THE CONTEMPORANEOUS CORRELATION OF STRUCTURAL SHOCKS AND INFLATION AND OUTPUT VARIABILITY IN PAKISTAN

Muhammad Nasir

Pakistan Institute of Development Economics

Wasim Shahid Malik

Quaid-i-Azam University

INTRODUCTION

- In the last two decades monetary policy has changed in number of ways.
- After the adoption by RBNZ, much of the research in the area of monetary policy has focused on Inflation Targeting framework.
- Characteristics of modern monetary policy:
  - Announcement of explicit inflation target and the achievement of this target as prime objective
  - Communication with the public
  - Transparency of policy decision
  - Credibility and accountability of monetary authority
  - Forward-looking nature of policy decisions.
- The last characteristics calls for contemporaneous response to structural shocks by the central bank.

- Any contemporary news that is relevant to inflation is reflected in inflation forecast, which in turn calls for changes in operational target or policy instrument, making demand and supply correlated.
- This requires decomposition of structural innovations into demand and supply shocks.

- **OBJECTIVES OF THE STUDY**

- The first objective of the underlying study is, therefore, to investigate the presence of contemporaneous between demand and supply shocks in Pakistan.
- 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.

THEORETICAL MODEL

- In other frameworks, central banks respond to inflation after it is observed.
- However, with forward-looking monetary policy, inflation forecast is used as intermediate target.
- Any shock that affect inflation forecast calls for contemporaneous change in monetary policy instrument.
- Consider the following AS-AD model:

$$\pi_t = \alpha y^e_{t-1} + v_t \qquad (2.1)$$

$$y_t = -\beta r^e_t + u_t \qquad (2.2)$$

- After some mathematical manipulations, the above equations take the form

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

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

The period loss function is given by:

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

taking equation (2.3) one period forward and then making use of (2.3) and (2.4):

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

the solution to the optimization 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. Thus, the central bank can find the optimal policy rate in period *t* as the solution to the simple period-by-period problem:

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

the FOC for the minimization of (2.7) with respect to i_t gives

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

Consequently, the *inflation forecast targeting loss function* will take place of the inflation targeting loss function

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

assuming $\pi^{*} = 0$ and equating it to equation (2.6) after taking expectations will give the optimal reaction function of the central bank:

$$r_t = d_1\pi_{t-1} + d_2 y_{t-1} + d_3\omega_t + d_4\eta_t \qquad (2.10)$$

correlation of demand and supply side variables.

this contemporaneous response is possible only if monetary policy is forward-looking.

ECONOMETRIC METHODOLOGY

HISTORICAL DEVELOPMENT OF VAR

- Rational expectations, Lucas Critique, and policy analysis with traditional econometrics [Lucas (1972; 1976)]
- Sims response and the introduction of VAR [Sims (1980)]
- Criticism on VAR: useful for forecasting only; mechanical technique with little economic content [Sargent (1979;1984), Learner (1985)]
- Response to criticism with Structural VAR (SVAR) using short-run restrictions for identification [Sims (1986), Bernanke (1986), Blanchard and Watson (1986)]
- Extension of Structural VAR (SVAR) using long-run restrictions [Shapiro and Watson (1988) and Blanchard and Quah (1989)]
- Decomposition of output in permanent and temporary components using SVAR [B-Q (1989), Spencer (1996)]
- Criticism on assumptions of B-Q Methodology [Mankiw and Romer (1991), Waggoner and Zha (2003), Hamilton *et al.* (2004)]
- Alternative Methodology [Cover *et al.* (2006), Enders and Hurn (2007)]

Blanchard-Quah Methodology

- Let the VAR model for a small open economy, as in Enders and Hurn (2007), is as follow

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

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

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

- The unobservable structural shocks and the observable VAR residuals are linked by the following relationship

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

- There are fifteen elements to identify:
- Six from the elements of var-cov matrix of the VAR residuals.
- The rest of the restrictions are provided by the standard assumptions of B-Q methodology.

