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Alternative Monetary Policy Rules for India

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Abstract

This paper empirically evaluates the operational performance of the McCallum rule, the Taylor rule and hybrid rules in India over the period 1996–2011 using quarterly data, with a view to analytically informing the conduct of monetary policy. The results show that forward-looking formulations of both rules and their hybrid version - setting a nominal output growth objective for monetary policy with an interest rate instrument - outperform contemporaneous and backward-looking specifications, especially when targeting core components of GDP and inflation, and combine the best parts of efficiency and discretion.

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"*….do not imagine that any actual central bank would ever turn their determination of instrument settings over to some clerk armed with a simple formula and a hand calculator—or even to a team of PhD economists armed with computers and Matlab simulation programs.*"

------Bennett McCallum, 2002

I. Introduction

Should monetary policy be conducted by rules known in advance or by the policy maker's discretion? This question, as unsettled today as it was in its origins (Simons, 1936)[2], continues to haunt the 'how' of monetary policy conduct. In the slipstream of 'seminal' work in the late 1970s on time–inconsistency, this debate has turned out to be among the most enduring and prolific in the literature. The case for rules was demonstrated across a general class of models rather than a specific view of the world such as the celebrated monetary rule (Friedman, 1960) – discretion implies selecting the decision which is best, given the current situation, but this may result either in consistent but sub-optimal planning or in economic instability (Kydland and Prescott, 1977).

Practitioners have argued that this advocacy for rules tends to trivialize one of their important concerns: how to account for the uncertainty in the link between policy instruments and ultimate objectives (Carlson, 1988). This warrants some flexibility, especially in the face of unforeseen contingencies that are potentially destabilizing and accordingly, it is reasonable to adopt a more pragmatic approach of rules with discretion. While the dialectic continues to evolve, it is generally recognized that discretion is essentially related to some sense of an underlying rule or deviation therefrom. The dichotomy between rules and discretion has to be seen as a continuum, and the actual practice of monetary policy as a point in this continuum determined by the degree of predictability of the relationship between goals and instruments. In fact, if predictability exists or at least variability is systematic, it is possible to incorporate feedback into a rule. Accordingly, using economic theory to evaluate alternative policy rules that are easily operated and understood is a valid exercise to inform policy making.

[2] Henry Simons discussed the issue as a choice between rules and authorities. In his view, "definite, stable, legislative rules of the game as to money are of paramount importance to the survival of a system based on the freedom of enterprise."

Operating characteristics are important as they determine the degree of commitment of the monetary authority to the rule. If commitment is low and therefore discretion is high, it generally reflects difficulties in making the rule operational. Thus, operationalising a policy rule and evaluating its performance over time assumes importance. In this context, two proposals – McCallum (1987) and Taylor (1993) - have raised the debate to an operationally concrete level. Both recognize the need for flexibility but differ in the manner in which flexibility is incorporated into the rule. By attempting to reduce uncertainty, both try to secure the credibility of monetary policy and to avoid the inefficiencies of time inconsistency associated with pure discretion. Empirical checks of their operational characteristics have naturally fascinated economists. In the recent period, a welcome development has been the growing strand of work on empirically testing for the operability of these alternative policy rules for emerging economies (Koivu, Mehrotra and Nuutilainen, 2008; Mehrotra and Sanchez-Fung, 2011; Khakimov, Erdogan and Uslu, 2009; Sun, Gan and Hu, 2010) and particularly for India (Virmani, 2004; Patra and Kapur, 2012). These efforts reflect a recognition of improvements in institutional frameworks of monetary policy regimes in these countries that has enhanced the operational autonomy of monetary authorities, alongside the growing sophistication of financial markets.

This paper joins the growing literature on this strand of work by empirically evaluating the operational performance of the McCallum rule and the Taylor rule in India, recognising that such an exercise has to be country-specific. The exercise spans the period 1996-2011 which witnessed two different policy regimes and the transition from one to the other. Consequently, the findings of the paper are able to throw some light not only on the operational feasibility of each rule in the Indian context but also on the degree of commitment of policy authorities to rules and variations therein, if any. Section II explores the literature on empirical features of the two alternative policy rules with a view to teasing out nuances and caveats that will condition the estimation and evaluation of the rules in the Indian context. Section III profiles the historical development of monetary policy conditions in India over the period of study against the backdrop of macroeconomic and financial developments that were the setting for prevailing policy regimes and shifts. This provides a reality check for the choice of alternative policy rules. Section IV describes the estimation framework, results and salient inferences. Section V offers some concluding remarks.

II. Select Empirical Literature

Over the recent decades, there has been a silent revolution. Modern central banks and monetary authorities have increasingly shed secrecy and mystique to engage in communicating to the public their policy framework and rationale, their goals and why they chose them, and the manner in which they intend to achieve their stated objectives. They and the public have shown a preference for a monetary policy that is disciplined by principles of systematic conduct so that the temptation of higher inflation can be resisted, accountability and credibility can be earned, and policy uncertainty among market participants reduced. This reveals a conscious effort to mitigate the problem of dynamic inconsistency extensively studied in the literature, with proximate solutions ranging from reputation-building (Barro and Gordon, 1983), choosing a conservative central banker (Rogoff, 1985), optimal contracts for central bankers (Walsh, 1995) to some kind of pre-commitment to a policy rule.

In this context, it is useful to start with some home truths. One monetary policy rule is better than another only if it results in better economic performance according to some criteria such as inflation or the variability of inflation and output. Neither theory nor evidence points convincingly to any of the numerous competing models as superior in explaining the interaction of nominal and real variables as occurs in actual practice. The relevance of expectations of the future and events of the past to current decisions gives the modern-day rules a dynamic feature. Shocks to preferences or technology or simply to decision rules make them stochastic. The rules pertain to the whole economy, not to an individual sector, and this makes them general equilibrium rules. Each of them incorporates some kind of temporary nominal rigidity, usually a variant of staggered wage or price setting, which results in a short-run trade-off between inflation and output or unemployment. With stochastic shocks, the trade-off is characterized as one between the variance of inflation and the variance of output, but there is no long-run trade-off.

Simple policy rules work well; their performance is surprisingly close to that of fully operational policies and more robust than complex rules across a variety of models. Although policy rules can be written down algebraically, they will probably be more useful as guidelines than as mechanical formulae for policy makers to follow exactly at least for the near future (Taylor, 1999a). A good rule is, therefore, one that provides a useful starting point for central bank deliberations. A central bank can benefit from having a collection of alternative good rules – rules that have optimal properties in a variety of models. This helps to deal with the uncertainty inherent in the monetary policy process – model uncertainty emanating from a variety of assumptions, and situation uncertainty – uncertainty about the current state of the economy and about where the economy would be going with no change in the policy rate (Feldstein, 1999).

A Brief Historical Journey

The quest for monetary policy rules has been traced back to the writings of Wicksell[3] who argued that the central bank should aim to maintain price stability. This simple interest rate rule did not attract much attention in policy discussions, perhaps because its exclusive focus on price stability and lack of explicit reference to developments in real economic activity did not go down well with the ruling orthodoxy of the day.

An early influential case for rules is reflected in the Chicago view which produced non-activist formulations (Friedman, 1960; Lucas, 1980). A simple but operable policy rule developed and revolutionized thinking on monetary policy in its time and beyond - that the central bank maintain a constant rate of growth of the money supply equivalent to the rate of growth of real GDP or the celebrated k-percent rule[4]. Giving governments any flexibility in setting money growth was believed to lead to inflation; countercyclical Keynesian-type monetary policy was to be avoided at all costs. During the 1960s and 1970s, Friedman's recommendation was that the Federal Reserve control the rate of money supply growth at 4 percent. The advantage of the constant money growth was that very little information was required to implement it. If velocity does not exhibit a secular trend, the only required

[3] "If prices rise, the rate of interest is to be raised; and if prices fall, the rate of interest is to be lowered; and the rate of interest is henceforth to be maintained at its new level until a further movement in prices calls for a further change in one direction or the other." (Wicksell, 1898; 1936). See Woodford (2003) and Orphanides (2007) for a brief account of this historical retrospective.

[4] "The stock of money [should be] increased at a fixed rate year-in and year-out without any variation in the rate of increase to meet cyclical needs" (Friedman 1960). "A set of aggregative policies which would I believe, lead, and have led, to satisfactory general economic performance are, compactly described: 1. A 4% annual rate of growth of M1, maintained as closely **as** possible on a quarter-to-quarter basis. 2. A pattern of real government expenditures and transfer payments, varying secularly but not in response to cyclical changes in economic activity 3. A pattern of tax rates, also varying secularly but not in response to cyclical changes in economic activity, set to balance the federal budget *on average.* 4. A clearly announced policy that wage and price agreements privately arrived at will not trigger governmental reactions of any kind (aside from standard antitrust policies and the general policy of government preference for low over high bids). The first three of these policy rules are taken directly from Friedman's writing. The fourth is simply a recognition of the fact that, since the time Friedman's proposals were originally formulated, intervention in the details of private price and wage negotiations has ceased to be viewed as an emergency measure so that a position on the generally accepted aspects of aggregative policy cannot omit mention of this fact."(Lucas, 1980)

element for calibrating the rule is the economy's natural growth of output. In addition, the calibration of this rule does not rest on the specification of any particular model and is stable across alternative models of the economy. Despite its intuitive appeal, however, the Friedman rule became difficult to operate in the face of real world developments as is well known. High inflation and a breakdown in the stability of the velocity of money brought on by deregulation of financial markets, innovations and advances in transactions technology made control of money supply futile. It suffered from logical weaknesses too. Ruling out policy feedback implied a belief that money was the exclusive determinant of GDP. Moreover, if a particular money rule would stabilize the economy, discretion preferring policy makers could always behave that way and still retain the flexibility to change the rule as needed (Fischer, 1988).

