

## The Effectiveness of Monetary Policy in Small Open-Economy: An SVAR Study for Pakistan

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### ABSTRACT

This paper examines the effectiveness of monetary policy and its transmission channels in Pakistan. Unlike previous studies, this paper considers external variables, including world commodity prices and trade-weighted variables of output and interest rate. This study has employed the structural vector autoregressive (SVAR) model with block-exogeneity and non-recursive identification scheme in modeling monetary policy shocks in Pakistan. The results have revealed that the effectiveness of monetary policy in Pakistan is limited in stabilizing key domestic variables. The shutdown methodology in SVAR has been used to examine the strength of monetary policy transmission channels i.e. interest rate, credit, exchange rate and asset price channels. The interest rate channel of monetary policy is only effective in the short run while credit channel in both short run and long run. This finding assures the State Bank of Pakistan (SBP) to rely on interest rate channel to control inflation and utilize the credit channel to enhance the output in the long run.

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## INTRODUCTION

The global economy has witnessed worst economic crises in 2008 and yet it has encountered another challenge due to the slump in commodity prices. The sluggish growth in the major and emerging economies has forced the International Monetary Fund (IMF) to downgrade its global growth outlook twice for 2016. These frequent turbulences in the global economy are causing contraction in the span of business cycles, which pose challenges to developing countries in particular. The reliance of developing countries on international trade keeps them vulnerable to global economic shocks. As a result of global economic imbalances, the policy decisions in world leading economies can also affect the economic activities in developing countries.

The monetary policy in developing countries can be meaningful in adjusting the short term imbalances in the economy if domestic policy actively monitors the external factors that can affect its economy. In the light of the recent global economic events, the understanding of the transmission mechanism of monetary policy has become crucial to formulate effective policy. This study extends this understanding on the monetary policy effectiveness in Pakistan. Pakistan being a small open economy has recently made into the emerging market economy after recovering from the 2008 global commodity crises<sup>1</sup>. *Figure 1* shows the economy of Pakistan had witnessed stagflation for a longer period after 2008 crisis. The adverse supply shocks were being a major reason behind these events<sup>2</sup>.

The State Bank of Pakistan (SBP) kept inflation rate as its overriding target during the years of stagflation, which compelled SBP to keep the policy rate high<sup>3</sup>. However, the over reliance of SBP on the traditional interest rate channel has been criticized. It is argued that policy reaction followed by the events in Pakistan's economy after 2008, has suppressed the growth and increased inflation rate (PIDE, 2010). The criticism is valid in the case of Pakistan, because in the context of developing economies the financial markets are relatively less developed as those in developed economies. Therefore, the monetary policy transmission may take longer time than anticipated and the over-reliance on the interest rate channel can amplify the effects on inflation<sup>4</sup>.

Keeping the above facts in view, this study examines the effectiveness of monetary policy in Pakistan. The previous studies on the effectiveness of monetary policy and its channels in Pakistan have ignored the external factors e.g. (Agha *et al.*, 2005; Hussain, 2009). Since the financial and trade liberalization reforms in 1990, the share of trade has remained steady around one third of GDP. However, the share of foreign remittances has increased from 3% in 1990 to 7% of GDP in 2015<sup>5</sup>. In the wake of these economic reforms, the central bank of Pakistan also implemented market based system of the monetary policy, allowing the interest rate liberalization in the country (Arby, 2004). In addition to it, SBP also switched the exchange rate

<sup>1</sup> IMF's World economic outlook report 2015.

<sup>2</sup> Supply shocks were largely responsible for higher inflation and low growth (stagflation) in Pakistan (Amjad *et al.*, 2011).

<sup>3</sup> The SBP being a central bank for Pakistan is a sole authority to stabilize inflation rate and output in the country. Since 1990 SBP has adopted the market based indirect system of monetary conduct. Using discount rate, T-bill auction rate, open market operations and cash reserve requirement as a monetary policy tools.

<sup>4</sup> Sims (1992) argued that increase in interest rate will initially reflects inflationary pressure in the economy, causing prices to increase i.e. price puzzle. Price puzzle is linked with the cost channel of monetary policy, which captures the supply side effects of the monetary policy in the economy. A rise in interest rate increases the production cost of firms, subsequently that cost will pass on to the prices. Hence, a raise in interest rate amplifies the effects on inflation.

<sup>5</sup> Source: World Bank indicators 2015.

regime from managed-floating to flexible in order to move towards the free market economy. These underlined facts and the effects of 2008 global crisis on the economy of Pakistan, has motivated us to study the effectiveness of monetary policy in an open economy framework.

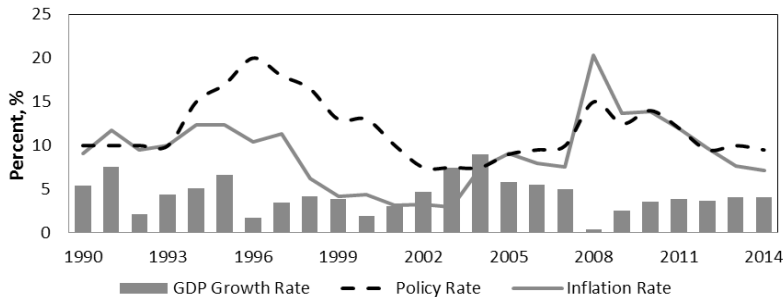


Figure 1: Macroeconomic Fluctuations in Pakistan

This study contributes to the existing literature in the following way. First, unlike previous studies on the effectiveness of monetary policy in Pakistan, it controls the external factors on the domestic economy. This is done by constructing trade-weighted measures of world output and interest rate of major trading partners of Pakistan, along with world commodity prices. The external factors are incorporated in the structural vector autoregressive (SVAR) model by imposing block-exogeneity assumption where the external factors can affect the domestic economy but not vice versa. Second, the non-recursive identification in SVAR is used to impose the restrictions on the basis of economic structure of a Pakistan economy. Thus, both assumptions are consistent in modeling the small-open economy. Finally, the relative strength of monetary policy transmission channels is provided using shutdown methodology in SVAR model<sup>6</sup>. The relative strength of interest rate, credit, exchange rate and asset price channels of monetary policy will provide an insight to SBP in order to discover the contribution of each channel in stabilizing output and inflation rate.

