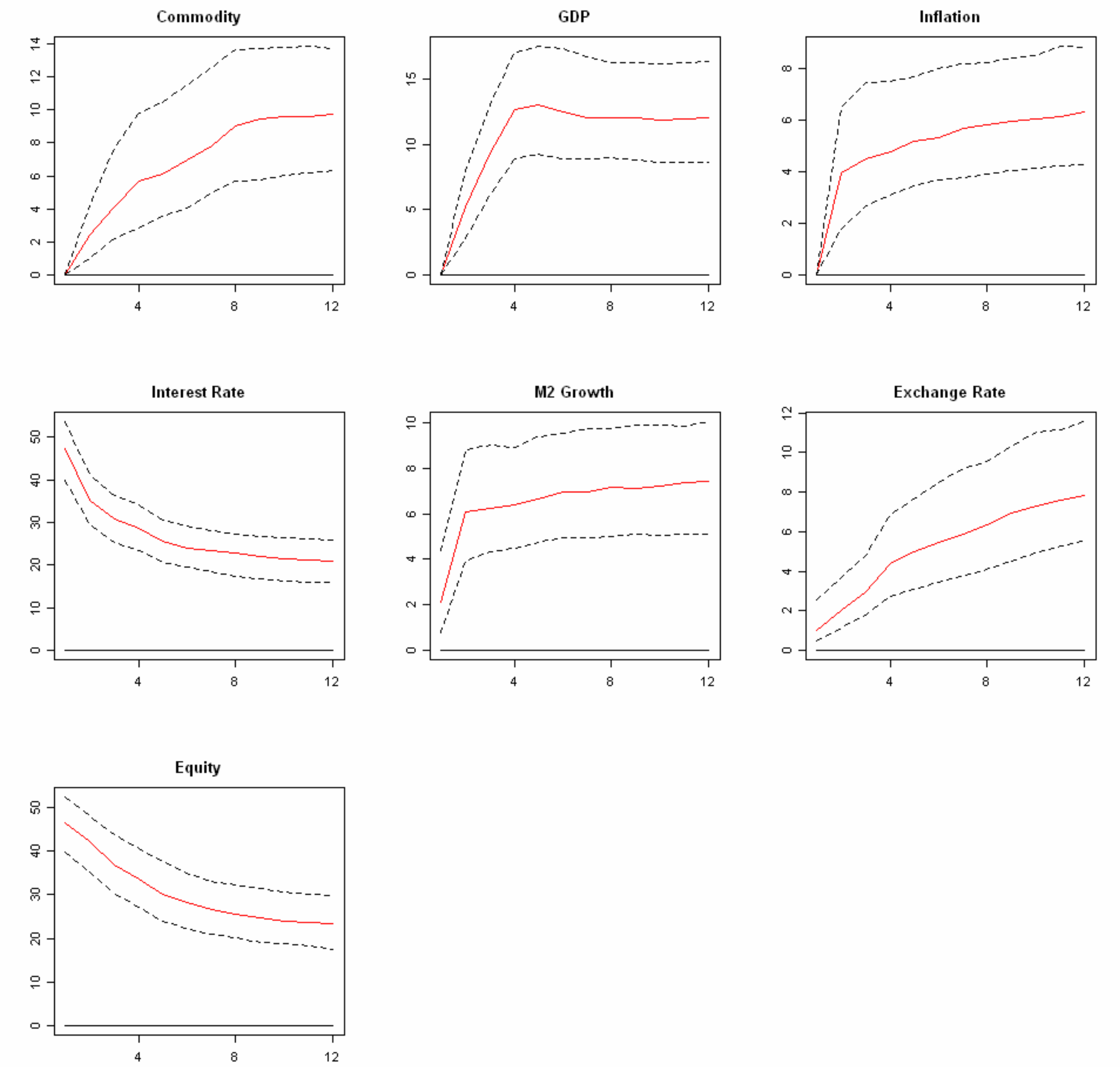


Figure 2: Percentage variance due to a monetary policy contraction.using Christiano *et al.* (2005) identification and data for Brazil.



As for Russia, the results displayed in Figure 3 show that a positive interest rate shock leads to: (i) a strong and persistent contractionary effect on GDP; (ii) a fall in the price of raw materials; (iii) an appreciation of the exchange rate; and (iv) a negative and persistent effect on the equity markets, which reach a trough of -10% after 2 quarters.

Esanov *et al.* (2005) test whether the central bank in Russia reacts to changes in inflation, output gap and the exchange rate in a consistent and predictable manner. Their results indicate that during the period of 1993-2002 the Bank of Russia has used *monetary aggregates* as a main policy instrument in conducting monetary policy.

Figure 4 confirms these findings, and suggests that monetary policy shocks are responsible for a substantial fraction of the variation of the stock price index (about 10% of the variation 12 quarters ahead). Russian interest rates being very high (in 3-digit levels) in the early nineties makes its variation from a 3-digit to a 1-digit level currently as a significant decline relative to other variables in the VAR. That is why in Figure 4 monetary policy shock accounts for the highest proportion of variation in interest rate.

Figure 3: Impulse-response functions to a monetary policy contraction using Christiano *et al.* (2005) identification and data for Russia.

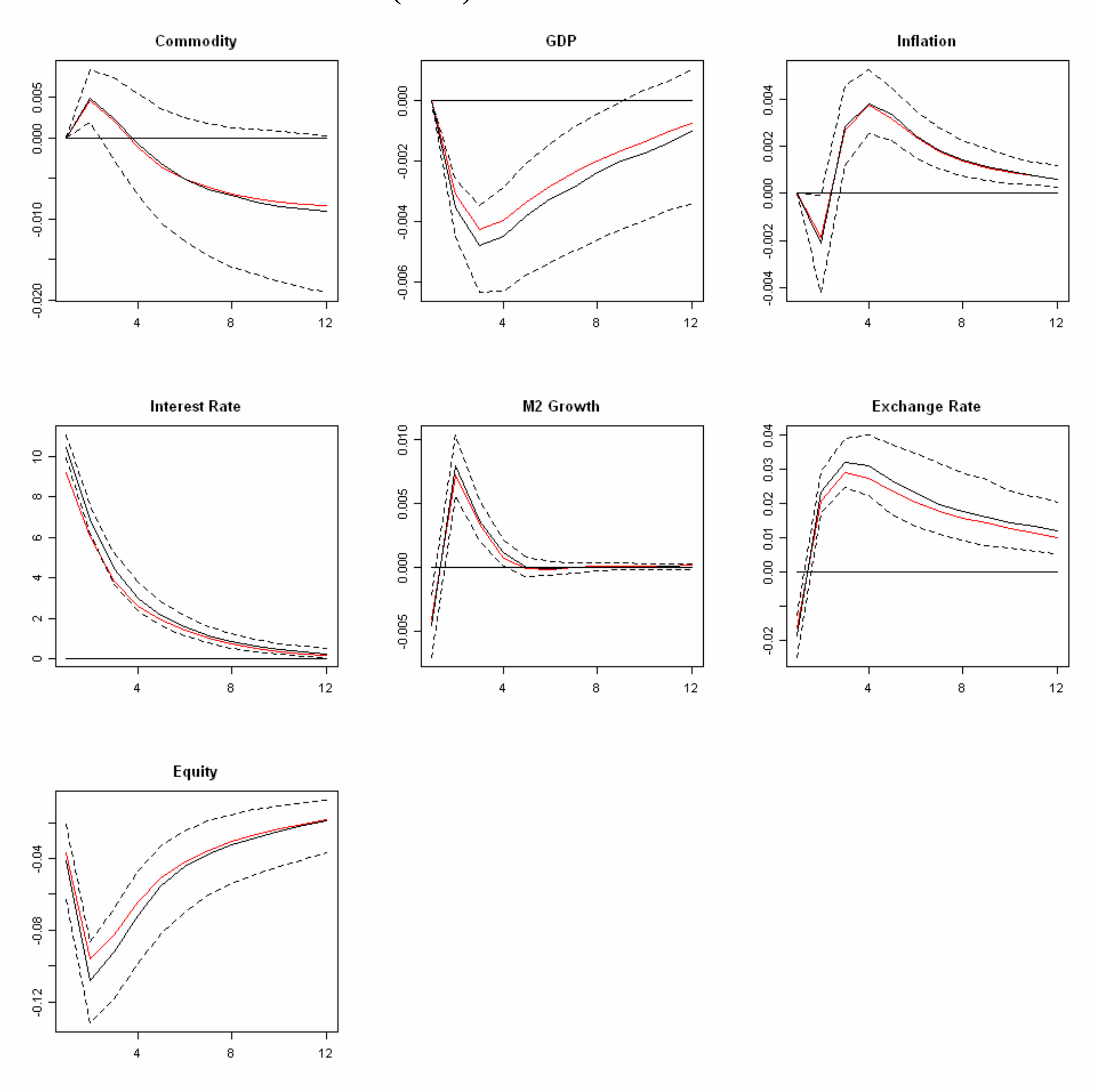


Figure 4: Percentage variance due to a monetary policy contraction.using Christiano *et al.* (2005) identification and data for Russia.

