Monetary Regime Switches in India: Policy or Structure?

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Abstract

We use a Markov switching model to estimate a time-varying Taylor-type rule for Indian monetary policy conduct. This empirical approach is consistent with statements of Indian monetary policy decision-makers. We find that the conduct of monetary policy over approximately the last two decades can be characterized by two regimes, which we term 'hawk' and 'dove.' In the first of these, policy making reveals a greater relative weight on checking inflation vis-à-vis narrowing the output gap.

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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. Some central banks have adopted formal inflation targets (e.g. New Zealand and Sweden), while others 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. 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, Gali, Gertler, 2000; Woodford, 2001). 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 rule 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. 2008).

The objective of our paper is to investigate the nature of monetary policy rules in an increasingly important emerging market economy—India—that has undergone major domestic and international financial development and deregulation over the past two decades. These developments have changed the financial environment and external constraints (e.g. balance of payments, exchange rates and regime shifts) facing the central bank (Reserve Bank of India, RBI), and may have influenced its operating procedures, effective policy tradeoffs between output-inflation-exchange rate stabilization, and hence its monetary policy rule. In particular, monetary market deregulation took place in 1987. Prior to that time, the money market was highly regulated and the interest rate was essentially fixed. 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 economic environment – may be employed to systematically describe central bank actions. The RBI describes its 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.

Our paper contributes to this literature in two major ways. Firstly, we adopt a regime switching model to an emerging market (India) 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[1]. Our approach, by contrast, allows for an emerging market central bank to operate in either of two regimes, and switch from one regime to another multiple times in response to changes in the economic conditions (e.g. inflation rate, output gap, and the exchange rate). For example, at times the central bank 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 the primary 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 second contribution to the literature is the application of the regime switching model to Indian monetary policy. Much like the US Federal Reserve, the Reserve Bank of India (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

[1] Owyang and Ramey (2004), Assenmacher-Wesche (2005) and Frommel et al. (2004) consider regime-switching models for monetary policy rules for advanced economies. No study of which we are aware applies regime-switching models to monetary policy rules in developing or emerging market economies.

macroeconomic and financial conditions.” (Mohan, 2006b; 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 of which we are aware has undertaken this line of research for India. In particular, we are aware of only two studies that 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 thirteen 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. 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 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.

Over the past couple of decades, the Indian economy has undergone important structural changes that would impact the RBI’s monetary policy making as well. For example, Shah (2008) identifies five dimensions in which the Indian economy has changed in fundamental ways: (1) a shift toward a more conventional business cycle, rather than agricultural shocks dominating economic fluctuations; (2) much greater openness, rather than an almost completely autarkic situation; (3) major reform of a tax system that was marked by highly distortionary direct and indirect taxes; (4) significant development of financial markets, rather than a situation of extreme financial repression; (5) movement away from a situation where fiscal deficits were automatically parked with public sector banks, or passively monetized by the RBI. 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. In effect, one has to allow the data to speak for itself, in tracing the impact of structural changes in the economy.

The next section discusses the evolution of monetary policy in India and related literature. We summarize some of the major changes that took place in this sphere. The third section discusses the methodology and data. 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. We describe the data used (quarterly data from 1987 to 2008), and procedures used to derive potential output, in particular. The fourth section discusses the results: in particular, the Markov switching model identifies two distinct regimes, which we label 'hawk' and 'dove.' The hawk regime occurs only early and late in the sample period, and we discuss how to interpret these two episodes, particularly the latter one, from 2002 to 2008. The fifth section concludes by summarizing our results and interpretation.

2. Monetary Policy and Financial Liberalization in India

The Indian economy witnessed several structural changes over the sample period, as well as changes in conduct of monetary policy. Some liberalization of government controls on the economy began in the 1980s, with the most relevant change for our purposes being the beginnings of freeing up of interest rates in the late 1980s. Following a balance of payments crisis in 1991, a deeper and more comprehensive series of liberalization and deregulation measures were implemented with regard to the banking sector and financial markets. 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. Over the 1990s, the exchange rate depreciated substantially against the US dollar, continuing a process that had begun in the 1980s.

The RBI targeted monetary growth between 1980 and 1998 and from 1999 onwards followed a multiple indicator approach. 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 had abated of the crisis spilling over to India.

