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Monetary Policy in Pakistan

Effectiveness in Inflation Control and Stabilization

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Monetary Policy in Pakistan: Effectiveness in Inflation Control and Stabilization*

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Abstract

Empirical evidence from VAR models (based on the conventional identification scheme) suggests that monetary policy shocks have an insignificant impact on output and inflation in Pakistan. This evidence raises concerns about the ability of the State Bank to control inflation and stabilize output. Frictions in the credit and foreign exchange markets in Pakistan could possibly impede the transmission of monetary policy effects, but our analysis of a DSGE model that incorporates such friction indicates that they do not sufficiently weaken the effect of monetary policy shocks to explain the VAR results. Another possibility is that VAR estimates understate the impact of monetary policy because of misidentification of the monetary shock. Analysis of data generated by stochastic simulation of the DSGE model supports this explanation.

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1. Introduction

Inflation and economic growth targets in Pakistan are set by the government and the State Bank of Pakistan (SBP) is responsible for formulating monetary policy to implement these targets. Structural models are useful for constructing different monetary policy scenarios and choosing appropriate policy actions. Macroeconomic effects of monetary policy actions, however, can vary significantly across different models, and empirical evidence is needed to guide the selection of suitable models.

One problem with empirical analysis of monetary policy effects is that changes in policy instruments often reflect a systematic response to variations in macroeconomic conditions. Thus, all shocks to the economy can potentially affect the behavior of policy instruments and their relation to key macroeconomic variables such as inflation and real GDP. One needs to isolate monetary policy shocks from other shocks to disentangle the effects of monetary policy. One widely-used tool for this purpose is the vector autoregressive (VAR) model. VAR models typically use high-frequency (at least quarterly) data to capture the short- and medium-term effects of monetary policy, but a major data limitation for Pakistan is that GDP data are available only on an annual basis. Recently, Hanif et al. (2013) have used interpolation methods to estimate a quarterly series for Pakistan's real GDP. Exploratory VAR analysis by Ahmad and Pasha (2014) utilizing this data suggests that monetary shocks have little effect on both inflation and real GDP in Pakistan.

This paper undertakes an extensive empirical analysis of monetary policy effects in Pakistan. We estimate a wide range of VAR models, which differ in the set of variables used, the choice of the instrument variable and the estimation period. We follow the conventional approach (based on a recursive scheme suggested by Christiano et al., 1999) to identify the monetary policy shock. The impulse response functions (IRFs) derived from the VAR models indicate that monetary policy shocks do not have a significant effect on real GDP and the sign of the effect is sensitive to the choice of the instrument. The short-run effect on inflation is generally negative but weak and insignificant.

The IRFs based on VAR models differ from the IRFs obtained from a Dynamic Stochastic General Equilibrium (DSGE) model designed for Pakistan's economy, which imply that a positive monetary shock (that raises the interest rate) has a contractionary effect on output and inflation. Financial markets in a developing economy like Pakistan are not well developed and fully integrated with the global markets. These conditions can introduce frictions which can impede the transmission of monetary policy effects. Incorporating these frictions in a DSGE model, we find that although these frictions diminish the monetary policy effects, they do not explain the VAR results. The response of output and inflation to the monetary shock in the DSGE model with frictions is significantly different from that estimated from the VAR model.

A possible explanation of the discrepancy between the results of DSGE and VAR models is that the VAR estimates are biased because the recursive structure used by the conventional approach for identifying the monetary policy shock does not generally hold. A number of alternative approaches have been used for the identification of structural shocks.[1] It is difficult, however, to come up with a credible non-recursive identification procedure. Recently, a number of studies have used sign restrictions to identify monetary policy shocks, which require only that the IRFs be consistent with the expected sign of the effect of a shock on certain variables.[2] A

[1] See, Lutz Kilian (2011) for a survey of this literature.
[2] See, for example, Canova and De Nicolo (2002), Peersman (2005) and Uhlig (2005). Also see Fry and Pagan (2010) for a critical review of this approach.

major limitation of this approach, however, is that sign restrictions do not imply unique IRFs, but generally yield a large set of IRFs. As no satisfactory alternative identification procedure is available, our strategy is to use simulated data from a DSGE model to estimate a VAR and explore how the recursive identification scheme might distort the IRFs for the monetary shock. An interesting result of this analysis is that the IRFs based on the recursive scheme indicate that the effect of the monetary policy shock on output and inflation is not significantly different from zero even though the true effect on these variables is clearly negative.

The next section describes the evolution of monetary policy in Pakistan and some stylized facts. Section 3 examines the evidence from the basic VAR model and its various extensions. Section 4 discusses results from DSGE models and compares their IRFs with those of the VAR models. The last section concludes.

2. Evolution of Monetary Policy in Pakistan

The monetary policy in Pakistan has evolved in response to structural developments in the domestic economy and changing dynamics in the international market. Although SBP Act 1956 assigned the dual objectives of stabilizing inflation at low level and sustaining high economic growth to monetary policy in Pakistan,[3] SBP did not have either any authority or the appropriate instruments to pursue these goals before 1990's. However, one important function of SBP was to implement the exchange rate policy. The exchange rate was fixed until 1982 and was then replaced by managed float. During the 1970's through 1990's, SBP's monetary policy had a

[3] See the Preamble to the Act and Section 9A (and sub-clause a) for this act.

limited role and was concerned primarily with administering directed credits to priority sectors at subsidized interest rates.[4]

In early 1990s, the government took initiatives for reforming the financial sector in Pakistan by privatizing some of nationalized banks and allowing residents to open foreign currency accounts. As part of financial sector reforms, SBP discontinued direct intervention in the market and adopted a market-based monetary and credit management system. Specifically, SBP introduced auction of governments' treasury bills (6-months T-bills) in 1992. In February 1992, it also introduced a 3-days Repo facility, which allowed commercial banks to obtain liquidity (overnight or up to 3-days in lieu of treasury bills as collateral) at SBP Reverse Repo rate.[5] SBP began to use this rate as a policy instrument and it is called the policy rate. Moreover, SBP replaced the system of credit ceiling with a system in which banks were free to extend credit within limits set in relation to the credit-deposit ratio. In the pursuit of financial market liberalization, SBP eventually abolished the use of the credit-deposit ratio as an instrument of credit control in 1995, and introduced *indicative* annual targets of monetary aggregates.

Monetary and credit policies continued to operate within the framework of Annual Credit Plan, in which the credit expansion during the year was calculated on the basis of growth and inflation targets set by the government.[6] In addition to the policy rate, SBP had a variety of instruments - - open market operations (OMOs), changes in cash reserve requirements (CRR) and statutory liquidity requirements (SLR) - - to implement the targeted monetary and credit expansion.

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[4] National Credit Consultative Council (NCCC) was established in early 1972, where the government set annual credit targets of commercial banks for priorities in agriculture and industrial sectors.

[5] The Repo facility replaced the discount window where commercial banks could rediscount bill of exchange or other eligible commercial paper at the Bank rate. The Bank rate was changed rarely. For instance, it remained at 10 percent during July 1977 through January 1992.

[6] Government, however, continued to set mandatory credit targets for priority sectors of agriculture and industrial sectors.

From 2001 onwards, SBP stopped giving indicative credit targets in order to move towards a more market-based monetary policy. The credit planning exercise was officially abandoned in 2006 and the National Credit Consultative Council (NCCC) was replaced with Private Sector Credit Advisory Committee (PSCAC) with a view to discuss the issues related to availability of credit with business community representatives. During this period, both the primary and secondary markets for intermediate (i.e. 12-month Treasury Bills) to long-term (FIBs and PIBs) government papers were gradually developed. At the same time, the exchange rate was gradually allowed to be influenced by market forces, which enhanced further the capital and financial accounts convertibility.

In 2006, SBP implicitly started to monitor the short-term money market interest rate in order to influence aggregate demand and arrest inflationary pressure on the economy. To further rationalize monetary policy, SBP explicitly announced an interest rate corridor (with SBP Reverse Repo rate as ceiling and SBP repo rate as floor) in August 2009. The overnight money market repo rate moves within the announced interest rate corridor. SBP also introduced standing facilities to manage liquidity in the money market and align the short term market interest rate with the monetary policy stance.

During the years, SBP monetary policy decision making process has also evolved over time with the amendments in SBP Act. These amendments not only enhanced the SBP authority in deciding monetary policy stance but also improved the operational tools available for monetary management. Although SBP does not have the independence to set growth and inflation targets, it acquired the authority to implement these targets.