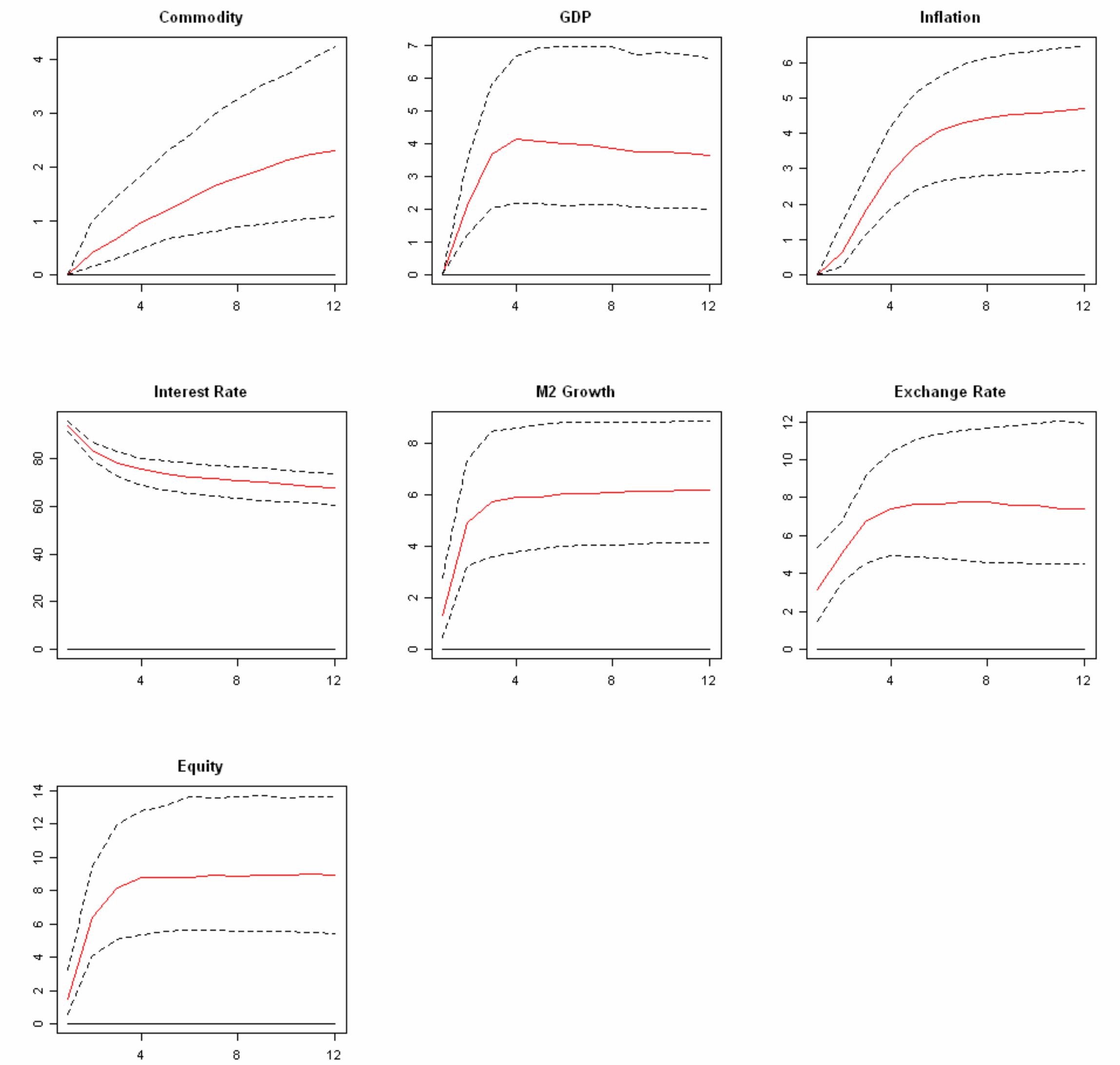


Figure 5 displays the impulse-response functions to a monetary policy contraction using data for India. In accordance with the findings for Brazil and Russia, the interest rate shock has a significantly negative effect on GDP, with a trough of -0.15% after 2 quarters. Similarly, the stock markets react in a substantially negative manner to the shock: the stock price index falls by about 4% over the first four quarters and the effect remains negative even 12 quarters ahead. This result is similar in spirit with Kramer *et al.* (2008), who argue that the room to regulate capital flows effectively through capital controls diminishes as financial integration increases. In contrast with Brazil and Russia, the price of raw materials does not seem to be affected by monetary policy, probably, reflecting the stronger reliance and dependence of those countries on the revenues from the trade of commodities. It also gives rise to the idea that monetary policy addresses multiple objectives of achieving and managing sustained growth, while ensuring macroeconomic stability (Singh and Kalirajan, 2006). Finally, the interest rate shock leads to an appreciation of the domestic currency for about 4 quarters, but as the central bank regularly intervenes in the FX market to limit currency appreciation, this appreciation does not persist for long. Figure 6 also reveals the important role that monetary policy has on the behaviour of stock markets, as it explains 15% of the variation of the stock price index 12 quarters ahead.

Figure 5: Impulse-response functions to a monetary policy contraction using Christiano *et al.* (2005) identification and data for India.

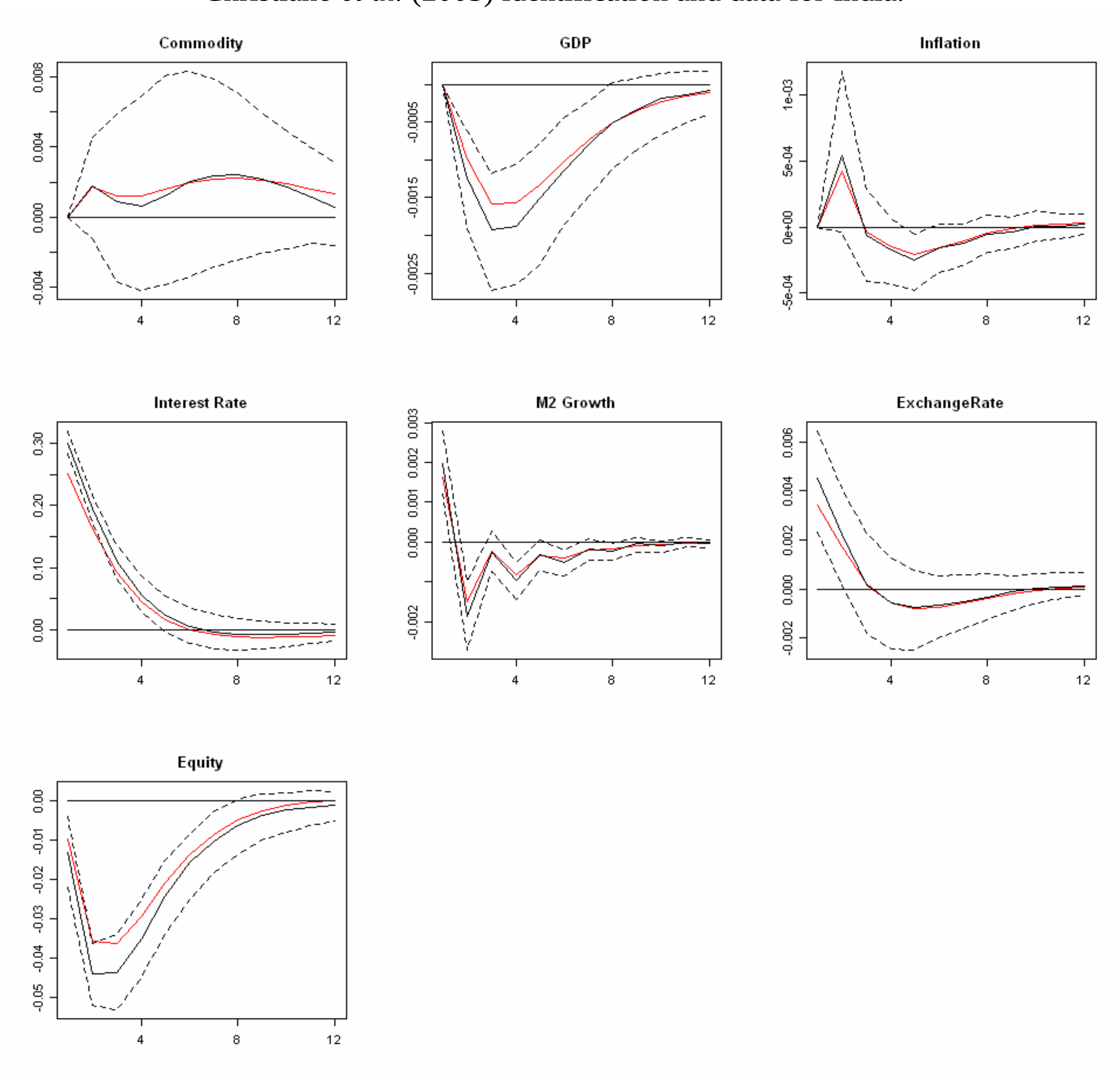
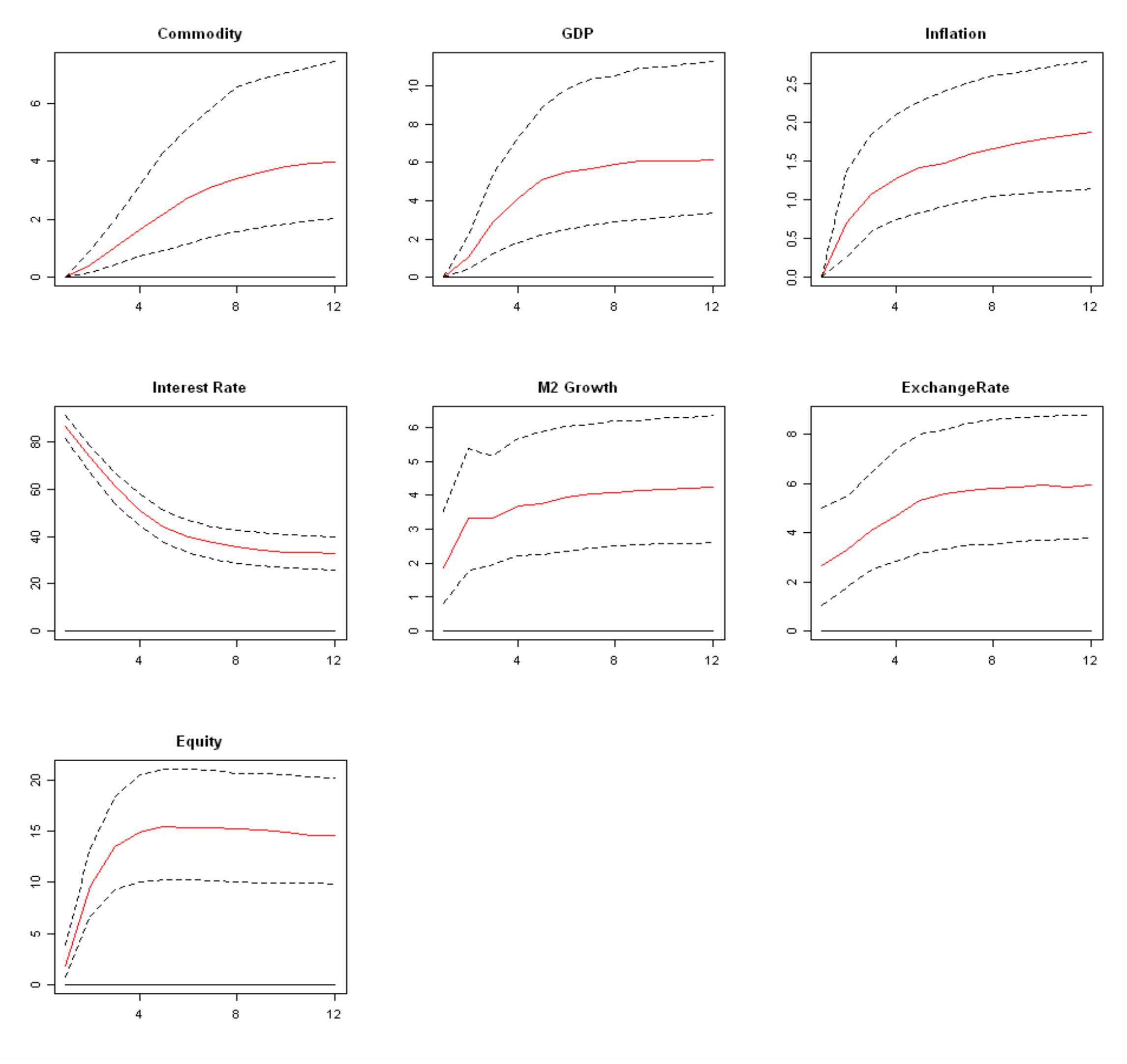


