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New Keynesian Macroeconomic Model and Monetary Policy in Pakistan

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The New Keynesian (NK) models have advantage over the Real Business Cycle (RBC) models as they allow rigidities in the structure of the model, hence provide built-in mechanism to incorporate the structural shocks. The estimation of the NK model for Pakistan's economy remains a relatively unexplored area. This study attempts to estimate a closed economy version of the NK model using robust econometric technique. On the empirical side macroeconomic dynamics have been investigated in response to unanticipated monetary shock. The reaction of the monetary authority (the State Bank of Pakistan) in response to structural shocks has been assessed by exploring the role of forward looking expectations. The SVAR model has been employed to estimate the structural parameters. The response of macroeconomic aggregates to structural shocks has also been simulated along with discussing the forecast error variance decomposition. The role of forward looking expectations is found to play prominent role in the prevailing market structure of the country. The State Bank of Pakistan (SBP) has been found to respond to shocks after a lag of one or more periods indicating time inconsistency problem which is due to discretionary monetary policy stance being adopted by the monetary authority. The distorted beliefs of economic agents about the stance of monetary policy have pointed towards weak effectiveness of the monetary policy. The results suggest that the SBP would have to adopt an independent and transparent monetary policy by following some sort of Taylor-type rule.

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1. INTRODUCTION

The macroeconomic models of the 1970s were heavily criticised due to lack of theoretical foundations.[1] The New Keynesian (NK) models of today have vastly improved the earlier versions as they include the role of expectations of economic agents and require policy makers to incorporate the role of expectations to attain macroeconomic stability. These models have the advantage over the Real Business Cycle (RBC) models as they allow rigidities in the structure of the model, hence provide built-in mechanism to

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[1]See the extensive work of 1970s of such luminaries as Lucas, Barro, Sargant, and Wallace.

incorporate the structural shocks. The theoretical model developed in the present study resembles to most of the closed economy Dynamic Stochastic General Equilibrium (DSGE) models that emphasise the importance of inter-temporal optimisation behaviour of economic agents, the role of forward looking expectations and nominal price rigidities. The four main objectives of the study are as follows. First is to investigate the macroeconomic dynamics in response to unanticipated monetary shock in the presence of rigidities in the goods and labour markets; second, to assess the reaction of monetary authority (the State Bank of Pakistan) to structural shocks; third to highlight the importance of forward looking expectations of economic agents in policy-making; and finally the identification of sources of variations in the macroeconomic aggregates.

This paper takes the lead over others as the rational expectations NK model has been estimated through maximum likelihood estimation procedure—a pioneering attempt in Pakistan. The identification scheme applied is unique in the sense that it has not been adopted earlier for modeling the Pakistan's economy. We have also attempted to implement the expectations type Taylor rule which provides an insight to the policy makers to target inflation and output gap in order to stabilise the economy. The estimation proceeds in two steps, following Keating (1990) who categorised this approach as the SVAR model. The impulse response analysis has been conducted which provides a valuable insight into the significance of structural shocks to the macroeconomic dynamics of the economy. Forecast error variance decomposition has also been computed which has the advantage to identify the sources of variation in the macroeconomic aggregates.

The results seem to confirm that the SBP has been pursuing discretionary policy rather than adopting any rule. This has been observed by examining the structural parameter estimates of the interest rate rule and the response of interest rate to the structural shocks. These findings highlight the role of expectations and the need for incorporating the direct and indirect impacts of factors which affect the macroeconomic dynamics. It, therefore, provides an insight to the policy-makers to achieve the short term and medium term targeted levels of inflation and economic growth in a more effective manner.

The paper is arranged as follows. Section 2 presents the closed economy model under rational expectations. Section 3 derives the identifying restrictions based on the structural macroeconomic model along with discussing the methodology. Section 4 presents and discusses the estimated results. Finally, Section 5 concludes the discussion, derives policy implications, and also suggests the scope for future research in the area of macroeconomic modeling for Pakistan.

2. FRAMEWORK OF FORWARD LOOKING MACROECONOMIC MODEL

One important aspect missing in the non-DSGE macroeconomic models is the lack of microeconomic foundations and nominal rigidities. In essence, the requirement is to develop a structural model which is free from such criticism and could be useful for policy analysis. Before we start discussing the model it is important to acknowledge the work of Haider and Khan (2008) and Ahmed, *et al.* (2012) that have worked on the structure of DSGE model. Both these studies have, however, 'managed' the unavailability of microeconomic parametric values by relying on 'borrowed' values from the countries other than Pakistan.

We start with the final equations of the closed economy version of the model presented by Clarida, *et al.* (1999) which consists of three main economic agents. First, the households who generate demand for goods and services hence provide aggregate demand equation (forward looking IS equation). Second, the profit maximising firms who provide forward looking Phillips curve equation (aggregate supply equation) and the third is the central bank that follows the Taylor type interest rate rule. We discuss these three components briefly.

2.1. Aggregate Demand Equation

Expectations type aggregate demand equation derived through the optimum behaviour of the household can be expressed as

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \epsilon_t^f \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.1)$$

The equation is obtained through log-linearising the Euler equation of consumption after imposing condition that consumption expenditure equals output minus government purchases. Since ϵ_t^f depends on expected changes in government purchases relative to expected changes in potential output, hence it shifts the IS curve. Therefore it is named as demand or fiscal shock.[2] The parameter φ represents inter-temporal elasticity of substitution and ρ is the time discount factor.

