SBP Working Paper Series

No. 22 March, 2008

Short-Run Effects of an Unanticipated Change in Monetary Policy: Interpreting Macroeconomic Dynamics in Pakistan

Mahmood-ul-Hasan Khan

STATE BANK OF PAKISTAN

SBP Working Paper Series

Editor: Riaz Riazuddin

The objective of the SBP Working Paper Series is to stimulate and generate discussions, on different aspects of macroeconomic issues, among the staff members of the State Bank of Pakistan. Papers published in this series are subject to intense internal review process. The views expressed in the paper are those of the author(s) and do not necessarily reflect those of the State Bank of Pakistan.

Price per Working Paper

Pakistan: Rs 50 (inclusive of postage)

Foreign: US$ 20 (inclusive of postage)

Purchase orders, accompanied with cheques/drafts drawn in favor of State Bank of Pakistan, should be sent to:

Chief Spokesperson
Corporate Services Department,
State Bank of Pakistan,
I.I. Chundrigar Road, P.O. Box No. 4456,
Karachi 74000. Pakistan

For all other correspondence:

Editor,
SBP Working Paper Series
Research Department,
State Bank of Pakistan,
I.I. Chundrigar Road, P.O. Box No. 4456,
Karachi 74000. Pakistan

Published by: Editor, SBP Working Paper Series, State Bank of Pakistan, I.I. Chundrigar Road, Karachi, Pakistan.

ISSN 1997-3802 (Print)
ISSN 1997-3810 (Online)

http://www.sbp.org.pk

Printed at the SBPBSC (Bank) – Printing Press, Karachi, Pakistan

Short-Run Effects of an Unanticipated Change in Monetary Policy: Interpreting Macroeconomic Dynamics in Pakistan

By

Mahmood-ul-Hasan Khan
Joint Director
Financial Stability Department
State Bank of Pakistan
Karachi, Pakistan.
mahmood.khan@sbp.org.pk

Abstract
The study provides an empirical update on the impact of an unanticipated change in monetary policy on key macroeconomic variables (output growth and inflation) in Pakistan. We use monthly data and multivariate structural vector auto-regression (SVAR) technique using long-run restrictions based on standard aggregate demand and supply model of the economy. The results indicate that an unanticipated positive shock in monetary policy leads to: (1) an increase in industrial output, which reverts to its original level over 23 to 32 month horizon; (2) an increase in inflation; and (3) nominal (monetary) shocks remain the dominant factor in explaining variation in inflation as compared to supply side disturbances. Transmission mechanism is much faster in case of prices compared to output, as over 75 percent change in CPI is realized during 12 months after the shock and this impact reaches the level of over 90 percent during 18 months. Sensitivity of these results to another specification indicates that response patterns of both industrial production index and CPI remain unchanged.

JEL Classification: C32, E52, E58

Key Words: Monetary Policy, Central Bank, SVAR, Long-run Restrictions

---

I would like to thank Riaz Riazuddin, Muhammad Mazhar Khan, Nadeem Hanif and Adnan Hyder for their valuable comments/suggestions to improve the paper. Views expressed in this paper are those of the author and do not necessarily represent those of the State Bank of Pakistan. Comments and suggestions are welcome.

Economists have spent lots of energies in understanding and explaining the links between monetary and real macroeconomic activities. All these efforts have culminated in near consensus among the economists on long-term relationship between monetary and real economic activities known as the long-run neutrality of money, which is well-documented in economic literature. In sharp contrast to this near consensus, the short-run interactions amongst the monetary and real variables, which are of vital importance for the conduct of monetary policy are still widely debated by the economists. On one hand, New Classical economists are of the view that prices are flexible and adjust *quickly* to clear the markets. On the other hand, New Keynesians argue that market-clearing models are unable to explain short-run economic fluctuation and believe in *stickiness of prices*. Based on *sluggish adjustment* of prices, both the Keynesians and the Monetarists recognize the effects of monetary policy on production activities in the short-run (Mankiw and Romer, 1991).

Notwithstanding Friedman's view that inflation is always and everywhere a monetary phenomenon, the role of supply-side factors is highlighted by the proponents of Structuralist school of thought. The supply chain management has potential to impact prices of *certain* items, if not all, which have implications for general price level in the economy. Pakistan is not an exception as State Bank of Pakistan (central bank of the country) has sometimes pointed out the role of supply side bottlenecks in explaining inflation in Pakistan.[1]

The above issues create uncertainty not only for the final outcome of policy actions but also for the transitory behaviors of the real and monetary variables in the economy. Specifically, the policy makers at central banks confront explicit policy questions like: what will be the effect of a one percentage point change in monetary policy instruments (interest rates or growth in money supply) on the prices and output in the economy. How the impact of monetary policy will differ in case of anticipated and unanticipated change in monetary policy? Similarly, the policy makers also seek information on the response pattern of macroeconomic variables (prices and output) as the impact of monetary policy always entails some lags.

A huge volume of theoretical and empirical research is trying to answer the above-mentioned questions. However, the results continue to differ on account of differences in empirical methodologies, definitions of variables, different time periods, sampling intervals etc. Moreover, the results also differ due to country specific factors including the level of development of financial sector and different monetary policy regimes followed by the countries. In this paper, we attempt to find out empirical evidence on the

---

[1] First Quarterly Report for the year 2006-2007 suggested that "food inflation pressures in Pakistan could be better controlled through by (1) improvement in supply of key staples, and (2) administrative measures as were taken in the month of *Ramadan*.

impact of unanticipated changes in monetary policy[2] on macroeconomic variables (output and prices) in case of Pakistan. We use monthly time series data from July 1991 to September 2006 for detailed analysis. The paper also attempts to analyze the response pattern of macroeconomic variables over time to an unanticipated monetary policy shock. The changes in monetary policy are proxied by both the behavior of monetary aggregates (M2) and the interest rates. While addressing the explicit policy questions at hand, the paper also explains the shortcomings of descriptive and reduced form Vector Autoregressive analysis widely used in empirical literature, especially related to Pakistan.

The paper is organized in five sections. Background information and the objectives of the paper are the subject of section I. Section II provides descriptive analysis of monetary and real macroeconomic variables based on cross correlations at various lags and leads. This simple analysis is followed by discussion on dynamic relationship among these variables based on reduced form VAR models. Results from reduced from VAR are discussed in section III. As the results from the widely employed reduced form VAR depends on specific ordering of the variables and structural interpretations of these results may be quite misleading, we will move towards structural VAR (SVAR) analysis. Identification restrictions and results based on SVAR are discussed in section IV. The final section is reserved for summarizing results and conclusions.

2. Descriptive Evidence

Based on the equation of exchange we relate monetary and real variables of the economy. We also proxy real economic activity in the economy by industrial production index (IPI) in the absence of higher frequency data for the real gross domestic product (GDP).[3] The consumer price index (CPI) has been used to measure the general price level in Pakistan. From monetary side we use broad money supply (M2). However, it is important to mention that various changes occurred in Pakistan on monetary policy front due to financial sector reforms continued since early 1990s. The SBP has moved from the use of direct to indirect tools of monetary management. As the M2 entails the elements of both demand and supply of money, we also use interest rate (cut-off yield of 6-month T-bills) to proxy monetary policy stance. In other words, we will be using both quantity and price of money to proxy monetary policy. All variables used in analysis are in log forms with the exception of interest rate.

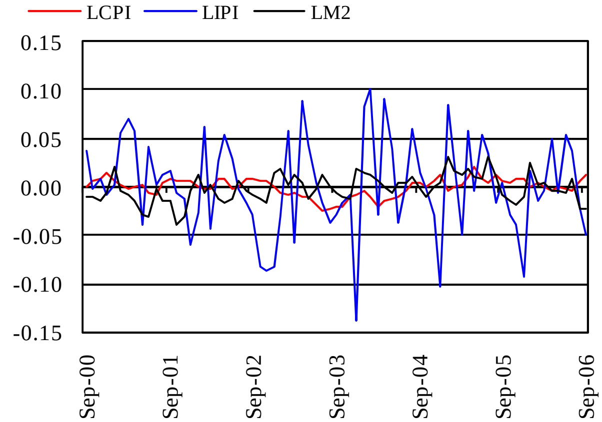
---

[2] The most striking finding of imperfect information models is that anticipated change in monetary policy does not matter. Although this finding is also controversial, we study the impact of an unanticipated change in monetary policy only (see Blanchard, 2000)

[3] One can argue that IPI may not be a very good proxy for overall economic activity as it covers around 20 percent of GDP. In this regard two points are worth noting. First, industrial sector performance has strong linkages with the agriculture and services sector of the economy, and is generally considered an important leading indicator. Secondly, the industrial sector is the largest recipient of bank credit, and any change in monetary policy directly alters the cost of borrowing of this sector.

We begin our descriptive analysis by looking at the graphs of detrended times series of the relevant variables.[4] A quick view of **Figure 1** indicates that it is really hard to draw any conclusion from visual inspection about the relationships among monetary aggregates, prices and industrial production. However, simple correlation coefficient over the period of analysis indicates that detrended monetary aggregates variable is positively associated with industrial output (correlation coefficient is 0.33) and is negatively associated with CPI (correlation coefficient is 0.16). This essentially means that periods of high level of industrial output from its potential (long-term trend) are positively associated with the periods of high level of broad money (from its long-term trends). On the other hand, a negative correlation between detrended LM2 and LCPI means that periods of high level of broad money are negatively correlated with the periods of low inflation. Two points are worth noting at this stage. First, the contemporaneous correlation of LM2 with LCPI and LIPI may be of little importance as lags and leads among monetary and macroeconomic variables play a vital role in explaining the relationships. Second, simple correlation among the variables does not necessarily suggest causation in economic sense.

