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Dove or Hawk? Characterizing monetary policy regime switches in India☆

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ABSTRACT

The past two decades have witnessed a worldwide move by emerging markets to adopt explicit or implicit inflation targeting regimes. A notable and often discussed exception to this trend, of course, is China which follows a pegged exchange rate regime supported by capital controls. Another major exception is India. It is not clear how to characterize the monetary regime or identify the nominal monetary anchor in India. Is central bank policy in India following a predictable rule that is heavily influenced by a quasi inflation target? And how has the monetary regime been affected by the gradual process of financial liberalization in India? To address these points, we investigate monetary policy regime change in India using a Markov switching model to estimate a time-varying Taylor-type rule for the Reserve Bank of India. We find that the conduct of monetary policy over the last two decades can be characterized by two regimes, which we term 'Hawk' and 'Dove.' In the first of these two regimes, the central bank reveals a greater relative (though not absolute) weight on controlling inflation vis-à-vis narrowing the output gap. The central bank however was found to be in the "Dove" regime about half of our sample period, focusing more on the output gap and exchange rate targets to stimulate exports, rather than moderating inflation. India thus seems to be following its own direction in the conduct of monetary policy, seemingly not overly influenced by the emphasis on quasi-inflation targeting seen in many emerging markets.

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1. Introduction

A major switch in the conduct of monetary policy has occurred in many nations over the past two decades. Although taking different forms, the switch has been towards more systematic rules and less discretion in the conduct of monetary policy. Many central banks in emerging markets have adopted formal inflation targets (ITs), including Brazil, Chile, Colombia, Czech Republic, Korea, Hungary, Israel, Peru, Philippines, Poland, South Africa, Thailand and Turkey. Other central banks have adopted systematic rules that de facto describe the behavior of the central bank's operating instrument response—usually interbank interest rates—to inflation, output gaps and the external environment. Rose (2007) argues that the move to IT regimes, either explicitly or implicitly (e.g. adopting systemic rules focusing on inflation), has created a new monetary system that is more stable than its predecessors such as exchange rate targeting and fixed exchange rates that existed in the erstwhile Bretton Woods system.

Theoretical studies that derive optimal monetary policy rules, and empirical studies that investigate their use in practice, are now commonplace in the literature (e.g. Taylor, 1993; Clarida et al., 2000; Woodford, 1999, 2001; Giannoni and Woodford, 2002). Taylor (1993) formulated a policy rule by which the U.S. Federal Reserve adjusts the policy rate in response to past inflation and the output gap (actual less potential output). He showed that this rule described Federal Reserve policy performance quite well from 1987 to 1992. Using a quadratic loss function for the welfare objective of the central bank, Woodford (2001) provided a formal normative justification for following a Taylor-type rule under certain conditions. Many studies subsequently applied and developed this class of policy rules to examine the behavior of central banks in industrialized countries (e.g., Clarida et al., 2000), and several have been applied to emerging and developing economies (e.g. Aizenman et al., 2011; Gonçalves and Salles, 2008). In fact, Gonçalves and Salles (2008) find that in a sample of 36 emerging market economies (13 of which implemented IT), the IT adopters experienced a greater decline in inflation and growth volatility compared to the non-adopters.

In light of the 2008–09 global financial crisis, it may be premature to make a final judgment on the desirability and durability of IT regimes and whether their widespread adoption has actually ushered in a new era of global monetary stability. It is noteworthy that the two largest, most populous, and, arguably, dynamic emerging markets, China and India, have *not* adopted IT regimes and withstood the global financial crisis reasonably well. China follows a quasi-fixed exchange rate regime against the U.S. Dollar, accumulates massive international reserves and maintains tight capital controls to keep the parity unchanged (e.g. Glick and Hutchison, 2009; Ouyang et al., 2010). In contrast, the monetary policy regime in India is less explicit and apparently more dynamic, with the authorities typically arguing that discretion is paramount in their policy decisions. [1]

The objective of our paper is to investigate the nature of monetary policy rules in India, a country that has undergone substantial domestic financial development and deregulation over the past two decades and has also experienced significant integration with the global economy. These developments have potentially altered the financial environment and external constraints (e.g. balance of payments, exchange rates) facing the central bank (Reserve Bank of India, RBI), and may have influenced its operating procedures as well as its policy tradeoffs between output–inflation–exchange rate stabilization. These considerations, in turn, may have impacted the formulation of monetary policy rule in India as mentioned in Mohan (2006b). In particular, money market deregulation took place in 1987. Prior to that, the money market was highly regulated and the interest rate was essentially fixed.[2] Since 1987 there has been much greater flexibility in money market rates, and the RBI started using it as the primary operating instrument of monetary policy. To this end, we investigate the monetary policy rule in India and whether simple Taylor-like policy rules—perhaps changing over time to account for the changing economic environment—may be employed to systematically describe RBI's actions. The RBI describes its own policy actions in terms of discretion, and states that a multitude of factors are taken into consideration when deciding the course of monetary policy. The question is whether the seemingly discretionary policy followed by the RBI may be empirically described by a systemic rule that allows for occasional regime switches.

[1] India and China are included in the Gonçalves and Salles (2008) sample as non-IT adopters.

[2] While arguments can be made for later starting dates, given the evolution of financial liberalization in India, and of the RBI's conduct of monetary policy, this particular liberalization episode seems to be the most appropriate beginning for our sample period.

Thus, our paper focuses on the monetary policy rule followed in India. In doing so, our analysis contributes to the relevant literature by adopting a regime switching model along the lines of Hamilton (1989) to allow for multiple changes over time in central bank preferences between "Hawk" and "Dove" monetary regimes that, in turn, shift the central bank operating policy rule. Previous work for emerging markets has focused on a stable monetary policy rule (constant coefficients) over time or perhaps a discrete shift from one rule to another in line with a change in the central bank leadership, institutional change or political change.[3] None has focused on monetary regime switching either in emerging market economies in general or in India in particular. Our approach, by contrast, allows for the Indian central bank to operate in either of two regimes, and switch from one regime to another, multiple times in response to changes in the macro-economic conditions (e.g. inflation rate, output gap, and the exchange rate). For example, at times the RBI may be primarily concerned with inflation in a "Hawk" regime, perhaps because inflation is viewed as the primary threat to economic stability, while at other times its focus may be shifted to stimulating output ("Dove" regime). These shifts may occur predictably over the business cycle or at other times, not necessarily representing an institutional change, but simply a complex policy rule that changes over time, shifting with a given probability in response to an evolving economic environment.

Our application of the regime-switching model to Indian monetary policy is interesting in its own right. Much like the U.S. Federal Reserve, the RBI has seemingly responded to the state of the economy in an apparently discretionary and flexible manner. A former Deputy Governor of the RBI described their approach as follows, "Thus the overall objective has had to be approached in a flexible and time variant manner with a *continuous rebalancing of priority between growth and price stability*, depending on underlying macroeconomic and financial conditions." (Mohan, 2006a; italics our own). The question is whether the apparently discretionary and flexible approach of the RBI can systematically and empirically be described in practice by a Taylor-type rule, albeit with the possibility of regime switches. Based on description of the conduct of monetary policy by RBI officials, India appears to be a good candidate to be described by a regime switching model between Hawk and Dove regimes.

