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The Contemporaneous Correlation of Structural Shocks and Inflation-Output Variability in Pakistan

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Monetary policy has changed in a number of ways in the last two decades. Along with other characteristics, modern monetary policy is forward-looking and today central banks, to maintain credibility, respond contemporaneously to structural shocks that might make inflation deviate from the target in future. This study aims at investigating this aspect of monetary policy for Pakistan. Using the modified version of Structural Vector Autoregression (SVAR) developed by Enders and Hurn (2007), the authors have found a weak policy response to supply side shocks as the correlation coefficient between demand and supply shocks is only 0.041. Moreover, the results show that the demand shocks have no significant contribution in output variability. On the other hand, both demand and supply shocks, along with foreign supply shocks, significantly contribute to inflation variability.

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1. INTRODUCTION

In the last two decades monetary policy has changed in a number of ways. It all started with the adoption of inflation targeting as monetary policy by the Reserve Bank of New Zealand (RBNZ) in 1989. After recognition that inflation targeting was a better option to control inflation, academicians and researchers started working on theoretical modelling of the framework [for early contributions, see for instance, Svensson (1997, 1999); Bernanke and Mishkin (1997) among others].[1]

Among other things a modern monetary policy would announce an explicit inflation target and make its achievement its prime objective, ensure transparency of policy decisions and implementation, make the monetary authority credible, the central bankers accountable and keep policy decisions forward-looking. This last characteristic makes central banks to respond contemporaneously to structural shocks that are expected to deviate inflation from the target in future. Any contemporary news that is relevant to

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[1]For critics on the subject, [see Calvo and Mendoza (2000); Calvo (2001) and Ball and Sheridan (2003), among others].

inflation is reflected in the inflation forecast, which in turn calls for changes in the operational target or policy instrument. Doing so makes demand and supply shocks contemporaneously correlated. A supply shock, which may result in the deviation of inflation from the target, calls for policy response that in turn affects the aggregate demand. This issue is of particular importance for decomposition of structural innovations into demand and supply shocks. More details on the issue are given in Blanchard and Quah (1989) and Enders and Hurn (2007).

Work on this aspect of monetary policy issues relating to Pakistan is limited. The authors may be right in thinking their study to be the first such attempt to estimate the contemporaneous response of demand to supply shocks and to find the contribution of structural shocks in output and inflation variability. The prime objective of this study, therefore, is to investigate the presence of contemporaneous correlation between demand and supply shocks in Pakistan. For this purpose the methodology of Enders and Hurn (2007) has been used which is a modification of the Blanchard and Quah (BQ) method. The second objective is to use the identified structural shocks, which otherwise are unobserved, to estimate the contribution of demand and supply shocks in output and inflation variability with the help of impulse response functions (IRFs) and forecast-error variance decomposition.

The rest of the study proceeds as follows: Section 2 discusses the theoretical model whereas econometric methodology used in the study is explained in Section 3. The fourth section deals with data and the construction of variables. The results and discussion are given in Section 5, and Section 6 concludes the study identifying some policy implications.

2. THEORETICAL FRAMEWORK

In a forward-looking monetary policy, inflation forecast is used as an intermediate target. Consequently, any shock which affects inflation forecast calls for contemporaneous change in the monetary policy instrument. The resultant changes in aggregate demand induced by this simultaneous response make demand and supply shocks contemporaneously correlated. Accordingly, we first develop a theoretical model that shows how the monetary policy instrument responds to contemporaneous shocks of inflation and economic activity.[2] Consider the following AS-AD model:

$$\pi_t = \alpha y_{t-1}^e + v_t \qquad \ldots \quad (2.1)$$

$$y_t = -\beta r_t^e + u_t \qquad \ldots \quad (2.2)$$

Equation (2.1) represents expectations-augmented-phillips curve, where π_t is inflation rate.[3] Equation (2.2) describes aggregate demand relationship where output gap, y_t, negatively depends on expected real interest rate, r^e.[4] Both u_t and v_t are independently and identically distributed and contemporaneously uncorrelated to demand and supply shocks. After simple mathematical manipulation the above equations take the following form:[5]

$$\pi_t = \gamma_1 \pi_{t-1} + \gamma_2 y_{t-1} + \omega_t \qquad \ldots \quad (2.3)$$

[2]For this type of model, see for instance, Svensson (1997).

[3]y_{t-1}^e is the expected value of aggregate expenditures for period t, expected in period t–1.

[4]r_t^e denotes real interest rate for period t+1, expected in period t.

[5]The detailed mathematical derivations of Equations (2.3) and (2.4) are given the Appendix.

$$y_t = \lambda_1 y_{t-1} - \lambda_2 r_t + \eta_t \quad \ldots \quad (2.4)$$

The coefficients γ_2 and λ_2 are assumed to be positive; where as λ_1 is non-negative and less than 1 and γ_1 may be less than or equal to 1. In case the monetary policy is forward-looking, the objective of the central bank in period *t* is to choose an arrangement of current and future course of action for policy rates that minimises the expected sum of discounted squared future deviations of inflation from the target [Svensson (1997)], is referred for more details] Moreover, the choice of a policy rate in period *t* by the central bank is conditional upon the information available in that period. The period loss function is, therefore, given as

$$L(\pi_t) = \frac{1}{2}(\pi_t - \pi^*)^2 \quad \ldots \quad (2.5)$$

Taking Equation (2.3) one period forward and then making use of Equations (2.3) and (2.4) would result in the following equation:

$$\pi_{t+1} = c_1\pi_{t-1} + c_2 y_{t-1} - c_3 r_t + (\gamma_1\omega_t + \gamma_2\eta_t + \omega_{t+1}) \quad \ldots \quad (2.6)$$

where

$$c_1 = \gamma_1^2, c_2 = \gamma_2(\gamma_1 + \lambda_1), c_3 = \gamma_2\lambda_2$$