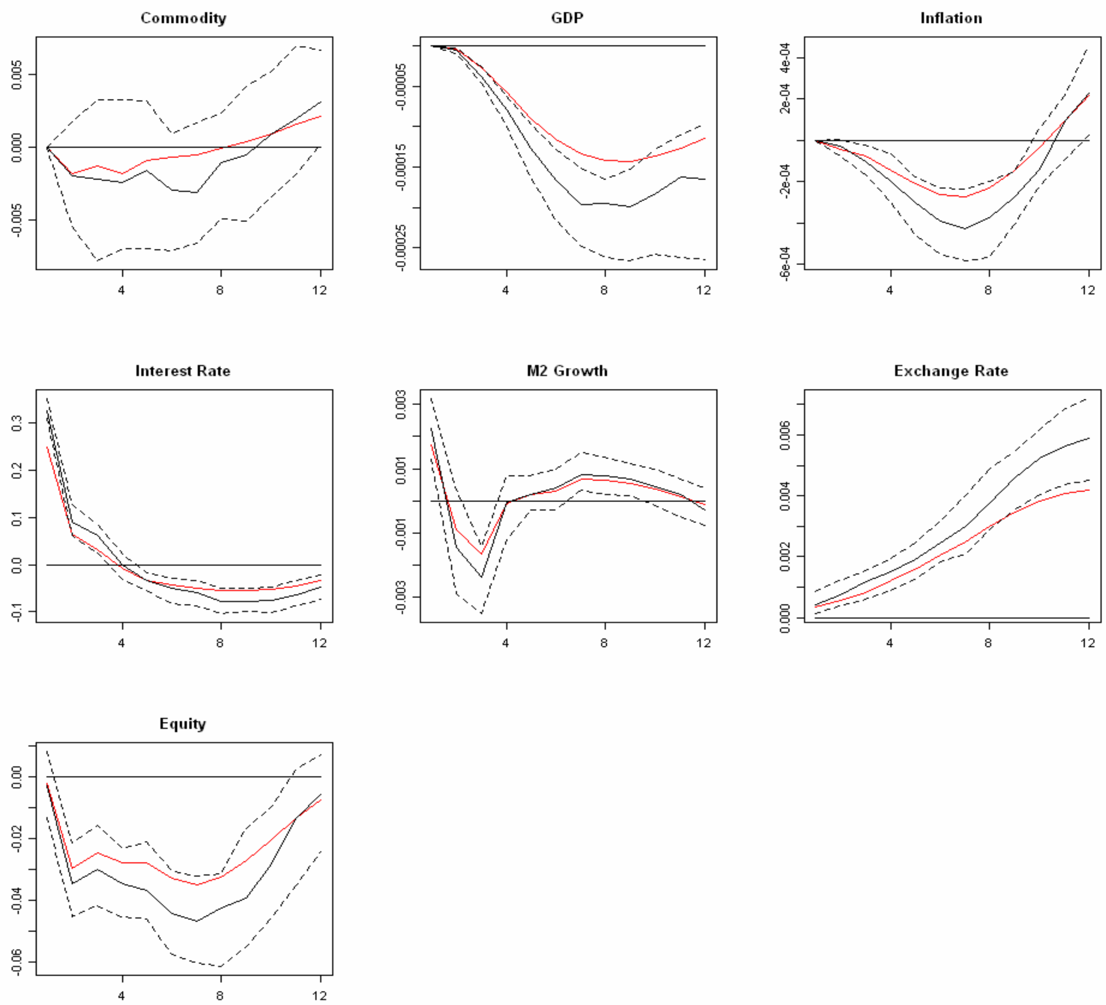
Figure 6: Percentage variance due to a monetary policy contraction.using Christiano *et al.* (2005) identification and data for India.



As for China, the results displayed in Figure 7 show that a monetary policy contraction produces: (i) a negative (although very small in magnitude) effect on GDP; (ii) a persistent fall in both the price of raw materials and the aggregate price level; and (iii) a negative impact of -4% on the equity markets. The strong and negative dynamics exhibited by the price level in reaction to the policy shock is consistent with the evidence, showing that the People's Bank of China follows a Taylor-type rule for the interest rate, with the aim of inflation targeting and output smoothing (Wang and Handa, 2007; He and Pauwels, 2008). It is also in line with Zhang (2009) who shows that that the price rule (that is, the use of the interest rate as the policy instrument) is likely to be more effective in managing the macroeconomy than the quantity rule (where the relevant policy instrument is the monetary aggregate), favouring the government's intention of liberalizing interest rates and making a more active use of the price instrument.[11]

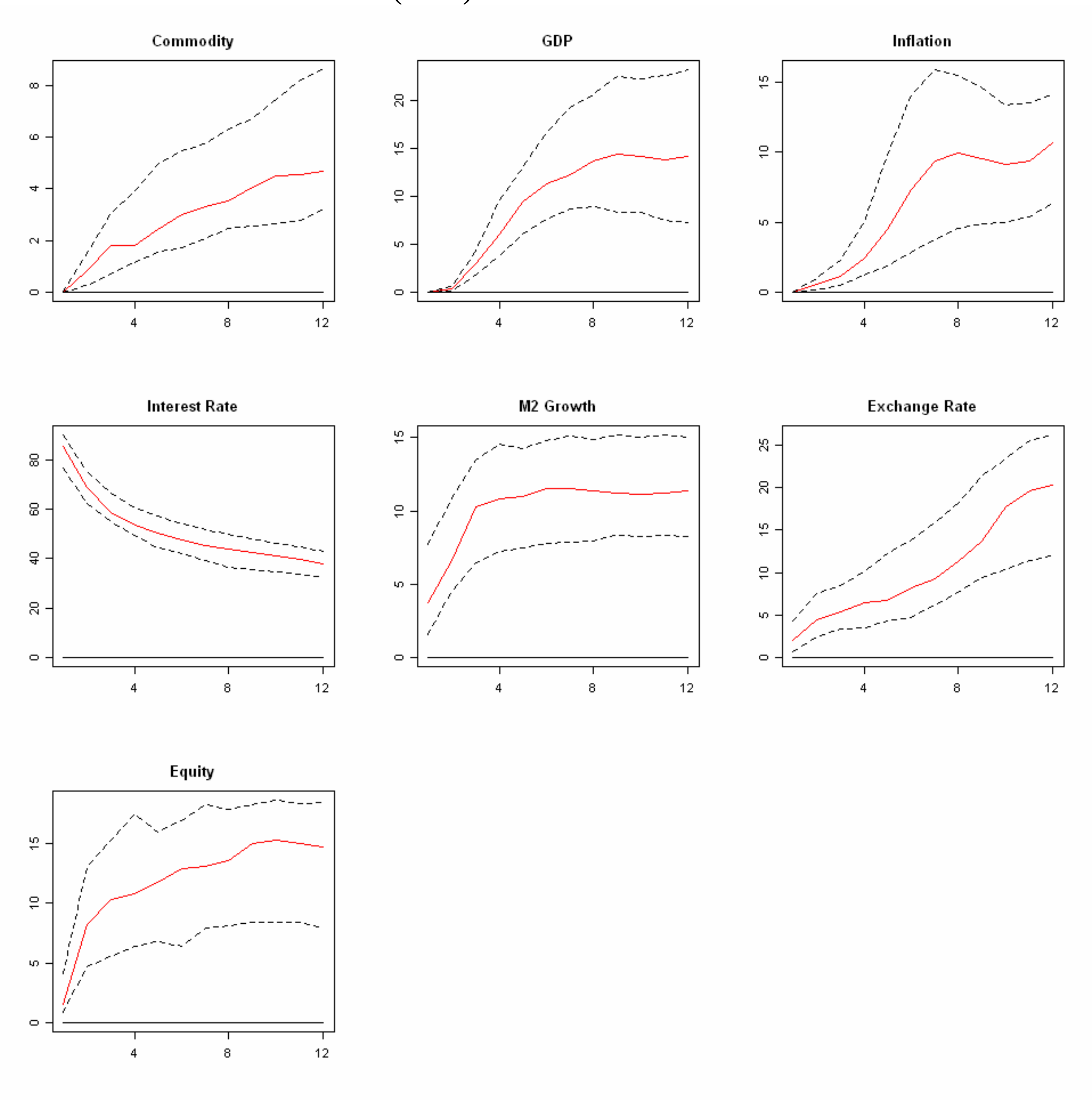
Figure 8 suggests that the interest rate shocks explain 10% and 15% of, respectively, the variation of the inflation rate and the stock price index 12 quarters ahead. As pointed out by Zhang (2009), it seems that the economy would have experienced less fluctuations had interest rate responded more aggressively to inflation.

Figure 7: Impulse-response functions to a monetary policy contraction using Christiano *et al.* (2005) identification and data for China.



11 As the economy becomes more market-oriented over time, the quantity rule seems to be less operable as China's money velocity and multiplier have increased significantly in the past 15 years (Zhang, 2009).

Figure 8: Percentage variance due to a monetary policy contraction.using Christiano *et al.* (2005) identification and data for China.



Finally, the results for South Africa, displayed in Figure 9, suggest that monetary policy has a contractionary effect on GDP, which reaches a trough (of -0.6%) after 8 quarters, and remains at a lower-than-initial level for about 12 quarters. The price of raw materials also substantially falls, which helps explaining the negative impact on inflation. This piece of evidence reveals the effectiveness of a monetary regime based on inflation targeting (Aaron and Muellbauer, 2007), the improvements in interest rate and inflation forecasts and the increase in transparency of monetary policy in South Africa, in particular, since the end of the nineties (Arora, 2007). The response of the growth rate of the monetary aggregate is negative and gradual, and the liquidity effect seems to be very persistent. The exchange rate appreciates for about 12 quarters which gives rise to the idea that monetary policy is not only interested in optimal monetary conditions but also in external stability (Knedlick, 2006). As for the stock price index, it immediately falls (by around -4%) after the shock and remains below its initial level.

Figure 10 displays the percentage of variance of the *k*-step-ahead forecast error due to an interest rate shock, and shows that policy shocks account for about 30%, 20% and 10% of, respectively, the variation of GDP, the stock price index and the commodity price index, 12 quarters ahead.

Figure 9: Impulse-response functions to a monetary policy contraction using Christiano *et al.* (2005) identification and data for South Africa.