This paper is organized as follows. Section 2 provides the review of literature that considers the importance of external variables in the transmission mechanism of monetary policy. Section 3 discusses the SVAR methodology in detail. Section 4 provides the empirical results based on impulse response functions and variance decomposition. Section 5 provides summary and conclusion on the findings of this study.

## REVIEW OF LITERATURE

The small open developing economies are constrained by the economic decisions of the developed economies, so it is required to consider the external factors into account while studying transmission mechanism of monetary policy in those economies. Cushman and Zha (1997) highlighted the importance of open economy SVAR model in order to avoid the empirical puzzles. They advocated that, due to the inappropriate identification of monetary

<sup>6</sup> Mishkin (1996) identified four prominent channels of monetary policy transmission, including interest rate, credit, exchange rate and asset price channels.

policy in close economy VAR models, have led inconsistent results. Mishra and Montiel (2012) argued that due to methodological limitations of the close economy models, the vast numbers of studies for developing countries on the transmission mechanism of monetary policy are subject to the strong criticism for proper inferences. Because the structural differences of developing countries requires specific models, which incorporate their features in order to better understand the transmission mechanism.

The literature identifies three external variables as important shocks to developing countries, i.e. the adverse supply shocks represented by oil prices or commodity prices, the world output and the world interest rates. The US income level and interest rates are usually considered to represent world economy due to being a large economy. However, representing a world economy by a single country can lead to misspecification problem. Buckle *et al.* (2007) suggested using the trade-weighted variables of major trading partners to represent world economy. They proved that trade-weighted variables can eliminate the misspecification problem in SVAR modeling for a small open economy.

In every aspect, these external factors have been declared crucial for affecting the macroeconomic variables of developing countries. For instance, a number of studies have found negative effects of adverse supply shocks on the productivity and the price level in developing economies (Brown and Yucel, 2002; Blanchard and Gali, 2007). The negative effects are due to the reliance of the developing countries on the imports of energy and raw materials for their domestic production. Similarly, Arora and Vamvakidis (2006) have found that world output has a positive impact on the output of developing countries. Frankel and Roubini (2001) and Aleem (2010) have shown that due to the integrated financial markets world over, a rise in the world interest rate has not only a negative effect on the growth rate, but it also influence the monetary policy stance in developing economies.

Due to the rapid developments and frequent turbulences in the global economy, many studies have recently emphasized the importance of external factors on the economic activities of developing countries. Allegret *et al.* (2012) have shown that external factors have a significant impact on the domestic variables of nine East Asian economies. Similarly, Zaidi *et al.* (2013) concluded that external variables play an important role in the variations of macroeconomic variables of Malaysia, Indonesia, and Thailand. Karim and Karim (2014) also found the importance of foreign shocks upon domestic macroeconomic fluctuations and monetary policy in Malaysia. Rahman (2015) also found similar results for Bangladesh.

The understanding of monetary policy effectiveness and the relative importance of its channels will improve, when the external factors are taken into account for developing countries. The open economy models are well suited to account for these features. For example, studies by Tang (2006), Aleem (2010), Davoodi *et al.* (2013), Mengesha and Holmes (2013), Perera and Wickramanayake (2013) used open economy vector autoregressive models to examine the relative importance of transmission channels. They reported that including external factors in their models have led consistent results. For instance, Tang (2006) found interest rate channel as a most important channel in affecting output and inflation in Malaysia. Aleem (2010) found strong evidence to support for credit channel in India, Davoodi *et al.* (2013) also found credit

channel of monetary policy as an important for East African countries. Whereas Mengesha and Holmes (2013) found bank lending channel as relevant in Eritrea. Perera and Wickramanayake (2013) also supported the bank lending channels in Sri Lanka. All of them proposed the inclusion of external variables, as they are crucial to formulate optimal monetary policy.

In the case of Pakistan, there is a limited literature regarding the effectiveness of monetary policy and the strength of its channels. However, the existing studies are usually done in closed economy models e.g. (Agha *et al.*, 2005; Hussain, 2009). Whereas some studies have considered partially open economy models, only allowing the oil prices in the models (Javid and Munir, 2011; Khan and Ahmed, 2014). There is no study, which has controlled the three major external factors to study the effectiveness of monetary policy and the relative importance of its channels.

A study by Agha *et al.* (2005), made a first attempt to discover the relative importance of monetary policy transmission channels by employing the close economy VAR models. They found interest rate and credit channel as highly effective. In contrast to this, Hussain (2009) found exchange rate channel to be an effective in curbing inflation and minimizing output gap in Pakistan, using trivariate VAR model. On the other hand, Javed and Munir (2011) found that the increase in interest rates leads to output puzzle along with price puzzle, which is regarded due to the misspecified VAR model (Sims, 1992). Whereas Khan and Ahmed (2014) have only shown the significant negative effects of the oil prices on the economy of Pakistan, while the effectiveness of monetary policy during the adverse shock was not considered in their study. The gap in the existing literature has allowed us to continue with estimating an open economy model, in order to improve our understanding regarding the transmission mechanism of monetary policy in Pakistan.

