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Articles

A Pragmatic Model for Monetary Policy Analysis I: The Case of Pakistan[1]

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Abstract: *We present the application of Forecasting and Policy Analysis System (FPAS) for monetary policy analysis in Pakistan. FPAS is a customized Dynamic Stochastic General-Equilibrium model widely used for monetary policy analysis. Over an eight-quarter horizon and in normal times, the inflation forecasting accuracy of the model is found to be superior to combinations of econometric models; while in more turbulent times the FPAS model compares at least as favorably to the alternatives. The model offers various scenario building tools to check robustness of the baseline forecasts.*

Keywords: Monetary policy, DSGE model, Pakistan

JEL Classification: C53,D5,E5,E17.

1. Introduction

The objective of this paper is to present the application of Forecasting and Policy Analysis System (FPAS) for monetary policy analysis in Pakistan. FPAS is a customized version of a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model with real and nominal rigidities. DSGE models are widely utilized for macro policy analysis across the globe. They have advantage of relatively good forecasting performance, micro foundations, general equilibrium, stochastic shocks and are able to address a wide range of policy issues (Adolfson et al. (2006), Smets and Wouter (2007), Edge et al.(2010), Edge and Gurkayanak (2010)). However, these advantages come at a cost that includes: complex theoretical structure; extensive macro and micro data requirements for calibration; and estimation purposes (Tovar (2009)) and, communication issues for policy makers (Alvarez-Lois et al. (2008)).

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Keeping in view the strengths of DSGE models and difficulties in their utilization in policy analysis, IMF economists Berg, Karam and Laxton (2006A & B) customized a standard DSGE model for monetary policy analysis. At present, similar models are being used for monetary policy analysis in many developed and developing economies and are commonly known as Forecasting and Policy Analysis System (Semi Structural Model) (Anderle et al. (2013), Charry et al. (2014), Bhattacharya and Patnaik (2014) and Castillo (2014)).

The main feature that distinguishes FPAS from a pure DSGE model is the former's compromise on explicit modelling of micro foundations to gain pragmatic usefulness in context of monetary policy analysis. However, even without explicit micro-foundations, there are at least seven features which make FPAS an attractive tool for monetary policy analysis. First, FPAS is a structural model in the sense that all equations have economic interpretations. Second, its general equilibrium nature allows a holistic analysis and effectively overcomes the shortcomings of partial analysis models. Third, this framework accommodates policy rules and behavior; hence relating actual policy levers available to policy makers to the state of economy. Fourth, forecasting performance of this framework is good- as we argue below. Fifth, it is a reduced form version of a true DSGE model. Six, owing to its simple structure, it is very easy to communicate its policy prescriptions to policy makers and general public. Seven, this model gives specific policy choices instead of general directions.

It serves as a useful exercise to compare FPAS with competing approaches. Vector auto-regression models (VARs) suffer from: a high degree of simultaneity, backward-looking nature, and have issues of regime shifts and structural breaks. Models based on financial programming, very common with countries under the IMF programs, are not directly useful for interest-rate setting as their core focus is on financing of budget deficits. To a great extent, FPAS overcomes these shortcomings.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 discusses the calibration. Section 4 evaluates the model on the basis of an in-sample forecasting exercise. Section 5 discusses some potential scenarios with the objective of illustrating the usefulness of the model. The final Section concludes.

2. Model

The structure of the model is divided into four blocks: (i) Aggregate Demand; (ii) Aggregate Supply; (iii) a representation of the external sector; (iv) and policymaker's reaction tools. We will now briefly consider each block in turn while a detailed coverage is available in Berg, Karam and Laxton (2006 A & B).

2.1. Aggregate Demand

The aggregate demand equation shows that output gap $(\hat{y}_t)$ is a function of lagged output gap $(\hat{y}_{t-1})$, monetary conditions index (mci_t) and foreign demand gap $(\hat{y}_t^*)$. ε_t^y represents shock to aggregate demand. a_1 reflects the extent of persistence of aggregate demand, a_2 reflects the extent of pass-through from monetary conditions to real economy and a_3 reflects the importance of foreign demand on domestic economy.

$$\hat{y}_t = a_1\hat{y}_{t-1} - a_2 mci_{t-1} + a_3\hat{y}_t^* + \varepsilon_t^y \qquad (1)$$

Monetary conditions index is a weighted average of real interest rate and real exchange rate relative to their respective trends. Nominal exchange rate is defined as local currency units per units of foreign currency, in our case Rupees per dollar, so that an *increase* in real exchange rate, $Rs/\$ \frac{P^*}{P}$ where P^*, P denote foreign and domestic prices, ceteris paribus, implies a domestic currency real depreciation and vice versa. $\hat{r}_t$ is real risk free interest rate, cr_prem_t is credit premium over the risk free real rate and $\hat{z}_t$ is real exchange rate gap- trend-deviation of the real exchange rate. a_4 is the importance assigned to domestic lending rate in monetary conditions index. Relatively large magnitude of a_4 indicates that credit conditions in the economy are more prone to domestic money market as compared to the real exchange rate. An increase in mci_t is associated with monetary tightening and vice versa.

$$mci_t = a_4(\hat{r}_t + cr\_prem_t) + (1 - a_4)(-\hat{z}_t) \qquad (2)$$

Equation (3) models cr_prem_t as a linear combination of its own lagged value and change in foreign exchange risk premium, $(prem_t - prem_{t-1})$. $\varepsilon_t^{cr\_prem}$ is an i.i.d. shock to credit premium. The inclusion of $prem_t$ in equation (3) reflects that in case of some foreign-exchange shock, domestic banking may get affected as well.

$$cr\_prem_t = a_5 cr\_prem_{t-1} + (1 - a_5)(prem_t - prem_{t-1}) + \varepsilon_t^{cr\_prem} \qquad (3)$$

Equation (4) provides definition of real exchange rate where s_t is nominal bilateral exchange rate, p_t^* and p_t are foreign and domestic price levels, respectively. Thus a fall in the real exchange rate implies that the domestic currency appreciates with ensuing losses to competitiveness.

$$\ln z_t = \ln s_t + \ln P_t^* - \ln P_t \qquad (4)$$

Throughout this paper, we stick to bilateral exchange-rate because: (i) it keeps the model tractable and easily interpretable; (ii) a high proportion of Pakistan's external debt is denominated is United States dollar (US$); and (iii) a large share of Pakistan's trade takes place in the US$ as well.

2.2. Aggregate Supply

Core inflation, π_t^{core} is modeled according to New Keynesian Phillips Curve (NKPC) with a backward-looking component. In terms of explicit micro foundations, such backward looking component could be obtained by augmenting pure forward looking NKPC with full indexation of prices as in Christiano et al. (2005) and partial indexation of prices as in Smets and Wouter (2003 and 2007).

$$\pi_t^{core} = b_1 \pi_{t-1}^{core} + (1 - b_1) E_t \pi_{t+1} + b_2 rmc_t^{core} + \varepsilon_t^{\pi^{core}} \qquad (5)$$

b_1 represents inertia in inflation process or inflation persistence. $(1 - b_1)$ is the weight of forward looking component in determination of core inflation. rmc_t^{core} represents real marginal costs and $\varepsilon_t^{\pi^{core}}$ is an i.i.d. shock to core inflation. In DSGE models with explicit micro foundations, real marginal costs of production are derived from profit maximizing behavior of a representative firm. Result of this optimization is a typical expression that describes real marginal cost, rmc_t^{core}, as a combination of real wage and real rental return on capital goods. However, owing to lack of reliable data on marginal costs, wages and rental return, this model expresses rmc_t^{core} as function of domestic and foreign demand components. b_3 is share of domestic component i.e. output gap and $(1 - b_3)$ is the share of foreign component i.e. real exchange rate gap.

$$rmc_t^{core} = b_3 \hat{y}_t + (1 - b_3) \hat{z}_t \qquad (6)$$

Food inflation, π_t^{food} has also been modeled on the lines of NKPC with a backward looking component.

$$\pi_t^{food} = b_{21} \pi_{t-1}^{food} + (1 - b_{21}) E_t \pi_{t+1} + b_{22} rmc_t^{food} + \varepsilon_t^{\pi^{food}} \qquad (7)$$

b_{21} shows food inflation persistence and $(1 - b_{21})$ is the impact of expected headline inflation on food inflation. rmc_t^{food} reflects real marginal costs related to food inflation. $\varepsilon_t^{\pi^{food}}$ is shock to food inflation. As assumed in the core inflation NKPC, food-specific marginal costs are also assumed to have foreign and domestic components. $\hat{z}_t^{food}$ is relative price of food.

$$rmc_t^{food} = b_{23}\hat{z}_t^{food} + (1 - b_{23})\hat{y}_t \qquad (8)$$

$\hat{z}_t^{food}$ is defined as world food price relative to domestic food price expressed in domestic currency.

$$\hat{z}_t^{food} = P_{world}^{food} + \hat{z}_t - P_t^{food} \qquad (9)$$

Oil price inflation, π_t^{oil} is assumed to have backward and forward looking components in line with previous versions of NKPC related to core and food inflation.

$$\pi_t^{oil} = b_{31}\pi_{t-1}^{oil} + (1 - b_{31} - b_{32})E_t\pi_{t+1} + b_{32}rmc_t^{oil} + \varepsilon_t^{\pi^{oil}} \qquad (10)$$

b_{31} shows magnitude of persistence in oil price inflation and b_{32} shows the pass-through of oil-specific marginal costs to oil inflation. Oil-specific marginal costs are a combination of global oil price inflation Δp_t^{oil}, change in nominal exchange rate Δs_t^{USD} and trend-growth in the real exchange rate $\Delta\bar{z}_t$.

$$rmc_t^{oil} = \Delta p_t^{oil} + \Delta s_t^{USD} - \Delta\bar{z}_t \qquad (11)$$

Headline inflation is a weighted average of core, food and oil inflation. w^{oil}, w^{food} and $(1 - w^{oil} - w^{food})$ are weights of oil, food and core inflation, respectively. ε_t^{π} reflects shock to headline inflation.

$$\pi_t = w^{oil}\pi_t^{oil} + w^{food}\pi_t^{food} + (1 - w^{oil} - w^{food})\pi_t^{core} + \varepsilon_t^{\pi} \qquad (12)$$

This specification of the aggregate supple curve leaves much to be desired. For instance, it ignores the role of prices regulated by the government, so-called administered prices, and in turn their impact on inflation and its expectations. For evidence on the role of administered-prices and inflation expectations see Abbas, Beg and Choudhary (2015). This specific deficiency in the model is addressed in a forthcoming companion paper.

2.3. External Sector

At center of modeling the external sector lies the uncovered interest rate parity (UIP) condition which establishes the link between the price of domestic and foreign currencies on the basis of their interest-rate differential and risk profile. However, we use an augmented version of UIP consistent with the idea that Pakistan imposes capital controls and therefore, in theory, can manage the currency over some horizon. Indeed, the Government of Pakistan's letter of intent to the IMF precisely reveals that[3]:

"The exchange rate will remain flexible and will reflect market conditions. Calibrated interventions in the foreign exchange market will be aimed at meeting the program's reserve targets and ensuing smooth functioning of the foreign exchange market (p. 5)."

