Monetary policy analysis in an inflation targeting framework in emerging economies: The case of India

Rudrani Bhattacharya Ila Patnaik*

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Abstract

Monetary policy in India has moved towards an increasingly flexible exchange rate regime without any explicit framework for an alternative nominal anchor. The failure of monetary policy to anchor inflationary expectations of agents, coupled with negative supply shocks has kept inflation above the acceptable range of 5-5.5% for last five years in India. In this paper we present a model for policy analysis for India that provides insights in the setting of an inflation targeting framework to anchor inflationary expectations. The model offers an understanding of the extent to which various shocks, including the post-global crisis fiscal stimulus, accommodative monetary policy and ensuing decline in global demand, explain growth and inflation in India.

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Keywords: Inflation, Monetary policy, India, Emerging economies

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1 Introduction

Monetary policy in India is motivated by the multiple objectives of fostering economic growth, controlling inflation and dampening the volatility of exchange rate movements. However, for the past five years, India is suffering from chronic inflation that is persistently hovering above the central bank's acceptable range of 5-5.5%. In this backdrop, anchoring inflation has emerged as one of the major challenges of the central bank, the Reserve Bank of India (RBI).

In this paper, we apply a semi-structural New Keynesian open economy model following Berg et al. (2006a,b); Boz et al. (2008) for India. These have been used both in countries with a full-fledged inflation targeting (IT) framework, as well as those transitioning to an IT regime (Andrle et al., 2013b; Anand et al., 2011).

Using this framework, we analyse the role of monetary policy in an inflation targeting framework, that will help in anchoring inflationary expectations. First, we filter international and Indian data on output, aggregate inflation, the exchange rate and the policy interest rate to recover a model-based decomposition of these variables into trends (or potential values) and gaps (cyclical movements). Second, we recover the sequence of domestic and international macroeconomic shocks that account for business cycle dynamics in India during 2005 Q1–2013 Q2. Finally, we present a model based interpretation of the current macroeconomic scenario in India.

Our model economy, calibrated to Indian data, performs satisfactorily in terms of historical decomposition of macroeconomic shocks. Our model captures the contribution of an aggregate demand shock, due to the post-global crisis fiscal stimulus, that pulled the output gap upward since 2010 Q1. The positive domestic aggregate demand shock outweighed the negative foreign demand shock. The negative foreign demand was additionally compounded by real exchange rate appreciation. The net effect was high enough to sustain a positive output gap till the beginning of 2012. High positive domestic demand coupled with accommodative monetary policy and supply-side pressures, resulted in unanchored inflationary expectations. This contributed significantly to sustained inflationary pressure above the central bank's acceptable range of 5%.

The rest of the paper is organised as follows. Section 2 describes the evolution of the key features of India's monetary policy framework over time and the role of monetary policy in the recent macroeconomic developments in India. Section 3 presents the model. Section 4 describes the data used in the analysis. Section 5 contains the calibration exercise and the results of the impulse response analysis. Section 6 analyses cyclical behaviour of the economy through a model-based filtration exercise and the historical decomposition of shocks and Section 7 relates this analysis with the macroeconomic episodes since 2009. Finally, Section 8 concludes.

2 Towards an inflation targeting framework in India

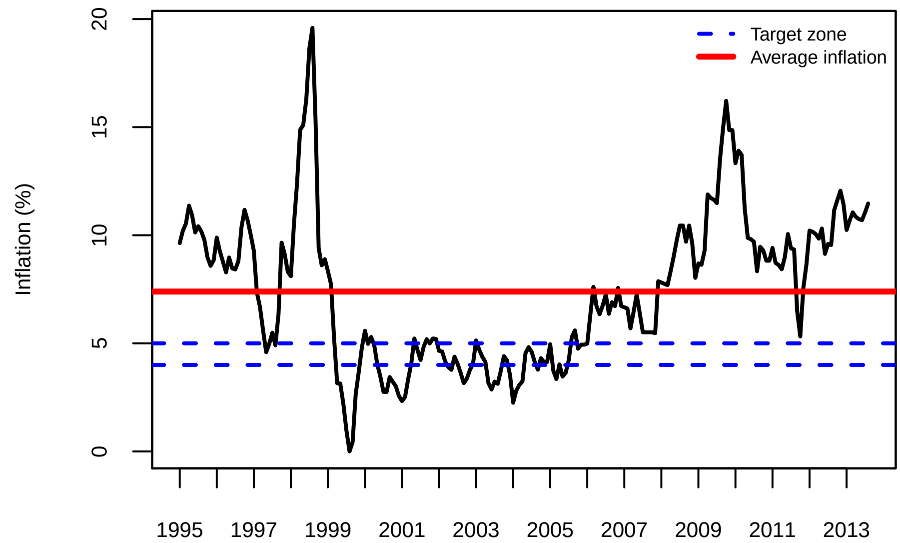
The RBI does not have a formal mandate to target inflation. Until 1991, prices of many goods were administered, there were limited financial markets and administered interest rates and there was no need felt for a monetary policy framework. After the 1991 liberalisation, prices became market determined, as the exchange rate regime changed from an administered rate to a market determined rate. The Indian economy opened up both on the trade account and on the capital account. Though India maintained permanent capital controls, there was a sharp increase in inflows and outflows of capital both due to easing of these controls and due to the controls being circumvented by the private sector (Patnaik and Shah, 2012). With the sharp increase in capital flows in and out of India, the rupee became more flexible. In recent years India is trying to set up a framework for inflation control.

Apart from a brief period in the early 2000s, inflation has remained above desired levels (Figure 1). India has witnessed years of consumer price inflation between 8-10%. In recent surveys, inflationary expectations of households have risen above 10%. Until 2008, monetary policy had a nominal anchor: a de facto peg to the USD (Patnaik, 2007). However, after that, the rupee has become flexible, but there is no nominal anchor (Figure 2).

The low volatility of the rupee dollar rate was achieved through intervention by the RBI in the foreign exchange market. Until 2004, the RBI was able to fully sterilise its intervention, but once it ran out of its holding of government bonds, it set up a new arrangement with the government to sell sterilisation bonds, the Market Stabilisation Scheme (MSS), where the government paid interest on these bonds but could not spend the money borrowed. This greater transparency reduced the extent to which RBI's foreign exchange intervention could be sterilised (Patnaik, 2006). After 2008, as seen in Figure 3, RBI intervention became insignificant.

Figure 1 Consumer price inflation

This figure plots YOY inflation in CPI during April 1995–November 2013. The figure shows that since mid-2005, CPI inflation in India has persistently remained over a desired range of inflation rateof 4-5%.



Since 2008, the rupee has largely been allowed to float (Zeileis et al., 2010). However, though policy shifted away from a pegged exchange rate to a floating exchange rate, monetary policy was left unanchored. The lack of a nominal anchor has contributed to raising inflationary expectations. More recently, the RBI has stated that it has a WPI target of 5% (Rajan et al., 2013).

3 Model

This section presents the building blocks of the model following Berg et al. (2006b); Boz et al. (2008). These types of models, often referred to as gap or core projection models, are used in IT central banks to assess the state of the economy, including the stance of monetary policy. We use such a model to evaluate the monetary policy stance appropriate to the expected inflation in India. The underlying framework of the FPAS model is a standard New-Keynesian model with rational expectations, nominal and real rigidities, with aggregate demand having a role in output determination. The framework blends a reduced form version of the forward-looking general equilibrium model with New-Keynesian features coherent with data.

Figure 2 Rupee volatility

This figure shows the time-series of moving window volatility of the rupee-dollar rate. Each point in the graph is the annualised volatility of two years of weekly percentage changes in the rupee, with a centred window. This shows two dates of structural change in the exchange rate regime, each of which was a near-doubling of exchange rate volatility (Zeileis et al., 2010; Patnaik et al., 2011a). When the headroom for sterilised intervention was lost in 2003, the annualised volatility of the rupee-dollar rate rose from 2.31 per year to 3.93 per year. In March 2007, there was another sharp rise to 9.14 per year.

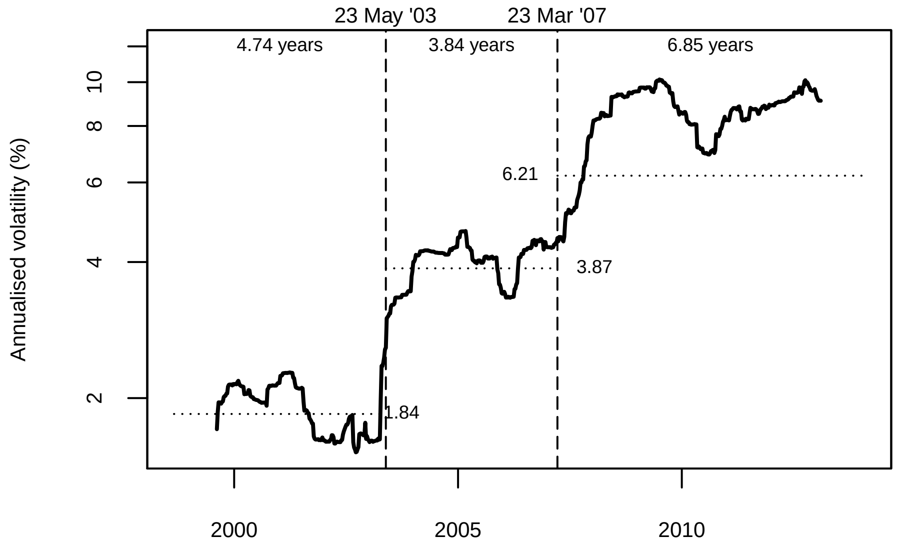
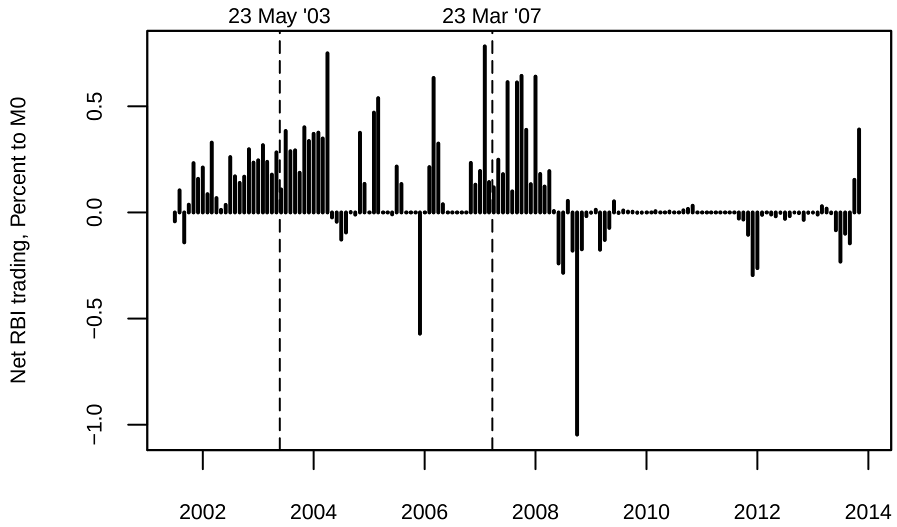


Figure 3 RBI intervention

This figure shows RBI intervention measured by net RBI trading as a share of base money. Intervention has come down sharply since 2008.