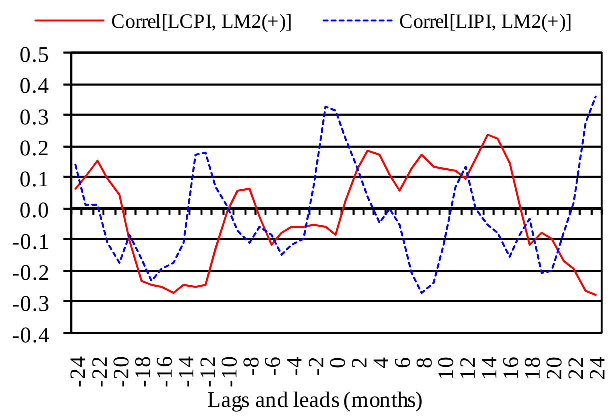
Figure 1: Detrended LIPI, LCPI and LM2



2.1 Macro Variables and Monetary Aggregates

To analyze relationship at various lags and leads in variable, we focus on timing of movements in detrended LM2, LIPI and LCPI. For this purpose, we use lags and leads of LM2 up to two years and compute dynamic correlations among the variables. The **Figure 2** shows that detrended LIPI is positively correlated with detrended LM2 up to 5 months lead and remained negative up to 11 months. Compared to this, correlation between LM2 and LCPI showed different pattern as both are positively associated up to 18 month lead. It implies that LCPI leads LM2. Specifically, periods of high level of inflation from its trend are followed by the periods of high monetary expansion (from its trend). This is exactly opposite to standard monetary

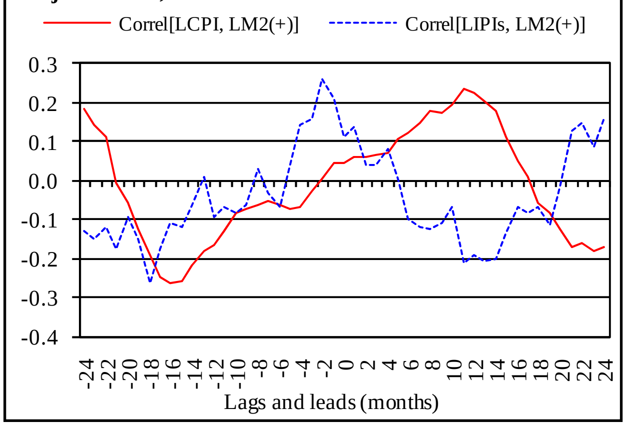
Figure 2: Dynamic Correlations between Detrended LM2, LIPI and LCPI



[4] We use Hodrick-Prescott filter to extract trends from various time series data.

economics that periods of high broad money should be followed by the periods of high inflation. Another point to note from **Figure 2** is the presence of seasonality in the data. Since the co-movement of variables may be due to similar seasonal patterns among the series, we calculate dynamic correlations by using seasonally adjusted data. The **Figure 3** shows that both the magnitude and patterns of correlations changes considerably if we seasonally adjust the data. However, the correlation patterns still do not reflect any systematic relationship between detrended LIPI and LM2. Compared to this, correlation between detrended LCPI and LM2 continued to increase up to 11 month lead and decline to almost zero at 18 month leads. The earlier results that LCPI leads LM2 remained intact. The possible explanation for this type of behavior comes from demand for money side (instead of money supply) as nominal demand for money is likely to increase due to high inflation.

Figure 3: Dynamic Correlations between Detrended Seasonaly Adjusted LM2, LIPI and LCPI



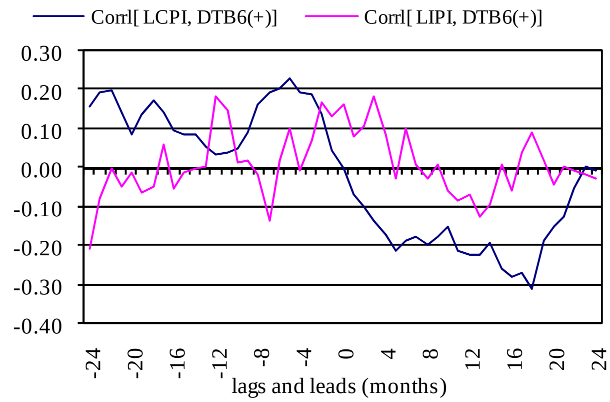
The above patterns of correlations do not match with the famous findings that "money matters" and "money leads output" (Friedman and Schwartz, 1963). Importantly, one should not conclude that changes in monetary aggregates negatively effects the IPI. In fact, above correlation patterns clearly reflect that monetary aggregates take into account the elements of demand for money. It means that *changes in monetary aggregates do not necessarily imply change in monetary policy*, as the behavior of both individuals and banks seems more important. Arcangelis and Giorgio (1999) also point out that "monetary aggregates cannot be viewed as correct indicators of monetary policy, as they combine elements of both money supply and money demand". There may be other explanations as well, like SBP may not be actively pursuing monetary aggregates as its intermediate target. In this case changes in interest rate become more important. This is what we are going to explore in the next subsection.

2.2 Macro Variables and Interest Rate

Discussion in preceding section suggests that monetary aggregates may not be a comprehensive indicator of monetary policy in case of Pakistan after financial sector reforms initiated in early 1990s. In this backdrop, we also analyze the relationships among changes in LIPI, LCPI and the interest rates (6-month cut-off yield of T-bills). [5]

A quick view of **Figure 4** reveals that there is no systematic pattern of association between detrended seasonally adjusted LIPI with changes in cut-off yield of 6-month T-bills (TB6). Moreover the magnitude of correlation remained low at various lags and leads. However, there exists a systematic relationship between detrended seasonally adjusted LCPI and DTB6 with maximum correlation coefficient of 0.31 in absolute terms. The figure shows that there is almost no contemporaneous association between LCPI and DTB6. This is according to well-known lagged impact of monetary policy as changes in interest rate in time period 't' are expected to effect inflation with some lag. However, positive association between changes in TB6 and future inflation represents the classic 'price puzzle' which is widely observed in empirical research (Aga et.al 2005, Bernanke and Blinder 1992, and Sims 1992). One of the possible explanations for the price puzzle could be the forwarded looking behavior of the central bank (Sims 1992).

Figure 4: Correlations between Detrended Seasionaly Adjusted LIPI and LCPI with DTB6



3. Reduced Form VAR Analysis

The descriptive analysis clearly shows that simple pair-wise correlations may be quite misleading for policy analysis. Notably, simple correlations are only indicative of interrelations among the variables and these temporal relations must not be confused with the causation. The endogeneity problems remained unattended. For example, cut-off T-bill yield is determined in an auction system, which is simultaneously affected by the demand conditions of the market and financing requirement of the government along with SBP monetary policy stance. The identification of monetary policy shock is further complicated by the fact that changes in monetary policy itself are in response to various shocks observed in the economy (feedback effect). All these issues suggest that we cannot unambiguously determine, from the lags and

[5] On the use of interest rate and monetary aggregates in the analysis, two points are worth noting. One is related to the confusion between the monetary aggregate and interest rate. To put it simply, one should not confuse between quantity and the price. Monetary aggregate is the quantity and interest rate is the price. Any change in monetary policy stance will affect both the quantity and the price. Theoretically, we can use any one of these variables. The idea of using both these variables is to be more exploratory. The second point is related to the use of 6-month cut-off yield of T-bills. In this regard, it may be noted that including interest rate does not mean that SBP is using interest rate as a monetary policy tool. It simply means that interest rates will change in response to change in monetary policy stance in an open market environment.

leads of correlations, that changes in monetary aggregates or interest rate are purely due to changes in monetary policy. In these setting, we use VAR analysis, which not only treats all the variables in the system as endogenous but also helps in identifying the shocks under certain assumptions. The validity of these assumptions will also be discussed in detail.

We estimate various reduced form VAR models including different combinations of industrial production index (IPI), consumer price index (CPI), broad money (M2) and interest rates. All VAR models include 12 lags of each variable in the system and 12 deterministic variables comprising of 11 dummy variables to capture seasonality in monthly data and a constant term. In next two sub-sections we will be using once monetary aggregates and short-term interest rate as policy instrument separately.