The subsequent period, through the mid-2000s, saw the RBI continuing to refine its approach to macroeconomic management. With global and domestic inflation relatively low, 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 move away from using the CRR as a policy instrument, focusing on interest rates instead (this intention 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 in this period.

A significant development in this period was an institutional innovation 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, and operates through repo and reverse repo auctions, thereby setting a corridor for the short-term interest rates, consistent with the policy objectives. The LAF therefore finally gave the RBI an explicit method for modulating short-term liquidity under varied financial market conditions, in order to influence call money rates. According to the RBI, the LAF has been operated "both as a tool for liquidity management and for interest rate signaling depending upon market conditions." Furthermore, the method of operation of the LAF has itself been evolving over time, in addition to variations in response to changing market conditions.

A final aspect of changing monetary management was the increase in capital inflows that began in the last decade. Capital inflows, if unchecked, increase the 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. In this period, therefore, the RBI apparently had to deal with trilemma of maintaining an independent monetary policy in the face of international capital flows and a desire to manage the exchange rate. Accordingly, we will address international factors and the implications of increasing openness of the Indian economy in our empirical analysis of monetary policy in India.

In any case, the take-away from this brief discussion of financial liberalization and changing policy perceptions in India over the last one or two decades is that it leads us to believe that a regime switching Taylor rule would be appropriate for uncovering the underlying preferences of the RBI's decision-makers. Even given the seemingly discretionary nature of policy, as articulated in statements by the RBI, its revealed preferences may be well captured by a model of systematic, though time-varying, behavioral responses.

3. Methodology and Data

Methodology 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, the exchange rate and lagged interest rate. With constant coefficients, this policy rule may be written as:

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

where i_t is the nominal interest rate, π_t is the year-on-year inflation rate (assuming a constant inflation target so the target is subsumed in the constant term of the equation) and y_t is the output gap at time t (deviation of actual output, measured as the index of industrial production, from potential output), e_t denotes the log of exchange rate and Δ is the first difference operator. The expected signs of the estimated coefficients are: α, β, χ and δ > 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 exchange rate depreciates. The lagged interest rate is introduced to capture the 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.

Equation (1) is the standard model for the estimation of central bank policy functions. It 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 the central bank's preferences may change in a systematic and predictable way 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 Owyang and Ramey, 2004 and Assenmacher-Wesche, 2005, 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 one regime (constant coefficients) model. In this circumstance, our estimation equation becomes:

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

with S_t representing the state at time t, i.e. S_t =1.... 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 (MSM), 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},…S_{t-r}, in which case the process is referred to as an r^{th} order Markov switching process.

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

$$P = \begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix} \quad (3)$$

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:

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

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:

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

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 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:

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

where $\Pr(S_t = m | S_{t-1} = n)$, m = 1, 2; n = 1, 2, are the transition probabilities (elements of matrix P above). 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:

$$\Pr(S_t = m \mid \Psi_t) = \frac{f(i_t \mid S_t = m, \Psi_{t-1}) \Pr(S_t = m \mid \Psi_{t-1})}{\sum_{m=1}^{2} f(i_t \mid S_t = m, \Psi_{t-1}) \Pr(S_t = m \mid \Psi_{t-1})} \quad (7)$$

where $f(i_t \mid S_t = m, \Psi_{t-1})$ 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. $\Pr(S_t = m \mid \Psi_t)$ where $t = 1, 2, \ldots, T$.[2]

Data

For the short-term policy rate, we use the overnight call/money market rate. The Indian central bank (RBI) follows a multiple instrument 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 derived from an unobserved components 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. To measure output, we use the Index of Industrial Production (IIP)[3]. 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

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

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

changes in the financial system in the late 1980s came money market deregulation and at that time it became the primary operating instrument of the central bank.

Prior to estimation, several data issues were dealt with. (i) 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. (i) 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 nominal exchange rate was used. (iii) 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 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. However, for 2007q4 there was an extreme spike in the interest rate that was recognized at the time as inadvertent, and not the result of a deliberate policy action. We have replaced this unrepresentative outlier by the average of interest rates in the weeks before and after that observation.

4. Empirical Results

Preliminaries

Figures 1-3 show the movements between the output gap and inflation (Figure 1), interest rate and inflation (Figure 2), and interest rate and output gap (Figure 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 latter sample (1996-2008).

