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Understanding Business Cycle Fluctuations in Pakistan

GULZAR KHAN and ATHER MAQSOOD AHMED

Notwithstanding the level of improvement in understanding the complexities of an economy, it is now well accepted that the ultimate incidence of various policy interventions leads to varied outcomes in terms of magnitude and persistence depending upon the structure of the economy. The objective of the present study is to disentangle the relative contributions of various exogenous and domestic shocks that contribute to business cycle fluctuations in Pakistan. The study is based on the New-Keynesian Open economy model, which is an extended version of (Gali & Monacili 2005). Keating's two-step approach (1990, 2000) is employed to capture the dynamic behaviour of the variables of interest. Impulse response functions, along with forecast error variance decomposition analyses, are used to gain useful insights into the understanding of the transmission mechanism of policy and non-policy shocks. It is observed that fiscal policy does matter, at least in the short-run. The interest rate shock leads to the exchange rate appreciation thereby confirming the exchange rate puzzle. In response to adverse supply shocks, the Monetary Authority responds with a monetary contraction that prolongs the recessionary periods. Furthermore, it has a limited power to control inflation as inflation in Pakistan stems from supply-side factors as well as fiscal dominance.

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1. INTRODUCTION

Notwithstanding the level of improvement in understanding the complexities of an economy, it is now well accepted that the ultimate incidence of various policy interventions leads to varied outcomes in terms of magnitude and persistence depending upon the structure of the economy (Cargill et al. 2003; Mohanty & Turner, 2008). Therefore, besides the knowledge of theoretical underpinnings, it is also important to know the degree of openness, nominal rigidities, sectoral distribution, institutional framework, financial liberalisation, and financial deepening within each economy.

Ghulzar Khan <gulzar.khan@s3h.nust.edu.pk> is visiting faculty at the Department of Economics, the School of Social Sciences and Humanities, the National University of Sciences and Technology, Islamabad. This paper is based on his PhD Dissertation successfully defended at the Federal Urdu University, Islamabad. Ather Maqsood Ahmed <ather.ahmed@s3h.nust.edu.pk> is Professor of Economics at School of Social Sciences and Humanities, National University of Sciences and Technology, Islamabad.

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Moreover, due to the large undocumented economy and lack of high-frequency macroeconomic time series, basic features of developing economies are expected to offer a completely different picture as compared to the developed economies where such discrepancies are less pronounced. Probably this is the reason that most of the policies being followed in the developed world when replicated in developing economies not only miss their targets but sometimes yield contradictory outcomes. Therefore, we contend that a thorough understanding of the true structure of a developing economy is imperative for modelling and consistent policy analysis.

The objective of the present study is to detangle the relative contribution of various exogenous factors contributing to business cycle fluctuations in Pakistan by incorporating domestic as well as external shocks in the analysis. We believe that open economy considerations have generally been overlooked. Some central concerns include the 'fear of floating' debate that highlights the significance of monetary and exchange rate policy interaction to minimise the exchange rate variation and its implications for a foreign exchange constrained economy. Similarly, the volatility of international commodity markets, which poses a profound negative impact on the economic growth of trade-dependent developing economies, is an important issue (Combes & Guillaumont, 2002; Guillaumont, 2009; Arezki & Gylfason, 2011). Moreover, keeping in view the extensive literature on oil price-macroeconomy relationship, especially in oil-importing countries like Pakistan, the oil needs to be added to the production function as an additional factor input to analyse the role of international oil price fluctuations.[1] Furthermore, fiscal policies, conducted in a pro-cyclical manner, do act as shocks intensifying the impact of exogenous shocks, and therefore have limited scope for stabilisation. We, therefore, have to specify government spending shock in the aggregate demand equation of the model, keeping in view the behaviour of fiscal policy and its dominant role in Pakistan.

Besides open economy considerations, various domestic factors (shocks) are also important for comprehensive coverage of the economy. Within this perspective, we believe that domestically-originating cost-push factors act as adverse supply shocks, embodying the impact of factors other than those originating from the demand-side of the economy on marginal cost. Similarly, the Monetary Authority (MA) of the country is assumed to anchor inflationary expectations, stabilise the output gap, and exchange rate variation through manipulating short-term interest rate confronted by the commercial banks. Thus, the monetary policy shock has to be incorporated into the model through a forward-looking Taylor rule (1993). It is expected that control over short-term interest rate along with money supply empowers the MA to influence the volume of liquidity in the economy, and the expectations of rational economic agents, which affects the consumption of durable goods and investment decisions, and finally the aggregate demand.

Based on the foregoing, this paper studies the response of various exogenous shocks on macroeconomic aggregates using the New-Keynesian Open economy model for Pakistan. The study is based on a model which is an extended version of Gali and Monacili (2005). Keating's (1990, 2000) two-step approach has been employed to capture the dynamic behaviour of the variables of interest. Impulse response functions,

[1]See for example Hamilton (1983, 1996, 2004); Blanchard and Gali (2007); Edelstein and Kilian (2007, 2009); Khan and Ahmed (2014) and many others.

along with forecast error variance decomposition analyses, are used to gain useful insights into the understanding of the transmission mechanism of policy and non-policy shocks.

The rest of the paper includes a detailed derivation of the model and methodological discussion in Sections 2 and 3, respectively. Data and empirical findings are presented in Section 4 and the final section concludes the study.

2. THEORETICAL FRAMEWORK

In this section, we describe the salient features of a small open economy (SOE) dynamic stochastic general equilibrium (DSGE) model, which is derived to represent the structure and functioning of the economy of Pakistan. This forward-looking model has micro-foundations and is closely linked to the SOE literature of Gali and Monacelli (2005) (GM, 2005 henceforth,), Clarida et al. (CGG henceforth) (1999, 2002) and McCallum and Nelson (MN henceforth) (1999, 2000). The basic concept is taken from GM (2005).[2] The world economy is assumed to be a continuum of small economies. The domestic economy is one among those economies, relatively very small in size (is of measure zero) with respect to the size of the rest of the world's economies. Hence, the actions (decisions) of domestic economic agents like consumer price level, interest rate, and aggregate demand, do not influence variables in the rest of the world. These economies are interconnected and share similar preferences and technology. Economic agents are rational and forward-looking, making the best use of all available information. Domestic prices and wages are sticky, adjust infrequently, and are partially indexed to expected inflation. This is the most powerful assumption and enhances the realism of the model.

We have introduced certain modifications to the original model to keep it tractable, so that it represents the mechanics of Pakistan's economy, and serves the required task of policy analysis. First, oil is introduced into the production process as a basic input where oil prices are assumed to be exogenously determined. Secondly, in view of the existence of a large-scale public sector in Pakistan, the role of fiscal policy is assessed by adding government spending to the aggregate demand function. Like other developing economies, the labour market in Pakistan confronts various types of rigidities, including minimum wage laws that distort equilibrium wages, and the demand for labour. Hence, we have assumed it to be imperfect. Finally, due to imperfect domestic financial markets and limited access to international financial markets, along with huge domestic and external debt, the risk premium is introduced in the uncovered interest parity condition to hold in the short-run.

2.1. Households' Problem

The household problem is standard where a representative domestic household is infinitely lived. The household's consumption basket includes domestically produced goods and foreign goods imported from the rest of the world. Households also provide differentiated labour effort to firms and get equivalent wage compensation. Furthermore,

[2]The complete model has been originally derived in Khan (2016) and reproduced in Khan and Ahmed (2017). It is presented in this section of the paper in response to one of the comments made by the referee of the journal.

firms are owned by households who receive profits generated by these monopolistically competitive firms.

The preferences of the representative household seeking to maximise lifetime utility are defined through the following separable utility function,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} + \frac{(M_t/P_t)^{1-\vartheta}}{1-\vartheta} \right) \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.1)$$

so that the period utility function becomes $U(C_t, N_t, M_t/P_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} + \frac{(M_t/P_t)^{1-\vartheta}}{1-\vartheta}$ where $N_t, C_t,\ M_t/P_t$ denotes labour effort, aggregate consumption index, and demand for real cash balances. Furthermore, $0 < \beta < 1$ is the discount factor, σ represents the degree of relative risk aversion and $\frac{1}{\sigma}$ is the elasticity of inter-temporal substitution. ϑ is the inverse of the interest elasticity of real money holding and φ stands for the inverse of the elasticity of labour supply. The household budget constraint can be written as:

$$P_t C_t + E_t\{F_{t,t+1} D_{t+1}\} + M_t \le D_t + W_t N_t + M_{t-1} + T_t \quad \dots \quad \dots \quad (2.2)$$

Solving Equations 2.1-2.2 yields the following optimality conditions (linearised versions).

$$w_t - p_t = \sigma c_t + \varphi n_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.3)$$

$$c_t = E_t\{c_{t+1}\} - \frac{1}{\sigma}(r_t - E_t\{\pi_{t+1}\} - \rho) \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.4)$$

$$m_t - p_t = [\frac{\sigma}{\vartheta}]c_t - \frac{1}{\vartheta}[\frac{1}{(1+i)i}]i_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.5)$$

where the lower-case letters denote the log of upper-case letters. Equation (2.3) represents the household labour supply decision and Equation (2.4) describes consumption smoothing behaviour. In general, given the diminishing marginal utility of consumption, the forward-looking household tries to smooth her consumption pattern through lending and borrowing where the real interest rate is the additional determinant of the current consumption. Equation (2.5) is the money demand function that shows that money demand is positively associated with income (transaction demand for money) and decreases due to an increase in the interest rate (speculative demand for money). The nominal interest rate is $log i_t = log(1 + i_t) \approx i_t$ and $\rho = -log\beta$.

