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The Effectiveness of Monetary Policy in Bangladesh: a VAR approach

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Abstract

This study examined the monetary policy effectiveness in Bangladesh with a vector autoregression (VAR) approach. Recursive identification was used to evaluate the dynamic response of macroeconomic variables to a positive nominal interest rate shock. The results show that over the period 2000-2013, the monetary policy was effective in influencing aggregate output, price level, exchange rate and stock prices. This paper also finds that money supply does not perform well as a monetary policy instrument to influence the real variables. Results from the Bangladesh model imply that output and prices are more sensitive to changes in the short term interest rates.

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1 Introduction

The financial sector of Bangladesh has experienced major reforms over the past two decades. The deposit and lending interest rates were gradually liberalized in the 1990s and floating exchange rate regime was adopted in 2003 (Bangladesh Bank 2009). Since then, monetary policy has gained importance in macroeconomic policy with greater autonomy of the monetary authority (Ahmed & Islam 2004). The monetary policy of Bangladesh aims at promoting faster and sustained economic growth, maintaining price stability, and ensuring external sector viability (Bangladesh Bank 2009). Critics often argue that a broader set of objectives has prevented Bangladesh's monetary policy from achieving its major goal of price stability (Hossain 2010).

The effectiveness of monetary policy depends on the macroeconomic and financial structure of an economy (Cottarelli & Kourelis 1994). However, there is broad agreement that a contractionary monetary policy (an increase in the short term interest rate) leads to a lower level of output and price, however only by a modest amount (Christiano et al. 1999). A higher interest rate increases the cost of capital which leads to a lower level of investment and aggregate demand and hence to a lower level of output and price. Friedman and Schwartz (2008) argue that an exogenous positive shock to the money supply is expected to increase output and price, and reduce interest rate in the short run. Fujiwara (2004) argues that a contractionary monetary policy is expected to appreciate the exchange rate in the short run. A higher interest rate causes foreign capital to flow into the domestic economy, leading to an excess supply of the foreign currency and hence to an appreciation of the exchange rate.

This paper uses the vector autoregression (VAR) approach (Sims 1980) and follows a recursive identification (Christiano, Eichenbaum & Evans 1996) to evaluate the effectiveness of monetary policy in Bangladesh. Using quarterly data for the period 2000-2013, this study investigates the dynamic response of the macroeconomic variables to a positive shock in the nominal interest rate, with the following Choleski ordering: output, price, interest rate, exchange rate and stock price. The monetary rule in Bangladesh is defined as the broad money (M2) targeting rule where reserve money is used as the operating target to influence the broad money growth path. The central bank announces its key policy interest rates (repo and reverse repo rates) to influence the growth of broad money. As repo rate in Bangladesh lacks sufficient variability, this paper uses the nominal interest rate (average of the deposit and lending interest rates) as a proxy for the policy interest rate on the assumption that any changes in the policy interest rates would be reflected in the short term interest rates.

The VAR models are able to produce rich dynamic behavior of the macroeconomic variables by treating all variables as endogenous. However, the VAR approach has not been widely utilized to evaluate the monetary policy effectiveness in Bangladesh. Rahman (2005) employs an unrestricted VAR and uses annual data for the period 1975-2003 to evaluate the relative effectiveness of fiscal and monetary policy in Bangladesh. He finds that an increase in real money supply leads to higher output growth. Applying a vector error correction model and using annual data for the period 1974-2000, Maroney et al. (2004) find that monetary policy is more effective than fiscal policy in influencing output, price and net exports in Bangladesh. Using quarterly data for the period 1979-2003, Ahmed and Islam (2004) analyze the monetary transmission mechanism in Bangladesh with an unrestricted VAR. They find that both bank lending and exchange rate channels are weak in influencing real output in Bangladesh.