## RESEARCH METHODOLOGY

In order to assess the effectiveness of monetary policy in Pakistan, this study employs the structural Vector Autoregressive (SVAR) model with non-recursive identification structure. The benefit of employing this particular model is to capture the salient features of a small open economy. Since each small open economy has a unique economic structure, ignoring their particulars can lead to inconsistent results. Cushman and Zha (1997) proposed that SVAR models are not only consistent but they also provide valid results, particularly in the case of small open economy. The non-recursive identification in SVAR models relies on economic theory to impose restrictions on the contemporaneous causal relationship of the variables instead of relying on the pure ordering of the variables.

The small open economy can be represented by the structural form of VAR model as:

$$BY_t = \Gamma_0 D_0 + \Gamma(L)Y_{t-1} + \varepsilon_t \quad (1)$$

Where B is a contemporaneous matrix of coefficients,  $Y_t$  is (n x 1) vector of variables included in a system.  $\Gamma_0 D_0$  is a vector of constants and dummy variable,  $\Gamma(L)$  is a square matrix polynomial in the lag operator L. The vector of structural shocks ( $\varepsilon_t$ ) satisfies the condition of zero mean  $E(\varepsilon_t) = 0$  and time invariant covariance matrix  $E(\varepsilon_t \varepsilon_t') = \Sigma \varepsilon = I$

The reduced form of an SVAR equation (1) is given as:

$$Y_t = A_0 D_0 + A_1 Y_{t-1} + e_t \tag{2}$$

where  $A_0 = B^{-1}\Gamma_0$ ,  $A_1 = B^{-1}\Gamma(L)$  and  $e_t = B^{-1}\varepsilon_t$  satisfies the condition  $E(e_t) = 0$ .  $E(e_t e_t') = \Sigma_e$  is a  $n \times n$  symmetric matrix. The relationship between structural shocks ( $\varepsilon_t$ ) and estimated residuals ( $e_t$ ) is given below by variance-covariance matrix ( $\Sigma_\varepsilon, \Sigma_e$ ):

$$\Sigma_e = E(e_t e_t') = E(B^{-1}\varepsilon_t \varepsilon_t' B^{-1'}) = B^{-1} \Sigma_\varepsilon (B^{-1})' \tag{3}$$

Hence,

$$\Sigma_\varepsilon = B \Sigma_e B' \tag{4}$$

For a symmetric matrix  $\Sigma_e$  consists  $n^2+n/2$  unknown elements, which requires to impose  $n^2-n/2$  additional restrictions to just identify the system, so as to recover all structural shock ( $\varepsilon_t$ ) from the estimated residuals ( $e_t$ ) in order to generate the Impulse Response Functions (IRF).

The structural shocks can be recovered from estimating the equation (2) where  $e_t = B^{-1}\varepsilon_t$ , alternatively  $\varepsilon_t = B e_t$ . This study imposes the short-run zero restrictions on matrix B as shown below in (5) in the compact matrix form. Christiano *et al.* (2006) proposed the short-run restrictions in SVAR models to generate the valid impulse responses. The restrictions in the SVAR models are justified on the theoretical arguments. Hence, we follow the theoretical procedure of Cushman and Zha (1997) and Dungey and Pagan (2000) for the contemporaneous restrictions in (5) and the block-exogeneity constraints in (6). The details are given below.

The matrix B is considered as recursive SVAR if all the elements in B are set equal to zero above its diagonal. However in equation (5) the non-recursive restrictions are imposed on the contemporaneous parameters of the SVAR model, based on the structural features of a small open economy. For the model to be just identified, the 36 zero restrictions are required. However a total of 43 zero restrictions are imposed on the system of equations in (5), therefore the model is over identified.

$$\begin{bmatrix} \varepsilon_{Ln\_WCP} \\ \varepsilon_{Ln\_WY} \\ \varepsilon_{WIR} \\ \varepsilon_{Ln\_DY} \\ \varepsilon_{INF} \\ \varepsilon_{DIR} \\ \varepsilon_{Ln\_CRD} \\ \varepsilon_{Ln\_NEER} \\ \varepsilon_{Ln\_KSEI} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 & b_{47} & 0 & 0 \\ b_{51} & 0 & 0 & b_{54} & 1 & 0 & 0 & 0 & 0 \\ b_{61} & 0 & 0 & b_{64} & b_{65} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{74} & 0 & b_{76} & 1 & 0 & 0 \\ b_{81} & b_{82} & b_{83} & b_{84} & b_{85} & b_{86} & b_{87} & 1 & 0 \\ b_{91} & b_{92} & b_{93} & b_{94} & b_{95} & b_{96} & b_{97} & b_{98} & 1 \end{bmatrix} \begin{bmatrix} e_{Ln\_WCP} \\ e_{Ln\_WY} \\ e_{WIR} \\ e_{Ln\_DY} \\ e_{INF} \\ e_{DIR} \\ e_{Ln\_CRD} \\ e_{Ln\_NEER} \\ e_{Ln\_KSEI} \end{bmatrix} \tag{5}$$

There are nine variables in the system divided into two blocks, a foreign block, and a domestic block. The foreign block includes the following three variables, world commodity prices, foreign output and foreign interest rate in (5) whereas the rest represent the domestic block. The foreign block is not only set ahead of the domestic block but it is also set as complete exogenous to the domestic block. This implies that domestic block contemporaneously responds to the foreign block but not otherwise. The order of foreign block to lead the domestic block has been guided by the prior literature on SVAR modeling for small open economy Cushman and Zha (1997), Dungey and Fry (2000) and Dungey and Pagan (2000).