This ground reality provides us the evidence that at least for the medium-term we can go beyond UIP for modeling the external sector in Pakistan. To recap, the traditional forward-looking version of UIP dictates that exchange-rate adjusts in such a manner that sum of foreign interest rate and country risk premium gets equated with the sum of domestic interest rate and expected depreciation/appreciation of the local currency.

$$s_t = E_t s_{t+1} + \frac{\left(i_t^* - i_t + prem_t\right)}{4} + \varepsilon_t^s \qquad (13)$$

The terms i_t, i_t^*, s_t and $prem_t$ denote annualized quarterly domestic and foreign interest rates, Pak Rupee/$ nominal exchange rate and country specific FX risk premium respectively. Purely forward-looking version of UIP is unable to capture foreign exchange market dynamics in the sense that it fails to generate the level of exchange rate persistence observed in the data, which implies that capital is not completely mobile in the case of Pakistan, as discussed earlier. To reflect this reality, it is assumed that the exchange rate expectations, the first term on the left-hand-side of equation (13), have both backward and forward looking components such that

$$\ln s_{t+1}^E = e_1\left(\ln s_{t-1} + \frac{1}{2}\Delta \ln \bar{s}_t\right) + \left(1 - e_1\right)E_t \ln s_{t+1} \qquad (14)$$

The first term in equation (14) is the backward-looking nature while the second term is forward looking part. The term e_1 captures the weight assigned to the backward-looking feature of exchange rate determination. The backward-looking nature of the exchange rate- the first term in equation (14), deserves an explanation. It accounts for

[3] Pakistan: Letter of Intent, Memorandum of Economic and Financial Policies, and Technical Memorandum of Understanding of December 5 2013. www.imf.org.

the *level* of the exchange rate achieved in the previous period given by $\ln s_{t-1}$. The second term is $\Delta \ln \bar{s}_t$ and it shows that the *change* in trend/equilibrium nominal exchange rate in current time period. It is assumed that this *change* in the trend in nominal exchange rate change is determined by its lagged value and inflation-target differential between Pakistan the United States.

$$\Delta\bar{s}_t = t_1\Delta\bar{s}_{t-1} + (1-t_1)(\bar{\pi}_t - \bar{\pi}_t^* + \Delta\bar{z}_t) + \varepsilon_t^{\Delta\bar{s}} \qquad (15)$$

After substitution of equation (15) in (14), we get the modified version of UIP with accounts for the desire to smooth the exchange rate movements.

$$s_t = (1-e_1)E_t s_{t+1} + e_1\left[s_{t-1} + \frac{2}{4}(\bar{\pi}_t - \bar{\pi}_t^* + \Delta\bar{z}_t)\right] + \frac{(i_t^* - i_t + prem_t)}{4} + \varepsilon_t^s \qquad (16)$$

The first term on the Left-hand-side is the forward-looking part of how the exchange rate evolves. The second-term captures the desire-to-smooth in that the recent most memory of the exchange rate *levels* has a say as well as historical a macroeconomic momentum captured by inflation-differentials as well as the *growth* in the real exchange rates between Pakistan and the US. The third term comes from UIP condition. Notice that, Equation (14) collapses to the the textbook UIP condition when $e_1 = 0$.

2.4. Policy-Maker Behavior

In this Section we model the behavior of the Central Bank which faces aggregate demand, aggregate supply and an external sector. Like many Central Banks, the objective of State Bank of Pakistan is price stability, but giving appropriate importance to economic growth. However, many developing economy central banks also care about exchange rate volatility and interest rates are calibrated to keep the exchange rate level in the “desired" range; the quote of the previous Section alludes to this kind of behavior in Pakistan. Equation (17) tries to capture interest-rate setting rule of a central bank under managed floating exchange regime as well as having a dual mandate. This equation is a modified version of the canonical Taylor rule. The term g_1 is the weight assigned to exchange rate considerations whereas $(1-g_1)$ is the weight assigned to usual central bank business of interest-rate setting in the context of the Taylor rule.

$$i_t = g_1\left[\frac{1}{1-e_1}\Delta s_{t+1} - \frac{e_1}{1-e_1}\Delta s_t + i_t^* + prem_t\right] +$$

$$(1-g_1)\left[f_1 i_{t-1} + (1-f_1)\{i_t^n + f_2(E_t\pi_{t+4} - \pi_t^T) + f_3\hat{y}_t\}\right] + \varepsilon_t^i \qquad (17)$$

Nominal interest i_t rate is sum of real interest rate r_t and expected Y-o-Y inflation $E_t\pi_{t+1}$.

$$i_t = \bar{r}_t + E_t\pi_{t+1} \qquad (18)$$

Equation (17) says that the interest-rate setting in this environment is determined by a weighted-average of the modified UIP and the Taylor rule. To explain, the Taylor rule evaluates economic conjuncture on the basis of Pakistan's inflation relative to its target, the output gap and a desire to smooth nominal interest rates decisions.

2.5. Exogenous Equations

In the previous section, we have presented the main endogenous behavioral equations for the four blocks of the economy. In this section, we present the relevant exogenous equations including various equilibrium equations, relevant foreign economy variables such as interest rate, output, inflation and world food and oil prices. All foreign variables have an asterisk.

The determination of equilibrium or trend levels of different domestic variables such as inflation, real exchange rate, output growth and real interest are an important part of the model. Importance of trends comes from the fact that to a large extent that monetary policy decision hinges upon current and expected path of gaps -the difference between actual and trend values. Consequently, the equations (19), (20), (21) and (22) respectively show that inflation target, real exchange rate change, real interest rate and real output growth trends have been modeled as linear combinations of their autoregressive terms, steady state values and i.i.d. shocks. Autoregressive component reflects the impact of most recent fluctuations and steady state values to capture the past averages.

$$\pi_t^T = t_1\pi_{t-1}^T + (1-t_1)\pi^T + \varepsilon_t^{\pi^T} \qquad (19)$$

$$\bar{\dot{z}}_t = h_1\bar{\dot{z}}_{t-1} + (1-h_1)\bar{\dot{z}} + \varepsilon_t^{\bar{\dot{z}}} \qquad (20)$$

$$\bar{r}_t = h_1\bar{r}_{t-1} + (1-h_1)\bar{r} + \varepsilon_t^{\bar{\bar{r}}} \qquad (21)$$

$$\bar{\dot{y}}_t = h_1\bar{\dot{y}}_{t-1} + (1-h_1)\bar{\dot{y}} + \varepsilon_t^{\bar{\dot{y}}} \qquad (22)$$

Equations (23), (24), (25) and (26) capture trends in foreign inflation, real interest rate and output growth respectively. These have been modeled as linear combinations of autoregressive components and steady state values.

$$\pi_t^{food\_world} = h_4\pi_{t-1}^{food\_world} + (1-h_4)\pi^* + \varepsilon_t^{\pi^{food\_world}} \qquad (23)$$

$$\pi_t^* = h_3\pi_{t-1}^* + (1-h_3)\pi^* + \varepsilon_t^{\pi^*} \qquad (24)$$

$$\bar{r}_t^* = h_1\bar{r}_{t-1}^* + (1-h_1)\bar{r}^* + \varepsilon_t^{\bar{r}^*} \qquad (25)$$

$$\hat{y}_t^* = h_2\hat{y}_{t-1}^* + \varepsilon_t^{\hat{y}^*} \qquad (26)$$

The Equation (27) describes the determination of foreign nominal interest rates.

$$i_t^* = h_3 i_{t-1}^* + (1-h_3)(\bar{r}_t^* + \pi_t^*) + \varepsilon_t^{i^*} \qquad (27)$$

The change in relative food price gap depends upon domestic and world food inflation differential after adjusting for exchange rate changes.

$$\Delta\hat{z}_t^{food} = \frac{\left[\pi_t^{food\_world} + \left(\dot{s}_t - \dot{\bar{z}}_t\right) - \pi_t^{food}\right]}{4} + \varepsilon_t^{\hat{z}\,food} \qquad (28)$$

Expected real exchange rate change depends upon real interest rate differentials.

$$E_t\left(\dot{\bar{z}}_{t+1}\right) = \bar{r} - \left(\bar{r}^* + prem_t\right) + e_t^{prem} \qquad (29)$$

The shock to FX risk premium is modeled as an autoregressive process.

$$e_t^{prem} = h_0 e_{t-1}^{prem} + \varepsilon_t^{prem} \qquad (30)$$

These set of equations together with the four-blocks of the economy show that the model is made up of short-run values but it also respects the historical momentum of the macroeconomic variables.

3. Calibration

In order to make this model work, it needs to be equipped with various types of statistics which we discuss in detail now.

Our parameterization exercise is guided by the following broad principles: (i) use of historic data series, (ii) direct inputs from policy makers involved in monetary policy formulation; and (iii) matching model properties with transmission mechanism established in literature. This approach has its merits and demerits. Merits include less restrictive nature as compared to pure econometric models, ability to incorporate most updated policy rule due to direct involvement of policy makers and easy incorporation of judgment in policy analysis. Demerits include a larger exposure to Lucas critique and lack of consistent methodology across a wide range of parameters. However, keeping in view the scarcity of microeconomic data necessary for calibration of structural or deep parameters, such pragmatic approach becomes a preferable alternative.

We calibrate parameters for quarterly frequency. Many of the rates have been annualized to allow an easy and more familiar interpretation but necessary changes have been done in the model so that appropriate quarterly figures have been incorporated in our analysis. We can classify the parameters in two broad classes: long run trend parameters and short run fluctuations parameters.

3.1. Parameters Related to Long Run Trends

The long run trend parameters are related to steady state properties of the model. In order to avoid computational issues related to nonlinearities, DSGE models are typically log-linearized and simulated in terms of gaps in order to provide some context to the computations. The gap here refers to the difference between actual and, potential or equilibrium value of some variable. The long run parameters play a key role in the determination of equilibrium or potential values. Inflation target π^T is set by Federal Government and its value is guided by recent trends in inflation. We set the annual value of this parameter to 8% in accordance with the Annual Development Plan of FY 15. π_X^T represents foreign inflation target. This parameter is calibrated at 2%. The real interest rate trend is denoted by r^n. This parameter is fixed at an annual value of 1%.[4]

Table 1 reports median and average values of real interest rate over the three periods: 1991-2014, 2000-2014 and 2010-2014. The median value of real interest rate for the sample period 2000Q1-2014Q4 is 1.2. The average value for this period is downward biased due to large inflation shock in 2007-08.

Table 1: Real Interest Rate Trend

	1991Q_2-2014Q_4	**2000Q_1-2014Q_4**	**2010Q_1-2014Q_4**
Average	1.48	0.39	1.66
Median	1.95	1.24	1.45

The term r_X^n represents foreign real interest rate trend. Value for this parameter has been fixed at 1%.

The real exchange rate trend has been computed using bilateral real exchange rate with US dollar. Table 2 shows average and median values of changes in the real exchange rate for the three sample periods discussed above. We see that real exchange

[4] Real interest rate was calculated using following formula: $r_t = i_t - E(\pi 4_{t+1})$.

rate shows slightly appreciating trend as depicted by negative values of average and median of real exchange rate changes. Accordingly, we fix this parameter at a *conservative* -1.5% for the post 2000 era.

Table 2: Real Exchange Rate Trend

	$1991Q_2$-$2014Q_4$	$2000Q_1$-$2014Q_4$	$2010Q_1$-$2014Q_4$
Average	-0.07	-1.68	-3.83
Median	-1.65	-1.92	-2.03

Potential output growth $\dot{y}$ is calibrated to 4%; it is pinned down by the average growth of GDP/LSM for the period of 2000-2014.

Table 3: GDP Growth Rate

	$1991Q_2$-$2014Q_4$	$2000Q_1$-$2014Q_4$	$2010Q_1$-$2014Q_4$
Average	3.98	4.08	3.27
Median	3.74	4.10	3.51

All the long run parameters have been summarized in Table 4.