However, these studies are mostly based on annual data and do not examine the effectiveness of monetary policy in Bangladesh under the post-floating exchange rate regime. This paper adds to the literature by covering more recent data for Bangladesh which includes the floating exchange rate regime. Further, unlike past studies this paper uses nominal interest rate as the monetary policy shock. The impulse response and variance decomposition results suggest that over the period 2000-2013, the monetary policy of Bangladesh has been effective in influencing output and price level. A positive shock to the interest rate leads to lower level of output and price and appreciation of the exchange rate. Further, this paper finds that money supply does not perform well in explaining the dynamics of output and price in Bangladesh, when used as a monetary policy shock.

The remainder of this paper is structured as follows. Section 2 provides a brief overview of the monetary policy framework in Bangladesh. The VAR model and short run restrictions are explained in Section 3. Section 4 summarizes and discusses the results and Section 5 concludes.

2 Monetary policy framework in Bangladesh

Bangladesh Bank (BB), the central bank of Bangladesh, formulates and implements monetary policy. The primary objective of BB's monetary policy is to maintain price stability and external sector viability (Bangladesh Bank 2009). Further, the monetary policy stance since 2010 campaign on financial inclusion policies such as directing credit towards the agriculture and small and medium enterprises to promote inclusive and higher economic growth (Bangladesh Bank 2011).

The monetary policy of Bangladesh during the 1970s and 1980s was characterized by direct control over the exchange rate and interest rates (Hossain 2010). Further, during that period, BB had active control over the volume and direction of credit flows. Major reforms took place in the late 1990s and early 2000s followed by the International Monetary Fund (IMF) supported Structural Adjustment Program (SAP) launched in the mid 1980s (Rahman 2005). Lending and deposit interest rates were gradually liberalized in the 1990s and floating exchange rate regime was adopted in May 2003. Key policy interest rates (repo and reverse repo rates) were introduced July 2002 and April 2003 respectively. However, there exist occasional central bank interventions in the credit and foreign exchange markets to stabilize sharp fluctuations around the trend (Bangladesh Bank 2011). Further, external capital account is controlled with restrictions on capital outflows.

Since 2006, Bangladesh Bank has been announcing its monetary policy stance semi-annually. The monetary rule is defined as the broad money (M2) targeting rule to influence the consumer price index (Bangladesh Bank 2009). BB draws up monetary programs each financial year with a target M2 growth path, consistent with the projected output growth and inflation. Reserve money (RM) growth path is used as the operating target to influence the broad money growth path, which in turn impact the consumer price index. Besides day to day changes in the reserve money, BB announces its key policy interest rates (repo and reverse repo rates) and adjusts cash reserve requirement (CRR) and statutory liquidity requirements (SLR) to influence the broad money growth path.

3 Method and Data

3.1 The VAR model

This paper employs a simple recursive vector autoregression approach following Christiano, Eichenbaum and Evans (1996) to examine the dynamic impact of a monetary policy shock on output, price level, exchange rate and the stock price. The VAR was estimated with the ordinary least squares (OLS) method using quarterly data for the period 2000-2013. The statistical software EViews (version 6) was used for estimation and diagnostic checks. The lag length was chosen optimally based on two considerations: information criteria and stability of the VAR. The Akaike Information Criterion suggests a lag order of 4 while the Schwarz Information Criterion and the Hannan-Quinn Criterion suggest a lag order of 1. However, the VAR is not stable at the lag order of 1; only a lag order of 4 satisfies the stability condition that no root lies outside the unit circle.