In this case, the interest rate in period *t* will only affect the inflation rate in period *t*+1, and onwards, and the interest rate in period *t*+1 will only affect the inflation rate in period *t*+2 and onwards, and so on. Hence, the solution to the optimisation problem can be obtained by assigning the policy rate in period *t* to hit, on an expected basis, the inflation target for period *t*+1. The same is possible for the future periods. Thus, the central bank can find the optimal policy rate in period *t* as the solution to the simple period-by-period problem:

$$\min_i E_t \delta^2 L(\pi_{t+1}) \quad \ldots \quad (2.7)$$

where δ is the discount factor whose value lies between 0 and 1. The first-order condition for the minimisation of Equation (2.7) with respect to i_t gives the following result:

$$\pi_{t+1/t} = \pi^* \quad \ldots \quad (2.8)$$

where $\pi_{t+1/t}$ denotes $E_t\pi_{t+1}$. According to Equation (2.8), the policy rate in period *t* should be such that the forecast of the one-period forward inflation rate, conditional upon information available in period *t*, equals the inflation target. Consequently, we can write the loss function as:

$$L^i(\pi_{t+1/t}) = \frac{1}{2}(\pi_{t+1/t} - \pi^*) \quad \ldots \quad (2.9)$$

The expectations of Equation (2.6) illustrate that the one-period inflation forecast is affected by both the previous and the current state of the economy as is evident from Equation (2.10) below:

$$\pi_{t+1/t} = c_1\pi_{t-1} + c_2 y_{t-1} - c_3 r_t + \gamma_1\omega_t + \gamma_2\eta_t \quad \ldots \quad (2.10)$$

Assuming $\pi^* = 0$ and equating the terms on the right hand side of Equations (2.8) and (2.10) would result in optimal reaction function of the central bank,

$$r_t = d_1\pi_{t-1} + d_2 y_{t-1} + d_3\omega_t + d_4\eta_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.11)$$

where

$$d_1 = \frac{c_1}{c_3},\ d_2 = \frac{c_2}{c_3}, d_3 = \frac{\gamma_1}{c_2},\ \text{and}\ d_4 = \frac{\gamma_2}{c_3}$$

Equation (2.11) is like the Taylor (1993) type rule. From this equation it is clear that the demand side variable, r_t, is contemporaneously correlated with the supply side shock, ω_t. This explains why the methodology of Enders and Hurn (2007) has been used to identify structural shocks, allowing for contemporaneous response of aggregate demand to aggregate supply shocks. Moreover, Equation (2.11) states that this contemporaneous response is possible only if monetary policy is forward-looking. In case monetary policy minimises the loss function described in Equation (2.5), rather than that given in Equation (2.9)—when the policy is not forward-looking—the contemporaneous response of aggregate demand to supply shock will be zero.

3. EMPIRICAL METHODOLOGY

Econometrics got new life from Sims (1980), in which he introduced the Vector Autoregression (VAR) model. Sims responded to "Lucas Critique" given in Lucas (1976) by treating all variables in the model as endogenous. The VAR in standard form is a reduced form methodology which could be estimated by Ordinary Least Squares. This, however, gave birth to the "identification problem", which calls for imposing restrictions on some of the structural parameters so that identification could be achieved. One response came in the form of Cholesky decomposition which provided an additional equation for the identification of the structural models [Enders (2004)].

However, the VAR analysis was criticised by many economists arguing that these models could only be used for forecasting purpose and not for policy analysis [Sargent (1979, 1984); Learner (1985)]. In response to this criticism, the Structural Vector Autoregression (SVAR) approach was developed by Sims (1986), Bernanke (1986) and Blanchard and Watson (1986). The SVAR approach allows for imposing restrictions on the basis of economic theory. Nevertheless, the SVAR developed by the above mentioned authors imposed only short-run restrictions on the structural parameters for identification purpose. An extension to the SVAR of Sims (1986) and others were made by Shapiro and Watson (1988) and Blanchard and Quah (1989) by imposing long-run restrictions on the structural parameters. Especially, the methodology developed by Blanchard and Quah (1989), henceforth B-Q, got tremendous popularity among the economists because the assumptions used by this methodology for the exact identification of structural shocks were innocuous. This methodology assumes that the structural shocks are orthogonal; these shocks are normalised to have unit variance; and one structural shock has no long run effect on one of the variables. In an AD-AS model, the first assumption would mean that the aggregate demand and aggregate supply shocks are uncorrelated, while the third assumption would imply that the aggregate demand shocks have no effect on output in the long run.

However, the assumptions of B-Q also faced criticism by both economists and econometricians. For example, the New Keynesian economists argue that monetary shocks need not be neutral [Mankiw and Romer (1991)]. On the other hand, Waggoner and Zha (2003) and Hamilton, *et al.* (2004) gave information about the important consequences for statistical inference of different normalisations in a structural VAR. Similarly, Cover, *et al.* (2006) argues that there are sound economic reasons for allowing a contemporaneous correlation between the aggregate demand and aggregate supply shocks. Specifically, it points to the intertemporal optimising models and the New Keynesians models in which aggregate supply may respond positively to a positive aggregate demand shock. Hence, Cover, *et al.* (2006) allowed for the contemporaneous correlation between the structural shocks and this correlation was found to be 0.576 for the US. Enders and Hurn (2007) then extended the alternative methodology developed in Cover, *et al.* (2006) for a small open economy and allowed for the contemporaneous correlation between the structural shocks for the reason that the economy was following an inflation targeting policy. The correlation between the structural shocks was found to be 0.736.