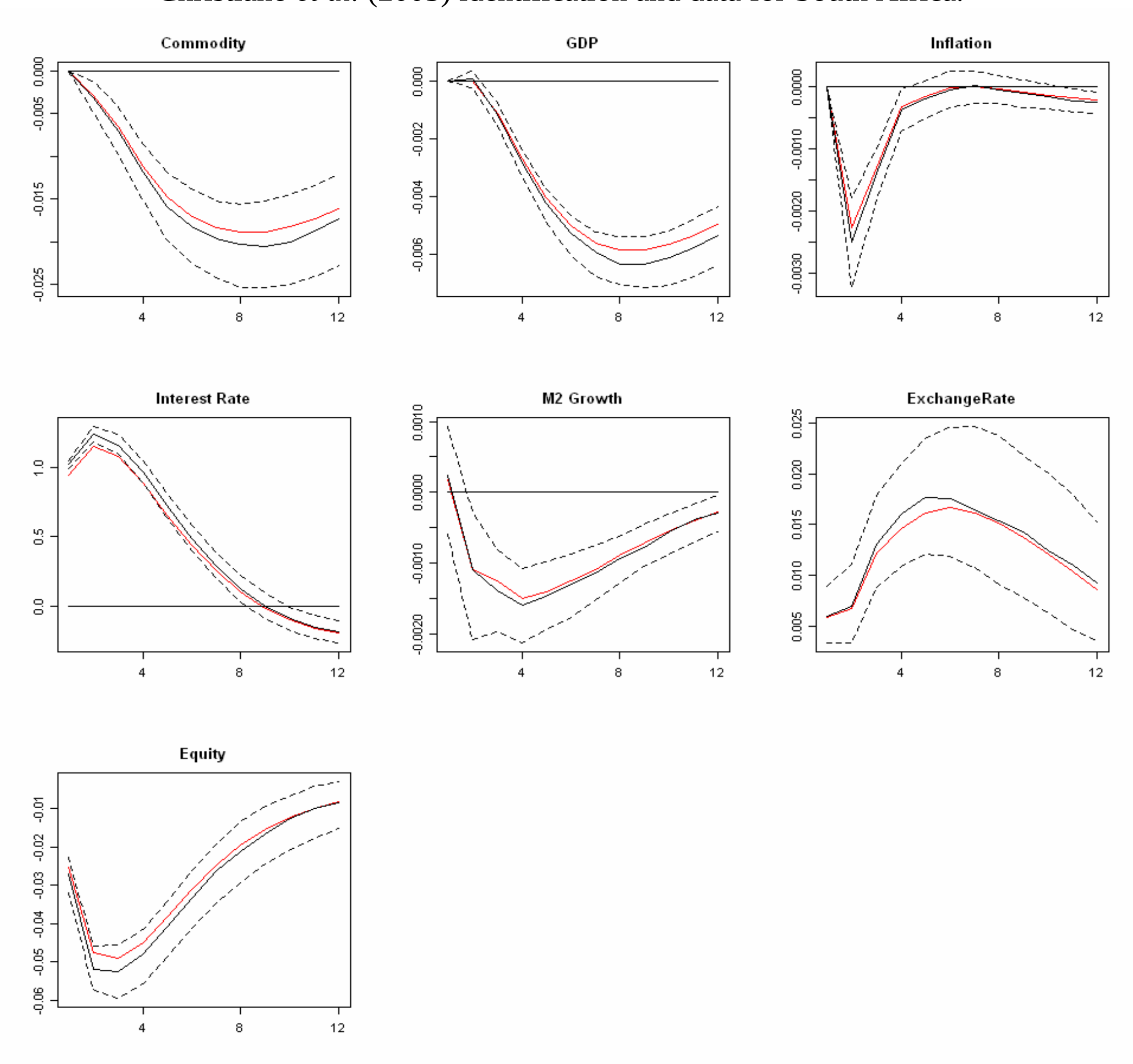
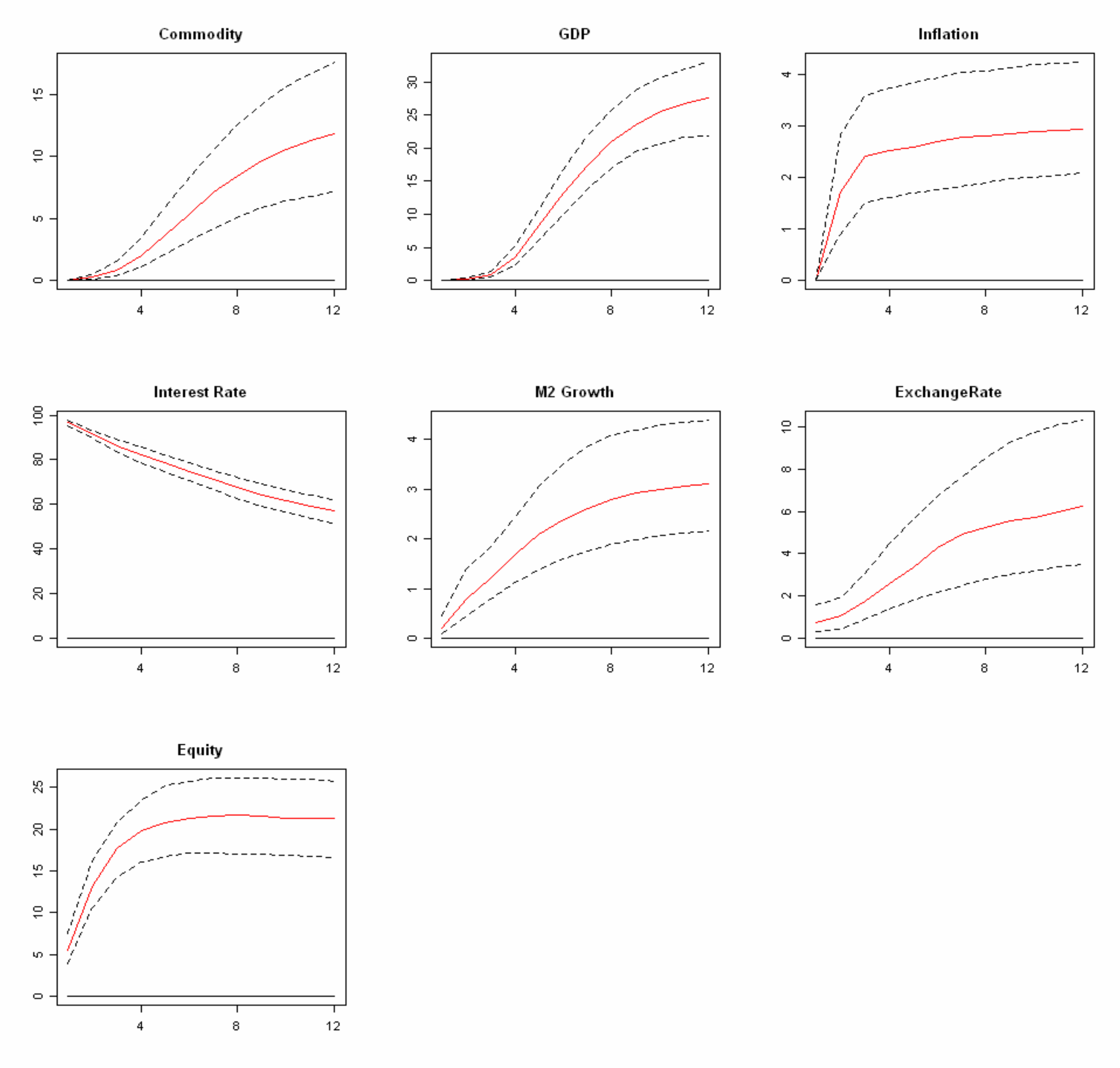


Figure 10: Percentage variance due to a monetary policy contraction.using Christiano *et al.* (2005) identification and data for South Africa.



5.2. The Sign Restrictions Approach

In order to further validate our BVAR results, we carry out the above 'pure sign restriction' identification strategy due to Uhlig (2005) using the following sign restrictions, not only upon impact, but for a few periods after the shock's impact, which are shown in the impulse responses in figures 11 to 15. The sign restrictions imposed are the same as the signs observed earlier in the above BVAR exercise. The reason why we are doing this is to check further the robustness of the results so far obtained. Three restrictions are imposed to identify a monetary shock – an increase in interest rate, a reduction in inflation, and a reduction in money growth. In addition, we also identify an exchange rate shock, as massive surge in capital flows can affect a central bank's balance sheet, forcing the monetary authority to intervene in the FX market. Such intervention usually takes the form of preventing a currency appreciation and thus generating an inflationary pressure due to a depreciated currency. So we identify an exchange rate shock first and then the monetary shock as defined in Exhibit 1.[12]

Exhibit 1: Identifying Sign Restrictions

	GDP	INFLATION	CBRATE	M2_GR	EXCRATE	EQ
Contractionary Monetary policy shock (increase in interest rate)	?	–	+	–	?	?
Exchange rate shock (depreciation)	?	+	?	?	–	?

The responses in figures 11 to 15 satisfy the sign restrictions for $k = 1,...,K$ quarters. The responses of these three variables have been restricted for the first 2 quarters, following the shock. The error bands based are illustrated as the dotted lines above and below the response line (the thick line), which are composed of the 16th, 84th and median percentiles of the impulse responses for each shock, and are based on 10000 draws. The results are as follows:

1) Russia seems to have experienced the largest fall in real output following a contractionary monetary policy shock, followed by Brazil, India, China and then South Africa. All countries seem to demonstrate monetary non-neutrality, except to a lesser extent in Brazil, China, and South Africa where the 84 percentile retreats back to zero. Overall it is found that a monetary policy shock leads to a fall in output.

2) Inflation declines in all five countries reacting almost immediately to a monetary policy shock, but the effect seems smallest and most short-lived, as it quickly goes back to its initial level, providing evidence for the 'price puzzle' in emerging markets.

[12] Even if we alter the ordering of the two shocks, the results remain insensitive. They are available upon request from the authors. We have not included these five sets of impulse responses in order to keep the size of the paper manageable.

3) Money growth falls in all five countries in response to a contractionary monetary shock, illustrating the 'liquidity effect', but the impact dies out quickly given the high rate of money growth in these emerging markets, except India where there has been higher degree of macroeconomic stability in the recent years compared to other countries.

4) Interest rates rise in all countries, slowly receding back to zero in all five cases. As shown in figures 11 to 15, we find that as interest rate increases, inflation gets reduced, but at the cost of reduction in output.

5) Also we find that a contractionary shock to monetary policy leads to persistent appreciation in the real exchange rates in all countries except South Africa where UIRP appears to hold.

6) In all five countries, the contractionary monetary shock has a negative effect on their respective equity markets.

In sum, although in the case of developing countries and emerging markets, the adequate policy instrument could not only be the short-term interest rate, but also the monetary base or the exchange rate, our results do show that it can be used to stabilize inflation but its major effects lay down on output. In addition, monetary policy seems to lead to a strong and persistent appreciation in the real exchange rate. In this context, one should note that the potential inclusion of the exchange rate in the central bank's reaction function would not contradict the objectives of central banks, in particular, if exchange rate stabilization is a precondition for both output stabilization and bringing down inflation to a targeted level (Taylor, 2001). So we have identified monetary policy shocks after having identified an exchange rate shock as shown in Exhibit 1. The responses of monetary policy shocks (after having identified a possible exchange rate shock) are shown in Figures 11-15.

Figure 11: Impulse-response functions to a monetary policy contraction using a Sign Restriction approach and data for Brazil.