The reduced form 5-variable VAR with a lag order of 4, ignoring the constant term is expressed as:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + A_3 Y_{t-3} + A_4 Y_{t-4} + U_t \qquad (1)$$

Where, Y_t is the (5×1) vector of endogenous variables, Y_{t-i} is the (5×1) vector of endogenous variables in lag i, Ai is the (5×5) matrix of coefficients in period t-i and Ut is the (5×1) vector of shocks. The VAR has been estimated in a logarithmic functional form where all variables in Y appear in their natural logs of actual value except for the nominal interest rate which appears in its actual value. The shock vector is specified as:

$$\begin{bmatrix} u_y \\ u_p \\ u_i \\ u_e \\ u_s \end{bmatrix} \sim N\left[\mathbf{0}, \begin{pmatrix} \sigma^2_{uy} & \sigma_{uy,up} & \sigma_{uy,ui} & \sigma_{uy,ue} & \sigma_{uy,us} \\ \sigma_{up,uy} & \sigma^2_{up} & \sigma_{up,ui} & \sigma_{up,ue} & \sigma_{up,us} \\ \sigma_{ui,uy} & \sigma_{ui,up} & \sigma^2_{ui} & \sigma_{ui,ue} & \sigma_{ui,us} \\ \sigma_{ue,uy} & \sigma_{ue,up} & \sigma_{ue,ui} & \sigma^2_{ue} & \sigma_{ue,us} \\ \sigma_{us,uy} & \sigma_{us,up} & \sigma_{us,ui} & \sigma_{us,ue} & \sigma^2_{us} \end{pmatrix}\right] \qquad (2)$$

Where,

y : log of industrial production index (proxy for output, 2010=100)

p : log of consumer price index (2010=100)

i : nominal interest rate (percent)

e : log of exchange rate (local currency per unit of US dollar)

s : log of stock price index (2010=100)

The nominal interest rate (average of the deposit and lending interest rates), i has been used as a proxy for the central bank's policy interest rates. We are interested to examine how an intrinsic shock to the monetary policy variable affects other variables in the VAR system dynamically. However, shocks in Ut are usually contemporaneously correlated so that ui may not be an intrinsic or orthogonal shock to the policy interest rate. In this case, it is not plausible to interpret that a shock to the other variables in the system is solely due to the monetary policy shock.

The diagonal elements in the variance-covariance matrix (2) denote constant variance and the off-diagonal elements denote non-zero covariance among the shocks. We need the shocks to be orthogonal to estimate the impulse response functions and variance decompositions. Therefore, we impose the short run restrictions where correlated shocks, Ut are expressed in terms of the structural shocks, Et as:

$$\underset{U_t}{\begin{bmatrix} u_y \\ u_p \\ u_i \\ u_e \\ u_s \end{bmatrix}} = \underset{T_t}{\begin{bmatrix} t_{11} & 0 & 0 & 0 & 0 \\ t_{21} & t_{22} & 0 & 0 & 0 \\ t_{31} & t_{32} & t_{33} & 0 & 0 \\ t_{41} & t_{42} & t_{43} & t_{44} & 0 \\ t_{51} & t_{52} & t_{53} & t_{54} & t_{55} \end{bmatrix}} \underset{E_t}{\begin{bmatrix} \varepsilon_y \\ \varepsilon_p \\ \varepsilon_i \\ \varepsilon_e \\ \varepsilon_s \end{bmatrix}} \qquad 3$$

$$\text{Where,} \begin{bmatrix} \varepsilon_y \\ \varepsilon_p \\ \varepsilon_i \\ \varepsilon_e \\ \varepsilon_s \end{bmatrix} \sim N\left[\mathbf{0}, \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}\right]$$

Thus, the correlated shocks in Ut are expressed in terms of the orthogonal shocks in Et which are normally distributed with unit variance and zero covariance. is now an orthogonal shock to the interest rate. The lower triangular matrix, Tt can be obtained by applying Choleski decomposition to the variance-covariance matrix, UtUt' as:

$$U_tU_t' = (T_tE_t)(T_tE_t)' = T_t(E_tE_t')T_t' = T_tIT_t' = T_tT_t'$$

Where, I is the (5×5) identity matrix. Thus, we can write (1) as:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + A_3 Y_{t-3} + A_4 Y_{t-4} + T_t E_t \quad (4)$$

Since the inverse of a lower triangular matrix is a lower triangular matrix, we can pre-multiply (4) by T-1 to obtain the structural VAR as:

$$Y_t = (I - T^{-1})Y_t + T^{-1}A_1 Y_{t-1} + T^{-1}A_2 Y_{t-2} + T^{-1}A_3 Y_{t-3} + T^{-1}A_4 Y_{t-4} + E_t \quad (5)$$

Thus, the reduced form VAR (Model 1) has been transformed into a structural VAR (Model 5) where shocks are orthogonal to each other. We can now estimate (5) by the OLS.