This forward looking IS equation shows that domestic output gap depends inversely on the real interest rate $[i_t - E_t\pi_{t+1} - \rho]$, that is, it reveals that with the rise in real interest rate consumers will save more which, in turn, will result in reduction in aggregate spending. The central bank can influence the consumption pattern of households through changes in the nominal interest rate, which results in changes in the real interest rate due to sluggish changes in the prices. The domestic output gap is directly determined by the future output gap expected in the current period$(E_t x_{t+1})$. ϵ_t^f is the disturbance term which obeys: $\epsilon_t^f = \mu\epsilon_{t-1}^f + \hat{e}_t$; $0 \le \mu \le 1$ and $\hat{e}_t$is i.i.d. random variable with zero expected value and constant variance.

2.2. Aggregate Supply Equation

The nature of inflation dynamics, which is the most distinctive feature of the new Keynesian paradigm, is captured by the New Keynesian Phillips Curve which is based on

[2] $\hat{c}_t = E_t\hat{c}_{t+1} - \frac{1}{\sigma}(\hat{\imath}_t - E_t\pi_{t+1} - \rho)$

$y_t = \hat{c}_t + g_t$as investment is suppressed. Thus $y_t - g_t = \hat{c}_t$ and $\hat{c}_{t+1} = y_{t+1} - g_{t+1}$

$$y_t = E_t(y_{t+1} - g_{t+1}) - \left(\frac{1}{\sigma}\right)(\hat{\imath}_t - E_t\pi_{t+1} - \rho) + g_t$$

$$y_t = E_t(y_{t+1}) - \left(\frac{1}{\sigma}\right)(\hat{\imath}_t - E_t\pi_{t+1} - \rho) - E_t(g_{t+1} - g_t)$$

Using $x_t \equiv y_t - y_t^p$, where x_t is output gap, y_t is the actual output and y_t^p is the potential level of output. The above equation can be written as

$$y_t - y_t^p = E_t\big(y_{t+1} - y_{t+1}^p\big) - \left(\frac{1}{\sigma}\right)(\hat{\imath}_t - E_t\pi_{t+1} - \rho) + E_t(y_{t+1}^p$$

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \epsilon_t^f$$

Calvo's (1983) model. According to this model inflation is determined by expected future inflation and firm's real marginal costs. The literature on the New Keynesian Phillips Curve is focused on two main issues: First, what measures can be appropriate in order to account for real activity. Second, expectations are a crucial element that can affect the results. The relation of inflation, evolved from the Calvo model, is of the following form $\pi_t = \lambda \widehat{mc}_t + \beta E_t \pi_{t+1}$. Following Clarida, *et al.* (2001), cost push shock can be added with the marginal cost which represents the imperfections in the labour market. Thus, $\widehat{mc}_t = \frac{N_t{}^{\varphi}}{C_t^{-\sigma}} e^{\epsilon_t^c}$, log-linearising and solving gives us the following relationship $\widehat{mc}_t = \lambda_0 x_t + \epsilon_t^c$; where λ_0 represents output elasticity of real marginal cost. The aggregate supply equation, derived from the optimising behaviour of firms can be transformed as under:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda_0 x_t + \epsilon_t^c \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2.2)$$

This equation shows that inflation (π) depends on inflation expectations and domestic output gap (x_t) and $\boldsymbol{\epsilon_t^c}$ is the cost-push shock, which can be described by $\epsilon_t^c = \mu \epsilon_{t-1}^c + \hat{e}_t$. Inflation expectations play a central role in the Phillips curve models. For long time horizons, inflation expectations may be a sign of a monetary authority's credibility to fulfil the commitment to price stability.

2.3. Forward Looking Monetary Policy Rule

Central banks target inflation and output gap to stabilise the economy by adjusting the interest rate which results in changes in real interest rate due to price rigidity. The interest rate reaction function is derived by inserting the reduced form of output gap in the aggregate demand equation and solving it for the nominal interest rate.

$$i_t = \gamma_3 + \gamma_1(E_t \pi_{t+1}) + \gamma_2 x_t + \epsilon_t^i \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2.3)$$

There is now a general acceptance for policy rule instead of discretionary policy to improve the economic performance. In this regard, the seminal paper by Barro and Gordon (1983) is a classic example where the time inconsistency associated with discretion rather than rule has been highlighted. Among others, Walsh (1995) has also argued for an independent central bank for reducing the inflationary bias. To circumvent this bias, Taylor (1993) formulated a very simple and practicable rule necessitating changes in short term policy rate in response to changes in inflation and output gap. It requires that the parameters of inflation and output gap should be positive. However, Taylor (1999) suggested more than one-to-one adjustment in policy rate due to changes in inflation and the parameter for output gap should not fluctuate significantly from 0.5 which otherwise indicates instability of the system. On the other hand if parameter values are negative then it simply shows that the central bank is not following the Taylor Rule and instead there is a satiation for discretionary monetary policy. There is evidence to prove that lack of transparency in policy deteriorates macroeconomic performance rather than improving it.

3. METHODOLOGY AND IDENTIFICATION OF RESTRICTIONS

Both DSGE and SVAR models have emerged after the failure of large scale models in the 1970s. Whereas the DSGE models have been developed on the basis of strong assumptions about the functional forms, exogeneity, market structure and dynamic structure of the constraints, the SVAR models were initially proposed with minimal restrictions on the dynamics of the endogenous variables. However, they impose cross equation restrictions so that models are robust enough to capture the true structure of the economy in comparison with the alternative ad hoc models. Gali (1999) viewed the SVAR models as informative as the DSGE models.