The inclusion of world commodity prices ahead of all variables is to represent, that world prices are relatively more exogenous in the model. Moreover, world commodity prices index is a broader indicator for external supply shock than oil prices, as it includes the prices of energy and non-energy commodities. World commodity prices are followed by world output and world interest rate. The world output is assumed to respond contemporaneously with world prices. Whereas the world interest rate shows that foreign monetary policy responds to external inflationary pressure and output variations contemporaneously. The identification of foreign block is in line with Allegret *et al.* (2012).

The domestic block leads with two target variables of monetary policy, domestic output and inflation rate in row four and five of (5). The domestic output and inflation contemporaneously respond to world commodity prices. As Pakistan is a developing economy and it relies on the imports of production inputs and commodities. A positive shock to the world commodity prices would instantly transmits into the domestic inflation and output. In addition to it, the domestic output is also affected by the world income, world interest rate, and domestic credit. The domestic output is represented by the industrial production index. Therefore, any change in the demand for the domestic credit will instantaneously affect the production capabilities in the economy. Moreover, a change in the income of major trading partners can immediately influence the demand for domestic products in those countries, thereby affecting the domestic output. Similarly, a rise in the world interest rate represents the slowdown of the world economy, which can also affect the domestic growth and output.

Row six represents the reaction function of monetary policy. This study assumes that the domestic monetary policy decisions are contemporaneously affected by the change in prices and real economic activity, following a standard Taylor rule. However, the inclusion of world commodity prices in the reaction function is to control the external supply shocks<sup>7</sup>.

The last three rows represent the transmission channels of monetary policy. The credit channel in row seven shows that the demand for credit depends on the interest rate and the level of output in the domestic economy. The exchange rate and asset price channel are assumed to respond contemporaneously with all variables in the foreign and domestic block, it is due to the fact that both variables are fast moving.

As the foreign block is assumed to be the block exogenous, the zero restrictions on the lag values of the domestic variables are represented in the equation (6) of the lag coefficient matrix.

$$\Gamma(L) = \begin{bmatrix} a_{11} & a_{12} & a_{13} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} & a_{47} & a_{48} & a_{49} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} & a_{57} & a_{58} & a_{59} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} & a_{67} & a_{68} & a_{69} \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & a_{77} & a_{78} & a_{79} \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & a_{88} & a_{89} \\ a_{91} & a_{92} & a_{93} & a_{94} & a_{95} & a_{96} & a_{97} & a_{98} & a_{99} \end{bmatrix} \begin{bmatrix} Ln\_WCP_{t-i} \\ Ln\_WY_{t-i} \\ WIR_{t-i} \\ Ln\_DY_{t-i} \\ INF_{t-i} \\ DIR_{t-i} \\ Ln\_CRD_{t-i} \\ Ln\_NEER_{t-i} \\ Ln\_KSEI_{t-i} \end{bmatrix} \quad (6)$$

<sup>7</sup> See Kim and Roubini (2000) and recently Ali Ahmed and Wadud (2011) for the inclusion of external supply shocks in the reaction function of monetary policy.

Equation (6) shows that the domestic variables have no effects on the foreign variables even in the lags. This is a valid assumption in the case of Pakistan for being a small open economy, as it has no impact on the world economy.

The structural parameters of matrix B in (5) are estimated using the maximum likelihood estimation, where the log likelihood function is given as:

$$\mathcal{L} = c - \frac{T}{2} \log |B^{-1} \Sigma_{\epsilon} B^{-1}| - \frac{1}{2} \sum_{t=1}^T T (\epsilon_t' B' \Sigma_{\epsilon}^{-1} B \epsilon_t) \quad (7)$$

Where c is a constant, B represents matrix B with restrictions,  $\Sigma_{\epsilon}$  = variance-covariance matrix of structural shocks and  $\epsilon_t$  is estimated residuals.

As the SVAR model is over identified with seven additional zero restrictions, the likelihood ratio (LR) statistic will validate the additional restrictions in the model. The LR test statistics is given as:

$$LR = T(\log \det (\Sigma_{\epsilon}^r) - \log \det (\Sigma_{\epsilon})) \quad (8)$$

Where  $\Sigma_{\epsilon}^r$  is a corresponding estimator, obtained from restricted structural form estimation, and  $\Sigma_{\epsilon}$  is a ML estimator of the reduced form model. This statistic has a Chi-square distribution with degrees of freedom equal to the number of over identifying restrictions.

In order to gauge the relative strength of the transmission channels in the presence of external shocks, the shutdown method proposed by Ramey (1993) has been used. This method allows shutting down a particular channel in a system to capture its contribution on the target variables i.e. output and inflation. For instance, to gauge the relative strength of credit channel in our system, the Impulse Response Functions (IRF) will be analyzed under two settings. Initially, the IRF of baseline model will be compared with the IRF of appended model, where credit channel is set exogenous in the system. Secondly, the deviations of the IRF of appended model from the IRF of baseline model will trace the strength of credit channel, i.e. larger deviations will represent credit channel as a strong channel in affecting the target variables. This method has also been used accordingly by Morsink and Bayoumi (2001), Disyatat and Vongsinsirikul (2003) and Perera and Wickramanayake (2013).

### Data and Variable Descriptions

The quarterly data have been used from 1992Q1 to 2014Q4. Most of the data have been collected from the IMF's international financial statistics except for credit (Ln\_CRD) and asset prices (Ln\_KSEI). The data for credit (Ln\_CRD) have been gathered from the State Bank of Pakistan, this data represents the total amount of loans disbursed to the private sector. The data for asset prices (Ln\_KSEI) represents Karachi stock exchange 100 index, that is a benchmark index and it is collected from Thomson Reuters DataStream.

