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Hutchison, Michael and Sengupta, Rajeswari and Singh, Nirvikar

University of California Santa Cruz

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Michael M. Hutchison
Department of Economics
University of California
Santa Cruz, CA 95064 USA
Email: hutch@ucsc.edu

Rajeswari Sengupta[1]
Department of Economics
University of California
Santa Cruz, CA 95064 USA
Email: rsengupt@ucsc.edu

Nirvikar Singh
Department of Economics
University of California
Santa Cruz, CA 95064 USA
boxjenk@ucsc.edu

Abstract

We investigate whether the seemingly discretionary and flexible approach of India's central bank, the Reserve Bank of India (RBI), can in practice be described by a Taylor-type rule. We estimate an exchange rate-augmented Taylor rule for India over the period 1980Q1 to 2008Q4, allowing for potential structural shifts between the pre- and post-liberalization periods in order to capture the potential impact of macroeconomic and institutional changes on the RBI's monetary policy rule. Overall, we find that the output gap seems to matter more to the RBI than inflation, there is greater sensitivity to Consumer Price (CPI) inflation that Wholesale Price (WPI) inflation, and exchange rate changes do not play an important role in constraining monetary policy. Moreover, the post-1998 conduct of monetary policy seems to have changed in the direction of less inertia.

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[1] Corresponding author: Department of Economics, E2 building, University of California, 1156 High Street, Santa Cruz, CA 95064, USA; rsengupt@ucsc.edu. Phone: (831) 239-8676. Fax: (831) 459-5077

1. Introduction

India's central bank, the Reserve Bank of India (RBI), has followed a pragmatic approach to monetary policy. Much like U.S. Federal Reserve, RBI has responded to the state of the economy in a seemingly discretionary manner. A former Deputy Governor of 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 2006). In his seminal work, Taylor (1993) formulated a policy rule by which the US Federal Reserve was assumed to adjust policy interest rate (Federal Funds rate) in response to past inflation and 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. Many studies have subsequently applied this class of policy rule to examine the behavior of central banks in industrialized countries (e.g., Clarida et al., 2000).

We investigate whether the RBI's seemingly discretionary approach can in practice be accurately described by a Taylor-type rule. There have been relatively few empirical analyses of monetary policy rules for emerging economies overall and only one study that we are aware of, focuses on India. Virmani (2004) estimates monetary policy reaction functions for Indian economy, with monetary base (termed in the literature as a "McCallum Rule") and interest rate (Taylor Rule) as alternative operating targets. He finds that a backward-looking McCallum rule tracks the evolution of 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. Typical of multi-country studies in this area, Mohanty and Klau (2005) augment the Taylor rule to include changes in 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 output gap and real exchange rate change are significant determinants of short-term interest rate.

However, neither of the above studies explores RBI's policy rule beyond early 2000s, nor do they consider structural changes in policy rule. Over the past two decades, Indian economy has undergone important structural changes including globalization and financial liberalization. Against this background, we conduct an updated and more comprehensive analysis of India's monetary policy that allows for possible structural changes. In particular, we estimate the exchange-rate-augmented Taylor rule for India over the period 1980q1 to 2008q4 and explore possible monetary policy shifts between pre- and post-liberalization periods.

2. Methodology

The simple Taylor rule is estimated as follows. As is standard in relevant literature, we assume that RBI reacts to both output gap and inflation rate while setting the short-term interest rate:

$$i_t = \delta_0 + \delta_1 y_t + \delta_2 \pi_t + \delta_3 i_{t-1} + \varepsilon_t , \tag{1}$$

where i_t is nominal interest rate, π_t is year-on-year inflation rate and y_t is output gap at time t (deviation of actual output from potential output). According to Taylor rule, δ_1, δ_2 and δ_3 should be positive. The rule indicates a relatively high interest rate when inflation is above its target or when output is above its potential level. We call this our baseline model. Lagged interest rate is introduced to capture inertia in optimal monetary policy, as specified by Woodford (2001).