Two Modern Formulations

The McCallum and Taylor rules are essentially efforts to develop simple and transparent rules that could deliver improved macroeconomic performance. They belong in the suite of rules driven by the belief that central banks should respond to evolving conditions in a relatively activist manner, in contrast to the types of rules proposed by the Chicago school.

The McCallum rule (McCallum, 2000) specifies the growth rate of the monetary base (instrument) in a non-discretionary feedback rule for nominal GDP (target) as

$$\Delta b_t = \Delta x^* - \Delta v_t + 0.5(\Delta x^* - \Delta x_{t-1}),$$

where Δb_t is the rate of growth of the monetary base; Δv_t is the rate of growth of base velocity averaged over previous four years[5]; Δx_t is the rate of growth of nominal GDP and Δx^* is the target rate of growth of nominal GDP (assumed at 5 percent by McCallum for the US) taken to be the sum of π^*, the target inflation rate (2 percent), and the long-run average rate of growth of real GDP (3 percent per year). Since technological and regulatory changes

[5] In a quarterly model, Δv_t = average growth of the base velocity over the previous 16 quarters = $(1/16)*[(x_{t-1} - b_{t-1}) - (x_{t-17} - b_{t-17})]$. Growth rate variables such as Δx_t have been measured as changes in logs. Therefore, such variables reflect quarterly changes, not annulized, and in fractional (rather than percentage) units. Accordingly, such variables need to be multiplied by 400 to be commensurate with similar variables as measured by Taylor and in most papers concerned with policy rules (McCallum, 2000).

alter the growth of base velocity from year to year, a problem that undermined Friedman's rule, Δv_t is averaged over the past four years and is intended as a forecast of the average growth rate of velocity over the foreseeable future rather than a reflection of current cyclical conditions which are represented by the term $\Delta x^* - \Delta x_{t-1}$. In substance, base money growth must equal the targeted growth of nominal GDP. There is a proportional feedback to the growth rate of base money from the gap between nominal GDP growth and its targeted rate. If the relationship between the monetary base and nominal income changes (say on account of financial innovations), the growth rate of the monetary base must be adjusted accordingly.

The Taylor rule (Taylor, 1993) prescribes the adjustment of interest rate policy instrument in a systematic manner in response to developments in inflation and macroeconomic activity. It can be written as

$$R_t = r + \Delta p_t + 0.5(\Delta p_t - \pi^*) + 0.5\, \acute{y}_t$$

where R_t is the nominal policy interest rate; r is the average equilibrium real interest rate; Δp_t is the inflation rate, recent or expected future value; π^* is the target rate of inflation, and $\acute{y}_t$ is the deviation of current real GDP from its potential or natural rate.

Taylor has used 2 percent for the average real rate of interest and has also assumed that 2 percent per year is the target rate of inflation. Different values could be specified for the coefficients on the terms $(\Delta p_t - \pi^*)$ and y_t, but the values of 0.5 were used in Taylor's original work. The presence of the term Δp_t on the right hand side implies that a measure of the real rate of interest, $Rt - \Delta pt$, is adjusted up or down relative to the average real rate r in response to departures of inflation and output from their target values. Taylor also noted that if the deviation of real quarterly output from a linear trend is used to measure the output gap, and the year-over-year rate of change of the output deflator to measure inflation, this parameterization appeared to describe Federal Reserve behavior well in the late 1980s and early 1990s.

Methodological Issues

In essence, a rule is a restriction on the monetary authority's discretion. Most rules proposed in the literature do not, however, eliminate discretion completely[6]. Modern policy rules recognize the desirability of some discretion in the monetary authority's response to the evolving state of the economy, and, therefore, incorporate feedback that allow it to react in a manner that minimizes the persistence of shocks. Both the McCallum rule and the Taylor rule incorporate feedback. While some evidence suggests improved performance, responding to the state of the economy can also be destabilizing. It is also important to take note of the Lucas (1975) critique and carefully consider the implications of changes in policies for expectations – what expectations of prior policy are built into the model and how the model will change with a new policy.

Methodological issues surrounding the operationalisation of rules essentially relate to the manner in which feedback is incorporated – the choice of policy instrument that the monetary authority can control directly and/or accurately – base money for McCallum and the short-term policy rate for Taylor (in some cases, the exchange rate); the target variable(s) – deviation of nominal GDP growth from its target for McCallum and deviations of inflation/real output from target/potential for Taylor (variants also incorporate the exchange rate); the baseline for the target variable – long run rate of nominal output growth for McCallum and the real rate of interest for Taylor; the monetary policy response parameter – the coefficients on the target variables; and the smoothing parameter (the coefficient on the lagged policy variable) which empirical analysis has shown to be important in gauging the pace of policy response.

(a) McCallum Rule

Turning to specific methodological issues, first, it is important to note that the policy instrument in the McCallum's rule i.e., the monetary base implicitly sums the effects of pure changes in high-powered money and those induced by changes in reserve requirements. Given the tendency of the central bank to systematically offset changes in reserve

[6] Even a relatively inflexible Friedman-type rule that prescribes a constant rate of money supply irrespective of developments in the economy can allow substantial judgment about the choice of instrument or of timing.

requirements with open market operations, the explanatory power of the monetary base as a policy instrument is significantly improved by adjusting for the short-run dynamics embodied in discrete changes in reserve requirements (McCallum, 1990; Haslag and Hein, 1995).

Second, the McCallum rule employs average velocity growth because trends in velocity growth can shift over time, but not every change in base velocity represents a long-lasting shift in the trend (McCallum and Nelson, 1999). The velocity growth adjustment is intended to reflect long-lasting institutional/technological changes affecting the demand for the monetary base[7].

Third, the term for deviations of nominal GDP growth from target is intended to account for cyclical influences and acts as an error-correction mechanism. As in all error-correction models, this confronts a trade-off between gradualism and immediate restoration of the target. Thus, the key element in McCallum's rule is the monetary response coefficient which determines how much base money – and eventually money stock – must change when nominal GDP deviates from its target. If the monetary response factor is too large, it can induce an explosive reaction or instability in the economy. On the other hand, a monetary response factor that is too small implies that monetary policy does not affect the economy much. There seems to be a range of ideal values for the monetary response factor (Croushore and Stark, 1996). McCallum's own research and other efforts (Hall, 1990) suggests using a factor of 0.5 for the US economy. In contrast, a lower feedback value (0.25) is needed for Japan (McCallum, 1993). For developing countries such as China, a smaller monetary response factor is found to be appropriate (Sun et al, 2010). Clearly, instrument instability is an important issue that has to be dealt with in a country-specific manner in the context of estimating McCallum's rule.

Fourth, McCallum rule also features feedback adjustments in velocity changes in response to cyclical departures of nominal income from the target path with the coefficient chosen to balance against the danger of instrument instability. However, the velocity

[7] Dueker (1993) uses a time-varying coefficient model with heteroscedastic errors, claiming the advantage of forecasting information about a host of explanatory variables besides the dependent variable, and better adaptation to structural breaks.

correction term could be omitted without any appreciable effect on results, attesting to the non-dependence of the McCallum rule on base velocity growth (McCallum, 2002).

In empirical analysis McCallum showed that if a rule such as his had been followed, the performance of the U.S. economy likely would have been considerably better than actual performance, especially during the 1930s and 1970s, the two periods of the worst monetary policy mistakes in the history of the Federal Reserve (McCallum, 2002). Several studies present supportive evidence for McCallum's rule in different developed countries (Hall, 1990; Judd and Motley, 1991; 1993; Razzak, 2003; Diez de los Rios, 2009). In the Indian context, a backward-looking version of McCallum's rule, with real exchange rate changes as an additional variable, has been found to work best. The nominal income gap is significant and correctly signed, suggesting that nominal income could be an implicit final target in the conduct of monetary policy (Virmani, 2004). The McCallum rule has been evaluated along with Taylor-type and hybrid rules for Russia with the finding that monetary aggregates can indeed be used as an effective policy instrument (Esanov et al, 2004). In the Chinese context, the monetary base has been substituted with broad money first by using the coefficients specified by McCallum, and then by allowing the data to determine the actual coefficient estimates. The actual developments of the monetary base were found to follow the values implied by the McCallum rule more closely than was the case with broad money since 2003. Monetary growth was observed to have been faster than what the McCallum would have suggested in the more recent period, partly due to hikes in reserve requirements boosting the monetary base (Koivu et al, 2009). For Turkey, the monetary response coefficient was found to be 0.1 (as against McCallum's original proposition of 0.5) in view of the history of high inflation. Monetary policy appears to be closely simulated by McCallum's rule over the whole period (2002-2008) whereas the Taylor rule provides a good approximation only from 2006 when prerequisites of an inflation targeting regime were in place. The smoothing component was also found to be higher under the McCallum rule (Khakimov et al, 2009).

Drawing on the results of estimating McCallum and Taylor rules as well as hybrids mixing instruments and targets for 20 emerging countries across Africa, Asia, emerging Europe and Latin America, it is observed that while the McCallum rule works well for countries that adopt leaning against the wind strategies, it is the hybrid McCallum-Taylor specifications with an interest rate instrument and a nominal income gap perform better than benchmark Taylor or McCallum rules. Instrument smoothing is significant across all specifications, but the exchange rate is not consistently significant (Mehrotra et al, 2011).