- **These assumptions include the following:**
  - Variances of structural shocks are normalized to unity: $(\sigma^2_{\varepsilon_1} = \sigma^2_{\varepsilon_2} = \sigma^2_{\varepsilon_3} = 1)$
  - All covariances are equal to zero: $(\sigma_{\varepsilon_1\varepsilon_2} = \sigma_{\varepsilon_1\varepsilon_3} = \sigma_{\varepsilon_2\varepsilon_3} = 0)$
  - Domestic shocks have no effect on the larger country: $h_{12} = h_{13} = 0$
  - Demand shocks are neutral in the long run: $h_{23}\left[1 - \sum_{i=1}^{k} \phi_{33j}\right] + h_{33}\left[1 - \sum_{i=1}^{k} \phi_{23j}\right] = 0$
- **Criticism on the assumptions of B-Q methodology:**
  - Waggoner and Zha (2003) and Hamilton *et al.* (2004) have warned that normalization can have effects on statistical inference in a structural VAR.
  - The New Keynesian economists argued that monetary shocks need not be neutral (Mankiw and Romer, 1991). Even the New Classical models may not necessarily allow for the super neutrality of money.
  - The contemporaneous correlation between structural shocks is forcedly zero due to orthogonality which does not allow for the contemporaneous response by the monetary authorities to structural shocks.

Alternative Methodology

- The Alternative methodology is developed by Cover et al. (2006) and extended by Enders and Hurn (2007) for a small open economy. Consider the following AD-AS model:

$$y_t^S = E_{t-1}y_t + \rho(\pi_t + E_{t-1}\pi_t) + \varepsilon_{2t} + \theta\varepsilon_{1t}$$
$$y_t^d + \pi_t = E_{t-1}(y_t^d + \pi_t) + \varepsilon_{3t}$$
$$y_t^S = y_t^d \qquad (3)$$

- Taking one period lag of (1) and taking the conditional expectations will result in following

$$H = \begin{bmatrix} h_{11} & 0 & 0 \\ \theta/(1+\rho) & 1/(1+\rho) & \rho/(1+\rho) \\ -\theta/(1+\rho) & -1/(1+\rho) & 1/(1+\rho) \end{bmatrix} \qquad (4)$$

- Nine restriction are required for the identification of three variances, three covariances of structural innovation along with h_{11}, θ, ρ
- six restrictions from the Var-Cov matrix of VAR residuals. Three more restrictions include the long neutrality of demand shock along with $h_{11} = 1, \sigma_{\varepsilon_1\varepsilon_2} = 0$
- **DIFFERENCES WITH THE BQ ASSUMPTIONS**
- First, the assumption of normalization 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 with in the model.
- Third, the small country assumption outlines that domestic shock has no effect on global economy.

DATA AND VARIABLES

- Quarterly data is used from 1991:4 to 2008:3.
- Three variables used for the identification of domestic demand, domestic supply and foreign output shocks include:
  - Domestic real GDP for domestic output [Kemal and Arby (2004)]
  - CPI for domestic inflation [IFS (2009)]
  - Index for foreign output [IFS (2009), Pakistan Economic Survey (various issues)]
- Data on domestic GDP have been extended from 2004 to 2008.
- Instead of taking US GDP as a proxy for foreign shock, we have constructed an index of foreign shocks which includes seven major trade partners of Pakistan, by multiplying the trade shares with their GDPs.
- US, UK, Japan, Germany, Saudi Arabia, Kuwait and Malaysia.
- This is more realistic index for foreign output shock.