We augment the Taylor rule to include exchange rate change as additional explanatory variable, given its significance in previous work (Mohanty and Klau, 2005):

$$i_t = \delta_0 + \delta_1 y_t + \delta_2 \pi_t + \delta_3 i_{t-1} + \delta_4 \Delta e_t + \varepsilon_t , \tag{2}$$

where e_t denotes log of nominal exchange rate and Δ is the first difference operator.[1] An increase in exchange rate implies depreciation. Expected signs of estimated coefficients

[1] We included real exchange rate in our analysis as well and obtained similar results that are not reported here for brevity but are available upon request. We chose the nominal rate here because it is more salient in discussions of Indian exchange rate policy.

are: δ_1, δ_2, δ_3 and δ_4 > 0. This implies a higher interest rate when exchange rate depreciates and lower interest rate when exchange rate appreciates. Equation (2) is our estimating equation.

3. Structural and Policy Changes

Indian economy witnessed several structural changes over the sample period, as well as changes in conduct of monetary policy. Following a balance of payments crisis in 1991, a series of liberalization and deregulation measures were implemented with regard to banking sector and financial markets. These structural changes are likely to have impacted the RBI's operating rule both directly and indirectly. Between 1991 and 1997, lending rates of commercial banks were deregulated, issue of ad hoc treasury bills was phased out (thereby eliminating automatic monetization of the budget deficit), Statutory Liquidity Ratio and Cash Reserve Ratio rates were sharply reduced, and the bank rate was reactivated. In 1994, India switched over to a mainly market-determined exchange rate system and instituted current account convertibility. RBI targeted monetary growth between 1980 and 1998 and from 1999 onwards followed a multiple indicator approach. Starting in 1998, RBI undertook strong monetary policy measures (increasing interest rates and withdrawing liquidity). Furthermore, the foreign exchange market was characterized by high degree of volatility following the onset of Asian crisis towards end of 1997. Against this background, we estimate equation (2) over following four sub-periods: (i) 1980Q1 to 1994Q4; (ii) 1995Q1 to 2008 Q4; (iii) 1980Q1 to 1998Q4 and (iv) 1999Q1 to 2008Q4.

4. Data

For the short-term policy rate, we use the overnight call or money market rate. The RBI follows a multiple instrument approach to influence the call money rate.[2] An important issue in estimation of monetary policy rules, especially in emerging markets such as India, is the measurement of output gap. There is no official measure of potential output levels. Virmani (2004) compared estimated potential GDP derived from an

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[2] We also used bank rate from 1999 onwards conditional upon data availability. Results remain the same and are available upon request.

unobserved components model with estimates derived from a Hodrick-Prescott (HP) filter, and found little difference. Similarly, we derive output gap using the HP filter for measuring trend output and taking the residual of 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 Wholesale Price Index (WPI). We also derive results using Consumer Price Index (CPI), since it receives policy attention. All data are quarterly and overall sample period is 1980q1 to 2008q4.

Prior to estimation, we consider several additional data issues: (i) Analysis of linear plot and Hylleberg-Engle-Granger-Yoo test suggest that quarterly IIP series has multiplicative seasonality. Hence we de-seasonalize the IIP series using the X-12 ARIMA procedure. (ii) Unit root tests, i.e. Augmented Dickey-Fuller, Phillips-Perron, Elliott-Rothenberg-Stock and Kwiatkowski-Phillips-Schmidt-Shin test results suggest the presence of a unit root in the exchange rate series in levels, but first differences appear to be stationary. We therefore use the first difference of the nominal exchange rate. (iii) Durbin Watson and Breusch-Godfrey tests suggest presence of serial correlation and Breusch-Pagan/Cook-Weisberg test shows the presence of heteroskedasticity in the error terms. Hence, we estimate our model using ordinary least squares regression with Newey-West variance-covariance matrix, in order to correct for both autocorrelation and heteroskedasticity.

5. Results

We present our estimation results in Tables 1 and 2, using WPI and CPI measures of inflation respectively. Each table has five columns. Column 1 gives results for the entire period. Columns 2 and 3 report estimates of a sample truncated at 1994Q4, and columns 4 and 5 report estimates of a sample truncated at 1998Q4. Each of these truncations represents a plausible break point from the perspective of changes in conduct of Indian monetary policy.