In the following lines we discuss the econometric methodology used in the study. We discuss both the B-Q methodology, proposed by Blanchard and Quah (1989), and the alternative methodology developed by Enders and Hurn (2007) for a small open economy, as both the methodologies are used in the study.

3.1. The Blanchard-Quah Methodology

Suppose the real foreign output, the real domestic output, and the domestic inflation rate are represented by $\hat{y}_t, y_t$ and π_t respectively. Then a VAR model for a small open economy, as in Enders and Hurn (2007), can be written as:

$$\hat{y}_t = \sum_{j=1}^{k} \phi_{11} \hat{y}_{t-j} + e_{1t}$$

$$y_t = \sum_{j=0}^{k} \phi_{21} \hat{y}_{t-j} + \sum_{j=1}^{k} \phi_{22} y_{t-j} + \sum_{j=1}^{k} \phi_{23} \pi_{t-j} + e_{2t}$$

$$\pi_t = \sum_{j=0}^{k} \phi_{31} \hat{y}_{t-j} + \sum_{j=1}^{k} \phi_{32} y_{t-j} + \sum_{j=1}^{k} \phi_{33} \pi_{t-j} + e_{3t} \quad \dots \quad \dots \quad \dots \quad (3.1)$$

It is obvious from the structure of the above equation that the foreign output evolves independently of domestic variables for the reason that the domestic country is assumed to be a small open economy. Nonetheless, the same small-country assumption requires the domestic variables to be dependant on the current and lagged values of foreign output.

The regression residuals, e_{1t}, e_{2t} and e_{3t} are assumed to be linked to each other through three different structural shocks, namely, a foreign productivity shock, ε_{1t}, a domestic supply shock, ε_{2t}, and a domestic demand shock, ε_{3t}. One of the important tasks is the identification of the three structural shocks, ε_{1t}, ε_{2t} and ε_{3t}, from the VAR residuals, since these structural shocks are not observable. Suppose the unobservable structural shocks and the observable VAR residuals are linked by the following relationship:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.2)$$

So there are fifteen unknowns in this set-up that need to be identified. These unknowns include nine elements, h_{ij}, of the matrix H, and three variances $\sigma^2_{\varepsilon_1}, \sigma^2_{\varepsilon_2}, \sigma^2_{\varepsilon_3}$ along with the three covariances $\sigma_{\varepsilon_1\varepsilon_2}, \sigma_{\varepsilon_1\varepsilon_3}, \sigma_{\varepsilon_2\varepsilon_3}$ of the variance-covariance matrix of the structural shocks. The variance-covariance matrix of the VAR residuals is given by:

$$\Sigma_e = H \Sigma_s H' \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.3)$$

Hence, six of the fifteen restrictions, required for the exact identification, are provided by the distinct elements of the variance-covariance matrix of the VAR residuals. The standard Blanchard-Quah methodology assumes that all the variances are normalised to unity $(\sigma^2_{\varepsilon_1} = \sigma^2_{\varepsilon_2} = \sigma^2_{\varepsilon_3} = 1)$ and all covariances are equal to zero ($\sigma_{\varepsilon1\varepsilon2} = \sigma_{\varepsilon1\varepsilon3} = \sigma_{\varepsilon2\varepsilon3} = 0$). Moreover, the domestic shocks do not affect the large country, $h_{12} = h_{13} = 0$, and finally and most importantly, the demand shocks have no effect on domestic output in the long run:

$$h_{23}\left[1 - \sum_{i=1}^{k} \phi_{33_j}\right] + h_{33}\left[1 - \sum_{i=1}^{k} \phi_{23_j}\right] = 0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.4)$$

Thus, with all these fifteen restrictions, the identification is achieved in the B-Q methodology. However, Waggoner and Zha (2003) and Hamilton, *et al.* (2004) have warned that normalisation can have effects on statistical inference in a structural VAR. The main objection, nonetheless, is raised by Cover, *et al.* (2006) and Enders and Hurn (2007) about the assumed orthogonality of the structural shocks in BQ methodology. They argue that, in the presence of a normal demand curve, a negative supply shock will reduce output and increase inflation. However, if the country is following the inflation targeting strategy, then the monetary authorities will contemporaneously raise the policy rate to shift the demand curve inward in order to keep inflation on target. The reverse will be done in case of a positive supply shock. This implies that the correlation between the demand and supply shocks may not necessarily be zero. The orthogonality assumption of B-Q methodology does not let demand to respond to supply shocks and hence in this methodology the correlation is forcibly set equal to zero.

3.2. The Alternative Methodology

Enders and Hurn (2007) start with the following simple AD-AS model:

$$\begin{aligned} y_t^s &= E_{t-1}y_t + \rho(\pi_t - E_{t-1}\pi_t) + \varepsilon_{2t} + \theta\varepsilon_{1t} \\ y_t^d + \pi_t &= E_{t-1}(y_t^d + \pi_t) + \varepsilon_{3t} \\ y_t^s &= y_t^d \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.5) \end{aligned}$$

In this model, $E_{t-1}\, y_t$ and $E_{t-1}\, \pi_t$ are the expected domestic output and inflation in period t conditional upon the information available at the end of period t–1. The superscripts s and d represent supply and demand, respectively. It is obvious that the first equation is the Lucas supply curve and the second equation represents aggregate demand relationship.