The Reverse Repo or the policy rate is the primary instrument of monetary policy in Pakistan. The 6-month Treasury Bill (TB) rate has closely followed the policy rate except in

2003-4 when large capital inflows lead to a fall in the TB rate causing it to diverge temporarily from the policy rate (see Figure 1). Because of the tendency of the two rates to move together, the market often perceives the TB rate to be an indicator of monetary policy. The dynamic relation of these rates with key macroeconomic variables in the recent period (2002Q1 to 2014Q4) is illustrated in Figures 2 and 3. Figure 2 shows dynamic correlation between interest rates and de-trended GDP (in logs) as a measure of output gap (the difference between actual and potential output).[7] The output gap is negatively correlated with the interest rates at the lags and positively correlated at the leads. These correlations, however, are small (are generally between -0.2 and 0.2). Figure 3 shows dynamic correlation between the interest rates and quarterly de-trended CPI inflation.[8] CPI inflation has a negative but small (between 0 and around -0.1) correlation with lagged interest rates and a positive but also small correlation with the current-period interest rate.

Dynamic correlation estimates provide a useful description of the interaction between policy instruments and macroeconomic conditions, but they are sensitive to the realization of different shocks. Monetary policy would be expected to raise interest rates in response to higher inflation and output in the pursuit of the twin goals of inflation control and output stabilization. Thus, non-monetary policy shocks to inflation and output would produce a positive correlation between these variables and the interest rates. On the other hand, monetary policy shocks (changes in interest rates not systematically related to macroeconomic variables) would have a contractionary effect on inflation and output and thus lead to a negative correlation between

[7] For quarterly real GDP, we use a recent series constructed by SBP staff which utilizes several indicator variables (available at quarterly frequency) and interpolation techniques to convert annual to quarterly data. Hodrick-Prescott filter is used to remove stochastic trend (assumed to be a measure of potential output). Output gap is expressed as a percentage rate.

[8] Inflation is measured by quarterly change in CPI in logs and is expressed as an annual percentage rate (i.e., the first difference in the log of quarterly CPI is multiplied by 400). Hodrick-Prescott filter is used to de-trend the inflation rate.

these variables and the interest rates. In the presence of both type of shocks, the signs and the magnitudes of correlations (contemporaneous as well as at different lags and leads) are ambiguous. Monetary policy shocks need to be isolated to draw inferences about the effectiveness and the conduct of monetary policy, and we turn to VAR models in the next section for this purpose.

3. Evidence from VAR Models

In this section, we estimate a variety of VAR models to explore the response of key macroeconomic variables to monetary policy shocks. Let Y_t denote an m-dimensional time series. Assume that it can be approximated by a VAR of order p given by

$$Y_t = c + B_1 Y_{t-1} + ... + B_p Y_{t-p} + u_t, \quad (1)$$

where u_t is a $m \times 1$ vector of reduced-form shocks, B_i's $(i = 1,..., p)$ are $m \times m$ matrices of coefficients, and c is a $m \times 1$ vector of intercepts (the VAR could also include a time trend). Consistent estimates of the VAR parameters can be obtained by ordinary least squares, which can be used to derive IRFs showing the response of all variables to each reduced-form shock. These shocks, however, are one step ahead forecast errors and do not represent the fundamental or structural shocks.

To relate reduced-form to structural shocks, assume that the structural model for Y_t is of the following form:

$$A_0 Y_t = c' + A_1 Y_{t-1} + ... + A_p Y_{t-p} + \varepsilon_t, \quad (2)$$

where ε_t is a m-dimensional vector of orthogonal structural shocks, c' is a $m \times 1$ vector of intercepts, and A_i's $(i = 0,..., p)$ are $m \times m$ coefficient matrices. The shock to monetary policy is of special interest and can be defined as the change in the instrument variable that is not accounted by the systematic monetary policy response to the state of the economy. The systematic response can be referred to as the monetary policy rule and can be identified with the equation in (2) which determines the instrument variable. The shock in this equation represents the monetary policy shock.

Pre-multiplying (1) with A_0 and relating the resulting equation to (2), we obtain the following correspondence between the reduced-form and structural shocks:

$$A_0 u_t = \varepsilon_t . \tag{3}$$

As (3) indicates, structural shocks are a weighted average of reduced-form shocks with weights (possibly equal to zero in some cases) given by matrix A_0. Thus, knowledge of this matrix is needed to identify structural shocks and derive IRFs for these shocks.

The conventional approach for identifying monetary policy shocks is based on a recursive scheme suggested by Christiano et al. (1999). To explain this scheme, let Z_t denote the instrument variable and partition the other variables in Y_t into two sets: $X_{1,t}$, and $X_{2,t}$. Variables in $X_{1,t}$ (generally associated with the goods markets) are assumed to be determined before Z_t is set while those in $X_{2,t}$ (typically associated with the money and financial markets) are assumed to be determined after the setting of Z_t. Thus the equations for the variables in $X_{1,t}$ do not include the contemporaneous values of variables in $X_{2,t}$ and Z_t, while the contemporaneous values of variables in $X_{2,t}$ are absent in the equation for Z_t.[9] Given these restrictions, it can be shown that the monetary policy shock can be identified using Choleski decomposition with variables in Y_t ordered such that the $X_{1,t}$ variable are included before and the $X_{2,t}$ variables after Z_t.[10]

The exclusion restrictions used in the above identification scheme are controversial and do not hold in many macroeconomic models. Indeed, they are not consistent with standard DSGE models, which imply that the monetary shock has a contemporaneous effect on output and inflation. However, as there is no consensus on non-recursive restrictions to identify matrix A_0, we focus on the conventional recursive scheme in this section, but later use simulated data from DSGE models to explore the bias introduced if this scheme is used to identify monetary policy shocks.

We first consider a basic 3-variable VAR that is often used (e.g., Castelnuovo and Surico, 2010) and can be related to small scale macroeconomic models. The three variables in this model are output gap, inflation and the monetary policy instrument. For the identification of the monetary policy shock, output gap and inflation are assumed to belong to set $X_{1,t}$ (set $X_{2,t}$ is empty in this case). For the instrument variable, we use two alternative indexes: the policy rate and the TB rate. We include 4 lags in the VAR.[11]As the monetary policy in Pakistan acquired the

[9] These restrictions imply that in matrix A_0, the rows corresponding to the $X_{1,t}$ variables have zeroes in the columns for Z_t and the $X_{2,t}$ variables, and the row for the Z_t contain zeroes in the columns corresponding to the $X_{2,t}$ variables.

[10] The ordering of variables within the $X_{1,t}$ and $X_{2,t}$ does not matter for the derivation of the IRFs for the monetary shocks.

[11] We also explored VARs with number of lags determined by several criteria, but as the basic results were not very sensitive to the choice of lags, we report below only the results for VARs with 4 lags.

authority and the instruments to control inflation and stabilize output in the 1990's, we use a sample period from 1991Q1 to 2014Q4.

For each measure of the instrument variable, the IRFs for the monetary policy shock are shown in Figure 4. The shock to the policy rate exerts a negative initial effect on both output gap and inflation as predicted by the theory, but this effect is weak and not significantly different from zero. The initial effect of the shock to the TB rate on output and inflation is similarly weak and insignificant (also, the sign of the initial output effect is reversed). The interest rate response to the shock is slightly more persistent for the policy rate than for the TB rate. We also explored variations of the basic VAR, which introduced a deterministic trend or alternatively, removed stochastic trends (using the Hodrick-Prescott filter) from the series for inflation and the interest rates.[12] These variations made little difference to the results.

As there were important changes in Pakistan's monetary policy in the early and mid 2000's, it can be argued that SBP's feedback rule may have shifted. To examine this possibility, we tested the VAR equation for the instrument variable for a shift around 2002Q1 and 2005Q1. Chow breakpoint test indicates a significant shift at the earlier date for the policy rate, and at the latter date for the TB rate. We re-estimated the policy rate and the TB rate VARs using the post-shift samples for the two rates. The IRFs based on these VARs still imply an insignificant response of output gap and inflation to the monetary shock (see Figure 5).