There are a total of nine variables divided into two blocks, as explained earlier. The foreign block includes world commodity price index (Ln\_WCP) including the prices of both energy



and non-energy commodities, provided by the IMF. The foreign output (Ln\_WY) and foreign interest rate (WIR) are calculated as trade-weighted variables for four major trading partners of Pakistan i.e. United States, United Kingdom, Germany, and China. The foreign output (Ln\_WY) is a trade-weighted industrial production index of major trading partners, similarly, a foreign interest rate (WIR) is also a trade-weighted short term interest rates of those countries. This study follows Zaidi *et al.* (2013), Zaidi and Karim (2014) and Othman *et al.* (2015) for calculating the trade-weighted measures of the foreign variables.

The domestic block includes industrial production index as a domestic output (Ln\_DY). Although the domestic GDP is a broader indicator for output but the Pakistan bureau of statistics reports annual GDP only. The domestic inflation rate (INF) has been calculated from the consumer price index of Pakistan, using standard inflation rate formula. Using inflation rate rather than consumer price index to represent price level is due to the fact that SBP targets inflation rate as its primary objective. The domestic interest rate (DIR) is represented by the six month government treasury bill rate<sup>8</sup>. The purpose of this short term interest rate is twofold, one, it will indicate the monetary policy stance in Pakistan, and second, it will also represent as the interest rate channel in the transmission of monetary policy. A similar approach has also been used by Perera and Wickramanayake (2013) in the context of a small open economy.

The remaining three variables are used to represent other three transmission channels. Credit channel has been represented by the total amount of loans provided by scheduled banks to the private sector (Ln\_CRD)<sup>9</sup>. This variable will allow us to capture both elements of bank lending and balance sheet effects in credit channel (Tang, 2006). The Karachi stock exchange 100 index (Ln\_KSEI) is used as a benchmark index to represent asset price channel and nominal effective exchange rates (Ln\_NEER) is for exchange rate channel. Any decrease in Ln\_NEER will represent the depreciation of domestic currency against the basket of currencies for all major trading countries to Pakistan and vice versa. Since our foreign variables are represented by trade weighted variables, so we used nominal effective exchange rates for exchange rate channel.

In addition to these variables, a dummy variable is also included in the model to capture the crises period of 2008. The X-12 procedure was used to adjust the seasonality in the variables. All variables are transformed into natural logs except domestic inflation and interest rates (foreign and domestic) they are kept in percentage points.

<sup>8</sup> The state bank of Pakistan (SBP) uses the discount rate as its policy rate. The discount rate is announced every two months as a policy stance in the country. Whereas SBP is also responsible for conducting the auction of governments treasury bill rate. The auction of six month treasury bill (T-bill) rate is conducted every two weeks, so the T-bill provides quick signals to the financial markets as compare to discount rate.

<sup>9</sup> Scheduled banks here refer to all commercial banks, Islamic Banks, Public Banks and Specialized Banks

**RESULTS AND DISCUSSION**

Before discussing the key findings from the SVAR model, the preliminary analyses are presented as following. Table 1 provides the results from the Augmented Dickey Fuller (ADF) unit root test. The test results indicate that all variables are integrated of order one except world interest rate and domestic inflation rate, as they are stationary in the levels. The Kwiatkowski Phillips Schmidt Shin (KPSS) unit root test also shows that results are not much different than ADF test<sup>10</sup>. In order to study the dynamic response of the variables in a system, we follow the approach of Cushman and Zha (1997), Kim and Roubini (2000) and recently Ibrahim and Sufian (2014) to estimate the SVAR in level despite the mix order of integration<sup>11</sup>. In addition to it, the SVAR models rely on economic theory and the theoretical relationships of economic variables are based on the level forms. Thus, we choose variables in their levels for the analysis.

**Table 1** Augmented Dickey Fuller (ADF) Unit Root Test

Variables	At Levels		At First Difference	
	Constant	Constant and Trend	Constant	Constant and Trend
Ln_WCP	-0.845	-2.370	-6.435***	-6.387***
Ln_WY	-2.538	-1.673	-3.651***	-3.861**
WIR	-1.102	-3.622**	-4.645***	-4.601***
Ln_DY	-0.503	-1.392	-13.663***	-13.588***
INF	-3.990***	-3.954**	-7.591***	-7.553***
DIR	-2.116	-2.101	-6.727***	-6.696***
Ln_CRD	-1.380	-1.0433	-5.794***	-5.927***
Ln_NEER	-0.693	-2.277	-6.815***	-6.787***
Ln_KSEI	0.117	-1.534	-5.613***	-5.655***

Note: The optimal numbers of lags are determined by Akaike information criterion (AIC) where maximum lag 4 was chosen. The Subscript \*\*\* indicates significant level at 1%, \*\* at 5% and \* at 10% respectively. The null hypothesis for ADF test is that variable has a unit root. Critical value for null hypothesis for constant is -3.515, -2.898, and -2.586 at 1%, 5% and 10% significant level, and the critical value for constant and trend is -4.073, -3.465 and -3.159 at 1%, 5% and 10% significant level respectively.

**Table 2** Lag Order Selection Criteria

Lags	FPE	AIC	SC	HQ
0	1.67e-15	-8.486860	-7.980132	-8.282712
1	1.93e-24	-29.07649	-26.28948*	-27.95367*
2	1.18e-24	-29.62735	-24.56007	-27.58587
3	1.42e-24	-29.60360	-22.25605	-26.64346
4	5.79e-25*	-30.81386*	-21.18603	-26.93505

Note: The Subscript \* indicates lag order selected by the criterion. Where FPE stands for final prediction error, AIC is Akaike information criterion, SC is Schwarz information criterion and HQ is Hannan-Quinn information criterion.

<sup>10</sup> The KPSS test results are not reported in order to conserve space. However, the results are available upon request.