RESULTS AND DISCUSSION

- Table 1: Results of Unit Root Test

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)

- Table 2: Results of Cointegration Test

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

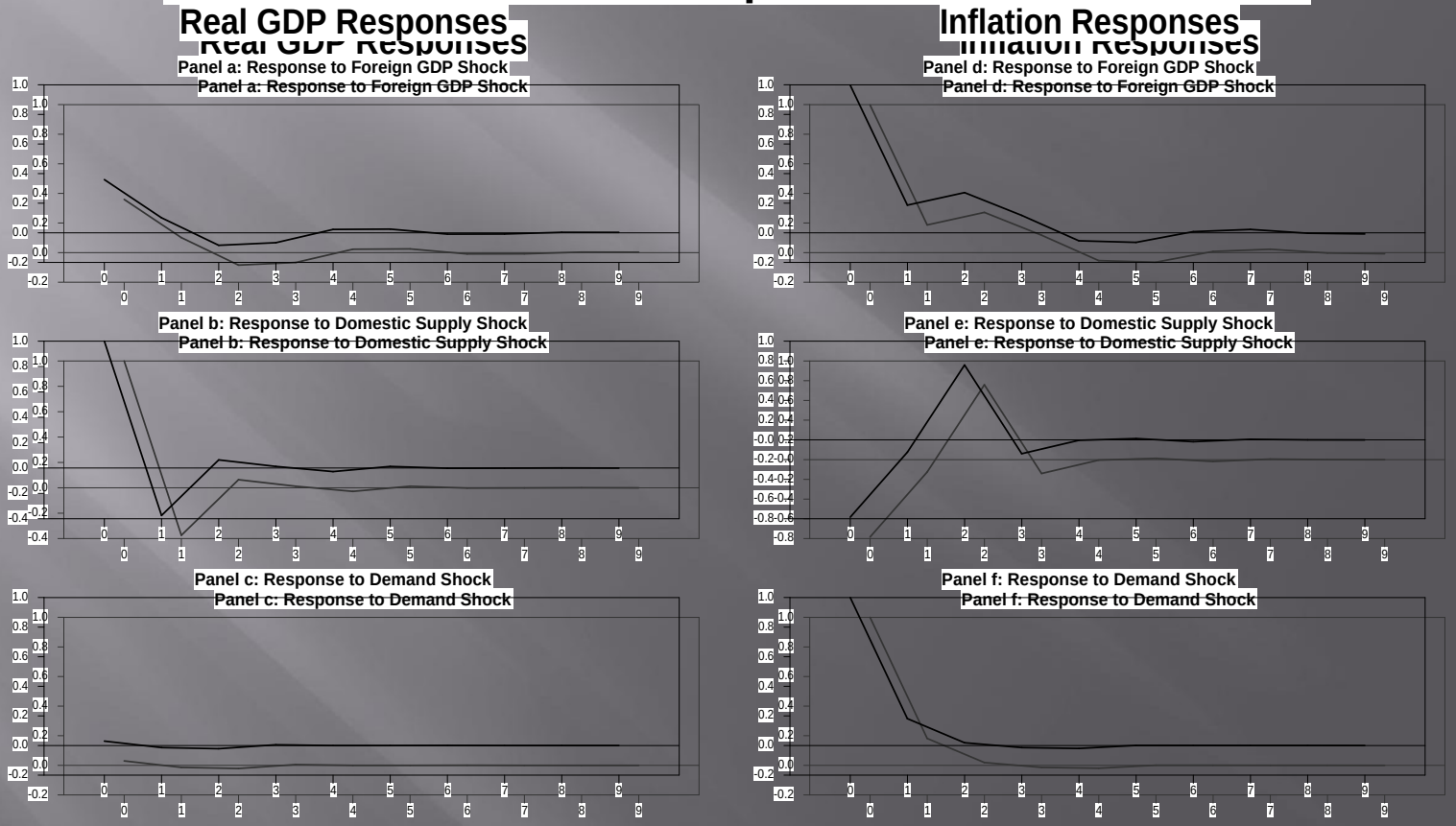
RESULTS FOR THE STANDARD B-Q DECOMPOSITION

- 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	FGDP	DSS	DS	FGDP	DSS	DS
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

Impulse Response Functions using BQ Decomposition

Figure 5.1: Standardized Impulse Response Functions



RESULTS FOR THE ALTERNATIVE DECOMPOSITION

- **Table 4: Forecast-Error Variance Decomposition with Alternative Decomposition**