While ordering is not important for the estimation of VAR, impulse responses derived from VAR depend crucially on how the variables are ordered in the Choleski decomposition. Usually, the most endogenous variable is placed last and the least endogenous variable is placed first so that the variables in the higher order are assumed not to be contemporaneously affected by the variables in the lower order.

The monetary authority usually looks at the current state of the economy when setting its operating instrument. Christiano et al. (1996) argue that among other variables, the central bank looks at the current output and prices when setting its policy instrument so that output and prices do not respond contemporaneously to the monetary policy shock. Conversely, some others (Leeper et al. 1996; Sims & Zha 2006) argue that this assumption is controversial as the current data on output and price is not available to the monetary authority when it decides monetary policy. They rather assume that current output and prices do not enter into the central bank's policy function. While both assumptions are debatable (Christiano et al. 1999), it is reasonable to assume that the monetary authority has some information on output and prices while deciding its policy.

This paper follows the recursive identification by Christiano, Eichenbaum and Evans (1996) that output and price respond to the monetary policy shock only with a lag. The central bank of Bangladesh looks at the current output (industrial production index) and price level, and then sets its policy interest rates which impact the exchange rate and stock prices contemporaneously. Therefore, the impulse responses were derived with the following Choleski ordering: output, price, interest rate, exchange rate and stock price.

The short run restrictions are:

- Output does not react contemporaneously to shocks to the other variables in the system.
- The price level does not react contemporaneously to the interest rate, exchange rate and stock price shocks, but is contemporaneously affected by the output shock.
- Interest rate is contemporaneously affected by the output and price shocks, but responds to the exchange rate and stock price shocks only with a lag.
- The exchange rate does not react contemporaneously to the stock price shock but is contemporaneously affected by the output, price and interest rate shocks.

- Finally, the stock price is contemporaneously affected by all the variables in the system but does not have contemporaneous effect on any variables.

3.2 Data

The study employed quarterly data for Bangladesh on the industrial production index, consumer price index, nominal interest rate, nominal exchange rate, and the stock price index for the period 2000-2013. All data were collected from the online database (International Financial Statistics) of the International Monetary Fund (IMF). Quarterly data on real GDP is not available for Bangladesh. Therefore, industrial production index was used as a proxy for real GDP. Nominal interest rate was calculated as the average of the deposit and lending interest rates, as a proxy for the policy interest rates.

The IMF collects data from the relevant statistical agencies of Bangladesh. No information was found about the seasonal adjustments of data on the industrial production index and consumer price index. However, when 'seasonal graphs' were plotted for these variables in EViews, seasonal patterns were observed. Therefore, seasonal adjustment was carried out through the 'U.S. Census Bureau's X12 seasonal adjustment program' in EViews. Then, all the variables were converted into their natural log except for the nominal interest rate.

3.3 Unit root test

All series were tested for unit root with the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. A time series is stationary (does not contain unit root), if it has constant mean, variance and covariance over time (Heij et al. 2004, p. 536). It is important for a time series to satisfy the stationary property; otherwise the series is exploding over time (Dickey & Fuller 1981).