No study to date has undertaken this line of research for India. In particular, only three studies that we are aware of have investigated monetary policy rules for India, none of which have considered regime-switching. In particular, Mohanty and Klau (2005) augment the Taylor rule to include changes in the real effective exchange rate. They use quarterly data from 1995 to 2002 for 13 emerging economies including India. They find that for India, the estimated inflation coefficient is relatively low whereas the output gap and real exchange rate change are significant determinants of the short-term interest rate. Virmani (2004) estimates monetary policy reaction functions for the Indian economy, with the monetary base (termed in the literature as the McCallum Rule) and interest rate (Taylor Rule) as alternative operating targets.[4] He finds that a backward-looking McCallum rule tracks the evolution of the monetary base over the sample period (1992q3–2001q4) reasonably well, suggesting that the RBI acts as if it is targeting nominal income when conducting monetary policy. In addition, neither of these studies explores the Indian central bank's policy rule beyond the early 2000s. Finally, Hutchison et al. (2010) estimate monetary policy rules for India with more recent data but use structural breaks chosen a priori as opposed to model-based estimates of systemic regime switches.[5]

In the next section we discuss the evolution of monetary policy in India and related literature. We summarize some of the major changes that took place in this sphere. In the third section we explain the methodology and data used. We describe Woodford's version of the Taylor Rule, and how we adapt Hamilton's Markov switching method to the case of monetary policy rules. In the fourth section we present the estimation results. In particular, the Markov switching model identifies two distinct regimes, which we label 'Hawk' and

[3] Owyang and Ramey (2004), Assenmacher-Wesche (2005) and Frommel et al. (2005) consider regime-switching models for monetary policy rules for advanced economies. Liu (2010) considers regime-switching models for 17 IT-targeting countries (not including India). In an unpublished manuscript, Steiner et al. (2013) consider a Markov switching model for Chile and Colombia since adopting an IT regime.

[4] Other recent studies of India not using our methodology, are those of Singh (2010), Patra and Kapur (2012) and Mohanty (2013b). Studies that have used McCallum's rule of monetary policy for other countries include Burdekin and Siklos (2008).

[5] In more general analyses of macro policy and financial structure, Hutchison et al. (2012a, 2012b) consider the trilemma trade-off for India, focusing on the constraints on monetary policy imposed by the exchange rate regime and international capital controls. Hutchison et al. (2012a, 2012b) consider the extent to which financial liberalization in India has led to closer integration of domestic and international financial markets.

'Dove.' We begin with a model that focuses on domestic variables, and subsequently consider the role of exchange rate in monetary policy making following Taylor (2001). In the fifth section we conclude by summarizing our results and interpretation.

2. Monetary policy and financial liberalization in India

The Indian economy experienced several major structural changes in financial markets and fiscal financing over the sample period that may have potentially influenced the conduct of monetary policy. As has been highlighted in debates about the timing of Indian economic reform (Panagariya, 2008), there was no single "big bang" moment, especially with respect to the evolution of the financial sector, making it difficult to identify well-defined structural breaks in the Indian economy. Nonetheless, a number of key developments for monetary policy may be identified. Firstly, fiscal deficits are no longer automatically parked with public sector banks, neither are they passively monetized by the RBI (Shah, 2008). Secondly, the liberalization of financial markets began in the late 1980s, moving towards a deeper financial sector and away from extreme financial repression (Shah, 2008). The process of financial liberalization accelerated following the balance of payment crisis in 1991.

Between 1991 and 1997, lending rates of commercial banks were deregulated, the issue of ad hoc treasury bills was phased out (thereby eliminating automatic monetization of the budget deficit), Statutory Liquidity Ratio (SLR) and Cash Reserve Ratio (CRR) rates were sharply reduced, and the RBI reactivated the refinance rate or bank rate (which is now used as a signaling rate to reflect the monetary policy stance). In 1994, India switched over to a mainly market-determined exchange rate system and instituted current account convertibility.

The RBI appears to have loosely targeted monetary growth between 1980 and 1998 and, from then onwards, followed a multiple indicator approach with discretion. Starting in 1998, the RBI undertook strong monetary policy measures (increasing interest rates and withdrawing liquidity by raising the CRR) to combat concerns about excessive liquidity and speculation in the foreign exchange market. The foreign exchange market was characterized by a high degree of volatility following the onset of the Asian financial crisis towards the end of 1997 and beginning of 1998. These emergency measures were gradually reversed once the threat of the crisis spilling over to India seemed to have abated.

The subsequent period, through the mid-2000s, saw the RBI continuing to refine its approach to macroeconomic management. With global and domestic inflation at relatively low levels, the RBI set a band for target inflation of 4–5%, which was low by historical standards. It announced an intention to bring the CRR down, and moved away from using the CRR as a policy instrument, focusing on interest rates instead—this intention however was not realized, in practice. The RBI also continued to slowly ease capital controls, with implications for the functioning of domestic financial markets. Relaxations of capital controls included easing of requirements for and caps on foreign institutional investors (FIIs), streamlining of approval processes, and allowing FIIs to hedge exchange rate risk in currency forward markets. While domestic fixed income markets continued to be thin (as opposed to vibrant stock exchanges), especially for corporate bonds, a market for government securities did develop during this period.

A significant development during this period was an institutional innovation introduced by the RBI to manage its own open-market operations. The new institution, termed the Liquidity Adjustment Facility (LAF) was introduced on June 5, 2000. It operated through repo and reverse repo auctions, thereby setting a corridor for the short-term interest rates, consistent with the policy objectives. Thus, the LAF finally gave the RBI an explicit method for monitoring short-term liquidity under varied financial market conditions, in order to influence call money rates.

A final aspect of changing monetary management was the increase in capital inflows that began in the last decade. Capital inflows, if unchecked, increase domestic money supply, resulting in a looser monetary policy than would otherwise be the case. Capital inflows also put pressure on the exchange rate to appreciate. The RBI engaged in sterilization of inflows and accumulation of foreign exchange reserves in this time frame. The RBI apparently had to deal with the trilemma of maintaining an independent monetary policy and stable exchange rate in the face of international capital flows. Accordingly, in this paper we address international factors manifested through exchange rate fluctuations and empirically analyze the implications thereof on the conduct of monetary policy in India.

This brief institutional discussion suggests that a regime-switching Taylor rule may be appropriate to uncover the underlying preferences of the RBI's decision-makers and in particular, their evolution over time. Given the seemingly discretionary nature of policy, as articulated in RBI statements, the central bank's revealed preferences may be well captured by a model of systematic, though time-varying, behavioral responses.

3. Methodology and data

3.1. Theory and estimation

The Woodford (2001) version of the Taylor Rule for an open economy expresses the policy instrument —the interbank interest rate—as a function of the output gap, inflation target, exchange rate and lagged interest rate. With constant coefficients, this policy rule may be written as:

$$i_t = c + \alpha y_t + \beta \pi_t + \chi \Delta e_t + \delta i_{t-1} + \varepsilon_t \tag{1}$$

where i_t is the nominal interest rate, y_t is the output gap at time t (deviation of actual output, measured by the index of industrial production, from potential output), π_t is the year-on-year inflation rate (assuming a constant inflation target such that the target is subsumed in the constant term of the equation) and e_t denotes the log of exchange rate with Δ being the first difference operator.[6] The expected signs of the estimated coefficients are: α, β, χ and $\delta > 0$. The rule indicates a relatively high interest rate when inflation is above its target, when the output is above its potential level, or when the central bank is attempting to limit exchange rate depreciation. The lagged interest rate is introduced to capture inertia in optimal monetary policy, as specified by Woodford (2001). We use end of period quarterly data for all variables for the period 1987Q1–2008Q4.

Eq. (1) is the standard model for the estimation of central bank policy functions—assumes that the policy response to economic variables is stable over time. Some authors allow for a discrete shift in policy following a central bank reform or other institutional change. Our argument above however, suggests that a central bank's preferences may change in a systematic and predictable manner such that there are switches between periods when inflation is the primary concern of policy ("Hawk" regime) and when the output gap is the primary concern of policy ("Dove" regime). The distinction between Hawk and Dove regimes is common in the literature (see Assenmacher-Wesche, 2005; Owyang and Ramey, 2004, for recent references). This implies that a regime-switching model that allows the coefficients to shift between two states ($s = 1, 2$) would be a better representation of monetary policy than the alternative of a one-regime (constant coefficients) model.[7] In this circumstance, our estimation equation becomes:

$$i_t = c + \alpha_{st} y_t + \beta_{st} \pi_t + \chi \Delta e_t + \delta i_{t-1} + \varepsilon_t \tag{2}$$

with S_t representing the state at time t, i.e. $S_t = 1 \ldots k$, where k is the number of states. Since we consider the switching to take place between 2 states ("Hawk" and "Dove" regimes), $k = 2$ in our case. In addition to switching the coefficients, we also allow the variance of the error term to switch simultaneously between the states, $\varepsilon_t \sim N(0, \sigma^2{}_{st})$

Markov switching models (MSMs), originally motivated by Goldfeld and Quandt (1973), have been popularized in business cycle and exchange rate analysis by Hamilton (1989) and Engel and Hamilton (1990). In our case, the model allows us to estimate how much weight the RBI assigns to the relevant macroeconomic variables in two different regimes. In a MSM, switching between regimes does not occur deterministically but with a certain probability. In general terms, the evolution of the discrete, unobserved state-variable S_t is serially dependent upon $S_{t-1}, S_{t-2}, \ldots S_{t-r}$, in which case the process is referred to as an rth order Markov switching process.