The fundamental departure from traditional to micro-based models started when Lucas (1976) presented his famous critique. In a drastically changed paradigm, today the emphasis is on micro-foundations in a forward looking environment. The models now rely on utility and profit functions of economic agents who formulate and reformulate their expectations as and when there are changes in the policy by government or the central bank. These changes in the expectations result in poor guides for the policy makers to evaluate the new regime thus there is need to estimate the deep structural parameters which have the feature of being invariant to policy changes. Such models with rational expectations, derived through optimisation by the agents, have the ability to identify the rational expectations restrictions. As indicated in the introduction, Keating (1990) has proposed a two steps procedure for estimating the structural model having forward looking components and named it as SVAR model. The procedure, prescribed by Keating (1990), facilitates the researchers to make the SVAR and DSGE models compatible. Impulse response functions and variance decomposition can also be generated using the restrictions and the model is named as structural VAR model. Following the procedure to identify the restrictions, the structural model is converted into a representation comprising the structural shocks and the residuals of unrestricted VAR model along with structural parameters. Forward looking expectations are formulated through innovations of the dynamic economic structure.

3.1. Identification of Restrictions

The complete DSGE model conforming to the NK framework for a closed economic environment, discussed in the previous section, is reproduced below.

$$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \epsilon_t^f \quad \dots \quad \dots \quad \dots \quad \dots \quad (3.1)$$

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda_0 x_t + \epsilon_t^c \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3.2)$$

$$i_t = \gamma_3 + \gamma_1(E_t\pi_{t+1}) + \gamma_2 x_t + \epsilon_t^i \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3.3)$$

Subtracting all variables in the above equations from their expected values at time $t-1$ yield the following set of equations

$$x_t - E_{t-1}x_t = -\varphi(i_t - E_{t-1}i_t) + \varphi(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + (E_t x_{t+1} - E_t x_{t+1}) + \epsilon_t^f \quad (3.4)$$

$$\pi_t - E_{t-1}\pi_t = \beta(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + \lambda_0(x_t - E_{t-1}x_t) + \epsilon_t^c \quad \dots \quad \dots \quad (3.5)$$

$$i_t - E_{t-1}\pi_t = \gamma_1(E_t\pi_{t+1} - E_{t-1}\pi_{t+1}) + \gamma_2(x_t - E_{t-1}x_t) + \epsilon_t^i \quad \dots \quad \dots \quad (3.6)$$

In the above equations, $y_t - E_{t-1}y_t$ for all the variables represent the respective reduced form residuals. However, $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$ and $(E_t x_{t+1} - E_{t-1}x_{t+1})$ are the forward looking components in the model and need to be estimated on the basis of contemporaneous observations of the variables. The procedure to calculate these forward looking components is elaborated as follows:

$$\begin{bmatrix} y_t \\ y_{t-1} \\ y_{t-2} \\ \vdots \\ y_{t-q+1} \end{bmatrix} = \begin{bmatrix} A_1 & A_2 & \cdots & \cdots & A_q \\ I_n & 0_n & \cdots & \cdots & 0_n \\ 0_n & I_n & 0_n & \cdots & 0_n \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0_n & \cdots & 0_n & I_n & 0_n \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{t-2} \\ y_{t-3} \\ \vdots \\ y_{t-q} \end{bmatrix} + \begin{bmatrix} I_n \\ 0_n \\ 0_n \\ \vdots \\ 0_n \end{bmatrix} e_t \quad \ldots \quad \ldots \quad \ldots \quad (3.7)$$

$$Y_t = AY_{t-1} + Qe_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.8)$$

One step conditional expectation of Equation (3.8) can be written as follows.

$$E_tY_{t+1} = AY_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.9)$$

It may be considered that the expected value of residuals is equal to zero, i.e. $E_t(e_t) = 0$.

As Y vector consists of all the endogenous variables, therefore to locate the variables of interest, i.e., output gap and inflation, there is a need to introduce vectors of length nq where n denotes the number of endogenous variables and q denotes their lag order.

$\acute{r}_x = (1,0,0,\ldots,0)$for the output gap
$\acute{r}_\pi = (0,1,0,\ldots,0)$for inflation

Pre-multiplying Equation (3.9) with the above vectors results in the following expected values of forward looking output gap and inflation.

$$E_tx_{t+1} = \acute{r}_xAY_t$$

$$E_t\pi_{t+1} = \acute{r}_\pi AY_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (3.10)$$

$$E_tx_{t+1} = a_{11}^x x_t + a_{12}^x \pi_t + a_{13}^x i_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (3.11)$$

$$E_t\pi_{t+1} = a_{11}^\pi x_t + a_{12}^\pi \pi_t + a_{13}^\pi i_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (3.12)$$

It helps us to calculate the expectations revision process for output gap $(E_tx_{t+1} - E_{t-1}x_{t+1})$ and inflation $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$.

$$E_tx_{t+1} - E_{t-1}x_{t+1} = \acute{r}_xA(Y_t - E_{t-1}Y_t)$$

$$E_tx_{t+1} - E_{t-1}x_{t+1} = a_{11}^x(x_t - E_{t-1}x_t) + a_{12}^x(\pi_t - E_{t-1}\pi_t) + a_{13}^x(i_t - E_{t-1}i_t) \quad \ldots \quad \ldots. \quad \ldots. \quad \ldots \quad \ldots. \quad \ldots (3.13)$$

$$E_t\pi_{t+1} - E_{t-1}\pi_{t+1} = \acute{r}_\pi A(Y_t - E_{t-1}Y_t)$$

$$E_t\pi_{t+1} - E_{t-1}\pi_{t+1} = a_{11}^\pi(x_t - E_{t-1}x_t) + a_{12}^\pi(\pi_t - E_{t-1}\pi_t) + a_{13}^\pi(i_t - E_{t-1}i_t) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad .. \quad (3.14)$$