This AD-AS model is consistent with a VAR if agents form their expectations based on it. Taking one period lag of Equation (3.1) and then taking the conditional expectations will result in $E_{t-1}\, y_t$ and $E_{t-1}\, \pi_t$. The parameters of the macroeconomic model enter into the following matrix H, placing restrictions on the relationships between the regression residuals and the structural shocks:

$$H = \begin{bmatrix} h_{11} & 0 & 0 \\ \theta/(1+\rho) & 1/(1+\rho) & \rho/(1+\rho) \\ -\theta/(1+\rho) & -1/(1+\rho) & 1/(1+\rho) \end{bmatrix} \quad \ldots \quad \ldots \quad \ldots \quad (3.6)$$

Here the six elements of the estimated variance-covariance matrix of VAR residuals can be used for the identification of three variances and three covariances of structural innovations along with h_{11}, θ, ρ. For the identification of the whole system, three more restrictions include $h_{11} = 1$, $\sigma_{\varepsilon 1 \varepsilon 2} = 0$, and the long-run neutrality of demand shock. This decomposition differs from the standard BQ decomposition in three ways. First, the assumption of normalisation of all structural shocks to unity is not imposed. Second, no restriction has been imposed on the contemporaneous correlation between structural shocks. It is allowed to be determined independently within the model. Third, the small country assumption outlines that domestic shock has no effect on global economy.

4. DATA AND CONSTRUCTION OF VARIABLES

This study uses quarterly data over the period 1991:4 to 2010:2 for Pakistan's economy.[6] The constant price GDP is used to represent domestic real output. For this purpose, we need to have the series of quarterly real GDP for Pakistan. Kemal and Arby (2004) have constructed such series for Pakistan for the period 1975-2004, whereas we use data up to 2010:2. Nonetheless, the absence of trends and the negligible variance in the already identified shares for the respective quarters in different years justify the use of average of these quarterly shares for the next few years to obtain the values of quarterly real GDP. Data on GDP is then seasonally adjusted using X12 method. Furthermore, the domestic inflation rate is calculated using the data on CPI.

We have not used United States' GDP to represent foreign output. Due to its large size of the economy and being the major trading partner of many countries, the United States is expected to affect the economic environment of its partners. That is why most studies take the real GDP of the US as proxy for the entire external sector, [for instance in Enders and Hurn (2007)]. However, this may not be a true representative of an external shock. Subsequently, the US GDP may not be a suitable proxy of foreign output for

[6]The reason for not extending this period beyond 1991 is that the SBP was not independent in setting the policy instrument before financial sectors reforms initiated in 1989.

Pakistan as it is not the only trade partner which can have significant effects on Pakistan's economy. Although the US has major share in the export composition of Pakistan, Saudi Arabia has a major import share in the import portfolio. In order to avoid any ambiguity, therefore, we have constructed an index of the foreign output where major trading partners of Pakistan are represented. These countries include the US, UK, Japan, Germany, Saudi Arabia, Kuwait and Malaysia. The index is constructed by taking the weighted average of its partners' GDP where the weights are Pakistan's trade shares with each country.[7] The sources of data for construction of the index of foreign output include *International Financial Statistics* (IFS) and various issues of *Economic Survey of Pakistan*.

5. RESULTS AND DISCUSSION

5.1. Unit Root and Cointegration Tests

The application of Vector of Autoregression (VAR) requires absence of unit roots in variables. Moreover the variables should not be cointegrated. Therefore, in order to check whether the variables are stationary or integrated to some order, the Augmented Dickey-Fuller (ADF) test has been used. The results of the ADF test are reported in Table 1 below.

Table 1

Results of the Unit Root Test Statistics

Variables	Level	First Difference	Conclusion
Foreign Output	–1.190	–3.610 **	I(1)
Domestic Output	–1.464	–12.230 ***	I(1)
Inflation	–1.490	–6.395 ***	I(1)

Note: The regressions include a constant. The ** and *** show rejection of null hypothesis at 5 percent and 1 percent levels of significance respectively.

The results of the ADF test in the above table indicate that all variables are non-stationary at conventional levels of significance. However, all these variables are stationary at first difference and hence are integrated of order 1. Nonetheless, the application of the VAR model necessitates the absence of any cointegrating relationship among the set of non-stationary variables. Thus it is desirable to check the number of cointegrating vectors among these variables. For this purpose, we make use of Johansen's approach to investigate the relationship among the three variables. Table 2 portrays the results.

[7]A problem that is confronted is the unavailability of both Real GDP in volume and GDP Index for some countries such as Saudi Arabia and Kuwait on quarterly basis. So we have taken the Index of Crude Petroleum Production as proxy of GDP Index for these two countries.

Table 2

Johansen Test for the Cointegrating Relationship

No. of CE(s)	Trace Statistics	5% Critical Value	Max. Eigen Statistics	5% Critical Value
None	15.131	29.797	8.833	21.131
At most 1	6.297	15.494	5.560	14.264
At most 2	0.737	3.841	0.737	3.841

Note: The Johansen cointegration test is conducted using two lags which are chosen using AIC. The test used the specification which allows for an intercept term but there is trend neither in cointegrating equation nor in VAR.

Results in Table 2 reveal that the null hypothesis of the absence of cointegrating relationship cannot be rejected at the conventional significance levels. Both trace statistics and maximum eigenvalue statistics confirm the absence of any cointegration vector. The absence of cointegrating relationship necessitates the application of VAR in the first difference.