The conceptual framework of the model rests on micro-founded dynamic general equilibrium models with New Keynesian features, namely, consumers maximise expected utility and monopolistically competitive firms adjust prices only periodically. However, the model framework does not explicitly model micro-foundations in detail, in contrast to Dynamic Stochastic General Equilibrium Models (DSGE) (Berg et al., 2006b). The advantage of abstracting away from the details of micro-foundations is that, the simulation or estimation of the model are independent of deep parameters of an economy, reliable estimates of which are often not available due to lack of good-quality micro-level data. The model also incorporates adaptive expectations to capture the inertia generally observed in macro data.

Simple models along these lines have several advantages over standard econometric techniques for monetary policy analysis (Berg et al., 2006a). The standard econometric methods such as Vector Auto-Regression (VAR) or Structural Vector Auto-Regression (SVAR) models have the following shortcomings: (1) the econometric models take policy parameters as given and are unable to incorporate forward-looking features. They cannot provide policy-makers with any useful information about the effect of policy changes under alternative rules; (2) the ordering of variables in SVAR framework are sometimes ad-hoc and may lead to identification problems due to misspecification of exclusion restrictions. In contrast, the FPAS framework is structural, as each of its equations carries an economic interpretation. It solves the causality and identification problem, and allows analysis of policy intervention under alternative policy parameters (Berg et al., 2006b).

The model consists of four basic behavioural equations: (1) an expectation augmented aggregate demand, or IS curve, relating current real activity to expected and past levels of real activities, the real interest rate and the real exchange rate; (2) an expectation augmented Phillips curve explaining how the current inflation rate depends on past and expected future inflation rates, the output gap and the exchange rate; (3) an uncovered interest parity condition that partially accommodates the backward-looking expectations on exchange rates; and (4) a monetary policy rule of the central bank for setting the policy interest rate that responds to the output gap and to the deviation of the expected inflation rate from the target inflation rate of the central bank.

Each of the variables in the model is expressed as its deviation from the long run equilibrium level. Given this structure, the model attempts to explain movements in the cyclical components of the variables, taking the long-run equilibrium real output, real exchange rate, real interest rate and the inflation target as given.

3.1 Aggregate demand (IS curve)

We begin by defining the aggregate spending relationship for a small open economy. This equation corresponds to the traditional IS curve augmented by foreign demand and shock as follows,

$$\hat{y_t} = \alpha_1 \hat{y_{t-1}} - \beta rmci_{t-1} + \alpha_4 E_t \hat{y}_{t+1} + \alpha_5 \hat{y_t^*} + \epsilon_t^y \tag{1}$$

where $\hat{y}_t$ and $\hat{y}_t^*$ denote domestic and foreign output gap respectively. We define the variable $rmci_t$ as the real monetary condition index. It is estimated as the weighted average of deviations of real interest rate and real exchange rate z_t from their long term trends respectively,

$$rmci_t = \beta_1 \hat{r}_t - (1 - \beta_1)\hat{z}_t \tag{2}$$

Substituting the expression for $rmci$ in equation (1), we arrive at the aggregate demand equation as

$$\hat{y_t} = \alpha_1 \hat{y_{t-1}} - [\alpha_2 \hat{r}_{t-1} - \alpha_3 \hat{z_{t-1}}] + \alpha_4 E_t \hat{y}_{t+1} + \alpha_5 \hat{y_t^*} + \epsilon_t^y \tag{3}$$

where $\alpha_2 = \beta\beta_1$ and $\alpha_3 = \beta(1-\beta_1)$.

The parameters α_1, α_2, α_3, α_4 and α_5 represent the output gap persistence, impact of the real interest rate gap and the real exchange rate gap on real economic activity, the impact of expected demand on current production and the impact of global economic condition on the domestic economy respectively. If monetary policy affects aggregate demand and output with a lag, the sum of α_2 and α_3 is expected to be smaller than the coefficient of lagged demand gap on output, namely α_1.

The real interest rate r_t is the expected inflation (YOY) adjusted nominal interest rate, $i_t - E_t\pi^A_{t+1}$. The long-term real rate of interest rate $\bar{r}$ is defined as follows

$$\bar{r}_t = \tau_1\bar{r}_{t-1} + (1-\tau_1)\bar{r}^{ss} + \epsilon^{\bar{r}}_t, \tag{4}$$

where $\bar{r}^{ss}$ is the steady state value of the real interest rate.

The aggregate demand shock is denoted by $\epsilon^{\hat{y}}_t$ which follows a normal distribution and does not contain serial correlation.

3.2 Aggregate supply (Phillips Curve))

The expectations-augmented Phillips curve represents the supply-side features of the economy,

$$\pi_t = (1-\theta_1)\pi_{t-1} + \theta_1 E_t\pi_{t+1} + \theta_2 rmc_t + \epsilon^{\pi}_t \tag{5}$$

Here π_t is the annualised seasonally adjusted QOQ inflation in aggregate price index, and $E_t\pi_{t+1}$ is the model-consistent inflation expectations. The parameter θ_1 represents the share of forward-looking agents in the economy, where as $1-\theta_1$ denotes the share of population that follows the rule of thumb of past inflation.

Calvo price-setting determines behaviour of domestic producers and importers over a given time horizon. The real marginal cost condition, rmc_t, reflects both domestic production conditions as well as import side pressures. The latter is captured by the real exchange rate that effects inflation of importables. Given the RMC condition of the economy, both types of suppliers maximise expected profits.

The variable rmc_t is defined as the weighted average of output gap and real exchange rate gap,

$$rmc_t = \theta_3\hat{y}_t + (1-\theta_3)\hat{z}_t \tag{6}$$

The coefficient θ_2 captures the effect of real marginal cost on inflation. The aggregate supply shock, denoted by ϵ_t^π also follows a normal distribution and does not contain serial correlation.

The Phillips curve equation suggests, higher the value of θ_1, the more is current inflation determined by expected future inflation. In this case, a small but persistent monetary policy change will substantially alter the current rate of inflation via the forward-looking inflation expectation behaviour of agents. In contrast, if θ_1 is small, current inflation is determined by the dynamics of past inflation. In such a scenario, sustained interest rate adjustments over a period of time will be able to move current inflation towards the target rate of inflation.

The effect of real exchange rate changes on inflation is captured by the effect $\theta_2(1-\theta_3)$. The magnitude of this effect will be large if the consumption basket of the economy includes a large share of importables.

3.3 Uncovered Interest Parity (UIP) condition

We assume that the currency regime is a floating exchange rate. The UIP condition is specified as follows,

$$s_t = \rho_1 E_t s_{t+1} + (1-\rho_1)(s_{t-1} + \frac{1}{2}\Delta\bar{s}_t) + (i_t^* - i_t + \eta_t + \bar{\eta}_t)/4 + \epsilon_t^s \quad (7)$$

$$\Delta\bar{s}_t = \pi^T - \pi_t^{*ss} + \Delta\bar{z}_t \quad (8)$$

Here s_t denotes the nominal exchange rate, while $E_t s_{t+1}$ is the model consistent expectation of nominal exchange rate in period $t+1$. The domestic and foreign rates of interest (annualised) are denoted by i_t and i_t^* respectively. The deviation from the UIP condition is contained in the movement in premium η_t and its trend value $\bar{\eta}_t$, where the premium η_t follows an AR(1) process as

$$\eta_t = \delta\eta_{t-1} + \epsilon_t^\eta \quad (9)$$

and the long term trend in premium is determined by the UIP condition in real terms which is satisfied in the long run,

$$\bar{r}_t - \bar{r}_t^* = E_t \Delta z_t + \bar{\eta}_t \quad (10)$$

The exchange rate expectation is a weighted average of forward and backward looking expectations. The forward looking expectation of exchange rate at period $t{+}1$ is captured by the term $E_t s_{t+1}$. The backward looking expectation of exchange rate projects exchange rate expectations at period $t+1$ as an extrapolation of the past rate s_{t-1} using the long term growth rate of nominal exchange rate $\Delta\bar{s}_t$. Again, the long term growth rate of nominal exchange rate $\Delta\bar{s}_t$ in turn is the change in exchange rate consistent with long-term economic fundamentals in an open economy as depicted in equation (9). The long term economic fundamentals are captured by trend growth of real exchange rate $\Delta\bar{z}_t$, and long-term inflation targets at home π^T and in the foreign economy π_t^{*ss} respectively.[1]

3.4 Monetary Policy rule (Taylor rule)

Being a floater, the monetary authority is assumed to respond to deviations of the next period's inflation from its target and to the output gap. It is also assumed that the policy stance of the previous period affects the policy stance in the current period. Hence, the monetary authority adjusts the interest rate gradually towards the level required to achieve the target level of inflation along with its response to current output gap. The dynamics of central bank's policy instrument is as follows:

$$i_t = \rho_2 i_{t-1} + (1-\rho_2)(i_t^n + \rho_3(E_t\pi_{t+4} - \pi_{t+4}^T) + \rho_4\hat{y}_t) + \epsilon_t^i \tag{11}$$

where i_t is the short term nominal interest rate and π^T denotes the target rate of inflation. The natural rate of interest rate i_t^n is the rate that keeps output at the potential level. It is the sum of the trend real interest rate and the target rate of inflation at period $t+4$,

$$i_t^n = \bar{r}_t + \pi_{t+4}^T \tag{12}$$

The inflation target of the central bank follows a stochastic process as in (Andrle et al., 2013b),

$$\pi_t^T = \rho_5\pi_{t-1}^T + (1-\rho_5)\bar{\pi}^T + \epsilon_t^{\pi^T} \tag{13}$$

where $\bar{\pi}^T$ is the long run target inflation rate.

[1] The backward looking feature of exchange rate expectations gives rise to persistence in the simulated nominal exchange rate series.