[6] Unlike the central banks of developed countries, the RBI does not have a forward-looking approach when it comes to deciding monetary policy.

[7] As noted earlier, one can allow for structural breaks in estimation, but the regime-switching method allows for a somewhat different approach to changing policy responses — the maintained hypothesis is of two policy stances, between which the policy maker chooses, depending on economic conditions.

As noted above, we assume a two-state, first order Markov switching process for S_t, characterized by constant transition probabilities $p_{ij} = \Pr\{S_t = m|S_{t-1} = n\}$. In particular, let P denote the 2×2 transition probability matrix for our two-state Markov process such that:

$$\mathrm{P} = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix}. \tag{3}$$

The estimation procedure classifies each observation as belonging to either regime. The regimes however, are not observed or specified ex-ante, but are estimated from the data.

To estimate the model, we consider the joint distribution of i_t and S_t conditional on past information:

$$f(i_t, S_t|\psi_{t-1}) = f(i_t|S_t, \psi_{t-1}) f(S_t|\psi_{t-1}) \tag{4}$$

where Ψ_{t-1} denotes information at time $t-1$ and $f(i_t|S_t, \Psi_{t-1})$ is the conditional normal density function for the regime $S_t = m$. The likelihood function we estimate is a weighted average of the density functions for the two regimes, the weights being the probability of each regime:

$$\ln L = \sum_{t=1}^{T} \ln\left\{\sum_{m=1}^{2} f(i_t|S_t, \psi_{t-1}) \Pr(S_t = m|\psi_{t-1})\right\} \tag{5}$$

where the weighting term $\Pr(S_t = m|\psi_{t-1})$ is the probability of being in each regime and is also referred to as the filtered probability. Given $\Pr(S_{t-1} = n|\psi_{t-1})$, n = 1,2, at the beginning of time t the weighting terms $\Pr(S_t = m|\Psi_{t-1})$ are calculated as:

$$\Pr(S_t = m|\psi_{t-1}) = \sum_{n=1}^{2} \Pr(S_t = m|S_{t-1} = n) \Pr(S_{t-1} = n|\psi_{t-1}) \tag{6}$$

where $\Pr(S_t = m|S_{t-1} = n)$, $m = 1, 2$; $n = 1, 2$, are the transition probabilities (elements of matrix P above).[8] Once Ψ_t is observed at the end of time t, the probabilities are updated using the iterative filter, as discussed in Kim and Nelson (1999). The updated probabilities are calculated as follows:

$$\Pr(S_t = m|\psi_t) = \frac{f(i_t|S_t = m, \psi_{t-1}) \Pr(S_t = m|\psi_{t-1})}{\sum_{m=1}^{2} f(i_t|S_t = m, \psi_{t-1}) \Pr(S_t = m|\psi_{t-1})} \tag{7}$$

where $f(i_t|S_t = m, \psi_{t-1})$ is given by the probability density function of a normal distribution for regime $S_t = m$. Note that this is simply Bayesian updating of the probabilities of being in each state, given the information available then.

To start the filter at time $t = 1$, we use the initial values obtained from an ordinary least squares regression. Once the coefficients of the model are estimated using an iterative maximum likelihood procedure and the transition probabilities are generated, we can use the algorithm in Kim and Nelson (1999) to derive the filtered probabilities for S_t using all the information up to time t i.e. $\Pr(S_t = m|\psi_T)$ where $t = 1, 2, \ldots, T$.[9]

3.2. Data

For the short-term policy rate, we use the overnight call money market rate.[10] This is the standard interest rate used to indicate the policy stance of the central bank. The RBI follows a multiple instrument

[8] Eq. (6) is useful in showing that while the transition probabilities are constant, the conditional probability of being in one regime or another depends on the history of the economy, summarized in the information available at that time, and therefore varies from period to period.

[9] The MSM model is estimated using the MS-Regress Matlab package for Markov Regime Switching Models, developed by Marcelo Perlin (2009).

[10] We use the call money market rate primarily because of availability of consistent data during our sample period.

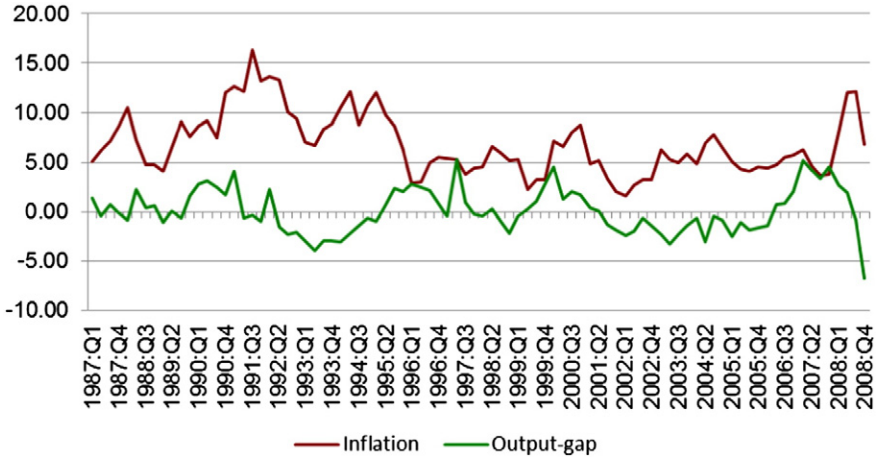

Fig. 1. Output gap and inflation (WPI).

approach to influence the call money rate. An important issue, especially in India, is the measurement of the output gap. Unlike advanced countries, there are no official measures of potential output levels. Virmani (2004) compared estimated potential GDP obtained from an unobserved component model with estimates derived from a Hodrick–Prescott (HP) filter, and found little difference. Accordingly we derive the output gap using the HP filter for measuring trend output and taking the residual of the HP filter.[11] To measure output, we use the Index of Industrial Production (IIP).[12] Year-on-year inflation is measured using annual percentage change in the Wholesale Price Index (WPI). The WPI is the price level employed by the RBI to calculate "headline" inflation in India. All data are quarterly and the overall sample period is 1987q1 to 2008q4. We start our sample at 1987q1 because interest rate regulation essentially fixed the money market rate prior to that time. With broad changes in the financial system in the late 1980s, came money market deregulation and at that time the money market rate became the primary operating instrument of the RBI. We stop our sample at the beginning of the transmission of the global financial crisis to India, as there was a distinct disruption in domestic financial markets at that time, and policy shifted away from traditional monetary policy operations.

Prior to estimation, several data issues were dealt with. Analysis of linear plots and the Hylleberg–Engle–Granger–Yoo test suggest that the quarterly IIP series has multiplicative seasonality. Hence it was de-seasonalized using the X-12 ARIMA procedure. Unit root tests, i.e. Augmented Dickey–Fuller, Phillips–Perron, Elliott–Rothenberg–Stock and Kwiatkowski–Phillips–Schmidt–Shin test results suggest the presence of unit root in the exchange rate series in levels, but the first difference of the series is stationary. Accordingly, the first difference of the nominal exchange rate was used. Durbin Watson and Breusch–Godfrey tests suggest the presence of serial correlation and the Breusch–Pagan/Cook–Weisberg test shows the presence of heteroskedasticity in error terms. Hence the Ordinary Least Squares (OLS) regressions have been run with the Newey–West variance–covariance matrix, to correct for both autocorrelation and heteroskedasticity.