2.2. Allocation of Government Spending

Similar to many other studies, including Corsetti and Pesenti (2005) and Ganelli (2005), to simplify the analysis we assume that government spending is home-biased. To abstract from debt-related issues, Ricardian equivalence is assumed to hold and nominal government spending equals lump-sum taxes and seigniorage revenues, i.e.,

$$P_{H,t} G_t = T_t + \frac{M_t - M_{t-1}}{P_t}.$$

Here, government spending is exogenous and follows an AR(1) process, where $\rho_g \in [0,1]$ and ε_t^g is an i.i.d. shock.

$$G_t = \rho_g\, G_{t-1} + \varepsilon_t^g \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2.6)$$

2.3. Consumer Price Inflation (CPI) and Exchange Rate

The bilateral real exchange rate ($\mathcal{Q}_{i,t}$) is defined as: $\mathcal{Q}_{i,t} = \frac{\mathcal{V}_{i,t}P_t^i}{P_t}$, where $\mathcal{V}_{i,t}$ is the nominal exchange rate and P_t^i is the country i's CPI; P_t is the domestic and $P_{F,t}$ is the aggregate CPI of the rest of the world. The real effective exchange rate (REER henceforth) can be defined as: $\mathcal{Q}_t = \frac{P_{F,t}}{P_t}$ whose log-linearising yields: $q_t = p_{F,t} - p_t.$

Using the log-linearised form of domestic CPI around the symmetric steady state $p_t = (1-\alpha)p_{H,t} + \alpha p_{F,t}$ and REER, we redefine the relationship between CPI, domestic inflation and REER as $p_t = p_{H,t} + \frac{\alpha}{1-\alpha}q_t$, which by forwarding and algebra manipulation yields the following expression:

$$\pi_{t+1} = \pi_{H,t+1} + \frac{\alpha}{1-\alpha}\Delta q_{t+1} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2.7)$$

We assume that asset markets are complete and similar preferences across different economies prevail. It means that the household, whether living in a small open economy or elsewhere in the world faces the same optimisation problem. Thus, by combining the domestic and foreign versions of the Euler equations, we get the following relationship, which is known as the risk-sharing condition. It implies that domestic consumption is a function of international consumption instead of the domestic economy's own current, lagged, or lead income.

$$c_t = c_t^* + \frac{1}{\sigma}q_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2.8)$$

Similarly, investors having access to domestic and foreign bonds due to complete financial markets, invest both in domestic and foreign bonds to minimise the idiosyncratic risk. However, keeping in view the riskiness of domestic bonds, a risk premium is involved for the foreign investor to invest in domestic bonds. In this case, the Uncovered Interest Parity (UIP) condition holds in the following form:

$$E_t\{\Delta q_{t+1}\} = (i_t - E_t\{\pi_{t+1}\}) - (i_t^* - E_t\{\pi_{t+1}^*\}) - \varepsilon_t^{\vartheta*} \quad \ldots \quad \ldots \quad (2.9)$$

where $\varepsilon^{\vartheta*}$ is the risk premium paid to a foreign investor to compensate for holding a domestic risky bond. We further assume that the risk premium is positively related to the default risk that stems from over-borrowing. The risk-sharing condition implies that the domestic economy can be shielded against internal idiosyncratic shocks but at a relatively higher cost.

2.4. Supply Side

Firm Problem: The firm's problem consists of two steps and is solved in two stages. In the first stage, the firm decides over the least-cost combination of inputs subject to existing technology and its specific demand function. In the second stage, the firm seeks to maximise its profits depending upon the revenue generated from selling the product at an optimal price conditioned that prices are sticky.

Cost Minimisation Problem: Assuming that oil and labour are the only inputs needed to produce the specific goods, the firm tries to minimise its cost of production by choosing the least-cost combination of the two inputs (oil and number of workers), subject to given prices of these inputs, and the prevailing state of technology. The short-run production function can, therefore, be written as:

$$Y_t(j) = [A_t N_t(j)]^{\eta}[O_t^d(j)]^{1-\eta} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots (2.10)$$

Where $O_t^d(j)$ is the amount of oil demanded by firm j as an intermediate input to produce one unit of output, η is the share of labour in total output, and $(1-\eta)$ is the share of oil. For computational ease, we assume perfect competition in the labour market, (later on this assumption will be relaxed). Log of productivity $a_t = log(A_t)$ is assumed to be stochastic and follows an AR(1) process $a_t = \rho_a a_{t-1} + \varepsilon_t^a$, where $\{\varepsilon_t^a\}$ is an i.i.d. shock to productivity and $\rho_a \in [0,1]$.

Solving the first-order conditions yield:

$$(1-\eta)W_t N_t(j) = \eta O_t^d(j) P_{O,t} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots (2.11)$$

The nominal marginal cost of the firm is:

$$MC_t^n = \frac{W_t}{\eta A_t^{\eta} N_t(j)^{\eta-1} O_t^d(j)^{1-\eta}}$$

Using the cost minimisation condition, the MC_t^n can be written as:

$$MC_t^n = \frac{W_t{}^{\eta} P_{O,t}^{1-\eta}}{\eta^{\eta}(1-\eta)^{(1-\eta)} A_t^{\eta}}$$

The real marginal cost in terms of the domestic price can be expressed as:

$$MC_t^n = \frac{W_t{}^{\eta} P_{O,t}^{1-\eta}}{\eta^{\eta}(1-\eta)^{(1-\eta)} A_t^{\eta} P_{H,t}}$$

Log-linearising the real marginal cost expression yield,

$$mc_t^r = \eta w_t + (1-\eta) p_{O,t} - \eta a_t - p_{H,t} \quad \dots \quad \dots \quad \dots \quad \dots (2.12)$$

It implies that the marginal cost function is increasing in the price of oil and the nominal wage but decreasing in productivity growth. The demand for oil by firm *j* is given by:

$$o_t^d(j) = \left[\frac{\eta\sigma+1+\varphi}{1+\varphi(1-\eta)}\right] y_t - \left[\frac{\eta(1+\varphi)}{1+\varphi(1-\eta)}\right] a_t - \left[\frac{\eta}{1+\varphi(1-\eta)}\right] p_{O,t} \quad \dots \quad \dots (2.13)$$

The aggregate domestic output of overall firms is $Y_t = \left[\int_0^1 Y_t(j)^{(\theta-1)/\theta} dj\right]^{\frac{\theta}{\theta-1}}$. Lastly, the log-linearised version of the production function is

$$y_t = \eta a_t + \eta n_t + (1-\eta) o_t^d \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots (2.14)$$

Firm Profit Maximisation: In the second stage, given that prices are sticky, firms choose an optimal price that maximises their expected profits. Following Calvo (1983), firms are assumed to share identical technology, produce differentiated goods, and face monopolistic competition. Due to price stickiness, a fraction ϱ of firms is incapable of adjusting its price in period *t* and stick to the price that prevailed in period *t-1*. Thus ϱ is naturally an index of price stickiness and represents the probability that firm *j* will not be able to adjust its price in period *t*. Then the firm's profit-maximising pricing strategy yields the following Phillips curve:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda\widehat{mc}_t \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.15)$$

where $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$ and $\widehat{mc}_t$ is the log deviation of real mc_t from its flexible price equilibrium. Now following CGG (2002) we relax the assumption of perfect labour markets and introduce a cost-push shock to the Phillips curve so that household labour supply decision can be written as:

$$C_t^{\sigma} N_t^{\varphi} exp^{\varepsilon_t^w} = \frac{W_t}{P_t} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.16)$$

where $exp^{\varepsilon_t^w}$ is the wage markup, reflecting government intervention in terms of minimum wage laws in the labour market that would distort the real wage from its equilibrium level under perfect markets. This allows us to rewrite Equation (2.15) as follows:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda\widehat{mc}_t + \mathcal{E}_t^w \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.17)$$

2.5. Demand Side Equilibrium

The goods market equilibrium requires:

$$Y_t(j) = C_{H,t}(j) + \int_0^1 C_{H,t}^k(j)dk + G_t \qquad \ldots \quad \ldots \quad \ldots \quad \ldots (2.18)$$

where $Y_t(j)$ is the total production of good *j* by all domestic firms, $C_{H,t}(j)$ is the total consumption demand by the domestic household for domestically produced goods *j* and $\int_0^1 C_{H,t}^k(j)dk$ is country *k's* demand for good *j* (exports).

$$Y_t(j) = (1-\alpha)\left(\frac{P_{H,t(j)}}{P_{H,t}}\right)^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\gamma} C_t + \alpha\left(\frac{P_{H,t(j)}}{P_{H,t}}\right)^{-\theta}$$
$$\int_0^1\left(\frac{P_{H,t}}{\mathcal{V}_{k,t}P^k{}_{F,t}}\right)^{-\theta}\left(\frac{P_{F,t}}{P^k{}_t}\right)^{-\gamma} C_t^k + \left(\frac{P_{H,t(j)}}{P_{H,t}}\right)^{-\theta}\left(\frac{P_{H,t}}{P_t}\right)^{-\gamma} G_t$$

But

$$Y_t(j) = \left(\frac{P_{H,t(j)}}{P_{H,t}}\right)^{-\theta} Y_t \qquad \text{or} \qquad Y_t = Y_t(j)\left(\frac{P_{H,t(j)}}{P_{H,t}}\right)^{\theta}$$

Using the optimal allocation of resources for SOE, ROW, the REER definition, and the behavioural similarity assumption we get,

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\gamma}\left[\left((1-\alpha) + \alpha\int_0^1\left(S_t^k S_{k,t}\right)^{\gamma-\theta} \quad \mathcal{Q}_{k,t}^{\gamma-\frac{1}{\sigma}}dk\right)C_t + \mathrm{G}_t\right]$$

where $\int_0^1\left(S_t^k S_{k,t}\right)^{\gamma-\theta}dk = 1$ in the symmetric a steady-state hence,