3.5 Defining identities in terms of domestic variables

3.5.1 Output gap block

The output (assumed to be adjusted for seasonal fluctuations) comprises of its potential or trend component and the cyclical component,

$$y_t = \bar{y}_t + \hat{y}_t \tag{14}$$

The annualised QOQ and YOY growth rates of output, Δy_t and $\Delta {y_t}^A$ respectively, and growth rates of trend component of output, $\Delta \bar{y}_t$ and $\Delta {\bar{y}_t}^A$ respectively, are defined as,

$$\begin{aligned}
\Delta y_t &= 4(y_t - y_{t-1}) & (15)\\
\Delta {y_t}^A &= y_t - y_{t-4} & (16)\\
\Delta \bar{y}_t &= 4(\bar{y}_t - \bar{y}_{t-1}) & (17)\\
\Delta {\bar{y}_t}^A &= \bar{y}_t - \bar{y}_{t-4} & (18)
\end{aligned}$$

where y_t is the log of output.

The growth rate of trend output follows a stochastic process as,

$$\Delta \bar{y}_t = (1 - \alpha_6)\Delta \bar{y}^{ss} + \alpha_6 \Delta \bar{y}_{t-1} + \epsilon_t^{\Delta \bar{y}} \tag{19}$$

where $\Delta \bar{y}^{ss}$ is the steady state growth rate of trend component of output.

3.5.2 Inflation block

The annualised QOQ and YOY inflation rates, π_t and π_t^A respectively, are defined as,

$$\begin{aligned}
\pi_t &= 4(p_t - p_{t-1}) & (20)\\
\pi_t^A &= p_t - p_{t-4} & (21)\\
& & (22)
\end{aligned}$$

where p_t denotes domestic aggregate price index in logs.

3.5.3 Exchange rate block

The RER consists of long term trend level and the cyclical component,

$$z_t = \bar{z}_t + \hat{z}_t \tag{23}$$

where z_t is the log of real exchange rate (RER).

The annualised QOQ and YOY growth rates of RER, Δz_t and $\Delta {z_t}^A$ respectively, and growth rates of the trend component of RER, $\Delta \bar{z}_t$ and $\Delta {\bar{z}_t}^A$ respectively, are defined as,

$$
\begin{aligned}
\Delta z_t &= 4(z_t - z_{t-1}) && (24)\\
\Delta {z_t}^A &= z_t - z_{t-4} && (25)\\
\Delta \bar{z}_t &= 4(\bar{z}_t - \bar{z}_{t-1}) && (26)\\
\Delta {\bar{z}_t}^A &= \bar{z}_t - \bar{z}_{t-4} && (27)
\end{aligned}
$$

The growth rate of trend RER follows a stochastic process as,

$$\Delta \bar{z}_t = \tau_2 \Delta \bar{z}_{t-1} + (1 - \tau_2)\Delta \bar{z}^{ss} + \epsilon_t^{\Delta \bar{z}} \quad (28)$$

where $\Delta \bar{z}^{ss}$ denotes the steady state growth rate in trend component of RER.

Similarly, annualised QOQ and YOY growth rates of NER, Δs_t and $\Delta {s_t}^A$ respectively, are defined as the following

$$
\begin{aligned}
\Delta s_t &= 4(s_t - s_{t-1}) && (29)\\
\Delta {s_t}^A &= s_t - s_{t-4} && (30)
\end{aligned}
$$

3.6 PPP condition

The following equation ensures that the purchasing power parity condition holds in the long run,

$$z_t = s_t - p_t + p_t^* \quad (31)$$

3.7 Foreign block

The dynamics of the external variables are specified in the following equations pertaining to the rest of the world.

3.7.1 Foreign output block

$$\hat{y}_t^* = \alpha_7^* \hat{y}_{t-1}^* + \alpha_8^* \hat{r}_t^* + \epsilon_t^{\hat{y}^*} \quad (32)$$

where $\hat{y}_t^*$ is the foreign output gap which is determined by past foreign output gap and foreign interest rate.

The foreign real interest rate is defined as the YOY inflation adjusted nominal interest rate,

$$r_t^* = i_t^* - E_t {\pi_{t+1}^*}^A \tag{33}$$

where $E_t {\pi_{t+1}^*}^A$ is the expected YOY inflation at period $t+1$.

The variable $\hat{r}_t^*$ in equation (32) denotes the deviation of the foreign real interest rate from the long term trend of real interest rate $\bar{r}_t^*$,

$$r_t^* = \bar{r}_t^* + \hat{r}_t^* \tag{34}$$

whereas the trend of the real interest rate is defined as follows,

$$\bar{r}_t^* = \tau_3 \bar{r}_{t-1}^* + (1 - \tau_3)(\bar{r}^*)^{ss} + \epsilon_t^{\bar{r}^*} \tag{35}$$

3.7.2 Foreign inflation block

The annualised QOQ and YOY inflation rates, π_t^* and ${\pi_t^*}^A$ respectively, are defined as

$$\begin{aligned} \pi_t^* &= 4(p_t^* - p_{t-1}^*) & (36) \\ {\pi_t^*}^A &= p_t^* - p_{t-4}^* & (37) \end{aligned}$$

where p_t^* denotes foreign price index in logs.

3.7.3 Foreign policy rule

Foreign nominal interest rate, i_t^*, responds to deviation of YOY foreign inflation from the target $(\pi_t^*)^A - (\pi^*)^{ss}$ and output gap $\hat{y}_t^*$, and adjusts for the past interest rate inertia $\rho_5 i_{t-1}^* + (1 - \rho_5)(\bar{r}_t^* + (\pi^*)^{ss})$. The past interest rate inertia is captured by a weighted average of last period's nominal interest rate i_{t-1}^* and an extrapolation using the trend real interest rate $\bar{r}_t^*$ and the long term target rate of inflation $(\pi^*)^{ss}$.

$$i_t^* = \rho_5 i_{t-1}^* + (1 - \rho_5)(\bar{r}_t^* + (\pi^*)^{ss}) + \rho_6((\pi_t^*)^A - (\pi^*)^{ss}) + \alpha_9 \hat{y}_t^* + \epsilon_t^{i^*} \tag{38}$$

4 Data

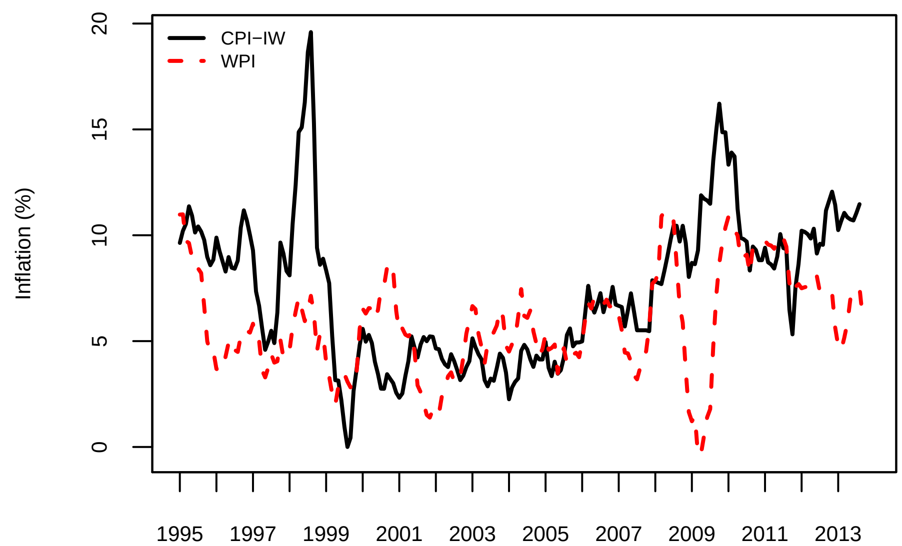
4.1 Measuring inflation

Inflation is measured in India based on the Consumer Price Index (CPI) and the Wholesale Price Index (WPI). There have historically been 4 measures of the CPI [2]. Since January 2011, a single new CPI measure has been created giving weightage to both urban and rural inflation [3].

The WPI is not identical to the Producer Price Index (PPI) as prices are captured at various stages of the distribution chain: starting from prices of raw materials for intermediate and final consumption, or prices of intermediate goods, to prices of finished goods up to the retail stage. Furthermore, the price data used in the WPI may sometimes contain discounts and rebates, taxes and subsidies on products, as well as trade and transport margins.

Figure 4 The divergence between CPI and WPI

This figure shows CPI-IW and WPI based inflation. We see a divergence in the two inflation rates (YOY) particularly after 2009.

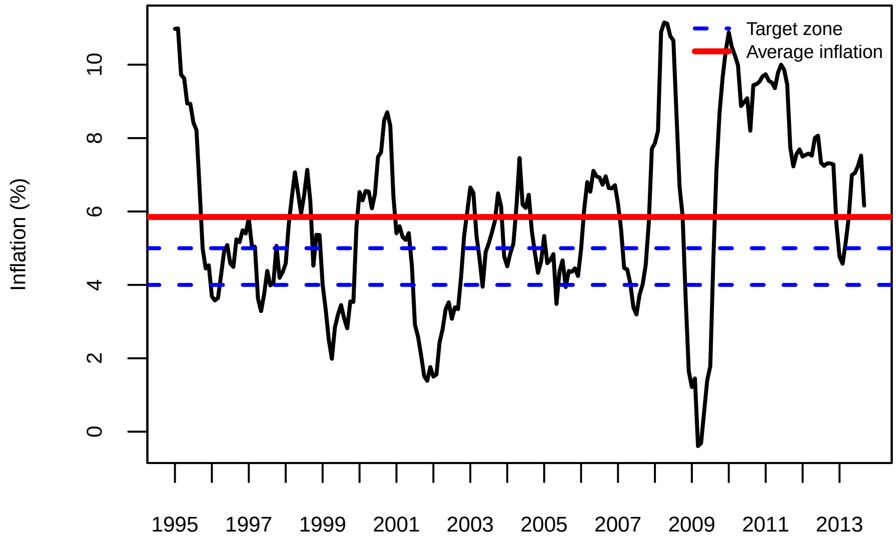


[2]These were the CPI for Industrial Workers (CPI-IW), CPI for Rural Labourers (CPI-RL), CPI for Agricultural Labourers (CPI-AL), and CPI for Urban Non-Manual Employees (CPI-UNME). The Ministry of Statistics and Programme Implementation discontinued CPI-UNME from January, 2011.

[3]The time series of the new CPI inflation is short and does not allow us to do a historical analysis.

Figure 5 Wholesale price inflation

This figure plots YOY inflation in WPI during April 1995–December 2013. The figure shows that since mid-2005, average headline inflation in India has often remained over a desired range of inflation rate of 5%.