Putting values of $(E_tx_{t+1} - E_{t-1}x_{t+1})$ and $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$ in Equations (3.4)-(3.6) results in the following set of equations

$$x_t - E_{t-1}x_t = -\varphi(i_t - E_{t-1}i_t) + \varphi\big(\acute{r}_\pi A(Y_t - E_{t-1}Y_t)\big) + (\acute{r}_xA(Y_t - E_{t-1}Y_t)) + \epsilon_t^f \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (3.15)$$

$$\pi_t - E_{t-1}\pi_t = \beta(\acute{r}_\pi A(Y_t - E_{t-1}Y_t)) + \lambda_0(x_t - E_{t-1}x_t) + \epsilon_t^c \quad \ldots \quad \ldots (3.16)$$

$$i_t - E_{t-1}i_t = \gamma_1(\acute{r}_\pi A(Y_t - E_{t-1}Y_t)) + \gamma_2(x_t - E_{t-1}x_t) + \epsilon_t^i \quad \ldots \quad \ldots (3.17)$$

Now the next step is to replace the values of $(E_t x_{t+1} - E_{t-1}x_{t+1})$ and $(E_t\pi_{t+1} - E_{t-1}\pi_{t+1})$ from Equations (3.13) and (3.14) in Equations (3.15)-(3.17) which yield the required rational expectation restrictions. The structural model based on economic theory corresponds to structural representation of structural shocks and reduced form innovations with reduced form and structural parameters. Therefore, explicit representation of restrictions on the structural parameters is not required as the derived rational expectations restrictions are entirely based on dynamic structural representation of the economy which is in line with Keating (1990). These restrictions are being used to estimate the dynamic closed economy structural VAR model through maximum likelihood procedure in the next section.

4. ESTIMATION AND ANALYSIS

The model is estimated by using quarterly data for the period starting from first quarter of 1993 to fourth quarter of 2013. The output gap is calculated by adopting its basic definition, i.e., the differential between log of actual real GDP and potential GDP. There are various methods to get potential GDP, e.g. it can be measured by regressing the log of real GDP on its trend or by the HP filter. Following Malik (2007), we have used the former approach. Data for quarterly GDP is based on estimates provided by Arby (2008) and Hanif, *et al.* (2013). The data for annual GDP (at constant US$ with base year 2005-06) is taken from WDI (2014) and the Economic Survey of Pakistan. CPI inflation is calculated using log of CPI adjusted for quarterly chain base method. The call money rate (i) is used as a measure for interest rate. Data for CPI and call money rate are taken from IFS (2014) wherein few observations for the year 2013 are picked from official website of the IMF.

To employ maximum likelihood estimation procedure through structural VAR model, we need to incorporate the estimated values of reduced form parameters and residuals' series for the restrictions identified on the basis of structural model, as derived in the previous section. According to Canova (2007), VAR model is appropriate to employ even if the variables are non-stationary. Consistent parameter estimates are obtained even if unit roots are present in the variables [Sims, Stock, and Watson (1990)]. Following Sims, *et al.* (1990) and Sims (1992), the cointegration test is applied here to investigate the long run relationship between variables for which unit root test for all variables is a pre-requisite.

The primary condition for employing unrestricted VAR model is to ensure the stationarity of all the variables at first difference (variables need to be I(1)). Considering the fact that we are using quarterly data, the Augmented Dickey Fuller test (ADF test) has low power to capture the potential seasonal unit roots and non-linearity in the data series, therefore, HEGY test, proposed by Hylleberg, Engle, Granger and Yoo (1990) is used to check the unit roots. This test has the advantage to pretest data before seasonal adjustment or to use data without seasonal adjustment [Charemza and Deadman (1997)]. Since seasonal adjustment can result in loosing information about peak and trough in the data series, therefore it is not advisable in models which are based on economic theory. The results are presented in Table 1.

Table 1

The HEGY Test Results

Variable	Auxiliary Regression	t-test for H_0: $\pi_1 = 0$ (Non-seasonal/Zero Frequency)	t-test for H_1: $\pi_2 = 0$ (Biannual Unit Root)	F-test for H: $\pi_3 = \pi_4 = 0$ (Annual Unit Root)
Output Gap	With Intercept and Seasonal Dummies	–1.69	–2.64**	9.79***
	With Intercept, Time Trend and Seasonal Dummies	–1.68	–2.64**	9.64***
Interest Rate	With Intercept and Seasonal Dummies	–1.84	–4.18***	36.42***
	With Intercept, Time Trend and Seasonal Dummies	–1.83	–4.14***	35.01***
Inflation	With Intercept and Seasonal Dummies	–1.75	–3.56**	20.67***
	With Intercept, Time Trend and Seasonal Dummies	–1.98	–3.56**	20.17***

The results indicate that we cannot reject the presence of unit root at zero frequency in all variables. However for seasonal frequencies, there is no evidence of unit roots. Thus we can safely conclude that the variables are I(1). The residuals for all the auxiliary regressions were found to be white noise.