Finally, we discuss our treatment of the interest rate series. Some other studies have used an average of the interest rate over the preceding quarter (or whatever the length of the period), presumably to capture the average policy stance for that period. However, this is not completely logical, since it creates a dependent variable that is partially determined prior to the right-hand side observations. Using the end-of-quarter interest rate avoids this inconsistency.

[11] The HP filter output is sensitive to the endpoints, and we examine the robustness of our results to this issue: this point is taken up in the Empirical results section.

[12] We also estimated output gap using real GDP (from 1994 onwards, conditional on data availability) and the results were found to be quite similar.

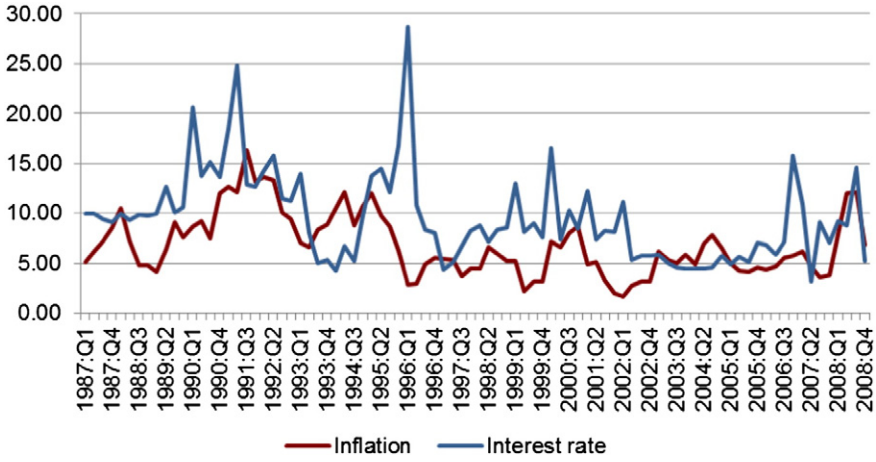

Fig. 2. Interest rate and inflation (WPI).

4. Empirical results

4.1. Preliminaries

Figs. 1–3 show movements between the output gap and inflation (Fig. 1), interest rate and inflation (Fig. 2), and interest rate and output gap (Fig. 3) in India over the 1987q1 to 2008q4 period. Table 1 shows the corresponding correlations between these series for the full sample (1987–2008), early sample (1987–1995) and later sample (1996–2008).

Fig. 1 does not show a distinct pattern between the output gap (right-hand-side scale) and inflation (left-hand-side scale) during the full sample period (overall correlation = −0.02), although a weak positive (and statistically significant) correlation emerges in the later period (0.06). The "output–inflation tradeoff" is not clearly evident through simple co-movements in these variables, but the relationship may be masked by a variety of real and financial disturbances to the Indian economy as well as by an activist monetary policy.

Fig. 2 shows the evolution of the interest rate (i.e. the overnight money market rate) and inflation. Trend inflation seems to have declined in India over the sample period. Inflation averaged at about 9%,

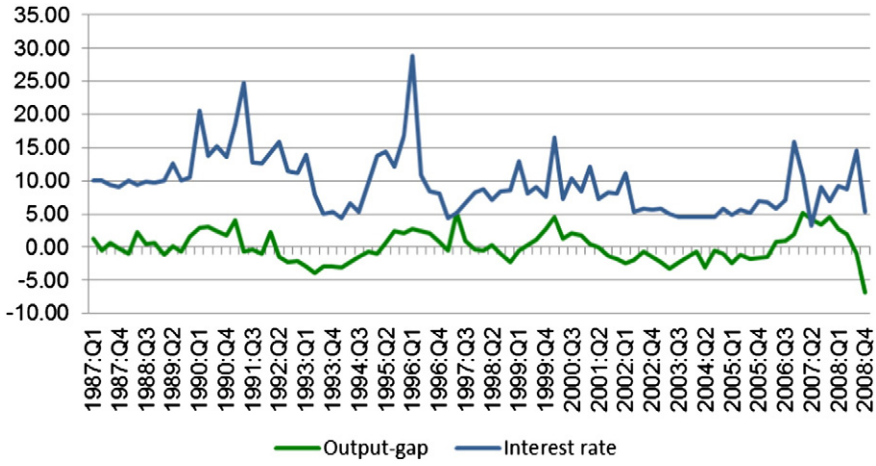

Fig. 3. Interest rate and the output gap.

Table 1
Correlations.

	1987q1–2008q4	1987q1–1995q4	1996q1–2008q4
Output gap–inflation	−0.0246	−0.0373	0.0625
Output gap–interest rate	0.3541***	0.5140***	0.3525**
Inflation–interest rate	0.3530***	0.2821*	0.0329

*** Denotes significance at the 1% level.
** Denotes significance at the 5% level.
* Denotes significance at the 10% level.

with wide variation (standard deviation of 2.9%), over the 1987 to 1995 period, and fell approximately to 5% during 1996–2007. Inflation was also more stable (standard deviation of 2.1%) in the later period. In mid-2008 inflation jumped in response to the world-wide food and energy price boom, but declined to the previous level by the end of 2008. Similarly, interest rates were at a much higher average level and were more volatile in the first sub-period (1987–1995) compared with the second sub-period (1996–2008). Lower levels and higher stability in inflation were thus associated with lower and more stable interest rates. Beyond simple averages, however, the figure also suggests that the money market interest rate moves sluggishly in response to swings in the inflation rate, especially in the later sample period. This suggests that the RBI, in setting interest rates, has generally been slow to respond to inflation movements, with an overall contemporaneous correlation of 0.35 for the full sample.

Fig. 3 shows the output gap (left-hand-side) and the money market interest rate (right-hand-side). Overall, swings in the output gap are followed by similar changes in the interest rates (correlation 0.35) and this pattern is evident in both the early and later sample periods. When the output gap is negative, interest rates tend to fall and vice versa. This correlation appears to be particularly strong in the early period (correlation 0.51). In the later period this pattern is clearly evident during most cycles with two exceptions, and this is confirmed by the decline in the correlation coefficient after 1995. There also appears to be a range of (small) fluctuations in the output gap that does not elicit an interest rate policy response.

Table 2
Constant coefficients and regime switching (output gap and inflation).

Parameters	Constant coefficients	Switching coefficients
$\alpha 1$	0.5373***	0.2213*
	(0.1898)	(0.1177)
$\alpha 2$		0.5606***
		(0.1000)
$\beta 1$	0.3421***	0.3786***
	(0.1097)	(0.0405)
$\beta 2$		0.4002***
		(0.0710)
δ	0.4042***	0.6811***
	(0.0860)	(0.0404)
$p11$		0.85
$p22$		0.76
$\sigma^2{}_1$	12.9026	2.8420***
		(0.5055)
$\sigma^2{}_2$		40.4376***
		(7.9018)
Constant	3.3261***	0.0000
	(0.8731)	(0.0002)
Expected duration of regime 1		6.87
Expected duration of regime 2		4.18
Final log likelihood		−222.1531

Note: Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

In sum, it appears that the RBI responds both to the output gap and inflation in setting policy interest rates. Interestingly, the correlations for both output gap and inflation with money market interest rates are almost identical over the full sample period (0.35) and both correlations decline after 1995, especially the contemporaneous linkage between interest rates and inflation.

Another variable that the RBI may sometimes target is the exchange rate. The RBI itself has argued that its focus has only been on controlling the volatility of exchange rate movements, rather than targeting the level of exchange rate. However, some analyses (e.g., Patnaik, 2007) have suggested that at times there has been a systematic attempt by the RBI to manage the level of the nominal Rupee–Dollar rate. In order to address this issue, we extend the basic Taylor Rule model to one that also includes the exchange rate as a determinant of policy, as shown in Eq. (1).