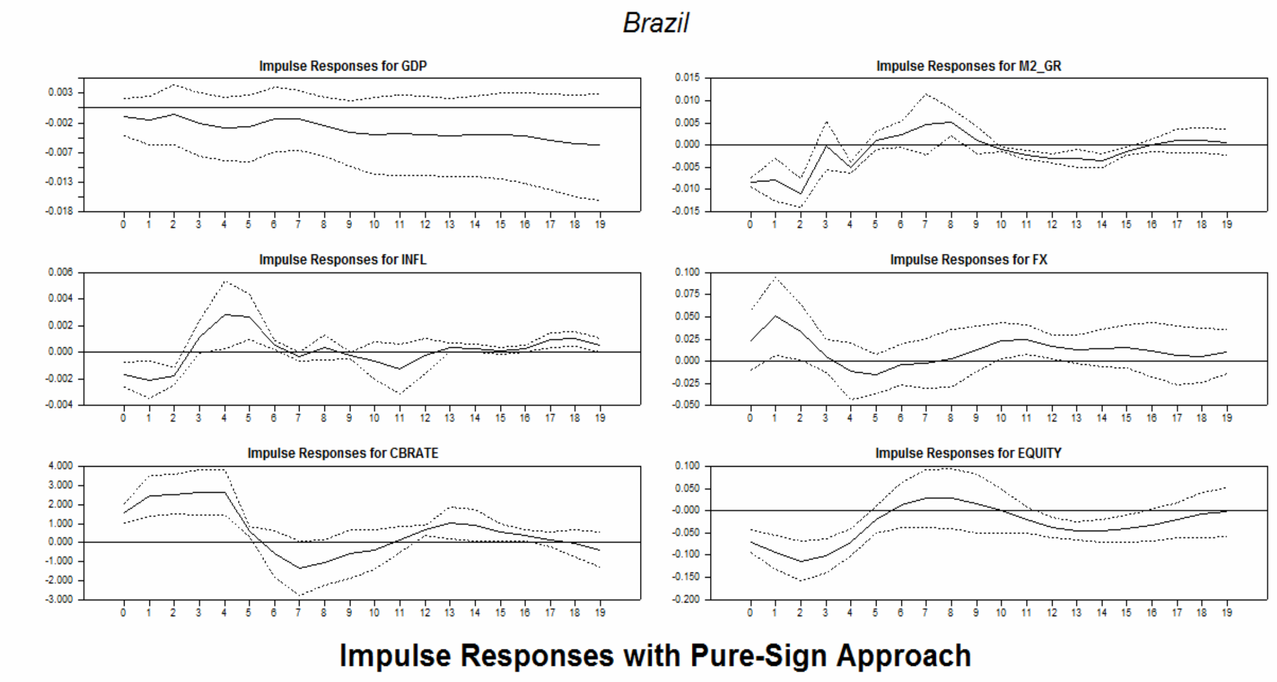


Figure 12: Impulse-response functions to a monetary policy contraction using a Sign Restriction approach and data for Russia.

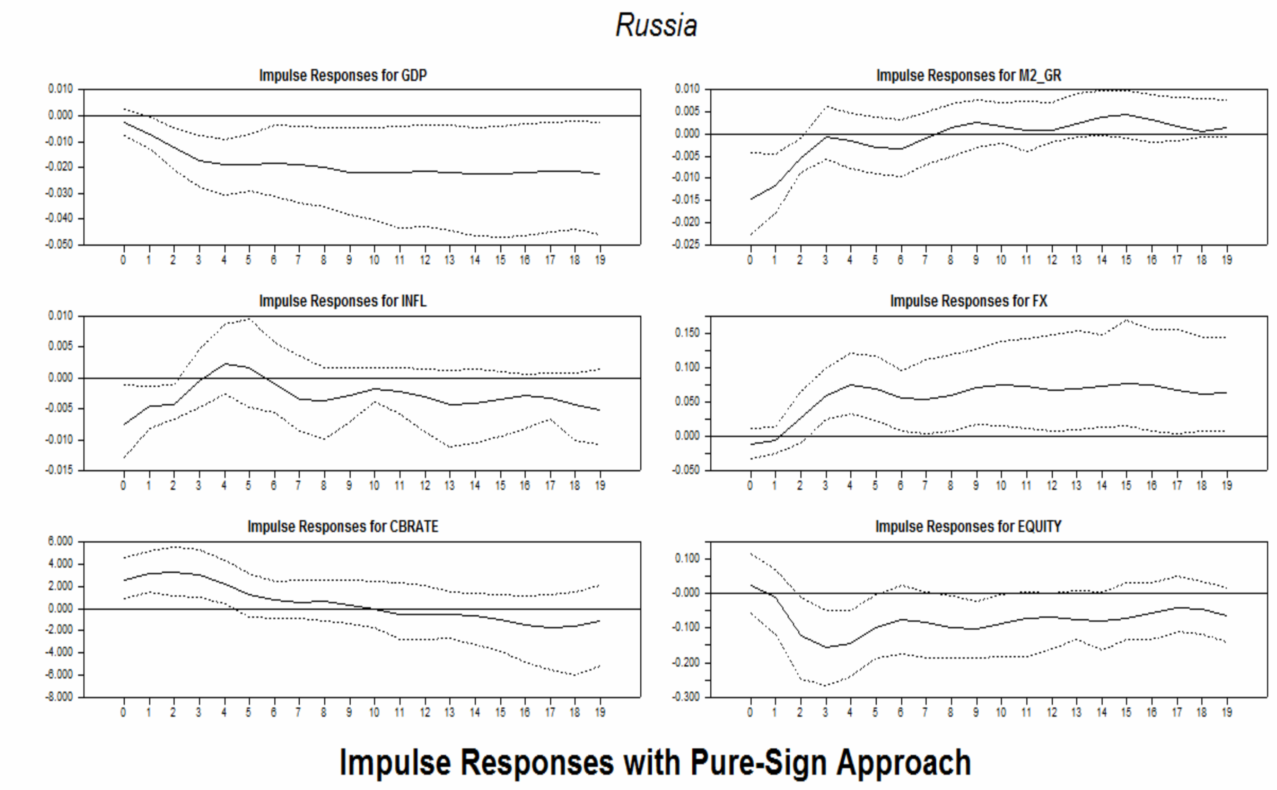


Figure 13: Impulse-response functions to a monetary policy contraction using a Sign Restriction approach and data for India.

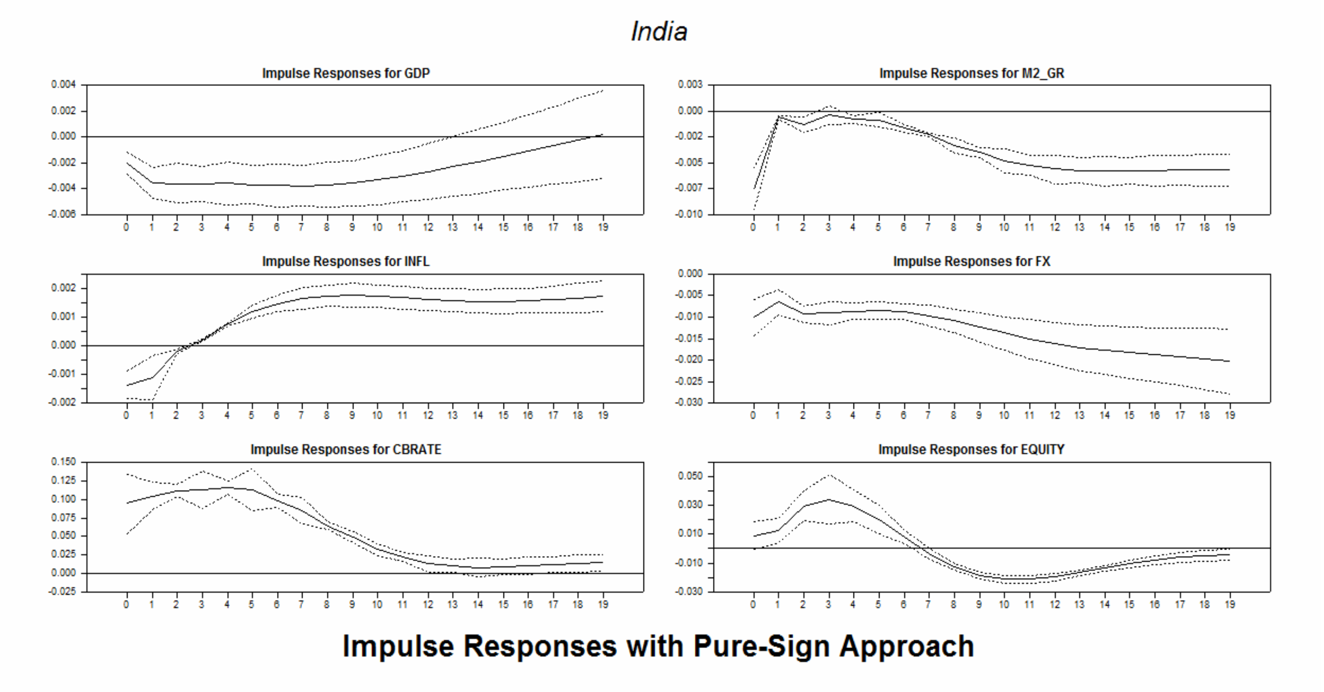


Figure 14: Impulse-response functions to a monetary policy contraction using a Sign Restriction approach and data for China.