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\gamma}\left[\left((1-\alpha) + \alpha\int_0^1 \mathcal{Q}_{k,t}^{\gamma-\frac{1}{\sigma}}dk\right)C_t + G_t\right]$$

Log-linearising around the symmetric steady-state and using $p_t - p_{H,t} = \frac{\alpha}{1-\alpha} q_t$ yields,

$$y_t = c_t + \alpha\left(\frac{(2-\alpha)\gamma}{1-\alpha} - \frac{1}{\sigma}\right) q_t + g_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.19)$$

Assuming $c_t^* = y_t^*$ substituting in risk-sharing condition $c_t = y_t^* + \frac{1}{\sigma} q_t$ and finally substituting in Equation (2.19) we get,

$$y_t = y_t^* + \left[\frac{\alpha\sigma\gamma(2-\alpha)+(1-\alpha)^2}{\sigma(1-\alpha)}\right] q_t + g_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.20)$$

Now substituting the Euler Equation (2.4) in Equation (2.19)

$$y_t = E_t\{c_{t+1}\} - \frac{1}{\sigma}\left(i_t - E_t\{\pi_{H,t+1}\}\right) - \left[\frac{\alpha(2-\alpha)(\gamma\sigma-1)}{\sigma(1-\alpha)}\right] q_t + g_t \quad \ldots \quad \ldots (2.21)$$

Forwarding Equation (2.19) one period ahead and solving for $E_t\{c_{t+1}\}$ yields

$$E_t\{c_{t+1}\} = E_t\{y_{t+1}\} - \alpha\left(\frac{(2-\alpha)\gamma}{1-\alpha} - \frac{1}{\sigma}\right) E_t\{q_{t+1}\} - E_t g_{t+1} \quad \ldots \quad \ldots (2.19)$$

By substituting (2.19) in Equation (21) and rearranging the terms we get:

$$y_t = E_t\{y_{t+1}\} - \frac{1}{\sigma}\left(i_t - E_t\{\pi_{H,t+1}\}\right) - \left[\frac{\alpha(2-\alpha)(\gamma\sigma-1)}{\sigma(1-\alpha)}\right] E_t\{\Delta q_{t+1}\} - E_t\{\Delta g_{t+1}\} \quad \ldots (2.22)$$

But from Equation (2.7)

$$E_t\pi_{t+1} = E_t\pi_{H,t+1} + \frac{\alpha}{1-\alpha} E_t\{\Delta q_{t+1}\}$$

Solving Equation (2.7) for $E_t\{\pi_{H,t+1}\}$ and substituting in Equation (2.22) we get

$$y_t = E_t\{y_{t+1}\} - \frac{1}{\sigma}(i_t - E_t\{\pi_{t+1}\}) - \alpha\left[\frac{1+(2-\alpha)(\gamma\sigma-1)}{\sigma(1-\alpha)}\right] E_t\{\Delta q_{t+1}\} - E_t\{\Delta g_{t+1}\} \quad \ldots (2.23)$$

2.6. Supply-Side Equilibrium

The New Keynesian Philips curve (NKPC hereafter) with real marginal cost cannot be estimated directly due to the non-availability of data on marginal cost in national income accounts. Two methods are generally employed in the literature to estimate NKPC by replacing marginal cost by an appropriate proxy variable. These are the Output-Gap method and Unit Real Labour Cost method. Following (GM, 2005) and (CGG, 2002), we proceed by establishing the relationship between marginal cost and economic activity through labour and goods market clearing conditions. The marginal cost function derived from the labour market [Equation (2.12)] can be transformed in real terms as below:

$$mc_t = -\eta a_t + \eta(w_t - p_t) + (1-\eta)\left(p_{O,t} - p_t\right) - \left(p_{H,t} - p_t\right) \quad \ldots \quad \ldots (2.24)$$

Substituting the intertemporal optimality condition (2.3) and the definition of CPI we get

$$mc_t = -\eta a_t + \eta(\sigma c_t + \varphi n_t) + (1-\eta)\tilde{p}_{O,t} + \frac{\alpha}{1-\alpha} q_t$$

where $\tilde{p}_{O,t} = p_{O,t} - p_t$ is the inflation-adjusted price of oil. Using the log-linearised version of cost minimisation (2.11), aggregate production function (2.14), and risk-sharing conditions (2.8), we get:

$$mc_t = -\psi_1 a_t + \psi_2 y_t^* + \psi_3 y_t + \psi_4 \tilde{p}_{O,t} + \psi_5 q_t \quad \ldots \quad \ldots \quad \ldots (2.25)$$

The above equation shows a negative relationship between marginal cost and productivity and a positive relationship between domestic and foreign output and the real price of oil. The parameters of (2.25) are: $\psi_1 = \frac{\eta(1+\varphi)}{1+\varphi(1-\eta)}$, $\psi_2 = \frac{\eta\sigma}{1+\varphi(1-\eta)}$, $\psi_3 = \frac{\eta\varphi}{1+\varphi(1-\eta)}$, $\psi_4 = \frac{(1+\varphi)(1-\eta)}{1+\varphi(1-\eta)}$, $and\ \psi_5 = \frac{\eta}{1+\varphi(1-\eta)} + \frac{\alpha}{1-\alpha}$

Solving (2.20) for y_t^* and substituting in (2.25) we get:

$$mc_t = -\psi_1 a_t + (\psi_2 + \psi_3) y_t - \psi_2 g_t + (\psi_5 - \psi_2 \varpi) q_t + \psi_4 \tilde{p}_{o,t} \quad \ldots (2.26)$$

where $\psi_6 = (\psi_2 + \psi_3)$. If there is no price rigidity and all firms are able to adjust their price optimally in each period under flexible price setting, then there will be no mark-up differential and all the firms will charge an equal mark-up $\overline{mc}_t = -\mu$. Here $\overline{mc}_t$ is the flexible price equilibrium constant marginal cost and $\mu = log\left(\frac{\theta}{1-\theta}\right)$. If $\overline{y_t}$ shows the flexible level of output, then solving (2.26) for flexible price-output yield:

$$\overline{y_t} = \frac{-\mu + \psi_1 a_t + \psi_2 g_t - (\frac{1}{1-\alpha} - \psi_2 \varpi) q_t - \psi_4 \tilde{p}_{o,t}}{\psi_6} \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.27)$$

where $x_t = y_t - \overline{y_t}$ is the output gap, according to the output-gap method, marginal cost is considered as cyclical in nature and varies directly with the gap between actual output and potential output. When the actual output is greater than potential output, the competition for available factors of production will push their prices up, and consequently the real marginal cost increases. Furthermore, marginal cost is also influenced by the exchange rate and a rise in oil price in the short run in a country like Pakistan. Thus

$$\widehat{mc}_t = \psi_8 x_t + \psi_9 q_t + \psi_{10} \tilde{p}_{o,t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.28)$$

The New-Keynesian Phillips Curve: Using expressions (2.28) and (2.17), the NKPC can be expressed as below:

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda\psi_8 x_t + \lambda\psi_9 q_t + \lambda\psi_{10} \tilde{p}_{o,t} + \mathcal{E}_t^w \quad \ldots \quad \ldots \quad \ldots (2.29)$$

The New-Keynesian IS Curve: Now using expression (2.23) along with the definition of the output gap, the AR (1) productivity process, and AR (1) oil price process, the New Keynesian IS curve can be written as:

$$x_t = E_t\{x_{t+1}\} - \frac{1}{\sigma}(i_t - E_t\{\pi_{t+1}\}) - \left[\frac{\frac{1}{1-\alpha} - \psi_2 \varpi}{\psi_6} + \alpha\left(\frac{1+(2-\alpha)(\gamma\sigma-1)}{\sigma(1-\alpha)}\right)\right]$$
$$E_t\{\Delta q_{t+1}\} - \frac{\psi_4}{\psi_6} E_t\{\tilde{\pi}_{o,t+1}\} + \frac{\psi_1}{\psi_6}(\rho_a - 1) a_t + (\frac{\psi_2}{\psi_6} - 2) E_t\{\Delta g_{t+1}\} \quad \ldots (2.30)$$

As we have assumed productivity and government expenditures to be exogenous shocks therefore the above equation can be rewritten as follows.

$$x_t = E_t\{x_{t+1}\} - \frac{1}{\sigma}(i_t - E_t\{\pi_{t+1}\}) - \left[\frac{\frac{1}{1-\alpha} - \psi_2 \varpi}{\psi_6} + \alpha\left(\frac{1+(2-\alpha)(\gamma\sigma-1)}{\sigma(1-\alpha)}\right)\right]$$

$$E_t\{\Delta q_{t+1}\} - \frac{\psi_4}{\psi_6} E_t\{\tilde{\pi}_{o,t+1}\} + \mathcal{E}_t^{af} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots (2.31)$$

2.7. Oil Price Setting

We assume that the SOE is a net oil importer and price taker in the international oil market. Further considering the existing legal framework regarding the oil pricing mechanism, we assume full exchange rate pass-through. During the period under consideration, oil prices were revised in Pakistan monthly initially by the Oil Company Advisory Committee (OCAC) and later by the Oil and Gas Regulatory Authority (OGRA). Thus, the price of imported oil in domestic currency can be expressed as:

$$\tilde{p}_{O,t} = \tilde{p}^*_{O,t} + q_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.32)$$

where, q_t is the log real effective exchange rate. Since, as the domestic economy has no power in setting international oil price, hence the oil price variable is taken as exogenous that follows an AR (1) process as:

$$\tilde{p}_{O,t} = \rho_o \tilde{p}_{O,t-1} + \varepsilon_t^{po} \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.33)$$

where ε_t^o is a shock to oil price and $\rho_o \in [0,1)$.