4.2. Constant coefficient estimates

The first column of coefficient estimates in Table 2 presents the results from estimating Eq. (1) i.e. assuming constant coefficients, but with the exchange rate omitted. The coefficients on the output gap, inflation and lagged interest rate are all significant at the 1% level and have signs predicted by theory. These estimates suggest that the RBI increases the overnight interest rate by 54 basis points in response to a one unit rise in the output gap (where positive increases in the output gap represent a rise in output relative to trend). The RBI also increases the interest rate by 33 basis points in response to a 100 basis point rise in inflation. The lagged interest rate coefficient of 0.40 suggests considerable inertia in policy implying that the long-run effects are substantially greater than the short-run impact effects. The long-run effect on the interest rate of a unit change in the output gap is 0.89 and of a 100 basis point increase in inflation is 0.55. The 95% confidence interval for the long-run coefficient on output gap is (0.71, 1.094) whereas that for the long-run coefficient on inflation is (0.519, 0.629) none of which contains zero, implying that the long-run estimated coefficients of both output-gap and inflation are statistically significant at the 5% level.[13] The long-run inflation-response of 0.55 is, however, considerably less than what Woodford (2001) suggests would in principle (greater than unity) be necessary to stabilize the economy.[14]

The constant term is also of interest. In the model formulation of (Woodford (2001), Eqs. 2.3 and 2.6), the constant term captures the deviation of the baseline interest rate from the target values of the inflation rate and output gap, each weighted by the response coefficients embodied in the monetary policy rule. Thus, in an equilibrium rule, the constant term in the specification estimated in Table 2 should be zero. If a Taylor-type rule is indeed being followed, we would thereby expect the constant term to be zero.

4.3. Markov switching model

In estimating the Markov switching model, we explore several variants of the baseline specification. This is necessary because of the complexity of the underlying economic dynamics, of the possible policy rule followed by the RBI, and of the estimation method itself. The specific role played by the exchange rate in Indian monetary policy conduct contributes further to this complexity. It is only by comparing estimates from different specifications and identifying robust features across the different results, that one can be reasonably confident about the policy rule that is potentially discovered by the empirical analysis.

4.3.1. Output gap and inflation coefficient switching

The second column of coefficients in Table 2 presents the initial regime switching model estimates, where both the output gap and inflation coefficients switch between different policy regimes. The output

[13] The confidence-interval calculations have been done using the delta method which in turn is based on a Taylor series approximation.

[14] Taylor (1993) suggested that a policy rule with coefficients of 0.5 on the output gap and 0.5 on inflation (from target) was able to predict the U.S. Federal Reserve interest rate policy responses. His formulation includes a base inflation term on the right hand side, so that his inflation coefficient is equivalent to a magnitude of 1.5 in the Woodford (2001) specification, which is used here. The lagged interest rate term is not in the original Taylor specification, but it does not affect the comparison once the long run effect is computed.

gap (inflation) coefficient estimate for state 1 is denoted by α_1 (β_1) and state 2 is denoted by α_2 (β_2). The lagged interest rate coefficient is given by δ. The table also presents the probability p_1 of staying in state 1 (state 2) if policy p_{11} is already in state 1 (state 2). Unity p_{22} minus this parameter gives the probability of switching from state 1 (state 2) to state 2 (state 1). The error variances of state 1 and state 2 are also presented, as are the expected duration of staying state 1 and state 2 and the total log likelihood.

The results show a clear distinction between the two regimes of the RBI policy stance with respect to the coefficient of the output gap but not the inflation coefficient. The inflation coefficients in the two states are almost identical, while the output gap coefficient in the first state is less than half of that of state 2. The output gap coefficient in state 2 is quite close to the estimate for the constant coefficient model, and this is also true of the inflation coefficients in both states. The lower weight given to the output gap in state 1 characterizes this state as a Hawk regime, with a *relative* emphasis on inflation developments. State 2 is characterized as a Dove regime with *relative* emphasis on the output gap. Several other observations on the results in Table 2 are noteworthy. First, the coefficient of lagged interest rate is substantially higher in the regime-switching model (0.681) than is the case for the constant coefficient estimates (0.404), reflecting higher inertia.[15] This implies that the long run impacts are now estimated to be higher, except for the long run response to the output gap in state 1, since other short run coefficients are similar. The long run output gap coefficients in the 2 states are 0.69 and 1.76, respectively. The long-run inflation responses are estimated to be 1.19 and 1.25, in regimes 1 and 2, respectively, above the threshold of unity that marks a stabilizing monetary policy rule with respect to inflation. Of course, the model also suggests that this response is very slow to be fully realized. Furthermore, in this switching model, the confidence intervals for the long-run coefficients are quite wide, suggesting greater imprecision with respect to estimating the long-run effects of policy in this case. In particular, the 95% confidence intervals for the long-run coefficients on output gap in regimes 1 and 2 are (−0.022, 1.410) and (0.415, 3.101) respectively. This implies that the long run output gap coefficient in regime 1 is not significantly different from zero, but is significantly different than zero in regime 2. The 95% confidence intervals for the long-run coefficients on inflation in regimes 1 and 2 are (0.902, 1.473) and (0.187, 2.323) respectively, none of which contain zero, implying that the long-run estimated coefficients of inflation in both states are statistically significant at the 5% level. However, the confidence intervals include values below unity for each regime.

Second, the estimates in Table 2 are consistent with the view of the former Deputy Governor of the RBI, since the expected lengths of the two regimes are quite short, being about 7 and 4 quarters respectively. The probabilities of staying in each state are not inordinately low, at 0.85 and 0.76 for states 1 and 2, respectively, but are low enough to lead to substantial switching between the two regimes. However, one significant difference between the two states is in the standard errors of the estimated regressions. The standard error for the Dove regime is about 14 times as high as that of the Hawk regime, implying that the former's overall variance is less well explained by the independent variables.

Finally, it is worth noting that the constant term in the switching regression is reduced essentially to zero, in contrast to the positive and significant value in the constant coefficient regression. As we noted earlier, a zero constant term is consistent with an equilibrium monetary policy rule, and we can take this feature of the estimation as a point in favor of the MSM approach over a constant coefficient model.

It is also important to examine the predicted time frames of the two different regimes. This information is captured probabilistically by the filtered probabilities (Eqs. (6) and (7)). Fig. 4 displays the filtered probabilities corresponding to the results of the regime-switching model of Table 2. While these probabilities have several peaks and troughs, our sense is that the output booms of the late 1980s, mid 1990s and early 2000s are all associated with high probabilities of state 1, the “Hawk” regime. The idea here is that monetary policy is relatively less concerned with the output gap in these boom times, though the absolute stance towards inflation remains roughly the same across the two states.

4.3.2. Output gap switching

The results of the first specification of the MSM indicate that one can impose the constraint that the inflation coefficient does not switch across the two regimes. In other words, only the coefficient of the output gap switches. These estimates, still without any consideration of exchange rate policy responses, are presented

[15] The relative magnitude of the lagged interest rate coefficient in the MSM model versus the constant coefficients case is in line with intuition, since the latter estimates would tend to assign regime switching effects to faster responses.

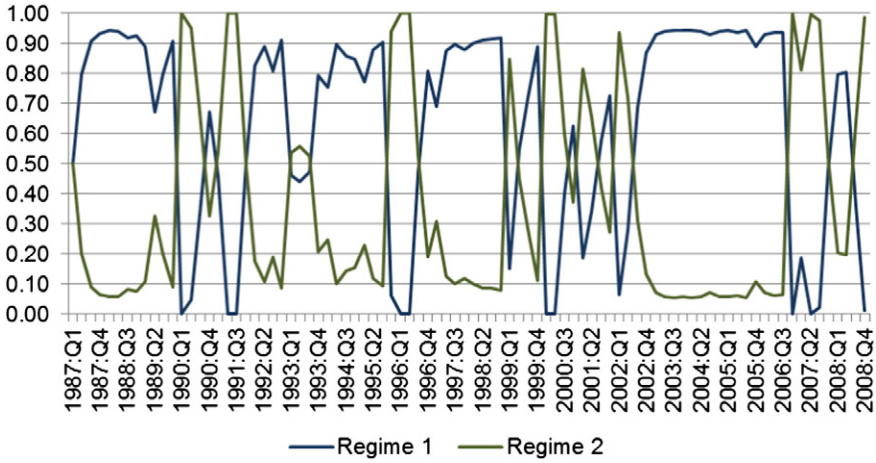

Fig. 4. Estimated regime probabilities and regime switching (output gap and inflation).

in Table 3. The short run coefficients are now lower than the estimates in Table 2. However, the larger coefficient on the lagged interest rate term (0.811) compensates for this change, and the long run coefficient estimates are very similar. The long-run output gap responses in states 1 and 2 are, respectively, 0.54 and 2.07, though the former is less precisely estimated than in the first specification. The 95% confidence intervals for the long-run coefficients on output gap in regimes 1 and 2 are again quite wide. They are (−0.551, 1.635) and (0.735, 3.406) respectively, implying that the long run output gap coefficient in regime 1 is not significantly different from zero but the long run coefficient in regime 2 is statistically significant at the 5% level. The estimated long-run inflation response, at 1.25, is essentially the same as the earlier state 2 long-run response estimate from Table 2. The stability of the estimates reinforces the assumption that the restriction imposed

Table 3
Regime switching (output gap only).