We next examine VAR models that extend the basic model to include additional variables. First, we explore models that use the policy rate as the instrument variable and include one or more financial variables in the $X_{2,t}$ set. These models reflect the view that the policy rate

[12] A motivation for detrending the inflation and interest rate series is that the inflation target or the long-run real interest rate is not constant over time.

is the primary instrument of monetary policy and does not react to financial variables, but these variables are needed to capture the transmission of monetary policy effects. In addition to the TB rate, we consider the following two variables as possible candidates for inclusion in the $X_{2,t}$ set: 4-quarter growth rate of M2 and quarterly rate of rupee depreciation relative to the US dollar, both expressed as percentage rates.[13]

Figure 6 displays the IRFs for the monetary policy shocks derived from the extended VAR models that add one financial variable at a time and are estimated for the whole sample. Addition of a financial variable to the VAR makes little difference to the effects of the monetary shock on output gap and inflation, which remain insignificant. In the VAR that includes the TB rate, the shock to the policy rate does have a significant effect on TB rate, which is consistent with the view that this rate is a useful indicator of monetary policy. In the VAR with M2 growth, the effect of the policy rate shock has the expected negative sign on money growth, but this effect is not significant. When exchange rate depreciation is included in the VAR, the effect of the policy rate shock on depreciation does not have the expected sign and is insignificant. These results change little even if we add all three variables to the VAR at the same time (instead of one at a time).

The VARs discussed above assume that the contemporaneous values of money growth or exchange rate depreciation do not enter the monetary policy rule. To check the sensitivity of the results to this assumption, we also explored variations where these variables were moved from the $X_{2,t}$ set to $X_{1,t}$ set (i.e., these variables were placed before the policy rate in the Cholesky

[13] Since one-quarter growth rate of M2 is noisy, we use the growth rate over 4 quarters defined as $[\log(M2_t) - \log(M2_{t-4})] \times 100$, where $M2_t$ is the average $M2$ money stock in quarter t. Letting er_t denote the average rupee/US dollar exchange rate in quarter t, the rupee depreciation rate is defined as $[\log(er_t) - \log(er_{t-1})] \times 100$.

decomposition), but these variations did not appreciably alter the response of either output gap or inflation to the policy rate shock.

4. Results from DSGE Models

The IRFs based on the VAR models indicate that monetary policy shocks do not have an appreciable effect on output and inflation. In this section, we use DSGE models to understand this result which suggests that monetary policy in Pakistan is ineffective. One potential explanation is that in a developing country like Pakistan, there are frictions in the credit and foreign exchange markets that impede the transmission of monetary policy effects. In the standard macroeconomic model, the effects of monetary policy operate mainly through two channels: interest rates and the exchange rate.[14] A positive shock to the policy interest rate increases the market interest rates which reduce investment and consumption. It also raises the exchange rate which worsens the trade balance. These effects decrease aggregate demand and thus cause a decline in output and inflation. Both of these channels may not function well in developing countries. Imperfections in the credit market can weaken the link between the policy and the market interest rates.[15] Lack of integration between domestic and foreign financial markets can diminish the impact of the policy rate on the exchange rate.

Choudhri and Hamza (2014) introduce these types of frictions in a DSGE model designed for monetary policy analysis in Pakistan. The model includes a banking sector that provides

[14] These effects, in fact, operate through real values of these variables. It is assumed that the response of the policy rate to inflation is sufficiently strong (i.e., the policy follows the Taylor principle) to cause a rise in both the nominal and real interest rates. Also, wages and prices are assumed to be sticky so that nominal and real exchange rates move together.
[15] Low pass-through from policy rate to interest rate on bank loans is observed in a number of low-income countries (Mishra et al., 2010).

intermediary financial services and allows for international financial transactions.[16] A friction in the credit market is introduced in this model by assuming that there are adjustment costs in setting the rate on bank loans (which finance investment). These costs make the bank loan rate sticky and thus weaken the short-run response of this rate to the policy interest rate. An exchange market friction is added to the model by the assumption that there are large transaction costs in international borrowing (lending), which increase in the stock of foreign liabilities (assets). This assumption has two important implications. First, intervention in the foreign exchange market (via buying or selling of international reserves) can have a significant influence on the exchange rate and can be used to reduce its volatility.[17] Second, if the exchange rate is stabilized, the impact of the policy interest rate on the exchange rate is weakened. The short-run effect of monetary policy in the model is further reduced by the additional assumptions that household expectation are an average of forward- and backward-looking expectations and the policy rate responds to current inflation.

The role of the frictions in determining monetary policy effectiveness is illustrated in Figure 7, which shows how the response of output and inflation to a monetary shock in the model with frictions differs from that without frictions.[18] In the model without frictions, we also let household price expectations be fully forward-looking and the policy rate to react to expected future inflation. In the model with frictions, a contractionary monetary policy shock (a positive

[16] The model also distinguishes between two types of households: low-income households who are liquidity constrained and high-income households who participate in the financial markets.
[17] If costs for international financial transactions are very small, then intervention in the foreign exchange market would cause an offsetting international capital flow and have little impact on the exchange rate.
[18] See the appendix for the specification of the models with and without frictions and their calibration. For further discussion of these models, see Choudhri and Malik (2013, 2014). The IRFs for the monetary shock in the figure are based on the values of the interest rate smoothing parameter in the monetary policy rule (ϕ_{rr}) and the standard deviation of the monetary shock ($x_{R,t}$), which were calibrated for the stochastic simulation discussed below.

shock to the policy interest rate) causes a considerably smaller decline in both output and inflation in the first two quarters than the model without frictions.

We next examine whether the DSGE model that incorporates frictions can explain the empirical results of the VAR model. Figure 8 compares the responses of output and inflation to a monetary shock in the two models. To facilitate comparison between the two models, the value of the monetary shock in each model has been adjusted such that it produces a one percent increase in the interest rate in the first quarter.[19] Even in the presence of frictions, the impact of the monetary shock on both output and inflation is much stronger in the DSGE than in the VAR model. The IRF for output from the DSGE model lies outside the 95% band for the IRF from the VAR model in the short and intermediate run. The 95% band for the VAR IRF for inflation is much wider, but even in this case, the DSGE IRF is outside the band in the first two quarters. Thus, although credit and exchange market frictions can account for less effective monetary policy, they do not appear to be a sufficiently strong factor for explaining the empirical evidence from VARs.

The VAR results use the recursive scheme with zero restrictions to identify the monetary shock. These restrictions are inconsistent with the DSGE model which implies a significant contemporaneous effect of the monetary shock on output and inflation (see Figure 8). If zero restrictions do not hold, the recursive scheme misidentifies the monetary shock and biases the estimates of the IRFs. To explore the direction and the degree of this bias, we undertake stochastic simulations of the DSGE model. These simulations are used to generate artificial series for the variables included in the VAR model. We then use the recursive scheme to identify

[19] To relate it to the DSGE model (where the central bank controls the interest rate on government bonds), we use the VAR where the policy instrument is the TB rate.

the monetary shock in the VAR model estimated from the artificial data, and examine how the IRFs based on the recursive scheme distort the true IRFs.

Potentially, shocks and the IRFs in a DSGE model can be matched with those in a properly-identified VAR model. Fernandez-Villaverde et al. (2007) derive an "invertibility" condition under which the behavior of observable variables in a DSGE model can be described by an infinite order VAR process. A VAR with finite lags can be estimated to approximate the infinite order process.[20] A necessary requirement to satisfy the invertibility condition is that the number of shocks equals the number of variables in the VAR.

To relate our DSGE model to the basic 3-variable VAR, we consider three shocks in the stochastic simulation of the DSGE model: a shock to government expenditures, a shock to TFP and a shock to the monetary policy rule. The government expenditure and TFP shocks follow an AR(1) process [see equations (54) and (55) in the appendix]. The autoregressive coefficients and the standard errors of the innovations for these processes are estimated from the quarterly time series for real government expenditures and TFP. For the monetary policy rule [equation (50) in the appendix], the interest rate smoothing parameter and the standard deviation of the monetary policy shock are chosen to match the standard deviations of output gap and inflation of the simulated data to those of the real data. The length of the simulated series was set equal to the size of the full sample (96 quarters).[21]

We use the model with frictions for stochastic simulation. Figure 9 shows the dynamic response of output gap and inflation to the monetary policy shock estimated from the simulated

[20] However, the structural matrix (A_0) needs to be identified in order to recover true IRFs from the VAR. Liu, and Theodoridis (2012) suggest an identification strategy that uses both qualitative and quantitative restrictions implied by the DSGE model.

[21] In fact, simulations were generated for 196 quarters and the first hundred values were dropped.

data using the recursive scheme to identify the shock. The monetary policy shock so identified has an insignificant effect (the zero line lies in the 95% band) on both output and inflation. We experimented with stochastic simulations of model variations (which removed certain frictions), but the results were similar. These results suggest that the improper use of zero restrictions to identify monetary shocks can introduce a sufficient bias to make the monetary policy effect appear not significantly different from zero when the true effect is negative.