Figure 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 latter period (0.06). The "output-inflation tradeoff" is not clearly evident in 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 attributable to an activist monetary policy.

Figure 2 shows the evolution of the interest rate and inflation. The interest rate is the overnight money market rate, represented on the right-hand-side scale, and represents the primary operating instrument of the RBI. Trend inflation has declined in India over the sample period. Inflation averaged about 9 percent, with wide variation (standard deviation of 2.9 percent), over the 1987 to 1995 period, and fell to around 5 percent during 1996-2007 as well as being more stable (standard deviation of 2.1 percent) in the latter period. Inflation jumped in mid-2008 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 much higher average level and more variable in the first sub-period compared with the second sub-period. Lower levels and more stability in inflation are 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 latter 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.

Figure 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 latter 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), whereas in the latter period the 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.

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 series 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.

Constant Coefficient Estimates

The second column of Table 2 presents the estimates of equation (2) assuming constant coefficients. The coefficients on the output gap, inflation and lagged interest rate are all significant at the 1% level and have signs predicted by theory—the RBI increases the policy 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), and increases the policy 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, so the long-run effects are substantially greater than the impact effects (i.e. 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 long-run inflation-response of 0.55 is considerably less than what Woodford (2001) finds theoretically (greater than 1.0) would be necessary to stabilize the economy.[4]

The coefficient on the exchange rate is positive as predicted by theory—currency depreciation, providing an impulse to future inflation via the pass-through channel, is correlated with a rise in the nominal interest rate. But this coefficient is not statistically significant. External considerations do not appear to be a significant factor influencing interest rate setting by the RBI. It may be the case that controls on international capital movements, despite some moves toward relaxation and increased domestic integration with foreign financial markets (Hutchison, Kendall, Pasricha and Singh, 2010), remain sufficiently binding to allow the RBI to essentially follow a monetary policy independent of external considerations. It is also possible that the RBI engaged in sterilization activities that neutralized the impact of international capital movements. When we included changes in foreign exchange reserves in the estimating equation, its

[4] 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 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 does not affect the comparison once the long run effect is computed.

coefficient was significant, and of the right sign.[5] Nevertheless, our estimation of the MSM suggests leaving out this variable from consideration, as we discuss later in the paper.

Markov Switching Model

The first column of Table 2 presents the regime switching model estimates. The output 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 coefficient on the (change in the) exchange rate is given by χ and the lagged interest rate coefficient by δ. The table also presents the probability p_{11} of staying in state 1 (state 2, p_{22}) if policy is already in state 1 (state 2). Unity 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 sharp distinction between two states of RBI policy which lead to the natural interpretation of a Hawk regime (state 1), when the focus is on inflation developments, and a Dove regime (state 2), when the focus is on the output gap. In particular, the output gap coefficient is statistically insignificant and the inflation coefficient is highly significant in state 1. The RBI appears to almost entirely concentrate on inflation stabilization in the Hawk regime, and little attention is focused on the output gap. State 2 coefficients are almost the opposite of those in state 1 in terms of statistical significance: the output gap is highly statistically significant and inflation is not statistically significant in state 2. Hence, the RBI appears to almost entirely concentrate on stabilizing output (reducing the output gap) in the Dove regime. Consistent with the constant coefficient estimates, the exchange rate does not appear to be a significant determinant of RBI policy.[6]

The estimates in Table 2 also suggest considerable inertia of the regimes, where the expected duration is very high, particularly for the Dove regime. In fact, the probability of staying in regime 2, the Dove regime, is greater (0.98) than the probability of staying in regime 1

[5] To obtain that result, we had to omit the exchange rate variable, which is also somewhat unsatisfactory.
[6] We also estimated regime switching models allowing the coefficient on the exchange rate to switch between state 1 and state 2. These results proved to be unstable, however, and are not reported.

(0.90), leading to a substantially higher expected duration for regime 2. Note that this inertia with respect to regimes is different from the inertia captured in the lagged interest rate term. The MSM model estimate of this coefficient is now substantially higher than in the constant coefficients case, suggesting that the RBI's policy responses to changing conditions may be slow. 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.