(b) Taylor Rule

The confluence of the econometric evaluation evidence and its usefulness for understanding historical monetary policy has generated widespread interest in the Taylor rule among numerous central banks to provide guidance in policy decisions. A generalized Taylor rule that nests the original specification and also allows for interest rate smoothing has been favoured in the empirical literature (Clarida, Gali and Gertler, 1998, 2000).

A key issue in the context of estimating the Taylor rule is, first, the size of the coefficients on the inflation and output gaps. The coefficient on inflation is 1.5, the coefficient on real output is 0.5 and the intercept term is $r - 0.5\ \pi^*$ (Taylor, 1993, 1999a). Some studies have shown that that the coefficient on real output is close to 1 (Brayton et al, 1997). However, higher weight to output in a policy rule gives a lower variance of output but may give a higher variance of inflation. Raising the coefficient on real output from 0.5 to 1.0 represents a trade-off between inflation variance and output variance, but the increase in average inflation variability is small compared with the decrease in average output variability, and moreover, interest rate variance is higher (Taylor, 1999b)

There is less ambiguity around the coefficient on the inflation gap. If the coefficient on inflation is less than one, the real interest rate would fall rather than rise when inflation rose (US in 1960s and 1970s), leading to even higher inflation and inflation would turn highly volatile. There can be bursts of inflation and output fluctuations that result from self-fulfilling changes in expectations (Clarida *et al*, 1998).

Second, methodological issue relating to operationalising the Taylor rule is about whether it should be forward-looking, contemporaneous or backward-looking. While Clarida *et al* (1998) demonstrate the case for a purely forward-looking rule in the context of the US, the UK and Japan, it is also argued that a rule that uses only information about the recent behavior of inflation and output does quite well (Taylor and Williams, 2010), as compared to one that uses forecasts of future inflation and output. Performance under the best kind of rule of this kind (measured in terms of variability of inflation, output and interest rates) is not significantly reduced if lagged inflation data is used (Rotemberg and Woodford, 1999;

Feldstein, 1999). Thus lags in the availability of accurate measurement of inflation are not necessarily a serious problem for the implementation of such a rule. Accordingly, backward looking rules are quite good approximations of optimal policy (Rotemberg and Woodford, *op cit*.). It is argued that there is no need for policy to be forward-looking as long as the private sector is. A commitment to raise interest rates later, after inflation increases, is sufficient to cause an immediate contraction of aggregate demand in response to a shock that is expected to give rise to inflationary pressures – aggregate demand depends on future interest rates and not simply on current short rates as long as the monetary authority is understood to be committed to adhering to the contemplated policy rule in the future and not only at the present time; and as long as the private sector has model-consistent rational expectations. However, for the euro area, there is evidence that policy-makers are neither purely backward nor forward-looking, but react to a synthesis of the available information on the current and future state of the economy (Blattner and Margaritov, 2010).

Third, adding the exchange rate - either though a monetary conditions index (weighted average of exchange rate and inflation rate) to replace the interest rate as the policy instrument or by introducing an exchange rate term in the right hand side - to the simple Taylor-type policy rules may improve macroeconomic performance (Ball, 1999).

Mohanty and Klau (2004) estimated an open economy Taylor rule for India, along with other emerging market economies (EMEs) in which the relationship between the short-term interest rate and the inflation rate turned out to be relatively weak, whereas the output gap was statistically significant. Similar findings are reported in other efforts (Inoue and Hamori, 2009; Singh, 2006; Jha, 2008; Hutchison et al, 2010; and Anand *et al*, 2010). On the other hand, a comprehensive analysis of monetary policy rules across different specifications in both backward- and forward-looking versions found monetary policy's reaction to inflation to be stronger than to the output gap for the period 1988-2009 (Singh, 2010). On the basis of a variety of alternative simulations, a forward-looking Taylor rule performed best for India in term of consistency with the Taylor principle. The coefficient on the inflation gap turned out to be greater than unity, while that on the output gap was unity (Patra and Kapur, 2012).

Methodological issues that arise in the actual estimation of the Taylor rule and its extensions have been comprehensively surveyed recently (Patra and Kapur, 2012). First, it is observed that while a forward-looking specification is recommended in theory (the target variables depend not only on the current policy stance but also on expectations about future policy), from practical considerations, a general specification with forward-looking terms and incorporating the well-documented interest rate smoothing by central banks (inertia in policy response) is preferred in the empirical literature (Clarida *et al*., 2000; Paez-Farrell, 2009). Second, exchange rate smoothing is found to be an important consideration in the policy reaction function of emerging economies, including India, in some studies.[8] Third, the use of the output gap, a variable which is not observed, presents a challenge particularly in view of frequent and often sizable revisions which can produce large divergences between real time data on which authorities make their policy judgments and the final revised data that are used in empirical work. Accordingly, it may be optimal to replace the output gap variable with its first difference (Taylor and Williams, 2010).

The greater prominence of the Taylor rule is attributed to it being more realistic in describing the conduct of actual monetary policy since 1986. Modern central banks focus upon interest rates, not the monetary base, in designing their policy actions. The ascendency of the new Keynesian framework from the late 1990s has also implied a downgrading of monetary aggregates in explaining the operational conduct of monetary policy. These developments notwithstanding, considerable academic support for nominal spending targets has existed since 1980 (Meade, 1978; Tobin, 1980). Keeping nominal GDP close to a target growth path would maintain inflation close to its desired value on average and would diminish fluctuations in real cyclical aggregates. This helps the policy maker to balance the two goals without having to control or accurately predict how nominal GDP divides between its constituents (McCallum, 1988). It also eliminates policy surprises due to undesirable fluctuations arising from pursuit of an optimal policy decision. Also, there is an observable tendency for an interest rate instrument to become something of a target variable that is thus adjusted too infrequently and too timidly (Taylor, 1999b).

In some ways, nominal income targeting rules can claim analytical superiority over pure interest rate formulations in the Taylor rule tradition. Illustratively, the growth rate version of nominal income targeting avoids the need to measure unobservables such as

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[8] See also Mohanty and Klau, 2004 for a review.

capacity or natural-rate output (for the output gap) or the real interest rate, as is required by Taylor's rule[9] (Orphanides, 2003). While Clarida *et al* (1998) provided formal econometric support for Taylor's findings in the context of US monetary policy, it has been shown that replacing expected future inflation in Clarida *et al* by expected current nominal income growth produces standard errors that are lower, and nominal income growth is significant with higher explanatory power (McCallum, 2000). Especially in an environment with near-zero short-term interest rates, the McCallum rule may be of interest – (Goodfriend, 2000; Krugman, 1998; Meltzer, 1998). Moreover, in the case of emerging economies, it has been claimed that a monetary base or some other monetary aggregate can still be a reasonable monetary policy instrument (Taylor, 2000; Beck and Wieland, 2008).

Experiments with hybrid rules have yielded promising results. Replacing the monetary base in the McCallum rule with the interest rate as the policy instrument produces a modified rule that is highly cointegrated with the standard Taylor rule. With similar degrees of sufficiently high instrument smoothing, each of these rules performs as well as the other – equality of unconditional variance of inflation and output cannot be rejected (Razzak, 2003). This seems to be the desirable direction of future research – a consensus approach.

III. India's Monetary Policy Framework

Proper judgment is important in selecting which reaction function is adequate on the basis of the declared policy regime and the institutional idiosyncrasies. The selected empirical rule would then be robust to minor variations (Mehrotra *et al*, 2011). Accordingly, before proceeding with the actual estimation of alternative policy rules for India and evaluating their performance, it is useful to undertake a brief review of the institutional and operating framework of monetary policy in India so as to situate the choice of policy rule in an appropriate perspective. In this context, Patra and Kapur (2012) provides a panoramic

[9] As pointed out in McCallum (2000), reliance of a policy rule upon any output gap measure is risky, for different measures give different values. Linear de-trending depends rather sensitively on the time period selected for fitting the trend. With respect to the HP filter, the problem is that this procedure produces a trend that is so flexible that it follows the path of actual GDP rather closely, yielding measures of the output gap that would appear to underestimate the economically relevant gap values. McCallum and Nelson (1999) argue that any gap measure based on an output de-trending procedure is conceptually inappropriate – positive shocks serve to increase the value of capacity output, not the values of output relative to capacity.

account of the history of monetary policy regime changes in India - the period up to the mid-1980s when monetary policy was dominated by fiscal policy did not matter, followed by monetary targeting with feedback, and then again in the late 1990s when interest rates progressively became the main instrument of monetary policy.

Up to the early 1980s, the conduct of monetary policy was reduced to a passive accommodation of budget deficits. The second round effects of such monetization had serious inflationary consequences that had to be tackled by curbing credit to the private sector. Apart from recourse to reserve requirements acting as statutory preemptions,[10] sectoral credit allocations were put in place, while panoply of interest rates were administered.