The two rates have diverged significantly in the recent past as seen in Figure 4. Ideally consumer price inflation should be used as a measure for the inflation target (Patnaik et al., 2011b). However, the RBI has so mostly used the WPI with an implicit target of 5% (Rajan et al., 2013). Therefore, we use the WPI based inflation rate for measuring inflation with a target rate of 5%t for our analysis.

4.2 Data Specification

The data is described in detail in Table 1. The data for India, includes real GDP measured at factor cost, WPI, the 91-day Treasury Bill interest rate and the rupee US dollar exchange rate. Quarterly GDP data, available from 1996 Q1, is sourced from Datastream. Hence, the period of analysis is 1996 Q1–2013 Q2.

We convert monthly price indices into quarterly indices using the average price level for the three months spanning that particular quarter. The exchange rate is the average for the period. Quarterly interest rate is obtained

Table 1 Description of data

This table summarises the data used in the analysis. It specifies the indicators and the sources of data for each indicator used for the analysis.

Series	Variable	Data used
Output	y	GDP, factor cost, Base: 2004-05
Prices	p	Wholesale Price Index
		All commodities, Base: 2004-05
Nominal exchange rate	s	INR/USD
Nominal interest rate	i	91-day Treasury Bill rate
Foreign demand	y^*	US GDP, Market prices
		Base: 2009, Seasonally adjusted
Foreign prices	p^*	US Consumer Price Index
Foreign nominal interest rate	i^*	US 13-week Treasury Bill rate

by taking the value corresponding to the last month of the quarter.[4] GDP at factor cost at constant prices is available from 1996 Q1 to 2010 Q2 at 1999–2000 base, and from 2004 Q2 at the new base year of 2004–05. We chain link the two series to convert the GDP series to 2004–05 prices starting from 1996 Q1. Similarly, we chain link monthly WPI series at 1993–94 base year spanning the period from April 1994 to December 2010 and the series at 2004–05 base year from April 2004 to obtain a single series at 2004–05 base year prices.

The rest of the world variables, comprising of foreign GDP, price level and interest rate are proxied by US indicators. The US data spans the period from 1995 Q1 to 2013 Q2. The GDP series is at 2009 constant prices and is seasonally adjusted. The price series comprises of CPI for all urban consumers for all items. The interest rate is proxied by the weighted average yield on the 13 week Treasury Bill rate.

5 Calibration

Table 2 and Table 3 summarise the calibrated parameter values. The calibration of coefficients and shocks are based on economic principles, available economic evidence and empirical analysis of data. An iterative calibration

[4]All price series, including exchange rate which captures price of a currency, may show large movements from one month to another within a quarter. Hence it is appropriate to take average rate for that quarter. On the contrary, policy rates for the next quarter are generally declared in the last month of the previous quarter and does not contain much of month-wise variation. Hence, interest rate at the last month of the quarter is taken as a proxy for the quarterly interest rate.

Table 2 Calibration of Parameters

This table reports the calibrated values for the parameters of our model.

Parameter	Description	Value	Source/Remarks
	Output Gap Equation		
α_1	Persistence of output gap	0.75	
α_2	Impact of real interest gap	0.11	
α_3	Impact of real exchange rate gap	0.15	
α_4	Impact of expected demand	0.05	
α_5	Impact of global economic condition	0.12	
	Philips Curve Equation		
θ_1	Share of forward looking agents	0.725	
θ_2	Share of backward looking agents	0.25	
	Costpush Equation		
θ_3	Impact of output gap on RMC	0.76	
	UIP Equation		
ρ_1	Impact of expected nominal exchange rate	0.7	
	Taylor Rule		
ρ_2	Persistence of policy rate	0.69	
ρ_3	Impact of deviation of expected inflation from target	1.23	
ρ_4	Impact of output gap	0.75	
	Auxiliary Equations		
τ_1	Persistence of trend real interest rate	0.7	
τ_2	Persistence of trend RER	0.55	
τ_3	Persistence of foreign trend real interest rate	0.86	
α_6	Persistence of growth rate of trend output	0.62	
α_7	Persistence of foreign output gap	0.8	
α_8	Impact of foreign real interest rate gap	0.2	
α_9	Impact of foreign output gap on policy rate	0.5	
ρ_5	Persistence of foreign policy rate	0.5	
ρ_6	Deviation of annualised foreign inflation from annualised steady state	1.3	
ρ_7	Persistence of inflation target	0.7	

process is followed until the impulse responses and historical shock decompositions of the simulated series closely resemble the empirically observed pattern in the data. The final calibration is consistent with our understanding of the functioning of the economy and sensibility of the model results.

Some of the parameters of the model like the equilibrium level of potential GDP growth rate, real exchange rate, and real interest rate are calculated by taking average of historical data. Other parameters reflect our view of structural features of the Indian economy and are consistent with earlier applications (Berg et al., 2006a; Andrle et al., 2013b). In the IS-curve equation, we give a relatively high weight to the backward-looking component ($\alpha_1 = 0.75$) and a small weight to the forward-looking component. This reflects our view that the expectation of future developments play a small role

Table 3 Trends and Steady-state values

This table reports the steady state values of the endogenous variables calculated by taking the average of historical data.

Parameter	Description	Value
$\Delta\bar{y}$	Growth of trend GDP	6.5
π^T	Inflation target	5
$\Delta\bar{z}$	Growth of trend exchange rate	2%
$\Delta\bar{i}^*$	Foreign interest rate	2.5

in output gap dynamics. The contribution of a real interest rate gap and a real exchange rate gap are calibrated as $\alpha_2 = 0.11$ and $\alpha_3 = 0.15$, with a negative impact of an increase in the real interest rate on the output gap. These parameter values suggest a significant impact of changes in the real interest rate and the real exchange rate on the output gap. Our choice of the parameter value capturing the impact of the real interest rate on output gap falls near the range found in a study on the effect of the real interest rate on investment and growth in India (RBI, 2013). This study finds that an increase in the real interest rate by 100 basis points may reduce GDP growth by about 20 basis points.

In the Phillips curve, we give a high weight to the backward-looking component of inflation ($1-\theta_1 = 0.725$). This is consistent with the current scenario where inflation rate has been quite persistent. In addition, when we estimate a Phillips curve equation using a simple linear regression model, we obtain high estimates for the coefficient of lagged inflation.[5]

We also give a high weight to domestic factors (aggregate demand pressures) as compared to external factors (real exchange rate) in explaining inflation because of the low contribution of imports in the WPI basket. These are calibrated as $\theta_2\theta_3 = 0.19$ and $\theta_2(1-\theta_3) = 0.06$.

For the Taylor rule, we give a high weight to the smoothening component, $\rho_2 = 0.69$. This is consistent with the empirical Taylor rule estimates of Patra and Kapur (2012); Mohanty (2013). The degree of responsiveness to the expected inflation deviation and the aggregate demand pressure in setting the policy interest rates are assumed to be $(1-\rho_2)\rho_3 = 0.38$ and $(1-\rho_2)\rho_4 = 0.23$. This suggests a significant contribution of expected inflation in determining the interest rate.

[5] A simple OLS regression for the Philips curve gives us the following equation: $\pi_t = 0.75(\mathit{0})\pi_{t-1} + 0.25(\mathit{0.3})E_t\pi_{t+1} + 0.099(\mathit{0.8})\hat{z}_t + 0.027(\mathit{0.12})\hat{y}_t$. The values in brackets are the $p-$ values. Significance is checked at 5% level.

Table 4 Trends and Steady-state values

This table reports the standard deviations of shocks to the endogenous variables.

Parameter	**Description**	**Value**
$\epsilon_t^{\hat{y}}$	Shock to output gap	0.25
$\epsilon_t^{\bar{y}}$	Shock to output trend	0.145
ϵ_t^{π}	Shock to inflation	0.5
$\epsilon_t^{\bar{\pi}^T}$	Shock to inflation target	0.075
ϵ_t^{s}	Shock to exchange rate	0.2
$\epsilon_t^{\bar{z}}$	Shock to exchange rate trend	0.2035
$\epsilon_t^{\hat{r}}$	Shock to real interest rate trend	0.07
ϵ_t^{prem}	Shock to premium	0.035
ϵ_t^{i}	Shock to interest rate	0.15
ϵ_t^{i*}	Shock to foreign interest rate	0.095
$\epsilon_t^{\bar{r}r*}$	Shock to foreign interest rate trend	0.08
$\epsilon_t^{\pi*}$	Shock to foreign inflation	0.123
$\epsilon_t^{\hat{y}*}$	Shock to foreign output gap	0.1

In the UIP equation, we allow for model consistent rational expectations for the exchange rate. A higher weight is given to the expected exchange rate as compared to the last quarter's exchange rate, $\rho_1 = 0.7$. This indicates a forward looking foreign exchange market or low central bank intervention, which is consistent with a flexible exchange rate regime in India.

Finally, the last set of parameters, the AR coefficients, and variances of the shocks (Table 4) are calibrated in such a way that they explain recent macroeconomic developments in India. To pin down these parameter values, we start with an initial calibration, assess the model-based decomposition of data, and iterate until the model-based interpretation fits the overall experience of the country.

5.1 Impulse response analysis

In order to understand the behaviour of our model and asses its dynamic properties, we analyse the effect of identified temporary shocks on endogenous model variables[6]. The impulse response functions to a temporary aggregate demand shock, a supply shock and a monetary policy shock are shown in Figures 6 to 8.

The response of endogenous macroeconomic variables to a 1% temporary shock to the aggregate demand equation is shown in Figure 6. The source of the shock can originate from fiscal policy or a change in foreign demand, etc.

[6]Results are presented in terms of deviation from the equilibrium level.

Figure 6 Impulse responses due to aggregate demand shocks

This figure shows impulse responses of the output gap, the deviation of inflation from the target, the deviation of the interest rate and the exchange rate from their long run trend values due to a 1% temporary shock to aggregate demand.

