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

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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.
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:

\[ \pi_t = \alpha y_{t-1} + \nu_t \]  
\[ y_t = -\beta r_t^e + u_t \] 

After some mathematical manipulations, the above equations take the form

\[ \pi_t = \gamma_1 \pi_{t-1} + \gamma_2 y_{t-1} + \omega_t \]  
\[ y_t = \lambda_4 y_{t-1} - \lambda_2 r_t + \eta_t \]
The period loss function is given by:

\[ L(\pi_t) = \frac{1}{2} (\pi_t - \pi^*)^2 \]  \hspace{1cm} (25)

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

\[ \pi_{t+1} = c_1 \pi_{t-1} + c_2 y_{t-1} - c_3 r_t + (\gamma_1 \omega_t + \gamma_2 \eta_t + \omega_{t+1}) \]  \hspace{1cm} (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:

\[ \min_i E_t \delta^2 L(\pi_{t+1}) \]  \hspace{1cm} (2.7)

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

\[ \pi_{t+1/t} = \pi^* \]  \hspace{1cm} (2.8)
Consequently, the *inflation forecast targeting loss function* will take place of the inflation targeting loss function

\[ L^I(\pi_{t+1|t}) = \frac{1}{2}(\pi_{t+1|t} - \pi^*) \]  \hspace{1cm} (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:

\[ r_t = d_1\pi_{t-1} + d_2y_{t-1} + d_3\omega_t + d_4\eta_t \] \hspace{1cm} (2.10)

correlation of demand and supply side variables.

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

\[
\hat{y}_t = \sum_{j=1}^{k} \phi_{11}\hat{y}_{t-j} + e_{1t} \\
y_t = \sum_{j=0}^{k} \phi_{21}\hat{y}_{t-j} + \sum_{j=1}^{k} \phi_{22} y_{t-j} + \sum_{j=1}^{k} \phi_{23}\pi_{t-j} + e_{2t} \\
\pi_t = \sum_{j=0}^{k} \phi_{31}\hat{y}_{t-j} + \sum_{j=1}^{k} \phi_{32} y_{t-j} + \sum_{j=1}^{k} \phi_{33}\pi_{t-j} + e_{3t}
\]

(1)

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

\[
\begin{bmatrix}
e_{1t} \\
e_{2t} \\
e_{3t}
\end{bmatrix} =
\begin{bmatrix}
h_{11} & h_{12} & h_{13} \\
h_{21} & h_{22} & h_{23} \\
h_{31} & h_{32} & h_{33}
\end{bmatrix}
\begin{bmatrix}
e_{1t} \\
e_{2t} \\
e_{3t}
\end{bmatrix}
\]

(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: \( \sigma_{\epsilon_1}^2 = \sigma_{\epsilon_2}^2 = \sigma_{\epsilon_3}^2 = 1 \)

- All covariances are equal to zero: \( \sigma_{\epsilon_1 \epsilon_2} = \sigma_{\epsilon_1 \epsilon_3} = \sigma_{\epsilon_2 \epsilon_3} = 0 \)

- 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:

\[ y_t^S = E_{t-1}y_t + \rho(\pi_t + E_{t-1}\pi_t) + \varepsilon_{2t} + \theta\varepsilon_{1t} \]
\[ y_t^d + \pi_t = E_{t-1}(y_t^d + \pi_t) + \varepsilon_{3t} \]
\[ y_t^s = y_t^d \quad (3) \]

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

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

Nine restriction are required for the identification of three variances, three covariances of structural innovation along with \(h_{11}, \theta, \rho\)

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.
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.
Table 1: Results of Unit Root Test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th>First Difference</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Output</td>
<td>-1.190</td>
<td>-3.610 **</td>
<td>I(1)</td>
</tr>
<tr>
<td>Domestic Output</td>
<td>-1.464</td>
<td>-12.230 ***</td>
<td>I(1)</td>
</tr>
<tr>
<td>Inflation</td>
<td>-1.490</td>
<td>-6.395 ***</td>
<td>I(1)</td>
</tr>
</tbody>
</table>

Table 2: Results of Cointegration Test

<table>
<thead>
<tr>
<th>No of CE(s)</th>
<th>Trace Statistics</th>
<th>5% Critical Value</th>
<th>Max. Eigen Statistics</th>
<th>5% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>15.131</td>
<td>29.797</td>
<td>8.833</td>
<td>21.131</td>
</tr>
<tr>
<td>At most 1</td>
<td>6.297</td>
<td>15.494</td>
<td>5.560</td>
<td>14.264</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.737</td>
<td>3.841</td>
<td>0.737</td>
<td>3.841</td>
</tr>
</tbody>
</table>
## RESULTS FOR THE STANDARD B-Q DECOMPOSITION

