Economics Bulletin

Volume 35, Issue 4

Inflation, uncertainty and monetary policy in India: a regime-switching analysis

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Abstract

Based on the characteristics of the inflation data for India, the paper first identifies the possible number of significantly different regimes using Kernel density estimates; and then it estimates a Markov-switching model using the Maximum Likelihood Estimation. Estimated results suggest that high inflation uncertainty in India has not only been a feature of very high levels of inflation but is also associated with the low levels.

We thank the anonymous referee for valuable comments.
Citation: Sudhanshu Kumar, (2015) "Inflation, uncertainty and monetary policy in India: a regime-switching analysis", *Economics Bulletin*, Volume 35, Issue 4, pages 2213-2219
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Submitted: June 17, 2015. **Published:** October 16, 2015.

1. Introduction

Inflation and inflation uncertainty remain a key policy puzzle in India. Most of the studies on inflation and its related uncertainty have so far concentrated on developed economies. The literature presents a mixed picture on this topic and can be broadly categorized into two contradicting views: Friedman (1977) says that level of inflation is positively related to inflation uncertainty, whereas Engle (1983) using U.S. data finds this relationship to be not significant. The positive relation argument is supported by the empirical studies such as Cukierman and Wachtel (1979), Fisher (1981), Ball and Cecchetti (1990), Evans (1991), Holland (1993) and Caporale and McKiernan (1997). In contrast, other studies, such as Cosimano and Jansen (1988) and Hwang (2001), do not support this argument, although they are consistent with Engle (1983). Given the costs associated with inflation and its uncertainty, the relation between level and volatility of inflation remains relevant.[1]

This paper examines the issue for India and provides an alternative empirical framework for looking at inflation and its associated uncertainty. The paper is organized as follows. Section 2 outlines the framework for the current analysis and discusses the estimation strategy. Section 3 gives empirical results while Section 4 concludes.

2. Data and the Methodology

2.1 Data

We use seasonally adjusted monthly Wholesale Price Index (WPI) data for the period from April, 1982 to October, 2014. WPI has a broader coverage and has been used for the purpose of policy formulation as the main measure of inflation in India during this period. The data are collected from various issues of the RBI Handbook of Statistics and the RBI Handbook of Monetary Statistics on the Indian Economy.

2.2 Methodology

Any inference regarding the relation between the level of inflation in India and the associated volatility needs to be made using a suitable non-linear framework. The relation between inflation and volatility estimates using a GARCH model is not linear for India and the shape of the possible non-linearity between two is not clearly established.[2]

As an alternative, the paper analyses inflation data for India with a regime-switching framework. The main feature of the Markov Switching Model (MSM) is its handling processes driven by heterogeneous states of the world. For technical details on MSMs, see Hamilton (1994) and Kim and Nelson (1999). Based on characteristics of the inflation data, inflation over time is divided into different states.

Using Kernel density estimates, we first establish the possible number of states (regimes) with significantly different mean and variance based on characteristics of the data. Then, a

[1] See Bailey (1956), Ireland (2009), Feldstein (1997), Kumar (2014), Lucas (2000) for further discussion on the cost of inflation.

[2] The detailed results on GARCH model estimates are not reported here for reasons of brevity. However, they are available on request.

Markov Switching Model (MSM) is estimated using Maximum Likelihood Estimation (MLE). We allow both the mean and the variances to be a function of the state indicator. Based on the filtered probability estimates obtained from the MLE, we calculate the conditional mean and the conditional volatility associated with the different states. The different volatilities for each state represent the uncertainty regarding the predictive power of the model in each state.

2.3 Determining the number of states for the MSM

Before estimating the Markov-switching models, we need to establish whether there is any evidence of more than one state, as a single state would boil down to the usual fixed parameter specification. Testing for number of states raises a particular situation when a 'nuisance parameter' is not identified under the null hypothesis and hence the usual Likelihood Ratio test cannot be applied (Hamilton (1994)). Under such circumstances, if the null hypothesis is that of a single state then the transition probability parameters under the alternative hypothesis are not identified under the null, since the likelihood function remains unchanged for any value of the transition probability.

In presence of regime shifts, the kernel density of the frequency distribution of the inflation series should be multimodal, where significantly different number of modes in the density corresponds to the number of regimes. In order to establish the relevant number of regimes, we perform '*Silverman bootstrap test for multimodality*'- an approach, which combines the Kernel density estimation with bootstrap methods (Silverman, 1986, Efron and Tibshirani, 1993). In order to preserve the time-series correlation of the data, we use the moving-blocks multimodality test (Efron and Tibshirani, 1993). Also, Silverman (1983) shows that the bootstrap test may tend to be conservative with respect to the null hypothesis if the standard levels of p-values are used to reject the null, hence resulting in underestimating the size of the modes in the density. Accordingly, we have used 0.17 as the cut-off probability.