2.8. Monetary Policy Reaction Function

The MA is assumed to respond by adjusting the rate of interest in a countercyclical manner. More precisely, it is assumed that the MA follows an augmented Taylor-type rule to anchor inflation expectations, check the output gap, and resist exchange rate volatility. Thus the rule is:

$$i_t = \phi_\pi E_t\{\pi_{t+1}\} + \phi_x x_t + \phi_q E_t\{\Delta q_{t+1}\} + \varepsilon_t^r \qquad \ldots \quad \ldots \quad \ldots (2.34)$$

3. METHODOLOGY AND IDENTIFICATION

The basic intuition behind the methodology adopted in this paper is to overcome the Lucas critique as rational economic agents are supposed to continuously update their information and revise expectations as they receive new information. Therefore, instead of relying on observed aggregate relations, the dynamic macro-econometric models are derived from microeconomic foundations where decision making by consumers and firms is conditional upon intertemporal optimisation problems. In this case, the need to estimate policy invariant deep structural parameters cannot be overemphasised. The DSGE models that fully incorporate micro-foundations along with nominal rigidities are probably the best options available to researchers for policy analysis given the state of knowledge at this moment. In the present study, the empirical estimation of deep structural parameters has been carried out based on Keating's strategy (1990, 2000) using the method of maximum likelihood. Prior to this, a similar approach has been followed by Leu (2011) for estimating the role of monetary policy for the Australian economy and Nawaz and Ahmed (2015) for Pakistan, among others. This estimation is followed by an analysis of the dynamic properties including the propagation mechanism and identification of the underlying sources of variation through impulse response functions and forecast error variance decomposition analysis. We start with the identification of the structural shocks under rational expectations.

(a) SVAR Identification Restrictions Under Rational Expectations

Identification of the SVAR model under rational expectations takes several steps as has been discussed earlier by Nawaz and Ahmed (2015). First, the extended version of the open economy model described in the theoretical framework can be expressed as follows.

$$x_t = E_t\{x_{t+1}\} - \alpha_1(i_t - E_t\{\pi_{t+1}\}) - \alpha_2 E_t\{\Delta q_{t+1}\} - \alpha_3 E_t\{\tilde{\pi}_{o,t+1}\} + \mathcal{E}_t^{af} \quad (3.35)$$

$$\pi_t = \beta_1 E_t\{\pi_{t+1}\} + \beta_2 x_t + \beta_3 \tilde{p}_{O,t} + \varepsilon_t^{w} \quad \dots \quad \dots \quad \dots \quad \dots (3.36)$$

$$\tilde{p}_{O,t} = \rho_o \tilde{p}_{O,t-1} + \varepsilon_t^{po} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots (3.37)$$

$$q_t = E_t\{q_{t+1}\} - \gamma_1(i_t - i_t^*) + \varepsilon_t^{q} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots (3.38)$$

$$i_t = \phi_\pi E_t\{\pi_{t+1}\} + \phi_x x_t + \phi_q E_t\{\Delta q_{t+1}\} + \varepsilon_t^{r} \dots \quad \dots \quad \dots \quad \dots (3.39)$$

The identification requires conversion of the system of equations (Equations 3.35 to 3.39) into an equivalent innovation representation. The transformed equations consisting of reduced-form VAR innovation and structural disturbances are achieved by subtracting from each variable observed value the expected value at time $t-1$ of that variable based on all publicly available information.

$$\begin{aligned}\mathcal{E}_t^{af} = {} & (x_t - E_{t-1}x_t) - (E_t\{x_{t+1}\} - E_{t-1}\{x_{t+1}\}) + \\ & \alpha_1(i_t - E_{t-1}i_t) - \alpha_1(E_t\{\pi_{t+1}\} - E_{t-1}\{\pi_{t+1}\}) + \alpha_2(E_t\{\Delta q_{t+1}\} \\ & -E_{t-1}\{\Delta q_{t+1}\}) + \alpha_3(E_t\{\tilde{\pi}_{o,t+1}\} - E_{t-1}\{\tilde{\pi}_{o,t+1}\}) \quad \dots \quad (3.35.a)\end{aligned}$$

$$\begin{aligned}\varepsilon_t^{w} = {} & (\pi_t - E_{t-1}\pi_t) - \beta_1(E_t\{\pi_{t+1}\} - E_{t-1}\{\pi_{t+1}\}) \\ & -\beta_2(x_t - E_{t-1}x_t) - \beta_3(\tilde{p}_{O,t} - E_{t-1}\tilde{p}_{O,t}) \dots \quad \dots \quad \dots \quad (3.36.a)\end{aligned}$$

$$\varepsilon_t^{po} = (\tilde{p}_{O,t} - E_{t-1}\tilde{p}_{O,t}) \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad 3.37a)$$

$$\varepsilon_t^{q} = (q_t - E_{t-1}q_t) - (E_t\{\Delta q_{t+1}\} - E_{t-1}\{\Delta q_{t+1}\}) + \gamma_1(i_t - E_{t-1}i_t) \dots \quad 3.38a)$$

$$\begin{aligned}\varepsilon_t^{r} = {} & (i_t - E_{t-1}i_t) - \phi_\pi(E_t\{\pi_{t+1}\} - E_{t-1}\{\pi_{t+1}\}) - \phi_x(x_t - E_{t-1}x_t) \\ & -\phi_q(E_t\{\Delta q_{t+1}\} - E_{t-1}\{\Delta q_{t+1}\} \dots \quad \dots \quad \dots \quad \dots \quad (3.39a)\end{aligned}$$

where $(x_t - E_{t-1}x_t)$, $(\pi_t - E_{t-1}\pi_t)$, $(\tilde{p}_{O,t} - E_{t-1}\tilde{p}_{O,t})$, $(q_t - E_{t-1}q_t)$, $(i_t - E_{t-1}i_t)$ are the VAR innovations (reduced-form residuals) of the output gap, inflation rate, oil price, exchange rate, and nominal interest rate equations. In addition to VAR innovations, the structural disturbances are related to forward-looking components describes as expectation revision process by the rational economic agents. The forward-looking economic agents continuously update their information set regarding future values of the relevant variables such as output gap $(E_t\{x_{t+1}\} - E_{t-1}\{x_{t+1}\}$, inflation rate $(E_t\{\pi_{t+1}\} - E_{t-1}\{\pi_{t+1}\})$, the exchange rate $(E_t\{\Delta q_{t+1}\} - E_{t-1}\{\Delta q_{t+1}\})$ and oil price $\left(E_t\{\tilde{\pi}_{o,t+1}\} - E_{t-1}\{\tilde{\pi}_{o,t+1}\}\right)$.[3]

[3]Innovations to foreign variables become factors inside the system of reduced form residuals to the five domestic variables.

Now to calculate these values effectively we rewrite the reduced-form VAR in stacked form as:

$$Y_t = AY_{t-1} + Qe_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (3.40)$$

Or equivalently

$$\begin{bmatrix} y_t \\ y_{t-1} \\ y_{t-2} \\ \vdots \\ y_{t-s+1} \end{bmatrix} = \begin{bmatrix} A_1 & A_2 & \cdots & \cdots & A_s \\ I_n & 0_n & \cdots & \cdots & 0_n \\ 0_n & I_n & 0_n & \cdots & 0_n \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ 0_n & \ldots & 0_n & I_n & 0_n \end{bmatrix} \begin{bmatrix} y_{t-1} \\ y_{t-2} \\ y_{t-3} \\ \vdots \\ y_{t-s} \end{bmatrix} + \begin{bmatrix} I_n \\ 0_n \\ 0_n \\ \vdots \\ 0_n \end{bmatrix} e_t \quad \ldots \quad \ldots \quad \ldots (3.41)$$

where n denotes the number of endogenous variables and s stands for lag-order of these variables. Since under rational expectations $E_t(e_t) = 0$, hence j periods ahead expectations of (Equation 3.40) can be written as

$$E_t Y_{t+j} = (A)^j Y_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (3.42)$$

To locate the variables to be forecasted, four vectors of length $n \times s$ are created:

$$\acute{r}_x = (1,0,0,0 \ldots,0) \text{ for the output gap} \quad \ldots. \quad \ldots \quad \ldots \quad (3.43a)$$

$$\acute{r}_\pi = (0,1,0,0 \ldots,0) \text{ for inflation rate} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.43b)$$

$$\acute{r}_{po} = (0,0,1,0, \ldots,0) \text{ for price of oil} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.43c)$$

$$\acute{r}_q = (0,0,0,0,1 \ldots,0) \text{ for the real effective exchange rate} \quad \ldots \quad (3.43d)$$

The expected values of the relevant endogenous variables can be calculated by pre-multiplying (3.42) by the vectors defined by (3.43) as:

$$E_t X_{t+1} = \acute{r}_x A \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.44a)$$

$$Y_t \; E_t \pi_{t+1} = \acute{r}_\pi A Y_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.44b)$$

$$E_t po_{t+1} = \acute{r}_{po} A Y_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.44c)$$

$$E_t q_{t+1} = \acute{r}_q A Y_t. \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3.44d)$$

The expectation revision process can now be defined as:

$$E_t X_{t+1} - E_{t-1} X_{t+1} = \acute{x} A(Y_t - E_{t-1} Y_t) = \acute{r}_x AQe_t \quad \ldots \quad \ldots \quad (3.45a)$$

$$E_t \pi_{t+1} - E_{t-1} \pi_{t+1} = \acute{r}_\pi A(Y_t - E_{t-1} Y_t) = \acute{r}_\pi AQe_t \quad \ldots \quad \ldots \quad (3.45b)$$

$$E_t Po_{t+1} - E_{t-1} Po_{t+1} = \acute{r}_{Po} A(Y_t - E_{t-1} Y_t) = \acute{r}_{Po} AQe_t \quad \ldots \quad (3.45c)$$

$$E_t q_{t+1} - E_{t-1} q_{t+1} = \acute{r}_q A(Y_t - E_{t-1} Y_t) = \acute{r}_q AQe_t \quad \ldots \quad (3.45d)$$