It was in this milieu that a wholesale rethinking of the manner in which monetary policy is to be conducted was set in motion[11]. From the second half of the 1980s, elements of a new regime were gradually put in place. While sub-serving the broader goals of overall economic policy, monetary policy came to be regarded as best suited to achieve price stability – it is price stability which provides the appropriate environment under which growth and social justice can be achieved ….money also matters (Rangarajan, 1988). Empirical estimations of the tolerable or threshold inflation led to the establishment of inflation in the range of 5-7 percent (but tending to 5-6 percent) as the objective of monetary policy (Rangarajan, 1997). These estimates are corroborated by recent studies (Mohanty *et al*., 2011; Pattanaik and Nadhanael, 2011) Statistical evidence of reasonable stability in the demand for money yielded the income elasticity of money demand of 1.77 as a key operating parameter, with the coefficient on inflation at unity (Rangarajan, 1994). The policy rule came to be formulated in the form of monetary targeting with feedback. Broad money (M3) became the appropriate intermediate monetary aggregate for which the rule could be set in

[10] By 1990, the statutory liquidity ratio had touched 38.5 percent of deposit liabilities. Since increasing the SLR was not adequate, the Reserve Bank of India become a residual subscriber to the government borrowing programme. In order to curb the expansionary impact of reserve money, the cash reserve ratio had to be progressively increased to 15 percent by 1990 (Rangarajan, 2001).

[11] In order to provide a robust analytical framework to policy, a committee was appointed under the chairmanship of Sukhamoy Chakravarty. Dr. Chakravarti Rangarajan, then deputy Governor of the RBI was an important member. The committee recognized the existence of a multiplicity of objectives of monetary policy in India, but assigned eminence to price stability. The committee also recommended monetary targeting, coordination between the government and the central bank on the extent of monetization, and a basis for the determination of the interest rate structure that would ensure positive real interest rates and allow greater freedom to banks in setting lending rates.

growth rate range formulation. The money multiplier had been found to be stable and predictable (Rangarajan and Singh, 1984); so the money supply rule in its reduced from consisted of determining the growth of reserve money adjusted for reserve requirements as the monetary authority could determine or at least influence the monetary base even in the presence of fiscal dominance and administered interest rates (Rangarajan, 1985). Ending automatic monetization of fiscal deficits was addressed in the context of central bank autonomy (Rangarajan, 1993)[12], and over the period 1994-97 it was phased out. In the second half of the 1980s, various segments of the financial market spectrum were developed; in particular, within the limits of an administered structure of interest rates, there was a move towards creating an active money market which could serve as a transmission channel for monetary policy (Rangarajan, 2001). Between 1988 and 1997, interest rates were rationalized and allowed to be freely determined in the market. This coincided with the institution of financial sector reforms from 1992-93, a market-determined exchange rate, current account convertibility and a progressive liberalization of the capital account.

The institution of the regime employing interest rates as the main instrument of monetary policy transmission can be located in 1997 when the Bank Rate was reactivated after a hiatus of seven years in an environment of development and deepening of various segments of the financial markets, and the progressive deregulation of interest rates. The analytics underpinning the monetary policy framework also underwent a silent transformation in the later part of the 1990s. In its monetary policy statement of April 1998, the RBI announced that it would switch to a multiple indicator approach "to widen the range of variables that could be taken into account for monetary policy purposes rather than rely solely on a single instrument variable such as growth in broad money (M3)"(RBI, 1998). The era of monetary targeting was drawing to a close and the paradigm in Indian monetary policy was shifting. In 1999-2000, the stance of monetary policy was conveyed through reductions in the (reverse) repo rate and the Bank Rate, and India was on the path to a new monetary policy framework. The reverse repo rates soon began to provide a floor for the overnight call money market rates while repo auctions were employed in the event of tightness in liquidity

[12] "The freedom of the central bank to pursue monetary policy according to its judgment requires that direct funding by the central government is restricted and the limits are made explicit. Then the onus of responsibility of conduct of monetary policy will be squarely on the shoulders of the Reserve Bank where it should logically rest" (Rangarajan, 1993).

conditions. It was the Bank Rate, to which all other rates on accommodations by the RBI were linked, that remained, till 2002, the main signaling rate for conveying the stance of policy, and the effective ceiling for money market rates.

An Interim Liquidity Adjustment Facility (ILAF) operated through repos and lending against collateral of Government of India securities was introduced in April 1999. The ILAF was a mechanism by which liquidity was injected at various interest rates, but absorbed at the fixed repo rate. Beginning in the following year, a full-fledged LAF was put in place in stages, providing a reasonable corridor for market play. The Bank Rate progressively gave way to the repo rate as the upper bound of the policy interest rate corridor. From November 2004, the LAF began to be operated with only overnight repo/reverse repo auctions and longer-term auctions were discontinued, although the RBI retained the option to conduct them at its judgment. With the establishment of real time gross settlement, a screen-based dealing platform and a clearing corporation, intra-day LAF auctions have also been employed with reasonable success. Over the ensuing period, the LAF has evolved into the principal operating procedure of monetary policy.

The operating policy rate alternated between repo and reverse repo rates from 2003 till early May 2011, depending upon the macroeconomic and liquidity conditions. There was the lack of a single policy rate. Against this background, the operating framework was modified effective May 3, 2011. First, the repo rate was made the only independently varying policy rate to transmit policy signals more transparently. Second, a new Marginal Standing Facility (MSF) was instituted under which scheduled commercial banks (SCBs) can borrow overnight at their discretion up to one per cent of their respective NDTL at 100 basis points above the repo rate to provide a safety valve against unanticipated liquidity shocks. Third, the revised corridor was defined with a fixed width of 200 basis points. The repo rate was placed in the middle of the corridor, with the reverse repo rate 100 bps below it and the MSF rate 100 bps above it (Mohanty, 2011). The Bank Rate, which had remained unchanged since 2003, was aligned to the MSF rate in February 2012.

The cash reserve ratio (CRR) has all through been seen as an important instrument in the RBI's arsenal for regulating liquidity in the economy, while the statutory liquidity ratio has taken the role of a prudential tool and liquidity buffer rather than a statutory pre-emption. Technically, the operating target of monetary policy continues to be bank reserves; however, the predominant reliance on the LAF for signaling the policy stance by modulating bank reserves has meant that the focus is increasingly on the interest rate as the effective target for monetary policy. The RBI has stated in its policy announcements that the conduct of monetary policy is guided by objectives of price stability, growth and financial stability with relative weights depending upon evolving domestic and global macroeconomic and financial conditions.

IV. Methodology, Data and Estimation Results

This section empirically evaluates alternative monetary policy rules due to Taylor and McCallum as well as hybrid rules combining features of these rules. While both Taylor and McCallum have articulated rules with the policy instrument adjusting to lagged macroeconomic variables, this paper also evaluates forward-looking versions of these rules wherein the policy instrument reacts to expected dynamics of the relevant macroeconomic variables. The forward-looking rules mirror the actual practice of monetary policy by major central banks. The McCallum rule assumes that the economy operates around a constant trend growth and base money growth is, therefore, adjusted for deviations of nominal income growth from this constant growth rate. The constant trend growth rate assumption may not hold for emerging countries like India where growth is on an upward trajectory interspersed with slope and intercept shifts, reflecting the process of structural transformation. In India, real output growth moved from an average of around 5.5 per cent during 1997-2001 to 9 per cent in the period 2004-08 but moderated under the impact of the global financial crisis and the global slowdown. Therefore, we specify the McCallum rule in terms of deviation of nominal income growth from a time-varying trend growth rate.

We also estimate hybrid policy rules by switching policy instruments and explanatory variables between the two rules. In all the permutations, we also add exchange rate variations as an explanatory variable to assess whether there is exchange rate smoothing by the central bank. Variables are defined in Annex 1. Thus, we have the following set of rules:

Contemporaneous/Backward-looking Versions

Taylor Rule:

$i_t = a0 + a1*(\pi_t - \pi^*) + a2*y_t + a3*\Delta e_{t-1} + a4*i_{t-1}$

McCallum Rule

$\Delta b_t = b0 + b1*(\Delta x_t^* - \Delta x_{t-1}) + b2*\Delta e_{t-1} + b3*\Delta b_{t-1}$,

Hybrid McCallum-Taylor Rule

$i_t = c0 + c1*(\Delta x_t^* - \Delta x_{t-1}) + c2*\Delta e_{t-1} + c3*i_{t-1}$

Hybrid McCallum-Hall-Mankiw Rule

$\Delta b_t = d0 + d1*(\pi_t - \pi^* + y_t) + d2*\Delta e_{t-1} + d3*\Delta b_{t-1}$

Forward-looking Versions

Taylor Rule:

$i_t = a0 + a1*(E_t\pi_{t+i} - \pi^*) + a2*E_t y_{t+i} + a3*\Delta e_{t-1} + a4*i_{t-1}$

McCallum Rule

$\Delta b_t = b0 + b1*(\Delta x_t^* - E_t\Delta x_{t+i}) + b2*\Delta e_{t-1} + b3*\Delta b_{t-1}$,

Hybrid McCallum-Taylor Rule

$i_t = c0 + c1*(\Delta x_t^* - E_t\Delta x_{t+i}) + c2*\Delta e_{t-1} + c3*i_{t-1}$

Hybrid McCallum-Hall-Mankiw Rule

$\Delta b_t = d0 + d1*[(E_t\pi_{t+i} - \pi^*) + E_t y_{t+i})] + d2*\Delta e_{t-1} + d3*\Delta b_{t-1}$

Variables

We use quarterly data for the period April 1996 to March 2011, the choice of period being determined by the availability of quarterly data on real GDP for India. All series which are in gap form (such as output gap, non-agricultural output gap, industrial output gap and real effective exchange rate gap) are based on seasonally adjusted data using the X-11 algorithm of the US Department of Commerce. Variables measured on a year-on-year (y-o-y) basis such as inflation and GDP growth are not seasonally adjusted. Also, the policy instruments – the policy interest rate and the y-o-y base money growth – are not adjusted for seasonality.