Table 4: Long Run Parameters

Parameter	Description	Value
π^T	Inflation target	8
π_X^T	Foreign long-run inflation (or foreign inflation target)	2
r^n	Domestic trend real interest rate	1
r_X^n	Foreign trend real interest rate	1
$\dot{z}$	Equilibrium real exchange rate appreciation/depreciation	-1.5
$\dot{y}$	Potential output growth	4

3.2. Parameters Related to Short Run Dynamics

The parameters that govern the short run dynamic properties of the model and can be classified in four broad categories: aggregate demand, aggregate supply, monetary policy reaction and external sector parameters.

3.2.1. Aggregate Demand Parameters

As depicted in equation (1), output gap depends upon its own lag, monetary conditions index and foreign demand. $a_3 = 0.15$ - the importance of foreign demand for Pakistan, is calibrated by taking the average of the exports to GDP ratio over the period 2000-2014.

For backward-looking coefficient a_1 and impact of MCI a_2, we take time series of monetary conditions index calculated by Qayyum (2002), Hyder and Khan (2007) and estimate following equation[5]

$$\hat{y}_t = a_1\hat{y}_{t-1} - a_2 mci_{t-1} + \varepsilon_t^y \qquad (31)$$

$\hat{y}_t$ is proxied by two variables: seasonally adjusted, in logs and HP filtered real quarterly GDP (Hanif et al. (2013)) and large scale manufacturing. Similarly, series of MCI provided by Qayyum (2002) and, Hyder and Khan (2007) were also HP-filtered. Results of regressions fail to show statistical or economic significance for a_2. This hints at weakness of monetary policy transmission mechanism in case of Pakistan[6]. This observation is confirmed by VAR model results (Agha et al. (2005) and Ahmad et al. (2014)). Accordingly, we set a_2 at 0.10.

As a_2 turns out to be statistically insignificant and economically negligible during the OLS estimation of $\hat{y}_t = a_1\hat{y}_{t-1} - a_2 mci_{t-1} + \varepsilon_t^y$, we drop MCI and regress output gap on its own lag[7]. This yields an estimate of $a_1 = 0.61$. This calibration shows that aggregate demand is a fairly backward looking affair in Pakistan.

[5] Qayyum (2002) provides series of MCI calculated based on inflation. Hyder and Khan (2007) provide 4 series of MCI based on inflation and output for different proxies of interest rates. Hence we have in total 5 series of MCI. We regress these 5 MCI series on two proxies of output: quarterly GDP and LSM to obtain 10 estimation results.

[6] The results are not included to conserve space and will be available upon request.

[7] Using quarterly GDP. LSM shows low level of persistence.

a_4 and $1-a_4$ represent the weight of real interest rate gap and real exchange rate gap in MCI. In literature, we find at least three studies that provide estimates of a_4. However, there is a clear lack of agreement among the estimates. For instance, Qayyum (2002) estimates weight of interest rate 74% and Khan and Qayyum (2007) report this coefficient to be 0.1%. Hyder and Khan (2007) construct 4 series of MCI based upon 4 different sets of weights of interest rate and exchange rate. All of these weights are summarized in Table 5. Considering the wide range of values for this parameter, we discussed calibration of this parameter with monetary policy makers. After this discussion, it appeared that exchange rate is an important element in MCI. Following introspection we set a_4 at 20%. This weighting scheme is quite close to estimated one by Hyder and Khan (2007) on the basis of regressing NEER and TBR on LSM.

Table 5: Weights for Monetary Conditions Index (MCI)

Studies	Coefficients		MCI Weights		Ratio
	IR	ER	IR	ER	
Abdul Qayyum (2002)	0.116	0.041	73.9%	26.1%	0.35
Haider and Khan (2007) (CPI, ER, CMR)	1.083	-1.116	49.2%	50.8%	-1.03
Haider and Khan (2007) (CPI, ER, TBR)	3.967	1.385	5.2%	4.8%	0.35
Haider and Khan (2007) (LSM, NEER, CMR)	0.063	0.237	21.0%	79.0%	3.76
Haider and Khan (2007) (LSM, NEER, TBR)	0.038	0.2	16.0%	84.0%	5.26
Khan and Khawaja (2007)			0.1%	99.9%	

3.3. Aggregate Supply Parameters

In our model, aggregate supply block consists of New Keynesian Phillips Curve (NKPC) equations related to core, food and oil prices inflation. $b1$ and $1-b1$ reflect impact of lag and lead of core inflation on current level of core inflation. The magnitude of $b1$ indicates the inertia in inflation process and has important implications for the conduct of monetary policy. Hanif et al. (2012) estimate inflation persistence for Pakistan using month-on-month data and report a coefficient of 0.16 for headline inflation. However, our estimates for quarterly data of core inflation and headline inflation yield much higher level of persistence equal to 0.8 and 0.67, respectively. The difference in estimates could be attributed to difference in frequency and measure of core vs. headline inflation.

b_2 measures the impact of real marginal cost on core inflation. As discussed earlier, real marginal costs are weighted average of factor costs i.e. wage and rental return in the economy. However, information on wages and rental returns are not available. As a result, real marginal costs are proxied by some indicator of aggregate demand. To capture this parameter, we regress inflation on HP-flitered GDP and LSM but we fail to obtain meaningful results. This observation is confirmed by literature. Saeed and Riaz (2011) use annual data 1970-2010 to estimate NKPC. Like our estimation results, they also conclude that output gap has no significant role in explaining inflation variations. Satti et al. (2007) estimate NKPC using annual data from 1976 to 2006. They report that marginal cost based upon labor compensation; not output gap is driving factor of inflation. They show that inflation has positive dynamic correlation with their measure of marginal cost and negative dynamic correlation with output gap. When they regress inflation on output gap, they get -0.154 as coefficient of output gap. Based on our estimations and available literature, we use a lower value of 0.15 for b_2.

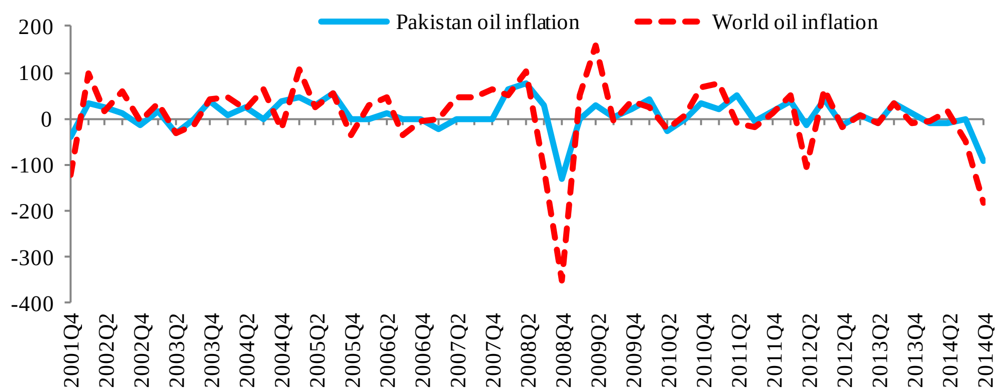
b_3 measures the weight of domestic output gap in real marginal cost expression. This parameter can be pinned down by exports to GDP ratio. As exports constitute 15% of GDP on average, therefore b_3 is fixed at 0.85 or 85%. b_{21} is coefficient of backward looking component in Phillips Curve related to food inflation. We estimate the following autoregressive process $\pi_t^{food} = c + b_{21}\pi_{t-1}^{food} + \varepsilon_t$ to get this persistence coefficient, and it is equal to 0.30. Considering the highly volatile nature of food prices, the low level of persistence in food inflation is in line with a priory expectations.

b_{22} measures the extent to which domestic food inflation is affected by food-specific marginal costs. In Pakistan, a large part of food markets fall in underground or informal sector which is typically characterized by quicker price revisions. Owing to the large informal sector and inelastic food demand, pass-through from changes in food-specific marginal costs to food inflation is likely to be high. Based upon these assumptions and model fit properties, we fix b_{22} in the range of 0.70.

Just like core inflation Phillips Curve, food-specific marginal costs are also proxied by a linear combination of domestic and foreign demand indicators. b_{23} measures the weight of global food inflation relative to domestic food inflation. $1-b_{23}$ provides the weight of domestic demand pressure measured by GDP gap. Calibration of $b_{23} = 0.25$ reflects our belief that although global food prices are important yet domestic considerations are key element in determination of domestic food prices. This is in line with Khan and Ahmed (2011) who conclude that world food market has limited impact on domestic economy. Correlation coefficient between world food inflation and domestic food inflation is also 0.31 and endorses our choice of low impact of world food inflation.

After removal of subsidies related to petroleum products, pass through of changes in world oil inflation to domestic oil inflation is quite high. Figure 1[8].shows that domestic and world oil inflation series have been co-moving and this co-movement has strengthened in recent past.

Figure 1: Pakistan and World Oil Price Inflation



The correlation coefficient between the two series is 0.78. Considering this high pass through, we calibrate b_{32} to be 0.80. We find little persistence in oil price inflation when we estimate the autoregressive equation $\pi_t^{oil} = c + b_{21}\pi_{t-1}^{oil} + \varepsilon_t$ and fix b_{31} at 0.03.

3.4. Monetary Policy Parameters

Monetary policy parameters are pinned down using results from Aleem and Lahiani (2011). They estimate different specifications of Taylor rule which, although not exactly same, yet are similar to the specification we have used in the model. Their results claim that SBP puts significant concern over depreciation by actively responding to exchange rate movements. The comparison of coefficient for inflation and real exchange rate reveals that the latter coefficient is greater than the former with a reasonable margin[9]. Following Aleem and Lahiani (2011), g_1 is calibrated to be 0.60. All of the Taylor rule specifications available in Aleem and Lahiani show that interest rate smoothing is statistically and economically significant. Therefore, we fix f_1 at 0.60, f_2 and f_3 reflect the weights of inflation and output, respectively. Aleem and Lahiani (2011) show that once interest rate response is accounted for, by real

[8] All the Figures are reported in the Appendix

[9] Aleem and Lahiani (2011), Table 1 (specification 7 & 8) and Table 2 (specification 18 & 19)

exchange rate movements, central bank's response to output fluctuations becomes unstable. However, the response to inflation remains significant and positive. Accordingly, we fix f_2 at 0.80 and f_3 at 0.20.

Table 6: Short Run Parameters

Parameter	Description	Value
a_1	Output gap persistence	0.60
a_2	Pass-through from monetary conditions to real economy	0.10
a_3	Impact of foreign demand on the output gap	0.15
a_4	The relative weight of the real interest rate and real exchange rate in real monetary conditions in the IS curve (mci)	0.20
a_5	Persistence in credit premium	0.80
b_1	Inflation persistence	0.67
b_2	The impact of real marginal costs on inflation (policy pass-through)	0.15
b_3	The relative weight of output gap and real exchange rate gap in firms' real marginal costs	0.85
b_{21}	Food prices persistence	0.30
b_{22}	The impact of real marginal costs on food prices	0.70
b_{23}	The relative weight of relative food prices output gap in food retailer's real marginal costs	0.25
b_{31}	Oil prices persistence	0.03
b_{32}	The impact of world oil prices on domestic oil prices	0.70
e_1	Backward-looking expectations on the FOREX market	0.60
e_2	Central bank smoothing (managing) of the exchange rate	0.5
f_1	Policy rate persistence in the Taylor rule	0.60
f_2	Weight put by the policy maker on deviations of inflation from the target in the policy rule	0.80
f_3	Weight put by the policy maker on output gap in the policy rule	0.20
g_1	Central bank's control of the domestic money market and its short-term nominal interest rate	0.60
t_1	Speed of exchange/inflation target rate adjustment	0.50
h_0	Persistence of shock to risk premium	0.50
h_1	Persistence in convergence of trend variables to steady state ()	0.50
h_2	Persistence in foreign GDP	0.50
h_3	Persistence in foreign interest rate and inflation	0.50
h_4	Persistence in cross exchange rate and world food & oil prices	0.10
w^{food}	Weight of food price in CPI	0.35
w^{oil}	Weight of oil price in CPI	0.07

e_1 represents the extent to which expectations formation regarding exchange rate is a backward looking process. We fix this parameter at 0.50, which we think is a reasonable value for a developing economy.