In looking at the coefficients of the MSM model, one can see that the output gap and inflation coefficients, whether or not they are significant, are lower in magnitude than the coefficients for the constant coefficient case. This means that the estimated short-run responses are lower once regime-switching is allowed for. However, the long-run responses are higher in the MSM model, because of the much larger coefficient on the lagged interest rate term. In the Dove regime, the long-run response to the output gap is 2.09, versus 0.89 for the constant coefficient estimates. In the Hawk regime, the long-run response of the interest rate to a 100 basis point rise in the inflation rate is 1.26, in contrast to 0.55 for the constant coefficient model. This is an important difference, because the magnitude in the MSM estimates is greater than one, the critical value for a stabilizing response to inflation. Of course, the model also suggests that this response is very slow to be fully realized. Note also that the best point estimate of the long-run response is also greater than one for the Dove regime, even though the coefficient is not precisely estimated in that case.

Returning to the behavior over time of the RBI, as captured in the MSM model, the estimated probability of RBI policy being in state 1 or state 2 (as calculated according to equation (7) and its preceding auxiliary equations) is shown in Figure 4. The probability of being in the Hawk regime (state 1) is very high during 1987-89, but abruptly switches and stays (with high probability) in the Dove regime (state 2) for an extended period during 1990-2002. The high probability of the RBI operating in the Hawk regime re-emerges during 2003-06, but again switches back to (a high probability of) the Dove regime during 2007-08.

Is the estimated pattern of Dove and Hawk regime switches consistent with our understanding of economic developments and RBI policy during this period of time? It is impossible to give a completely definitive answer, since there were many changes in policy framework, policy-makers, and the overall economic environment, over this entire period. However, the premise of the MSM model is that it allows the data to reveal how all these factors may have combined to yield particular overall policy stances at different times.

One way of approaching this issue is to graph the probability of being in the Hawk regime with inflation (Figure 5), and the probability of being in a Dove regime with the output gap (Figure 6). We would expect the probability of the Hawk (Dove) regime to rise with an increase (decrease) in the rate of inflation (output gap). Turning to Figure 5, the two large jumps in the probability (and then staying in the state) of the Hawk regime (early 1987 and late 2002) are indeed associated with upward swings in inflation. The presumed negative link between Dove probability and the output gap is more difficult to ascertain (Figure 6), perhaps because this state dominated the sample period. During most of this period a negative relationship is discernable, but with two major exceptions of which one is late 2006 when the output gap rose quite substantially (temporarily) and coincided with a switch to the Dove regime.

The joint behavior of the output gap and the inflation rate may also be responsible for the fact that, although our model identifies 2003-06 as a (likely) period of a Hawk regime, the interest rate does not seem to be particularly high over that period. One possible story we can tell is that, while the inflation rate was picking up, leading to the move to a more ‘hawkish’ stance, the output gap was such that this did not translate into a large interest rate response. The inertia in response within either regime, discussed earlier, may also be a factor in reconciling the behavior of the various individual variables, and the model’s identification of regimes.

We close with a brief discussion of external effects again. We have noted (footnote 6) that allowing for regime switching in the case of the exchange rate led to unstable results. Nor is the exchange rate coefficient significant in the MSM model. When we replaced the (change in the) exchange rate by the change in reserves, the latter coefficient is significant, but the MSM model is poorly estimated. This includes the log-likelihood, the standard errors, the probabilities in the Markov matrix (3), and the regime durations. Hence, we are not able to accept those estimates as useful or believable. Our conclusion, therefore, is that, at least for the period under examination, the trilemma does not seem to be a major concern for the RBI in its conduct of monetary policy, and external factors take a back seat to a more traditional focus on balancing concerns about the levels of inflation and of real economic activity.

5. Conclusion

This paper investigates the conduct of monetary policy in India by estimating policy rules that may switch over time depending on the economic environment. Our primary question 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. Our methodological approach is estimation of Taylor-type (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 the RBI policy may be characterized by Hawk and Dove regimes over the 1987-2008 period. The Dove regime appears to dominate, however, with the estimates suggesting that there was a high probability of being in a Dove regime (at least 50 percent likelihood) about 72 percent of time. Moreover, the model estimates suggest that the RBI focuses almost exclusively on the output gap during the Dove regime, with almost no attention to inflation in this state. Hence, the output gap appears the primary concern of the RBI during most of the sample with only occasional systematic focus on the inflation rate.[7] Moreover, we found no evidence that external considerations, represented here by movements in the exchange rate, systemically influenced RBI policy. Capital controls, policy responses such as sterilization, and other impediments to financial integration have apparently insulated RBI policy to a high degree from constraints imposed by external balance considerations.