5. Conclusions

This paper explores why the conventional VAR analysis (based on the recursive identification scheme) finds the monetary policy shock to have an insignificant impact on output and inflation in Pakistan. One possible explanation is that credit and exchange market frictions diminish the effectiveness of monetary policy in Pakistan. After introducing such frictions in a DSGE model designed for Pakistan's economy, we find that their presence in the model is not enough, by itself, to explain the VAR results. Another explanation of why the VAR results differ from the predictions of the DSGE model is that these results are biased because the recursive scheme does not properly identify the monetary policy shock. Stochastic simulation of the DSGE model supports this explanation: VAR estimates based on simulated data generated by a model where monetary policy exerts significant effects, can produce the result that monetary policy is ineffective if the recursive scheme is used to identify the monetary shock.

There is need for further empirical work to explore what variant of the DSGE model fits the data better and is well suited as a tool of monetary policy analysis. A promising approach would be to employ widely-used Bayesian methods to estimate and evaluate DSGE models for Pakistan. One difficulty with this approach is that there is limited availability of time series for key macro variables at quarterly frequency. However, a reasonable quarterly data set can be assembled using interpolation techniques to convert annual to quarterly series, and this set could be used to estimate at least a small scale DSGE model. It would also be useful to relate DSGE and VAR models and explore if IRFs form an estimated DSGE model can be matched with those from a structural VAR that identifies shocks using restrictions that are more general than the estimated DSGE model.

Appendix

Model with Frictions

Model Equations

H (high-income) households

$$c_{H,t} = \frac{sumni_t + b^*_{t-1}}{sumr_t}, \tag{4}$$

$$sumni_t = \frac{1}{s_t(1+r^*)(1-TC_{t-1})} ni_t + \frac{1}{(1+r^*)(1-TC_{t-1})} sumni_{t+1}, \tag{5}$$

$$sumr_t = \frac{1}{s_t(1+r^*)(1-TC_{t-1})} + \frac{\left[\beta(1+r_t)\right]^{1/\theta}}{(1+r^*)(1-TC_{t-1})} sumr_{t+1}, \tag{6}$$

$$ni_t = p_{X,t} z_{X,t} + p_{D,t} z_{D,t} + s_t r\bar{m}^*_t - i_t - g_t - c_{L,t} - AC_t, \tag{7}$$

$$b^*_t = (1+r^*)(1-TC_{t-1}) b^*_{t-1} + (ni_t - c_t)/s_t, \tag{8}$$

$$(1+r_t) = \frac{E_t s_{t+1}(1+r^*_t)(1-TC_t)}{s_t}, \tag{9}$$

$$TC_t = \frac{e^{\mu b*} - 1}{e^{\mu b*} + 1}, \tag{10}$$

$$cu_{H,t}{}^{-\chi} = \frac{c_{H,t}{}^{-\theta}}{\xi_{HC}} \left(\frac{1 + r_t - 1/\Pi^e_t}{1 + r_t} \right), \tag{11}$$

$$d_{H,t}{}^{-\kappa} = \frac{c_{H,t}{}^{-\theta}}{\xi_{HD}} \left(\frac{r_t - r_{D,t}}{1 + r_t} \right), \tag{12}$$

$$(1-AC_{WH,t})(\varepsilon-1)w_{H,t}=\varepsilon\xi_{HN}(n_t)^{\nu}(c_{Ht})^{\theta}-(w_{H,t})^2\frac{\partial AC_{WH,t}}{\partial w_{H,t}}$$
$$-\frac{1}{1+r_t}\frac{n_{H,t+1}}{n_{H,t}}\frac{w_{H,t}w_{H,t+1}}{\Pi_t^e}\frac{\partial AC_{WH,t+1}}{\partial w_{H,t}}, \tag{13}$$

$$\Pi_t^e=(E_t\Pi_{t+1})^{\Lambda}(\Pi_{t-1})^{1-\Lambda},\quad 0<\Lambda\le 1, \tag{14}$$

$$AC_{WH,t}=\frac{\omega_{WH}}{2}\left(\frac{w_{H,t}\Pi_t}{w_{H,t-1}\Pi_{t-1}}-1\right)^2, \tag{15}$$

L (low-income) households

$$c_{L,t}=w_{L,t}n_{L,t}(1-AC_{WL,t}(l))+s_t r\bar{m}_t^*+cu_{L,t-1}/\Pi_t-cu_{L,t}-\tau_{L,t}, \tag{16}$$

$$cu_{L,t}{}^{-\chi}=\frac{c_{L,t}{}^{-\theta}}{\xi_{LC}}\left(1-\frac{\beta E_t c_{L,t+1}{}^{-\theta}}{\Pi_t^e c_{L,t}{}^{-\theta}}\right), \tag{17}$$

$$(1-AC_{WL,t})(\varepsilon-1)w_{L,t}=\varepsilon\xi_{LN}n_{L,t}{}^{\nu}c_{L,t}{}^{\theta}-w_{L,t}{}^2\frac{\partial AC_{WL,t}}{\partial w_{L,t}}$$
$$-\frac{1}{1+r_t}\frac{n_{L,t+1}}{n_{L,t}}\frac{w_{L,t}w_{L,t+1}}{\Pi_{t+1}^e}\frac{\partial AC_{WL,t+1}}{\partial w_{L,t}}, \tag{18}$$

$$AC_{WL,t}=\frac{\omega_{WL}}{2}\left(\frac{w_{L,t}\Pi_t}{w_{L,t-1}\Pi_{t-1}}-1\right)^2, \tag{19}$$

Banks

$$d_{H,t}=\xi_{BD}(cr_t)^{\gamma}(b_{B,t})^{1-\gamma}, \tag{20}$$

$$l_{B,t}=\xi_{BL}n_{HB,t}, \tag{21}$$

$$cr_t+b_{B,t}+l_{B,t}=d_{H,t}, \tag{22}$$

$$cr_t = \gamma \left[\frac{\lambda_{B,t} - (1 + r_{D,t})}{\lambda_{B,t} - 1 / \Pi_t^e} \right] d_{H,t} \, , \tag{23}$$

$$b_{B,t} = (1-\gamma) \left[\frac{\lambda_{B,t} - (1 + r_{D,t})}{\lambda_{B,t} - (1 + r_t)} \right] d_{H,t} \, , \tag{24}$$

$$\begin{aligned} \lambda_{B,t} &= (1 - AC_{B,t})[1 + r_{L,t}(1 - 1/\sigma_B)] + (1 + r_{L,t})(r_{L,t} / \sigma_B)(\partial AC_{B,t} / \partial r_{L,t}) - (w_{H,t} / \xi_{BL,t}) \\ &+ \beta (c_{H,t+1}^{-\theta} / c_{H,t}^{-\theta}) \left[(1 + r_{L,t+1})(l_{B,t+1} / l_{B,t})(r_{L,t} / \sigma_B)(\partial AC_{B,t+1} / \partial r_{L,t}) \right], \end{aligned} \tag{25}$$

$$AC_{B,t} = \frac{\omega_B}{2} \left(\frac{[1 + r_{L,t}(b)]}{[1 + r_{L,t-1}(b)]} - 1 \right)^2 , \tag{26}$$

Investment

$$q_t = 1 + \omega_I \left(\frac{i_t}{k_t} - \delta \right), \tag{27}$$

$$1 + r_{L,t} = \frac{E_t re_{t+1} + (1-\delta) E_t q_{t+1}}{q_t} \, , \tag{28}$$

$$k_{t+1} = i_t + (1-\delta) k_t \, , \tag{29}$$

$$i_t = l_{B,t} - \overline{l}_H \, , \tag{30}$$

Demand

$$z_t = c_{H,t} + c_{L,t} + i_t + g_t - AC_t \, , \tag{31}$$

$$AC_t = (p_{D,t} - mc_t) z_{D,t} AC_{PD,t} + (p_{X,t} - mc_t) z_{X,t} AC_{PX,t} + AC_{WH,t} w_{H,t} n_{H,t} + AC_{WL,t} w_{L,t} n_{L,t} + AC_{I,t} \, , \tag{32}$$

$$z_{D,t} = (1-\psi) z_t \, p_{D,t}{}^{-\eta} \, , \tag{33}$$

$$z_{M,t} = \psi z_t \, p_{M,t}{}^{-\eta} \, , \tag{34}$$

$$1=\left[\psi\, p_{M,t}{}^{1-\eta}+(1-\psi)\, p_{D,t}{}^{1-\eta}\right]^{\frac{1}{1-\eta}}, \tag{35}$$