Based on the results produced by AIC, FPE, LM, lag length is set to be 5. Although SC and HQ support lag length of 4 but it is ignored due to the presence of autocorrelation in the residuals of reduced form VAR model.

To empirically analyse the long run relationship between the macroeconomic aggregates (the output gap, inflation and interest rate), we have used the Johansen and Juselius's (1990, 1992, 1994) system cointegration test. It has the advantage of utilising all available information in the data set, thereby increasing reliability of the estimates. Gonzalo (1992) has shown that the Johansen's maximum likelihood techniques perform better in finite samples than the univariate methods. It also does not rely on arbitrary normalisation Engle and Granger's (1987) method. Test results, presented below show that all the variables are cointegrated which means that a long run relationship exists among all the variables.

Once the reduced form VAR model is estimated, the residuals need to be statistically adequate. For the purpose, diagnostic tests are required to test the hypothesis of no autocorrelation, no heteroskedasticity, and normality. The results show that there is no evidence of serial correlation and heteroskedasticity even at 99 percent level of significance.[3]

[3]The results of reduced form VAR model and Diagnostic tests can be shared, if required.

Table 2

The Cointegration Test Outcome

Unrestricted Cointegration Rank Test (Trace)				
Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.278671	41.05337	29.79707	0.0017
At most 1	0.141998	15.24723	15.49471	0.0545
At most 2	0.039070	3.148429	3.841466	0.0760
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.278671	25.80615	21.13162	0.0102
At most 1	0.141998	12.09880	14.26460	0.1070
At most 2	0.039070	3.148429	3.841466	0.0760

4.1. Maximum Likelihood Structural Parameter Estimates

Conventionally, VAR studies along with studies based on DSGE framework focus on the mutual relationships of the endogenous variables (impulse response functions) rather than estimating structural parameters.[4] The structural parameter estimates are discussed here to show the dimension and magnitude of the impact of different independent variables on the dependent endogenous variable (in the specific macroeconomic relationship) in simultaneous equations system. These estimates also help to understand the macroeconomic dynamics in response to different structural shocks.

The transformation of endogenous variables and identifying restrictions are largely different from the previous studies that have used macroeconomic data for Pakistan. The reason could be that none of these studies have estimated the NK macroeconomic model through maximum likelihood estimation method. In this perspective, the estimated parameters are not comparable with any of the previous studies of Pakistan. Nonetheless, the results are consistent with the literature. The structural parameters estimated through maximum likelihood estimation are presented in Table 3.

All the parameters are significantly different from zero which reflects the significant impact of the variables on the corresponding dependent variables. In the aggregate demand equation, φ (the elasticity of inter-temporal substitution in consumption by the households) is significant even at 99 percent significance level which shows that reduction in real interest rate $[i_t - E_t\pi_{t+1}]$ increases the aggregate demand. The finding is in consonance with the theory expounded by Gali and Gertler (2007) along with others.

The parameter of forward looking inflation (β) in the Phillips curve equation has a value of 0.7362 which indicates that agents place larger weight to future expected inflation than inflation of past periods. This outcome is in line with the findings of Cho and Moreno (2002) and Gali and Gertler (1999). Finally, λ_0 indicates the effect of output gap on the inflation dynamics of the country.

[4]According to Joiner (2002), this is due to the underlying feature of the impulse responses to reflect the dynamic response of macroeconomic variables and that structural parameters do not reflect the dynamics.

Table 3

The Maximum Likelihood Structural Parameter Estimates

	Coefficient	Std. Error	z-Statistic	Prob.
φ	0.178022	0.002399	74.21324	0.0000
β	0.736175	0.000416	1770.512	0.0000
λ_0	–0.002851	0.000663	–4.303656	0.0000
γ_1	–4.828962	0.014359	–336.2983	0.0000
γ_2	1.440747	0.019326	74.55026	0.0000

$x_t = -\varphi[i_t - E_t\pi_{t+1} - \rho] + E_t x_{t+1} + \epsilon_t^f$
$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda_0 x_t + \epsilon_t^c$
$i_t = \gamma_3 + \gamma_1(E_t\pi_{t+1}) + \gamma_2 x_t + \epsilon_t^i$

While majority of the literature for developed countries [including that of Gali and Gertler (2007)] confirm positive impact of output gap on inflation in the short run. The output gap may, however, have a negative impact on inflation for the developing countries like Pakistan where Central Banks deal with the dual mandate of not only controlling inflation but also achieving high economic growth in the country Akbari (2005). The negative impact of output gap on inflation, as is obtained in our estimated model, shows that economic growth is inflation reducing. It is not surprising to see the negative sign for the estimated parameter of inflation and positive sign of output gap (with more than one-to-one adjustment) in the interest rate rule because SBP has never claimed to follow the Taylor rule. The negative impact of inflationary expectations on the interest rate shows that the policy was both ineffective and not independent. The positive impact of output gap on interest rate, with more than one-to-one adjustment, indicates that SBP has mainly targeted high economic growth in the country during the period of estimation. One possibility could be that the economy enjoyed a relatively better growth during this period due to external factors and the authorities in the SBP allowed this momentum to continue. This is also evident from the work of Malik and Ahmed (2010). They have found that the SBP has not followed a rule based policy in the past and the preference has always been for discretionary policy, which at times was accommodating in nature, notwithstanding the inflationary pressure.