<sup>11</sup> For the detailed specification of level form VAR model, we refer to the work of Sims, Stock, and Watson (1990), Lütkepohl and Reimers (1992) and Ramaswamy and Sloek (1997). Whereas, the specification of SVAR with mix order variables I(0) and I(1) we refer to Levitchenkova *et al.* (1998).

Table 2 provides the optimal lag length under different information criteria. The lag length 4 is suggested by the Akaike Information Criterion (AIC) and final prediction error (FPE) while the lag length of 1 is suggested by the Schwarz (SC) and Hannan-Quinn Information Criterion (HQ). Due to the contradiction in the results of optimal lag length, the LM test for serial correlation is reported in Table 3(a). The test reports the issue of serial correlation in lag length 1, 3 and 4, while lag 2 and 5 are free from serial correlation. Thus, lag length 2 is selected because including more lags might involve the degrees of freedom problem. In addition, the literature on monetary policy transmission mechanism on quarterly data, also suggests that lag order of 2 is enough to capture the dynamics of the system, See Ramaswamy and Sloek (1997) and Disyatat and Vongsinsirikul (2003). However, in order to validate the serial correlation problem, the Portmanteau test is also conducted for the VAR models with lag length 2 and 4 separately. The test results in Table 3(b) confirm that VAR with 2 lag is appropriate to choose, with a marginal significance level.

**Table 3** Residual Diagnostic Tests

**a. Residual Serial Correlation Lagrange Multiplier (LM) test**

Lags	LM-Stat	P-Value
1	107.9071	0.0245
2	86.49077*	0.3177*
3	112.5859	0.0117
4	101.9342	0.0579
5	96.80331*	0.1111*

Note: The null hypothesis for LM test is; no serial correlation

**b. Residual Serial Correlation Portmanteau Test**

Panel A: VAR (4)		Panel B: VAR (2)	
Tested order	16	Tested order	16
Test Statistics	1164.9632	Test Statistics	1241.1839
P-Value	0.000	P-Value	0.0912*

Note: The null hypothesis for Portmanteau test is; no serial correlation

**c. Residual Heteroskedasticity ARCH-LM Test**

Variables	Teststat	P-Value (Chi-sq)	F stat	P-Value (F)
Ln_WCP	2.8001	0.9999	0.1819	0.9998
Ln_WY	10.7065	0.8272	0.7823	0.6981
WIR	8.9660	0.9148	0.6376	0.8395
Ln_DY	10.8500	0.8186	0.7946	0.6852
INF	12.0221	0.7425	0.8971	0.5758
DIR	17.0760	0.3807	1.3874	0.1811
Ln_CRD	11.6448	0.7680	0.8637	0.6114
Ln_NEER	9.8222	0.8757	0.7078	0.7743
Ln_KSEI	5.4889	0.9927	0.3705	0.9844

Note: The null hypothesis for ARCH-LM test; no heteroskedasticity in residual

After choosing the lag 2 for the SVAR model the ARCH-LM (autoregressive conditional heteroskedasticity) test was performed to check the heteroskedasticity in the residuals. Table 3(c) confirms that there is no ARCH behavior in the residuals. Table 4 shows that the SVAR model with 2 lag length satisfies the stability condition, which indicates that impulse response functions generated from the model, are valid and stable<sup>12</sup>.

**Table 4** Stability of Structural-VAR Model; Inverse Roots of Characteristic Polynomial

Modulus	0.978	0.943	0.943	0.904	0.904	0.771	0.771	0.662	0.662
	0.608	0.551	0.397	0.397	0.369	0.369	0.210	0.171	0.171

Note: No root lies outside the unit circle, VAR satisfies the stability condition.

The estimation results of the contemporaneous SVAR model are presented in Table 5. The LR test for the over-identification restriction finds the additional restrictions to be valid, with the probability value of 0.2543. The estimated coefficients of the matrix B in (5) are reported in the lower panel of Table 5, there are sixteen coefficients that are found significant. As the estimated coefficients of matrix B are expressed on the same side of equation (5), the signs shall be read as reversed. Most of the coefficient carries expected signs, for instance, the coefficient of inflation rate shock in the monetary policy reaction function enters positively ( $b_{65}$ ). Similarly, the world commodity prices shock ( $b_{57}$ ) carries expected sign for the inflation rate equation, showing the positive relationship between world and domestic price level. However, as mentioned earlier that the goal of SVAR analysis is not the parameter estimations but the dynamic response, because the estimated coefficient exhibits limited significance so the inference should rely on the dynamic interaction of the variables. The dynamic responses are captured through IRF and are given below.

**Table 5** Estimation Results of Structural-VAR Model

Log Likelihood	2211.5797	
LR test for over-identification:		
Chi-square (7)	8.9767	Probability 0.2543