Consider,

$$Z_t = \delta Z_{t-1} + v_t$$

$H_0: \delta = 1$, Z_t is non-stationary

$H_A: \delta \neq 1$, Z_t is stationary

The ADF test is specified as,

$$\Delta Z_t = \alpha + \beta t + \delta Z_{t-1} + \Upsilon_i + \sum_{i=1}^{m} \Delta Z_{t-i} + w_t \quad (6)$$

The ADF test checks stationarity of Zt by testing the null hypothesis in (6), H0: δ=0, (Zt is non-stationary). If the test statistic is smaller than the critical τ (tau) statistic, developed by MacKinnon (1996, p. 13) at 5 percent level of significance, we reject the null hypothesis and conclude that Z_t is stationary. Unlike the ADF test, the Phillips-Perron test employs non-parametric methods to consider possible serial correlation in the error term, wt and does not include the lagged difference term, $\sum_{i=1}^{m} \Delta Z_{t-i}$ (Phillips & Perron 1988). Both ADF and PP tests were carried out again at first difference if a series was found non-stationary at level at 5 percent level of significance. The unit root results are reported in Table 1.

Table 1 Augmented Dickey-Fuller and Phillips-Perron test results for unit root

Variables	Test statistics				Decision
	ADF		Phillips-Perron		
	At level	At first difference	At level	At first difference	
Output (y)	-2.64	-10.53***	-2.64	-13.97***	I(1)
Price (p)	-2.78	- 6.18***	-2.84	- 6.13***	I(1)
Interest rate (i)	-3.17	- 5.40***	-2.55	- 5.35***	I(1)
Exchange rate (e)	-1.79	- 5.27***	-1.57	- 5.43***	I(1)
Stock price (s)	-2.13	- 5.44***	-2.05	- 5.52***	I(1)

All variables are in their natural log except for the nominal interest rate.
Schwarz Information Criterion is used for the ADF test.
Tests include trend and intercept, except for the nominal interest rate which includes intercept only.
*** indicates the series is stationary at 1% level.
I(1) indicates the series is stationary at its first difference.

The unit root test results suggest that while all the variables in their natural log (except for the nominal interest rate) are non-stationary at their levels, they are stationary at their first difference, that is, they are I(1).

4 Results

4.1 Impulse response functions

Figure 1 presents the impulse responses to a positive interest rate shock from the 5-variable VAR (Model 5), with the Choleski ordering specified above. The dynamic path of the endogenous variables is computed with one standard deviation shock to the interest rate. The point estimates of the impulse responses are given by the solid lines and the dotted lines indicate 95 percent confidence interval about the point estimates. LY, LP, LE and LS indicate output, price, exchange rate, and stock price respectively in their natural log, while I indicates the nominal interest rate. The impulse responses are reported for 20 quarters.

Figure 1 shows that a contractionary monetary policy (a positive shock to the interest rate by 42 basis points in the first quarter) leads to a lower level of output and price. Output declines from the third quarter and the aggregate price level falls from the second quarter in response to a positive interest rate shock. Output exhibits the peak decline in quarter 6 (1.8 percent). The confidence interval suggests significant negative response of output between the fourth and tenth quarter to a positive interest rate shock. On the other hand, the price level falls significantly from the seventh quarter and up to the tenth quarter. The exchange rate appreciates and the stock price falls immediately following a positive interest rate shock. A higher interest rate leads to a significant drop in the stock price over the first six quarters.

The results therefore suggest that the model performs well in explaining the dynamics of Bangladesh economy in response to a monetary policy shock. To check the robustness of short term nominal interest rate as a monetary policy shock, the VAR was estimated again (with a lag order of 4) with the interest rate replaced by the broad money (M2) stock. The impulse responses were derived with the following Choleski ordering: y, p, m, e, s where, m indicates money supply and all variables appear in their natural logs in the VAR estimation. The impulse responses to a positive money supply shock are presented in Figure 2. We do not observe expected dynamics of output, price and exchange rate in response to a positive money supply shock. In response to an expansionary monetary policy (a positive shock to the money supply), output and price falls and the exchange rate appreciates in the short run. Further, the impulse responses are not significant. This suggests that aggregate output and price level in Bangladesh are more sensitive to changes in the nominal interest rate compared to the money supply shock.