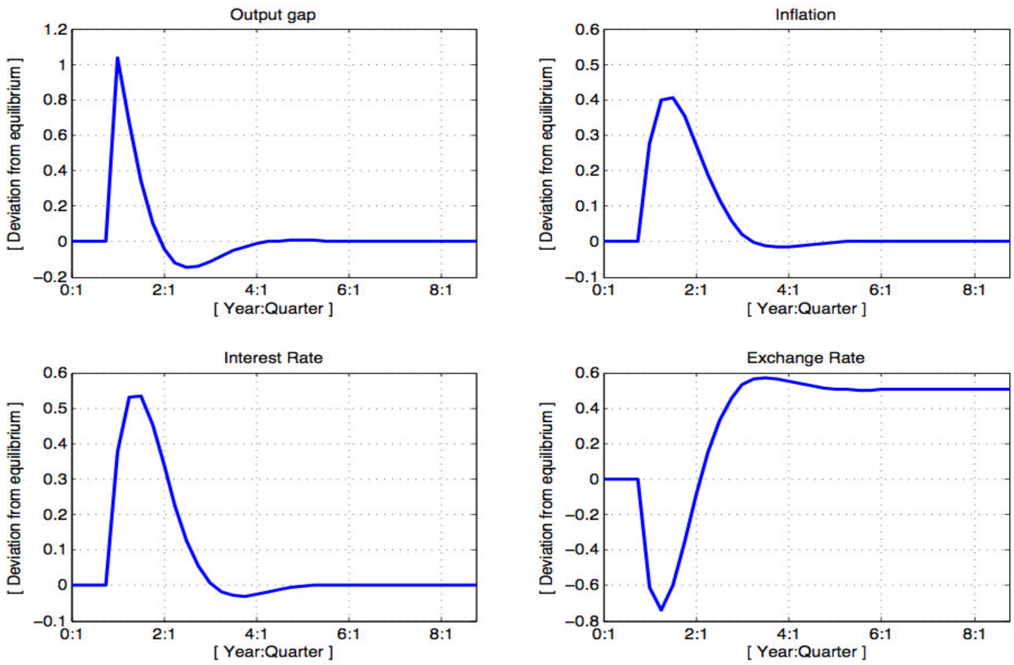
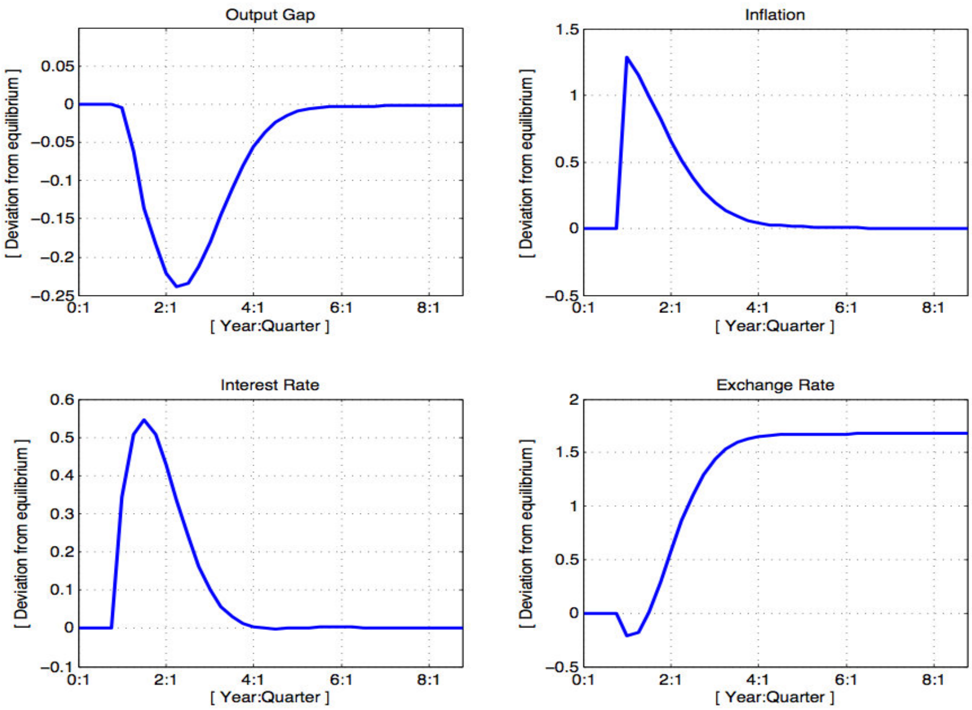


Figure 7 Impulse responses due to aggregate supply shocks

This figure shows impulse responses of the output gap, the deviation of inflation from the target, the deviation of the interest rate and the exchange rate form their long run trend values due to 1% temporary shock to aggregate supply.

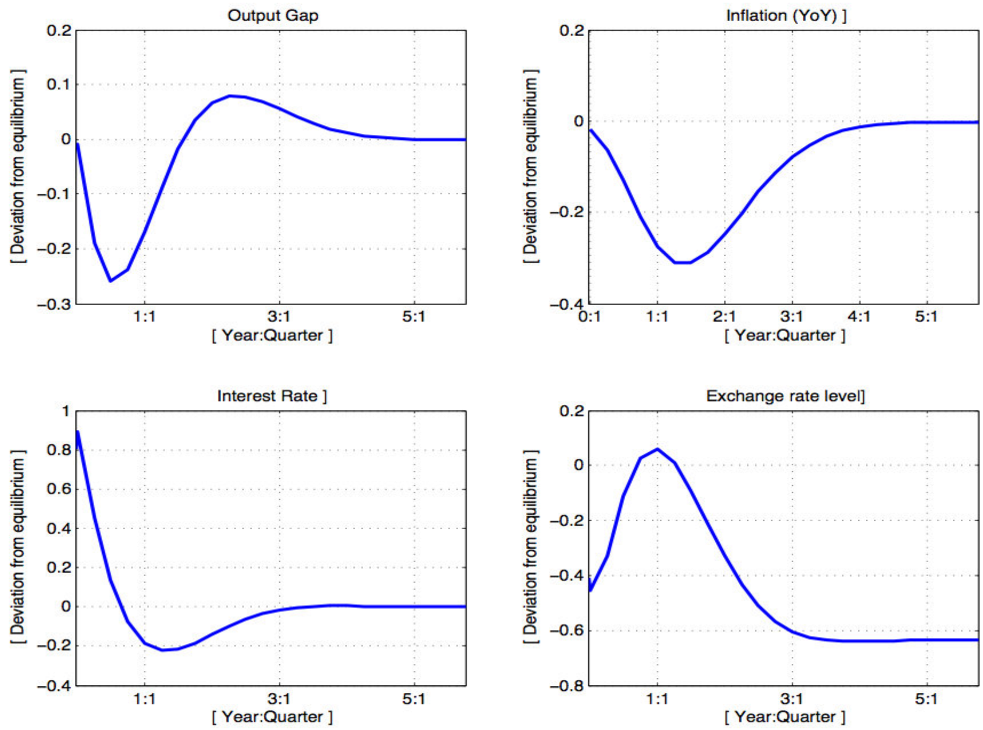


An increase of 1% in the aggregate demand gap leads to a 0.34% increase in inflation. The central bank responds to a positive inflation deviation from the target and the high aggregate demand pressure by tightening its policy stance and increasing the policy rate by around 0.5%. The tightening of aggregate demand affects inflation. A lag of around 2-4 quarters is consistent with the monetary transmission mechanism in India observed by Aleem (2010); Bhattacharya et al. (2011). Increasing interest rates attracts capital flows and leads to appreciation of the exchange rate as specified in the UIP condition.

Figure 7 shows responses of output gap, deviation of inflation from the target, interest rate and the exchange rate deviations to a 1% temporary shock to aggregate supply. An increase of one percentage in inflation leads to an approximate 0.24 percent negative deviation of output from its trend level, after a lag. In response to the rise in inflation, the central bank tightens

Figure 8 Impulse responses due to monetary policy shocks

This figure shows impulse responses of the output gap, the deviation of inflation from the target, the deviation of the interest rate and the exchange rate form their long run trend values due to 1% temporary shock to the interest rate.



monetary policy, and the interest rate gap rises by 0.5 percent. This brings down inflation after some lag. Initially, the exchange rate does not appreciate significantly in response to the rise in interest rates. There is pass-through of an increased rate of interest on inflation and exchange rate through the Taylor rule and the UIP. Eventually, falling interest rates lead to a significant depreciation of the nominal exchange rate, which increases to 1.5% above the equilibrium level and then remains unchanged.

In Figure 8, we look at the monetary transmission mechanism by giving a positive shock to interest rates, a contractionary monetary policy shock. A positive shock to the interest rate raises the cost of domestic borrowing for consumers. This leads to a decline in aggregate demand by about 0.25%. The contraction in demand leads to fall in inflation. The nominal exchange rate appreciates initially because of the rise in the interest rate which leads to a high demand of domestic bonds. It then appreciates slightly when the real interest rate falls, and finally stabilises at an appreciated level of 0.6 below its equilibrium level. The monetary transmission mechanism predicted by impulse responses is consistent with existing studies of the monetary policy transmission mechanism in India (Anand et al., 2010; Kapur and Behera, 2012). These studies have found a significant impact of contractionary monetary policy shocks on demand and inflation. Thus, the model shows reasonable and expected patterns with shocks in demand, supply, and monetary policy.

6 Filtering Indian data through the model

We now analyse the dynamics of key macroeconomic variables in India in the light of the model. For that purpose, we filter the data through the model using the Kalman smoother outlined in Andrle et al. (2013a). Kalman filter and smoother are recursive algorithms used to estimate a set of unobserved variables whose dynamics are outlined by a state-space model and a sequence of other observable variables which are linearly related to the unobserved variables. In other words, Kalman filter uses a series of measurement variables observed over time to estimate unobserved components specified in the model. In our case, the trend and cyclical components, and the shocks affecting the endogenous macroeconomic variables outlined in the model, are the unobserved components to estimate. The dynamics of the unobserved components are jointly determined by the VAR(1) representation obtained as a solution of the state-space model. The observables here are the actual data on various macroeconomic indicators for India and the rest of the world proxied by the US economy.

In order to interpret the joint movement in macroeconomic indicators in India, we focus on two major outcomes of the filtration exercise: (1) a decomposition of the endogenous variables into a trend (potential), a gap (cyclical) component, and (2) a decomposition of the current value of a variable into various observed and unobserved components driven by different shocks affecting the model economy.

6.1 Decomposition into trend and gaps

We begin our analysis with the decomposition of real interest rate (r_t), real exchange rate (z_t) and output (y_t). These are shown in Figures 9 and 10.

Figure 9 Trends based on Kalman filtration

This figure shows trend estimates of the real interest rate, the real exchange rate and the YOY growth in GDP from Kalman filter based on the theoretical model outlined above, along with the actual data for each of the variables.