Finally, another possible interpretation of these results is that the RBI is following a very discretionary monetary policy in which the output gap is usually very important, but is complemented by a host of other economic considerations. Inflation and external considerations may indeed enter their policy calculus upon occasion but not in a systematic way that may be easily measured using Taylor-type mechanical rules.

[7] We may temper this a little by noting that the point estimate of the inflation coefficient in the Dove regime is not low, just imprecisely estimated.

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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

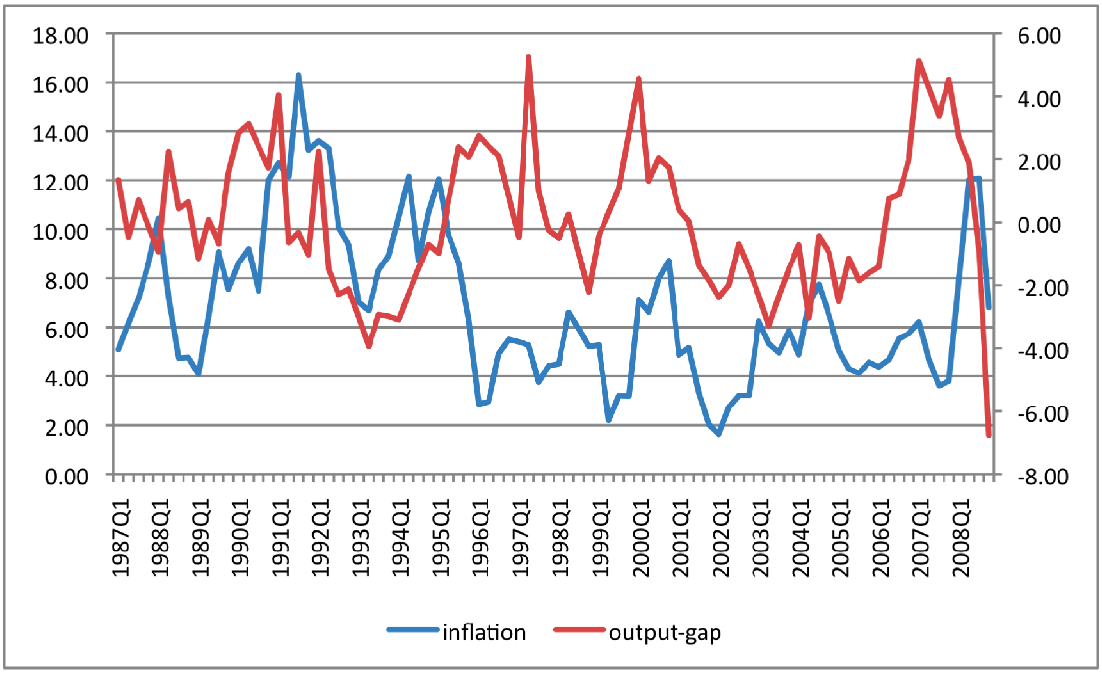
Note: *** (**) (*) denotes significance at the 1%, 5% and 10% level, respectively.

Table 2: Regime Switching and Constant Coefficients Models (1987q1-2008q4)

Parameters	Switching-Coefficients	Constant-Coefficients
α_1	0.1147 (0.1141)	0.5394*** (0.1858)
α_2	0.3883*** (0.0577)	
β_1	0.2346** (0.1021)	0. 3298*** (0.1047)
β_2	0.2325 (0.1502)	
χ	-1.7004 (4.3896)	3.1329 (12.5261)
δ	0.8144 *** (0.1023)	0.3961*** (0.0950)
p_{11}	0.90	
p_{22}	0.98	
σ^2_1	0.1781*** (0.0485)	
σ^2_2	20.0594*** (1.6616)	
Constant	0.0000 (0.0005)	3.4411*** (0.8300)
Expected Duration Regime 1	10.43	
Expected Duration Regime 2	44.23	
Final Log Likelihood	-222.0993	Adj. R Squared: 0.3647