$$z_{X,t}=\psi^{*} z_t{}^{*}(p_{X,t}^{*})^{-\eta}, \tag{36}$$

Firms

$$y_t=\xi_{Y,t} n_{HY,t}{}^{\alpha_H} n_{L,t}{}^{\alpha_L} k_t^{1-\alpha_H-\alpha_L}, \tag{37}$$

$$n_{HY,t}=\alpha_H y_t mc_t / w_{H,t}, \tag{38}$$

$$n_{L,t}=\alpha_L y_t mc_t / w_{L,t}, \tag{39}$$

$$n_{H,t}=n_{HY,t}+n_{HB,t}, \tag{40}$$

$$k_t=(1-\alpha_H-\alpha_L) y_t mc_t / re_t, \tag{41}$$

$$y_t=z_{D,t}+z_{X,t}, \tag{42}$$

$$AC_{PD,t}=\frac{\omega_P}{2}\left(\frac{p_{D,t}\Pi_t}{p_{D,t-1}\Pi_{t-1}}-1\right)^2, \tag{43}$$

$$AC_{PX,t}=\frac{\omega_P}{2}\left(\frac{p_{X,t}\Pi_t}{p_{X,t-1}\Pi_{t-1}}-1\right)^2, \tag{44}$$

$$\begin{aligned}(1-AC_{PD,t})\left[(\sigma-1)p_{D,t}-\sigma mc_t\right]&=-p_{D,t}(p_{D,t}-mc_t)\frac{\partial AC_{PD,t}}{\partial p_{D,t}}\\&-\frac{z_{D,t+1}}{(1+r_t)z_{D,t}}p_{D,t}(p_{D,t+1}-mc_{t+1})\frac{\partial AC_{PD,t+1}}{\partial p_{D,t}},\end{aligned} \tag{45}$$

$$\begin{aligned}(1-AC_{PX,t})\left[(\sigma-1)p_{X,t}-\sigma mc_t\right]&=-p_{X,t}(p_{X,t}-mc_t)\frac{\partial AC_{PX,t}}{\partial p_{X,t}}\\&-\frac{z_{X,t+1}}{(1+r_t)z_{X,t}}p_{X,t}(p_{X,t+1}-mc_{t+1})\frac{\partial AC_{PX,t+1}}{\partial p_{X,t}},\end{aligned} \tag{46}$$

$$p_{M.t} = s_t \bar{p}^*_{M,t} \,, \tag{47}$$

$$p_{X.t} = s_t p^*_{X,t} \,, \tag{48}$$

Fiscal and monetary policy

$$b_t = g_t - \tau_{H,t} - \bar{\tau}_L - (mb_t - mb_{t-1} / \Pi_t) + (1 + r_{t-1}) b_{t-1} \,, \tag{49}$$

$$\tau_{H,t} = \bar{\tau}_H + \phi_{\tau b} \left(b_{t-1} - \bar{b} \right), \tag{50}$$

$$m\bar{b}(1 - 1/\bar{\Pi}) = \bar{g} - \bar{\tau}_H - \bar{\tau}_L + \bar{r}\bar{b} \,, \tag{51}$$

$$mb_t = cu_{H,t} + cu_{L,t} + cr_t \,, \tag{52}$$

$$\ln(1 + R_t) = \phi_{rr} \ln(1 + R_{t-1}) + (1 - \phi_{rr}) \{ \ln(1 + \bar{R}) + (1 + \phi_{r\pi}) \ln(\Pi_t / \bar{\Pi}) + \phi_{ry} \ln(y_t / \bar{y}) \} + x_{R,t} \,, \tag{53}$$

$$1 + r_t = (1 + R_t) / \Pi^e_t \,, \tag{54}$$

$$1 + \bar{R} = (1 + \bar{r}) \bar{\Pi} \,, \tag{55}$$

$$dirs^*_t = \phi_{ir} (s_t - \bar{s}) \,, \tag{56}$$

Shocks

$$\ln g_t = (1 - \rho_G) \ln \bar{g} + \rho_G \ln g_{t-1} + x_{G,t} \,, \tag{57}$$

$$\ln \xi_{Y,t} = (1 - \rho_Y) \ln \bar{\xi}_Y + \rho_Y \ln \xi_{Y,t-1} + x_{Y,t} \,. \tag{58}$$

Endogenous variables

Note: Real values are expressed in terms of the home composite good while foreign real value are in expressed in terms of the foreign composite good. The real exchange rate represents the price of the foreign composite good in terms of the home composite good.

AC_t = total adjustment costs; $AC_{B,t}$ = adjustment costs for bank loans; $AC_{PD,t}$ = adjustment costs for domestic prices; $AC_{PX,t}$ = adjustment costs for export prices; $AC_{WH,t}$ = adjustment costs for H household wages; $AC_{WL,t}$ = adjustment costs for L household wages; b_t = real stock of domestic bonds; b_t^* = real stock of foreign bonds; $b_{B,t}$ = banks holding of domestic bonds; $c_{H,t}$ = real consumption of H households; $c_{L,t}$ = real consumption of L households; cr_t = banks real cash resrerves; $cu_{H,t}$ = real currency held by H households; $cu_{L,t}$ = real currency held by L households; $d_{H,t}$ = real deposits held by H households; $dirs_t^*$ = change in foreign real value of international reserves; g_t = real govt. expenditures; i_t = real investment; k_t =capital stock; $l_{B,t}$ = real bank loans; mb_t = real monetary base; mc_t = real marginal cost; $n_{H,t}$ = total labor supply of H households; $n_{HB,t}$ = banks labor demand for H households ; $n_{HY,t}$ = firms labor demand for H households; $n_{L,t}$ = labor supply of L households; ni_t = H households net real income; $p_{D,t}$ = real price of domestic goods; $p_{M,t}$ = real price of imports; $p_{X,t}$ = real price of exports; $p^*_{X,t}$ = foreign real price of exports; q_t = real price of installed capital; r_t = real interest rate; $r_{D,t}$ = real deposit rate; $r_{L,t}$ = real loan rate; re_t = rental rate for capital; R_t = nominal interest rate; $\bar{R}$ = nominal long-run interest rate; $w_{H,t}$ = H households real wage; $w_{L,t}$ = L households real wage; y_t = ouput; s_t = real exchange rate; $sumni_t$ = discounted value of H households net income stream; $sumr_t$ = a conversion factor; TC_t = transaction cost for foreign bonds; z_t = total real expenditure; $z_{D,t}$ = real expenditure on domestic goods; $z_{M,t}$ = real expenditure on imports; $z_{X,t}$ = real expenditure on exports; $\lambda_{B,t}$ = shadow price for banks constraint ; $\tau_{H,t}$ = H households real taxes; $\bar{\tau}_H$ = long-run value for $\tau_{H,t}$; Π_t = current to last period price ratio; Π_t^e = expected value of Π_t; $\xi_{Y,t}$ = total factor productivity.

Exogenous variables

Note: Values of the exogenous variables are given in parenthesis.

$\bar{b}$ = target value for govenment bonds (0.6); $\bar{g}$ = long-run value of g_t (0.198); $\overline{mb}$ = long-run value of mb_t (0.589206); $\bar{l}_H$ = real value of household loans from banks (.166095); $\bar{p}^*_M$ = foreign real value of imports (1); $\bar{r}$ = long-run value of the real interest rate (0.01); $\overline{rm}_t^*$ = foreign real value of remittances (0.042); $\bar{\tau}_L$ = real value of L household taxes (0.075); $\bar{\Pi}$ = target value of Π_t (1.025); $x_{G,t}$ = shock to the process for g_t; $x_{R,t}$ = shock to the interest rate rule; $x_{Y,t}$ = shock to the process for $\xi_{Y,t}$.

Parameters

$\alpha_H = 0.363, \quad \alpha_L = .0242, \quad \beta = 1/1.01, \quad \chi = 1.01, \quad \delta = 0.0203472, \quad \varepsilon = 6, \quad \phi_{ir} = -5, \quad \phi_{rr} = 0.65, \quad \phi_{r\pi} = 0.1,$
$\phi_{ry} = 0, \quad \phi_{\tau b} = 0.025, \quad \gamma = 0.778876, \quad \eta = 2, \quad \mu = 20, \quad \nu = 2, \quad \theta = 1.01, \quad \rho_G = 0.86, \quad \rho_Y = 0.88, \quad \sigma = 6, \quad \sigma_B = 10,$
$\omega_b = 1200, \omega_I = 4, \quad \omega_{WH} = 400, \quad \omega_{WL} = 200, \quad \omega_P = 100, \quad \xi_{BL} = 377.777, \quad \xi_{HC} = 0.0192189, \quad \xi_{BD} = 11.1569,$
$\xi_{HD} = 0.00321047, \xi_{LC} = 0.038543, \quad \xi_{HN} = 18.588, \quad \xi_{LN} = 6.39184, \quad \bar{\xi}_Y = 0.740024, \quad \psi = 0.154511, \quad \Lambda = 0.5,$
$\psi^* z_t^* = 0.119$, s.d. of $x_{G,t} =$ 0.025 ; s.d. of $x_{R,t} =$ .0095 ; s.d. of $x_{Y,t} =$ 0.0028 .