4.2. Impulse Response Functions

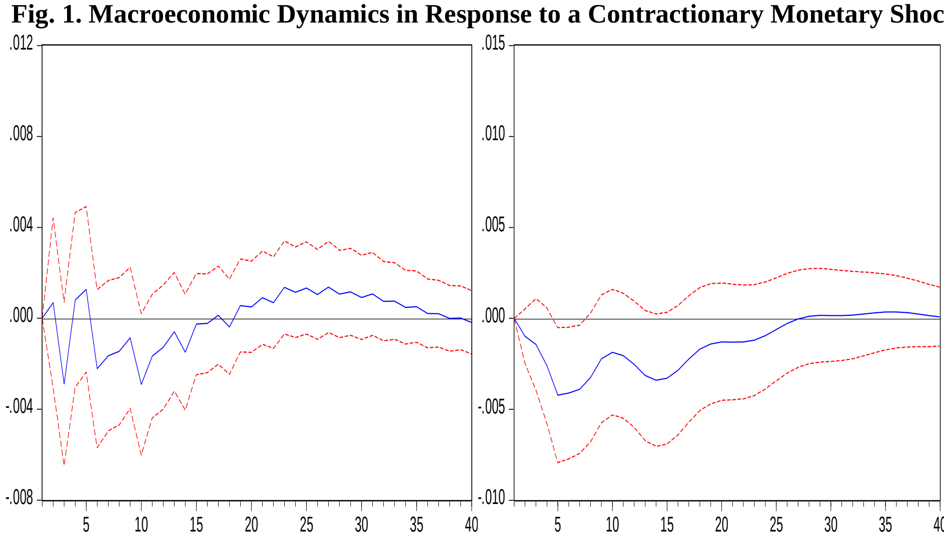
From policy perspective it is important to know the impact of various macroeconomic shocks on key macro aggregates. The literature reveals that monetary policy affects the economy with lag(s) and also generates variability and uncertainty about target achievement. It forces the monetary authority to be forward looking to take necessary steps to stabilise the economy. The study focuses on two sets of Impulse responses—the response of macroeconomic variables to a monetary policy shocks and the response of interest rate (call money rate) to macroeconomic variables. We have also analysed the impact of fiscal shock and aggregate supply shock to complete the discussion. One standard deviation shock is applied and 95 percent confidence bands of the standard errors are projected using the analytical framework.

4.2.1. *Contractionary Monetary Policy Shock*

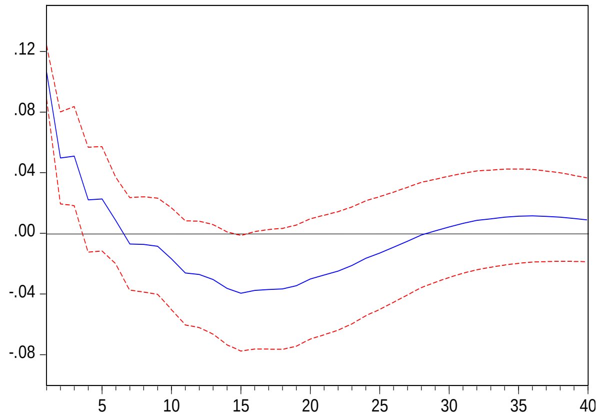
An unanticipated contractionary monetary policy shock in the shape of an increase in call money rate has been examined. It has been found that the unanticipated innovation in the call money rate by the SBP results in an immediate, but slight increase in the output gap in the same quarter which gets lower than the potential level up to fourth quarter. However, a large reduction in the output gap occurs in the fifth quarter and it continuously remains below the stability path up until the tenth quarter. Since the SBP, like other Central Banks of developing economies, pursue the objectives of growth and price stability in the short run, the theory suggests that with an increase in interest rate there is a decrease in consumption and investment spending. This should lead to a decrease in aggregate demand. Whereas the impulse response apparently shows fluctuations in the first four quarters, one observes that the output gap remains below the long run stability path or the steady state from fifth quarter onwards. This indicates the success of SBP in controlling aggregate demand through contractionary monetary policy action. It may be added that besides private expenditure, an important component of aggregate demand is government spending, especially for economies like Pakistan where fiscal dominance prevails [Choudri and Malik (2012)]. In such a scenario, growth and inflation targets are mostly set by the Government and the role of the SBP reduces to follow this 'dependent policy scenario'.

Panel (b) of Figure 1 confirms that the SBP is successful in lowering inflation in the country with a monetary policy tightening. The results are consistent with the idea of 6-18 months lag in achieving reduction in the demand pressures. Inflation touches the long run stability path after twenty five quarters. Thus, the identification scheme generates no price puzzle. The monetary easing in the subsequent periods has resulted in expansionary effects. The results further indicate that the monetary shock has immediately transmitted positive signals to interest rate which dies out to zero in the seventh quarter.