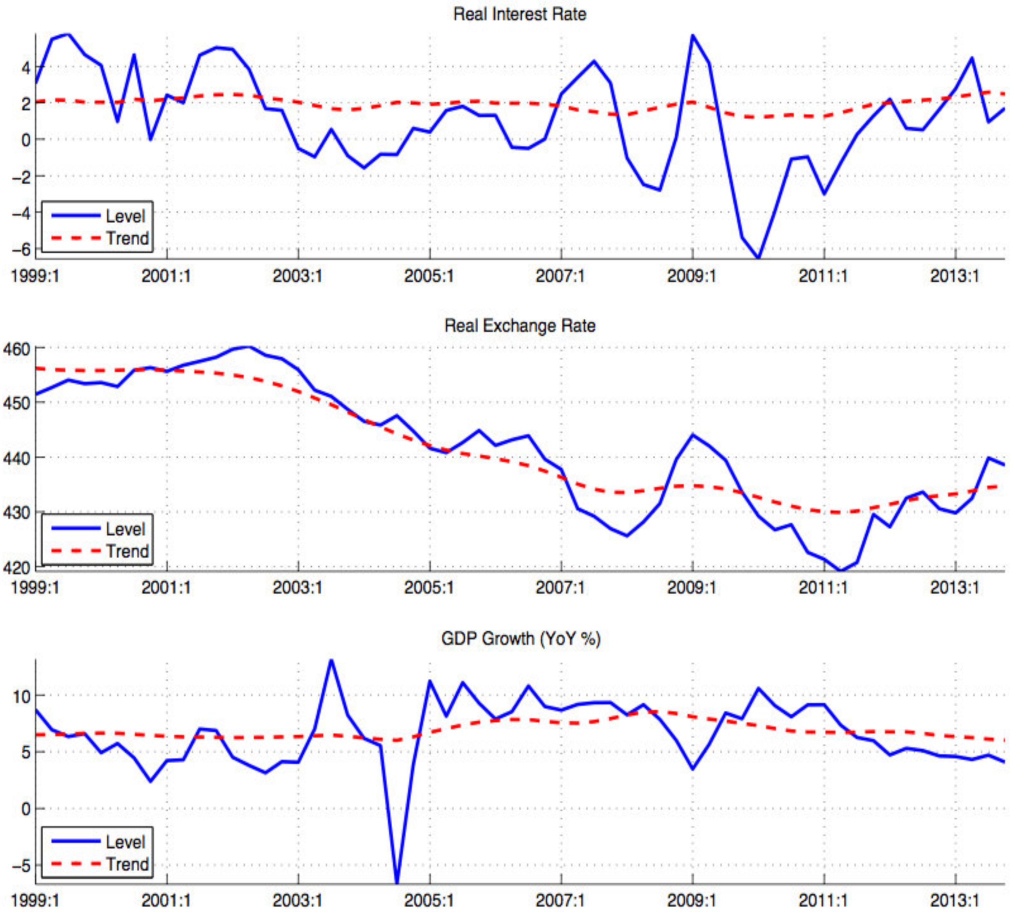


Figure 10 Gaps based on Kalman filtration

This figure shows cyclical components of the real interest rate, the real exchange rate and the output estimated using Kalman filter based on the theoretical model outlined above.

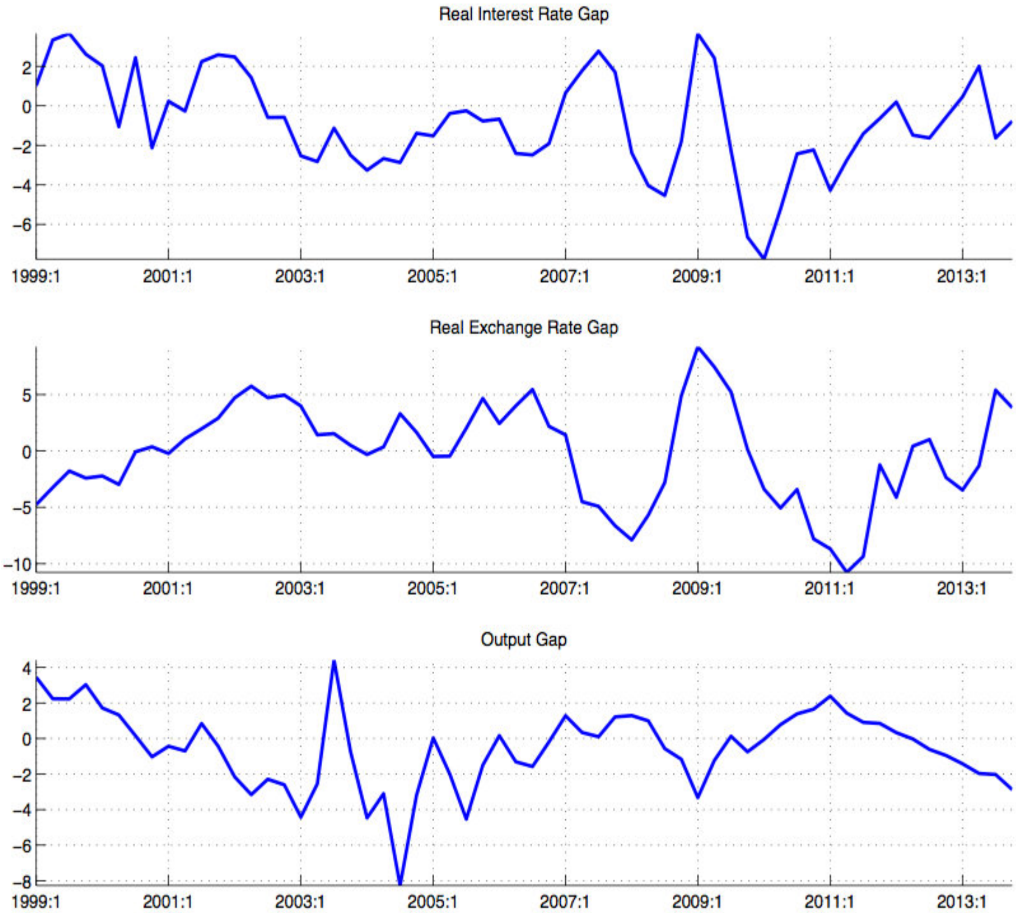


Figure 9 displays the observed value (dark line) in levels and trends calculated using Kalman filtration (dashed line) for real interest rate, real exchange rate and output respectively. The estimates of the gap components of the same variables are shown in 3.

As we see from the first subplot of Figures 9 and 10, there was monetary policy easing during the Global Financial Crisis (GFC). This is captured by the negative real interest rate gap falling significantly to -6%. In 2009 Q1, the real interest rate attained a peak of 6%, although monetary policy continued to be loose, with the yield on 91-day Treasury Bill rate hovering below 5% (Figure 15). This can be explained by a sharp decline in the headline WPI inflation, falling from 10.5% (YOY) during 2008 Q3 to 0.6% (YOY) in 2009 Q3. This sudden dip in inflation can be attributed to slowing foreign and domestic demand and falling world and food prices. Post-2009, we witness a persistent negative real interest rate gap. This suggests that the RBI policy remained accommodative during this period and may have contributed to rising inflation. We examine this in detail in Section 7. Recently, since 2012, we observe a positive real interest rate gap, suggesting that the RBI is taking aggressive steps to counter inflation using the policy rate.

The second subplot in Figure 9 shows the real exchange rate along with its trend value. The real exchange rate gap, shown in Figure 10 was negative during late 2009 and early 2011, because of an appreciating nominal exchange rate and high inflation, which reduced the competitiveness of India's domestic products in the international market. It also had a negative impact on exports and output gap as visible in Figure 11 in Section 7. In 2013, we see a sudden depreciation in the real exchange rate level because of a depreciating nominal exchange rate, caused predominantly by speculation of early tapering by the US Federal Reserve. This contributed positively to an increase in the output gap, also evident in the rise in export numbers.

The last subplot of Figure 9 shows the output growth and its trend or the potential growth. As seen in the figure, we observe that the potential GDP growth rate has been declining post-GFC because of a slow down in the Indian economy. The output gap rose during 2010-2011 because of the fiscal stimulus provided by the government. However, in recent years, the output gap has been falling continuously, as shown in Figures 10 and 11.

In sum, filtering Indian macroeconomic variables through the model using Kalman filter helps us to identify various periods with sizeable gaps in output, real interest rate, and real exchange rate. Since the behaviour of these gaps has implications for the dynamics of inflation, we further decompose the current value of key macroeconomic variables, namely output gap, policy rate and inflation into contributions of estimated components of other variables. We then interpret the behaviour of key macroeconomic variables in the light of historical episodes during 2010–2011. These are discussed in detail in the next section.

6.2 Decomposition into shocks

We decompose the dynamics of the output gap, monetary policy and inflation into the different estimated shocks and initial conditions. These are seen in Figure 11 and 12 respectively. We regroup a total of 13 shocks affecting the model economy into 6 categories as follows:

- Shocks related to the output gap: ϵ_t^y, $\epsilon_t^{\bar{r}}$, ${\epsilon_t}^{\Delta y}$
- Shocks related to inflation: ϵ_t^{π}
- Shock related to monetary policy: ϵ_t^i, ϵ_t^{π}, $\epsilon_t^{\pi^T}$
- Shocks affecting exchange rate: ϵ_t^s, ϵ_t^{η}, $\epsilon_t^{\Delta z}$
- Shock affecting foreign output gap: $\epsilon_t^{y^*}$, $\epsilon_t^{\bar{r}^*}$
- Other shocks affecting foreign block: $\epsilon_t^{\pi^*}$, $\epsilon_t^{i^*}$

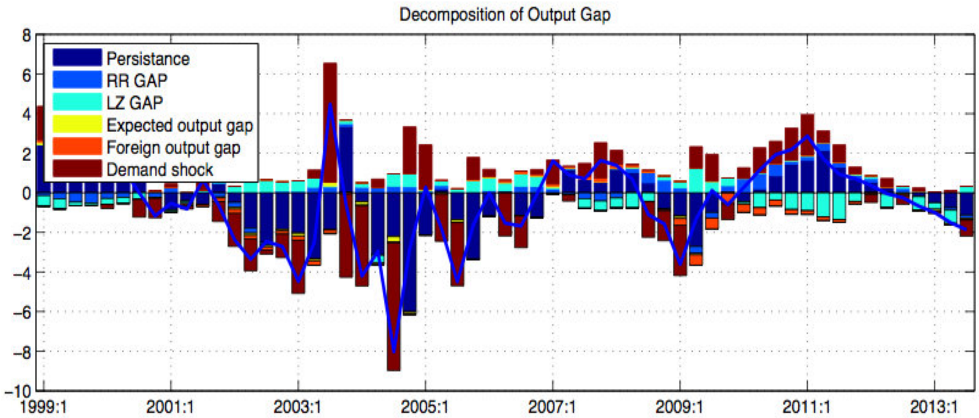
The first panel of Figure 11 shows the historical decomposition of the output gap into its various components. It shows that the output gap started increasing in 2010–11. The real interest gap was negative, which contributed positively to output gap[7] from 2010 Q1. Also, a negative foreign demand shock is evident in the first panel of Figure 11. This is consistent with the lack of exchange rate depreciation because of which the real exchange rate appreciated. The real exchange rate gap can be seen to be negative, which reduced competitiveness of Indian goods in the international market. However, aggregate demand is seen to be going up. This could be due to the post-GFC fiscal stimulus which pulled the output gap to higher levels.