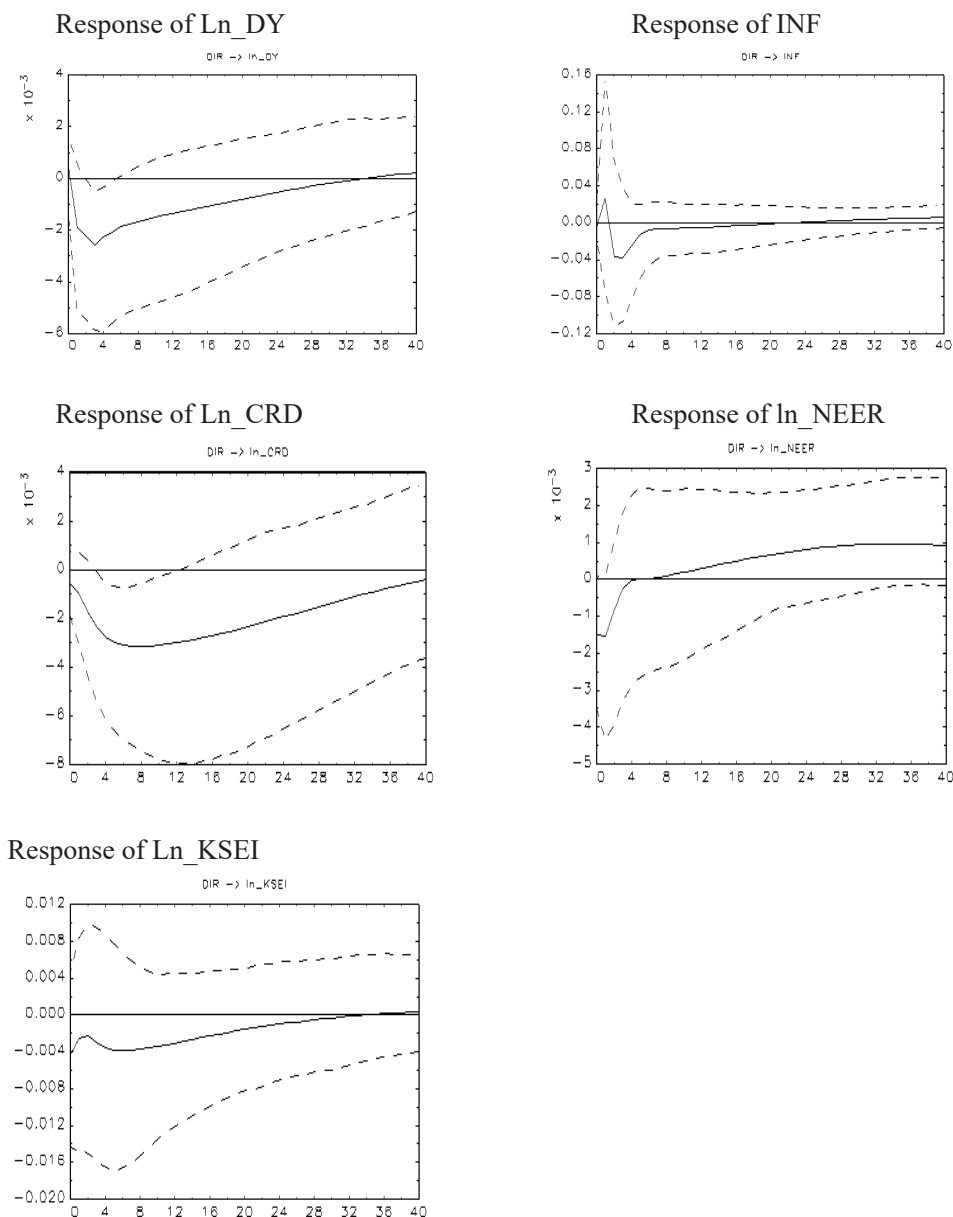
The IRF's from the SVAR model are presented in Figure 2 and 3. The solid line in Figure 2 shows the estimated response while the two dashed lines represent the confidence bands. These confidence bands are calculated from Hall's bootstrapping method, where 95% confidence interval and 2500 bootstrap replications were chosen for estimation.

### Impulse Response Functions of Domestic Variables to Monetary Policy Shocks

Figure 2, shows the response of domestic variables to the innovation in monetary policy shocks. The first row of Figure 2 contains the response from the output and inflation rate. The domestic output responds negatively to the rise in the domestic interest rate, the negative response is significant and bottomed out at the end fourth quarter. The unexpected tightening of monetary policy lead to significant decrease in the domestic output indicates that monetary

<sup>12</sup> Robustness of the model is tested using different lag lengths and the results confirmed that the IRF are stable with lag length of 2.

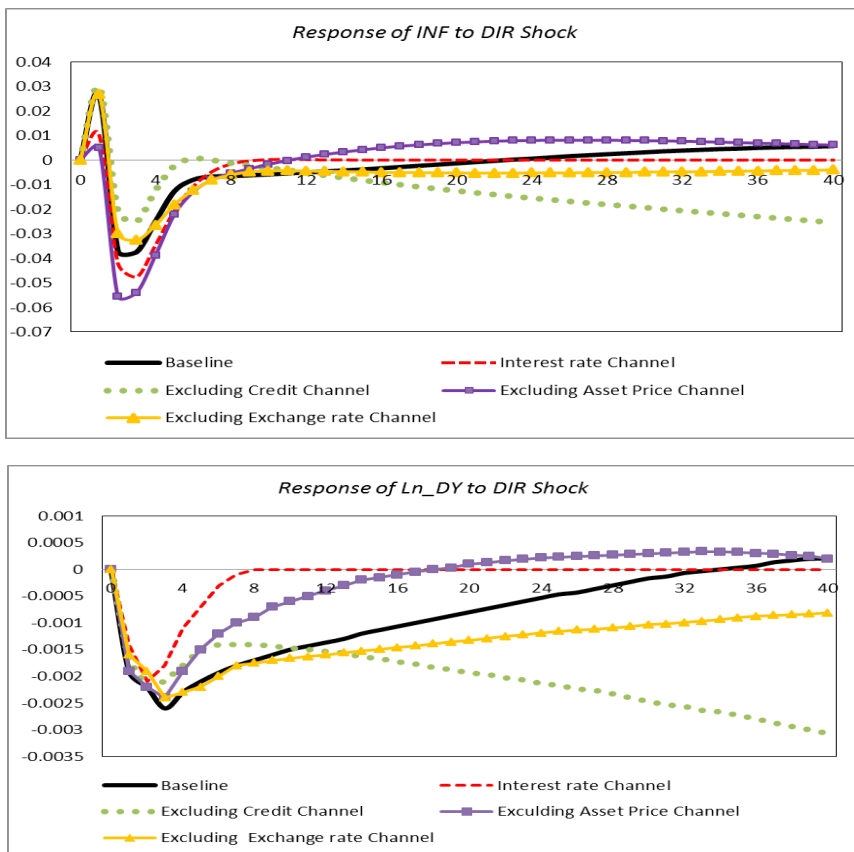
policy is effective in the short run. The positive response of inflation rate in the first quarter followed by negative response implies a price puzzle. This shows that the inclusion of world commodity prices have not removed the price puzzle, as it was expected to eliminate such anomaly. The possible explanation that is provided in the literature is due to the existence of the cost channel in the economy. Rehman and Malik (2010) have shown that manufacturing industries in Pakistan are able to shift the cost of capital to their prices. Hence, there is a strong support for the existence of cost channel in Pakistan which is responsible to this price puzzle.