3.5. Decomposition of Observed Variables into Trends and Gaps

Decomposition of actual series of domestic and foreign output, real interest rate and exchange rates into trend and gap components is very important part of Forecasting and Policy Analysis System due to two reasons. First, historic analysis of gaps can help understanding stylized facts related to business cycles in the economy. Second, the structural model is linearized around long term trends and, stability condition requires gaps to close so that actual variables converge to their respective long term trend values. Due to this convergence property of model, initial conditions of gaps play an important role in forecast generated from dynamic solution of the model.

Different filtration techniques available to decompose economic variables into gaps and trends can be broadly classified into univariate and multivariate filters. Univariate filters, including Hodrick-Prescott filter and Band-Pass filter, exclusively rely on the own history of filtered variable. On the other hand, multivariate filters like Kalman filter and smoother can accommodate different economic relationships to improve filtration exercise. While decomposition of an economic time series into trend and gap components, Kalman fitler uses only information upto the decomposed period whereas Kalman smoother uses entire sample data for decomposition exercise. ((Andrle et al.(2013))

We use Kalman smoother for decomposing actual series into trend and gap components. Rational expectations' solution of structural model is obtained by expressing all state variables of the model as functions of their lag values and shocks.

$$X_t = TX_{t-1} + R\varepsilon_t; \quad \varepsilon_t : \left(0, \Sigma_\varepsilon\right)$$

X_t represent the set of all transition variables and T represent the transition matrix. ε_t is vector of i.i.d. shocks normally distributed with 0 mean and Σ_ε is the variance-covariance matrix of shocks. Since we assume that shocks are uncorrelated, therefore Σ_ε is diagonal matrix. State variables are linked with observable variables through a linear stochastic measurement equation

$$Y_t = ZX_t + H\eta_t; \quad \varepsilon_t : \left(0, \Sigma_\eta\right)$$

where Y_t represents the vector of measurement variables and η_t represents the vector of measurement shocks.

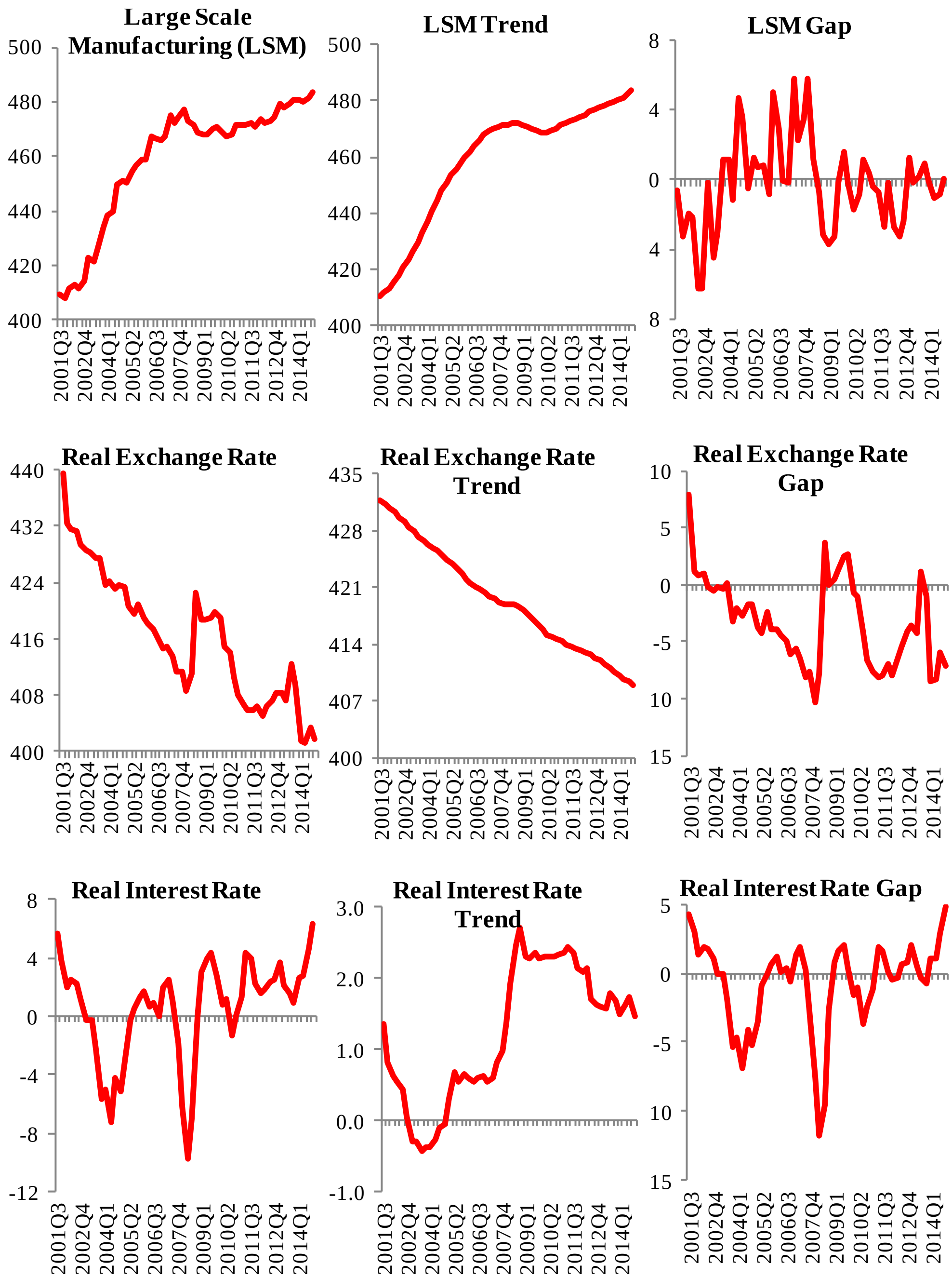
Standard deviations of transition shocks are given in Table 7. List of measurement variables includes logs of output, exchange rate, domestic and foreign CPI and, levels of domestic and foreign interest rates, core inflation, food inflation, inflation target and world food inflation.

Table 7: Standard Deviations of Transition Shocks

Parameter	Domestic Output Gap Shock	Standard Deviation
e^{y}	Core Inflation Shock	1.00
$e^{\pi^{core}}$	Food Inflation Shock	0.50
$e^{\pi^{food}}$	Headline Inflation Shock	0.70
$e^{\pi^{food}}$	Nominal Exchange Rate Level Shock	0.60
e^{s}	Nominal Interest Rate Shock	0.70
e^{i}	Nominal Exchange Rate Target Growth Shock	1.00
$e^{\Delta s}$	Inflation Target Shock	0.70
$e^{\pi^{target}}$	Foreign Output Gap Shock	0.50
$e^{y^{*}}$	Foreign Nominal Interest Rate Shock	0.50
$e^{i^{*}}$	Foreign Headline Inflation Shock	1.00
$e^{\pi^{*core}}$	Equilibrium Real Interest Rate Shock	0.50
e^{r}	Foreign Equilibrium Real Interest Rate Shock	0.50
e^{r*}	Foreign Equilibrium Real Exchange Rate Growth Shock	0.50
$e^{\Delta\bar{z}}$	Credit Premium Shock	0.50
e^{prem}	Domestic Equilibrium Output Gap Growth Shock	0.70
$e^{\Delta\bar{y}}$	Weight of Food in Inflation Growth Shock	0.80
$e^{\Delta w^{food}}$	Real Exchange Rate Food Gap Shock	1.00
$e^{z^{foodgap}}$	Output Gap Measurement Shock	0.80
$mesllsm$	Domestic Output Gap Shock	0.10

Obtained plots of gaps and trends along with their actual counterparts for LSM, real interest rate and real exchange rate are presented in Figure 2.

Figure 2: Decomposition of Actual Series into Gaps and Trends



3.6. Data Sources

In Table 8 below we list the data sources for the interested reader.

Table 8: Data Sources

Data Series	Definition	Source
LSM*	Large Scale Manufacturing Index	PBS
CPI	Consumer Price Index[10]	PBS
CPI Food	Food price Index	PBS
CPI Oil	Oil price Index	PBS
CPI Core	Non-food-non-energy price Index	PBS
Exchange Rate	Bilateral exchange rate between PKR and USD	SBP
Nominal Interest Rate	6-Month T-Bill rate	SBP
Foreign GDP	USA GDP Index	IMF
Foreign CPI	USA CPI	IMF
Foreign Interest Rate	USA 3-Month T-Bill Interest Rate	IMF
Inflation Target	Inflation Target set by Federal Government	MoF
World Oil Price	Index of World Oil Price	IMF
World Food Price	Index of World Food Price	IMF

4. Evaluation of the Model

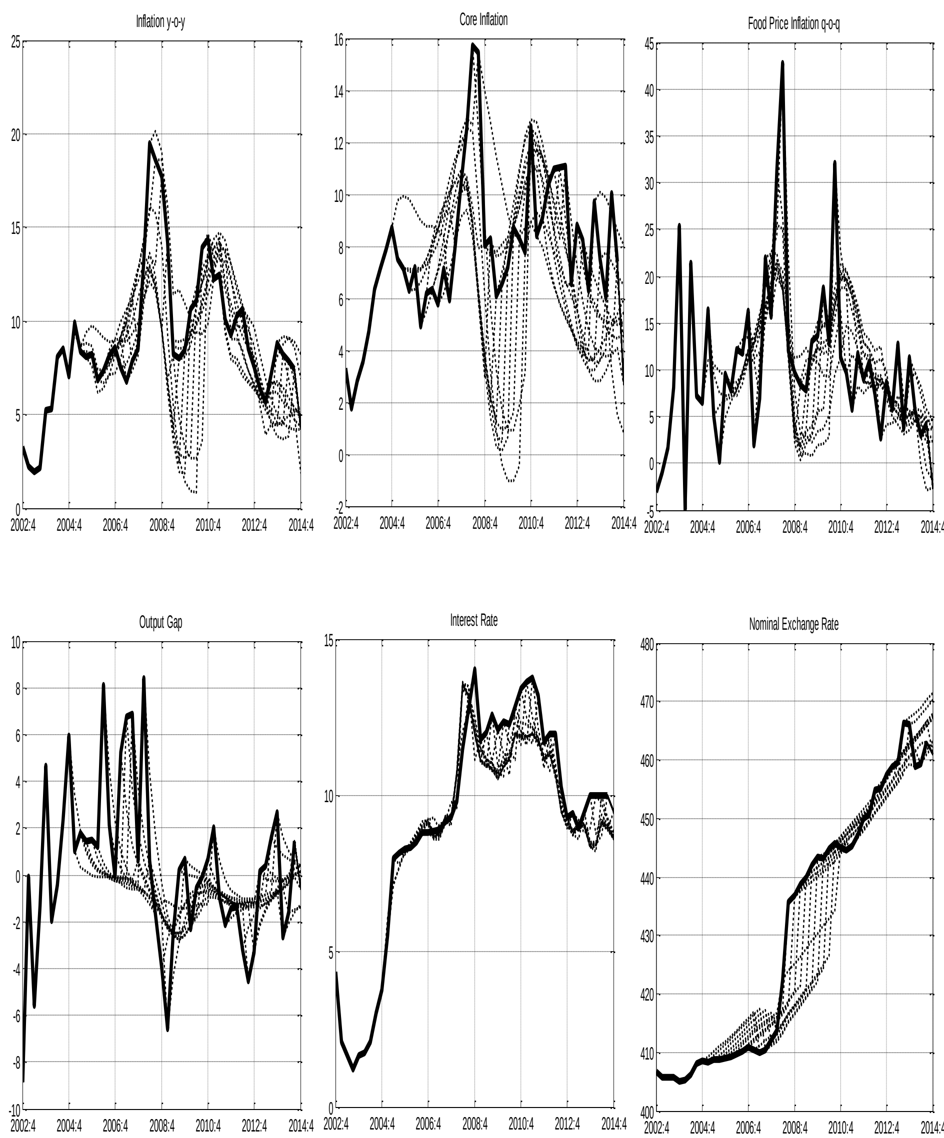
Before we turn to constructing scenarios for policy-making, it is important to know how does out model perform relative to actual values. Figure 3 shows the in-sample recursive forecasts and actual data of key economic variables. Model forecasts for headline inflation, core inflation and food inflation have been reasonably close to actual data with the exception of high volatility period of financial crisis (2008 to 2010). In this period, the model has been over predicting the fall in prices. Given the fact that the model is based upon gap analysis under the implicit assumption that actual values of variables are not far away from their respective steady states, poor inflation forecast in presence of large fuel and food price shocks of 2008 are not surprising.