3.1: M2 as a Proxy for Monetary Policy

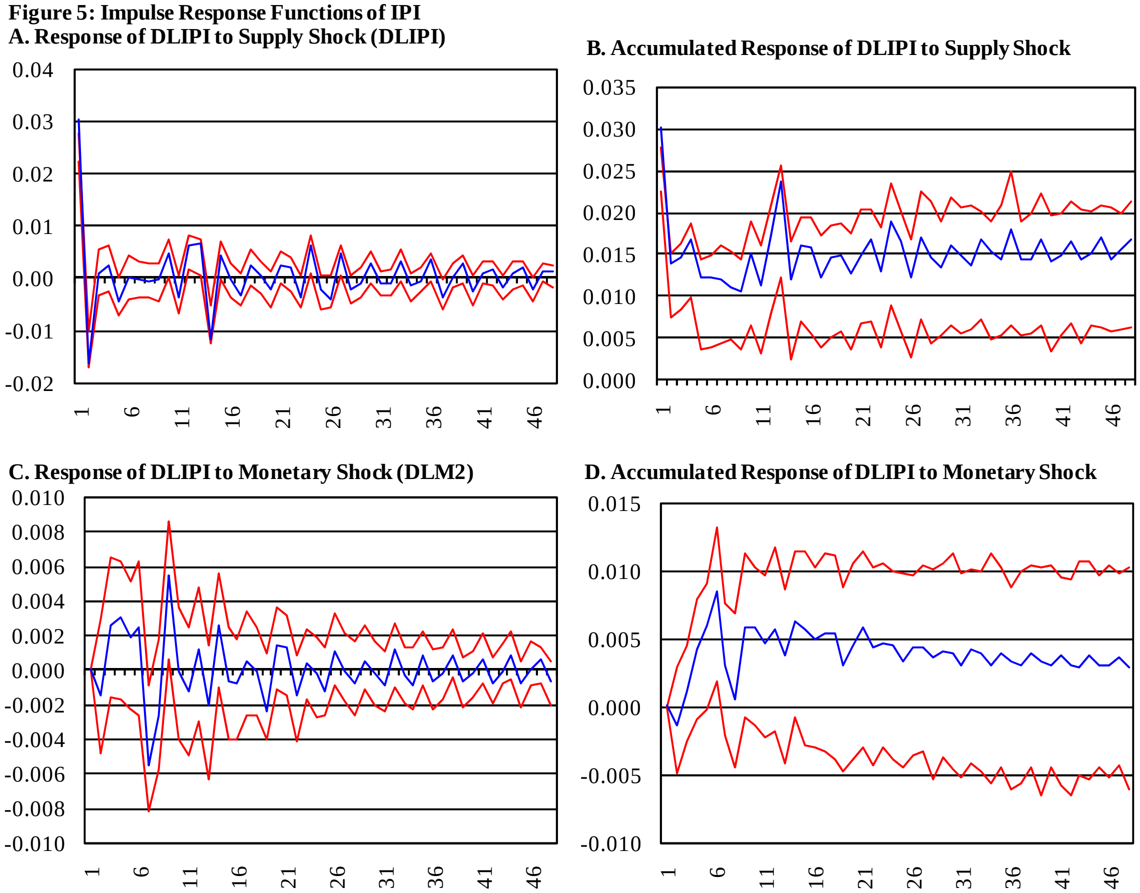
As a first step, we estimate reduced form VAR models based on difference stationary and trend stationary series of LIPI, LCPI and LM2. Temporal Granger-causality tests indicate that results from difference and trend stationary models are similar (see **Table 1**). Specifically, the results indicate that both LIPI and LCPI are exogenously determined as we fail to reject zero restrictions on lagged coefficients in both equations. The tests also indicate that LCPI and LM2 do not Granger-cause LIPI. The most surprising result is that LIPI and LM2 do not granger cause LCPI. This is contrary to the economic theory as changes in monetary aggregates affect inflation in the economy. Without disputing the standard relationship between money supply and inflation, we explore the specification issues and inherent weaknesses of attaching structural interpretation to the results obtained from reduced form VAR models, and short span of the data used in this study.

Table 1: Granger Causality Tests

	Difference Stationary		Trend Stationary	
	F-Statistic	**Level of Significance**	**F-Statistic**	**Level of Significance**
Dependent Variable: LIPI				
LIPI	6.62	0.0000	2.82	0.0021
LCPI	0.97	0.4781	0.66	0.7842
LM2	1.14	0.3380	1.30	0.2298
Dependent Variable: LCPI				
LIPI	1.19	0.2963	0.94	0.5126
LCPI	2.39	0.0087	28.37	0.0000
LM2	1.32	0.2191	1.20	0.2949
Dependent Variable: LM2				
LIPI	2.02	0.0290	2.01	0.0293
LCPI	0.52	0.8965	0.56	0.8706
LM2	1.76	0.0628	19.75	0.0000

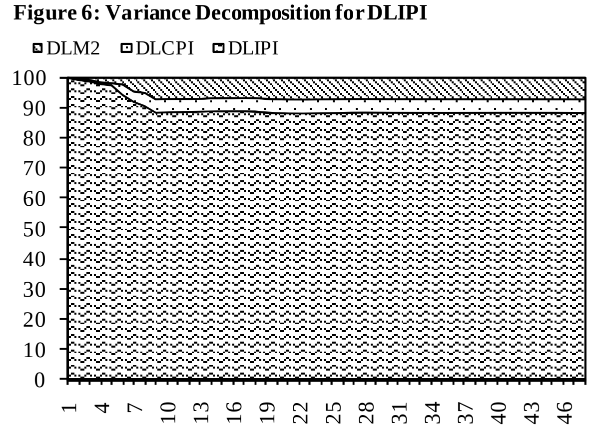
Impulse response functions from above reduced form VAR model are obtained by using Cholesky decomposition, which is a mechanical way of imposing minimum number of restrictions that exactly identifies the structural model. Specifically, this method uses the ordering of variables in the VAR and assigns entire effect of any shock to first variable in VAR ordering. Using this Cholesky decomposition, the impulse responses of industrial production to its own innovations (supply shock) and to nominal shock are shown in **Figure 5** up to 48-months (4 years). Bottom right panel of **Figure 5** indicates that accumulated response of DLIPI to unexpected shock in monetary aggregate (monetary expansion) is positive after two months. Importantly, impulse responses also indicate that accumulated response of DLIPI does not revert to its original level due to monetary policy shock even after 4 years. This type of response is against the wisdom of long-run money neutrality.

Figure 5: Impulse Response Functions of IPI



While the above response functions help in understanding the time path of DLIPI in response to shock in innovations, the relative importance of various shocks in explaining total variation in endogenous variables in the system is analyzed by using variance decomposition. **Figure 6** indicates changes in DLIPI are primarily explained by its own shocks (supply shocks). The estimates suggest that random shocks to broad money only

Figure 6: Variance Decomposition for DLIPI



accounts for 6.7 percent variation in DLIPI after one year. It means that unexpected positive shock to monetary aggregate (LM2) is unable to explain any sizeable variation in industrial output. If we ignore technical issues with this VAR specification, the results favor the argument of Real Business Cycle (RBC) theory that money is not an important factor in explaining variation in output.

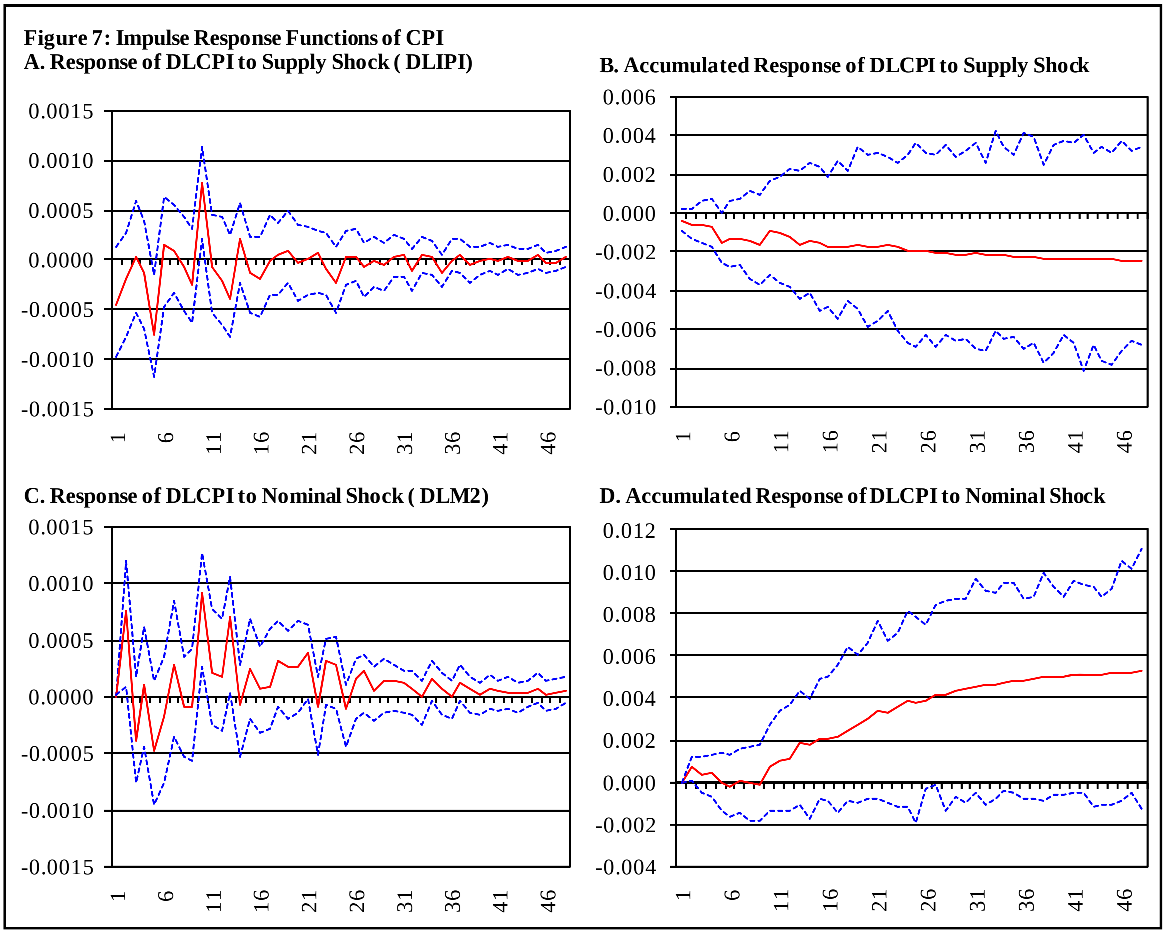


Figure 7: Impulse Response Functions of CPI

Impulse response function of DLCPI to supply shock (shocks to innovation of DLIPI) and nominal shock (DLM2 innovations) followed the expected time path (see **Figure 7**). Decline in accumulated DLCPI in response to positive supply shock is in line with economic theory, as the eased-off supply conditions should have negative effect on price level keeping other things constant. The impact of nominal shock on accumulated DLCPI is also according to economic theory as a positive nominal shock is likely to increase inflation. However, time path followed by the DLCPI seems too long. Around 22 percent increase in accumulated DLCPI is recorded after one year of nominal shock, which increases only to 41 percent after 18 months. This slow response of accumulated DLCPI to nominal shock does not match with prior expectation as 6 to 8 quarters (18 to 24months) are generally considered long enough for nominal shock to effect prices.