5.2. Estimation Results

5.2.1. *Results of the Standard B-Q Decomposition*

The results of the standard Blanchard-Quah decomposition bring forth the determinants of output and inflation in Pakistan.[8] It is evident from the forecast-error variance decomposition reported in Table 3 that demand shocks do not explain any significant variation in domestic output at any forecasting horizon. After three periods, the explained variation in output due to demand shocks remains at 0.12 percent for the rest of the horizon. On the other hand, domestic supply shocks have a dominant role in output variation. Almost 88 percent of variation in output is attributed to domestic supply shocks. However, the foreign GDP shocks explain little (around 11.7 percent) output variability. Results in Table 3 also demonstrate the determinants of inflation variability. Interestingly, all the three shocks contribute to inflation variability. For the first two quarters, for instance, both domestic supply shocks and foreign GDP shocks explain 23 percent and 38 percent variations respectively. However, beyond this two-step horizon, the explained variation by the two shocks changes to 36 percent and 33 percent respectively. Likewise, the demand shocks initially explain 38 percent variation in inflation which then slides down to 30.5 percent after the two-period horizon.

Table 3

Forecast-error Variance Decomposition Using B-Q Decomposition

	Percentage Variation in Domestic Output due to			Percentage Variation in Domestic Inflation due to		
Horizon	FGDPS	DSS	DDS	FGDPS	DSS	DDS
1	11.437	88.484	0.079	38.114	23.454	38.340
2	10.894	89.022	0.085	38.226	23.396	38.377
3	11.350	88.530	0.119	33.003	36.072	30.925
4	11.655	88.224	0.121	33.083	36.296	30.621
5	11.683	88.196	0.121	33.137	36.261	30.602
6	11.724	88.156	0.121	33.218	36.219	30.563
7	11.729	88.150	0.121	33.215	36.225	30.559
8	11.733	88.146	0.121	33.225	36.220	30.555
9	11.734	88.145	0.121	33.225	36.220	30.554
10	11.735	88.145	0.121	33.226	36.220	30.554

Note: FGDPS= Foreign GDP Shock, DSS= Domestic Supply Shock, DDS= Domestic Demand Shock.

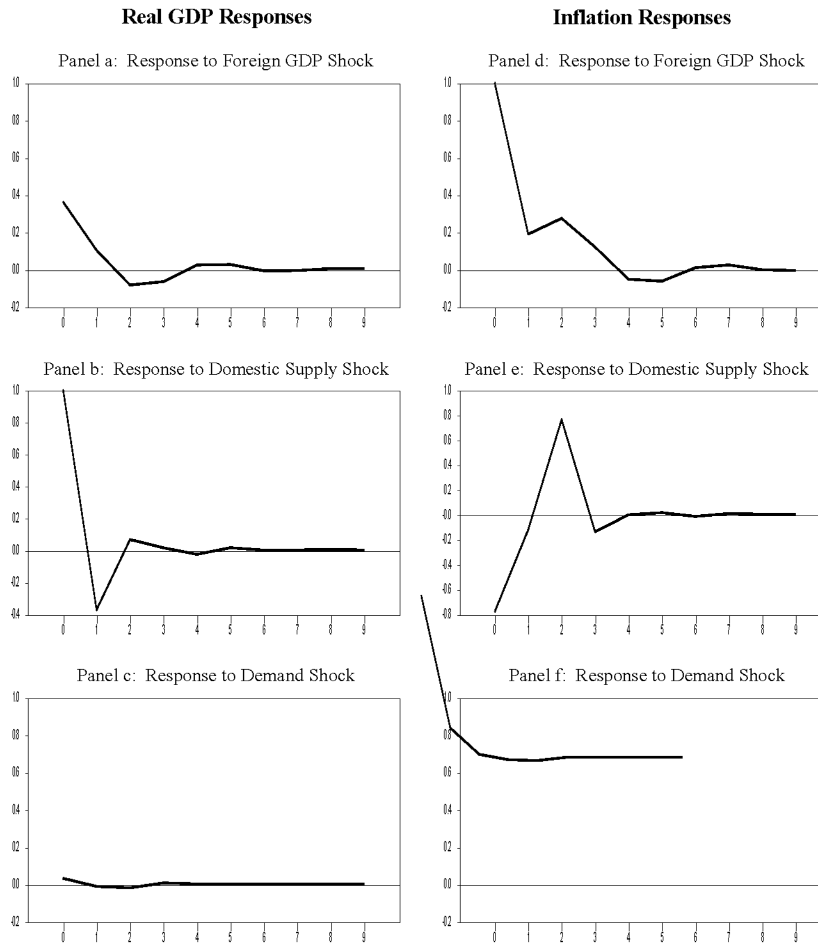
[8]The estimation results are obtained using RATS software.

The results of Table 3 highlight some important issues that call for attention. First, the foreign GDP shocks explain smaller variation in output and relatively greater variation in inflation. So the effects of the shocks transmit more to price level than to output in Pakistan. This is true for most developing countries which confront the problem of capacity utilisation due to various reasons such as unskilled workforce, energy crises, weak infrastructure etc. Furthermore, this pattern is more likely if the basket of imported goods contain more finished products than intermediate products. The second issue is concerned with the effects of the shock on different forecast horizons. As is evident from the above table, after the two-step horizon, the inflation variability, explained by foreign output shocks, reduces whereas that by the domestic supply shocks increases. One possible interpretation is that the effects of foreign shocks translate into domestic supply shocks. For example, an adverse oil price shock is initially a foreign supply shock for Pakistan. However, after some time the effects of increased oil price transmit to domestic prices which ultimately result in backward shift of the aggregate supply curve.