As noted in the calibration section, we have used LSM as proxy of GDP. Although LSM is positively correlated with GDP yet it is much more volatile than GDP. Apart from volatility, LSM shows a high degree of seasonality. The model captures most of the fluctuations of LSM. Since model has been over predicting the fall in prices, therefore interest rate forecasts are downward biased. General equilibrium nature of the model forces exchange rate forecast to be in line with domestic and foreign interest rate differential in the short run. In the medium term, model projects exchange rate to converge towards a level implied by domestic and foreign inflation differential. Since domestic and foreign inflation differential in steady ($\pi^T - \pi_X^T$) is about 6%, therefore to stay in equilibrium i.e. to avoid over-valuation of PKR against USD, the model calls for a secular depreciation of PKR. Since the model abstracts from capital

[10] All price indices are from Base FY2007-08

flows or foreign exchange reserves, it fails to forecast the relatively stable period of 2004-2007 and FX crisis of 2008. However, the model does a reasonable job in forecasting the exchange rate during 2010-2013.

Figure 3: In-Sample Recursive Forecasts



Making pictorial evaluations in order to check the forecast accuracy of various forecasted variables is at best interesting, but not rigorous. Therefore, we now turn to a comprehensive out-of-sample evaluation of Y-o-Y headline inflation forecasts over 2, 4, 6 and 8 quarter horizons.

This exercise is carried out for the low, high and moderate inflation periods in Pakistan given by $Q_3$2002-$Q_2$2007, $Q_3$2007-$Q_2$2009 and $Q_3$2009-$Q_4$2014 respectively. The selection of horizons and forecasting periods is based on the forthcoming work by Hanif and Malik (2015). The models selected to compete against the FPAS also come from the Hanif and Malik (2015). Hanif and Malik (2015) extensively evaluate forecasts of most econometric models available for Pakistan and provide guidance so as to which econometric model dominates over the economic cycle. They found that no one model was superior but using averages as well using trimmed-forecasts outperforms specific models.

Table 9: Root Mean Squared Errors for Evaluation of Inflation Projections

	$Q_3$2002-$Q_2$2007		$Q_3$2007-$Q_2$2009		$Q_3$2009-$Q_4$2014	
	Econometric Model*	**FPAS**	**Econometric Model**	**FPAS**	**Econometric Model**	**FPAS**
2-Quarters	1.74	1.18	3.26	3.68	2.4	1.63
4-Quarters	2.46	2.66	4.84	7.23	2.82	2.14
6-Quarters	5.68	5.02	2.57	5.70	2.32	1.70
8-Quarters	2.72	5.76	3.58	4.48	2.52	1.72

*Econometric Model is chosen from a suite of 15 different econometric models based upon criteria of minimum RMSE from Hanif and Malik (2015, forthcoming).

In order to evaluate FPAS, we choose the best combination of econometric models suggested for each period in Hanif and Malik (2015); therefore, giving the FPAS a tough evaluation environment for its inflation projections. We use root mean squared errors (RMSE) of recursive forecasts to evaluate the forecasting performance of FPAS and best-combination models in Hanif and Malik (2015), with the difference that in this paper out-sample forecasts are compared with the actual data whereas in Hanif and Malik (2015) forecasts are evaluated against either a Random Walk, ARIMA or AR(1). This further intensifies the evaluation environment for FPAS and the results are reported by horizon in Table 9.

The results are striking in that RMSE are close irrespective of the period evaluated. This implies that the inflation projections of our micro-founded-rich model are as good as the combined forces of alternatives. However, let us delve deeper into periods of evaluation to establish the superiority of FPAS. For the period of $Q_3$2009-$Q_4$2014, a moderately inflationary period, FPAS clearly dominates the combined power of econometric models in that RMSE is lower for FPAS than the alternatives. For the period $Q_3$2002-$Q_2$2007 period, FPAS and the alternative have similar RMSE with the exception of 8 quarter horizon of the alternatives are better. However, for the $Q_3$2007-$Q_2$2009 period, FPAS model under performs but for only quarter four and six.

The overall conclusion is that FPAS offers inflation projections that are superior to the combination of best alternatives available in the market. This is especially true for normal or moderate inflation periods.

5. Use of Model for Policy Analysis

In order to use model for policy analysis, we analyze impulse response functions of key variables to different shocks, purely model-based forecasts and forecasts under different scenarios related to economic factors.

5.1. Impulse Response Functions

5.1.1. Nominal Interest Rate Shock

1% shock in nominal interest rate causes surge in real interest rate gap and tightens monetary conditions. Higher domestic interest rate causes capital inflows and nominal exchange rate decline-i.e. causing appreciations of PKR against dollar. The appreciation of nominal exchange rate causes drop in real exchange-rate gap, which further contributes to tight monetary conditions through exchange-rate channel. Tighter monetary conditions reduce aggregate demand and ease pressure on core inflation. Reduction in core inflation causes reduction in overall inflation. Since core and food inflation expectations are linked to next period overall inflation level, therefore fall in overall inflation causes further reduction of core and food inflations. 1% interest rate shock causes about 0.35% reduction in overall inflation and it takes almost a year before inflation fully responding to interest rate shock. The same shock causes about 2% appreciation in nominal exchange rate. These chain of events are summarized as follows:

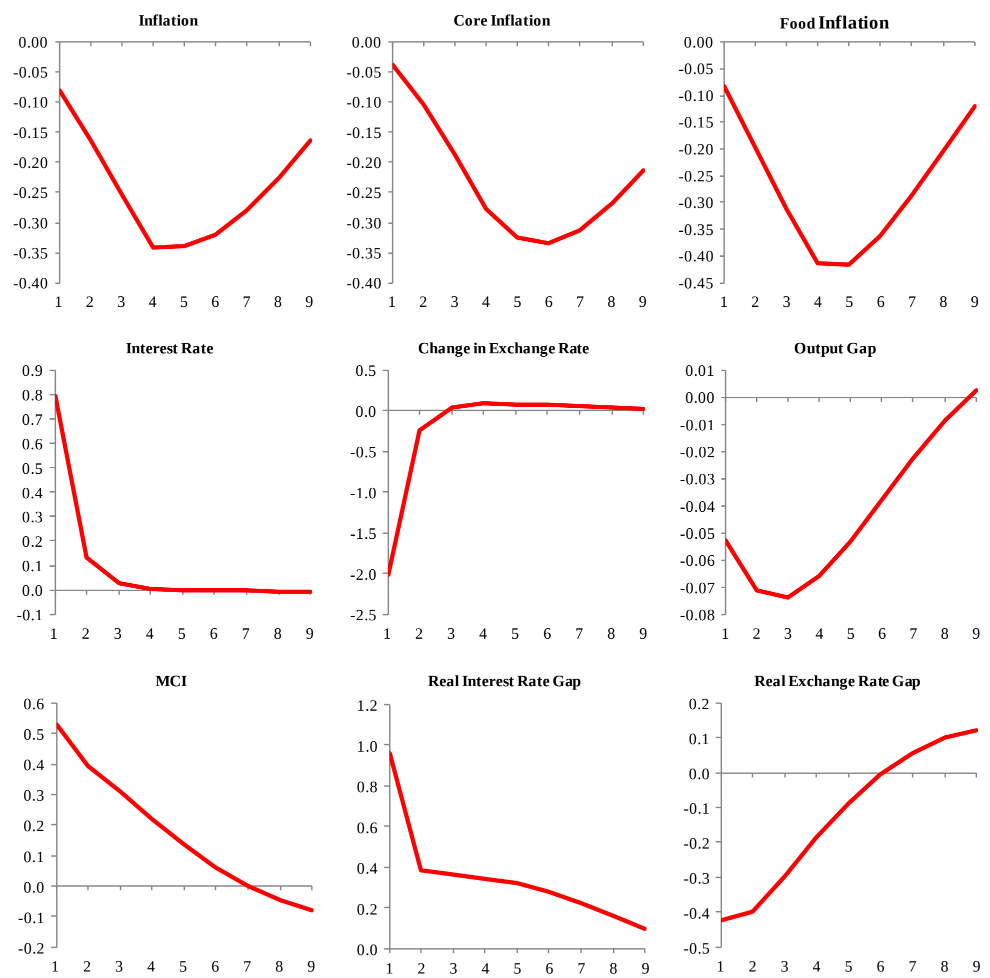
Interest Rate Channel:

$$\varepsilon_t^i \uparrow \Rightarrow i_t \uparrow \Rightarrow r_t \uparrow \Rightarrow \hat{r}_t \uparrow \Rightarrow MCI \uparrow \Rightarrow \hat{y}_t \downarrow \Rightarrow \pi_t^{core} \downarrow \Rightarrow \pi_t \downarrow$$

Exchange Rate Channel:

$$\varepsilon_t^i \uparrow \Rightarrow i_t \uparrow \Rightarrow s_t \downarrow \Rightarrow z_t \downarrow \Rightarrow \hat{z}_t \downarrow \Rightarrow MCI \uparrow \Rightarrow \hat{y}_t \downarrow \Rightarrow \pi_t^{core} \downarrow \Rightarrow \pi_t \downarrow$$

Figure 4: IRFs in Response to a 1% Interst Rate Shock



5.1.2. Aggregate Demand Shock

1% shock in output gap puts pressure on prices and raises core inflation. The persistence of shock to output gap and inflation expectations causes a further increase in inflation till almost four quarters. The central bank responds to rising inflation by raising interest rate, this increase in interest rate invites capital inflows and causes nominal exchange rate appreciation. Nominal appreciation causes real exchange rate appreciation. Calibrations show that exchange rate is the most important variable in Taylor rule of the central bank. Moreover, real exchange rate has 80% share in MCI. Although real interest rate gap shows that nominal interest rate response to rise in inflation is not sufficient enough to raise real interest rate. However, the large share of real exchange rate in MCI ensures tightening of MCI against rising inflation due to aggregate demand shock. The chain of events describing these channels is presented below.

$$\hat{y}_t \uparrow \Rightarrow rmc_t^{core} \uparrow \Rightarrow \pi_t^{core} \uparrow \Rightarrow \pi_t \uparrow$$