Parameters	Switching coefficients
$\alpha 1$	0.1024
	(0.0924)
α_2	0.3913***
	(0.0587)
β	0.2354***
	(0.0978)
δ	0.8110***
	(0.0970)
$p11$	0.90
$p22$	0.98
$\sigma^2{}_1$	0.5563
	(0.3736)
$\sigma^2{}_2$	20.9685***
	(5.4980)
Constant	0.0000
	(0.0002)
Expected duration of regime 1	10.36
Expected duration of regime 2	43.06
Final log likelihood	−225.3404

Note: Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

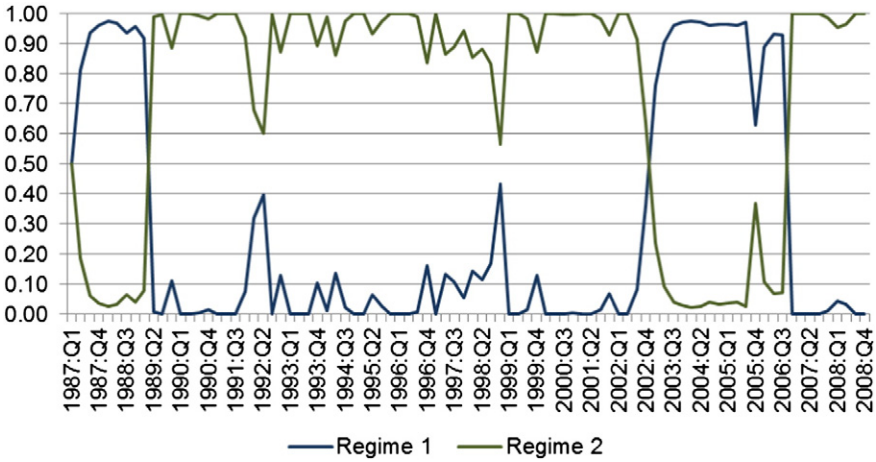

Fig. 5. Estimated regime probabilities and regime switching (output gap only).

here is valid.[16] The 95% confidence interval for the long-run coefficient on inflation is (0.003, 2.488), which does not contain zero, but clearly containing a large range of values below unity. The constant term in this case, and in subsequent MSM specifications stays at zero, supporting the robustness of the MSM approach as capturing equilibrium behavior.

The regression standard errors are much lower in Table 3 than in Table 2, but the relevant and striking difference is in the estimates of the transition probabilities. These are much higher than before, and as a result, the switching between regimes is highly attenuated. In fact, the expected duration of regime 2, the Dove regime, is as high as 10 years, and the graph of filtered probabilities for these estimates, in Fig. 5, suggests that there are only two likely Hawk periods, where the RBI was not giving much weight to the output gap—the two major booms of the late 1980s and the early 2000s. Given the dynamics of the Indian economy in the 1990s, we believe that this specification does not fully capture the conduct of monetary policy over this period.[17] This leads us to turn to considering external factors and exchange rate policy, which is believed to have had major implications for the conduct of domestic monetary policy at various times over the sample period (Patnaik, 2007).

4.3.3. Output gap switching with an exchange rate term

Following on the previous discussion, we include change in the log of nominal exchange rate into both the constant coefficient model and the MSM model—in the latter we allow only the output gap coefficient to switch between two regimes.

The first column of coefficient estimates in Table 4 presents the results from estimating Eq. (1) i.e. assuming constant coefficients. The coefficients on the output gap, inflation and lagged interest rate are significant at the 1% level and have signs predicted by theory as in Table 2. Also quite similar to the results in Table 2, these estimates of Table 4 suggest that the RBI increases the overnight interest rate by 54 basis points in response to a one unit rise in the output gap and the interest rate by 34 basis points in response to a 100 basis point rise in inflation. The lagged interest rate coefficient of 0.40 suggests a similar inertia in policy as in Table 2, implying once again that the long-run effects are substantially greater than the impact effects. The long-run effect on the interest rate of a unit change in the output gap is 0.89 and of a 100 basis point increase in inflation is 0.55. The 95% confidence interval for the long-run coefficient on output gap is (0.291, 1.495) whereas that for the long-run coefficient on inflation is (0.225, 0.868), neither of which contains zero, implying that the long-run

[16] We also estimated the MSM with only the inflation coefficient allowed to switch. The lagged interest coefficient and both inflation coefficients were almost identical to their counterparts in Table 3, as were most other features of the regression (standard errors, transition probabilities and average regime lengths). The output coefficient was insignificant, and the point estimate was close to the regime 1 point estimate in Table 3. This further supports the imposition of the constraint of no switching of the inflation coefficient.

[17] The estimates with only the inflation coefficient being allowed to switch, mentioned in the previous footnote, share this unsatisfactory feature.

Table 4
Regime switching (output gap only) with exchange rate.

Parameters	Constant-coefficients	Switching-coefficients
$\alpha 1$	0.5394***	0.1890**
	(0.1858)	(0.0782)
α_2		0.5760***
		(0.0902)
β	0.3298***	0.3894***
	(0.1047)	(0.0404)
χ	3.1329	7.4694**
	(12.5261)	(3.3821)
δ	0.3961***	0.6589***
	(0.0950)	(0.0374)
$p11$		0.86
$p22$		0.84
$\sigma^2{}_1$	13.0468	2.4452***
		(0.4283)
$\sigma^2{}_2$		29.7200***
		(2.0682)
Constant	3.4411***	0.0000
	(0.8300)	(0.0008)
Expected duration of regime 1		7.35
Expected duration of regime 2		6.32
Final log likelihood		−224.4692

Note: Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

estimated coefficients of both output-gap and inflation are significantly different from zero at the 5% level. However, the confidence interval for the long-run inflation coefficient lies entirely below unity.

The MSM results for the model with the exchange rate are presented in the second column of Table 4. The two regimes differ in their output gap coefficients, with regime 1 being where the output gap receives less weight from the policymakers. The short run coefficients in Table 4 are now back to being close to their values in Table 2, but the lower lagged interest rate coefficient means that the long run responses are once again similar to those in Tables 2 and 3. The estimated long-run responses to the output gap are 0.55 (regime 1) and 1.69 (regime 2). The long-run inflation response is estimated at 1.14, only slightly lower than the previous estimates. The 95% confidence intervals for the long-run coefficients of output gap in regime 1

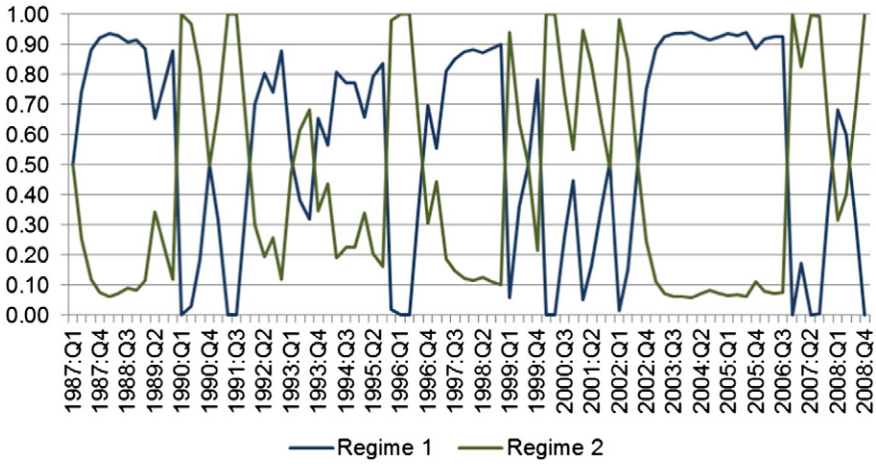

Fig. 6. Estimated regime probabilities and regime switching (output gap only) with exchange rate.