The variance decomposition of DLCPI shown in **Figure 8** indicates that innovations in both DLM2 and DLIPI remained unable to explain any significant size of variation in DLCPI. In simple words, both variables are of little importance in explaining inflation over the estimation period. Relatively low importance of DLIPI in explaining variation in inflation (DLCPI) provides no support to the structuralist view in case of Pakistan. The above findings do not support the monetarist view also, as the nominal shock accounts for only 7.7 to 11.1 percent variation in inflation from one to two year horizon (more on this issue later).

Figure 8: Variance Decomposition For DLCPI

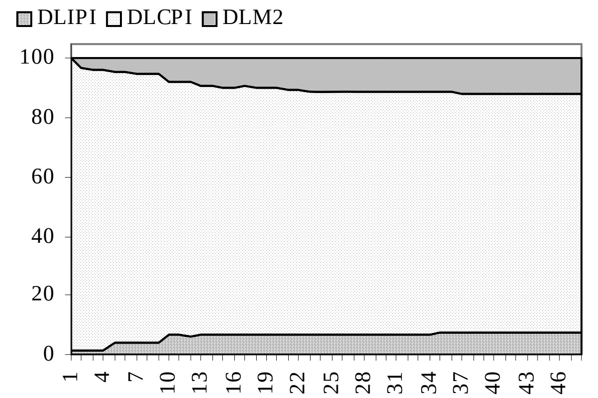
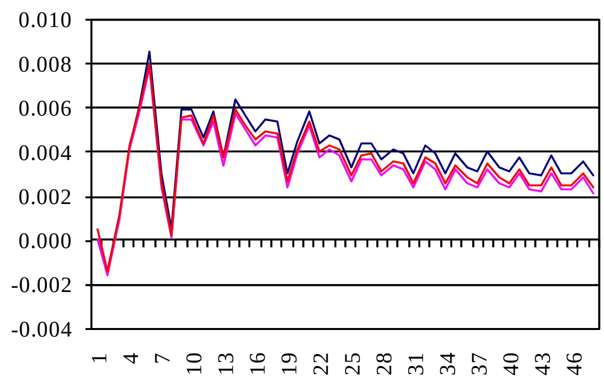


Figure 9: Accumulated Response of DLIPI to Monetary Expansion under different Choleski Ordering



As mentioned earlier, the impulse response functions and variance decomposition depend on the ordering of the variables in the VAR. The intensity of this dependence rests on cross-correlations among the residuals from VAR equations. From the reduced form VAR, the correlation coefficient among the residuals is less than 0.1 in all cases. This suggests that Cholesky ordering is not important here. This same is also confirmed in **Figure 9**, which depicts the accumulated response of DLIPI to monetary expansion according to three different ordering of the VAR variables.

3.2: Interest Rate as a Proxy for Monetary Policy

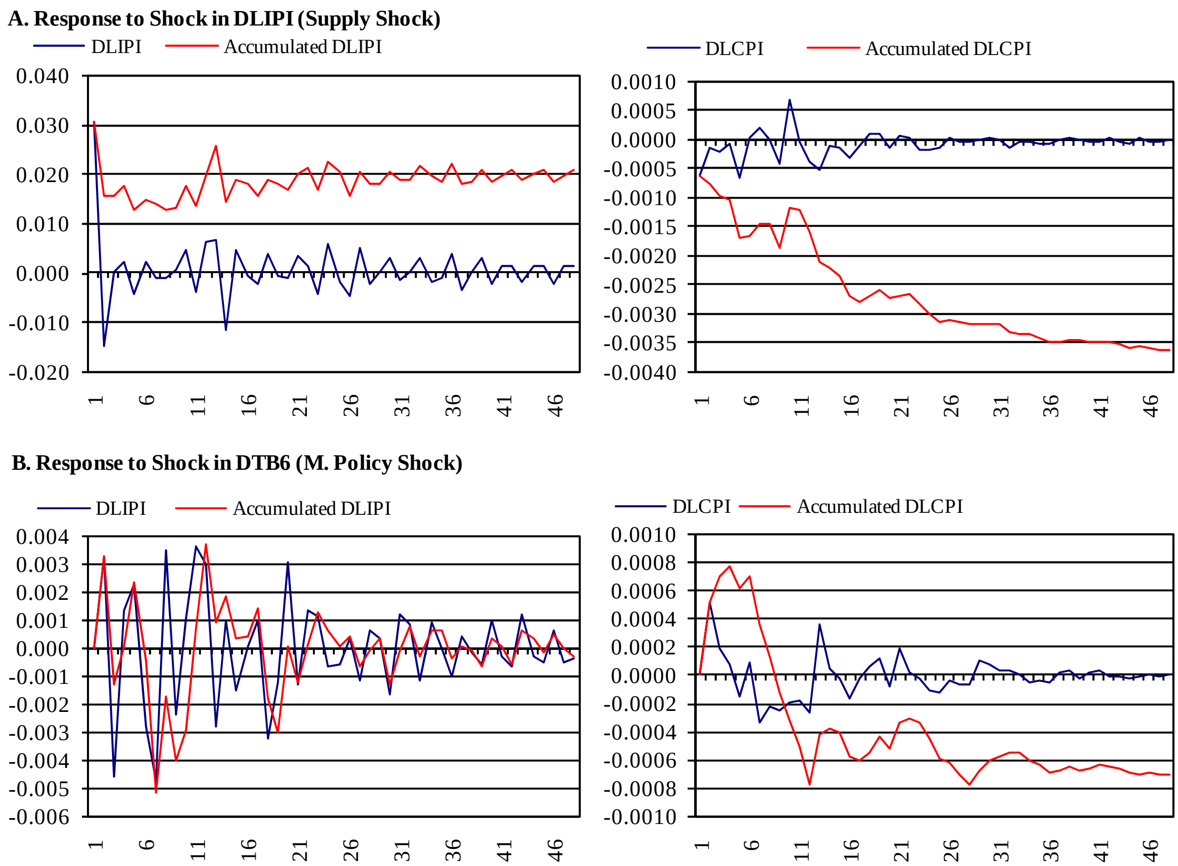
As highlighted in descriptive analysis that monetary aggregates (M2) may not be a good indicator of monetary policy stance, in this section we use cut off yield of 6-month T-bills (TB6) as a proxy for monetary policy. **Table 2** indicates that changes in log IPI and log CPI are again exogenously determined as was the case with monetary aggregates. The impulse response functions of DLIPI to one standard deviation

Table 2: Granger Causality Tests

	F-Statistic	Level of Significance
Dependent Variable: DLIPI		
DLIPI	8.241	0.000
DLCPI	0.680	0.767
DTB6	0.970	0.482
Dependent Variable: DLCPI		
DLIPI	1.046	0.413
DLCPI	2.297	0.012
DTB6	0.638	0.806
Dependent Variable: DLM2		
DLIPI	1.156	0.324
DLCPI	1.140	0.336
DTB6	1.808	0.055

supply shock and to cut-off yield of 6-month T-bill indicate that accumulated DLIPI recorded considerable changes up to 24 months (see **Figure 10**). An important point to note is the response of DLIPI to shock in TB6, which approached towards zero over the four year horizon. These response patterns are according to the expectation, as it is generally accepted that supply shock should have permanent impact on the level of output, and nominal shock (innovation in TB6) should not have any impact over long horizon.

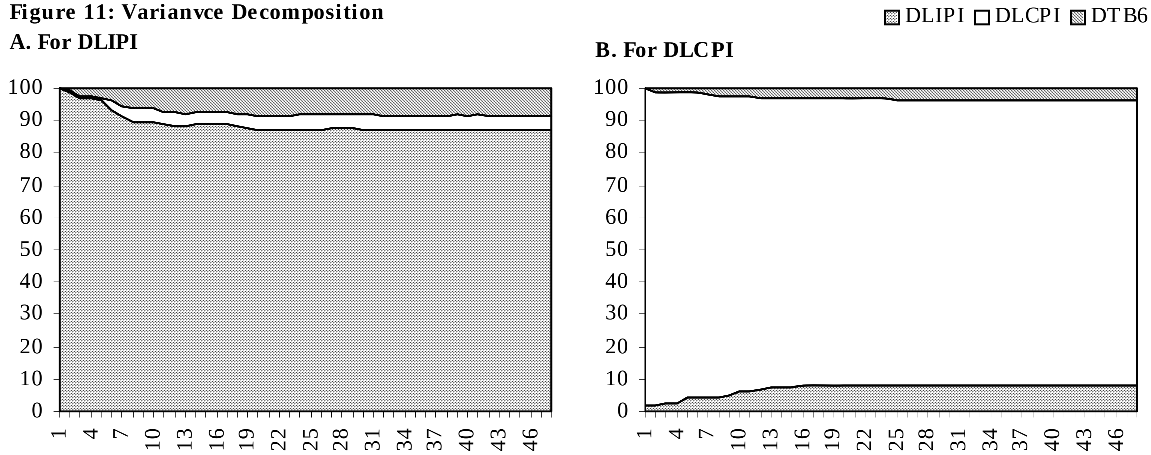
Figure 10: Impulse Response Function of Log IPI and Log CPI



As so for the response pattern of accumulated DLCPI is concerned, it continued to decline in response to supply shock. The same was also observed in previous section and is according to expectation. However, behavior of DLCPI indicates the presence of price puzzle (also observed in descriptive analysis) as accumulated DLCPI increases at initial stages following the rise in TB6. Inflation picked up sharply following the positive shock in T-bill rate and reached its maximum after 4-month. Since then, accumulated DLCPI witnessed steep decline up to 12 months and ended in negative zone. Specifically, around 50 bps rise in T-bill yield will decline accumulated DLCPI by 100 bps over the next three years. Although magnitude seems to be on lower side, the behavior represents the standard monetary policy outcome that increase in interest rate will negatively affect the level of inflation.