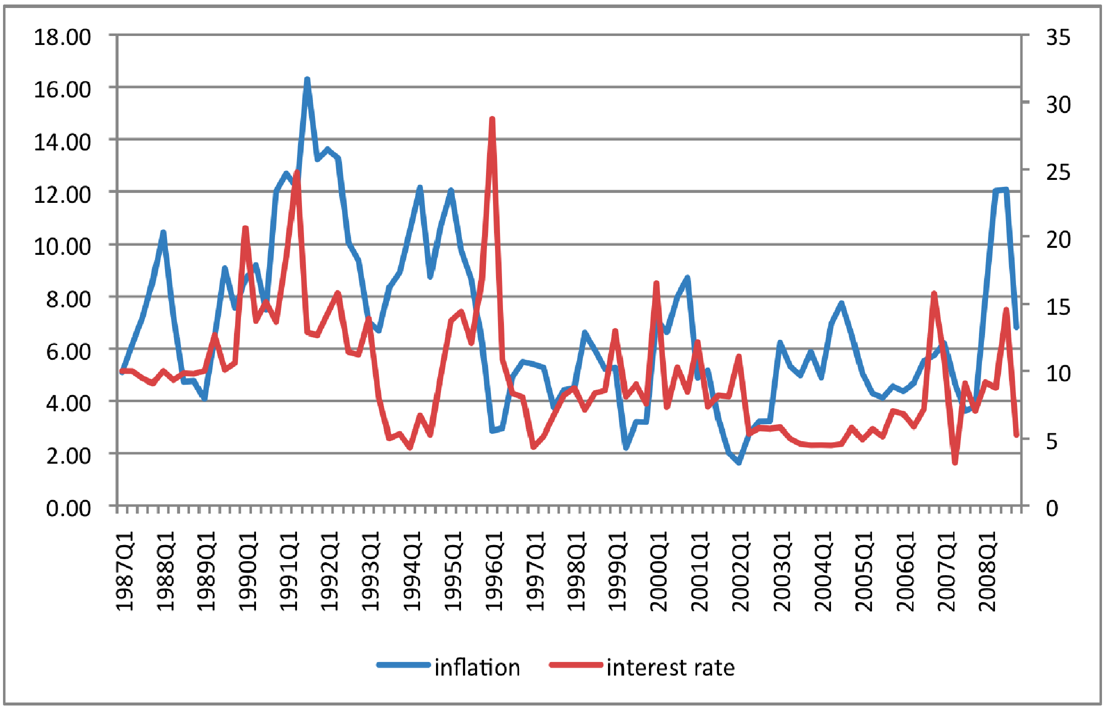
Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Figure 1: Output Gap and Inflation (WPI)



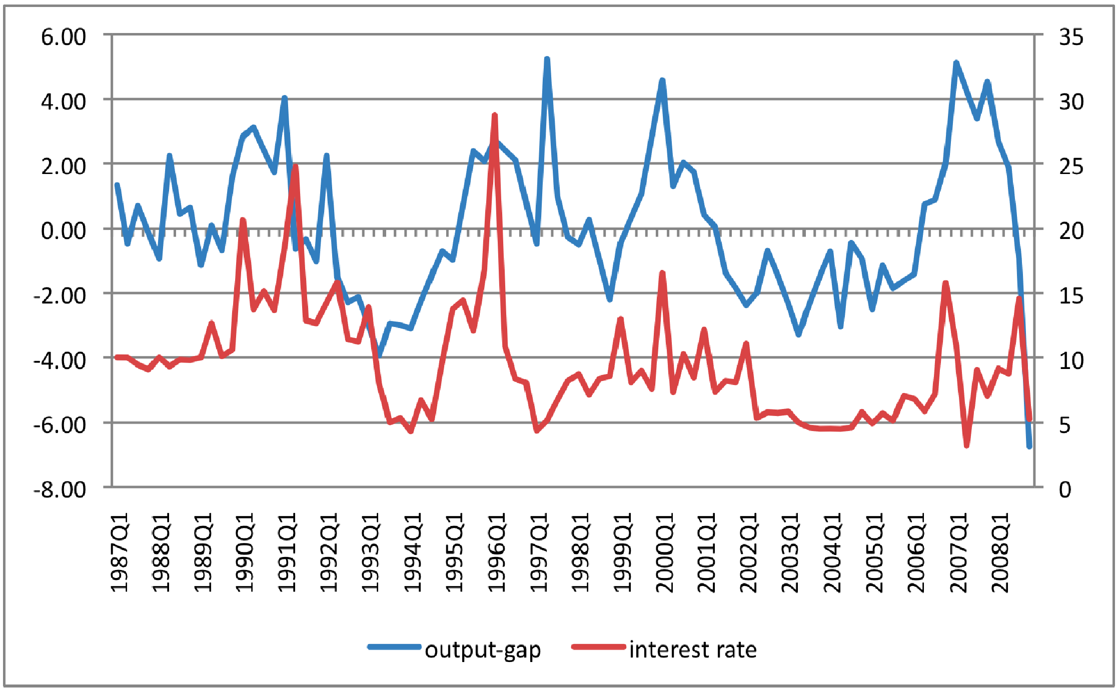
Note: Inflation is measured on the LHS axis and output gap on the RHS axis.