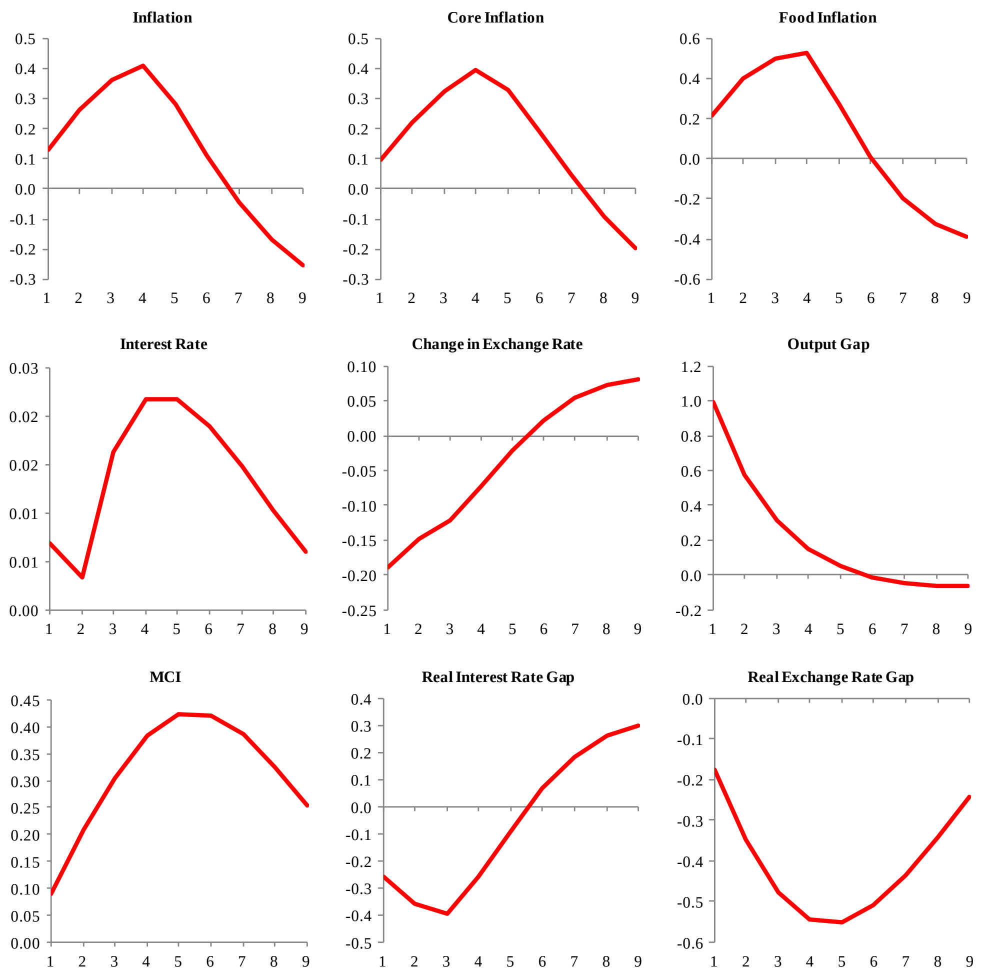
Interest Rate Channel:

$$i_t \uparrow \Rightarrow r_t \uparrow \Rightarrow \hat{r}_t \Rightarrow MCI \uparrow \Rightarrow \hat{y}_t \downarrow \Rightarrow \pi_t^{core} \downarrow \Rightarrow \pi_t \downarrow$$

Exchange Rate Channel:

$$i_t \uparrow \Rightarrow s_t \downarrow \Rightarrow z_t \downarrow \Rightarrow \hat{z}_t \downarrow \Rightarrow MCI \uparrow \Rightarrow \hat{y}_t \downarrow \Rightarrow \pi_t^{core} \downarrow \Rightarrow \pi_t \downarrow$$

Figure 5: IRFs in Response to 1% Aggregate Demand Shock

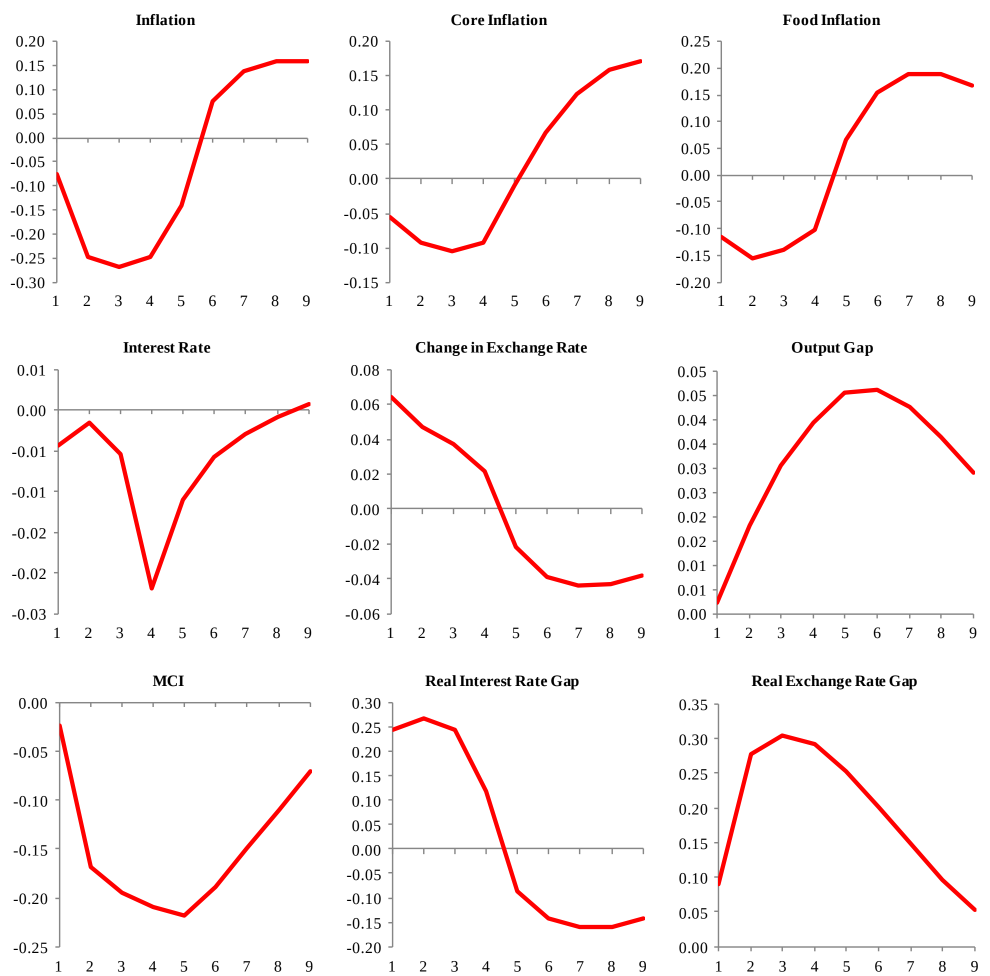


5.1.3. Oil Price Shock

A 10% decrease in world oil price will cause almost 0.1% immediate decreases in headline inflation. Although oil prices constitute only 7% of CPI yet pass-through from world oil price to domestic oil price is quite strong ($b_{32} = 0.80$). Reduction in headline inflation will cause a reduction in core and food inflation through the expectations channel. Falling inflation will raise real interest rate gap and require the central bank to respond by lowering interest rate. Declining interest rate will cause capital outflows, depreciation in nominal exchange rate and positive real exchange rate gap. Now, real interest rate gap and real exchange rate gap are moving in opposite directions: interest rate gap indicates tightening and exchange rate gap indicates easing monetary conditions. Real exchange rate gap will be dominant due to its high share in MCI. Easing MCI will boost aggregate demand which will put pressure on inflation. Inflation ends up being at higher level than its pre-shock level.

$$\varepsilon_t^{\pi^{oil}} \downarrow \Rightarrow \pi_t^{oil} \downarrow \Rightarrow \pi_t \downarrow \Rightarrow E(\pi_{t+1}) \downarrow \Rightarrow \pi_t^{core}, \pi_t^{food} \downarrow \Rightarrow \pi_{t+1} \downarrow \Rightarrow i_t \downarrow \Rightarrow r_t \downarrow \Rightarrow \hat{r}_t \downarrow \Rightarrow MCI \downarrow \Rightarrow \hat{y}_t \uparrow$$

Figure 6: IRFs in Response to 10% Decline in Oil Prices



5.1.4. Core Inflation Shock

1% shock to Q-o-Q core inflation will show its full impact on Y-o-Y core inflation with some time lag. Central bank responds to rising inflation by raising interest rate. As noted earlier, raise in nominal rate is not sufficient enough to raise real interest rate. However, rise in interest rate invites capital inflows and nominal exchange rate appreciates by 0.10%. Unlike the interest rate, nominal exchange rate appreciation is enough to cause real appreciation that leads towards tightening of monetary conditions index. Tightening of MCI causes output gap to become negative and removes pressure from price level. This chain of event is described as follows:

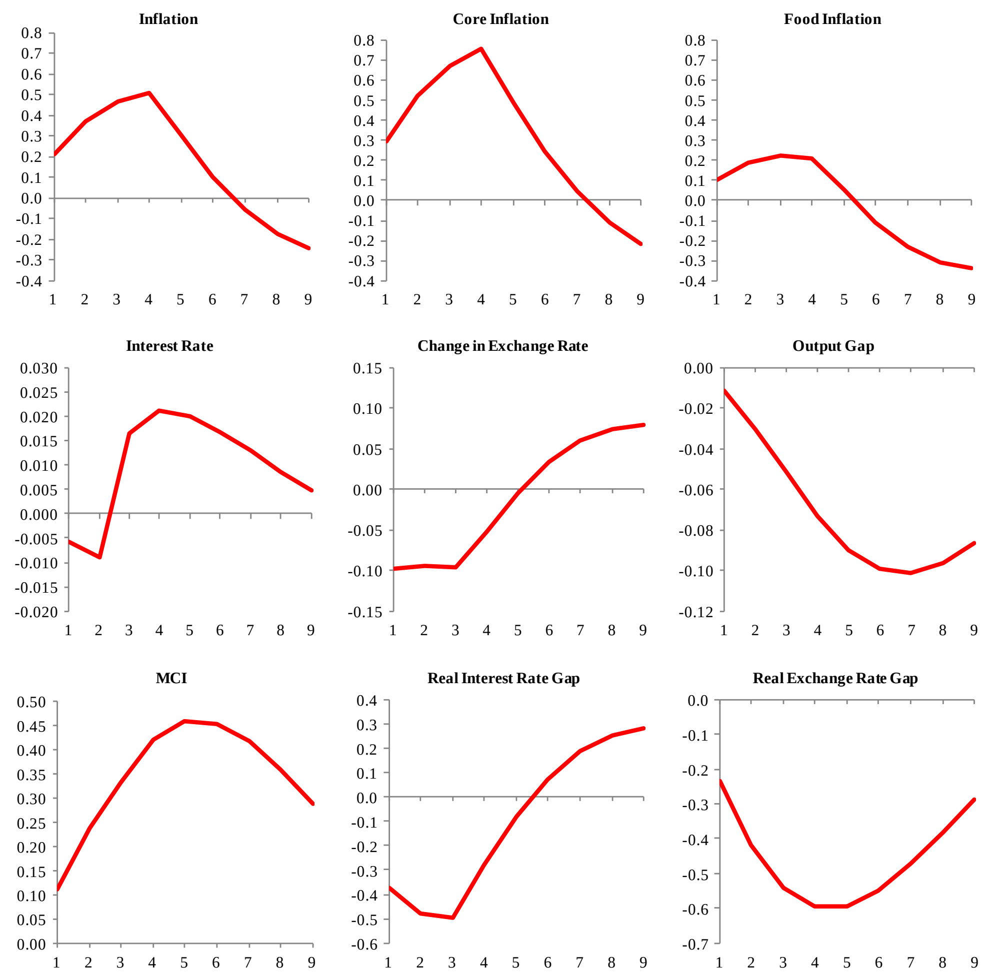
Interest Rate Channel:

$$\pi_t^{core}\uparrow \Rightarrow \pi_t \uparrow \Rightarrow E(\pi_{t+1})\uparrow \Rightarrow i_t \uparrow \Rightarrow r_t \uparrow \Rightarrow \hat{r}_t \uparrow \Rightarrow MCI \uparrow \Rightarrow \hat{y}_t \downarrow \Rightarrow \pi_t^{core} \downarrow \Rightarrow \pi_t \downarrow$$

Exchange Rate Channel:

$$i_t \uparrow \Rightarrow s_t \downarrow \Rightarrow z_t \downarrow \Rightarrow \hat{z}_t \downarrow \Rightarrow MCI \uparrow \Rightarrow \hat{y}_t \downarrow \Rightarrow \pi_t^{core} \downarrow \Rightarrow \pi_t \downarrow$$

Figure 7: IRFs in Response to 1% Core Inflation Shock



5.2. Forecasts

After discussing some of the impulse response functions, we will now discuss the baseline forecast and some alternative scenarios.