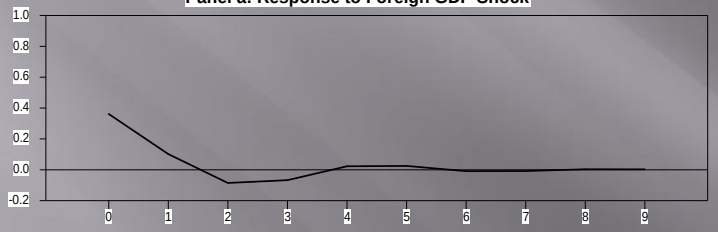
	Percentage Variation in Domestic Output due to			Percentage Variation in Domestic Inflation due to		
Horizon	FGDP	DSS	DS	FGDP	DSS	DS
1	11.564	88.311	0.126	33.370	33.568	33.062
2	10.019	88.849	0.132	33.479	33.416	33.105
3	11.474	88.361	0.165	29.666	42.948	27.387
4	11.782	88.052	0.167	29.774	43.074	27.152
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

Impulse Response Functions using Alternative Decomposition

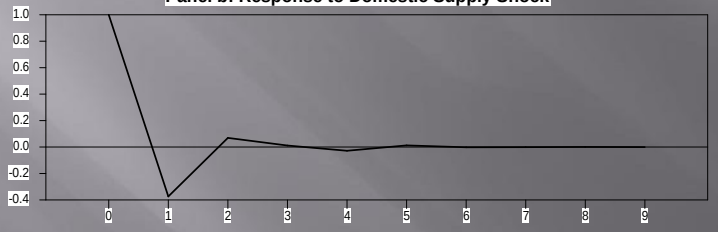
Figure 5.2: Standardized Impulse Response Functions