Variance decomposition for DLIPI indicates that innovations in DTB6 remained unable to explain any significant portion of variation in this variable (see **Figure 11**). Specifically, its contribution in explaining variation in DLIPI is around 7 percent at one year horizon (almost same level is observed in case of LM2). Similarly, innovations in DTB6 and DLIPI remained unable to explain any significant level of variation in DLCPI.

Figure 11: Varianvce Decomposition



In sum, the above results clearly indicate that both changes in log of monetary aggregate and changes in cut-off yield of 6-month T-bill remained unable to explain any significant variation in endogenous variables (DLIPI and DLCPI) in the systems. This poor explanatory power can be attributable to a number of factors ranging from misspecification issues to definitional problems attached with the variables. More importantly, responses from reduced form VARs are difficult to interpret economically, as they are obtained by using ad-hoc statistical/mechanical assumption (Cholesky decomposition) to identify ceteris paribus shocks. For example, we interpreted innovations to DLM2 and DTB6 as unanticipated monetary policy shock in above reduced form VAR models. However, this may not be the case as innovations to DLCPI can also be interpreted as nominal shock. It means the above reduced form VAR models remain unable to separate nominal shock from real demand shock, while the supply shock is identified by the innovations of industrial production index. All this suggests that we can not attach structural interpretation to the impulse response functions obtained from reduced form VAR models. However, the above analysis helps in understating dynamic relationships among the variables.

4. Structural VAR Analysis

The structural vector auto-regression (SVAR) attempts to overcome the problems attached with reduced form VAR models by using restrictions derived from the underlying structural model (economic theory), instead of using ad-hoc statistical/mechanical assumptions. In this paper, we follow Blanchard and Quah

(1989) SVAR approach, where restrictions are derived from long-run impact of exogenous shocks on endogenous variables. This approach has several advantages. First, long-run effects of exogenous variables are substantially less controversial as compared to the short-run effects. Furthermore, the long-run effects generally hold in a wider range of economic models relative to short-term effects which are more model-specific. Second, the long-run restrictions allow analyzing the short-term dynamics of endogenous variables to exogenous shocks without imposing any restrictions. In other words, the short-run responses will be purely determined by the data (unrestricted short-term responses). Finally and more importantly this allows to identify structural innovations that can be given economic, ceteris paribus, interpretations.

4.1 A Reference Economic Model

We use standard aggregate supply (AS)/aggregate demand (AD) framework for a small open economy as it provides a convenient way to understand short-run impacts of monetary policy. In this AS/AD framework, real demand or nominal shock will shift AD in the short-run and causing output to deviate from its natural level (because of sticky prices--prices and wages--assumption). As prices adjust in the long-run, economy will move back to its natural level of output. This framework also suggests that real interest rates will move back to its original position in response to nominal shock over long horizon. Another macro variable that will return back to its original level in the long-run is the real exchange rate. However, both real interest rate and real exchange rate will exhibit some transitory effects in the short-run.

Keeping this AS/AD framework in mind, we will make use of output (industrial production index), real interest rate and consumer price index to study the impact of an unexpected change in monetary policy on output and prices. As short-run deviation in output can arise from both supply and demand side factors, the use of real interest rate (or real exchange rate) will help to identify changes in output in response to real demand shock. Both, real interest rate (or real exchange rate) and CPI will help in identifying real demand shocks from nominal shocks in the system.

As SVAR results are sensitive to identification restrictions and choice of variables, we use two identification schemes with different variables. In first scheme, we will analyze the responses of endogenous variables in the system (denoted by $\Delta Z_t = [\Delta LIPI_t, \Delta RIR_t, \Delta LCPI_t]'$ a 3 by 1 vector of system's 3 variables) to structural shocks denoted by $\varepsilon_t = [\varepsilon_{yt}, \varepsilon_{dt}, \varepsilon_{mt}]'$. In second identification scheme, we analyze the responses of $\Delta Z_t = [\Delta LIPI_t, \Delta LREER_t, \Delta LCPI_t]'$ to the structural shocks denoted by $\varepsilon_t = [\varepsilon_{yt}, \varepsilon_{dt}, \varepsilon_{mt}]'$. It may be noted that ΔRIR_t in first identification scheme is replaced with log of real effective exchange rate denoted by $LREER_t$.

4.2 Identification of Restrictions in SVAR

The above AS/AD is used as reference economic model to obtain identification restrictions instead of using ad-hoc statistical restrictions. The restrictions can be bifurcated with respect to time into short-run (contemporaneous) and long-run restrictions. The contemporaneous restrictions are easy to interpret, but prior knowledge of contemporaneous (short-term) responses is rarely available in practice. In addition, contemporaneous restrictions are tricky as endogenous variables are affected contemporaneously in most of the cases by all of the shocks. Compared to this, we use a more plausible way suggested by Blanchard and Quah (1989) to make use of long-run theory-based restrictions. These long-run structural VARs use partial information about the long-run effects to indirectly identify the economic shocks. We derive our restriction from the AS/AD framework discussed earlier in this section. Specifically:

1. A real demand shock (ε_{dt}) has zero effect on the real level of output in the long-run. In fact, this restriction is based on traditional Keynesian view of fluctuation that demand disturbances have the transitory effect only.
2. A nominal shock (ε_{mt}) has no long-run effect on the real level of output. This is the famous money neutrality assumption.
3. A nominal shock (ε_{mt}) has zero long-run effect on real aggregate demand.

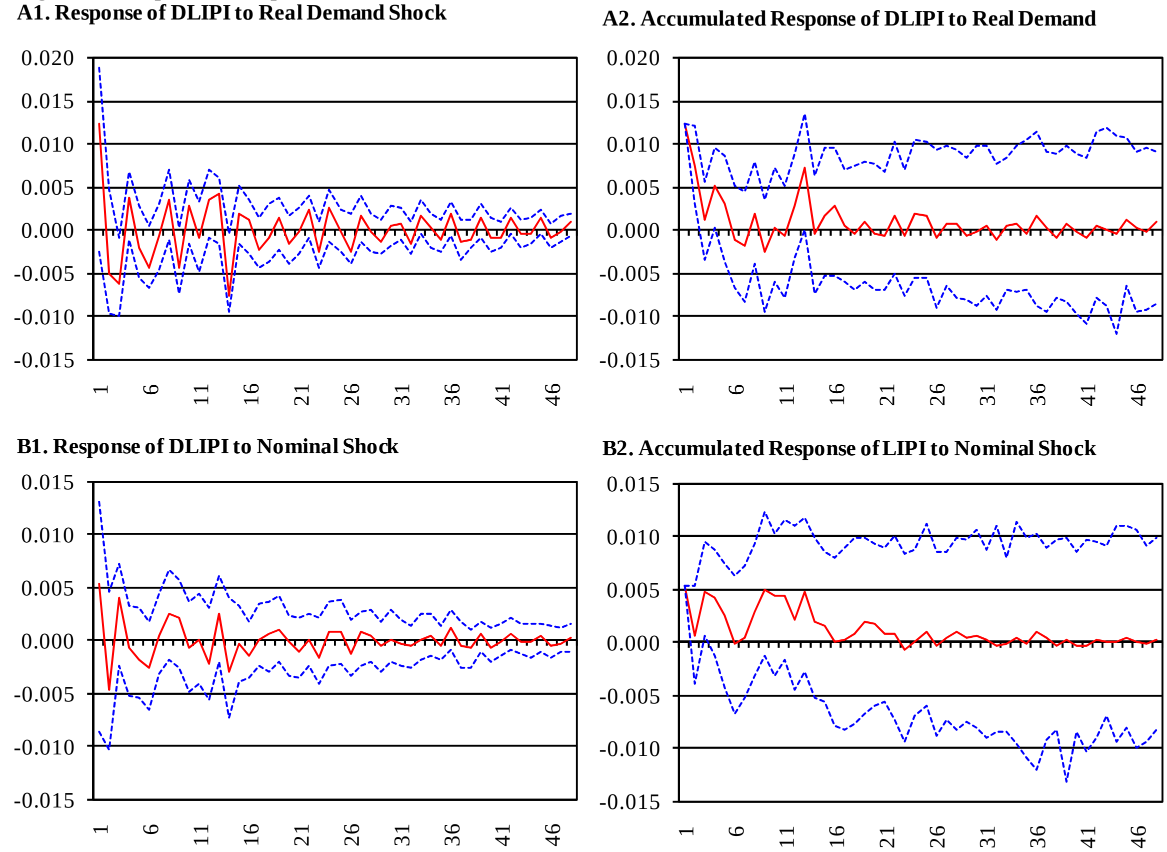
4.3 Results Based on SVAR

Table 3: Estimates of long-run Coefficients

	Shocks		
	Supply	**Real Demand**	**Nominal**
LIPI	0.0210	0.0000	0.0000
RIR	-0.2098	0.7261	0.0000
LCPI	-0.0096	0.0069	0.0087

The estimation of reduced from VAR with suitable transformations allows us to obtain the long-run impulse responses of the levels of endogenous variables to the structural shocks. The values of this specific matrix (i.e $A(1)$) are reported in **Table 3**. The results indicate that a supply shock (equivalent to 0.0272, measured by standard deviation of changes in Log IPI) has a negative effect on the real interest rates in the long-run. Specifically, it is likely to reduce real interest rate by 21 basis points over a long time horizon. Similarly, same size of supply shock is expected to reduce accumulated DLCPI by 0.0096 (equivalent to 99 bps). Compared to supply shocks, the effect of real demand shocks is more pronounced, as it will increase the real interest rate by 72.6 bps and would increase DLCPI by 0.0069 (equivalent to 100.7 bps increase in CPI) in the long-run. In the long-run, the nominal shock has zero effect on the accumulated DLIPI and level of real interest rate. These results are based on our identification restrictions. Similarly, real demand shock has zero effect on the long-run level of log IPI.