Finally, applying the definition of Equation (3.45a-d) in the open economy model, the system of equations described through (3.35-3.39) can be written in innovation as:

$$\begin{aligned} \varepsilon_t^x &= e_t^x - r_x' AQe_t + \alpha_1 e_t^i - \alpha_1 r_\pi' AQe_t - \alpha_2 e_t^{p_o} + \alpha_3 r_q' AQe_t \\ &\quad - \alpha_3 e_t^q + \alpha_2 r_{p^*o}' AQe_t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (3.46) \end{aligned}$$

$$\varepsilon_t^{\pi} = e_t^{\pi_t} - \beta_1 r_\pi' AQe_t - \beta_2 e_t^{x} - \beta_3 e_t^{p^*o} \quad \dots \quad \dots \quad \dots \quad \dots (3.47)$$

$$\varepsilon_t^{o} = \tilde{p}_{o,t} \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots (3.48)$$

$$\varepsilon_t^{q} = e_t^{q} + \gamma_1 e_t^{i} - r_q' AQe_t - \gamma_1 r_\pi' AQe_t \quad \dots \quad \dots \quad \dots \quad \dots (3.49)$$

$$\varepsilon_t^{i} = e_t^{r} - \phi_\pi r_\pi' AQe_t - \phi_x e_t^{x} - \phi_q r_q' AQe_t \quad \dots \quad \dots \quad \dots \quad \dots (3.50)$$

To estimate the system of equations we proceed by rewriting the structural model in matrix form as:

$$\Gamma_0 y_t = \Gamma_1 y_{t-1} + \cdots \Gamma_q y_{t-q} + \Lambda_0 z_t + \Lambda_1 z_{t-1} + \cdots + \Lambda_k z_{t-k} + \varepsilon_t, \quad \varepsilon_t \sim (0, D) \quad \dots (3.51)$$

Where $y_t = (x_t, \pi_t, q_t, o_t, i_t)'$ represents the vector of endogenous variables. The vector of exogenous variables includes $z_t = (y_t^*, \pi_t^*, i_t^*)'$ where Γ and Λ are the parameters matrices for endogenous and exogenous variables. Similarly, $\varepsilon_t = (\varepsilon_t^x, \varepsilon_t^\pi, \varepsilon_t^o, \varepsilon_t^q, \varepsilon_t^i)$ is the vector of structural shocks and D is a variance-covariance matrix. Multiplying (3.51) by Γ_0^{-1} yields the reduced-form VAR as follows:

$$y_t = \mathrm{A}_1 y_{t-1} + \cdots \mathrm{A}_q y_{t-q} + \mathrm{B}_0 z_t + \mathrm{B}_1 z_{t-1} + \cdots + \mathrm{B}_k z_{t-k} + e_t \quad \dots \quad \dots (3.52)$$

The final estimation is carried out in two steps, First, the reduced form VAR is estimated, and the parameter estimates are obtained. In the second step, the rational expectations restrictions contained in (3.46 – 3.50) are imposed on Γ_0 and exclusion restrictions are placed on the exogenous variables in Λ_0. The structural system dictated by (3.51) is then estimated through FIML observing the standard assumptions of normality in structural shocks (disturbances).

4. DATA, VARIABLES, AND EMPIRICAL FINDINGS

The estimation of the core model makes use of Pakistani data that ranges between 1993Q4 and 2016Q2 with a total of 91 observations. The dataset includes five domestic (endogenous) variables, three foreign (exogenous) variables, and three dummy variables. The endogenous variables include gross domestic product (GDP), consumer price index (CPI), international oil price, real effective exchange rate, and money market rate. The foreign (exogenous) variables include US GDP, US consumer price index, and the federal funds rate. The dummy variables are used to filter seasonal variations. The data on all these variables are retrieved from International Financial Statistics (IFS) explorer. Since quarterly GDP data for Pakistan are not available in published form, we have used Kemal and Arby (2005) and Hanif et al. (2013) to construct the required time series. Using quarterly GDP data, the output gap series has been constructed through HP-filter. For robustness, we have also followed an alternative approach suggested by Malik (2007) where potential GDP is estimated by regressing real GDP in log form on its time trend and then subtracted from actual observations. The inflation rate has been calculated as the percentage change in CPI on a year-on-year basis. The real price of oil has been constructed by converting the international oil price into domestic currency price by multiplying the oil price (in US dollars per barrel) with the average nominal exchange rate (Pak. Rupee/US dollar) and then dividing by the general price level. The data regarding the real effective exchange rate and money market rate are directly taken from the IFS, where the money market rate represents the short-term nominal interest rate. The selection of the sample period is based on the financial sector regulatory reforms initiated in Pakistan in 1993.

The estimation involves estimating the reduced form VAR parameter estimates and the VAR innovations.[4] These are then combined with rational expectation restrictions dictated by the system of equations presented above to estimate the structural system. The statistical fitness of the estimated reduced-form VAR parameter estimates is important for accurate policy inferences (Spanos, 1990), therefore, several tests including pre-estimation tests and post-estimation diagnostic tests have been conducted. As a pre-requisite, the stationarity of the variables has been checked through HEGY test, proposed by Hylleberg, Engle, Granger, and Yoo (1990). This test has been found to have an advantage over the traditional Augmented Dicky-Fuller (ADF) unit root test to test the data before deseasonalisation (Charemza & Deadman, 1997). Canova (2007) and Sims et al. (1990) have argued that the VAR model can be estimated for a consistent parameter even if the variables are found to be non-stationary. Next, the ARDL bound testing approach developed by Pesaran et al. (2001) has been employed to examine the long-run relationship. This test is based on the Wald coefficient test and investigates the joint significance of the parameters of lagged variables. This method has been selected among many others for its flexibility in choosing the lag-length for endogenous variables and its superior performance in the case of small samples.

The results of HEGY test are reported in Table 1. The results show that the existence of unit root at zero-frequency for all endogenous variables cannot be rejected. However, for seasonal frequencies (biannual and annual), there is no indication of the existence of a unit-root in any variable. These results confirm that all variables are integrated of order one [I(1)] that supports the suitability of data series for further estimation.

Table 1

HEGY Seasonal Unit Root Test

Variable	H_0: $\pi_1 = 0$ (Non-seasonal Zero Frequency)	H_1: $\pi_2 = 0$ (Seasonal Biannual)	H: $\pi_3 = \pi_4 = 0$ (Seasonal Annual)
Output Gap	–1.77	–2.67	24.84
	(0.42)	(0.03)	(0.00)
Inflation Rate	–1.69	–5.91	27.35
	(0.78)	(0.00)	(0.00)
Exchange Rate	–0.65	–4.97	33.02
	(0.93)	(0.01)	(0.00)
Oil Price	–1.88	–9.20	32.59
	(0.36)	(0.00)	(0.00)
Interest Rate	–1.84	–7.15	78.30
	(0.20)	(0.00)	(0.00)

Note: Values in parenthesis are simulated p-values.
With intercept, time trend, and seasonal dummies.

[4]There are various methods available to estimate DSGE models and every method has its own limitations and benefits. The Bayesian estimation technique is considered to be the most appropriate one, as indicated by one of the reviewers, but this technique demands an extensive set of information regarding the values of structural parameters and their accurate distributions. Such information is mostly based on micro-based surveys that are hardly available in developing economies, like Pakistan. Even though many authors tend to borrow these values of parameters from research completed in the developed economies, in our opinion it seems inappropriate considering the fundamental structural differences in the developed and the developing economies.

The estimation proceeds with cointegration analysis to confirm the existence of a long-run relationship. The empirical results produced by the ARDL bound testing approach to cointegration are reported in Table 2. The results confirm that there is a statistically significant long-run relationship between endogenous variables and that the endogenous variables are cointegrated.

Table 2
ARDL Bounds Test

Dependent Variable	Independent Variables	F-statistics	Optimal Lag Length	Result
Output Gap	π, opd, q, i	4.09	(4, 1, 1, 0, 0)	Cointegration
Inflation Rate	x, opd, q, i	6.15	(2, 2, 4, 0, 1)	Cointegration
Exchange Rate	x, π, opd, i	4.24	(2, 2, 3, 0, 0)	Cointegration
Interest Rate	x, π, opd, q	4.40	(2, 1, 0, 0, 0)	Cointegration

Where $\pi, opd, q, i, and\ x$ are symbols for the inflation rate, oil price, exchange rate, interest rate, and the output gap.

Critical Value Bounds

Significance Level	I0 Bound	I1 Bound
10%	2.45	3.52
5%	3.25	4.01
1%	3.74	5.06

Note: (Null Hypothesis: No long-run relationships exist).

After confirming the long-run relationship, the VAR model has been estimated. To estimate the reduced form VAR, selection of the optimal lag-length is crucial and various methods have been considered. Whereas LR, AIC, and FPE confirmed an optimal lag-length of 5, the SCI and HQ criteria suggest an optimal lag-length of 4. Due to the fact that at the lag-length of 5 the VAR residuals are free from autocorrelation and ARCH effect, we have opted for a lag length of 5.

4.1. Diagnostics of the Reduced-form VAR Residuals

Several tests have been conducted to examine the autocorrelation, heteroskedasticity, normality, the functional form, and the goodness of fit of reduced-form VAR estimates. The residual diagnostic tests reported in Table 3 are the LM test, the ARCH effect test, Jarque-Bera test, Ramsey RESET test, and R-squared. Besides the high goodness of fit, the results do not reject the null hypothesis of no serial correlation and heteroskedasticity in all cases. Similarly, not only the residuals are normally distributed but it has also been found that none of the equations in the system is misspecified.