Real GDP Responses

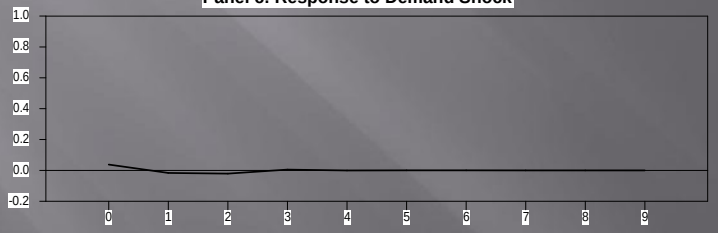
Panel a: Response to Foreign GDP Shock



Panel b: Response to Domestic Supply Shock

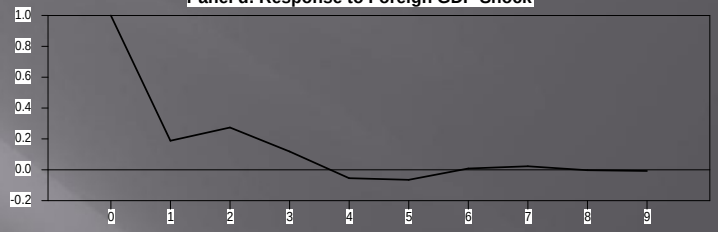


Panel c: Response to Demand Shock

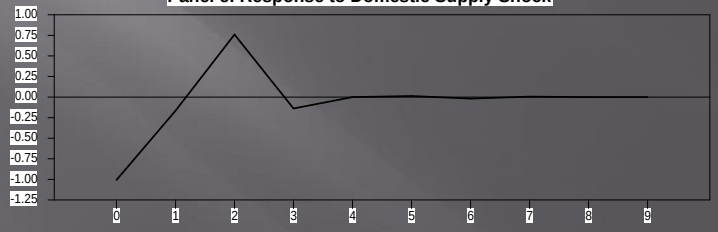


Inflation Responses

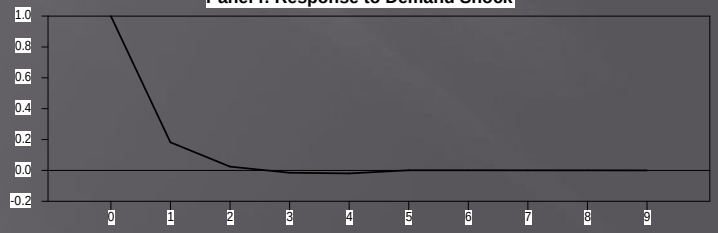
Panel d: Response to Foreign GDP Shock



Panel e: Response to Domestic Supply Shock



Panel f: Response to Demand Shock



- Using the alternative decomposition, our findings suggest that there is correlation of only 0.041 between the two shocks which is negligible. Consequently, we may conclude that the State Bank of Pakistan does not respond contemporaneously to supply side shocks.
  - The policy may not be forward-looking
  - Absence of a proper forecasting model
- This is consistent with Malik and Ahmed (2007) where the coefficient of inflation variable is less than one – a requirement for Taylor principle to hold.
- There is not much difference in the results of the two methodologies.
- The result for the sub sample period (1999:1 to 2008:3) does not show any evidence of the contemporaneous response either. The correlation between the two structural shocks is even lower (only 0.012).
- Again the results of the two methodologies does not differ significantly for the sub sample period.

RESULTS FOR THE STANDARD B-Q DECOMPOSITION

- Table 5: Forecast-Error Variance Decomposition Using B-Q Decomposition

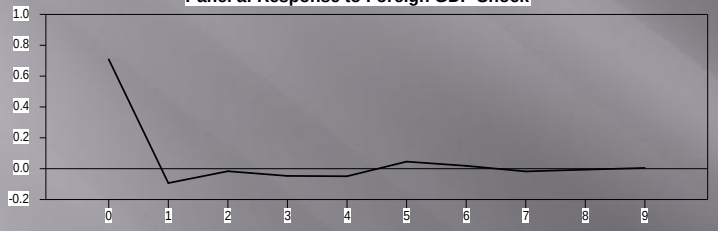
	Percentage Variation in Domestic Output due to			Percentage Variation in Domestic Inflation due to		
Horizon	FGDP	DSS	DS	FGDP	DSS	DS
1	33.417	66.518	0.064	58.446	19.294	22.261
2	30.670	69.254	0.085	59.123	18.909	21.968
3	30.653	69.242	0.106	53.712	28.994	17.294
4	30.607	69.283	0.110	53.027	29.892	17.081
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

Impulse Response Functions using BQ Decomposition

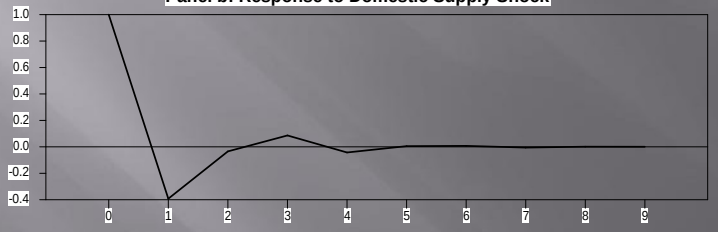
Figure 5.3: Standardized Impulse Response Functions