The output gap is measured by the difference between real GDP (seasonally adjusted) and its trend obtained by the HP filter. Headline inflation in India is measured by y-o-y variations in the wholesale price index (WPI). For the purpose of estimation, we use headline WPI inflation as well as the core inflation indicator (non-food manufactured products WPI inflation).

Turning to policy variables, the McCallum rule requires the use of the monetary base. In view of frequent changes in the cash reserve ratio (CRR) in the conduct of monetary policy, the concept of adjusted reserve money (*i.e.,* adjusted for the CRR impact) is important in the Indian context. Over the period of study, the CRR was initially reduced from 13.5 per cent (April 1996) to 4.5 per cent by June 2003. It was then raised to 9.0 per cent by September 2008, but in response to the global financial crisis it was lowered to 5.0 per cent by January 2009. It was increased to 6.0 per cent by April 2010 and is 4.75 per cent currently (March 2012) Accordingly, we compute an adjusted reserve money series as the base money aggregate as it would have been if the CRR had remained unchanged at 5 per cent i.e., its initial value at the beginning of the sample period. For the periods for which the actual CRR is 5 per cent, the unadjusted and adjusted series coincide.

As regards the policy interest rate, we follow Patra and Kapur (2012), in using the effective policy rate *i.e.*, the interest rate through which the RBI engaged in its liquidity operations with market participants, depending on prevailing liquidity conditions - the Bank Rate until February 2002; the reverse repo rate during March 2002-June 2006 and December 2008-May 2010 when liquidity was abundant and the RBI was in absorption mode; and the LAF repo rate in all other phases of the period of study (July 2006-November 2008 and June 2010-March 2011) when liquidity was tight and the RBI injected liquidity through repo operations.

Data Sources

All data are taken from published sources. Data on global real GDP growth and the index of world non-fuel commodity prices are from the IMF's World Economic Outlook and database on Primary Commodity Prices, respectively. Data on the US federal funds rate target are from the Fred database of the Federal Reserve Bank of St. Louis (http://research.stlouisfed.org/fred2/). All data on the Indian economy - quarterly real and nominal GDP, components of GDP, reserve money and CRR changes, the various measures of inflation, the policy rates, the nominal exchange rate of the Indian rupee against the US dollar and the real effective exchange rate (REER) index covering 36 partner countries are taken from the RBI's "Handbook of Statistics on Indian Economy 2010-11" supplemented by information from the RBI's Monthly Bulletin and data put out on the website of the Central Statistical Organisation (CSO) of the Government of India (http://www.mospi.gov.in/mospi_press_releases.htm).

Estimation Procedure

For forward-looking specifications of the monetary policy rules, we estimate the equations using Generalised Method of Moments (GMM) following Clarida *et al.* (1998, 2000)[13]. For the contemporaneous/backward-looking specifications as well as equations which use RBI's publicly available projections, estimation is done through ordinary least squares (OLS) estimates.

Results

(a) McCallum Rule

While the original McCallum rule is backward-looking, we estimate both forward-looking and backward-looking versions of the rule. We also assess the monetary policy response to exchange rate dynamics. Given the volatility imparted by agricultural shocks to both growth and inflation in India, we estimate McCallum rules separately for total nominal income and its core component, non-agricultural income. Here, it is necessary to note an important caveat: in the McCallum rule, the income growth term is defined as trend growth minus actual growth, in contrast to a Taylor-type rule which typically defines it as actual growth minus trend growth. Consequently, we expect the income gap term to have a positive coefficient – illustratively, when it increases *i.e.*, actual income growth is declining relative to trend growth, monetary policy is expected to be accommodative and base money expands.

The empirical results are summarized in Table 1. All specifications indicate a sizable degree of policy smoothing, and this is true of all specifications estimated in this paper.

[13] All estimations have been done in Win RATS (version 8.10) with standard errors corrected with Newey-West/Bartlett window and 3 lags in all cases.

Turning to specific findings, first, consistent with *a priori* expectations, we find a positive and statistically significant (at the 10 percent level) reaction of base money growth – the policy instrument – to deviations of trend growth in nominal income from its expected growth in the next quarter (Column 7). However, the response of base money to deviations in nominal income growth is found to be stronger and significant at the 1 percent level for the core component of GDP (i.e., non-agricultural GDP) one quarter forward (Columns 10 and 11) and two quarters forward (Column 13). In either case, whether it is overall GDP growth or non-agricultural GDP growth, the policy response is stronger – between 0.6 and 2.1 - *vis-à-vis* the range suggested by McCallum – 0.25 to 0.50 for mature economies such as Japan and the US. Second, an important finding in this context is that the expected relationship between base money growth and deviations in nominal income/non-agricultural nominal income growth does not materialize in the backward-looking specification that characterizes the conventional McCallum rule - the coefficient is sometimes wrongly signed and insignificant in all cases (Columns 2-5). Third, the term for exchange rate changes which enters with a one-quarter lag is found to have the correct sign and is statistically significant in all specifications - monetary policy reacts to, rather than preempts, large movements in exchange rates out of line with fundamentals through smoothing interventions that affect its net foreign assets and thereby base money. While this may produce a tightening of monetary conditions, it is not necessarily associated with a tightening of monetary policy. As the empirical results from Taylor rule estimations will show subsequently, the RBI does not respond to exchange rate movements with changes in policy interest rates which, in the current framework, more accurately reflect the policy stance. Moreover, the long run coefficient on exchange rate changes is low at 0.19 to 0.30 relative to the monetary response coefficient on nominal income growth.

Table 1: Estimates of McCallum Rule
(Dependent Variable: Growth in Base Money (Δb_t))

1	2	3	4	5	6	7	8	9	10	11	12	13
Constant	4.54	4.94	4.95	5.26	4.81	4.02	4.48	4.48	4.73	4.13	4.26	3.75
	(2.52)	(3.45)	(3.02)	3.93	1.78	1.40	1.56	1.36	1.74	1.99	1.29	1.23
$\Delta x_t^* - \Delta x_{t-1}$	-0.09	-0.09										
	(1.36)	(1.25)										
$\Delta xc_t^* - \Delta xc_{t-1}$			0.05	0.03								
			(0.54)	(0.35)								
$\Delta x_t^* - E_t\Delta x_{t+1}$					0.08	0.18						
					(1.00)	(1.80)						
$\Delta x_t^* - E_t\Delta x_{t+2}$							0.01	0.07				
							(0.06)	(0.56)				
$\Delta xc_t^* - E_t\Delta xc_{t+1}$									0.39	0.49		
									(2.74)	(5.08)		
$\Delta xc_t^* - E_t\Delta xc_{t+2}$											0.15	0.34
											(1.33)	(2.27)
Δeq_{t-1}		-0.05		-0.05		-0.05		-0.05		-0.07		-0.06
		(1.79)		(1.69)		(2.95)		(2.16)		(5.29)		(2.64)
Δb_{t-1}	0.68	0.66	0.66	0.64	0.68	0.74	0.70	0.70	0.71	0.77	0.73	0.78
	(5.92)	(6.87)	(6.27)	(7.23)	(3.86)	(3.72)	(3.72)	(3.09)	(3.84)	(5.41)	(3.29)	(3.68)
$\bar{R}^2$	0.44	0.46	0.43	0.45	0.44	0.46	0.42	0.44	0.46	0.47	0.41	0.42
LB-Q(8)	0.15	0.15	0.17	0.16	0.16	0.12	0.16	0.12	0.14	0.13	0.12	0.09
J-test					0.14	0.09	0.15	0.10	0.11	0.11	0.15	0.11

1. Variable names are in Annex 1.

2. Figures in parenthesis are t-statistics based on HAC standard errors corrected with Newey-West/Bartlett window and three lags.

3. LB-Q test gives significance level (p-value) of Box-Pierce-Ljung Q-statistic for the null of no residual autocorrelation for 8 lags. J-test reports p-value for test for over-identifying restrictions for GMM estimates.

4. Columns 2-5 report OLS estimates. Columns 6-13 report estimates by GMM methodology using one lag each of the following variables as instruments: constant, Δb, Δe, DNFC, DM3, FEDTARGET, and the relevant lag of nominal income deviation term.

(b) *Hybrid McCallum-Taylor Rule*

We followed the encouraging results thrown up in the literature (see Section II) on hybrid McCallum-Taylor rules by estimating formulations in which the effective policy interest rate as the policy instrument reacts to deviations of nominal income growth from its trend. The results are again presented for both backward- and forward-looking specifications as well as for overall growth in nominal income and in its non-agricultural component. Here, the expectation is that the income term will be negatively signed i.e., when it is increasing or nominal output growth is falling relative to trend, monetary policy turns accommodative and policy interest rates are reduced, and *vice versa*.

Our results provide strong support for such hybrid rules (Table 2). First, the coefficient on the nominal income growth deviation term is negative in all cases consistent with *a priori* expectations and is also statistically significant in most cases. This is true both for backward- and forward-looking specifications. Second, the policy response is found to be stronger for specifications using forward-looking versions (absolute long-run coefficient is 1.1-1.7) vis-a-vis backward-looking specifications (0.4). Finally, in contrast to the conventional McCallum rule and consistent with our results for the Taylor rule, the exchange rate coefficient is wrongly signed and insignificant in all specifications.

