

**Operationalising Taylor-type Rules for the Indian Economy**  
Issues and Some Results (1992Q3 – 2001Q4)

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# Operationalising Taylor-type Rules for the Indian Economy

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*This study is an attempt to formulate a monetary policy reaction function for India. In particular I model backward and forward looking Taylor and McCallum rules for the period post BoP crisis. It is found that backward-looking McCallum rule tracks the evolution of monetary base over the sample period reasonably well, suggesting that RBI acts as if it is targeting nominal income when conducting monetary policy. Recent declaration by the RBI that reserve money is its operating target (Annual Reports, 2001-02 and 2002-03) lends support to the findings of the study.*

## I. Introduction

It's been more than a decade since the financial sector reforms began in India and an important question currently facing the policy makers is that of the selection of an appropriate regime for conducting monetary policy; in a situation where the structural reforms have only partially taken effect and, more importantly, are still underway. Under such a scenario it would be useful to see what the Indian central bank can learn from the recent developments in the area of rules for monetary policy.

In this study I attempt to operationalise Taylor (1993a) type rules for the Indian economy. After Taylor's popular paper on rules versus discretion where he described the evolution of the U.S. Federal funds rate after mid '80s as a function of output and inflation gap, literature on such monetary policy 'reaction functions' has been abounding. Even though reaction functions per se have been around for many years (Khoury, 1992), Taylor's paper reignited interest in the area and now the term Taylor rule has almost become synonymous with monetary policy reaction functions.

I set out to estimate such monetary policy reaction functions for the Indian economy, with monetary base (termed in the literature as the McCallum Rule) and interest rate (Taylor Rule) as alternative operating targets. In this study I model both the backward looking (on the lines of Judd and Rudebusch, 1998) and the forward looking versions of the reaction functions (on the lines of Clarida, Gali and Gertler, 1998, 2000; henceforth CGG). While prior to mid '90s, high degree of monetization of deficits made such an exercise quite for India meaningless, lack of high frequency contemporaneous data on output and output gap also made it impracticable.

After a brief discussion on the price stability as the main goal of monetary policy in **Section II**, I discuss the literature on Taylor-type rules in **Section III**. In **Section IV** I discuss the issues

associated with using Taylor-type rules for monetary policy and describe the methodology. **Section V** describes the estimation strategy and reports the results. **Section VI** is a discussion of results against the backdrop of the monetary/macro developments in India in the late '90s. **Section VII** concludes after performing an out-of-sample check of the results.

## II. Price Stability

If there is one area in the theory of monetary policy that has the consensus of both academicians and practitioners it is that of price stability as the main target of monetary policy. Today, central banks of most developed countries use price level or inflation rate in some form or the other as their main target of monetary policy. Academicians though, still like to think about the decision problem in terms of the traditional loss function, with both inflation and the gap between actual real GDP and potential GDP as the arguments.<sup>1</sup> There are some economists, however, who argue that the most suitable objective of monetary policy is the nominal income.<sup>2</sup>

Rangarajan (1997) reminds us that monetary policy is just a tool to achieve the broad economic policy objectives of a faster rate of economic growth, a reasonable degree of price stability, and promotion of distributive justice. In this situation of equally desirable objectives, and the constraint on equality of number of instruments and objectives, he argues that, monetary policy seems to be best suited to achieving the goal of price stability. Settling for price stability as the chief objective of monetary policy he claims that:

*“Inflation control policies should not be viewed as inimical to growth promotion policies...[and] it is possible to contain the inflationary pressure on the economy, while maintaining a sustained improvement in growth.”<sup>3</sup>*

Macroeconomic theory tells us that in the long-run<sup>4</sup> monetary policy cannot influence real magnitudes. In keeping with that and the above discussion, this study works on the premise of ensuring price stability as the main long-term goal of the monetary policy in India.