Figure 12: Response of Output to Demand Shocks

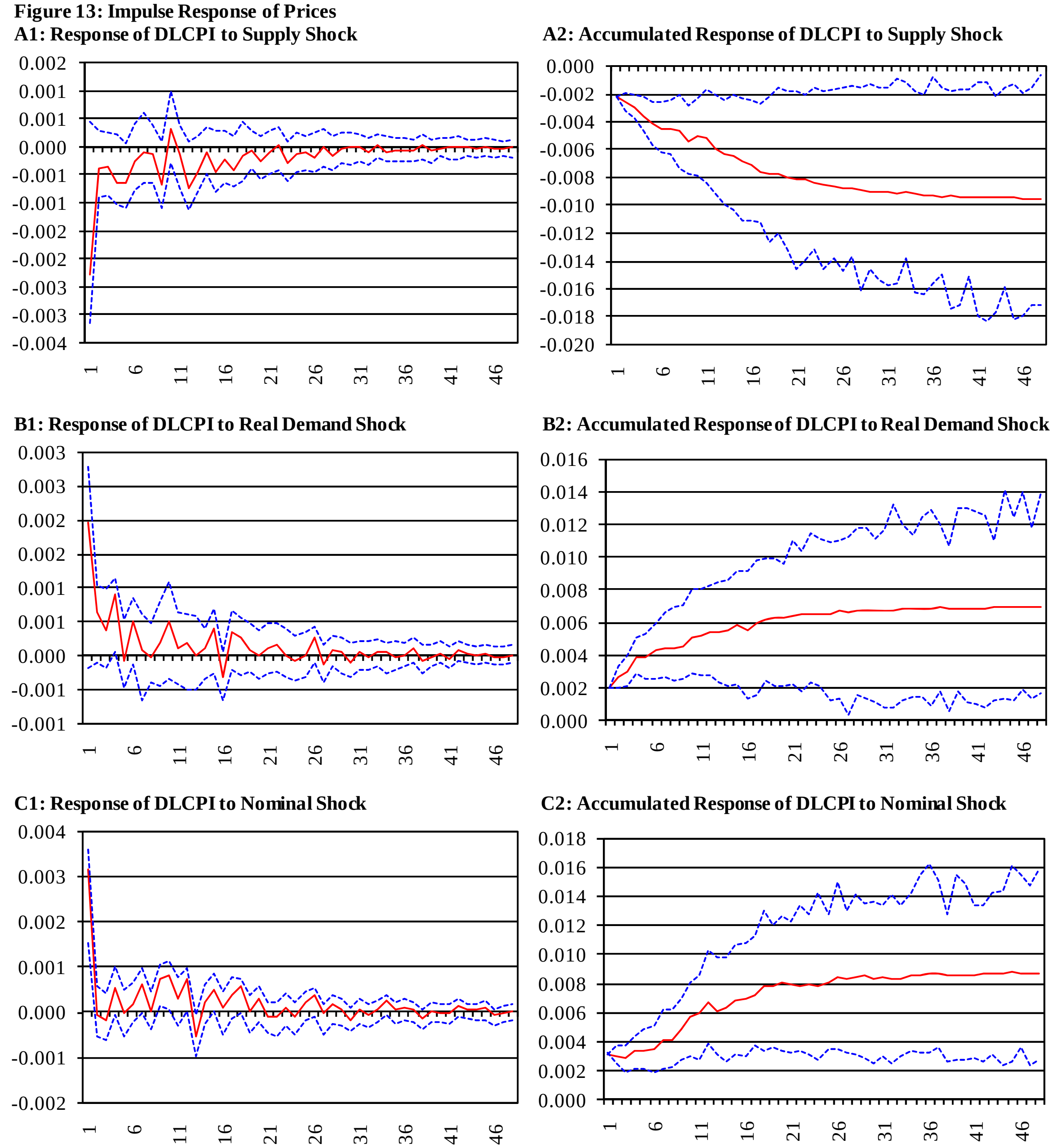


Short-Run Dynamics: Given the long-run responses, the short-run dynamics are analyzed with the help of impulse response functions based on above long-run restrictions. The **Figure 12** shows the impulse response functions of DLIPI and accumulated DLIPI to one unit shock to real demand and nominal structural innovations. The accumulated DLIPI reverts to its original level with some fluctuation after 23 months in case of a nominal shock. The fluctuations become really small after 32 months. In other words, impact of a positive nominal shock on DLIPI dies out after 32 months (11 quarters). The output takes almost similar time to revert to its original level in response to real demand shock. However, it is difficult to conclude that real demand shock has relatively strong effect on DLIPI as compared to nominal shock due to wide range of 90 percent confidence interval.

The impulse response functions of another macro variable of our interest (DLCPI) in response to all three shocks are shown in **Figure 13**. Accumulated DLCPI followed the expected time path. Response pattern shows that over 75 percent change in accumulated DLCPI in response to nominal shock is realized during

12 months. Another 15 percent impact is realized during next 6 months. This implies that more than 90 percent change in accumulated DLCPI in response to nominal shock takes place during first 18 months following the nominal shock. The response of DLCPI to real demand shock followed almost the same time path. An important point to note is that the ultimate impact of real demand shock on accumulated DLCPI is relatively smaller than the nominal shock in absolute terms. While it can not be established statistically due to wide range of confidence intervals, the response functions of accumulated DLIPI and DLCPI jointly suggest that this seems to be the case. A relatively strong affect of real demand shock on accumulated DLIPI (output) contains its inflationary impact on accumulated DLCPI (inflation) to some

Figure 13: Impulse Response of Prices



extent. On the other hand, relatively smaller affect of nominal shock on output leave more room for prices to adjust even in the short-run.

Relative Importance: The relative importance of each variable is again analyzed by using structural variance decomposition. The variance decomposition reported in **Figure 14** explains what proportion of forecast error variance of the variable '*i*' is accounted for by the '*j*'th shock at time horizon 1 to 48 months. Variance decomposition for the series DLIPI indicate that contribution of nominal demand shock stabilize after 3 quarters, while it takes 5 quarters for the real demand shock. The figure also shows that nearly 70 percent change in log IPI (DLIPI) is explained by its own innovations (i.e supply shock according to our specifications). The contribution of nominal shock in explaining changes in log IPI is just 3.1 to 6.5 percent over one year horizon. Compared to nominal shock, the contribution of real demand shock (innovations of RIR) is much higher as it accounts for 16.6 percent to 23.5 percent variation in change in log IPI over 18 months. Moreover, the real demand shock innovations are more important than the nominal demand innovations in explaining variation in DLIPI. These findings are very much consistent with the economic theory, as fiscal policy (real demand shock) is generally considered more effective than the monetary policy (nominal shock) to counter cyclical changes in output.

Figure 14: Variance Decomposition for DLIPI

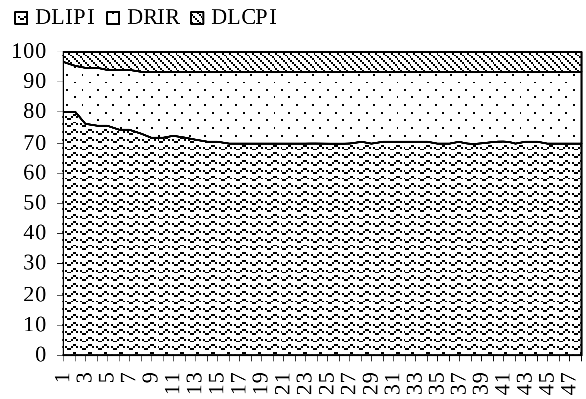
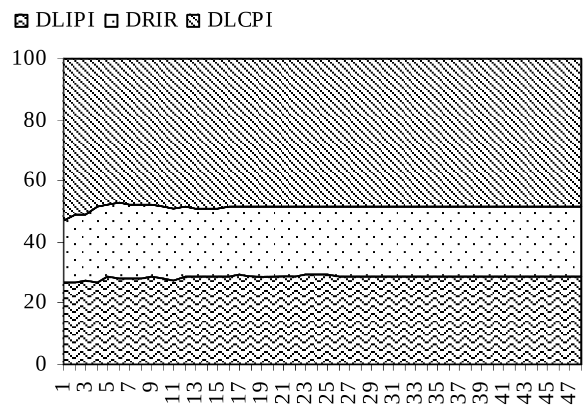


Figure 15: Variance Decomposition for DLCPI



Variance decomposition for the changes in log CPI (inflation) series indicates that nominal shocks remained the largest contributor with its share around 50 percent (see **Figure 15**). One the other hand, the contribution of supply innovations was near to 28 percent. The contributions of both supply and demand side shocks stabilize at time horizon of 18 months. These findings are consistent with Khan and Schimmelpfennig (2006) that "monetary factors have played a dominant role in recent inflation, affecting inflation with a lag of about one year". It may be noted that this is not to say that supply side disturbances are not important for inflation. The results only suggest that supply shocks are not the dominating factor.

Alternative Model: As mentioned earlier that results from SVAR depends on identification restrictions and the variables used to identify certain shocks, we estimate another SVAR using log of real effective exchange rate denoted by $LREER_t$ in place of real interest rate (RIR_t). The impulse response functions shown in **Appendix 2** indicate that accumulated DLIPI and DLCPI follow the same time path in response to nominal shock as was the case in previous model. However, the relative importance of nominal shock in explaining variation in DLIPI increased substantially. Specifically, variance decomposition indicates that nominal shock account for approximately 35 percent variation in DLIPI, as compared to around 7 percent in the base model. Compared to this visible change, variance decomposition for DLCPI again suggests that nominal disturbance have the dominating role.