Table 5
Regime switching (exchange rate only).

Parameters	Switching coefficients
α	0.2726***
	(0.0819)
β	0.3861***
	(0.0426)
χ_1	10.5081**
	(4.7422)
χ_2	−16.6013***
	(5.1837)
δ	0.6718***
	(0.0365)
$p11$	0.87
$p22$	0.84
$\sigma^2{}_1$	2.6090***
	(0.4148)
$\sigma^2{}_2$	29.3076***
	(2.5337)
Constant	0.0000
	(0.0001)
Expected duration of regime 1	7.79
Expected duration of regime 2	6.26
Final log likelihood	−224.1054

Note: Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

and regime 2 are (0.132, 0.977) and (0.458, 2.919) respectively and that for the long-run coefficient of inflation now is (0.431, 1.503), none of which contains zero, implying that the long-run estimated coefficients of output-gap in both regimes as well as inflation are significantly different from zero at the 5% level. Again, the long-run confidence interval for the inflation term does not lie entirely above unity.

The estimates in Table 4 retain the lower regression standard errors of the second specification, but have the lower transition probabilities and expected regime durations of the first specification. The associated filtered probability graphs (Fig. 6) provide a picture of monetary policy responses in the 1990s that are close to those derived for the first specification, with some switching between the Hawk and Dove regimes, which differ in their stance towards the output gap. It appears that the Hawk and Dove regimes are each in force for roughly half the sample period, with well-defined episodes for each.

Most importantly, the estimates in Table 4 have a positive and statistically significant coefficient for the exchange rate term, indicating that the RBI responded to exchange rate depreciations (appreciations) by increasing (decreasing) the interest rate. This is consistent with a nominal exchange rate target, or with an attempt to "smooth" or dampen exchange rate movements, and with other empirical analyses of RBI behavior (though not necessarily with the RBI's own public position on its exchange rate stance). In many ways, therefore, the specification reported in Table 4 seems to be a reasonable, parsimonious description of the conduct of monetary policy in India over this period.

4.3.4. Exchange rate switching

Given that the exchange rate appears to be an important target variable for monetary policy, it is worth checking if it is also subject to regime switching. We examine two alternative specifications. A baseline specification allows only the exchange rate coefficient to switch, so as not to force changes in the stance towards the exchange rate to be tied to changes in the stance towards the output gap. Accordingly, Table 5 and Fig. 7 present the results for the MSM model where only the exchange rate coefficient switches. However, Table 6 and Fig. 8 also provide estimates where both the output gap and the exchange rate coefficients are allowed to switch between regimes.

The results with exchange rate switching demonstrate the robustness of the results in Table 4 (where only the coefficient of the output gap was allowed to switch). The coefficient of the inflation is stable across the

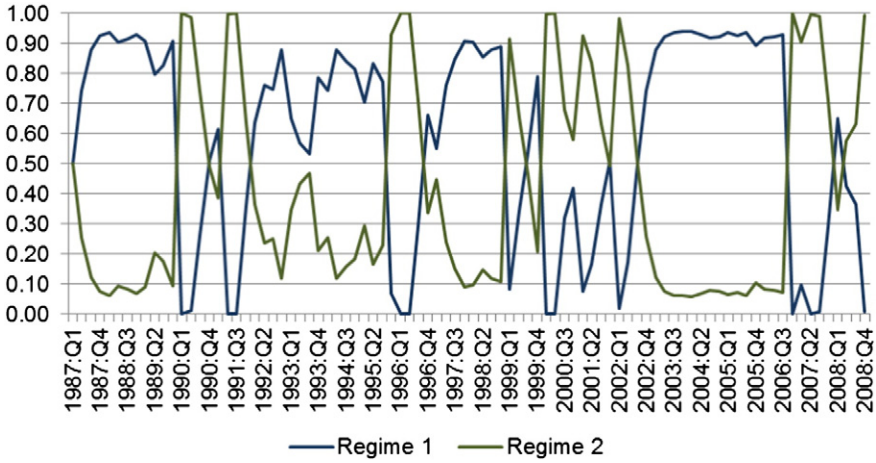

Fig. 7. Estimated regime probabilities and regime switching (exchange rate only).

three specifications (i.e. Tables 4, 5 and 6), as is the coefficient of the lagged interest rate. The coefficients of the output gap in the two cases where switching is allowed on this dimension are also quite close (Tables 4 and 6). Furthermore, the filtered probability graphs are also similar across the three specifications, suggesting that the RBI adjusted its stance on several occasions in the 1990s, as well as during the booms of the late 1980s and early 2000s.

The regime-specific regression standard errors and constant terms are also very close across the three specifications that involve the exchange rate, as are the transition probabilities. In the case of joint switching

Table 6
Regime switching (output gap and exchange rate).

Parameters	Switching coefficients
$\alpha 1$	0.2212***
	(0.0645)
$\alpha 2$	0.5399***
	(0.1527)
β	0.3810***
	(0.0389)
$\chi 1$	11.7969**
	(5.0357)
$\chi 2$	−15.3889**
	(6.2878)
δ	0.6680**
	(0.0312)
$p11$	0.93
$p22$	0.88
$\sigma^2{}_1$	2.6367***
	(0.4298)
$\sigma^2{}_2$	28.6072***
	(2.8689)
Constant	0.0000
	(0.0001)
Expected duration of regime 1	13.86
Expected duration of regime 2	8.36
Final log likelihood	−224.2626

Note: Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.

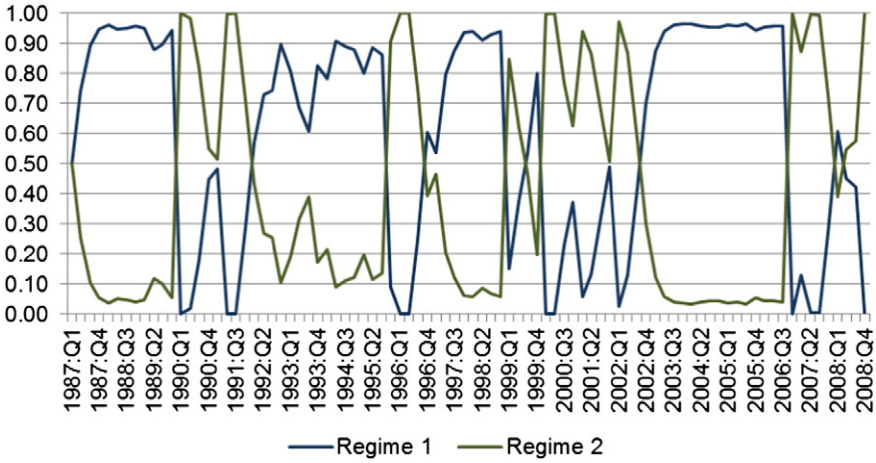

Fig. 8. Estimated regime probabilities and regime switching (output gap and exchange rate).

of the output gap and exchange rate coefficients, the transition probabilities are slightly higher, resulting in somewhat longer expected durations of regimes in this case: about 14 quarters for regime 1 (almost double the other two cases) and about 8 quarters for regime 2 (versus about 6 in the other two cases). However, these longer expected durations are plausible, unlike the 10–11 year expected duration for regime 2 in Table 3.[18]

The exchange rate switching models therefore suggest that the results are robust, but also raise two additional, possibly related, puzzles. First, in both cases of exchange rate switching, the coefficient of the exchange rate in regime 2 is negative. This means that depreciation in the nominal exchange rate (a positive difference in the variable as defined) is being met with a decrease in the interest rate, which would tend to accentuate the depreciation, rather than acting to stabilize the exchange rate (as would be the case with a positive coefficient). Second, in the case where both the coefficients of the output gap and the exchange rate are allowed to switch together, what can be the rationale for this pairing? In the case of the output gap and inflation, the idea that high inflation and high output go together is intuitively understandable in terms of the business cycle, but here that obvious connection does not exist. Since the first puzzle is common across both final specifications (Tables 5 and 6), and there is strong evidence that switching of the output gap coefficient is appropriate, it makes sense to focus on the results of Table 6, where regime 2 has the interpretation as the Dove regime with respect to the output gap, and the gap is more negative (output is weak). In this case, a possible interpretation of our results is that the negative coefficient of the exchange rate represents an attempt at stimulating exports in a weak economy, rather than exchange rate targeting or inflation control. This is a conjecture that would require further investigation, but seems consistent with how exchange rate policy is viewed by the Indian media, or by Indian industry associations, for example.