5.2.1. Baseline Forecast

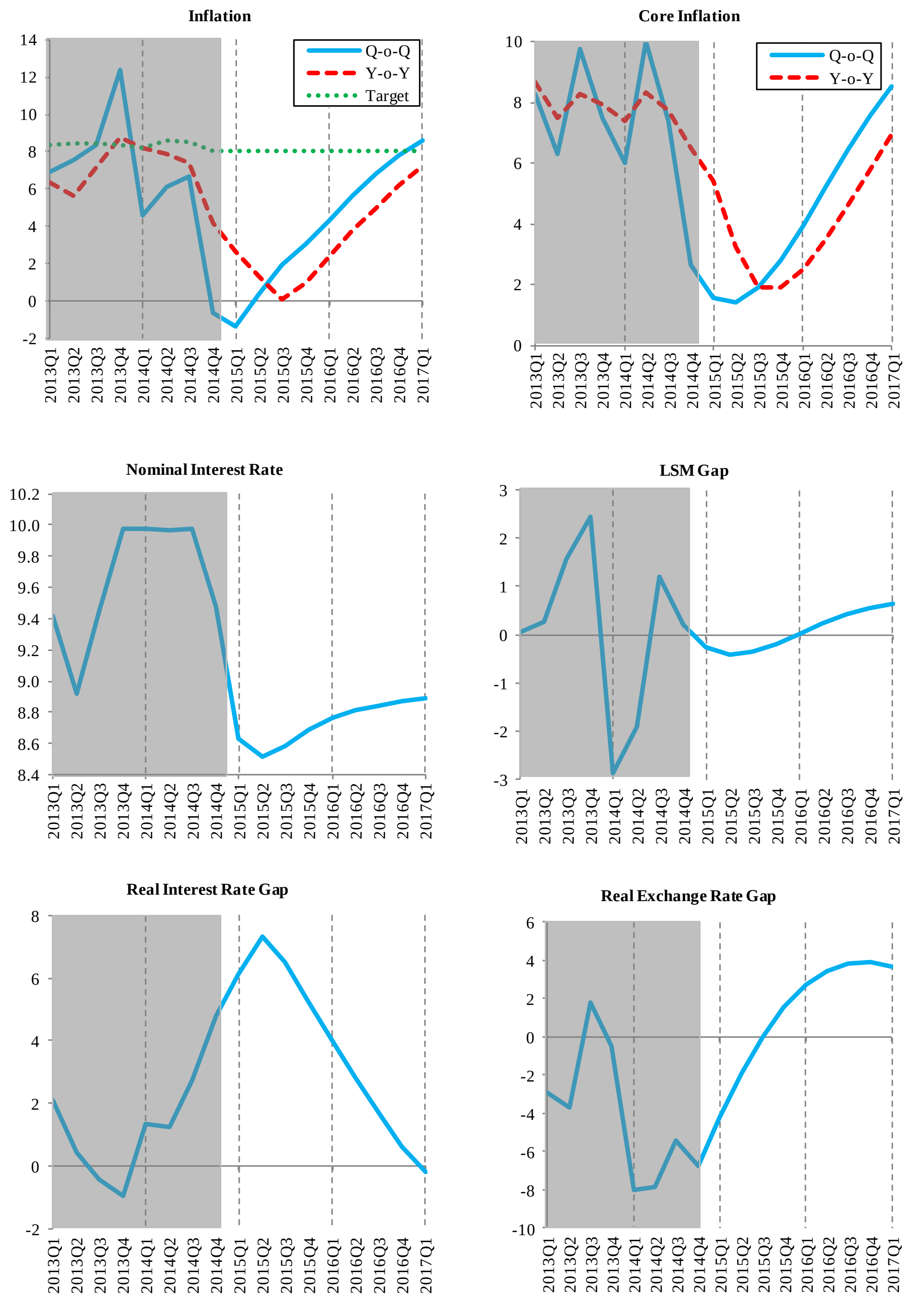
The purely model based forecast is obtained by solving the model under given initial conditions of output gap, real interest rate gap, real exchange rate gap and different inflation series. These gaps are worked out by application of Kalman Filter to decompose aggregate time series into gap and equilibrium/trend components. In order to improve baseline forecast, we incorporate information that is not contained in model or initial conditions. For instance, Figure 7 presents baseline forecasts under the assumption that domestic oil prices will fall by 20% in first quarter of calendar year 2015. This is an interesting variable to consider because the Government of Pakistan is responsible for the pass-through of oil price-shocks to petrol pump prices.

The output of the forecast in Figure 7 is presented in an informative fashion. The grey area shows the actual past to current values of a variable of interest. The white areas plot the model based forecast of key variables of interest. This way of presenting the plots allow to some extent for a counterfactual for each variable of interest. This then helps the policy maker to contextualize the information at the time of decision making in very general-equilibrium sense. Now, let us examine the result of this forecast exercise. The baseline forecast projects Y-o-Y inflation to fall from an initial 4.2% in 2014Q4 to almost zero percent in $2015Q_3$, assuming current information and past behavior. This decline in inflation is caused by slightly negative output gap, negative real exchange rate gap and positive real interest rate gap. Apart from these demand-compressing conditions, falling oil prices also contribute to a lower projection of inflation. The interest rate forecast constitutes the recommendation of the model regarding monetary policy decision. Considering negative exchange rate gap, positive interest rate gap and falling inflation due to oil prices, the model calls for a policy rate cut of almost 100 basis points in this scenario given all current information.

5.2.2. Alternative Scenarios

The alternative scenarios allow a robustness analysis to the baseline forecast and offer comparisons of different policy trade-offs. These alternative scenarios are constructed by creating potential shocks in our endogenous variables. For the sake of demonstration, we present few alternative scenarios to test the robustness of our baseline forecast.

Figure 8: Baseline Forecast



Scenario I: -2% Consumer Confidence Shock for Next Two Quarters

Owing to political uncertainty or other vulnerabilities associated with the economy, a lower consumer-confidence can boost savings for precautionary measures and reduce consumption and investment; resulting in lower aggregate demand. Figure 8 shows that output gap will be 2% more negative due to shock. This will lead towards a lower level of inflation, interest rate and less appreciated exchange rate relative to the baseline.

Scenario II: Oil prices remain stable in 2015 but pick up in 2016 to reach $100 mark in 2017Q1

Figure 9 shows a hypothetical medium term scenario regarding global oil prices. It assumes that after reaching a low level of $47 per barrel in February 2015, they are likely to remain stable during 2015 and then gradually recover in 2016 to reach $100 per barrel in 2017Q1. The headline, food and core inflation are likely to be higher than baseline in this scenario. Since this scenario is quite close to the internal persistence of the model, no drastic differences from the baseline forecast are observed in this particular alternative scenario.

Scenario III: Change in Policy Rate

We can use the model to analyze how different variables will behave corresponding to different scenarios of policy rate. Figure 10 analyzes how other variables will behave if interest rate is increased from 9.5% to 10.5%. This leads to an overall tightening of the monetary condition index in that the real-interest gap increases while the real exchange rate gap continues to present challenges in terms of competitiveness. The overall impact is falling output and inflation.