Figure 1 Impulse responses to a positive interest rate shock

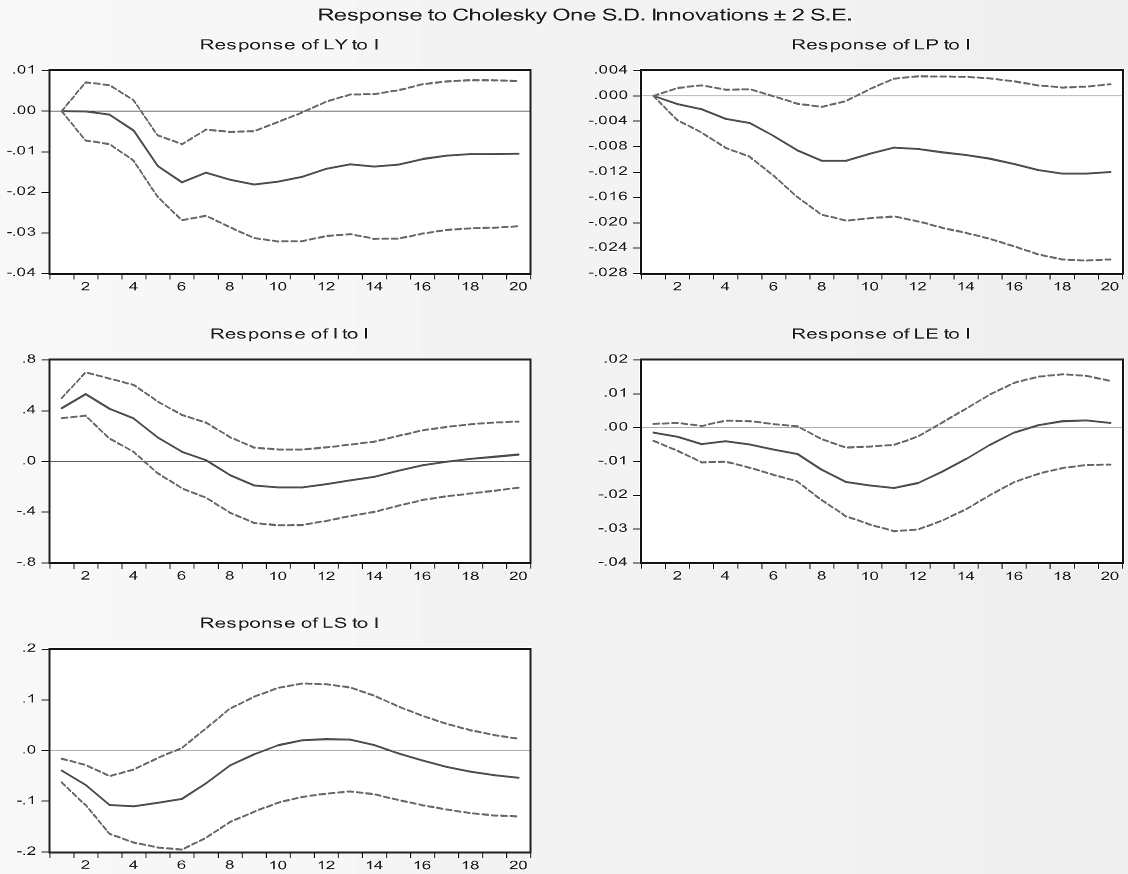
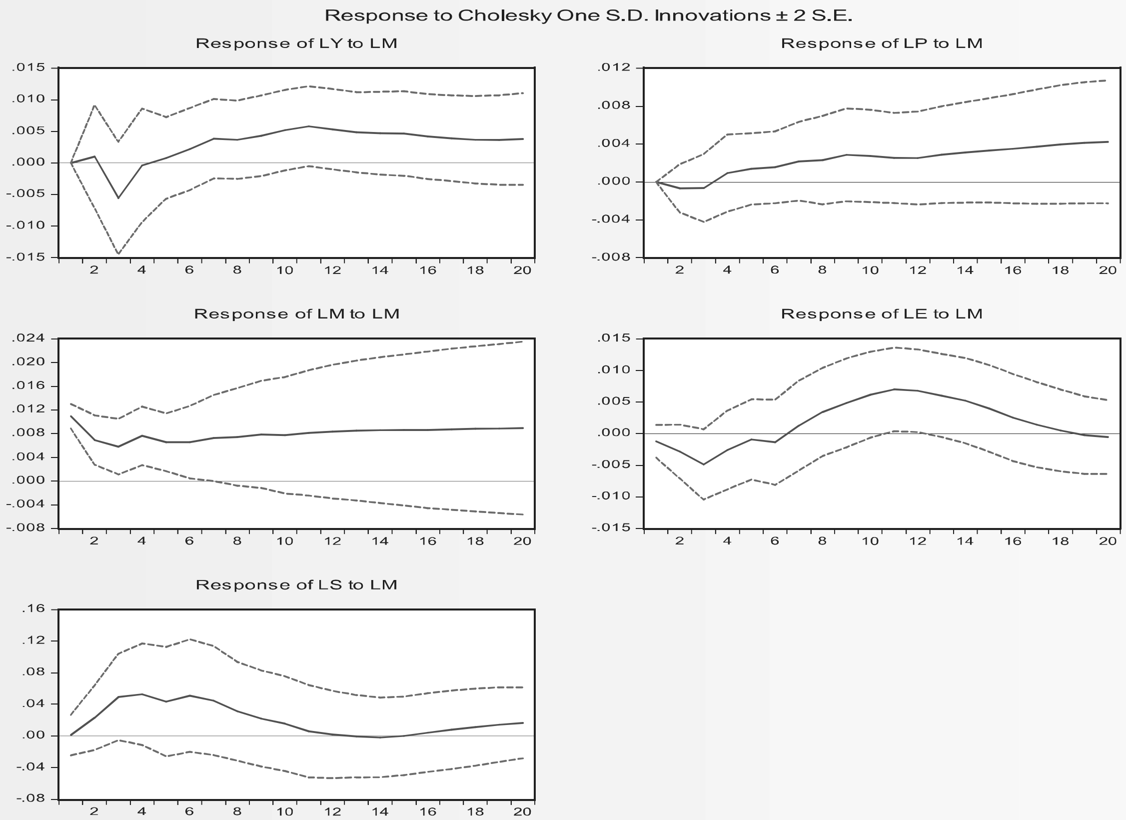