Figure 2: Interest Rate and Inflation (WPI)



Note: Inflation is measured on the LHS axis and interest rate on the RHS axis.

Figure 3: Interest Rate and the Output Gap



Note: Output gap is measured on the LHS axis and Interest rate on the RHS axis

Figure 4: Estimated Regime Probabilities, Hawk Regime (state 1) and Dove Regime (state 2)

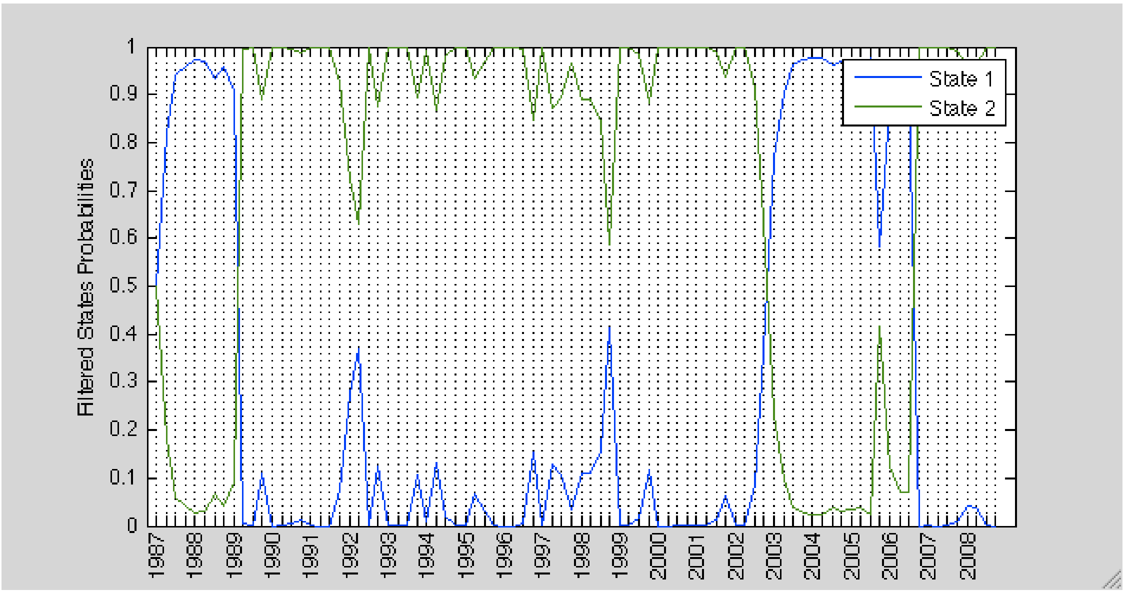
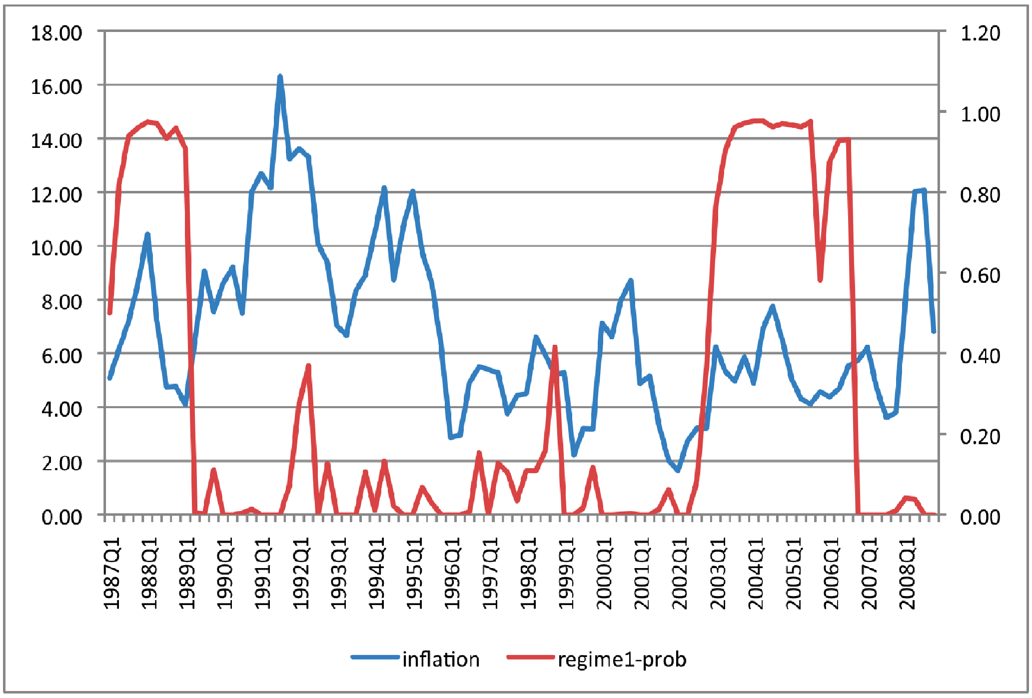