5 Summary and Conclusions

The paper analyzes the short-run impact of an unanticipated change in monetary policy on macroeconomic variables in Pakistan, specifically on industrial production index and consumer price index. We use monthly time series data from July 1991 to September 2006 (post reform period) and multivariate vector auto-regression (VAR). To focus on short-run and unanticipated impact only, we make use of detrended and difference stationary series. Long-term trends in monetary and real variables were eliminated by using HP Filter. Pair-wise correlation patterns of macroeconomic variables do not seem to reflect either the traditional Keynesian or Monetarist view of monetary policy.

Descriptive analysis is followed by a reduced form VAR analysis. The selected lag length for VAR analysis is 12 month -- long enough to eliminate any serial correlation from the residuals. The results indicate that both DLIPI (output growth) and DLCPI (inflation) are exogenously determined, as we failed to reject the null that broad money does not Granger-cause IPI and CPI. Notably, the results remained unchanged even after replacing broad money with cut-off yield of 6-month T-bills. Despite these results, the impulse response functions based on these VARs clearly indicate that increase in money supply or reduction in cut-off yield of 6-month T-bills increases output and inflation in the short-run. The variance decomposition indicates that importance of shocks to monetary variables (broad money and cut-off yield) in explaining short-run variation in DLIPI is limited from 3 to 7 percent only. Another important point to note from reduced form VAR analysis is the permanent change (although small) in the level of IPI in response to changes in broad money.

The results from SVAR indicate that a positive nominal shock will increase output growth in the short-run and this positive effect will die out between 23 to 32 months horizon. Similarly, from 70 to 90 percent increase in inflation in response to a positive nominal shock is observed during 12 to 18 months. The SVAR results also suggest that: (1) the impact of real demand shock on output growth is relatively stronger than the impact of monetary shock; (2) the impact of nominal shock on inflation is stronger than the impact of real demand shocks; and (3) the nominal disturbances remained the dominant factor in explaining variation in inflation. The results from an alternative SVAR indicate that the response patterns of both industrial output growth and inflation remained unchanged in response to a positive nominal shock. The notable point is the change in relative importance of nominal shock in explaining variation in industrial output. The results confirm the earlier finding that nominal shocks remained the major source of inflation. In both models, the contribution of supply disturbances is around 25 percent in total variation in inflation.

While the above results provide useful information on the impact of nominal shocks on both output growth and inflation (two key macro variables), the empirical evidence in this paper is not conclusive on the relative importance of real demand and nominal shock disturbances. Moreover, nominal shocks in SVAR are interpreted as an unexpected change in monetary policy because supply and real demand shocks were clearly identified. Further analysis in this direction could be the separation of nominal shock into money demand and money supply shocks, as this will help in identifying the changes in log IPI and CPI in response to pure money supply shock only. Finally, this paper uses two alternative SVAR specifications to analyze the sensitivity of results; a possible extension of this paper could be sensitivity analysis using a range of alternatives restrictions and the variables.

References

Agha Asif I., Noor Ahmed, Y.A. Mubarik and Hastam Shah (2005). "Transmission Mechanism of Monetary Policy in Pakistan." State Bank of Pakistan Research Bulletin, Vol. 1, No. 2: 1-23.

Arcangelis, Giuseppe De and Giorgio Di Diorgio (1999). Monetary Policy Shock and Transmission in Italy: A VAR Analysis. Economics and Business Working Paper No. 446, University Pompeu Fabra.

Bernanke, Ben S., and Alan S. Blinder (1992). "The Federal Funds rate and the Channels of Monetary Transmission." American Economic Review, Vol. 82 (September): 901-21.

Blanchard, Olivier, J. (1990). Why Does Money Affect Output? A Survey (eds) Friedman B.M. and F.H. Hahn, Handbook of Monetary Economics, Volume II, Elsevier Science Publishers, B.V. 1990.

Blanchard, Olivier, J. and Danny Quah (1989). "The Dynamic Effects of Aggregate Demand and Supply Disturbances." American Economic Review, Vol. 79: 655-73.

Gali, Jordi (1992). "How Well Does the IS-LM Model fit Postwar US Data." Quarterly Journal of Economics, Vol. 107: 709-38.

Khan, Mohsin, S. and Axel Schimmelpfennig (2006). "Inflation in Pakistan: Money or Wheat." State Bank of Pakistan Research Bulletin, Vol. 2, No. 1: 213-36.

Monticelli, Carlo and Oreste Tristani (1999). What Does the Single Monetary Policy Do? A SVAR Benchmark for the European Central Bank., Working Paper Series, No.2, European Central Bank.

Mankiw, N. Gregory, and David Romer (eds). New Keynesian Economics. Vol. 2. 1991.

Sims, Christopher A. (1992) "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy." European Economic Review, Vol. 36(June): 975-1000.

Appendix 1: Specification and Identification of Restrictions in SVAR

As ΔZ_t denotes the vector of first differences of endogenous variables, the reduced form VAR can be expressed as: [6]

$$R(L)\Delta Z_t = \mu_t \quad and \quad Var(\mu_t) = \Omega_\mu \qquad (1)$$

Where, $R(L)$ is a 3X3 lag polynomial matrix. Inverting this reduced from VAR produces the reduced from vector moving average (VMA) representation of the data as follow.

$$\Delta Z_t = F(L)\mu_t \quad where \quad F(L) = R(L)^{-1} \; and \quad Var(\mu_t) = \Omega_\mu \qquad (2)$$

The problem with this representation is that the shock (μ_t) have no meaningful economic interpretation. Compared to this, we are interested in structural form VMA representation in which movement in all endogenous variables is expressed as functions of past *structural* shocks (ε_t) and these structural shocks are distinct economic phenomena. [7] Mathematically, the structural VMA can be expressed as follow.

$$\Delta Z_t = A(L)\varepsilon_t \quad Var(\varepsilon_t) = \Omega_\varepsilon = I \qquad (3)$$

Where $\varepsilon_t \sim i.i.d$. This implies that the vector ε_t is white noise with a covariance matrix that has unit variances[8] and zero covariance. In other words, covariance matrix is an identity matrix.

The comparison of reduced from VMA (equation 2) and structural form VMA (equation 3) representation of the endogenous variables indicates that:

$$\Delta Z_t = F(L)\mu_t = A(L)\varepsilon_t \qquad (4)$$

The evaluation of above polynomial representation at $L = 0$ will yield the following expression

$$F(0)\mu_t = A(0)\varepsilon_t \qquad (5)$$

From reduced from VMA, we know that $F(0) = I$ by construction. Therefore equation (5) can be written as

$$\mu_t = A(0)\varepsilon_t \quad or \qquad \varepsilon_t = A(0)^{-1}\mu_t \qquad (6)$$

The above expression suggests that complete knowledge of matrix $A(0)$ allows moving from reduced form VMA to structural form VMA, as ε_t and μ_t are related to each other through this matrix.

---

[6] Constant terms (a vector of intercepts) are omitted for the sake of simplicity.

[7] Shocks are thought to be economically distinct from each other. In other words, these are independent of one another: technically termed as orthogonal.

[8] This is attributable to the fact that individual shocks can be arbitrarily normalized.

Furthermore, the assumption of orthogonality and unit variance of structural shocks (ε_t) allow to derive the following expression.

$$\Omega_\mu = A(0)A(0)' \qquad (7)$$

While we can directly estimate Ω_μ from the reduced form representation, still it will not allow to identify the required matrix $A(0)$ as Ω_μ is a symmetric matrix. Specifically, for three variables VMA we will have six number of equation in Ω_μ and nine number of unknown in $A(0)$ matrix. Therefore, the identification requires three additional equations that can restrict $A(0)$, as partial information about structural shocks (ε_t) is not sufficient.

The restrictions can be bifurcated with respect to time into short-run (contemporaneous) and long-run restrictions. The contemporaneous restrictions are easy to interpret, but prior knowledge of contemporaneous (short-term) responses is rarely available in practice. In addition, contemporaneous restrictions are tricky as endogenous variables are affected contemporaneously in most of the cases by all of the shocks. Compared to this, we use a more plausible way suggested by Blanchard and Quah (1989) to make use of long-run theory-based restrictions. These long-run structural VARs use partial information about the long-run effects to indirectly identify the required $A(0)$ matrix.

The matrix of long-run multipliers can be obtained by evaluating the polynomial representations given in equation 3 at $L = 1$ and is denoted by $A(1)$. The restriction that the structural shock '*j*' has no long-run effect on the level of endogenous variable '*i*' implies the element $A(1)_{i,j}$ of the long-run multipliers matrix $A(1)$ should be equal to zero. In our three variable structural VAR, we are in the need of three [3(3-1)/2] additional long-run restrictions to exactly identify the model. We derive our restriction from the AS/AD framework discussed earlier in this section. Specifically:

1. Real demand shock (ε_{dt}) has zero effect on the real level of output in the long-run. In terms of restrictions, this implies that $A(1)_{1,2} = 0$. In fact, this restriction is based on traditional Keynesian view of fluctuation that demand disturbances have the transitory effect only.
2. A nominal shock (ε_{mt}) has no long-run effect on the real level of output. In term of restrictions on $A(1)$ matrix, this implies $A(1)_{1,3} = 0$. This is the famous money neutrality assumption.

3. A nominal shock (ε_{mt}) has zero long-run effect on real aggregate demand. This restriction in our SVAR models implies that $A(1)_{2,3} = 0$.