4.2. Structural Parameter Estimates

Using the information contained in the reduced-form VAR and the rational expectations restrictions, the SVAR model has been estimated for the economy of Pakistan. Besides offering an explanation about the dynamics of the economy through the Impulse Response Functions (IRF) and Forecast Error Variance Decomposition (FEVD), the present study also assesses the structural parameter estimates to determine the robustness and transparency of the estimates. These results are presented in Table 4.

Table 3

Post-estimation Reduced-form Diagnostic Tests

Test	Equation x	π	opd	q	i
R-square	0.95	0.91	0.96	0.99	0.88
Serial	2.15	0.22	0.79	0.83	0.18
Correlation	(0.12)	(0.79)	(0.46)	(0.33)	(0.83)
ARCH	0.00	0.20	0.37	1.45	1.19
	(0.97)	(0.65)	(0.53)	(0.23)	(0.27)
Normality	2.07	1.14	1.18	1.53	2.16
	(0.39)	(0.56)	(0.12)	(0.46)	(0.09)
Functional Form	0.76	0.05	1.82	1.05	3.56
	(0.32)	(0.95)	(0.08)	(0.31)	(0.07)

Note: p-values are reported in parenthesis.

Table 4

Maximum Likelihood Parameter Estimates

Equation	Parameter	Coefficient	Std. Error	z-Statistic	Prob.
IS Equation	α_1	0.687255	0.183036	3.754747	0.0002
	α_2	–0.038641	0.861719	–0.044841	0.9642
	α_3	0.910442	13.67411	0.066581	0.9469
Phillips Curve	β_1	0.824651	0.035412	23.28710	0.0000
	β_2	–0.266274	0.023022	–11.56624	0.0000
	β_3	0.098225	0.001185	82.90473	0.0000
UIP Condition	γ_1	–0.017783	1.453538	–0.012235	0.9902
Interest Rate Rule	ϕ_π	–0.913302	0.694461	–1.315123	0.1885
	ϕ_x	1.953390	0.159816	12.22271	0.0000
	ϕ_q	–0.170185	0.388343	–0.438233	0.6612

The SVAR estimated parameters recovered through the method of maximum likelihood (ML) facilitate the following interpretation. In the case of the IS equation, although all estimates of the parameters have correct signs, most of them are statistically insignificant. Whereas oil price is negatively associated with output gap and exchange rate appreciation widens the output gap through expenditure switching effect, the outcome suggests that these variables do not play any significant role in influencing the output gap in the short-run. The interest rate is the only important variable that appears to stimulate economic activity in Pakistan. The insignificant role of oil price appears to be a serious concern, but a possible explanation could be that Pakistan switched towards domestic and inexpensive natural gas during the period under consideration which might have cushioned the adverse impact of international oil price shocks. It may be relevant to add that (Blanchard & Gali, 2007; Kilian & Lewis, 2011; Kilian, 2009; Herrera & Pessavento, 2009) have also found similar results for the US economy and Du et al. (2010) did so for the Chinese economy.

For the Phillips curve, representing the supply side of the economy, the parameter associated with forward-looking inflation is highly significant which implies that many firms are forward-looking and future-oriented. This outcome is in-line with Nawaz & Ahmed (2015), who estimated a closed economy model for Pakistan and Gali & Gertler (2007), whose focus was the US economy. The oil price pass-through into the domestic price is captured by β_3, which shows that an increase in the international price of oil significantly inflates the domestic price level. The price-demand relationship represented by β_2 appears with a negative sign which theoretically may appear odd, but this possibility exists when the monetary authority is more inclined towards growth instead of stabilisation. Nawaz & Ahmed (2015) and Akbari (2005) have also found similar results for Pakistan using different methodologies.

Further, the statistically insignificant UIP condition indicates that instead of the interest rate differential, the exchange rate dynamics in Pakistan are driven by some other factors. Among them, pursuing inconsistent policies, poor law and order situation, and an onslaught of terrorism are the major issues that discouraged capital inflow over an extended period. Similarly, the results for the MA reaction function appear to be at odds with the theoretical predictions of (Taylor, 1993; Malik & Ahmed, 2010). The insignificance of inflation and exchange rate parameters implies that neither inflation targeting, nor stabilisation is the prime objectives of the MA. In fact, the MA has been ineffective in anchoring inflationary expectations. This raises concerns about the credibility and independence of the MA.[5] Another important finding is that inflation in Pakistan is not demand-driven. Rather, many supply-side factors are also responsible for price changes as discussed above. Therefore, the adoption of demand management policies alone may not be an effective strategy for controlling inflation.

4.3. Impulse Response Functions (IRFs)

We now report the IRFs with a 95 percent confidence interval for the five structural shocks, i.e. fiscal policy, cost-push, oil price, risk premium, and monetary policy shocks, and these are displayed in Figures 1-5. Each shock is of one standard deviation where the responses show mean reversion, which is the stationarity of the model. The detailed responses are as follow:

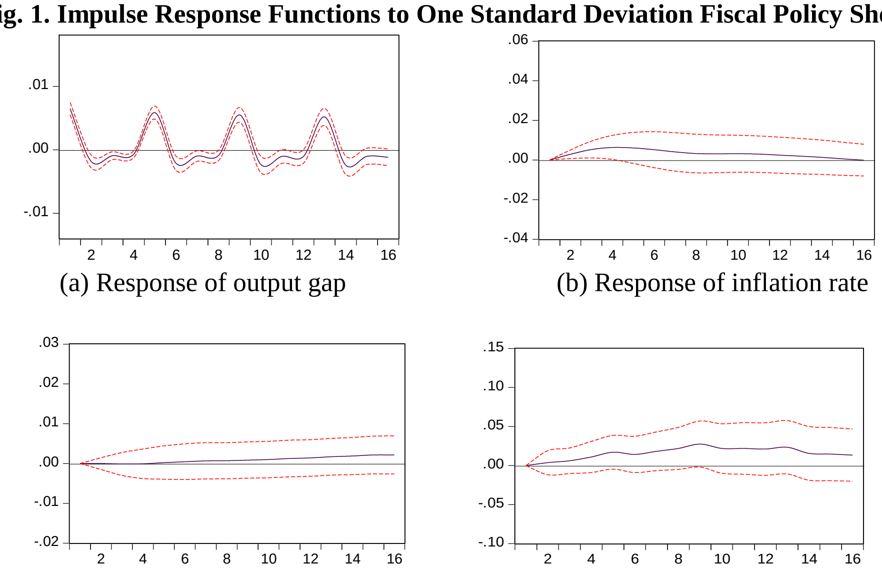
4.3.1. *Fiscal Policy Shock*

Most of the developing economies experience low per capita incomes, low savings, and hence low capital formation. Therefore, government spending is often used to stimulate aggregate demand as there is evidence of a complementary relationship between public and private investment. Expansionary fiscal policy is, therefore, considered an effective tool to utilise the idle capacity to boost economic activity in collaboration with the private sector. Panel (a) of Figure 1 displays the impact of a positive shock to government spending on the output gap. The output gap increases when the fiscal policy shock hits the economy and stays above the initial level for two quarters.

[5] Unfortunately, the persistence of budget deficit and the heavy reliance of the Government on domestic borrowings has rendered monetary policy quite irrelevant and redundant. A number of policy measures taken recently clearly demonstrate that the MA is playing a second fiddle to the fiscal authority, and therefore the monetary policy in Pakistan has become subservient to the fiscal policy.

It again goes up in the fourth and eighth quarters and in each case, the expansionary effect lasts for two quarters.[6] These results support the Keynesian notion of crowding-in effect. On the other hand, an increase in government spending results in inflation that lasts for more than a year. The exchange rate does not show any response to a fiscal expansion in the short-run but starts to rise after a lag of one year and continues to appreciate in the longer run. A possible reason could be that fiscal expansion stimulates demand for domestic as well as imported goods that, in turn, puts upward pressure on exchange rate through expenditure switching effect. As a result, the exchange rate appreciates upon impact i.e., the domestic currency depreciates. The MA responses to inflationary pressure and exchange rate volatility in the shape of monetary tightening significantly raise the interest rate. However, this policy remains ineffective at least in the case of exchange rate stabilisation.

Fig. 1. Impulse Response Functions to One Standard Deviation Fiscal Policy Shock



(a) Response of output gap

(b) Response of inflation rate

(c) Response of exchange rate

(d) Response of interest rate

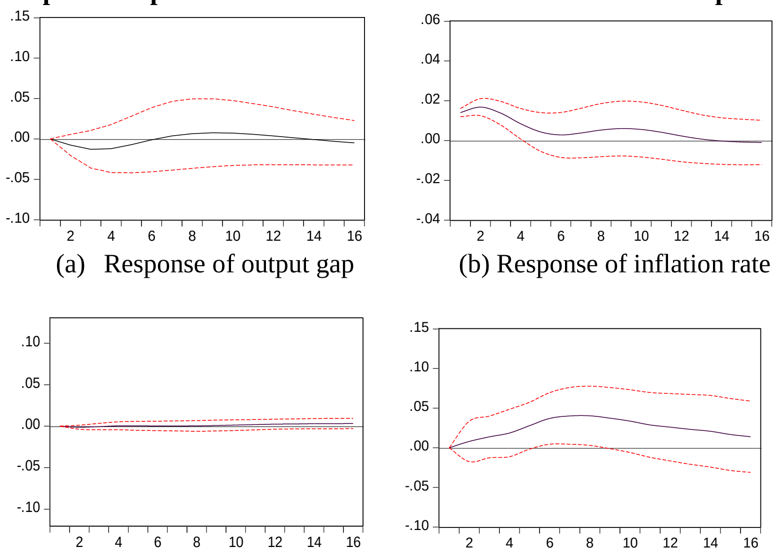
4.3.2. *Cost-push Shock*

Figure 2 displays the estimated IRFs to one standard deviation positive shock to inflation that may be regarded as an adverse aggregate supply shock that leads to an increase in the marginal cost of production. From panel (a) of Figure 2, it is evident that the cost-push shock has an adverse impact on output. It causes output to decrease which remains below its long-run equilibrium level for about four quarters. This shock also results in inflation that lasts for the next one year. The inflationary pressures may be due to excess demand that emerges from short supply. Once the cost-push shock hits the economy and the inflationary pressure sets in, the monetary authority opts for a tight monetary stance that results in an upward shift in interest rate. The interest rate peaks in the eighth quarter and then decreases slowly. It takes almost three years for the interest

[6]This outcome may not indicate stationarity problem. Instead it may have been due to the procedure adopted in the study for quarterisation of the GDP data.

rate to converge. Finally, the estimated IRFs show that cost-push shock has a negligible effect on the exchange rate. The preceding analysis points to an important policy area. Whereas the optimal response to an adverse supply shock should have been an expansionary, or at least an accommodative monetary stance, instead an aggressive tackling of the situation with a substantial increase in the interest rate has prolonged the recessionary period. This is a classic example of a policy dilemma in developing economies where the central banks put larger weight to stabilisation rather than output growth.