Table 2: Estimates of Hybrid Taylor-McCallum Rule
(Dependent Variable: Effective Policy Interest Rate (INT))

1	2	3	4	5	6	7	8	9	10	11	12	13
Constant	0.78	0.75	0.79	0.75	0.54	0.04	0.45	-0.37	0.49	0.14	0.38	-0.18
	(3.09)	(2.25)	(3.05)	(2.22)	(2.11)	(0.07)	(1.61)	(0.50)	(1.76)	(0.36)	(1.16)	(0.28)
$\Delta x_t^* - \Delta x_{t-1}$	-0.05	-0.05										
	(1.78)	(1.85)										
$\Delta xc_t^* - \Delta xc_{t-1}$			-0.05	-0.05								
			(1.37)	(1.50)								
$\Delta x_t^* - E_t\Delta x_{t+1}$					-0.11	-0.15						
					(3.26)	(2.74)						
$\Delta x_t^* - E_t\Delta x_{t+2}$							-0.10	-0.11				
							(2.01)	(2.01)				
$\Delta xc_t^* - E_t\Delta xc_{t+1}$									-0.16	-0.19		
									(3.33)	(2.73)		
$\Delta xc_t^* - E_t\Delta xc_{t+2}$											-0.16	-0.18
											(1.92)	(2.09)
Δeq_t		0.00		0.00		-0.03		-0.05		-0.02		-0.03
		(0.20)		(0.21)		(0.92)		(1.18)		(1.11)		(0.93)
INT_{t-1}	0.87	0.87	0.86	0.87	0.90	0.97	0.91	1.05	0.89	0.94	0.90	0.99
	(23.76)	(20.25)	(23.39)	(18.78)	(23.47)	(12.21)	(22.28)	(8.89)	(20.57)	(16.73)	(20.57)	(9.99)
$\bar{R}^2$	0.83	0.83	0.83	0.83	0.83	0.79	0.82	0.75	0.84	0.81	0.81	0.77
LB-Q(8)	0.77	0.81	0.73	0.79	0.48	0.49	0.63	0.10	0.32	0.48	0.60	0.25
J-test					0.28	0.23	0.33	0.50	0.23	0.18	0.30	0.37

1. Variable names are in Annex 1.

2. Figures in parenthesis are t-statistics based on HAC standard errors corrected with Newey-West/Bartlett window and three lags.

3. LB-Q test gives significance level (p-value) of Box-Pierce-Ljung Q-statistic for the null of no residual autocorrelation for 8 lags. J-test reports p-value for test for over-identifying restrictions for GMM estimates.

4. Columns 2-5 report OLS estimates. Columns 6-13 report estimates by GMM methodology using one lag each of the following variables as instruments: constant, INT, Δe, DNFC, DM3, FEDTARGET, and the relevant lag of nominal income deviation term.

(c) ***Hybrid McCallum-Hall-Mankiw Rule***

We also estimate the hybrid McCallum-Hall-Mankiw rule in which the policy instrument - base money growth – reacts to the sum of the inflation gap and the output gap. As before, we examine both backward- and forward-looking specifications and versions based on growth in overall nominal income and its non-agricultural component.

Our empirical evidence does not support such rules (Table 3). First, while the coefficient on the inflation gap plus output gap term is correctly signed (negative) in the contemporaneous versions, it is incorrectly signed in the forward-looking versions. In all formulations, however, the coefficients are statistically insignificant. Second, consistent with our findings for the McCallum rule, the exchange rate coefficient is correctly signed but insignificant in all specifications.

Table 3: Estimates of Hybrid McCallum-Hall-Mankiw Rule
(Dependent Variable: Growth in Base Money (Δb_t))

1	2	3	4	5	6	7	8	9
Constant	5.28	5.64	5.24	5.58	6.21	5.85	6.46	5.88
	(3.00)	(3.94)	(2.89)	(3.73)	(5.22)	(4.97)	(5.14)	(4.68)
$[(\pi - \pi^*) + YGAP]_t$	-0.01	-0.01						
	(0.08)	(0.16)						
$[(\pi_{MPNF} - \pi^*_{MPNF}) + YGAP^C]_t$			-0.04	-0.06				
			(0.37)	(0.62)				
$[(\pi - \pi^*) + YGAP]_{t+1}$					0.12	0.10		
					(1.16)	(0.90)		
$[(\pi_{MPNF} - \pi^*_{MPNF}) + YGAP^C]_{t+1}$							0.08	0.03
							(0.82)	(0.29)
Δeq_{t-1}		-0.04		-0.04		-0.03		-0.03
		(1.42)		(1.48)		(1.33)		(1.39)
Δb_{t-1}	0.63	0.61	0.63	0.61	0.57	0.60	0.57	0.61
	(5.49)	(6.30)	(5.32)	(6.03)	(7.10)	(7.44)	(6.81)	(7.10)
$\bar{R}^2$	0.38	0.39	0.38	0.39	0.33	0.34	0.35	0.37
LB-Q(8)	0.11	0.13	0.11	0.13	0.14	0.12	0.15	0.14
J-test					0.72	0.68	0.71	0.64

1. Variable names are in Annex 1.

2. Figures in parenthesis are t-statistics based on HAC standard errors corrected with Newey-West/Bartlett window and three lags.

3. LB-Q test gives significance level (p-value) of Box-Pierce-Ljung Q-statistic for the null of no residual autocorrelation for 8 lags. J-test reports p-value for test for over-identifying restrictions for GMM estimates.

4. Columns 2-5 report OLS estimates. Columns 6-9 report estimates by GMM methodology using one lag each of the following variables as instruments: constant, Δb, $[(\pi - \pi^*) + YGAP]$, $[(\pi_{MPNF} - \pi^*_{MPNF}) + YGAP^C]$, Δe, DNFC, DM3, and FEDTARGET.

(d) Taylor Rule

In this paper, we refine and broaden the Taylor rule estimations conducted in the context of operationalisation of the new Keynesian model in Indian conditions in Patra and Kapur (2012). They estimated a monetary policy reaction function for India using the output gap, inflation (measured by the y-o-y change either in the GDP deflator or in WPI inflation) and the effective policy rate. Robustness properties were explored by estimating contemporaneous and forward-looking versions of the Taylor rule and across alternative sample periods.

At the outset of this sub-section, it is useful to set out a critical issue in the empirical estimation of Taylor rules. The Taylor principle is that the long-run coefficient on the inflation term should be more than unity. As pointed out in Section II, a coefficient of less than unity implies that the real interest rate falls when inflation is rising, characteristic of the policy mistakes found in the US in the 1960s and 1970s, and this will lead to even higher inflation. Patra and Kapur (2012) show that the Taylor principle is amply satisfied in the Indian context for forward-looking versions of the rule. For contemporaneous versions, the long-run coefficient was found to be less than unity, thus violating the Taylor principle. In contrast to Patra and Kapur (2012), others such as Anand *et al* (2010), Hutchison et al (2010) and Mohanty and Klau (2004) obtained a long-run inflation coefficient less than unity. Patra and Kapur (2012) suggested that this counter-Taylor principle result could be the outcome of a number of factors such as (a) use of contemporaneous reaction functions, ignoring the normal lags associated with the operation of monetary policy; (b) use of call money rate/Treasury bill rate as a proxy for the policy rate; and (c) use of industrial output as the activity variable rather than overall GDP.

In this paper, we empirically revisit this issue and in doing so, we examine additional aspects such as: (a) use of actual GDP growth rates rather than the unobservable output gap; (b) use of the output gap based on industrial GDP rather than overall GDP; (c) use of provisional/preliminary data *i.e*., data actually used by the central bank at the time of taking policy action) and not the revised estimates[14]; (d) using the RBI's monetary policy projections for growth and inflation (semi-annual up to mid-2005 and quarterly thereafter), which can obviate the need for use of instruments and, therefore, estimable by OLS; (e) use of non-food manufactured products WPI inflation (in *lieu* of headline inflation) recently articulated by the Reserve Bank as an indicator of core demand pressures and the non-agricultural output gap to abstract from volatility caused by supply shocks; and (f) use of the call money rate instead of the effective policy rate. For the various potential combinations,

[14] Orphanides (2003) suggests that the results can be sensitive to the vintage of the data

we present results for both forward-looking and contemporaneous specifications. In all cases, we also assess as to whether exchange rate dynamics play any role in the policy reaction functions.

The results for these alternative explanatory variables/combinations are presented in Tables 4 and 5. The main findings are summarized below: First, the estimation results obtained in Patra and Kapur (2012) are robust to using various alternative indicators of inflation and growth.

Second, the coefficients on inflation and output gap terms are statistically significant and satisfy the Taylor principle in almost all the forward-looking specifications (Table 4). The coefficient estimates indicate stronger policy response to non-food manufactured products inflation dynamics, consistent with the Reserve Bank's recent emphasis on this indicator of underlying demand pressures in the context of the 2010-11 inflation episode.

Third, the only instance in the forward-looking specifications when the coefficient on the inflation term is insignificant is when we use call rate as the policy instrument in lieu of the effective policy rate (Table 4, columns 14-15). Moreover, the $\bar{R}^2$ drops substantially to 0.26 vis-à-vis 0.80-0.90 in the specifications using the effective policy rate. Over the period of evolution of the current monetary policy regime in India, there have been brief periods when the call rate has exhibited significant volatility and has moved significantly away from the policy corroder set by the repo and the reverse repo rate.