The second panel of Figure 11 shows the decomposition of the interest rate gap. Though expected inflation increased, as seen in higher inflation deviation, the central bank did not tighten interest rate in 2009–10. The policy interest rate remained below what the Taylor rule prescribed. Monetary policy was tightened with a delay in 2011–12, raising rates to that consistent with the Taylor rule.

[7] The real interest gap enters with a negative sign in the aggregate demand equation.

Figure 11 Decomposition of output gap and monetary policy rate

This figure shows decomposition of the output gap and and the policy rate due to other factors affecting the model economy. The factors contributing to output gap are the past output gap, real interest rate gap, real exchange rate gap, expected output gap, and foreign output gap. The factors contributing to dynamics of the policy rate are past interest rate inertia, natural rate of interest, inflation deviation and output gap.



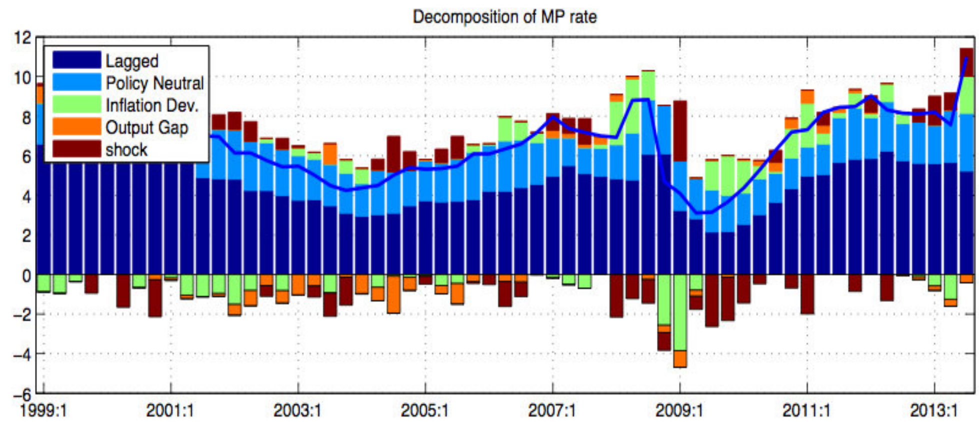


Figure 12 Shock decomposition of YOY inflation rate

This figure shows a decomposition of the inflation rate due to other factors such as expected future inflation, past inflation inertia, output gap, and real exchange rate gap, driven by various shocks affecting the model economy.

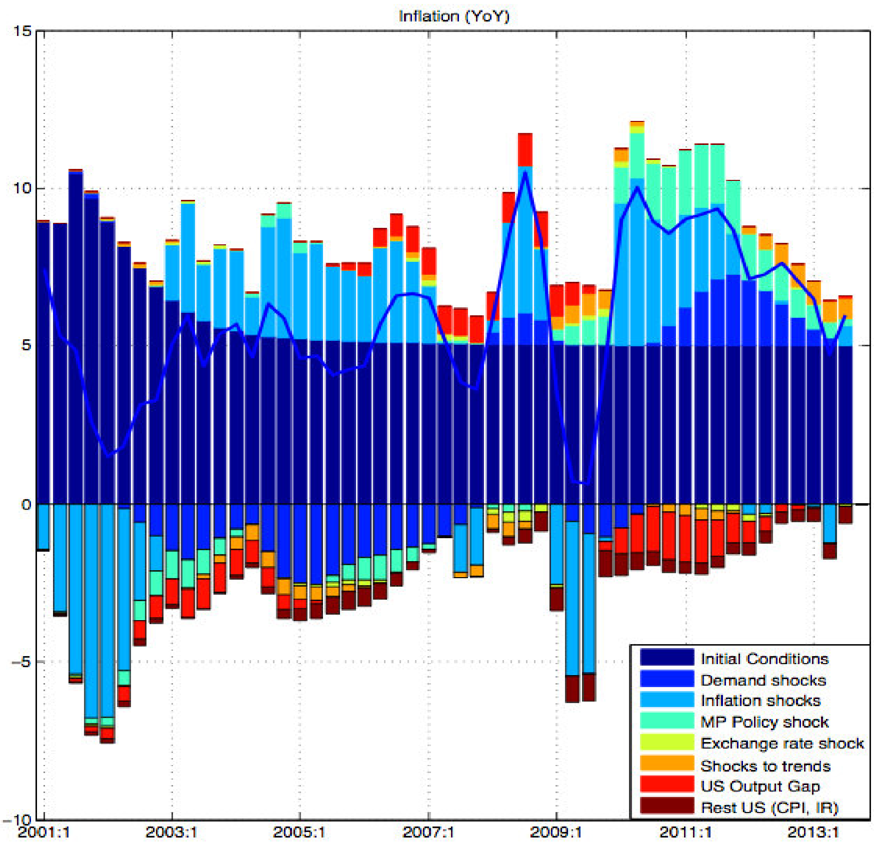
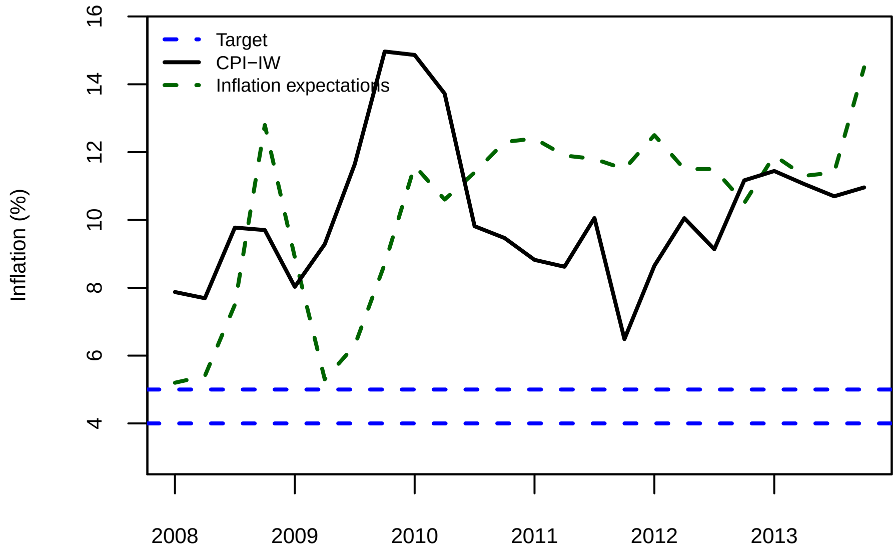


Figure 12 shows the shock decomposition of inflation. The period 2010–12 was one of high inflation. Initially, the increase in inflation was due to a supply side shock. Later, inflation is primarily driven by past inflation inertia and unanchored future inflationary expectations. Apart from that, during 2010-11, after the post-GFC fiscal stimulus and accommodative monetary policy, the increase in aggregate demand contributed to inflation. The negative oil shock appears as a shock that pulled down inflation. The decline in the US foreign output gap reduced domestic demand. However, this was offset by domestic increase in demand, because of which aggregate demand went

Figure 13 Consumer price inflation (CPI) expectations

This figure shows YOY inflation in CPI-IW and expected inflation based on RBI household surveys.

The rise in inflationary expectations support the analysis of the model.



up. Also during 2013:Q1, a large supply side shock has caused a sharp rise in the inflation.

7 A model-based interpretation of a historical episode

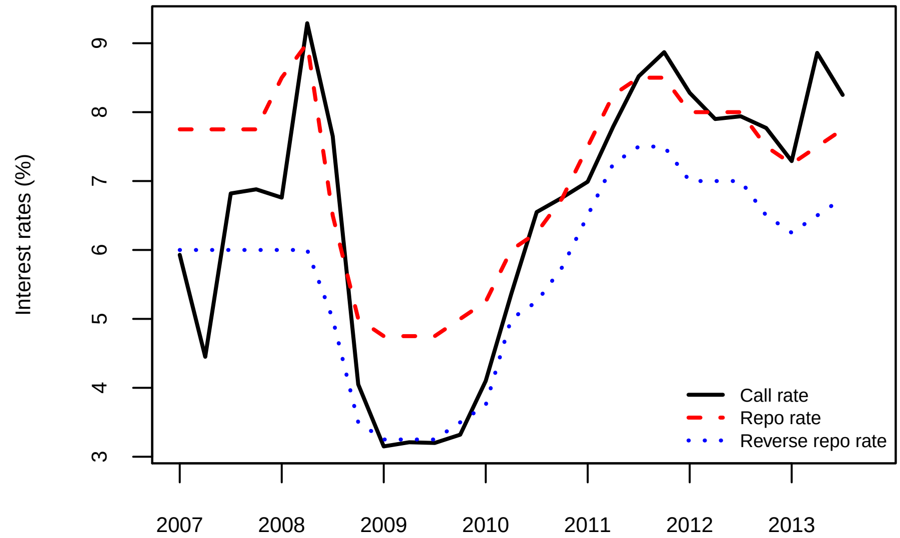
We now examine how to interpret recent macroeconomic episodes in India in the light of the model.

7.1 The 2009-2012 period

The 2008 global crisis led to a sharp fall in trade and investment. GDP growth fell from 9.58% in 2007 Q4 to 6.11% in 2008 Q4. Falling exports and a deteriorating external position due to low foreign demand worsened an already wide current account deficit. Financial and capital inflows were hurt due to liquidity strains on the world financial markets. The nominal

Figure 14 Quarterly interest rates

This figure shows the time series of short term interest rates in recent years.



exchange rate depreciated sharply by more than 23% between 2007 Q4 and 2008 Q4.