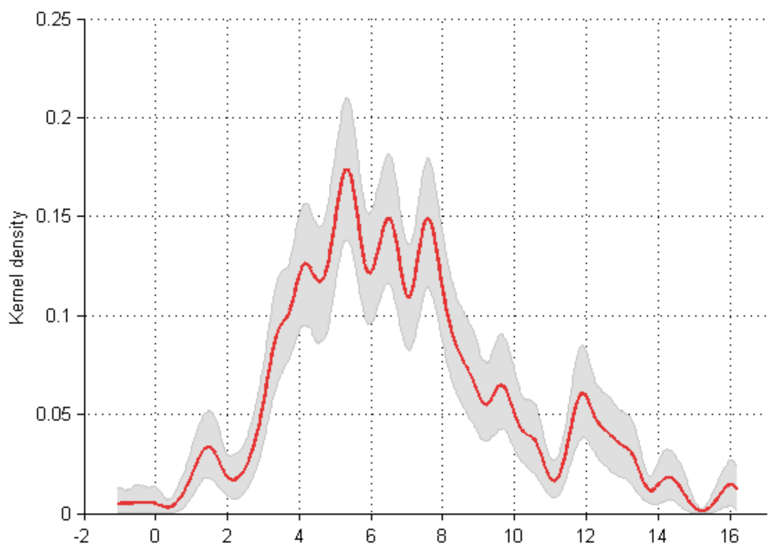
2.4 Regime-dependent autoregressive parameters

It is also interesting to check whether the inflation persistence in different regimes differs. However, the problem is that with the appropriate number of the autoregressive parameters in the model, the numerical maximization algorithm fails to converge to the global maximum from the MLE. Hence, an alternative approach by Bianchi and Zoega (1998) is used to identify the state-dependent autoregressive parameters. First, we estimate a model with the state-dependent mean and variance without any additional autoregressive parameters. An autoregressive process, $\mathrm{AR}(p)$, is fitted to the model's residuals under the null hypothesis of constant autoregressive parameters. A dummy variable matrix D_s is constructed of the order $(N-p)\times m$, where m is number of states, p is the appropriate number of lags and N is the number of observations. An $\mathrm{AR}(p)$ model is fitted to the residual data with D_s, under the alternative hypothesis. Based on the Likelihood estimates from these two models, a Likelihood Ratio test is performed. If the null hypothesis gets rejected, we find evidence for the state-dependent autoregressive parameters.

3. Results and Analysis

In order to carry out the Markov-switching analysis we need to establish whether there are regime switches and then to impose the optimal number of regimes or states before carrying out Maximum Likelihood Estimation. The multi-modal kernel density plot (Figure 1) is used as evidence for the presence of multiple states. However, the exact number of significantly different states cannot be inferred from this plot. The Silverman bootstrap test for multimodality is performed to establish the relevant number of states.

Figure 1: Kernel Density of Inflation in India for an optimal Bandwidth (0.26) with 95% bootstrap confidence intervals



The p-values along with the critical bandwidths corresponding to the different number of modes are reported in Table 1. The results suggest that there are three regimes for India's inflation for a cut-off p-value of 0.17.

Table 1: Moving-blocks bootstrap multimodality test result		
Number of Modes	**Critical Bandwidths**	**p-value**
1	0.99	0.13
2	0.76	0.14
3	0.64	0.17
4	0.26	0.26
Note: p-values are obtained from the 1000 bootstrap replications of the sample. The block-length used is 15.		

We next estimate a Markov-switching model with three states using the Maximum Likelihood Estimates (MS-MLE). Again, to ensure the convergence of the model, we estimate the model without any autoregressive term. But we allow both the mean and the variance to switch among the different states. We check for the possibility of changing autoregressive parameters following the approach used in Bianchi and Zoega (1998). The detail of the approach is discussed in the methodology section.

Table 2 presents the estimated mean and variance along with the associated p-values. The means and variances in the different states are different from each other.

Table 2: Inflation in India: MS-MLE estimate (1982:M04 – 2014:M10)

	Mean (p-value)	**Conditional Variance (p-value)**
State 1 (Low)	3.85 (0.00)	1.62 (0.00)
State 2 (Moderate)	6.64 (0.00)	0.99 (0.00)
State 3 (High)	10.68 (0.00)	4.64 (0.00)

LR test statistics for the test of constant autoregressive parameters across the states (based on the residual series) is 58.64~χ^2 (39)