Model without Frictions

The following changes were made to remove frictions.

1. To eliminate adjustment costs for bank loans, set $\omega_B = 0$.

2. To make transaction costs for foreign bonds negligible, set $\mu = .01$. Also assume no exchange market intervention and set $\phi_{ir} = 0$.

3. To introduce forward looking behavior, set $\Lambda = 1$ in price expectations and replace the policy rule (50) by

$$\ln(1+R_t) = \phi_{rr} \ln(1+R_{t-1}) + (1-\phi_{rr})\{\ln(1+\bar{R}) + (1+\phi_{r\pi})\ln(E_t \Pi_{t+1} / \bar{\Pi}) + \phi_{ry} \ln(y_t / \bar{y})\} + x_{R,t} \quad .$$

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Figure 1. The TB and the policy rates: 1991M1-2014M12

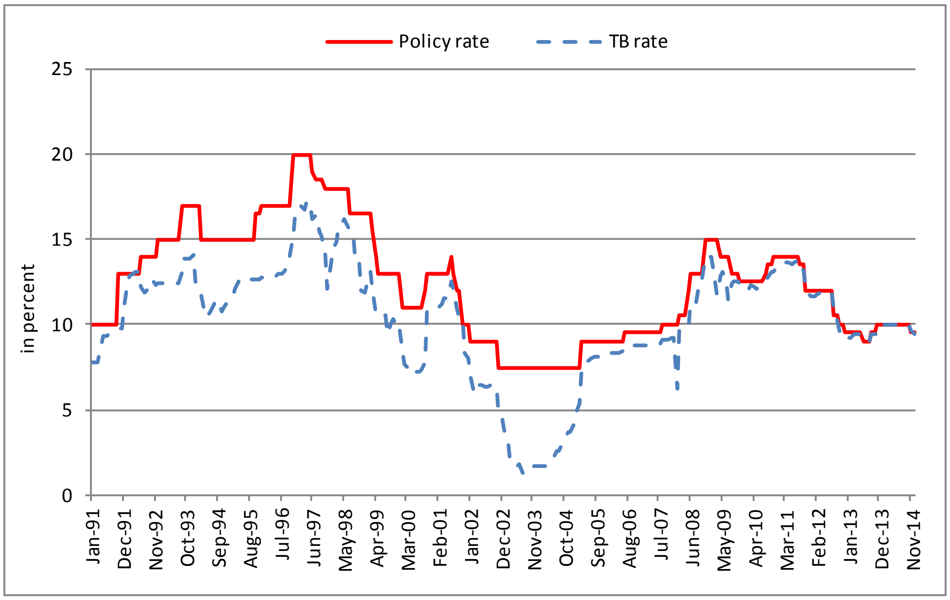


Figure 2. Dynamic Correlation: Output gap and the interest rates, 2002Q1-2014Q4

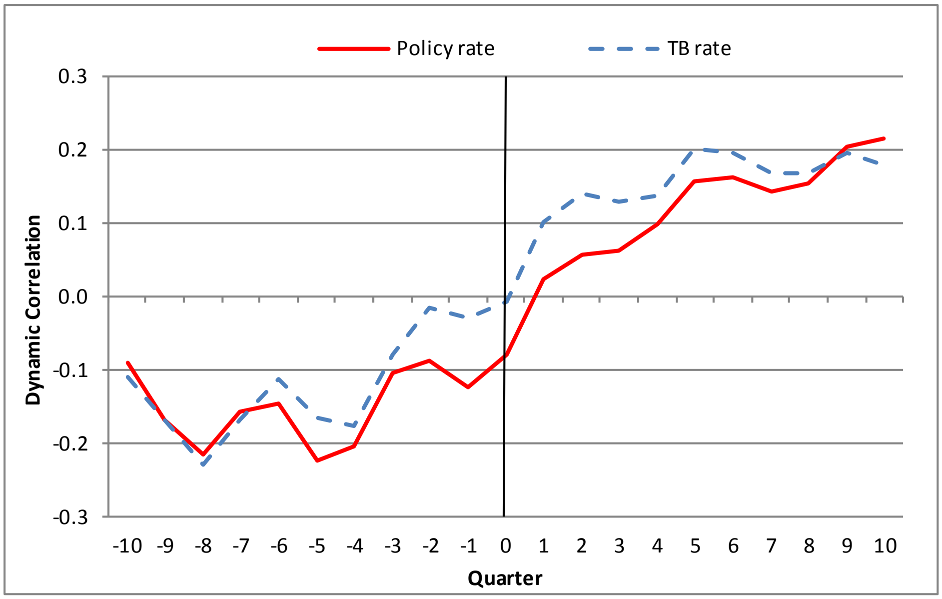


Figure 3. Dynamic Correlation: Inflation and the interest rates, 2002Q1-2014Q4

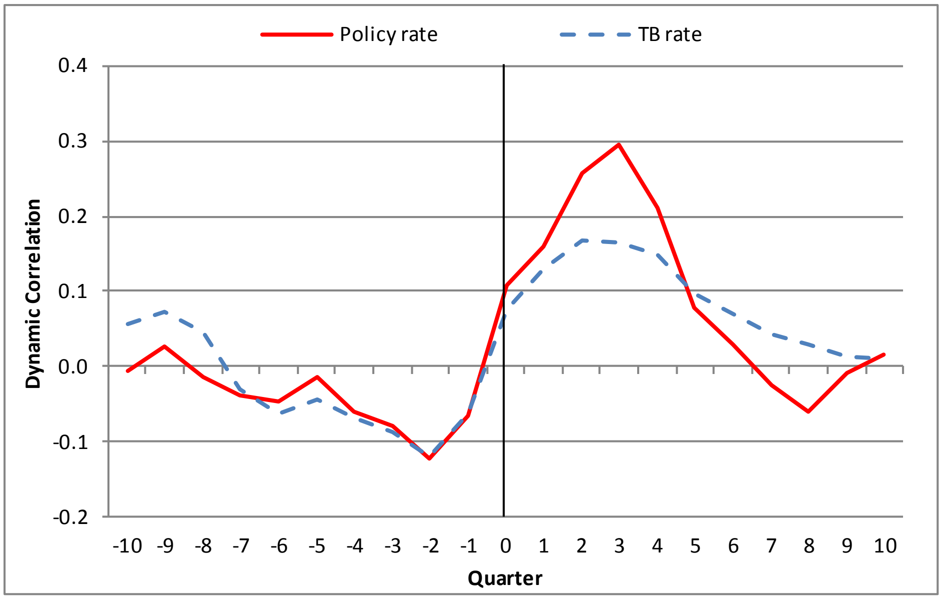
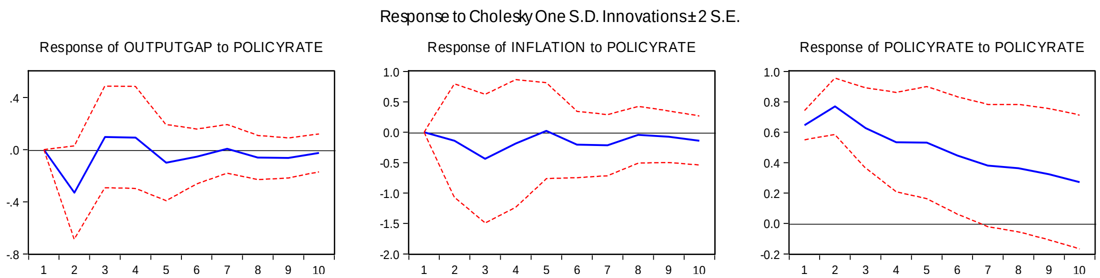
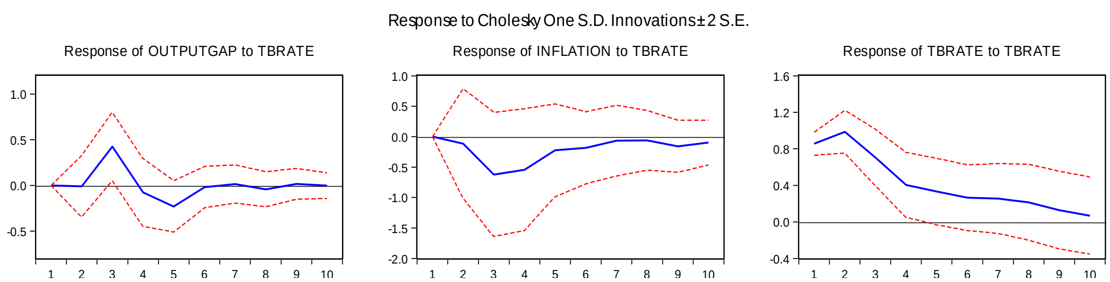