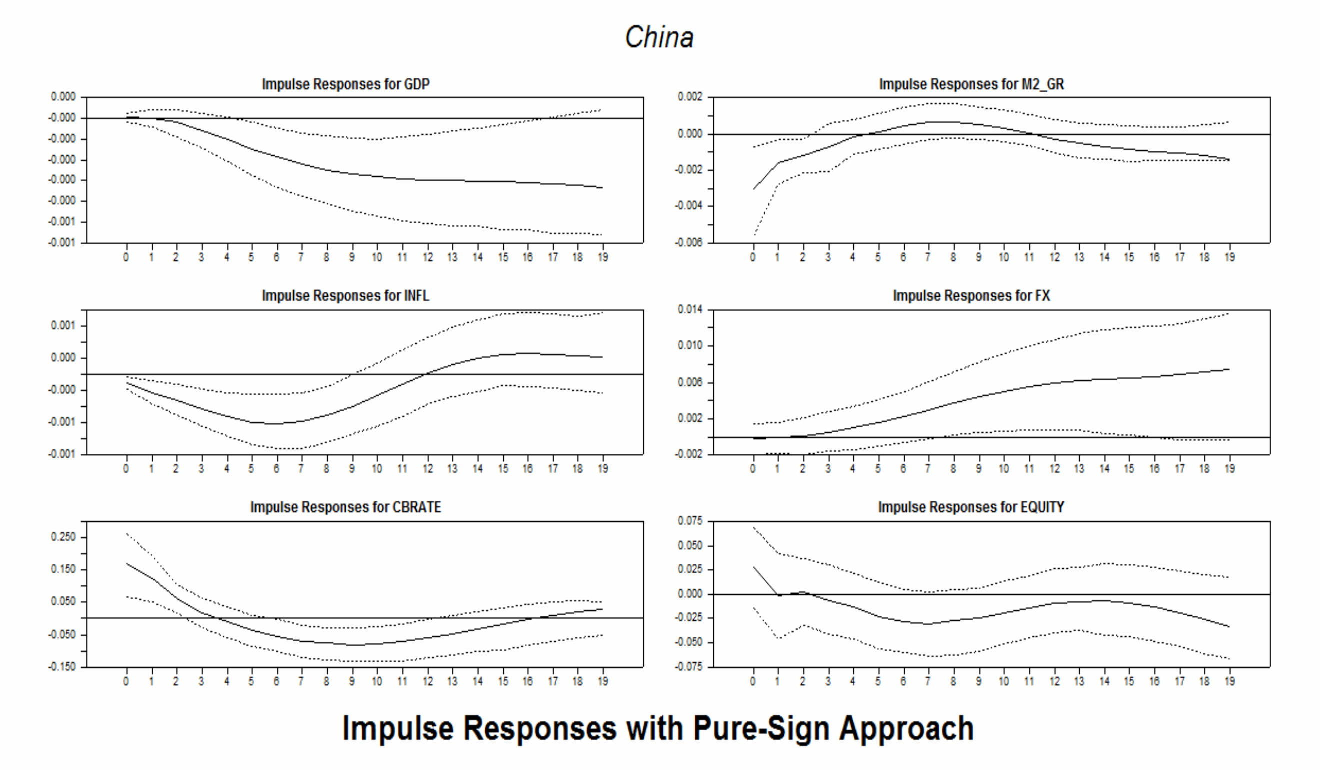
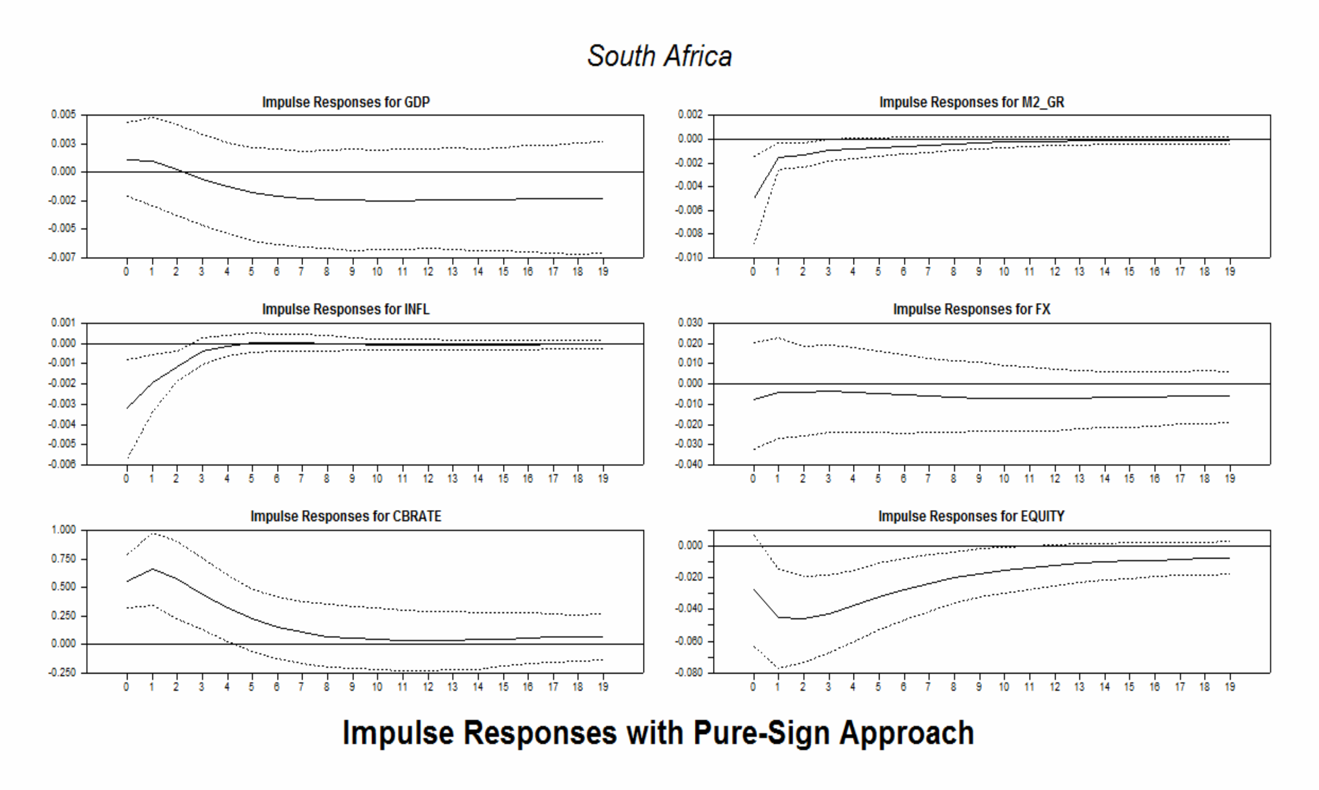


Figure 15: Impulse-response functions to a monetary policy contraction using a Sign Restriction approach and data for South Africa.



5.3. A PVAR Assessment

In this Sub-Section, we report the results from the estimation of the PVAR defined in (9). We transform the system in a "recursive" VAR (Hamilton, 1994) and impose a triangular identification structure, therefore, assuming that the growth rate of M2, the exchange rate and the equity price adjust simultaneously to shocks to the interest rate. Moreover, shocks to the policy instrument affect the commodity price, the GDP and the inflation rate only with a lag. The ordering of the variables in the system is, therefore, common in the literature on monetary policy (Christiano *et al*., 1999, 2005).

We start by considering a six-variable framework, where we exclude the exchange rate (Figure 16). In Figure 17, we drop the equity price index and replace it with the exchange rate. That is, while keeping the parsimony of the model, we also aim at assessing the robustness of the previous findings by separately considering a small number of variables among the set of determinants that react contemporaneously to the monetary policy shock.

Figure 16 corroborates the results of the B-SVAR and the sign restriction approach. In fact, it can be seen that a positive interest rate shock leads to: (i) a contractionary effect on GDP with a trough that is reached after 2 to 4 quarters; (ii) a quick fall in the price of commodities, despite a small price puzzle; (iii) a negative liquidity effect that erodes after 6 quarters; and (iv) a substantial and negative effect on the equity price, which remains at a lower level even 12 quarters ahead.

The main findings remain unchanged when one replaces the equity price index by the exchange rate in the PVAR as can be seen in Figure 17. Moreover, the results suggest that a monetary policy contraction leads to an appreciation of the domestic currency in line with the evidence from the previous methodologies for identification of the monetary policy shock.

Figure 16: Impulse-response functions to a monetary policy contraction using a Panel Vector Auto-Regressive (PVAR) approach, inclusion of equity.

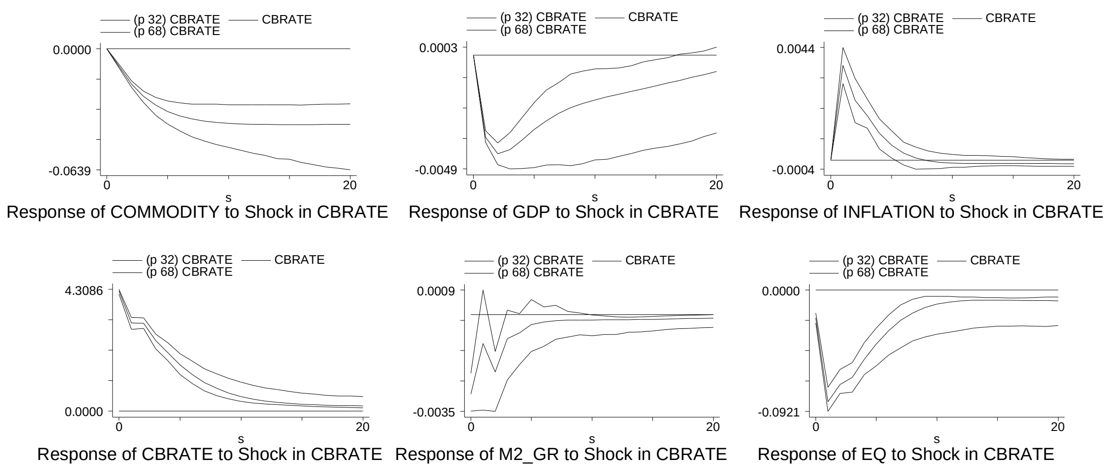
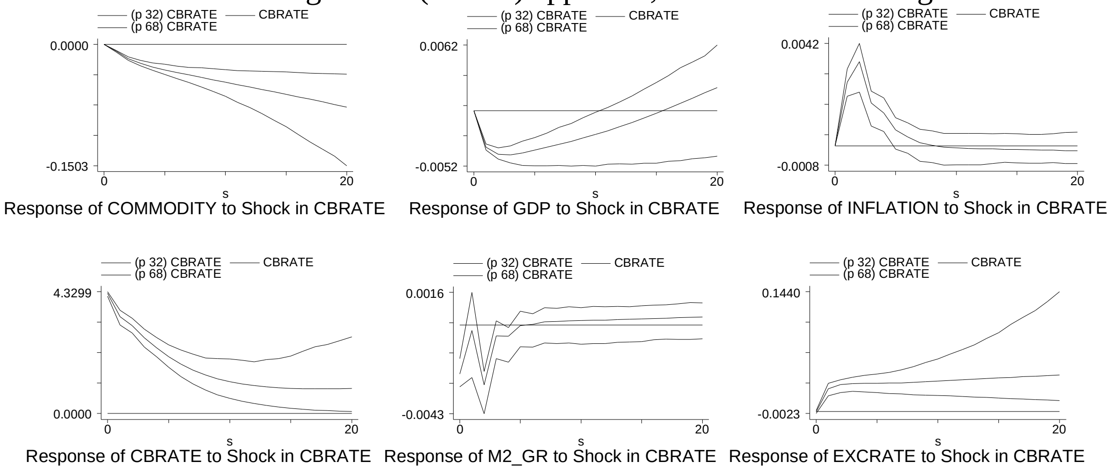


Figure 17: Impulse-response functions to a monetary policy contraction using a Panel Vector Auto-Regressive (PVAR) approach, inclusion of exchange rate.



We assess the robustness of the PVAR findings by looking at the impulse-response functions for different sub-samples. We consider two periods: 1990:1-1999:4 (Figure 18) and 2000:1-2008:3 (Figure 19). The major differences between the two sub-samples lie on the (negative) responses of GDP and inflation to the monetary policy shock, which are negative in the period 1990:1-1999:4. In addition, while equity prices react in a substantially negative manner in the first sub-sample, the impact of a positive interest rate shock on equity markets does not seem to be significant in the period 2000:1-2008:4.

Figure 18: Impulse-response functions to a monetary policy contraction using a Panel Vector Auto-Regressive (PVAR) approach, sub-sample period 1990:1-1999:4.