Fig. 1. Macroeconomic Dynamics in Response to a Contractionary Monetary Shock



(a) Response of Output Gap to Monetary Shock (b) Response of Inflation to Monetary Shock

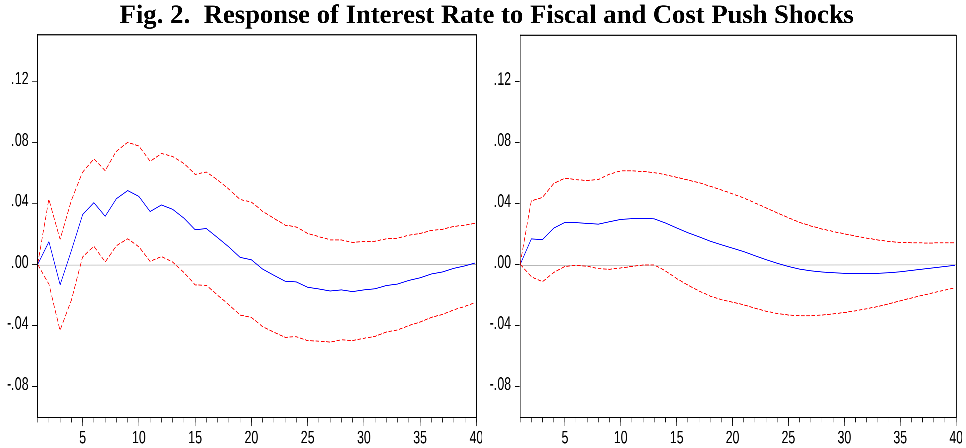


(c) Response of Interest Rate to Monetary Shock

4.2.2. *Assessing Reaction Function*

The focus on the dynamic response of interest rate to fiscal and aggregate supply shocks is expected to allow us to see whether or not the policy reaction function is specified correctly or whether or not the SBP has ever adopted the policy reaction function during the period of investigation. The responses can be traced in Figure 2 below. The results show that in response to a fiscal shock, interest rate increases and takes twenty quarters to get back to its long run path which is facilitated by the expansionary policy in the subsequent periods. In response to positive cost push shock in the country, interest rates started increasing and remained on the higher side up to twenty five quarters.

Fig. 2. Response of Interest Rate to Fiscal and Cost Push Shocks

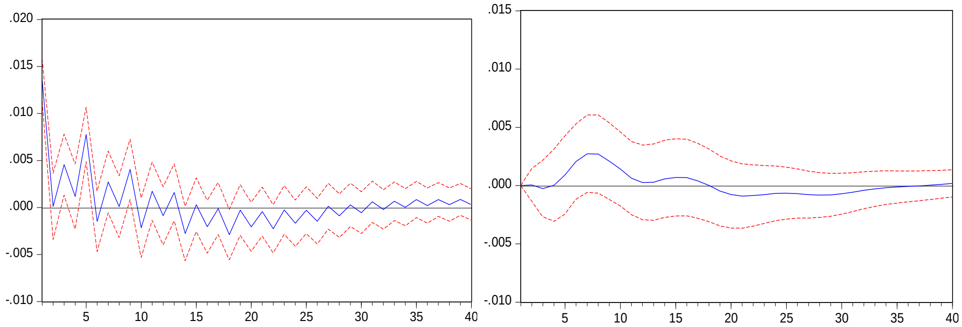


(a) Response of Interest Rate to Fiscal shock (b) Response of Interest Rate to Cost Push Shock

4.2.3. *Impact of Fiscal and Aggregate Supply Shocks on Macroeconomic Dynamics*

In response to positive fiscal shock, both output gap and inflation started rising. However, whereas the output gap increases immediately after the fiscal shock hits the economy, the inflation rate started to rise after four quarters.

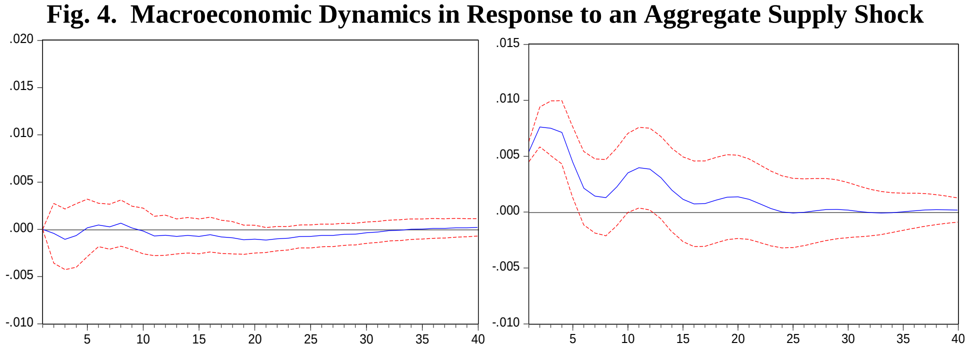
Fig. 3. Macroeconomic Dynamics in Response to a Fiscal Shock



(a) Response of Output Gap to Fiscal Shock (b) Response of Inflation to Fiscal Shock

The cost push shock originates from labour market imperfections. Inflation started rising soon after the cost push shock hits the economy but the output gap decreases during the first few quarters but it largely remains close to the long run stability path. This outcome indicates that the cost push shock does not have any significant impact on aggregate demand in the country.

Fig. 4. Macroeconomic Dynamics in Response to an Aggregate Supply Shock



(a) Response of Output Gap to Cost Push Shock (b) Response of Inflation to Cost Push Shock

4.3. Variance Decomposition

The relative importance of each structural shock can be examined by studying the variance of forecast error which is decomposed for each structural shock separately.

The top panel of Table 4 depicts the variance of forecast error in the output gap for each structural shock separately for long time horizon. It is evident that the fiscal shock is the major contributor to variations in the output gap which is around 83.6 percent for up to 40 quarters. The monetary policy shock, on the other hand, is the second contributor which remained around 12.84 percent of the forecast error variance. This confirms the significance of fiscal shock in influencing the output gap. The results are in line with the impulse response which shows that even though the SBP is successful in managing the demand pressures, the economy mainly remains demand driven.