Table 4: Estimates of Taylor Rule (Forward-looking Specifications)
(Dependent Variable: Effective Policy Interest Rate (INT))

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Constant	0.64	0.58	-1.45	-1.45	0.46	0.51	0.41	-0.03	-0.21	-0.43	0.50	0.34	1.72	2.66
	(2.41)	(1.20)	(1.99)	(1.96)	(2.06)	(1.67)	(1.87)	(0.08)	(0.60)	(1.08)	(2.16)	(1.06)	(3.10)	(2.18)
$(\pi - \pi^*)_{t+2}$	0.16	0.15							0.11	0.10	0.15	0.15		
	(2.63)	(2.10)							(2.62)	(1.83)	(2.51)	(2.38)		
$YGAP_{t+2}$	0.18	0.17												
	(2.16)	(1.60)												
$(\pi_{PROV} - \pi^*)_{t+2}$			0.09	0.09										
			(1.72)	(1.49)										
GDPPROJ{+1}			0.26	0.26										
			(3.07)	(3.29)										
$(\pi_{MPNF} - \pi^*_{MPNF})_{t+2}$					0.21	0.21								
					(5.23)	(5.02)								
$YGAP^{C}_{t+2}$					0.15	0.16								
					(2.75)	(2.01)								
$(\pi - \pi^*)_{t+1}$							0.14	0.19					0.17	0.09
							(4.50)	(4.04)					(2.28)	(1.09)
$\Delta(YGAP)_{t+2}$							0.37	0.31						
							(1.50)	(0.85)						
GDPRG									0.06	0.07				
									(1.70)	(1.80)				
$YGAP^{IND}_{t+2}$											0.11	0.10		
											(2.82)	(2.60)		
$YGAP_{t+1}$													0.48	0.48
													(2.68)	(2.18)
Δe_t		-0.01		0.00		0.00		-0.03		-0.01		-0.01		0.08
		(0.29)		(0.11)		(0.27)		(2.13)		(0.86)		(0.89)		(1.86)
INT_{t-1}	0.88	0.89	0.94	0.94	0.91	0.91	0.92	0.99	0.95	0.98	0.91	0.93		
	(24.02)	(11.90)	(34.87)	(24.89)	(29.54)	(18.84)	(27.61)	(18.74)	(28.52)	(18.46)	(26.95)	(19.30)		
$CALL_{t-1}$													0.71	0.58
													(7.67)	(3.03)
$\bar{R}^2$	0.85	0.84	0.90	0.90	0.86	0.86	0.82	0.81	0.85	0.84	0.84	0.83	0.26	0.32
LB-Q(8)	0.79	0.79	0.76	0.75	0.57	0.57	0.75	0.41	0.67	0.63	0.66	0.56	0.70	0.80
J-test	0.55	0.44			0.71	0.64	0.68	0.64	0.57	0.47	0.56	0.54	0.77	0.71
Long-run coefficients														
Inflation	1.33	1.40	1.45	--	2.43	2.24	1.77	16.14	2.39	4.73	1.60	2.28	0.58	--
Output	1.51	1.58	4.16	4.25	1.71	1.71	--	--	1.21	3.12	1.18	1.53	1.69	1.15

Note: 1. Variable names are in Annex 1.
2. Figures in parenthesis are t-statistics based on HAC standard errors corrected with Newey-West/Bartlett window and three lags.
3. LB-Q test gives significance level (p-value) of Box-Pierce-Ljung Q-statistic for the null of no residual autocorrelation for 8 lags. J-test reports p-value for test for over-identifying restrictions for GMM estimates.
4. Estimation is by GMM methodology for the sample period 1997:2 to 2011:1 using one lag each of the following variables as instruments: *int*, *ygap*, πgap^{gdpd}, πgap^{cpi}, πgap^{wpi}, INFG, *oil*, Δe, DNFC, DM3 and *fedtarget* for the specification in columns 2-3 and 6-15; for columns 14 and 15, the instrument 'int' is replaced by 'call'. Columns 4 and give are OLS estimates.

Table 5: Estimates of Taylor Rule (Contemporaneous Specifications)
(Dependent Variable: Effective Policy Interest Rate (INT))

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Constant	0.61	0.53	0.63	0.58	0.51	0.43	0.01	-0.01	-0.41	-0.46	-0.55	-0.56	0.74	0.73	3.84	4.06
	(2.60)	(1.92)	(2.21)	(1.81)	(2.39)	(1.49)	(0.03)	(0.03)	(0.64)	(0.81)	(1.38)	(1.49)	(3.10)	3.01	4.46	4.90
$(\pi - \pi^*)_t$	0.07	0.08			0.09	0.10	0.08	0.08					0.06	0.06	0.08	0.03
	(3.37)	(2.80)			(3.47)	(2.88)	(3.19)	(2.63)					(1.79)	(1.79)	(0.78)	(0.28)
$YGAP_t$	0.19	0.19													0.50	0.53
	(2.88)	(3.09)													(3.08)	(2.95)
$(\pi_{MPNF} - \pi^*_{MPNF})_t$			0.06	0.06												
			(1.89)	(1.83)												
$YGAP^C{}_t$			0.31	0.31												
			(3.15)	(3.05)												
$\Delta(YGAP)_t$					0.08	0.08										
					(1.26)	(1.22)										
GDPRG							0.08	0.08								
							(2.15)	(2.51)								
INFWPIPROJDEV									0.20	0.20						
									(2.21)	(1.85)						
GDPPROJ									0.13	0.13						
									(1.53)	(1.71)						
$(\pi_{PROV} - \pi^*)_t$											0.08	0.09				
											(3.08)	(2.37)				
GDPRGPRELIM											0.16	0.15				
											(2.50)	(2.77)				
$YGAP^{IND}{}_t$													0.18	0.17		
													(1.83)	(2.16)		
Δeq_t		-0.01		-0.01		-0.01		0.00		-0.01		-0.01		0.00		0.05
		(0.61)		(0.54)		(0.56)		(0.27)		(0.45)		(0.54)		(0.07)		(1.90)
INT_{t-1}	0.90	0.91	0.90	0.91	0.91	0.92	0.90	0.90	0.91	0.92	0.89	0.91	0.88	0.88		
	(24.7)	(24.4)	(20.7)	(19.9)	(29.7)	(25.6)	(29.4)	(25.0)	(31.1)	(30.1)	(15.5)	(23.1)	(23.4)	(25.0)		
$CALL_{t-1}$															0.40	0.36
															(3.67)	(3.32)
$\bar{R}^2$	0.90	0.90	0.91	0.91	0.89	0.89	0.86	0.85	0.90	0.90	0.82	0.82	0.91	0.91	0.35	0.39
LB-Q(8)	0.95	0.93	0.79	0.81	0.79	0.85	0.86	0.87	0.76	0.77	0.51	0.59	0.74	0.74	0.77	0.84
Long-run coefficients																
Inflation	0.70	0.90	0.55	0.65	0.99	1.26	0.77	0.86	2.12	2.42	0.74	0.95	0.47	0.48	---	---
Output	1.86	2.04	3.02	3.34	--	--	0.75	0.77	--	1.58	1.48	1.58	1.45	1.45	0.83	0.83

1. Variable names are in Annex 1.

2. Figures in parenthesis are t-statistics based on HAC standard errors corrected with Newey-West/Bartlett window and three lags.

3. LB-Q test gives significance level (p-value) of Box-Pierce-Ljung Q-statistic for the null of no residual autocorrelation for 8 lags.

Fourth, in the contemporaneous specifications, the inflation coefficient is correctly signed (positive) and statistically significant in almost all cases; however, the long-run inflation coefficient is below unity in all permutations with the notable exception when non-food manufactured products inflation is used as an indicator of inflation (Table 5).

Fifth, the coefficient on the various alternative output terms is positive and statistically significant in almost all specifications, both in the forward-looking and contemporaneous specifications. Thus, the central bank focuses on both inflation and output stabilization.

Sixth, turning to the issue of whether the monetary authority uses the interest rate instrument to lean against exchange rate volatility, the coefficient is found to be wrongly signed and insignificant in all instances. This is true for both the forward-looking and the contemporaneous specifications (Tables 4-5). The results are consistent with the WPI inflation specifications in Patra and Kapur (2012). The only instance in which the exchange rate variable enters the regression with the correct sign (positive) is when the call rate is used as the policy rate; however, when we use the call rate, the inflation terms, as noted earlier, lose significance. The exchange rate variable being insignificant in the policy reaction function appears to reflect the RBI's approach to exchange rate management. The exchange rate regime in India has been described as a "bounded float" (Gokarn, 2012) under which the exchange rate is determined by daily variations in demand and supply and in excessively volatile market conditions, "smoothing" interventions help to keep markets orderly and prevent large jumps that can induce further spirals. Notably, the use of policy interest rates to target any level or band of the exchange rate is never resorted to.

Finally, the alternative specifications in the forward-looking version indicate that the neutral policy rate is around 5.5 per cent.

(e) Alternative Interest Rate Rules in the Literature

Even as the Taylor rule has come to be widely regarded as the most representative way of defining modern-day monetary policy reaction functions, there remains significant disagreement about several issues around it. Perhaps the most visited of these contentious themes has been that of the weights on the various coefficients. While there is unanimity that the long-run coefficient on the inflation term should be more than unity, there are a range of opinions regarding other variables in the rule – whether there should be any weight on the output gap term at all; whether there should be interest rate smoothing; and so forth. An assessment of these views is dependent upon the model of the economy that the rule is nested in, and the superiority of one rule over another could be model-dependent. Influential work on the consolidation of work on alternative monetary policy rules has assessed five different policy rules for robustness (Taylor, 1999a). They are reproduced below:

Table 6: Alternative Taylor-type Monetary Policy Rules			
Rule	Coefficient on		
	Inflation gap	Output gap	Lagged interest rate
1	2	3	4
I	3.0	0.8	1.0
II	1.2	1.0	1.0
III	1.5	0.5	0.0
IV	1.5	1.0	0.0
V	1.2	0.06	1.3

Rules I and II (interest-rate smoothing rules) have the interest rate reacting to the lagged interest rate with a response coefficient of one. Rule I has a high weight on inflation compared to the weight on output, and Rule II has a smaller weight on inflation compared to Rule I, but a relatively higher weight on output. Rule III is the simple rule proposed by Taylor (1993) without any interest rate smoothing. Rule IV is on the same lines as Rule III but with a coefficient on real output that is twice as high. Rule V, suggested in Rotemberg and Woodford (1999), places a very small weight on real output and a very high weight on the lagged interest rate. Rule VI is the forward-looking rule estimated in this paper (Table 4, column 2).