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

For both inflation measures, and for all time-periods, we find that output gap is statistically significant, sometimes at the 10 percent level, but more typically at 5 percent or 1 percent levels. This is consistent evidence that Indian monetary policy is responsive to the output gap. The raw coefficients are all quite similar in magnitude, but the effective responsiveness to output gap depends on adjusting for the magnitude of lagged interest rate coefficient. The latter coefficient varies somewhat, but is higher for the earlier periods (with either break). It is not significant for the 1999q1-2008q4 period. For instance, when the lagged interest rate coefficient is taken into account, the output gap coefficient in both WPI and CPI regressions for the earlier period of 1980q1-1998q4 is close to 1.13 whereas for the later period of 1999q1-2008q4, it is around 0.58. Hence, our results indicate that the most recent monetary policy framework has little inertia, and is somewhat less responsive to the output gap than in earlier periods.

The WPI regressions indicate no policy responsiveness to inflation as opposed to the CPI regressions. Moreover, there is a marked difference between earlier and later periods in the CPI regressions. However, the inflation coefficient, even when adjusted for a lagged interest rate term, is never greater than one, indicating a weak policy response to inflation as reflected in short-term market interest rates.

Further, in line with RBI's own public stance, we find that exchange rate movements do not constitute a systematically important determinant of its monetary policy conduct over the entire sample period. There is some evidence of an effect in the most recent period (1999q1-2008q4), during which Indian economy witnessed appreciably more exchange rate flexibility and a higher degree of international capital flows.

Overall, our results provide a clear picture of Indian monetary policy conduct. The output gap seems to matter more than inflation, there is greater sensitivity to CPI inflation (which gives more weight to food items, and can therefore be politically more salient), exchange rate changes do not constitute an important policy factor, and the post-1998 conduct of monetary policy seems to have changed in the direction of less inertia.

6. Conclusion

We are extending the initial research discussed above, in several ways. We are considering Markov regime-switching models to capture shifts in monetary policy making, incorporating monthly data, and exploring alternative specifications of Taylor-type rules for estimation. Since Indian monetary policy is conducted in a highly discretionary way, and somewhat non-transparently, our empirical analyses can provide important insight into the "revealed preferences" of monetary policy makers in an important emerging market economy.

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Table 1: Modified Taylor Rule Estimations: With WPI Inflation

VARIABLES	1980q1-2008q4	1980q1-1994q4	1995q1-2008q4	1980q1-1998q4	1999q1-2008q4
y_t	0.488*** (0.182)	0.632** (0.244)	0.463** (0.209)	0.547* (0.292)	0.581*** (0.176)
π_t	0.134 (0.102)	0.015 (0.097)	0.281 (0.185)	0.067 (0.116)	0.097 (0.211)
i_{t-1}	0.434*** (0.090)	0.548*** (0.092)	0.356** (0.143)	0.519*** (0.113)	0.051 (0.131)
Δe_t	8.249 (10.488)	4.194 (12.313)	-0.607 (17.448)	-2.177 (12.152)	27.556* (15.929)
Constant	4.229*** (0.850)	4.549*** (1.186)	3.842*** (1.418)	4.453*** (1.344)	6.744*** (1.577)
Observations	115	59	56	75	40
Adj. R-Sq.	0.335	0.436	0.209	0.339	0.188

*** p$<$0.01, ** p$<$0.05, * p$<$0.1

Robust Standard errors in parentheses

Table 2: Modified Taylor Rule Estimations: With CPI Inflation

VARIABLES	1980q1-2008q4	1980q1-1994q4	1995q1-2008q4	1980q1-1998q4	1999q1-2008q4
y_t	0.498*** (0.190)	0.636** (0.246)	0.504** (0.224)	0.541* (0.292)	0.588** (0.226)
π_t	0.202* (0.081)	-0.008 (0.118)	0.306* (0.160)	0.065 (0.102)	0.403** (0.193)
i_{t-1}	0.409*** (0.089)	0.551*** (0.089)	0.281** (0.126)	0.520*** (0.115)	-0.008 (0.111)
Δe_t	6.188 (10.762)	4.357 (13.185)	1.013 (18.562)	-2.474 (12.227)	23.822* (13.789)
Constant	3.848*** (0.822)	4.719*** (1.726)	4.074*** (1.269)	4.367*** (1.513)	5.733*** (1.508)
Observations	115	59	56	75	40
Adj. R-Sq.	0.345	0.436	0.235	0.337	0.247

*** p$<$0.01, ** p$<$0.05, * p$<$0.1

Robust Standard errors in parentheses