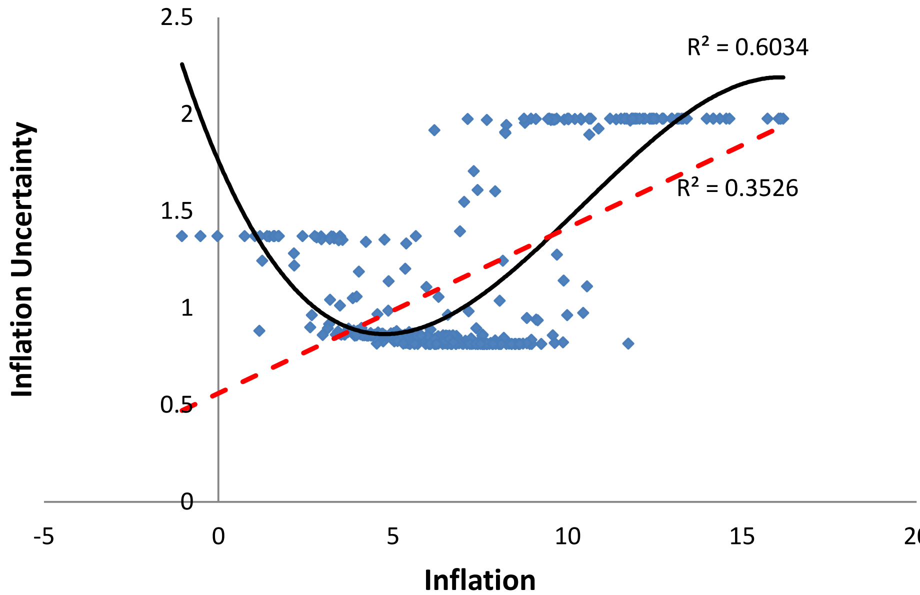
The last row in the table 2 reports the LR-test statistics for the test of constant autoregressive parameter across the states, based on the residual series from the fitted model. The null of constant autoregressive parameters is rejected. This suggests that the persistence of inflation in the different states is significantly different.

The estimated conditional variances associated with the different states of inflation are also reported in Table 2. The variances are significantly different from zero. The volatility of inflation is high in the states of very high and low levels of inflation, whereas in the intermediate states it is relatively low, indicating that the higher inflation uncertainty is linked with both the low and high levels of inflation.

The inflation uncertainty associated with the levels of inflation can be better examined from the Figure 2. The trend lines are fitted to infer about the possible association between inflation and its volatility. There are three clusters visible in Figure 2 and the non-linear trend line fits better than the linear line. It suggests that the relationship between inflation and its uncertainty is not linear.

The low and high levels of inflation are associated with higher inflation uncertainty in India. Thus, the empirical evidence suggests that the relationship is non-linear in the Indian inflation data. This result not only contradicts Friedman's (1977) observation that inflation level is positively linked with high inflation uncertainty, it also differ from Engle's (1983) evidence based on a GARCH model using U.S. data. The related literature for developed economies provides sufficient ground regarding the association between high uncertainty and high inflation. However, what explains the higher uncertainty associated with low level of inflation compared to that during moderate levels of inflation?

Figure 2: Inflation and Inflation Uncertainty from the MS-MLE model



This might be explained by policy makers' lack of commitment towards price stability and a higher temptation to pursue an expansionary monetary policy when inflation is below its comfort level. A central bank burdened with multiple objectives (e.g. output along with inflation) might shift its attention away from inflation stabilization as soon as inflation enters into the low state. The expansionary policy in low inflation regime could put inflationary pressure and make it more volatile. This probable explanation resonates with the view expressed by the then Reserve Bank of India (RBI) governor, Y V Reddy (2007), "… the twin objectives of monetary policy in India have evolved over the years as those of maintaining price stability and ensuring adequate flow of credit to facilitate the growth process. The relative emphasis between the twin objectives is modulated as per the prevailing circumstances and is articulated in the policy statements by the Reserve Bank from time to time." Thus, the presence of multiple objectives coupled with the fiscal dominance in India shifted the focus of monetary authority to support the fiscal goal of achieving higher growth when inflation was low during the period of analysis.[3] This might have led to higher inflation uncertainty.

4. Conclusion

This paper finds that inflation in India exhibits high and varying level of uncertainty for different regimes. Inflation uncertainty does not exhibit a linear relation with different levels of inflation. Higher inflation uncertainty may not only be a feature of very high levels

[3] In an interview to the WSJ on July 16, 2012, the RBI governor V Reddy said, "The issue of fiscal dominance has been a factor for most of the time in India. It is worrisome, it continues to be worrisome. Sometimes more worrisome, sometimes less worrisome but it's not new." Accessed on August 27, 2015 at http://blogs.wsj.com/indiarealtime/2012/07/16/qa-former-rbi-chief-y-v-reddy/

of inflation but also of low levels. Our results with Indian data thus shed a different light than what was envisioned by Friedman (1977) and documented by Engle (1984) with U.S. data.

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