Figure 4. Dynamic effects of the monetary policy shock: basic VAR model, full sample

(a) Policy rate as the instrument variable



(b) TB rate as the instrument variable

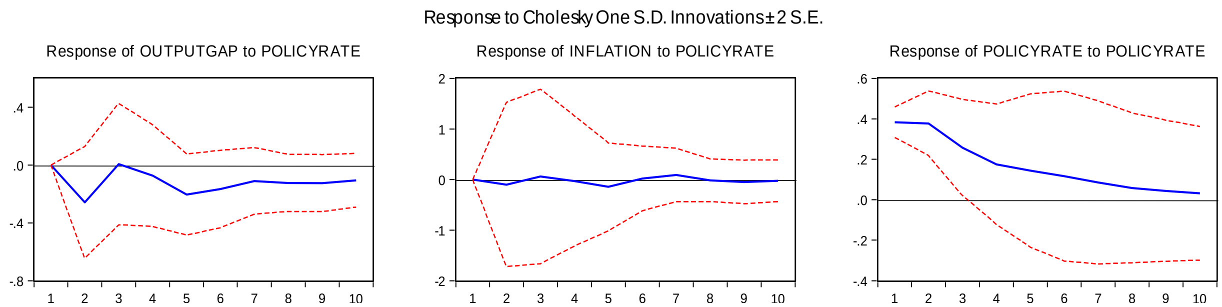


Note: IRF's for the monetary policy shock are derived from the basic VAR model using Cholesky decomposition with variables in the following order: output gap, inflation, instrument variable. The sample period is from 1991Q1 to 2014Q4.

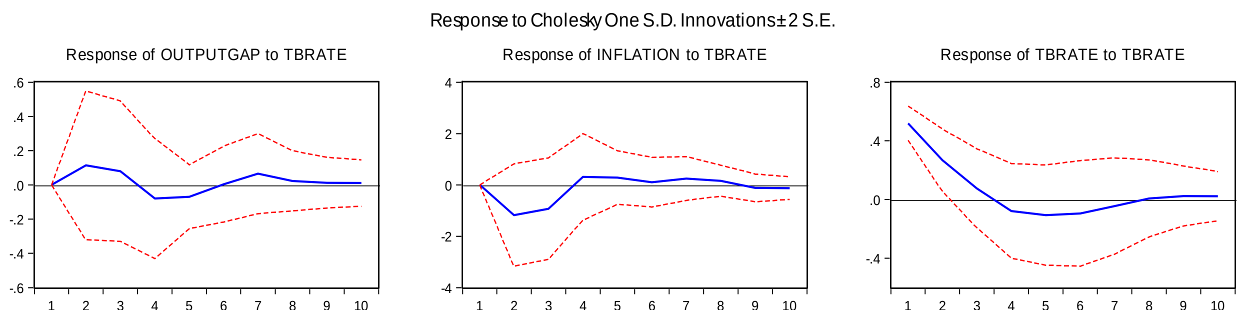
Figure 5

Dynamic effects of the monetary policy shock: basic VAR model, post-shift samples

(a) Policy rate as the instrument variable



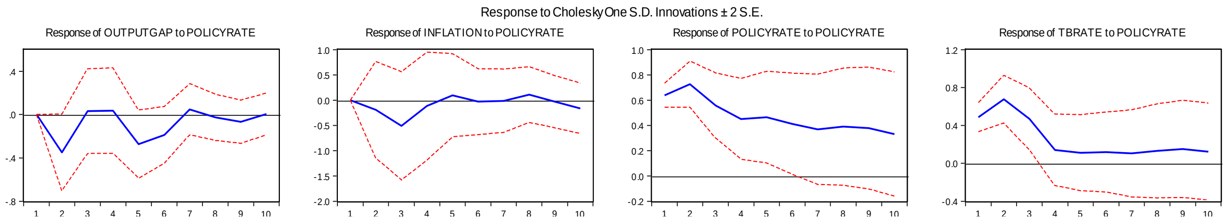
(b) TB rate as the instrument variable



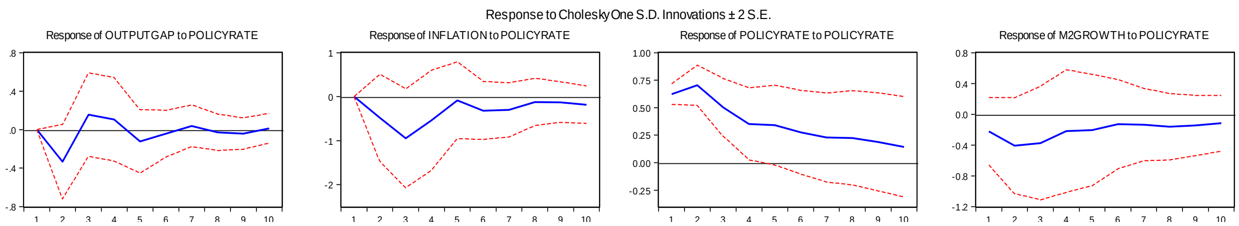
Note: IRF's for the monetary policy shock are derived from the basic VAR model using Cholesky decomposition with variables in the following order: output gap, inflation, instrument variable. The sample period is from 2002Q1 to 2014Q4 for the VAR with the policy rate and from 2005Q1 to 2014Q4 for the VAR with the TB rate.

Figure 6. Dynamic effects of the monetary policy shock: extended VAR model, full sample

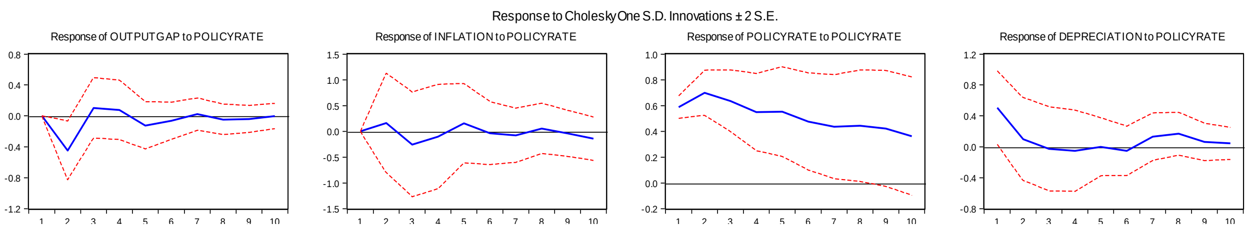
(a) TB rate as the additional variable



(a) M2 growth as the additional variable



(c) Exchange rate depreciation as the additional variable

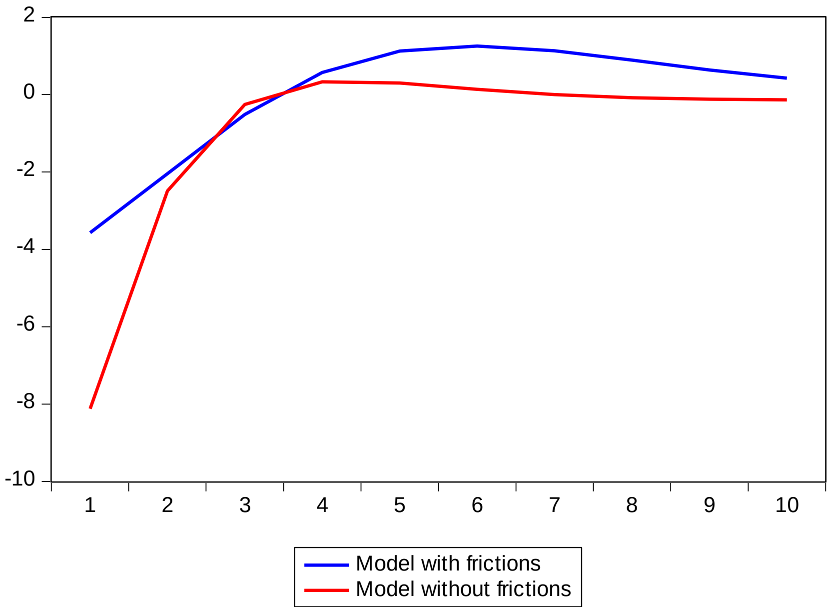


Note: IRF's for the monetary policy shock are derived from the extended VAR model using Cholesky decomposition with variables in the following order: output gap, inflation, the policy rate, indicated financial variable. The sample period is from 1991Q1 to 2014Q4.