Real GDP Responses

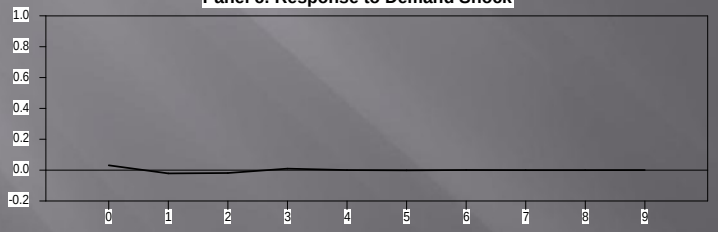
Panel a: Response to Foreign GDP Shock



Panel b: Response to Domestic Supply Shock

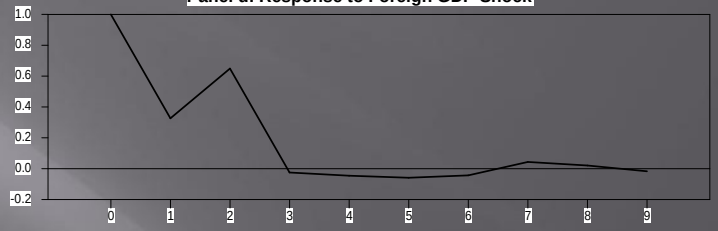


Panel c: Response to Demand Shock

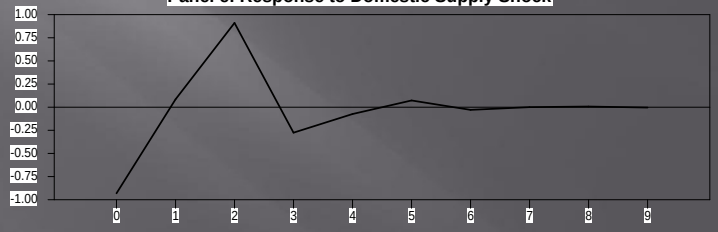


Inflation Responses

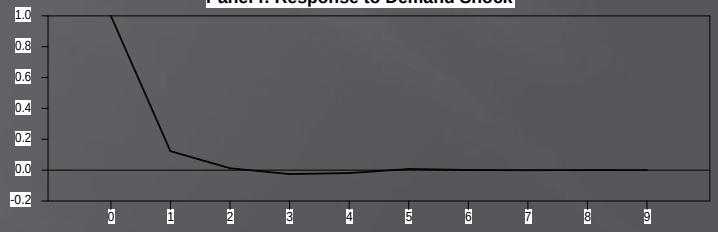
Panel d: Response to Foreign GDP Shock



Panel e: Response to Domestic Supply Shock



Panel f: Response to Demand Shock



RESULTS FOR THE ALTERNATIVE DECOMPOSITION

- **Table 6: Forecast-Error Variance Decomposition with Alternative Decomposition**

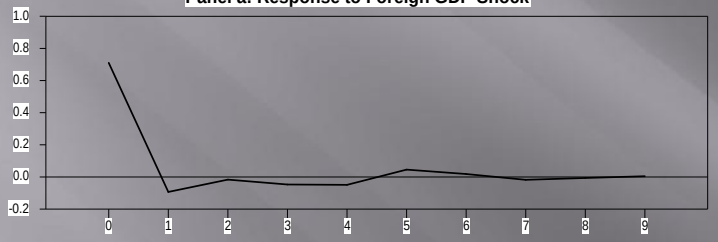
	Percentage Variation in Domestic Output due to			Percentage Variation in Domestic Inflation due to		
Horizon	FGDP	DSS	DS	FGDP	DSS	DS
1	33.510	66.416	0.074	56.816	21.640	21.544
2	30.767	69.137	0.096	57.535	21.180	21.285
3	30.751	69.132	0.117	52.584	30.558	16.858
4	30.707	69.171	0.122	51.935	31.407	16.658
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

Impulse Response Functions using Alternative Decomposition

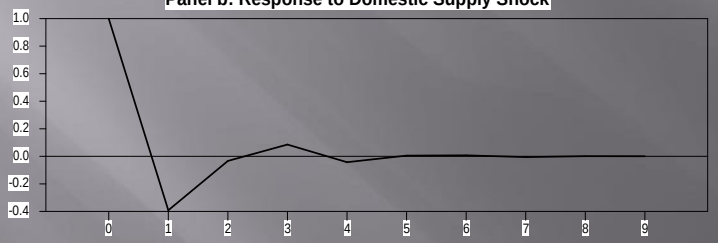
Figure 5.4: Standardized Impulse Response Functions