**Figure 2** Response of Domestic Variables to Monetary Policy Shocks

The second row in Figure 2 shows the response of credit and exchange rate channel. The effects of monetary tightening are negative on credit to private sectors provided by scheduled banks. Following a one percentage point increase in interest rate reduces the credit to the private sector by 0.31% significantly, within a second year of shock. The exchange rate response is negative (depreciation) initially to the tight monetary policy, but followed by a positive (appreciation) response. The initial response of exchange rate is regarded as exchange rate puzzle while later is regarded as a delayed overshooting in the exchange rates. Grilli and Roubini (1995) showed that explanation of exchange rate puzzle is similar to that of price puzzle in the results. The delayed overshooting in the exchange rate is a common empirical finding against the overshooting theory of exchange rates . Similar response of exchange rates are commonly observed in small open economies (Phiromswad, 2015). Finally, the domestic stock market has also responded negatively with an increase in interest rate. This is because monetary tightening slowdowns the economic activity, which affect dividend payments and ultimately reducing asset prices.

### Relative Strength of Monetary Policy Transmission Channels



**Figure 3** Relative Strength of Monetary Policy Transmission Channels

Figure 3, provides the relative strength of monetary policy transmission channels on output and inflation rate. The upper panel shows the relative strength of each transmission channel on the domestic inflation rate, whereas lower panel shows for domestic output. Each figure consists of five impulse responses combined together, in order to compare their strength. The baseline impulse response is presented by a solid line and it is calculated from the baseline SVAR model given in equation (5). The other four impulse responses belong to each transmission channel, and these impulse responses are calculated by the shutdown method explained earlier.

The impulse response function of the interest rate channel is acquired when the baseline SVAR model is amended by the shutdown method, setting credit, exchange rate and asset price channel exogenous in the model. In the short run (at the end of fourth quarter) the interest rate channel is proved to be important, as it brings additional one third changes in inflation rate and it also contributed less in the initial price puzzle. However, its importance is only limited to short run because its effects on the inflation rate dissipate after two years. The credit channel accounts for the half of variations in the inflation rate during short run, whereas in the medium run its effects increases more than half. The credit channel not only found important during the short and medium run (at the end of the eighth quarter) but it also proved to be important in the long run, as its exclusion from model makes the impulse response unstable in the long run. Asset price channel found to be important in the long run that is beyond the second year. Whereas exchange rate channel proves to be least important on the inflation rate, as its exclusion from the model provides long lasting effects on the inflation rate.

In the case of output, the interest rate channel found to be important in the short run. The interest rate channel brings almost half variation in the output level at the end of the first year, compare to other channels. But its effects are short lived, till the end of second year output returns back to its historical trend. The credit channel has been found not only important in short run but also in the long run. During short run, it brings additional one fourth variations in the domestic output, and if the credit channel is excluded from the model the impulse response becomes unstable in the long run. The relative importance of interest and credit channel is followed by asset price and exchange rate channel on domestic output.

## CONCLUSION

This study empirically examined the contemporaneous causal relationship of monetary policy and macroeconomic variables in Pakistan, by employing open economy structural VAR model with block-exogeneity and non-recursive identification. The focal point of this study is to examine the monetary policy effectiveness in the presence of external variables. In order to serve this objective, we examined the effects of contractionary monetary policy on domestic target and intermediate variables. In addition to it, the relative strength of monetary policy transmission channels has also been analyzed using shutdown methodology in SVAR modeling.

The empirical results based on structural impulse response functions reveals following findings. First, the unexpected monetary policy shocks significantly reduce output in the short run which implies the slowdown in the domestic economic activity. In the case of inflation, the monetary policy is found to be effective in medium to long run. Whereas in very short

run the monetary policy tightening has a positive effect on inflation causing a price puzzle. The existence of price puzzle is due to the active cost channel in Pakistan. Furthermore, the results also suggest that monetary policy is effective in influencing all intermediate variables in addition to the output and inflation.

Second, the interest rate channel of the monetary policy is found effective on the inflation rate and output in the short run. The credit channel of transmission proves to be effective in short run and also in long run comparing to other two asset price and exchange rate channel. This implies that during the inflationary pressure on the domestic economy the interest rate channel shall be utilized to contain the inflation rate, whereas the credit channel must be utilized to enhance output in the long run. These findings are consistent with other studies on small open economies e.g. Tang (2006), Aleem (2010) and Perera and Wickramanayake (2013).

After allowing the external variables in the model the findings suggest that the effectiveness of monetary policy in Pakistan is limited to stabilize the macroeconomic variables. Therefore, we draw two important policy implications. One, the monetary authorities are required to closely monitor the turbulences in the global economy in order to safeguard the macro performance of the economy. Second, the importance of interest rate channel in the short run and credit channel in both short run and long run, assures monetary authorities to rely on former to control inflation and later to enhance output.

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