Aside from the issue of whether the RBI's policy stance towards the exchange rate keeps switching, the sequence of estimations we have presented here does support the importance of the exchange rate in monetary policy (something that has not always emerged clearly in other estimates of Taylor-type rules for India which do not allow for switching). Even more clearly, the evidence points strongly towards a consistent inflation stance, mildly positive in its control effects, but with a substantially varying concern with respect to the output gap.[19]

[18] In an earlier draft of this paper, we estimated and presented an MSM model with the output gap and inflation coefficients both being allowed to switch, but with the exchange rate included (unlike Table 2). In that case also, only the two output booms toward the beginning and end of our sample period were identified as likely Hawk regimes, with the entire decade in between as the Dove regime. The exchange rate coefficient was not significant, and the inflation coefficients in both regimes were similar, though marginally insignificant in regime 2. These observations suggest that either underdetermining the switching model (Table 3 here) or over determining it (the case of our previous draft) leads to a misspecification that shows up in failing to capture regime switches adequately.

[19] We also investigated allowing the coefficients of all three variables to switch between regimes, but the model was not well estimated in that instance. In any case, all the other evidence indicates a lack of switching in the inflation stance.

5. Conclusion

In this paper we investigate the conduct of monetary policy in India by estimating policy rules that may switch over time depending on the underlying macro-economic environment. The broader context is to explore the monetary policy regime of a large, dynamic, emerging market that apparently eschews the popular policy rule of explicit or implicit inflation targeting. Our primary question then is whether Indian monetary policy, usually described by RBI policymakers as highly discretionary, may in fact be described by simple policy rules, as has been the case for many central banks. That is, is the RBI more systematic in policy implementation than it claims and may its policy be accurately described by quasi-IT or Taylor rule? Our specific methodological approach is estimation of Taylor (1993) rules along the lines of Woodford (2001), but allowing for switches in the preferences of the central bank over time, using a regime-switching model (Hamilton, 1989).

Overall, our results suggest that a regime-switching model may characterize RBI policy, with the regimes naturally characterized as Hawk and Dove regimes, over the 1987–2008 period. Based on the likelihoods of the two policy stances, the Dove regime appears to have been in force (at least 50% likelihood) about half of the entire period, comprising four (possibly five) well-defined episodes. The model estimates suggest that the RBI focuses relatively more on the output gap during the Dove regime, with attention to inflation being essentially the same across the Hawk and Dove regimes. We also found strong evidence that external considerations, represented here by movements in the nominal exchange rate, systemically influenced RBI policy over the sample period. This policy seems to have taken the standard form of responding to exchange rate depreciation (appreciation) by raising (lowering) the interest rate. However, there is also a possibility that the RBI took steps to depreciate the exchange rate in order to stimulate exports when the economy was relatively weak (i.e. when the economy was in regime 2).

Our sample period ends in 2008, before the effects of the global financial crisis (GFC) were felt in the Indian economy. In this sense, we estimate our model during a period of relative "normalcy" in financial markets and monetary policy conditions, during which discussions and implementation of inflation targeting were taking place in emerging markets around the world. The GFC represents such extraordinary circumstances that central banks, including the RBI, have resorted to emergency measures to stabilize economies. This GFC episode is unique, characterized by very specific policy and statistical features not likely to be repeated. However, we would expect the broad statistical outlines of our model to eventually reemerge as markets and economies stabilize. This conjecture is on our agenda for future research to be pursued after a long enough period of time after the GFC has transpired to undertake meaningful econometric analysis.

Nonetheless, several general characterizations of the RBI response to the GFC and its aftermath is evident. As is well known, the GFC introduced major shifts in policy-making regimes throughout the world, not only emerging markets. The U.S. Federal Reserve System, impacted immediately at the onset of the crisis, responded by reducing interbank interest rates to zero, creating numerous emergency special funding facilities to provide liquidity to financial institutions, and began a series of "quantitative easing" (QE) measures that amounted in large part to very substantial purchases of government long-term debt and mortgage-backed securities.[20] By mid-2013, almost five years after the onset of the crisis, the Federal Reserve kept interbank rates at zero, expressed a commitment to zero interest rates for an extended period, and maintained QE operations. Similar emergency measures were taken by many central banks in advanced and emerging markets, including the European Central Bank, Bank of Japan, Bank of England, Central Bank of Brazil, and the Bank of Korea.[21] These varied in intensity depending on country-specific conditions, but were common responses to world-wide liquidity shortages, fragile financial sectors, falling trade volumes and slowing economies.

The RBI was no exception, responding vigorously to the crisis by loosening monetary policy with unprecedented alacrity. During the seven month period following the Lehman bankruptcy the RBI lowered interest rates sharply (the repurchase rate of the central bank was reduced by almost half, 425 basis points, as was the reverse repurchase rate), substantially reduced the cash reserve ratio of banks, and increased the total amount of

[20] There are several excellent sources detailing the extraordinary measures taken by the Federal Reserve in response to the crisis. See, for example, the website of the Federal Reserve Bank of St. Louis: http://timeline.stlouisfed.org/.

[21] See Yehoue (2009) for a discussion of the central bank responses in emerging markets to the GFC.

primary liquidity to the financial system by over ten percent of GDP (Mohanty, 2013a).[22] Shortly after the worst part of the crisis, however, India experienced a resurgence of headline inflation in the double-digit range combined with lower economic growth. Unlike the U.S. and Europe, the RBI raised interest rates to dampen inflation in a series of moves from early 2010 through early 2012.

In conclusion, our study finds that the trend towards inflation targeting by central banks in emerging markets prior to the GFC was not followed by India. India, like China, did not adopt an IT or quasi-IT monetary regime—the RBI neither concentrated exclusively on inflation nor adopted a form of inflation targeting. Our empirical work finds that the output gap systemically played an important role, as did inflation, in determining policy actions. We also find that the RBI fluctuated between two distinct monetary regimes, which we term Hawk and Dove, where the relative emphasis switched between inflation and output respectively. However, our estimates also indicate a great deal of policy discretion followed by the RBI, as articulated by the central bank's own senior officials.

With the advent of the GFC and its immediate aftermath, extraordinary monetary policy measures in India and elsewhere were quickly adopted. Inflation targeting was not at the forefront of monetary policy discussions for several years after the GFC and, where it had been adopted, the regime was usually suspended.[23] Central banks moved towards discretion and away from policy rules, more in line with traditional monetary policy making in India. Nonetheless, discussion of IT and the case of Indian "exceptionalism" in its approach to the conduct of monetary policy will likely remerge when economies and financial markets fully recover from the GFC.

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[22] Deepak Mohanty, Executive Director of the Reserve Bank of India, has argued (Mohanty, 2013a, 2013b) that the RBI response to the crisis may have been insufficient, and, when growth recovered after the crisis, monetary tightening may also have been implemented too slowly. He suggests that the RBI's estimate of potential output growth may also have diverged from what was actually happening after the crisis.

[23] See Baldwin and Reichlin (2013) for a series of articles discussing how inflation targeting was impacted by the GFC.

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