Figure 7

Dynamic effects of the monetary policy shock: DSGE model with and without frictions

(a) Response of output gap to 1 s.d. monetary shock



(b) Response of inflation to 1 s.d. monetary shock

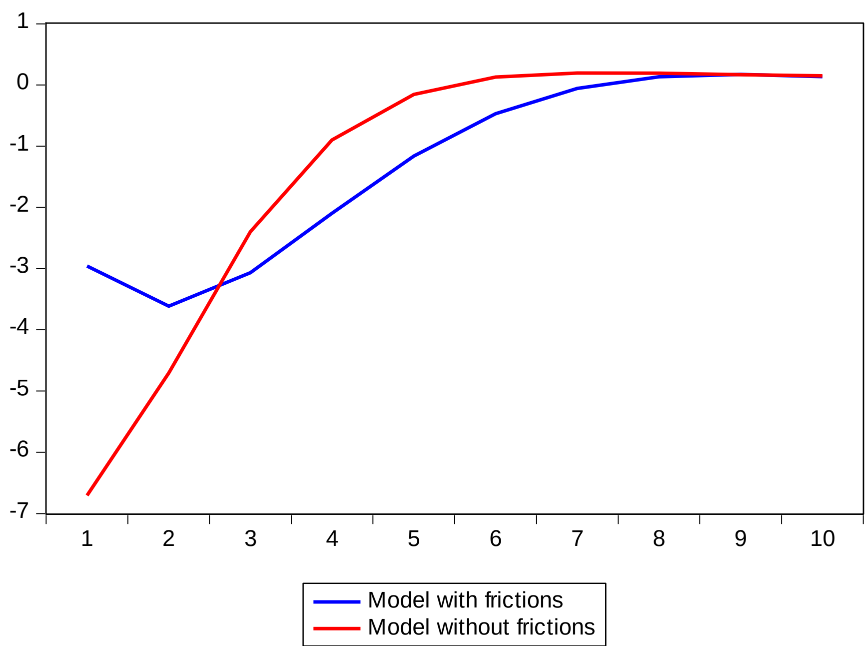
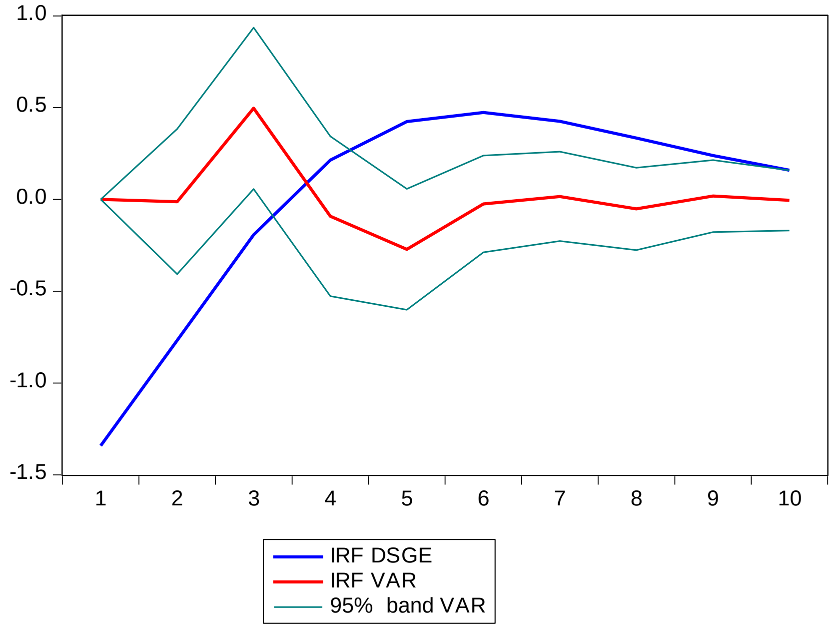


Figure 8

Dynamic effects of the monetary policy shock: DSGE and VAR models

(a) Response of output gap to a monetary shock generating 1% interest rate increase in quarter 1



(b) Response of inflation to a monetary shock generating 1% interest rate increase in quarter 1

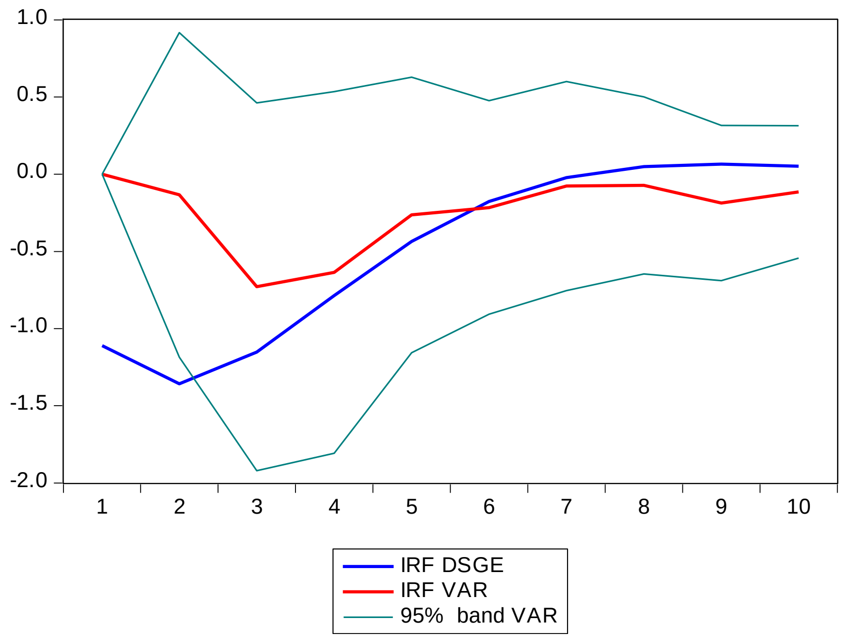
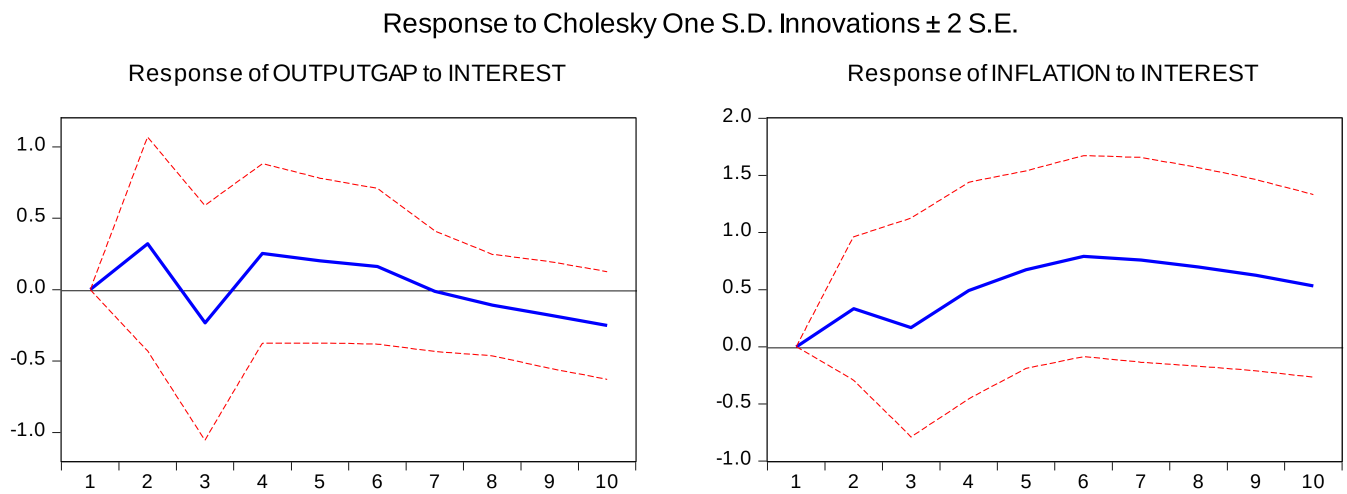


Figure 9

Dynamic effects of the monetary policy shock: simulated data



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