Figure 9: Alternative Scenario I: 2% Consumer Confidence Shock

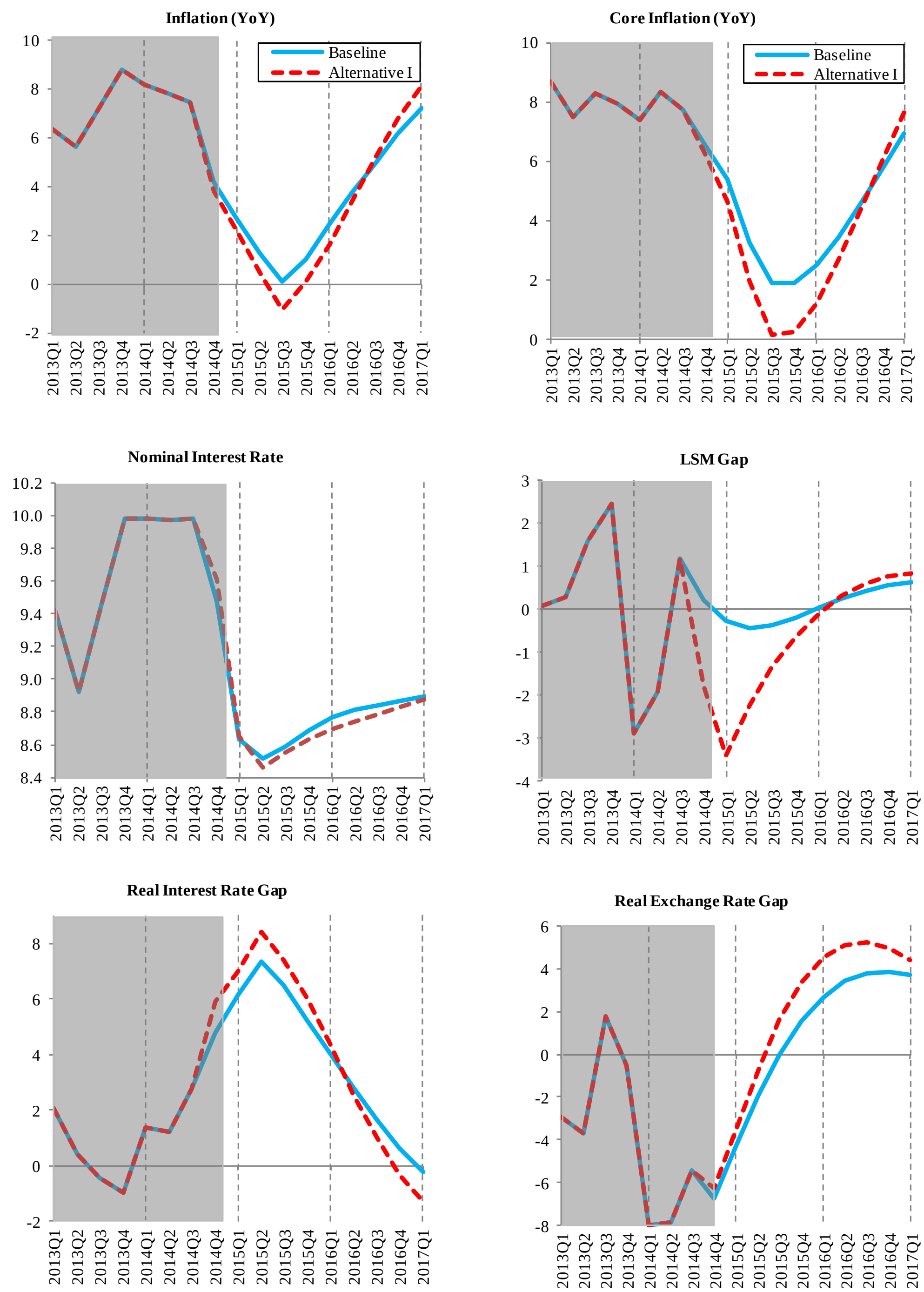


Figure 10: Alternative Scenario II: % Medium Term Oil Price Scenario

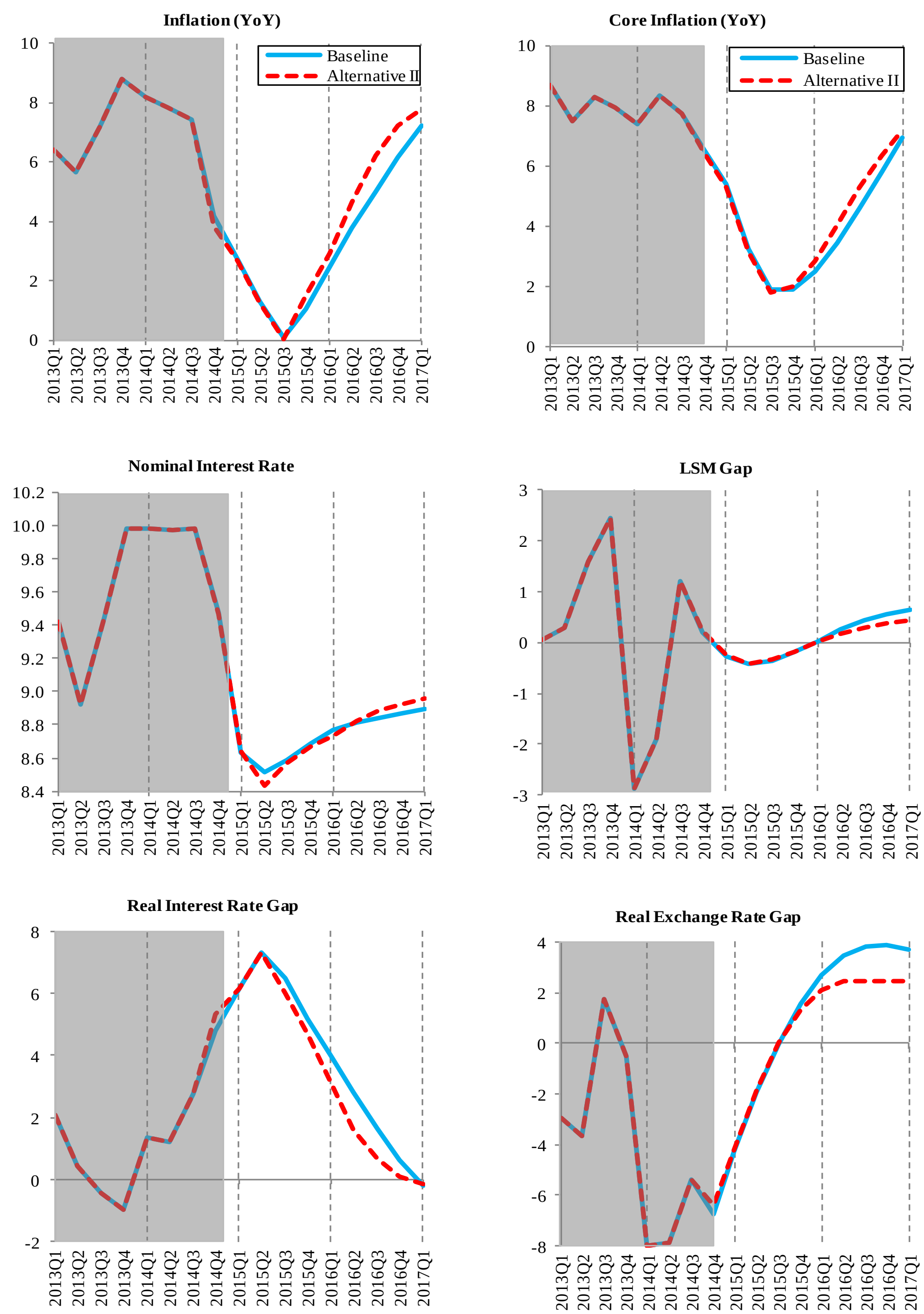
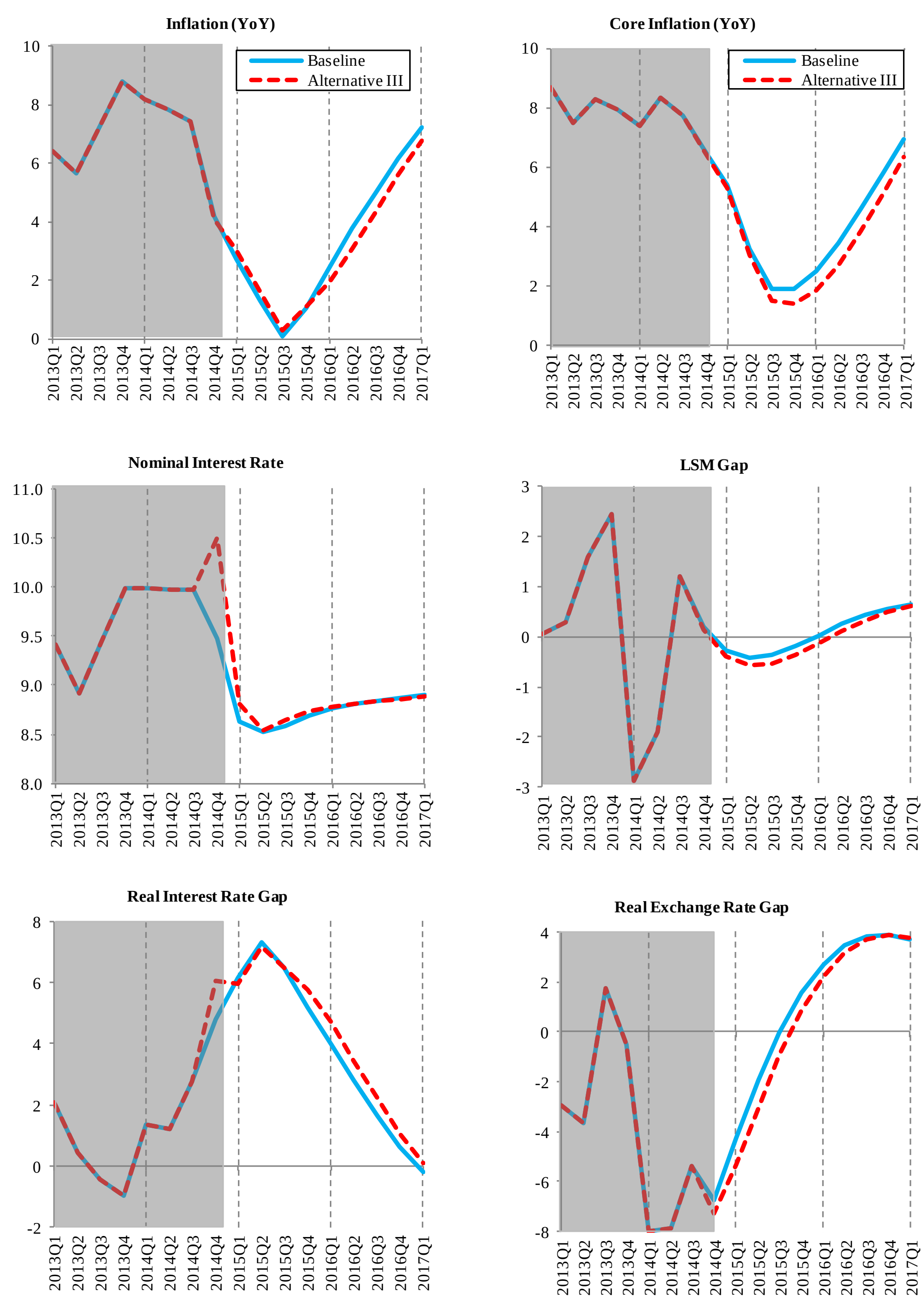


Figure 11: Alternative Scenario III: Policy Rate Scenario



6. Conclusion

The objective of the paper is to introduce a working reduced-form open economy DSGE model- also known as the FPAS, for Pakistan economy using appropriate long-term and short run parameters. The model also integrates behavioral features of policy-makers by incorporating, where feasible, some of their expert assessment regarding some of the short run parameters. In an out-of-sample forecasting exercise considering upto eight-quarter horizon, the model appears to perform well compared to the combined-forces of econometric models. In particular, in periods of moderate inflation, the FPAS model outperforms the econometric models. However, the forecast accuracy falls, but only for medium-term horizon, in times of large unexpected shocks such as the one experienced in 2008. Furthermore, it also makes scenario-building exercise a relatively easy task. In a companion paper, we improve the aggregate supply block of the present model by integrating the essential role of administrated prices in Pakistan; and we compare our augmented-model with competing forecasting methodologies.

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Appendix: Identities and Definitions

Real interest rate (domestic and foreign), output and exchange rate gaps are obtained by subtracting trend values from their actual counterparts.

$$\hat{r}_t = r_t - \bar{r}_t$$

$$\hat{r}_t^* = r_t^* - \bar{r}_t^*$$

$$\hat{y}_t = \ln y_t - \ln \bar{y}_t$$

$$\hat{z}_t = \ln z_t - \ln \bar{z}_t$$

Quarterly levels and changes are linked through following identities

$$\ln s_t = \ln s_{t-1} + \frac{\dot{s}_t}{4}$$

$$\ln \bar{s}_t = \ln \bar{s}_{t-1} + \frac{\Delta \bar{s}_t}{4}$$

$$\ln \bar{z}_t = \ln \bar{z}_{t-1} + \frac{\dot{\bar{z}}_t}{4}$$

$$\ln \bar{y}_t = \ln \bar{y}_{t-1} + \frac{\Delta \bar{y}_t}{4}$$

$$\ln P_t = \ln P_{t-1} + \frac{\pi_t}{4}$$

$$\ln P_t^* = \ln P_t^* + \frac{\pi_t^*}{4}$$

$$\dot{z}_t = 4(\ln z_t - \ln z_{t-1})$$

$$\dot{y}_t = 4(\ln y_t - \ln y_{t-1})$$

Q-o-Q series of headline, core and food inflation are converted into their Y-o-Y counterparts by taking averages over 4 quarters.

$$\pi 4_t = \frac{(\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3})}{4}$$

$$\pi 4_t^{core} = \frac{\left(\pi_t^{core} + \pi_{t-1}^{core} + \pi_{t-2}^{core} + \pi_{t-3}^{core}\right)}{4}$$

$$\pi 4_t^{food} = \frac{\left(\pi_t^{food} + \pi_{t-1}^{food} + \pi_{t-2}^{food} + \pi_{t-3}^{food}\right)}{4}$$

Foreign real interest rate has been defined as nominal interest rate minus inflation.

$$r_t^* = i_t^* - \pi_t^*$$