Fig. 2. Impulse Response Functions to One Standard Deviation Cost-push Shock



(a) Response of output gap

(b) Response of inflation rate

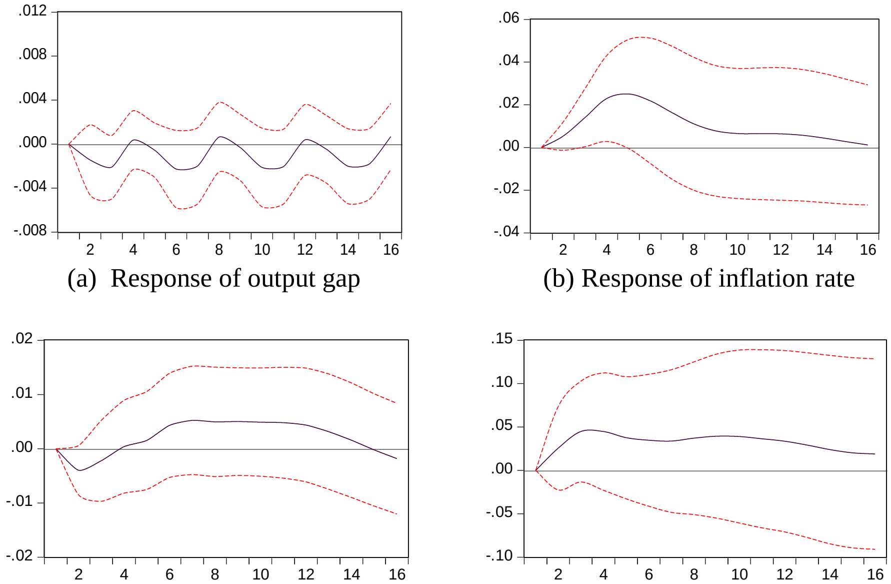
(c) Response of exchange rate

(d) Response of interest rate

4.3.3. *Oil Price Shock*

Figure 3 shows how an exogenous and unanticipated shock to the real price of oil disturbs the variables in the system. Panel (a) of Figure 3 reports a negative response of the output gap to oil price shock. The output gap declines smoothly and takes three quarters to recover. However, there is a cyclical trend that persists and the output gap perpetually oscillates on the lower side in the long run. This phenomenon has been explained in the literature based on supply, demand, wealth-transfer, and monetary policy channels. The combined impact of these channels is generally negative in the case of an oil-importing economy as has been found by Khan & Ahmed (2012). The inflation rate gradually rises upon impact and stays substantially high for the next six quarters. This result shows that there is a positive and statistically significant relationship between inflation rate and an increase in the international oil price. The exchange rate depreciates marginally in the beginning but recovers significantly after two quarters and the appreciation continues for more than three years. This happens because an increase in international oil price increases the import bill and creates a balance of payment deficit which, in turn, puts significant pressure on local currency *vis-à-vis* the demand for dollars that consequently leads to the exchange rate appreciation. The increasing pressure of oil price fluctuations on Pakistani rupee is quite evident for the last few years. Since the MA perceives the oil price pass-through into the general price level as a potential threat, it responds to this shock with monetary tightening to anchor inflationary expectations. The outcome highlighted in Figure 3 (d) shows that there is an increase in interest rate. It may be added that even though the contractionary monetary policy successfully reduces inflation, it does so at the cost of lower output.

Fig. 3. Impulse Response Functions to One Standard Deviation Oil Price Shock



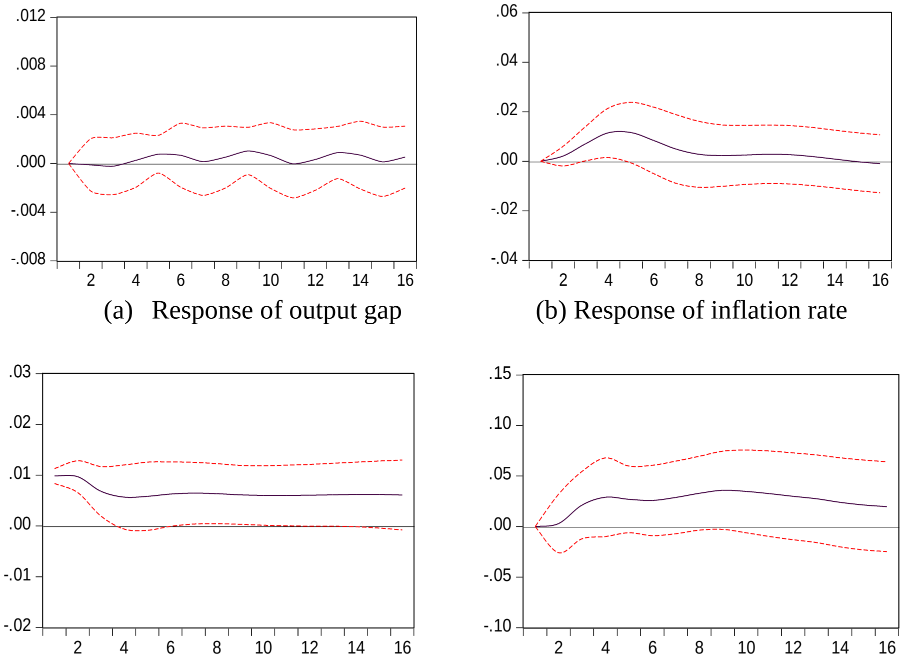
(a) Response of output gap (b) Response of inflation rate

(c) Response of exchange rate (d) Response of interest rate

4.3.4. *Risk Premium Shock*

One standard deviation positive shock to risk premium leads to an instantaneous appreciation of the exchange rate that exerts pressure on Pakistani rupee for the entire horizon of four years considered in this study. The combined effect of risk premium and exchange rate appreciation also affects inflation adversely implying that the exchange rate pass-through into domestic inflation is significant. Theoretically, an exchange rate appreciation leads to a rise in aggregate demand due to expenditure-switching effect but the estimated IRFs display that the output gap remains stable for about three quarters and then goes up slightly in the fourth quarter upon impact. The possible reason for this outcome could either be inelastic export demand for Pakistani goods or the supply-side problem may have arisen due to the non-availability of export surplus. The output gap keeps oscillating above the trend line onward. The exchange rate stability is incorporated as one of the primary objectives of the MA for various reasons such as avoiding balance of payment crises, maintaining external debt burden within sustainable limits, and avoiding inflationary consequences. The result indicates that the MA increases interest rate significantly to minimise such adversities. The potential capital flight is also prevented in the process.

Fig. 4. Impulse Response Functions to One Standard Deviation Risk Premium Shock



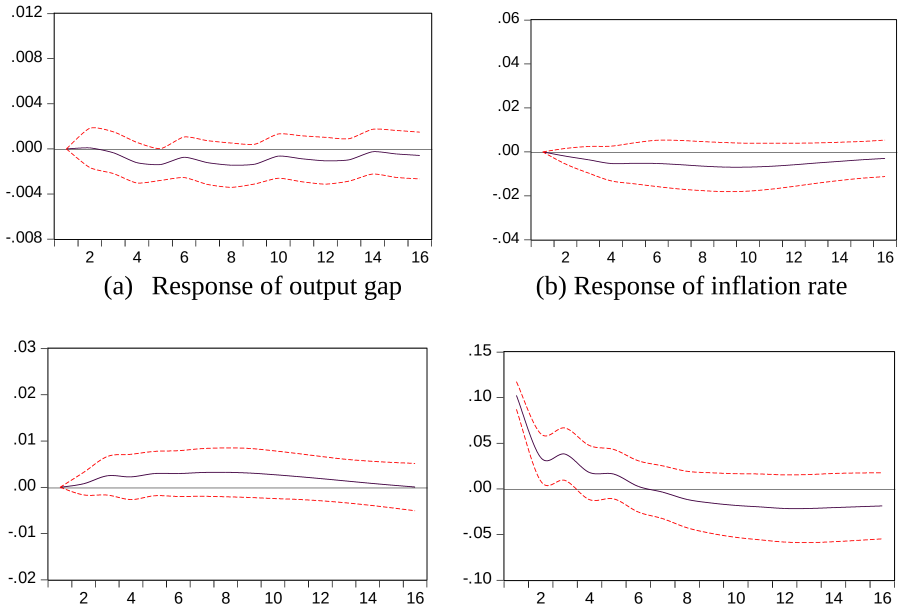
(a) Response of output gap (b) Response of inflation rate

(c) Response of exchange rate (d) Response of interest rate

4.3.5. *Monetary Policy Shock*

Figure 5 reports the response to one standard deviation unanticipated positive shock to interest rate over the sixteen quarter horizon. In response to this shock, the output gap initially remains stable and responds with a lag of two quarters. After that, it starts to decline but improves slightly after six quarters when the interest rate reverts to its initial position. However, it stays below its equilibrium level, and the contractionary impact takes fourteen quarters to vanish completely. This clearly shows that monetary policy intervention has a real effect. As far as the response of inflation to monetary contraction is concerned, it has been observed that inflation responds with some delay. This sluggish response can be attributed to nominal rigidities present in the system. The inflation rate starts to decrease after two quarters (six months) and stays below its initial position for about fifteen quarters. The maximum impact of shock has been observed within the span of six and twelve quarters. This result is in-line with Malik (2007), Malik & Ahmed (2010), and Ahmed & Malik (2011). Finally, the contractionary monetary policy stance creates a positive interest rate differential, making domestic financial assets more attractive that induce capital inflow. The result confirms the exchange rate puzzle as Pakistani rupee, rather than appreciating, weakens substantially and this situation persists for about sixteen quarters. This is not surprising as Hnatakovska et al. (2012) also found the exchange rate puzzle for about 80 percent of developing countries in their study. The finding of Javid and Munir (2011) are similar. Besides empirical support, this phenomenon can also be explained theoretically based on a favourable money demand effect and an unfavourable fiscal and output effect.