The impulse response functions for the standard B-Q model are illustrated in Figure 1. One can easily observe the similarity of results shown both by the variance decomposition and the impulse response functions. Panel *a* of Figure 1 demonstrates that one unit shock in foreign output shifts the domestic output up by 0.35 units in the first quarter, 0.09 standard deviation in the second quarter, and –0.08 standard deviations in the third quarter. Afterwards, the successive values of domestic GDP steadily converge to zero. The reason for the positive effect of foreign GDP shock on domestic output is more than obvious. A favourable output shock in foreign countries will raise their national incomes. Since a country's exports depend on her trading partners' income, there will be an increase in demand for Pakistani exports, thereby boosting the domestic output. Panel *b* confirms that the domestic supply shocks have significant effect on output. The effect, however, is short-lived as it converges to zero in the second quarter. Demand shocks do not affect output as is evident from Panel *c*. The possible reason could be the assumptions in the standard Blanchard-Quah model that call for long run neutrality of demand shocks and the zero correlation between aggregate demand and aggregate supply shocks.

The results in panel *d* illustrate that foreign output shocks have positive effects on domestic inflation as well. As explained earlier, the effect of foreign shocks, whether positive or negative, are absorbed more by the price level than by domestic output. Panel *e* suggests that a favourable domestic supply shock will reduce inflation in the first quarter. Though it goes up in the second quarter, possibly due to the cobweb phenomenon, it converges to zero in the fourth quarter. Panel *f* indicates that demand shocks positively affect inflation. A one unit demand shock increases inflation by 0.97 units in the first quarter. However, the successive values of the effect on inflation, thereafter, converge to zero. This means that in the B-Q methodology, approximately the whole effect of the demand shock is absorbed by inflation only. Cover, *et al.* (2006) and Enders and Hurn (2007) argue that these results may be the consequence of the assumptions of standard B-Q model. We now turn to the results obtained by using Enders and Hurn (2007) methodology.

Fig. 1. Plots of the Standardised Impulse Response Functions for B-Q Decomposition



5.2.2. *Results of the Alternative Decomposition*

Interestingly, the results obtained by using the alternative model are not much different from those of the standard Blanchard-Quah model. This is obvious from both Table 4 and Figure 2. Both the forecast-error variance decomposition and the impulse response functions obtained using the identified structural shocks demonstrate almost the same pattern as was found for B-Q decomposition. Table 4 results indicate that demand shocks explain only 0.16 percent variation in output beyond a two-step horizon. This suggests that demand shocks do not have significant effect on output in Pakistan. On the other hand, output variability is explained more (88 percent) by the domestic supply shock. Foreign output shocks explain only 11.86 percent of the variation in output.

Table 4

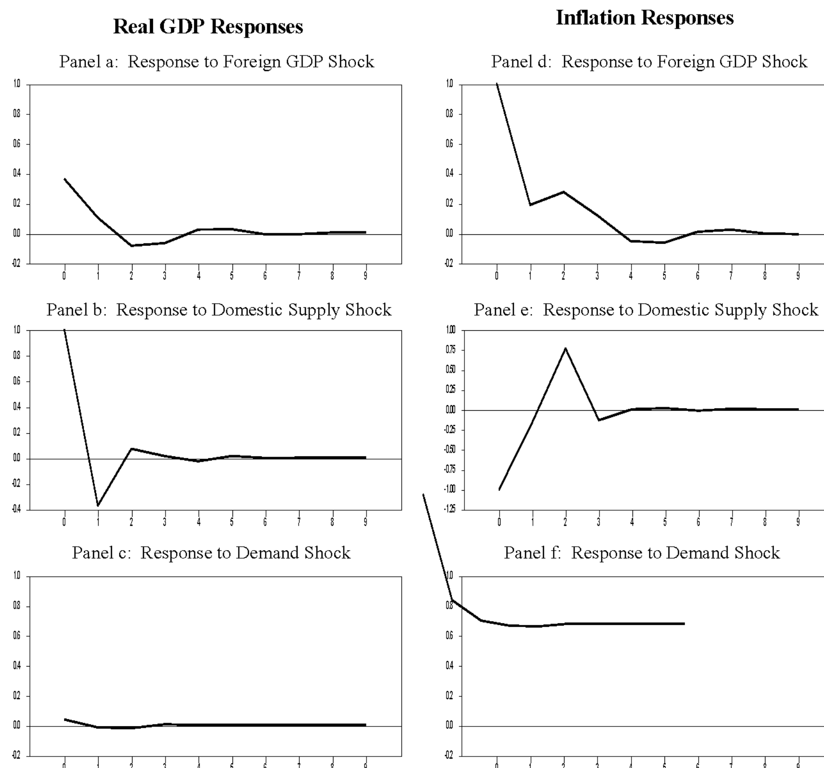
Forecast-error Variance Decomposition Using Alternative Decomposition

	Percentage Variation in Domestic Output due to			Percentage Variation in Domestic Inflation due to		
Horizon	FGDPS	DSS	DDS	FGDPS	DSS	DDS
1	11.564	88.311	0.126	33.370	33.568	33.062
2	10.019	88.849	0.132	33.479	33.416	33.105
3	11.474	88.361	0.165	29.666	42.948	27.387
4	11.782	88.052	0.167	29.774	43.074	27.152
5	11.810	88.023	0.166	29.826	43.036	27.138
6	11.851	87.982	0.166	29.903	42.991	27.107
7	11.856	87.977	0.166	29.901	42.995	27.104
8	11.861	87.973	0.166	29.910	42.990	27.100
9	11.861	87.972	0.166	29.910	42.990	27.100
10	11.862	87.972	0.166	29.911	42.989	27.099

As reported in Table 4, all the three types of structural shocks contribute in explaining variation in inflation even in this decomposition. However, the variation explained by domestic supply shocks increased to 43 percent in the current decomposition compared to 36 percent obtained using the BQ method. Nevertheless, the contribution of demand shocks and foreign output shocks to inflation variability declines from 30.5 percent and 33 percent to 27 percent and 30 percent respectively. Hence, the results obtained from alternative decomposition do not significantly differ from those obtained through B-Q decomposition. However, the findings of this work are in significant contrast to both Enders and Hurn (2007) and Covers, *et al.* (2006) who found that the effect of demand shocks was more on output and less on inflation.