For the purpose of complete simulation of the alternative policy rules within the new Keynesian model, we update the preferred specifications of aggregate demand and aggregate supply functions in Patra and Kapur (2012). The estimated equations are as below (t-statistics are in parentheses; LB-Q(8) gives p-value of Box-Pierce-Ljung Q-statistic for the null of no residual autocorrelation for 8 lags):

$$YGAP_t = \underset{(1.1)}{0.08} - \underset{(1.9)}{0.06}*RIR_{t-2} + \underset{(6.9)}{0.49}*YGAP_{t-1} + \underset{(7.3)}{0.40}*WYGAP_t - \underset{(3.6)}{0.10}*RER_{t-2} + \underset{(10.7)}{1.81}*D01{:}4 - \underset{(9.1)}{1.91}*D02{:}4 - \underset{(24.5)}{2.07}*D04{:}1$$

$\bar{R}^2 = 0.74$ LB-Q (8) = 0.45

$$\pi_t = \underset{(5.9)}{2.18} + \underset{(2.0)}{0.19}*YGAP_{t-1} + \underset{(14.1)}{0.95}*\pi_{t-1} - \underset{(5.2)}{0.44}*\pi_{t-2} + \underset{(4.2)}{0.07}*INFG_t + \underset{(2.5)}{0.06}*EXCHA_t + \underset{(3.7)}{3.32}*D98{:}3$$

$\bar{R}^2 = 0.82$ LB-Q (8) = 0.21

where, YGAP, RIR, WYGAP, RER, π, INFG, and EXCHA are the output gap, real interest rate (= nominal effective policy rate less y-o-y WPI inflation), global output gap, real effective exchange rate gap, WPI inflation (y-o-y), international non-fuel commodity price inflation (y-o-y) and variation (y-o-y) in the exchange rate, respectively. D01:4, D02:4 and D04:1 are dummies for 2001:4, 2002:4, 2004: and 1998:3, respectively, to control for large movements in agricultural activity due to weather-related shocks and D98:3 is a dummy for the large increase in primary commodity prices.

Following McCallum and Nelson (1999), we simulate the six rules listed in Table 6 and report results for standard deviations of the policy interest rate, output gap and inflation. We simulate the model 500 times for each rule. The reported values are mean values of standard deviations over 450 replications (the first 50 replications are ignored, following McCallum and Nelson (1999) to abstract from start-up departures from stochastic steady state conditions).

Table 7: Simulation Results for Alternative Monetary Policy Rules

Rule	Standard Deviation of		
	Effective Policy Rate	Output Gap	Inflation
1	2	3	4
I	27.6	2.8	3.4
II	11.7	1.5	3.0
III	4.4	1.0	2.8
IV	4.5	1.0	2.8
V	736.8	47.0	13.2
VI	1.2	1.0	2.7

Note: See Table 6 and text for definition of various Rules.

An analysis of the results indicates that Rules I, II and V are dominated by Rules III and IV, a finding consistent with Taylor (1999a,b) for the US. Rule V results in very high standard deviations. Comparing Rules III and IV with the estimated monetary policy rule for India (Rule VI), simulations suggest that Rule VI dominates both Rules III and IV – it leads to lower variability in the policy rate and output gap, while matching volatility in inflation. However, the model in this paper does not study the impact of higher interest rate variability on output and inflation. Higher variability in interest rates can potentially lead to greater uncertainty and have an adverse impact on investment and economic activity. This channel is not incorporated in the model and, if such a channel were to be incorporated, Rule VI could arguably dominate Rules III and IV even more. Overall, the stochastic simulations in this section suggest that the conduct of monetary policy by the RBI has led to lower variability in inflation, output and interest rates vis-à-vis other potential candidate rules in the literature.

V. Summary and Conclusion

Rules versus discretion? The debate will continue to generate heat, dust but also, importantly, light. As long as uncertainty is their stock-in-trade, central banks and monetary authorities will regard some discretion as their due. Nevertheless, policy outcomes can arguably tend towards optimal if that discretion is evaluated against some sense of a rule even if it is at the back of an envelope. Or even better, against a suite of alternative policy rules. From a practical perspective, easy operability and a reasonably accurate description of reality will obviously have to be features of this effort for it to be meaningful enough to engage monetary authorities.

In this paper, we empirically assessed the McCallum Rule and the Taylor Rule under Indian conditions as alternatives rather than as competing guideposts for the operational conduct of monetary policy. This is in itself a difficult task. Each is replete with methodological nuances that have been intensively researched enough to set them up against each other. While one has found appeal because it more realistically portrays modern-day monetary policy, the other enables the balancing of multiple objectives while avoiding unobservables that have measurement issues in real life, despite their empirical elegance. Cross-fertilisation yielded results that comparable to thorough-breds and their extensions. Both Rules apply to the monetary policy framework in India as it has evolved over the past one and a half decades – while the interest rate is the main policy instrument currently, its impact on the rest of the economy continues to be conveyed by modulating bank reserves or adjusted reserve money.

Our results can be best summarized as follows: first, a forward-looking McCallum Rule in which the reserve money changes react to changes in non-agricultural output gap with a significant degree of instrument smoothing outperforms other base money rules. Second, the forward-looking hybrid McCallum Rule using the interest rate as the policy instrument reacting to movements in non-agricultural output gap is strongly supported by the data in explaining the conduct of Indian monetary policy. Third, a forward-looking Taylor Rule with the effective policy interest rate (repo rate or reverse repo rate depending on liquidity conditions) reacting to non-food manufacturing inflation and the two-period ahead output gap – overall and/or non-agricultural – appears best suited to Indian conditions among interest rate rules. Fourth, exchange rate movements do not play a significant role in policy setting, and typically evoke only lagged quantity adjustments. Finally, simulation exercises indicate that the interest rate reaction function followed by the RBI dominates alternative Taylor rules recommended in the literature as it yields lower variability of inflation, output and interest rate.

The empirical results of this paper suggest that there is scope for future work by extending the simulation analysis for Taylor-like rules in this paper to McCallum and the hybrid Rules and to compare the outcomes for volatility in inflation and output across alternative rules. Such an exercise would throw light on the question as to whether setting a nominal output growth objective *a la* McCallum or whether responding to inflation and output developments in a flexible manner *a la* Taylor combine the best parts of efficiency and discretion.

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Annex I: List of Variables

CALL = Overnight call money rate

CRR = Cash reserve ratio

DLM3 = Variation (y-o-y) in broad money (M3)

DLNFC = Variation (y-o-y) in non-food credit

EXCHA = Variation (y-o-y) in exchange rate of the Rupee vis-a-vis the US dollar

FEDFUND = US Federal Funds rate target

GDP^{PROJ} = RBI's monetary policy projection for real GDP growth (year-on-year)

GDPRG = Real GDP growth (year-on-year)

$GDPRG^{PREL}$ = Real GDP growth (year-on-year) based on preliminary data

INFG = International commodity price inflation (year-on-year) (measured by IMF's non-fuel index in US $ terms)

INT = Effective nominal policy rate (as defined in text)

REERGAP = real exchange rate gap = 36-currency real effective exchange rate (seasonally adjusted) less its HP filtered series

RPR = Real policy rate (nominal effective policy rate less y-o-y WPI inflation)

YGAP = Output gap = Real GDP (seasonally adjusted) less its HP filtered series

$YGAP^{C}$ = Non-agricultural output gap = Real non-agricultural GDP (seasonally adjusted) less its HP filtered series

$YGAP^{IND}$ = Industrial output gap = Real industrial GDP (seasonally adjusted) less its HP filtered series

Δb = Growth (y-o-y) in reserve money (adjusted for CRR changes)

Δe = Variation (q-o-q, annualized) in exchange rate of the Rupee vis-a-vis the US dollar

Δx = Growth (y-o-y) in nominal GDP

Δx^* = Trend growth (y-o-y) in nominal GDP

Δx^c = Growth (y-o-y) in non-agricultural nominal GDP

Δx^{c*} = Trend growth (y-o-y) in non-agricultural nominal GDP

π = Wholesale price index (WPI) inflation (year-on-year)

π^* = Monetary policy inflation objective (taken as 5 per cent)

π^{MPNF} = Non-food manufactured products WPI inflation (year-on-year)

π^{*MPNF} = Monetary policy objective for non-food manufactured products inflation (taken as 4 per cent)

π^{PROV} = Provisional wholesale price inflation (year-on-year)

π^{PROJ} = RBI's monetary policy projection for wholesale price inflation (year-on-year)

πgap^{cpi} = Deviation of consumer price inflation (year-on-year) from policy objective

πgap^{gdpd} = Deviation of GDP deflator inflation (year-on-year) from policy objective

Note: All data are in percentages.