Table 3: Forecast-Error Variance Decomposition Using B-Q Decomposition

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Percentage Variation in Domestic Output due to</th>
<th>Percentage Variation in Domestic Inflation due to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FGDP</td>
<td>DSS</td>
</tr>
<tr>
<td>1</td>
<td>11.437</td>
<td>88.484</td>
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<tr>
<td>2</td>
<td>10.894</td>
<td>89.022</td>
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<tr>
<td>3</td>
<td>11.350</td>
<td>88.530</td>
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<td>4</td>
<td>11.655</td>
<td>88.224</td>
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<tr>
<td>5</td>
<td>11.683</td>
<td>88.196</td>
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<tr>
<td>6</td>
<td>11.724</td>
<td>88.156</td>
</tr>
<tr>
<td>7</td>
<td>11.729</td>
<td>88.150</td>
</tr>
<tr>
<td>8</td>
<td>11.733</td>
<td>88.146</td>
</tr>
<tr>
<td>9</td>
<td>11.734</td>
<td>88.145</td>
</tr>
<tr>
<td>10</td>
<td>11.735</td>
<td>88.145</td>
</tr>
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</table>
Impulse Response Functions using BQ Decomposition

Figure 5.1: 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
Table 4: Forecast-Error Variance Decomposition with Alternative Decomposition

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Percentage Variation in Domestic Output due to</th>
<th>Percentage Variation in Domestic Inflation due to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FGDP</td>
<td>DSS</td>
</tr>
<tr>
<td>1</td>
<td>11.564</td>
<td>88.311</td>
</tr>
<tr>
<td>2</td>
<td>10.019</td>
<td>88.849</td>
</tr>
<tr>
<td>3</td>
<td>11.474</td>
<td>88.361</td>
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<td>88.052</td>
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<tr>
<td>5</td>
<td>11.810</td>
<td>88.023</td>
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<tr>
<td>6</td>
<td>11.851</td>
<td>87.982</td>
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<tr>
<td>7</td>
<td>11.856</td>
<td>87.977</td>
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<tr>
<td>8</td>
<td>11.861</td>
<td>87.973</td>
</tr>
<tr>
<td>9</td>
<td>11.861</td>
<td>87.972</td>
</tr>
<tr>
<td>10</td>
<td>11.862</td>
<td>87.972</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Percentage Variation in Domestic Output due to</th>
<th>Percentage Variation in Domestic Inflation due to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FGDP</td>
<td>DSS</td>
</tr>
<tr>
<td>1</td>
<td>33.417</td>
<td>66.518</td>
</tr>
<tr>
<td>2</td>
<td>30.670</td>
<td>69.254</td>
</tr>
<tr>
<td>3</td>
<td>30.653</td>
<td>69.242</td>
</tr>
<tr>
<td>4</td>
<td>30.607</td>
<td>69.283</td>
</tr>
<tr>
<td>5</td>
<td>30.673</td>
<td>69.217</td>
</tr>
<tr>
<td>6</td>
<td>30.758</td>
<td>69.132</td>
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<tr>
<td>7</td>
<td>30.770</td>
<td>69.119</td>
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<tr>
<td>8</td>
<td>30.783</td>
<td>69.107</td>
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<tr>
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<td>30.784</td>
<td>69.105</td>
</tr>
<tr>
<td>10</td>
<td>30.785</td>
<td>69.105</td>
</tr>
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</table>
Figure 5.3: Standardized Impulse Response Functions

Real GDP Responses
Panel a: Response to Foreign GDP Shock

Inflation Responses
Panel d: Response to Foreign GDP Shock

Panel b: Response to Domestic Supply Shock
Panel e: Response to Domestic Supply Shock

Panel c: Response to Demand Shock
Panel f: Response to Demand Shock
Table 6: Forecast-Error Variance Decomposition with Alternative Decomposition

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Percentage Variation in Domestic Output due to</th>
<th>Percentage Variation in Domestic Inflation due to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FGDP</td>
<td>DSS</td>
</tr>
<tr>
<td>1</td>
<td>33.510</td>
<td>66.416</td>
</tr>
<tr>
<td>2</td>
<td>30.767</td>
<td>69.137</td>
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<tr>
<td>3</td>
<td>30.751</td>
<td>69.132</td>
</tr>
<tr>
<td>4</td>
<td>30.707</td>
<td>69.171</td>
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<tr>
<td>5</td>
<td>30.772</td>
<td>69.106</td>
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<tr>
<td>6</td>
<td>30.857</td>
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<td>69.008</td>
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<tr>
<td>8</td>
<td>30.883</td>
<td>68.996</td>
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<td>9</td>
<td>30.884</td>
<td>68.994</td>
</tr>
<tr>
<td>10</td>
<td>30.885</td>
<td>68.993</td>
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</tbody>
</table>
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
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 0.041 suggest 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 whereas 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