Real GDP Responses

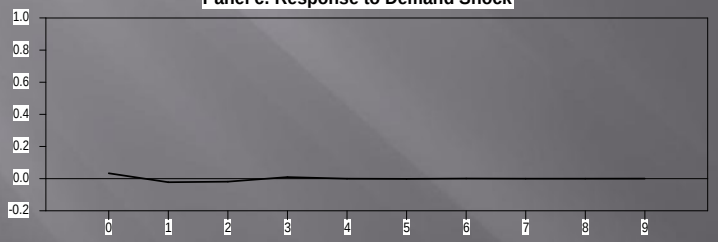
Panel a: Response to Foreign GDP Shock



Panel b: Response to Domestic Supply Shock

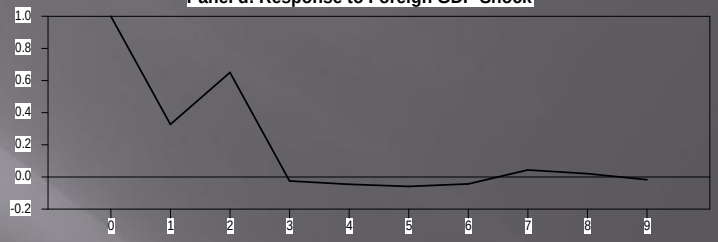


Panel c: Response to Demand Shock

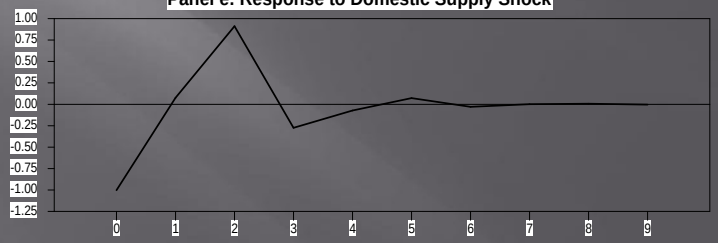


Inflation Responses

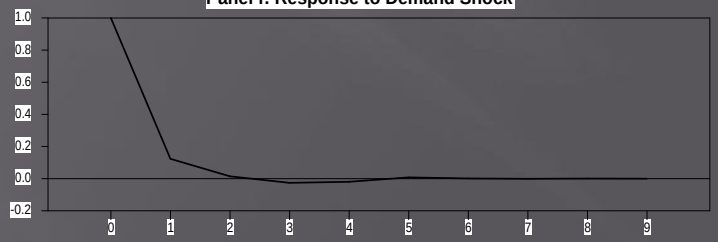
Panel d: Response to Foreign GDP Shock



Panel e: Response to Domestic Supply Shock



Panel f: Response to Demand Shock



CONCLUSION AND POLICY IMPLICATIONS

CONCLUSIONS

- The first conclusion is that the SBP has not been pursuing a forward-looking policy. The contemporaneous correlation between the AD-AS Shocks of 0.041suggest the negligible contemporaneous response of the policy to supply-side shocks.
- The FEVD of both models consider the domestic supply shock (88%) as the major factor in output variability. Foreign supply shock and domestic demand shocks account for 11% and less than 1% of variation in output respectively.
- The contribution of demand shock to inflation varies from 27% to 31% in both methodologies. The remaining 70% is assigned to the two supply shocks.
- In the face a positive foreign supply shocks, the effect of the shock transmits more to the price level than to output.
- There is no evidence of contemporaneous response even in sub sample period.
- The contribution of demand shock in inflation reduces where as the role of foreign supply shock increase in output and inflation variability in the sub sample period.

POLICY IMPLICATIONS

- The central bank should be very careful in controlling inflation through tight monetary policy as demand contributes less to inflation especially after 1999. Rather, the cost channel of monetary policy may come into effect.
- In this context, the continuous increase in the policy rate by the SBP in recent times is astonishing and rather undesirable.
- The SBP needs to build a proper forecasting model if it is following a forward-looking policy.
- The policy makers should avoid exploiting inflation-output trade-off, since the role of demand in output growth is negligible. Instead, they should focus on the problems of real sector and enhance the production capacity of the economy.

THANK YOU