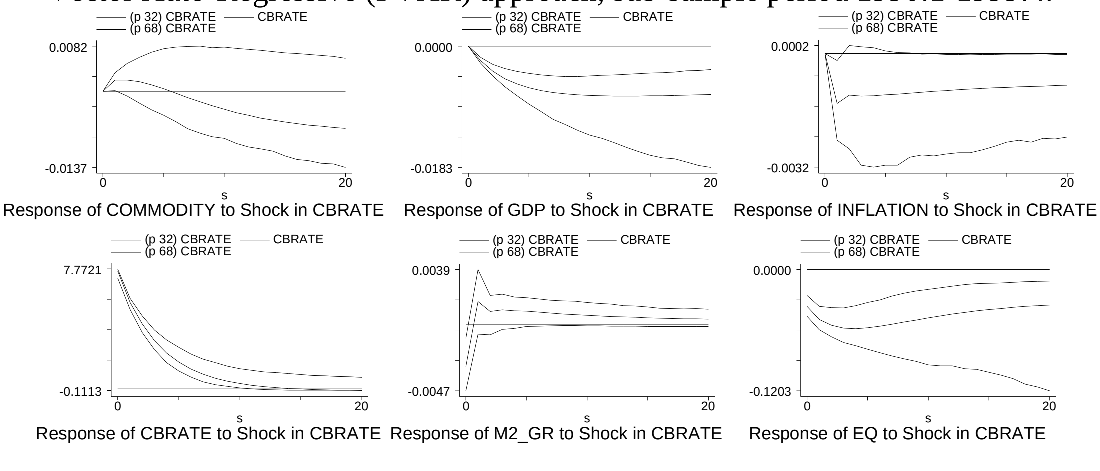
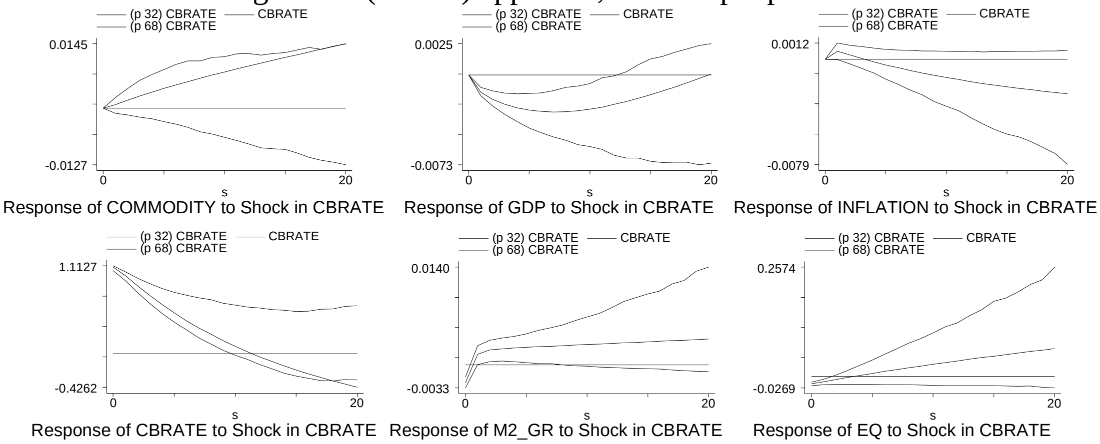


Figure 19: Impulse-response functions to a monetary policy contraction using a Panel Vector Auto-Regressive (PVAR) approach, sub-sample period 2000:1-2008:4.

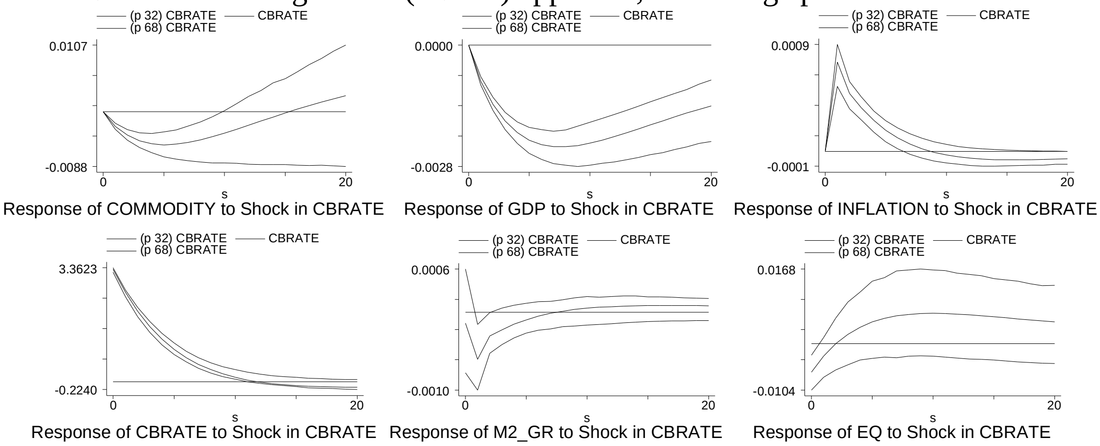


Finally, given that emerging markets have frequently been the stage for episodes of economic, financial and/or currency crises and that the anticipation of these events may affect lending and market default premia (Dell'Ariccia *et al*., 2006), we create two dummy variables, $\boldsymbol{D}_{i,t}^{CRISIS}$ and $\boldsymbol{D}_{i,t}^{NO\,CRISIS}$. We define the dummy variable $\boldsymbol{D}_{i,t}^{CRISIS}$ as follows: it takes the value of 1 if either the change (year-on-year) of real GDP or real equity price index is more than two times the country-specific standard deviation of the variable; and 0, otherwise. In addition, the quarters before and after the peak of crisis are also marked with 1, and all other periods (normal periods) are marked with 0. By its turn, the dummy variable $\boldsymbol{D}_{i,t}^{NO\,CRISIS}$ takes the value of 1 in case of absence of episodes of crises and 0 otherwise. Then, we estimate a dummy variable augmented PVAR model of the form:

$$\mathrm{Y}_{\mathrm{i,t}} = \Gamma_0 + \Gamma_{\boldsymbol{CRISIS}}(\boldsymbol{L})\boldsymbol{Y}_{\mathrm{i,t}} \bullet \boldsymbol{D}_{\boldsymbol{I},\boldsymbol{T}}^{\boldsymbol{CRISIS}} + \Gamma_{\boldsymbol{NO\,CRISIS}}(\boldsymbol{L})\boldsymbol{Y}_{\mathrm{i,t}} \bullet \boldsymbol{D}_{\boldsymbol{I},\boldsymbol{T}}^{\boldsymbol{NO\,CRISIS}}$$
$$+\nu_{\mathrm{i}} + \boldsymbol{d}_{\boldsymbol{c},\boldsymbol{t}} + \boldsymbol{\varepsilon}_{\boldsymbol{i},\boldsymbol{t}} \quad \mathrm{i} = 1,...,\mathrm{N} \quad \mathrm{t} = 1,...,\mathrm{T_i} \qquad (10)$$

This robustness test checks whether the previous findings were biased because the episodes of crises were not appropriately controlled for. Figure 20 displays the impulse-response functions in the case of NO CRISIS scenario. The results support the robustness of the previous findings and show that, in the absence of periods of extreme instability (that is, in "normal" periods), monetary policy still has a very contractionary effect on GDP, produces a small liquidity effect, leads to a fall in the commodity prices and negatively and quickly impacts on equity markets.

Figure 20: Impulse-response functions to a monetary policy contraction using a Panel Vector Auto-Regressive (PVAR) approach, excluding episodes of crisis.



6. Conclusion

This paper provides time-series and panel evidence on the monetary policy transmission for five key emerging market economies: Brazil, Russia, India, China, and South Africa (BRICS).

Instead of the conventional Choleski decomposition, we use modern estimation techniques – namely, the Bayesian Structural Vector Auto-Regressive (B-SVAR) and the sign-restrictions VAR, and the panel VAR (PVAR) - to identify the monetary policy shock along with the more recent sign restrictions approach.

The analysis is based on high-frequency (quarterly) data for the period 1990:1-2008:4, and the model includes 7 key variables: the interest rate (that is, the policy rate), a set of macroeconomic variables that adjust to the shock with a lag (GDP, inflation, and the commodity price), and a set of variables that react contemporaneously to the policy shock (the growth rate of the monetary aggregate, the exchange rate, and the equity price index).

We show that a monetary policy contraction: (i) has a negative effect on output; (ii) leads to a quick fall in the commodity price, but the aggregate price level exhibits strong persistence; (iii) produces a small liquidity effect; (iv) has a strong and negative impact on equity markets; and (v) generates an appreciation of domestic currency.

Finally, to summarise the response for this group of key emerging market economies, we carry out a panel VAR exercise, which provides further robustness of our finding that contractionary monetary policy has a negative effect on output. These results are robust to changes in the specification, the methodology and sub-sample time horizon.

References

Aron, J., and J. Muellbauer (2002). Estimating monetary policy rules for South Africa', in Loayza, N., and K. Schmidt-Hebbel (eds.), *Monetary policy: rules and transmission mechanisms*, Series on Central Banking, Analysis and Economic Policies, 4, Central Bank of Chile, 427–75.

Aaron, J., and J. Muellbauer (2007). Review of monetary policy in South Africa since 1994, *Journal of African Economies*, 16(5), 705-744.

Agénor, P.-R., C. J. McDermott, and E. S. Prasad (2000). Macroeconomic fluctuations in developing countries: some stylized facts. *World Bank Economic Review*, 14, 251-285.

Ahmed, S. (2003). Sources of economic fluctuations in Latin America and implications for choice of exchange rate regimes, *Journal of Development Economics*, 72(1), 181-202.

Albuquerque, P. H., and S. Gouvêa (2001). Using a money demand model to evaluate monetary policies in Brazil, Central Bank of Brazil, Working Paper No. 29.

Arellano, M., and S. Bond (1991), Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations, *Review of Economic Studies*, 58(2), 277-297.

Arellano, M., and O. Bover (1995). Another look at the instrumental variables estimation error component models. *Journal of Econometrics*, 68(1), 29-51.

Arora, V. (2007). Monetary policy transparency and financial market forecasts in South Africa, IMF Working Paper No. 123.

Bauwens, L., Lubrano, M., and J.-F. Richard (1999). *Bayesian inference in dynamic econometric models*. Oxford: Oxford University Press.

Beaudry, P., and F. Portier (2006). Stock prices, news, and economic fluctuations. *American Economic Review*, 96(4), 1293-1307.

Blanchard, O. J., and D. Quah (1989). The dynamic effects of aggregate demand and supply disturbances. *American Economic Review*, 79(4), 655-673.

Blundell, R., and S. Bond (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1), 115-143.

Bravo H., C. García, V. Mies, and M. Tapia (2003). Heterogeneidad de la transmisión monetaria: effectos sectoriales y regionales, *Economia Chilena*, 6, 5-26.

Bruno, M., and W. Easterly (1998). Inflation crises and long-run growth, *Journal of Monetary Economics*, 41(1), 3-26.

Burdekin, R. C. K., and P. L. Siklos (2008). What has driven Chinese monetary policy since 1990? Investigating the People's bank's policy rule, *Journal of International Money and Finance*, 27 (5), 847-859.

Canova, F., and E. Pappa (2007). Price differentials in monetary unions: the role of fiscal shocks, *Economic Journal*, 117(520), 713-737.

Céspedes, B. J. V., Lima, E. C. R., Maka, A., and M. J. C. Mendonça (2005). Measuring monetary policy stance in Brazil, Institute of Applied Economic Research (IPEA) Discussion Paper No. 1128.

Christiano, L. J., Eichenbaum, M., and C. L. Evans (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1), 1-45.

Christiano, L. J., Eichenbaum, M., and C. L. Evans (1999). Monetary policy shocks: what have we learned and to what end? in Taylor, J., and M. Woodford, eds, *Handbook of Macroeconomics*, 1A, Amsterdam: Elsevier.

Dedola, L. and S. Neri (2007). What does a technology shock do? A VAR analysis with model-based sign restrictions. *Journal of Monetary Economics*, 54 (2): 512-549.

Dees, S., di Mauro, F., Pesaran, M. H., and V. Smith (2006). Exploring the international linkages of the euro area: a Global VAR analysis, *Journal of Applied Econometrics*, 22(1), 1-38.