Specifically, 3X 3 SVAR with identification restrictions will have the following representation.

$$\Delta Z_t = \begin{bmatrix} DLIPI \\ DRIR \\ DLCPI \end{bmatrix}, \quad A(1) = \begin{bmatrix} A(1)_{1,1} & 0 & 0 \\ A(1)_{2,1} & A(1)_{2,2} & 0 \\ A(1)_{3,1} & A(1)_{3,2} & A(1)_{3,3} \end{bmatrix}, \textit{ and } \quad \varepsilon_t = \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{dt} \\ \varepsilon_{mt} \end{bmatrix}$$

A conscious ordering of endogenous variable in the reduced form VAR together with the long-run restriction will yield the $A(1)$ matrix as a lower triangular matrix. The next step is to use this long-run responses matrix to obtain the $A(0)$ matrix, which can be obtained as follow after some matrix algebra.

$$A(0) = R(1)\,A(1)^{/} \quad or \quad A(0) = F(1)^{-1}A(1) \qquad (8)$$

This identification of the $A(0)$ matrix allows us to compute unrestricted dynamic responses of endogenous variables in ΔZ_t to the structural shocks (ε_t).

Constructing Confidence Intervals

Confidence intervals for impulse response functions are estimated by using simulation technique known as “bootstrapping”. Specifically, we followed the following steps.

Step 1: The reduced form VAR is estimated and treated as best estimate for unknown values of the parameters.

Step 2: The distribution of μ_t is modeled as it has zero mean and $\hat{\Omega}_\mu$ variance covariance matrix.

Step 3: We used the computers random number generator to obtain a large number of draws based on specified distribution of μ_t .

Step 4: These simulated series are used to construct 200 realization of the VAR and subsequently the 200 realizations of structural VAR.

Step 5: The resulting 200 simulated realizations of impulse response values for each period are used to construct 90 percent confidence interval of these simulated values for all response functions. Specifically, the marginal values for top 5 percent and bottom 5 percent are used to construct 90 percent confidence interval.

Appendix 2: Results based on alternative SVAR Specification

Figure 1: Response of Output

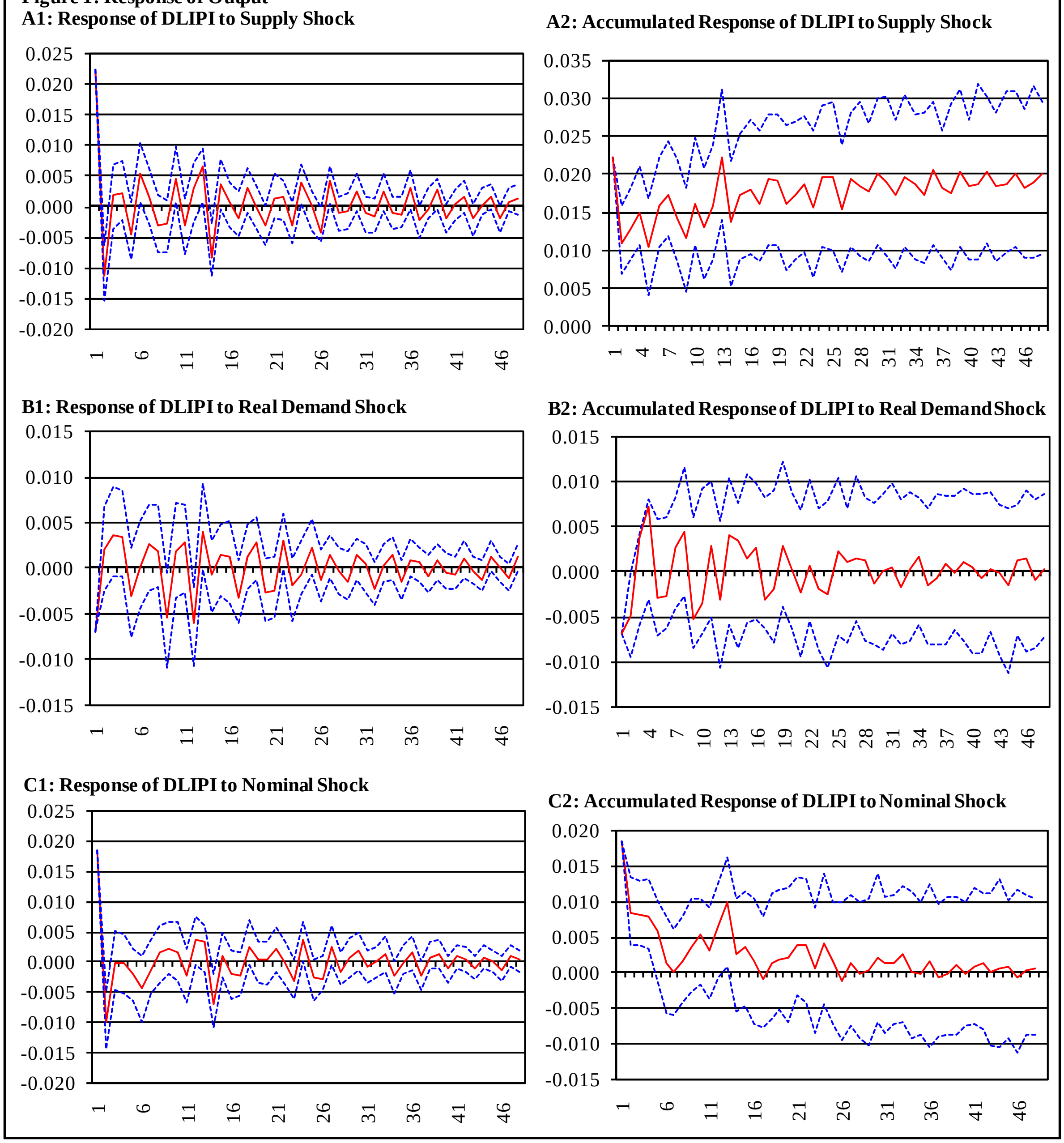


Figure 2: Response of Prices

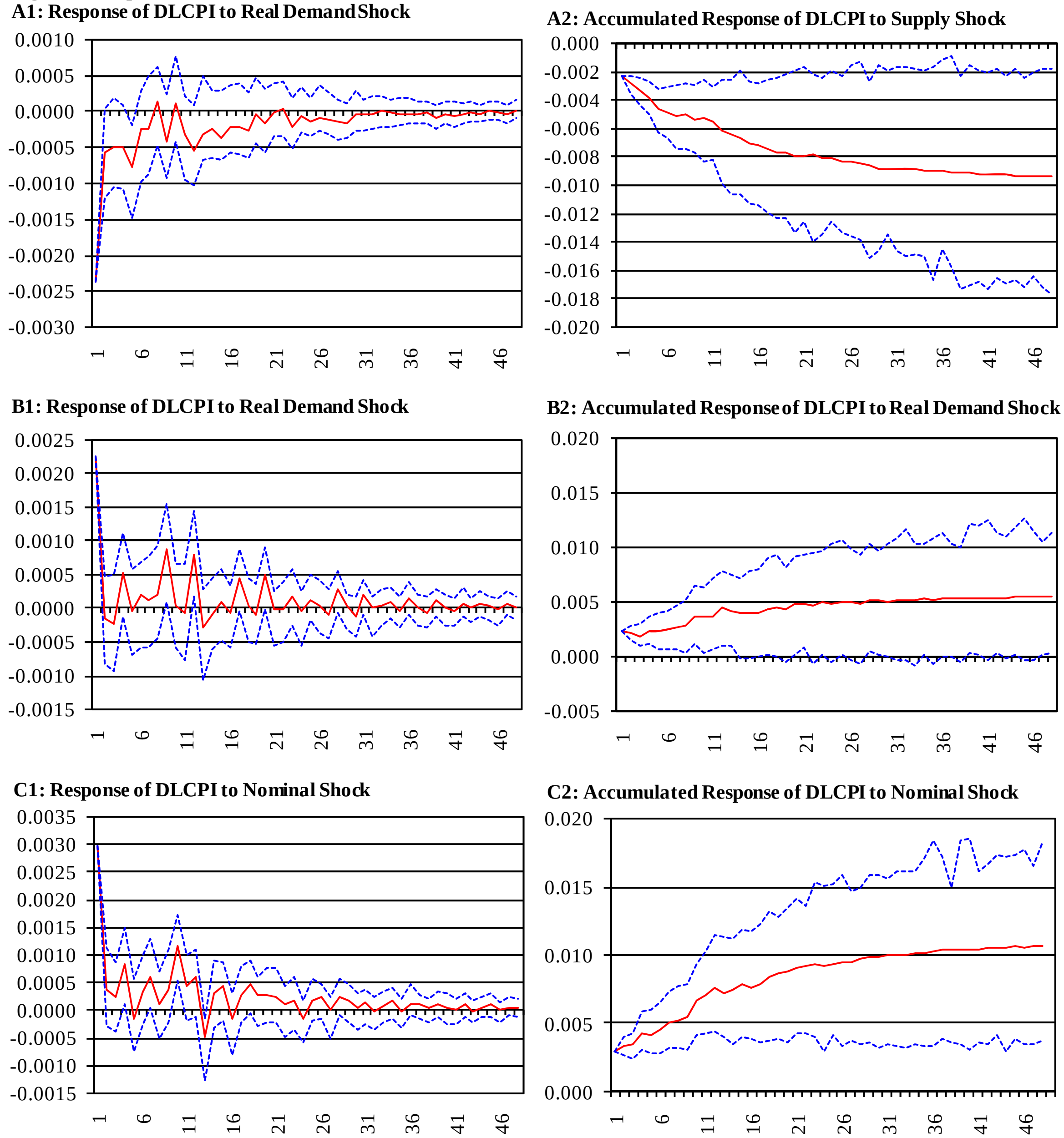


Figure 3: Variance Decomposition