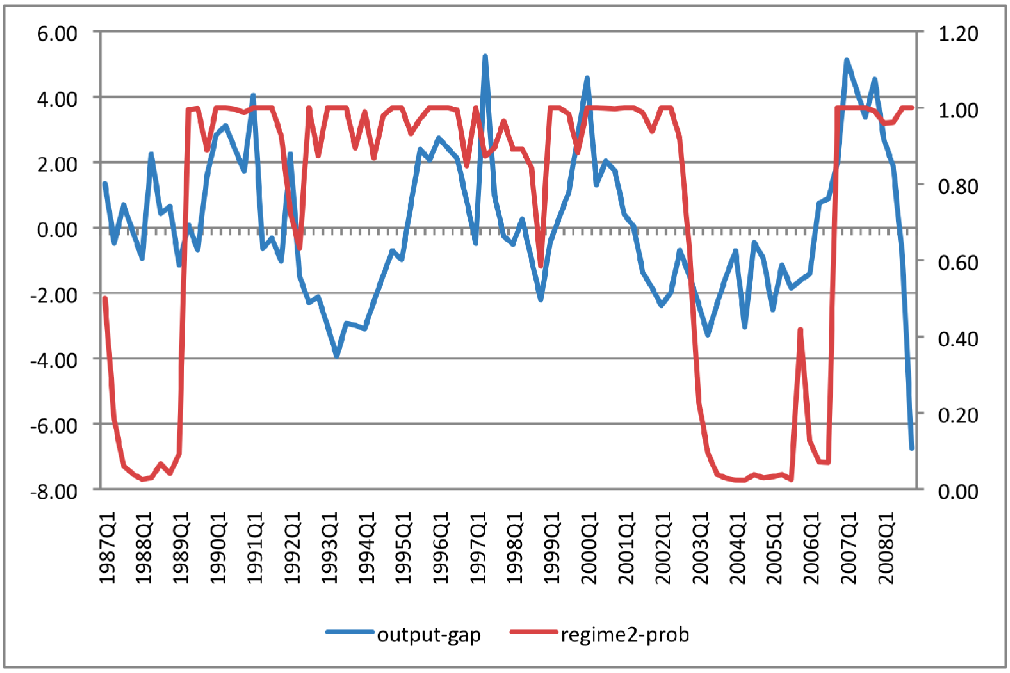


Figure 5: Probabilities of Hawk Regime (state 1) and Inflation Rate



Notes: Inflation is measured on the LHS axis and probabilities on the RHS axis. Inflation is measure as year over year inflation rate.

Figure 6: Probabilities of Dove Regime (State 2) and Output Gap



Note: Output gap is measured on the LHS axis and probabilities on the RHS axis.