Figure 2 Impulse responses to a positive money supply shock



4.2 Variance decompositions

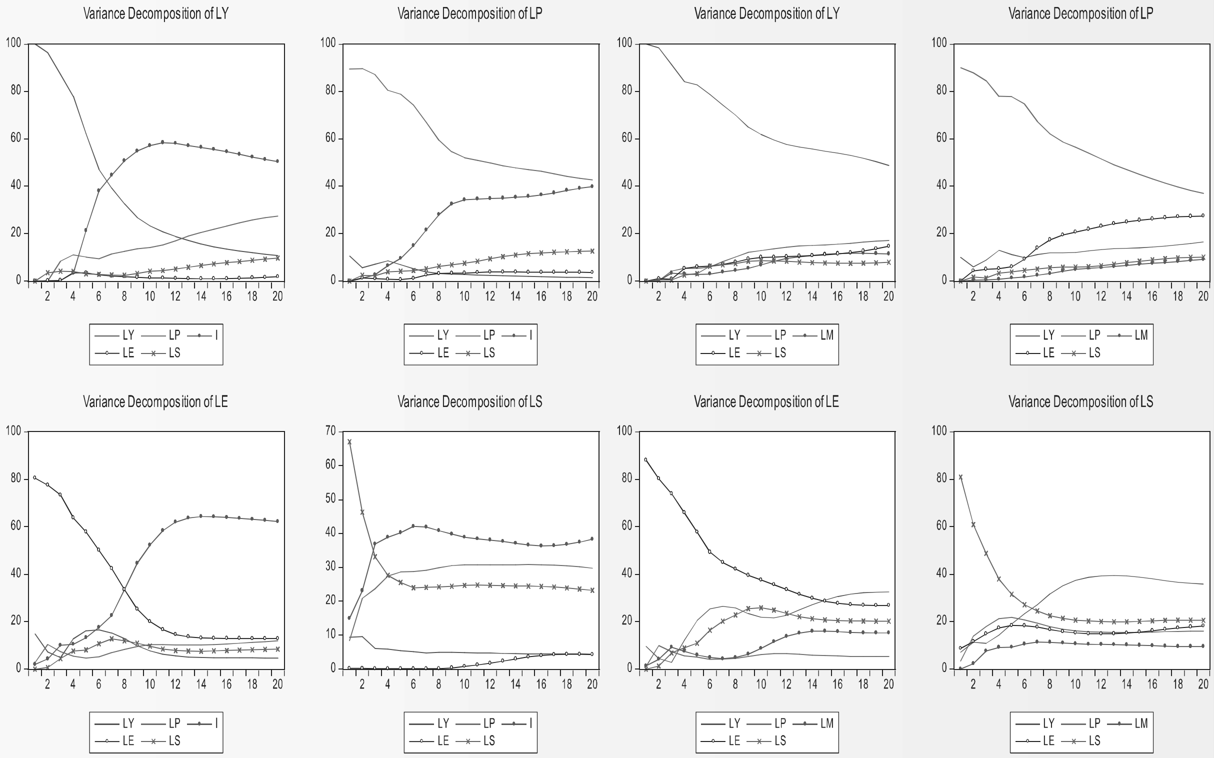
The VAR model allows decomposition of the sources of variance of each endogenous variable, which is known as the variance decomposition. The variance decomposition shows the proportion of variations in each variable that can be explained by all shocks in the VAR system. The variance decomposition results are presented in Figure 3.

In the fourth quarter, the interest rate shock explains only 4 and 6 percent of the variations in output and price level respectively (Figure 3a). Around 78 percent of the variations in output are explained by its own shock and 80 percent of the variations in the price level are explained by itself in the fourth quarter. However, by the tenth quarter, the interest rate shock accounts for 57 percent and 34 percent of the variations in output and price respectively, and also explains significant proportion of variations in the exchange rate and stock prices.

Conversely, when money supply is used as a monetary policy shock (Figure 3b), it accounts for less than 10 percent of the variations in output and price level. This suggests that money supply does not perform well as a monetary policy instrument to explain variations in output and price in Bangladesh.

Figure 3 Variance decompositions

(a) Interest rate shock (b) Money supply shock



5 Conclusion

It is important for a central bank to evaluate the effectiveness of monetary policy under different policy regimes. This paper examines the effectiveness of monetary policy in Bangladesh over the period 2000-2013, which includes the floating exchange rate regime. A 5-variable VAR has been estimated with a simple recursive identification to evaluate the dynamic response of aggregate output, price level, exchange rate and stock prices to a positive shock in the nominal interest rate. The impulse responses perform well in explaining the dynamics of economic aggregates and support theoretical context and other empirical studies. A higher nominal interest rate reduces output and price, and leads to an appreciation of the exchange rate. Further, the interest rate shock accounts for significant proportion of variations in output and price. This paper also finds that a shock to the money supply does not have significant impact on output and price in Bangladesh.

However, the results would be more reliable if the data on policy interest rates were available. Further, a time varying VAR could be applied to account for structural changes (if any) during the sample period. A ‘sign restricted VAR’ approach could be employed to explain the unexpected dynamic responses of the economic aggregates in Bangladesh to a money supply shock. Future research on the monetary policy of Bangladesh can explore these issues.

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