The results of impulse response functions in Figure 2 tell a similar story. These response functions are obtained using structural shocks identified by alternative decomposition. Results in panel *a* show that a one unit foreign GDP shock raises the output by 0.35 units in the first quarter, and after the third quarter, the successive values of the shock converge to zero. It is clear from panel *b* that a favourable domestic supply shock has immediate effect on output, and the effect starts declining to zero after the second quarter. Yet again, demand shocks fail to show any significant impact on output as is evident from Panel *c*. The impact of foreign output shocks, domestic supply shocks, and demand shocks on inflation are portrayed in Panels *d, e* and *f* respectively. These response functions confirm and validate the results shown by the forecast-error variance decomposition.

Fig. 2. Plots of Standardised Impulse Response Functions for Alternative Decomposition



5.3. Contemporaneous Correlation of Demand and Supply Shocks

The main objective of this study is to establish whether or not the State Bank of Pakistan (SBP) responds contemporaneously to supply side shocks. For this purpose, the contemporaneous correlation was allowed between the two structural shocks. Using the alternative decomposition method mentioned above, the findings suggest that there is correlation of only 0.041 between the two shocks which is negligible. Consequently, it may be concluded that the SBP has not been responding contemporaneously to supply side shocks.[9] This result points to the fact that the policy has not been forward-looking in the sample period. Another possible reason for this result may be the absence of a proper forecasting model with the SBP, at least until recently.

5.4. Estimation Results for Sub-sample Period

It is usually believed that the appointment of Ishrat Hussain as Governor of the SBP was the beginning of an era when the central bank started enjoying relatively greater

[9]The finding that the SBP has not been following inflation targeting policy is consistent with Malik and Ahmed (2007) who find, while estimating Taylor rule, the coefficient of inflation is less than one failing to satisfy the requirement of Taylor principle.

independence from the government since the institution of financial sector reforms. This provides the grounds for the use of a sub-sample period for this analysis. Using data over the period 1999:1 to 2010:2, both the B-Q and alternative methodologies have been used for the identification of structural shocks as well as for the detection of any contemporaneous correlation among these shocks. The results of forecast-error variance decomposition using both methodologies are reported in Table 5 and Table 6. It is clear that there is no significant difference in outcomes of both methodologies. The results in Table 6 show that the foreign output shock, domestic supply shock and domestic demand shock explain, respectively, 31 percent, 69 percent and 0.12 percent of variation in output. Similarly, it is found that 52 percent of inflation variability is explained by foreign output shock, 31.5 percent by domestic supply shock, and 16.6 percent by domestic demand shock. The results for the B-Q model are the same with a slight difference of approximately 1 percent.

Table 5

Forecast-error Variance Decomposition Using B-Q Decomposition

	Percentage Variation in Domestic Output due to			Percentage Variation in Domestic Inflation due to		
Horizon	FGDPS	DSS	DDS	FGDPS	DSS	DDS
1	33.417	66.518	0.064	58.446	19.294	22.261
2	30.670	69.254	0.085	59.123	18.909	21.968
3	30.653	69.242	0.106	53.712	28.994	17.294
4	30.607	69.283	0.110	53.027	29.892	17.081
5	30.673	69.217	0.110	52.992	29.943	17.065
6	30.758	69.132	0.110	52.972	29.988	17.041
7	30.770	69.119	0.110	52.979	29.988	17.033
8	30.783	69.107	0.110	52.994	29.979	17.027
9	30.784	69.105	0.110	52.997	29.977	17.026
10	30.785	69.105	0.110	52.999	29.976	17.025

Table 6

Forecast-error Variance Decomposition Using Alternative Decomposition

	Percentage Variation in Domestic Output due to			Percentage Variation in Domestic Inflation due to		
Horizon	FGDPS	DSS	DDS	FGDPS	DSS	DDS
1	33.510	66.416	0.074	56.816	21.640	21.544
2	30.767	69.137	0.096	57.535	21.180	21.285
3	30.751	69.132	0.117	52.584	30.558	16.858
4	30.707	69.171	0.122	51.935	31.407	16.658
5	30.772	69.106	0.122	51.903	31.453	16.643
6	30.857	69.021	0.122	51.886	31.494	16.620
7	30.870	69.008	0.122	51.894	31.494	16.613
8	30.883	68.996	0.122	51.908	31.484	16.608
9	30.884	68.994	0.122	51.911	31.482	16.607
10	30.885	68.993	0.122	51.913	31.481	16.606

However, the results of this sub-sample are much different in terms of explanation of variation in output and inflation from those of the full sample. For instance, with the alternative decomposition, variability in output and inflation explained by foreign GDP shock increase from 12 percent and 30 percent to 31 percent and 52 percent respectively. This indicates the increased exposure of domestic economy to foreign shocks in the sub sample period. Likewise, the role of domestic supply shock in both output and inflation variability reduces to 69 percent and 31.5 percent respectively. Nonetheless, it still remains the major source of variation in output. Interestingly, the role of demand shock in inflation variability reduces from 29 percent to 16.6 percent. This is an important result for the SBP to consider when it goes for tight monetary policy to reduce inflation in the economy. The lesser share of demand shocks in explaining inflation variability suggests that the SBP should be careful while controlling inflation, through demand management policy, as it may be caused more by supply shocks. Yet again, demand does not play any significant role in output variability for the sub-sample period.[10] Finally, the findings of this study give no indication of a forward-looking policy even in this era of central bank independence. In fact, the contemporaneous correlation coefficient between demand and supply shocks reduces to 0.012, which is less than the value obtained for the entire period of the analysis. This shows the presence of enough fiscal pressure for the SBP to be not able to target an explicit inflation rate.