Del Negro, M., and F. Obiols-Homs (2001). Has monetary policy been so bad that it is better to get rid of it? The case of Mexico, *Journal of Money, Credit and Banking*, 33, 404-33.

Dell'Ariccia, G., Schnabel, I., and J. Zettelmeyer (2006). How do official bailouts affect the risk of investing in emerging markets? *Journal of Money, Credit, and Banking*, 38(7), 1689-1714.

Devereux, M.B., Lane, P. R., and J. Xu (2006). Exchange rates and monetary policy in emerging market economies, *The Economic Journal*, 116(511), 478-506.

Du Plessis, S. (2006), Reconsidering the business cycle and stabilisation policies in South Africa, *Economic Modelling*, 23(5), 761-774.

Esanov, A., Merkl, C., and L. Vinhas de Souza (2005). Monetary policy rules for Russia, *Journal of Comparative Economics*, 33(3), 484-499.

Fachada, P. (2001). Inflation targeting in Brazil: reviewing two years of monetary policy 1999/00, Central Bank of Brazil, Working Paper No. 25.

Feliz, R. A., and J. H. Welch (1997). Cointegration and tests of a classical model of inflation in Argentina, Bolivia, Brazil, Mexico, and Peru, *Journal of Development Economics*, 52(1), 189-219.

Fetisov, G. (2009). Russia’s monetary policy. Goals, tools, and principles, *Problems of Economic Transition*, 51(9), 3-32.

Gabrielli, M. F., McCandless, G., and M. J. Rouillet (2004). The intertemporal relation between money and prices: evidence from Argentina, *Cuadernos de Economia*, 41, 199-215.

Gavin, W., and A. Theodorou (2005). A common model approach to macroeconomics: using panel data to reduce sampling error. *Journal of Forecasting*, 24(3), 203-219.

Goldman Sachs (2003). Dreaming with BRICs: the path to 2050, Global Economics Paper No. 99.

Gonçalves, C. E. S., and J. M. Salles (2008). Inflation targeting in emerging economies: What do the data say? *Journal of Development Economics*, 85(1-2), 312-318.

Hamilton, J. (1994). *Time series analysis*, Princeton: Princeton University Press.

He, D., and L. L. Pauwels (2008). What prompts the People's Bank of China to change its monetary policy stance? Evidence from a discrete choice model, *China & World Economy*, 16(6), 1-21.

Hoffmaister, A. W., and J. E. Roldós (2001). The sources of macroeconomic fluctuations in developing countries: Brazil and Korea. *Journal of Macroeconomics*, 23 (2), 213–239.

Holtz-Eakin, D., Newey, W., and H. S. Rosen (1988). Estimating vector autoregressions with panel data. *Econometrica*, 56(6), 1371-1395.

Hsing, Y. (2004). Responses of Argentine output to shocks to monetary policy, fiscal policy and exchange rates: a VAR model, *Applied Econometrics and International Development*, 4(1), 21-36.

Knedlik, T. (2006). Estimating monetary policy rules for South Africa, *South African Journal of Economics*, 74(4), 629-641.

Kramer, C. F., Poirson, H. F., and A. Prasad (2008). Challenges to monetary policy from financial globalization: the case of India, IMF Working Paper No. 131.

Laxton, D., and P. Pesenti (2003). Monetary rules for small, open, emerging economies, *Journal of Monetary Economics*, 50(5), 1109-1146.

Leeper, E. M., and T. Zha (2003). Modest policy interventions. *Journal of Monetary Economics,* 50(8), 1673-1700.

Leeper, E. M., Sims, C. A., Zha, T., Hall, R. E., and B. S. Bernanke (1996). What does monetary policy do? *Brookings Papers on Economic Activity*, 27(2), 1-78.

Liu, L., and W. Zhang (2007). A New Keynesian model for analysing monetary policy in Mainland China, The Hong Kong Monetary Authority, Working Paper No. 18.

Lopes, C. (2004). Monetary policy and external vulnerability in Brazil, Brazilian Association of Graduate Programs in Economics, Proceedings of the 32th Brazilian Economics Meeting, No. 071.

Mallick, S. K. (2006). Policy instruments to avoid output collapse: an optimal control model for India, *Applied Financial Economics*, 16(10), 761-776.

Minella, A., de Freitas, P. S., Goldfajn, I., and M. K. Muinhos (2003). Inflation targeting in Brazil: constructing credibility under exchange rate volatility, *Journal of International Money and Finance*, 22(7), 1015-1040.

Mishkin, F. S. (2000). Inflation targeting in emerging-market countries, *The American Economic Review*, Papers and Proceedings, 90(2), 105-109.

Mountford, A., and H. Uhlig (2009). What are the effects of fiscal policy shocks? *Journal of Applied Econometrics*, 24(6), 960-992.

Nelson, E. (2003). The future of monetary aggregates in monetary policy analysis, *Journal of Monetary Economics*, 50(5), 1029-1059.

Nickell, S. (1981). Biases in dynamic models with fixed effects, *Econometrica*, 49, 1417-1426.

Ortíz, G. (2002). Monetary policy in a changing economic environment: the Latin American experience. Paper presented at the Federal Reserve Bank of Kansas City's symposium on Rethinking Stabilization Policy, Jackson Hole, Wyoming, August 29–31.

Quispe Misaico, Z. Q. (2001). Transmission mechanisms of monetary policy in an economy with partial dollarisation: the case of Peru, in *Modelling Aspects of the Inflation Process and the Monetary Transmission Mechanism in Emerging Market Countries, BIS Papers No. 8*, Bank for International Settlements, Basle, 210-31.

Pesaran, M. H., and R. Smith (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, 68(1), 79-113.

Pesaran, M. H., Schuermann, T., and S. Weiner (2004). Modelling regional interdependencies using a global error-correcting macroeconometric model, *Journal of Business and Economic Statistics*, 22, 129-162.

Rabanal, P., and G. Schwartz (2001). Testing the effectiveness of the overnight interest rate as a monetary policy instrument, *Brazil: Selected Issues and Statistical Appendix*, Country Report No. 01/10, International Monetary Fund, Washington, DC.

Rangarajan, C. (1998). *Indian economy: essays on money and finance*, New Delhi: UBS Publishers & Distributors.

Reddy, Y. V. (1999). Monetaty policy in India: objectives, instruments, operating procedure and dilemmas, *Reserve Bank of India Bulletin*, 53(7), 945-950.

Reddy, Y. V. (2007). Monetary policy developments in India: an overview, Speech at the Sveriges Riksbank, Stockholm, 7 September 2007.

Schervish, M. J. (1995). *Theory of statistics*. New York: Springer.

Sims, C., and T. Zha (1999). Error bands for impulse-responses. *Econometrica*, 67(5), 1113-1155.

Sims, C., and T. Zha (2006a). Were there regime switches in U.S. monetary policy? *American Economic Review*, 96(1), 54-81.

Sims, C., and T. Zha (2006b). Does monetary policy generate recessions? *Macroeconomic Dynamics*, 10(2), 231-272.

Singh, K., and K. Kalirajan (2006). Monetary policy in India: objectives, reaction function and policy effectiveness, *Review of Applied Economics,* 2(2), 181-199.

Stals, C. (1997). Effect of the changing financial environment on monetary policy in South Africa. Address to the Annual Review of Monetary Policy in South Africa since 1994 743 Dinner of the Economic Society of South Africa, Pretoria Branch, 15 May.

Taylor, J. (2001). The role of the exchange rate in monetary policy rules, *American Economic Review Papers and Proceedings,* 91, 263-267.

Uhlig, H. (2005). What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics* 52(2), 381-419.

Wang, S., and J. Handa (2007). Monetary policy rules under a fixed exchange rate regime: empirical evidence from China, *Applied Financial Economics*. 17(12), 941-950.

Zellner, A. (1971). *An introduction to bayesian inference in econometrics*, New York: Wiley.

Zhang, W. (2009). China's monetary policy: Quantity versus price rules, *Journal of Macroeconomics*, 31(3), 473-484.

Appendix

A. Data and Summary Statistics

Table A.1: Data sources.

Variable	Source	Definition	Remark
Commodity price	HA	Commodity price index	Deflated
GDP	HA	Gross Domestic Product	CP, SA
Inflation	HA	Change of GDP deflator	CP, SA
Central Bank rate	HA	Central Bank rate	Nominal
M_2 growth rate	HA	M_2 growth rate	Deflated
Exchange rate	HA	Exchange rate versus the U.S. dollar	Deflated
Equity price	HA / GFD*	Composite Index	Deflated

Notes: * for Russia and South Africa.
In the source section, HA stands for Haver Analytics, GFD for Global Financial Database, CP means constant price, SA means seasonally adjusted, and Deflated means deflated using the GDP deflator.

Table A.2: Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Commodity price	311	3.360	3.154	-2.774	7.746
GDP	327	8.240	3.297	4.404	14.060
Inflation	308	0.035	0.076	-0.359	1.110
Central Bank rate	298	16.792	21.571	2.700	180.000
M_2 growth rate	306	0.018	0.046	-0.479	0.208
Exchange rate	311	-0.068	3.965	-8.037	4.121
Equity price	284	5.674	3.298	0.715	9.818

Table A.3: Sample size.

Country	Obs	Sample period
Brazil	43	1998:1-2008:3
China	43	1997:2-2007:4
India	42	1998:2-2008:3
Russia	47	1997:1-2008:3
South Africa	74	1990:2-2008:3

Table A.4: Annual average by country.

	Commodity price	GDP	Inflation	Central Bank rate	M_2 Growth rate	Exchange rate	Equity price
All	3.360	8.240	0.035	16.792	0.018	-0.068	5.674
Brazil	-2.406	4.683	0.052	24.914	0.015	-7.399	1.616
China	2.311	6.145	0.032	5.813	0.017	-1.151	1.6408
India	5.443	8.576	0.013	7.288	0.028	3.673	8.509
Russia	5.941	8.041	0.058	38.148	0.026	3.298	6.304
South Africa	5.619	13.731	0.022	12.966	0.010	1.775	9.060

Note: All series are in logs.

Table A.5: Correlation coefficients.

	Commodity price	GDP	Inflation	Central Bank rate	M_2 Growth rate	Exchange rate	Equity price
Commodity price	1.000						
GDP	0.711	1.000					
Inflation	-0.050	-0.125	1.000				
Central Bank rate	0.066	-0.097	0.599	1.000			
M_2 growth rate	0.028	-0.053	-0.317	-0.107	1.000		
Exchange rate	0.976	0.611	-0.077	0.001	0.063	1.000	
Equity price	0.850	0.858	-0.133	-0.067	0.035	0.806	1.000

Table A.6: Panel unit root test results.

	Commodity price	GDP	Inflation	Central Bank rate	M_2 Growth Rate	Exchange rate	Equity price
Levin, Lin Chu t-stat	-0.378	-0.951	-0.378	-1.236	-0.559	-1.026	-0.831
p-value	0.690	0.466	0.690	0.091	0.998	0.750	0.894
Im, Pesaran and Shin W-stat	-2.240	-3.355	-2.240	-4.036	-2.326	-2.777	-2.573
p-value	0.028	0.000	0.028	0.000	0.017	0.001	0.003

Note: All series are in log differences.

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