Figure 5: Impulse Response Functions to One Standard Deviation Monetary Policy Shock



(a) Response of output gap (b) Response of inflation rate

(c) Response of exchange rate (d) Response of interest rate

4.4. Forecast Error Variance Decomposition Analysis

The Forecast Error Variance Decomposition (FEVDs) analysis provides an insight into the relative contribution of various shocks at different horizons. It enables us to track down the transmission mechanism through which exogenous (policy and non-policy) interventions spillover into the economy. Table 5 reports the FEVDs results of five variables to five shocks. The five variables include the output gap, inflation rate, oil price, exchange rate, and interest rate. The five shocks pertain to fiscal policy, cost-push, oil price, risk premium, and monetary policy. The time horizon is stretched over 20 quarters.

The results confirm that the fiscal policy shock is the most important driver explaining aggregate variability. It accounts for nearly 57 percent forecast error variance (FEV, hereafter) in the short-run and 54 percent in the long run on the output gap. It means that the government seems to have greater command over manipulating aggregate demand in Pakistan. The cost-push shock is the second important contributor causing variability in the output gap. The share of cost-push shock is around 27 percent in the short run, and with a slight decrease, it contributes around 25 percent FEV in the long-run. The monetary policy ranks third in influencing the output gap, with a consistent contribution of around 16 percent at all horizons. Finally, the share of the remaining two shocks (oil price shock and risk premium shock) is relatively small at all horizons. For an economy that experiences nominal frictions due to multiple reasons, the significance of demand management policies is an interesting outcome that is consistent with the NK literature. It is also worth noticing that fiscal stimulus appears to be relatively more effective as compared to monetary push in influencing aggregate demand.

Table 5

Forecast Error Variance Decomposition Analysis

		Structural Shocks				
Series	Period	Fiscal Policy	Cost-push	Oil Price	Risk Premium	Interest Rate
Output Gap	1	56.76	26.56	0.06	0.05	16.55
	2	56.74	26.55	0.06	0.08	16.55
	3	56.64	26.51	0.09	0.23	16.51
	4	56.33	26.36	0.09	0.78	16.42
	6	56.37	26.33	0.09	0.79	16.40
	8	56.02	26.18	0.15	1.35	16.30
	12	55.74	26.04	0.15	1.82	16.22
	16	54.75	25.58	0.16	3.57	15.92
	20	53.99	25.23	0.16	4.92	15.70
Inflation Rate	1	28.00	19.07	21.78	16.33	14.80
	2	54.03	23.07	5.90	1.76	15.21
	3	48.22	21.56	2.28	14.17	13.74
	4	45.36	20.58	1.59	19.44	13.00
	6	49.82	22.84	0.99	11.72	14.59
	8	37.97	17.29	0.62	32.87	11.23
	12	36.38	16.38	0.48	35.90	10.83
	16	31.82	14.31	0.59	43.76	9.49
	20	31.58	14.22	0.61	44.15	9.42
Oil Price	1	0.00	0.00	100.00	0.00	0.00
	2	0.96	0.34	97.89	0.79	0.00
	3	2.38	1.15	95.42	1.00	0.03
	4	4.26	1.83	92.99	0.79	0.10
	6	7.40	1.96	89.31	0.78	0.52
	8	9.56	1.65	85.52	1.67	1.57
	12	11.62	1.70	77.80	3.69	5.17
	16	11.64	1.81	73.80	4.96	7.77
	20	11.71	2.66	72.04	5.54	8.03
Exchange Rate	1	0.05	0.04	0.10	99.79	0.01
	2	0.03	0.02	0.27	99.66	0.01
	3	0.17	0.07	0.28	99.39	0.06
	4	0.16	0.07	0.24	99.44	0.06
	6	0.23	0.11	0.19	99.38	0.07
	8	0.87	0.44	0.15	98.28	0.23
	12	3.68	1.78	0.13	93.38	1.00
	16	7.05	3.36	0.12	87.48	1.96
	20	8.32	3.94	0.11	85.25	2.32
Interest Rate	1	49.59	24.10	6.04	0.29	19.95
	2	28.19	7.87	5.46	41.84	16.62
	3	24.89	9.20	4.11	50.73	11.04
	4	30.55	11.57	3.47	44.37	10.02
	6	37.97	17.80	1.69	31.67	10.85
	8	45.07	20.91	1.22	19.75	13.03
	12	46.56	21.34	0.66	17.75	13.66
	16	43.54	19.85	0.80	22.95	12.84
	20	43.30	19.74	0.96	23.20	12.77

For the inflation rate, the FEVD analysis shows that the fiscal policy shock is again a dominant factor that explains its FEV. This shock accounts for 28 percent percent of FEV in the short run, that goes up to around 32 percent in the long run. Oil price shock explains around 22 percent variability in the inflation rate within a one-quarter horizon, which decreases sharply to about 0.6 percent in the long run. This result confirms a complete oil price pass-through into domestic petroleum products and consumer prices. The cost-push shock is the third important driver of inflation in the country that accounts for 19 percent of the variability in the short-run that increases to around 23 percent in the medium-run but declines to around 14 percent in the long run. Finally, the risk premium, as well as monetary shocks, also leave an impact on inflation. These findings reconfirm that domestic prices are not only influenced by domestic supply and demand constraints; part of inflation is an imported phenomenon (Naqvi et al. 1983).

In the case of the exchange rate, the risk premium shock is the sole source of variation during the entire horizon. This result implies that the exchange rate in Pakistan is independent of prevailing macroeconomic conditions. And that it is managed through an opaque exchange rate policy. Finally, the fiscal policy shock accounts for around 43 percent to 50 percent of variations in the interest rate at different time horizons. This result reconfirms that notwithstanding its independence, the monetary authority is quietly conceding to fiscal dominance.

5. SUMMARY AND CONCLUSIONS

The present study attempted to understand business cycle fluctuations in Pakistan based on the NKOE model, forward-looking rational economic agents respond to policy interventions introduced to exploit nominal rigidities in the system. An SVAR model has been estimated using time series data covering the period between 1993Q4 and 2016Q2. The contemporaneous structure of the SVAR model has been taken from Khan (2016) and the estimation has involved a two-step procedure proposed by Keating (1990, 2000). The dynamic properties of the economy have been examined and analysed based on IRFs and FEVD.

Based on structural parameter estimates, it has been found that interest rate movements cause the output to decline that, in turn, is responsible for the economic slowdown. Whereas the oil price shocks are one of the major contributors to domestic inflation, a significant number of firms have been found to be more attentive to expected inflation that confirms the New-Keynesian notion of forward-looking behaviour. Finally, the parameter estimates of the monetary policy reaction function confirmed that, contrary to popular perception, stabilisation has never been the prime objective of the monetary authority in Pakistan.

The dynamic response of the output gap supported the crowding-in effect; suggesting that an increase in government spending stimulates economic activity. On the other hand, monetary contraction, oil price, and cost-push shocks cause a sizeable decline in output. Furthermore, in response to an adverse supply shock, monetary contraction reinforces the recessionary impact of the shock. This policy dilemma where an accommodative policy stance would have been an appropriate policy stance is consistent with Bernanke, Gertler & Watson (1997) who argued that the 1970s stagflation was largely the result of an inadequate policy response to oil price shock. Another important finding of the present study is the reconfirmation of the exchange rate puzzle wherein response to an increase in interest rate, the exchange rate appreciates substantially. The delayed response of inflation to interest rate shock confirms the existence of price and wage rigidities in Pakistan. Meanwhile, it is disturbing to note that the exchange rate policy has largely been ineffective in talking about the balance of payment crisis. The currency depreciation fails to influence aggregate demand via export promotion or import substitution. The FEVD analysis further confirms the anecdotal evidence of fiscal dominance in Pakistan as a major source of variation in aggregate demand, inflation, and interest rate originates from the fiscal policy shock. The monetary policy shocks are also responsible for economic fluctuations but only moderately and with a long lag.

We conclude by acknowledging certain limitations of the study. The foremost being the absence of a well-integrated financial side in the model. The missing link has attracted the attention of macroeconomists only after the financial crises of 2007-08 (Blanchard et al. 2012). Since then the DSGE model has been revised and still being revised where besides macroeconomic stability, the emphasis has also been given to financial stability to have further insights on macroeconomic fluctuations. This extension is still at its nascent stage in Pakistan. The analysis in the present study has been completed with this caveat in mind.

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