6. CONCLUSIONS AND POLICY IMPLICATIONS

The objectives of this study include the identification of structural shocks, examining the relative contributions of these structural shocks in output and inflation variability, and the investigation of whether or not the SBP responds contemporaneously to supply side shocks. For this purpose, use has been made of the Structural Vector Autoregression (SVAR) by considering both Blanchard-Quah methodology and an alternative methodology initially developed by Cover, *et al.* (2006) and later extended by Enders and Hurn (2007). Some important findings are given in the following lines.

The first and the main finding of the study is that the SBP has not been pursuing a forward-looking policy. The contemporaneous correlation between the aggregate demand and aggregate supply in Pakistan is only 0.041, which suggests a negligible contemporaneous policy response to supply-side shocks. The second outcome is concerned with the role of structural shocks in explaining variation in both inflation and output. Interestingly, but not surprisingly, the results of both methodologies do not differ significantly. The domestic supply shock is considered to be the major factor contributing in output variability, followed by foreign shock. Domestic demand shock, on the other hand, does not play a significant role in output variation. Moreover, the domestic supply shock is the central cause of variation in inflation with foreign supply shock at the second and domestic demand shock at the third place.

The third finding concerns the impact of foreign supply shock on domestic output and inflation. A positive foreign supply shock affects domestic inflation more than the domestic output. This may be due to the fact that whenever due to increase in foreign

[10]Like the forecast-error variance decomposition, there is not any significant difference in the impulse response functions of the two decompositions for the selected sub-sample. These results of the IRFs can be obtained on request from the authors.

output, the income of foreigners and, consequently, the demand for Pakistani exports rises, the economy does not respond positively or in a suitable manner. Instead of increasing domestic output, the effect of the shock is allowed to transmit more to the price level. The weak response of output may be the result of an inefficient real sector because of unskilled labour force, weak infrastructure, and energy constraints etc.

The results of this study bring forth important policy implications. Firstly, and most importantly, the central bank should be careful in controlling inflation through tight monetary policy. An increase in interest rate in order to reduce demand may not reduce inflation to the desired extent as demand contributes less to inflation. Rather, the cost channel of monetary policy may come into play. In this context, the continuous increase in the policy rate by the SBP in recent times can be said to be undesirable. Moreover, a tight monetary policy may not be efficient in the absence of coordination between demand management policies. Secondly, the policy-makers should avoid exploiting inflation-output trade-off, since the role of demand in output growth is negligible.

In this study the researchers have modelled monetary policy on the contemporaneous response of demand to supply shock. Therefore, for future research, it will be more appropriate if interest rate is directly included in the VAR as a monetary policy instrument. This is important as monetary policy is not the only factor that makes changes in demand. Subsequently, by including interest rate in the model, one can differentiate among changes in demand brought about by monetary policy and those by the other factors.

APPENDIX

Let the expectation augmented Phillips Curve is given by the following equation:

$$\pi_t = \alpha y_{t-1}^e + v_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(I)}$$

Also we know that

$$\Delta y_t^e = a(y_{t-1} - y_{t-2}^e)$$

or

$$y_{t-1}^e = a y_{t-1} + (1-a) y_{t-2}^e \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(II)}$$

Now taking Equation (I) one period backward and solving for y_{t-2}^e gives the following equation:

$$y_{t-2}^e = \left(\frac{1}{\alpha}\right)\pi_{t-1} - \left(\frac{1}{\alpha}\right)v_{t-1} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(III)}$$

Substituting Equation (III) in Equation (II) would result in following:

$$y_{t-1}^e = a y_{t-1} + (1-a)\left[\left(\frac{1}{\alpha}\right)\pi_{t-1} - \left(\frac{1}{\alpha}\right)v_{t-1}\right] \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(IV)}$$

Substituting equation (IV) in Equation (I) would give the following result:

$$\pi_t = \gamma_1 y_{t-2} + \gamma_2 \pi_{t-1} + \omega_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(V)}$$

Where

$\gamma_1 = a\alpha$, $\gamma_2 = (1-a)$, $\omega_t = v_t - (1-a)v_{t-1}$

Similarly the aggregate demand relationship is given by following equation:

$$y_t = -\beta r_t^e + u_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(VI)}$$

Since

$$\Delta r_t^e = b(r_t - r_{t-1}^e)$$

Or

$$r_t^e = br_t + (1-b)r_{t-1}^e \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(VII)}$$

Now taking Equation (VI) one period backward and solving for r_{t-1}^e gives the following result:

$$r_{t-1}^e = \left(\frac{1}{\beta}\right) y_{t-1} + \left(\frac{1}{\beta}\right) u_{t-1} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(VIII)}$$

Substituting the Equation (VIII) in Equation (VII) and then putting the resultant value of r_t^e in Equation (VI) gives the following equation:

$$y_t = \lambda_1 y_{t-1} - \lambda_2 \gamma_t + \eta_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(IX)}$$

Where

$$\lambda_1 = (1-b)\,, \lambda_2 = \beta b\,, \eta_t = \left(\frac{1-b}{\beta}\right) u_{t-1} + u_t$$

Equations (V) and (IX) are the ones representing Equations (2.3) and (2.4) in the text.

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