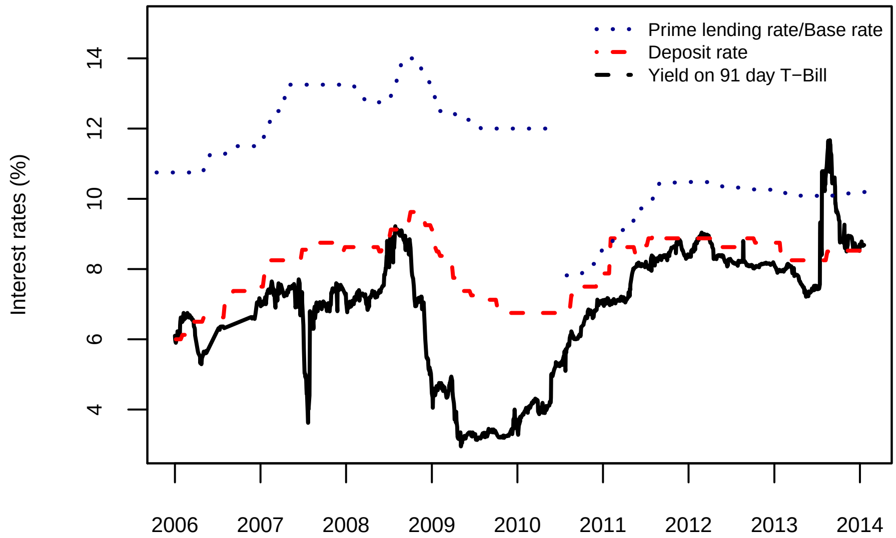
Until 2008, the RBI focused on preventing an appreciation of the exchange rate by buying dollars (Figure 3). However, from the beginning of 2009, the exchange rate was allowed to be flexible, though monetary policy did not have a nominal anchor. There was no framework in place to target inflation. As a consequence, inflationary expectations (Figure 13) were unanchored and started rising.

During this period, RBI did not tighten the policy rate. Instead, the repo rate or nominal short term interest rate declined. It can be seen in Figure 14 that not only were the repo and reverse repo rates cut sharply, the call money rate, which is expected to lie within this corridor, was hugging the lower end of the corridor. Liquidity was loose after the cut in the Cash Reserve Ratio (CRR) and remained so until 2011. As a consequence, the yield on the 91-day Treasury Bill rate, which is seen as the summary statistic of the interest rate and liquidity situation, or the stance of monetary policy, remained low for a long time (Figure 15).

In 2010, CPI inflation started rising sharply: it increased to about 15.44% as measured by the CPI-IW,YOY in 2010 Q1, from less than 10% a year earlier. Inflation was fuelled by rising food and oil prices as well as the exchange rate

Figure 15 Indian Monetary Policy

This figure shows time series of various short term policy rates in recent years.



appreciation. All through 2010 inflationary pressures continued to rise.

Lending rates remained low and did not rise to the pre-2008 levels even by 2012. This was primarily because of the slow down in GDP that spurred policy makers to keep monetary policy easy, despite the rising inflation.

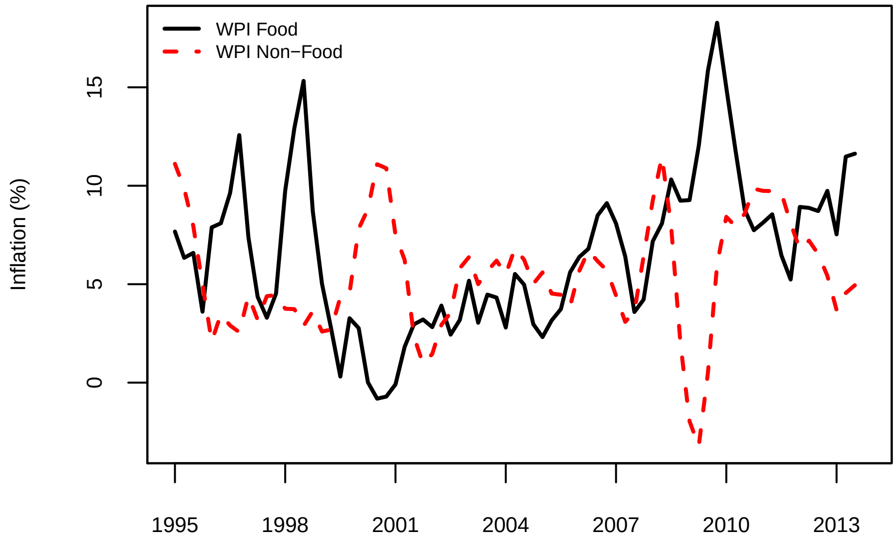
The Union Budget presented in March 2013 provided a stimulus to the economy through an increase in expenditure and a cut in taxes. Both fiscal and monetary policy were countercyclical to support the domestic economy which had slowed down.

Growth rebounded, reaching a quarterly average of approximately 8.09% in 2010 and reopening the output gap. The recovery was driven by the fiscal stimulus as well as the accommodative monetary policy. Real interest rates remained low for a long period and were not raised even though inflation started to rise. The decomposition of inflation due to various shocks as seen in Figure 12 shows the significant role played by the expectations of agents that inflationary pressures would persist. This is captured by the forward-looking behaviour of the agents in the model. Such expectation formation may have stemmed from loose monetary policy exercised by the central bank despite inflationary pressures.

The question of anchoring inflation expectations depends on two critical factors: the magnitude and timeliness of the response to prevailing inflationary

Figure 16 WPI food and non-food

This figure shows divergence in WPI food and non-food inflation seen after 2009.



conditions. Bhattacharya et al. (2008), using point-on-point (POP) seasonally adjusted WPI inflation, a timely indicator compared to conventionally used YOY inflation, find that during the high inflation episodes in 1994-95 and 2007-08, RBI has not responded to the inflationary pressure in a timely manner. Christadoro and Veronese (2011) compare the short-term interest rate in the period with what would have been obtained by a Taylor rule. Except for the third and fourth quarter of 2008–09, where the interest rate set by the RBI was much lower than prescribed by the Taylor rule, on all occasions interest rate changes by the RBI has been at least two percentage points lower than what one would expect to combat inflation. International Monetary Fund (2011) also reached similar conclusions.

The model estimation suggests that demand pressures during 2011 were close to the highest within the historical sample. Food price inflation was also lifted by the rise in domestic demand. Factors such as a country-wide rural employement guarantee scheme put purchasing power in the hands of rural poor and pushed up the demand for food. These demand-side factors also contributed to the rise in inflation in India during 2009–11 (Figure 16).

Table 5 Fiscal Deficit to GDP (in %)

This table shows the time series of Fiscal Deficit (FD) as a percentage of GDP in recent years. The post crisis fiscal stimulus is reflected in the sharp rise in the fiscal deficit ratio in 2010.

Year	FD to GDP (in %)
2008	2.5
2009	5.9
2010	6.4
2011	4.7
2012	5.7
2013	5.1

7.2 A model-based interpretation of current scenario

The model shows that at present inflationary expectations are high and inflation is persistent. Our finding of high inflationary expectations is also supported by consensus forecasts and of household inflationary expectations conducted by the RBI (Subbarao, 2012). The inflationary expectations of households refer mainly to the CPI (Figure 13) and are higher than what we may expect for WPI, but also indicate the rise in expectations as seen in the model.

The decline in inflation is explained by the shock decomposition of inflation. Figure 12 showing the shock decomposition of inflation suggests that there are three drivers of the present scenario: a negative shock to trend output, a negative external demand shock that was important until recently (but has receded in the last two quarters) and a reduction in the positive domestic demand shock as the fiscal and monetary stimulus has subsided.

The model suggests that there has been a shock to potential output, or a supply side shock. This might be reflecting the shock in recent years in the form of a slowdown in investment activity in the Indian economy.

The external shock visible till two quarters ago can primarily be explained by the slowdown in the world economy. With the pickup in the US economy, this may reduce.

Third, the model suggests that the size of the domestic demand shock has reduced in size. This can be explained by the fiscal consolidation in 2013. The increase in fiscal deficit after the stimulus since 2009 led to difficulties for India such as a credit rating downgrade and a large current account deficit which was understood to be partially caused by a spill-over of the fiscal deficit to the external sector. The government needed to bring its fiscal deficit under control (Subbarao, 2012). The year 2013 has seen an attempt at fiscal consolidation. Since July 2013, in response to the sharp rupee depreciation, the RBI raised interest rates. The increase in interest rates has further reduced the size of the aggregate demand shock.

Interest rates may remain high as RBI has emphasised the need for bringing inflation under control (Rajan et al., 2013).

8 Conclusion

In this paper, we develop a semi-structural New Keynesian open economy model for India that provides insights on the role of an inflation targeting framework that will help in anchoring inflationary expectations towards a desired target rate of inflation. Such semi-structural models are extensively used as the tool for monetary policy analysis by central banks in many inflation targeting economies and also applied to several developing economies under transition towards an inflation targeting regime. There is however no such model for India. The contribution of this paper is to fill this gap.

Since 2009, Indian monetary policy has moved towards a flexible exchange rate regime without any explicit framework for an alternative nominal anchor. The failure of monetary policy to anchor inflationary expectations of agents, coupled with negative supply shocks has persistently driven inflation much above the acceptable range of 5-5.5% for last five years in India. The calibrated model for India sheds new insights on the role of an inflation targeting monetary policy framework to anchor inflation expectation in the country. The model provides insights on the extent to which various shocks, including post global crisis fiscal stimulus, accommodative monetary policy, the decline in global demand etc, explain the dynamics of macroeconomic variables in India. Such insights are essential for setting appropriate monetary policy to reach the desired level of inflation in the economy.

However, in India, much of the inflation is explained by food and oil inflation, the dynamics of which are not captured in our baseline aggregate model. Future extension of the model by disaggregating headline inflation will allow us to explore the consequences of alternative targets, such as CPI vs. WPI inflation. This will provide further guidance for implementing an inflation targeting regime in India.

A Acronyms

Table 6 Acronyms

CRR	Cash Reserve Ratio
CMIE	Centre for Monitoring Indian Economy
CPI	Consumer Price Index
CPI-AL	Consumer Price Index (Agricultural Labourers)
CPI-IW	Consumer Price Index (Industrial Workers)
CPI-RL	Consumer Price Index (Rural Labourers)
CPI-UNME	Consumer Price Index (Urban Non-Manual Employees)
DSGE	Dynamic Stochastic General Equilibrium Models
FD	Fiscal Deficit
FPAS	Forecasting and Policy Analysis Systems
FX	Foreign Exchange
GFC	Global Financial Crisis
GDP	Gross Domestic Product
IRF	Impulse Response Function
INR	Indian Rupee
IT	Inflation Targeting
IMF	International Monetary Fund
MSS	Market Stabilisation Scheme
NSS	National Sample Survey
NER	Nominal Exchange Rate
OLS	Ordinary Least Squares
PPI	Producer Price Index
PPP	Purchasing Power Parity
QOQ	Quarter-on-Quarter
RER	Real Exchange Rate
RMC	Real Monetary Cost
RBI	Reserve Bank of India
RMSE	Root Mean Squared Error
SVAR	Structural Vector Auto-Regression
UIP	Uncovered Interest Parity
US	United States of America
USD	United States Dollar
VAR	Vector Auto-Regression
WPI	Wholesale Price Index
WEO	World Economic Outlook
YOY	Year-on-Year

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