The second panel of Table 4 displays the relative importance of the structural shocks in explaining inflation in the country. The results show that supply shock is the main contributor in explaining inflation. From the remaining two shocks, monetary shock has high power to explain variations in inflation which contribute up to 32.72 percent to variations. Thus the role of the SBP is vital in managing inflation in the country.

Finally, the monetary shock plays the most prominent role in explaining variations in interest rate. The fiscal shock turns out to be the second important determinant of variations in interest rate.

Table 4

Forecast Error Variance Decomposition

	Period	S.E.	Fiscal Shock	Supply Shock	Monetary Shock
Output Gap	1	0.01358	100	0	0
	2	0.01361	99.67213	0.077648	0.250222
	3	0.01462	95.10921	0.810396	4.080392
	4	0.01471	94.70157	0.969436	4.328993
	5	0.01673	95.30892	0.771204	3.919878
	9	0.01778	92.42992	0.819893	6.750182
	13	0.01851	88.63415	1.328436	10.03741
	17	0.01897	87.94153	1.8474	10.21107
	21	0.01944	87.03123	2.850895	10.11788
	25	0.01983	85.54143	3.375936	11.08263
	29	0.02006	84.27488	3.551183	12.17393
	33	0.02017	83.65552	3.547379	12.7971
	37	0.02022	83.59664	3.536292	12.86707
	40	0.02025	83.60757	3.549026	12.8434
Inflation	1	0.00541	0.014161	99.98584	0
	2	0.00933	0.020945	98.87868	1.100378
	3	0.012	0.161422	97.76989	2.068685
	4	0.0141	0.154935	94.98598	4.859086
	5	0.01529	0.241972	88.09243	11.6656
	9	0.01758	5.984871	69.96725	24.04788
	13	0.01955	5.277532	69.05278	25.66969
	17	0.02055	4.887102	63.54804	31.56486
	21	0.02092	5.222687	62.47403	32.30329
	25	0.0211	5.752717	61.51857	32.72871
	29	0.02116	6.25228	61.18585	32.56187
	33	0.02119	6.460753	61.03369	32.50555
	37	0.02121	6.4608	60.97638	32.56282
	40	0.02121	6.469064	60.96894	32.562
Interest Rate	1	0.10628	0.713581	0.500079	98.78634
	2	0.12042	3.020116	3.208405	93.77148
	3	0.13247	2.982892	4.90387	92.11324
	4	0.1371	3.405951	8.020343	88.57371
	5	0.14605	8.479319	11.06629	80.45439
	9	0.17634	27.09277	16.94016	55.96707
	13	0.20522	32.50431	20.0214	47.4743
	17	0.22588	30.14057	19.71455	50.14487
	21	0.23589	27.81507	18.77032	53.41461
	25	0.24047	27.93342	18.10356	53.96301
	29	0.24334	29.28425	17.82769	52.88807
	33	0.2457	30.072	17.67618	52.25182
	37	0.2472	30.02404	17.54731	52.42865
	40	0.24779	29.89015	17.46739	52.64246

5. CONCLUDING OBSERVATIONS

In a path breaking article Lucas (1976) highlighted the inability of macroeconomic models to forecast the consequences of unannounced policy changes. The NK macroeconomic models of recent years possess sundry features, the most consequential being the forward looking expectations modeling approach. The model presented in the present study has been adopted taking into account the NK perspective that incorporates the role of expectations and rigidities.

Rather than relying on 'borrowed' values of parameters, the maximum likelihood estimation procedure through structural VAR model has been used to estimate these values. The parameter estimates confirmed that an increase in real interest rate results in subsequent decrease in output gap which is supported by the theory. The results also demonstrated that forward looking expectations played important role in determining inflation. Output gap helped to lower the inflation rate. The structural parameter estimate of expected inflation rate has shown a negative impact on interest rate. The output gap has an explosive positive impact on interest rate. These results have allowed us to conclude that despite adopting a discretionary stance, the monetary policy has been ineffective, partly because the SBP did not enjoy 'real' autonomy. Since discretionary policy stance generally lacks transparency, it may be useful for the SBP to stick to some sort of rule as has been suggested earlier by Malik and Ahmed (2010). Furthermore, as expectations play prominent role in the prevailing market structure in the country, it is important for the SBP to show commitment towards controlling inflation along with the need for stabilising the demand pressures.

Investigation of the macroeconomic dynamics in response to unanticipated monetary shock has always been an area of interest for the economists that have normally been investigated by analysing impulse response functions. The results have shown that in response to monetary tightening by the authority, aggregate demand displayed a trend consistent with the idea of 6–8 months lag in achieving reduction in the output to its long run stability point. There is no evidence of price puzzle. On the other hand, in response to positive fiscal shock, the monetary authorities raised interest rate to counter the negative effects of fiscal shock to the economy. The results exposed the importance of expectations of economic agents in determining macroeconomic dynamics of the economy which are found to be forward looking. Finally, variance decomposition has emphasised the relevance of fiscal, monetary and cost push shocks as major sources of variation in forecast errors of output gap, inflation and interest rate.

Before closing the discussion, it may be useful to add that there are various methods to estimate DSGE models other than the SVAR model. These alternatives, however, require microeconomic survey based values of parameters which are seldom available. Hence, there has been a 'natural' limitation to rely only on SVAR model. Accordingly, future research in the area of modeling would require that microeconomic surveys are conducted to generate the values of microeconomic parameters. These surveys will also allow the possibility of inclusion of informal sectors of the economy in the modeling approach to have a holistic view of the economy.

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