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<sup>1</sup> See Svensson (1999)

<sup>2</sup> See McCallum (1984) and Taylor (1985)

<sup>3</sup> C. Rangarajan, “The Role of Monetary Policy”, *EPW*, December 27, 1997, p. 3325

<sup>4</sup> The “long-run” here refers to the notion that the economy has ‘absorbed’ both demand and supply shocks

### III. Monetary Policy Reaction Functions: The Taylor and the McCallum Rule

Before proceeding an important thing that needs to be understood regarding the monetary policy reaction functions is that rules are just *a* tool in the toolbox of the central banker. A central banker possesses (or at least is expected to possess!) a number of macro models assisting it in making monetary policy decisions. Monetary policy reaction functions are what they are – simplified representations of a central bank’s behaviour relating the evolution of (monetary policy) instruments to changes in goals (price and output) and intermediate targets (interest rate/money growth rate/exchange rate). As shown by Taylor (1993b), Levin, Wieland and Williams (1997) and Rudebusch and Svensson (1998), such reaction functions when calibrated/estimated with an IS curve and a backward looking/expectation augmented Phillips Curve, stabilize inflation and output reasonably well in a variety of macro models and are thus worthy of study.

Also, monetary policy rules are a good way of summarizing a central banker’s behaviour on the operating target of its choice, giving its likely behaviour based on information about future inflation and output gap. Rules add to enhancing credibility of the bank that it has its eyes on its goals and helps facilitating discussions both within the bank and with the academic/professional community.

#### ➤ *Interest Rate Targeting – The Taylor Rule*<sup>5</sup>

Though the rule that Taylor ‘designed’ was for the level of operating targets, for the U.S. it actually relates the value of the intermediate target relying on the aggregate demand channel and transmission via changes in the interest rate structure. Although the rule was developed empirically, Taylor (1998) argues, it can be easily derived from the quantity theory equation.<sup>6</sup> Also, as shown by Assuming away the lags in the response of velocity to interest rates or income changes, and using (stationary) output gap instead of real output, he comes with up with the following linear equation:

$$i = r^* + \pi + \alpha(\pi - \pi^*) + \beta z \quad [1]$$

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<sup>5</sup> Made popular by Prof. John Taylor of Stanford University; See Taylor (1993a, 1993b, 1998)

<sup>6</sup> Noting that the velocity of money depends on the interest rate and real output the quantity theory equation can be reduced to the form of the Taylor equation.

where  $i$  is the short term interest rate,  $\pi$  is the inflation rate, expressed as annualized percentage changes in the price level,  $\pi^*$  is the targeted inflation rate, and  $z$  is the output gap expressed as annualized percentage deviation of real output from trend (in logarithms).

In the above equation the parameters  $\pi^*$ ,  $r^*$ ,  $\alpha$  and  $\beta$  are treated as constants. Thus, given the values of  $\pi$  and  $z$  for any period the Taylor rule suggests the target value of the short term nominal interest rate  $i$ . Taylor (1993a) showed that the following equation gave a good description of the Fed's interest rate for the period 1987-1992:

$$i = 2 + \pi + 0.5(\pi - \pi^*) + 0.5z \quad [2]$$

This implies an inflation target of 2%, an average short-term real rate of 2%, and an equal weight on output gap and the deviation of inflation from the target. On whether a rule derived from empirical observation can serve as a general guideline for monetary policy Taylor asserts from his studies that the basic results about simple rules designed for the United States apply to most developed countries.<sup>7</sup>

Apart from Taylor's (1993a) own study which "assumes" parameter values, there have been subsequently been attempts to fit the rule using formal econometric procedures. CGG (1998, 2000), Judd and Rudebusch (1998) and Kozicki (1999) do so for the US while Nelson (2000), using the rule as a guide, describes the evolution of the monetary policy in the UK. Taylor (1993b) and CGG (1998) report estimates for the UK, Japan, France, Italy and Germany using backward and forward looking versions of the rule respectively.

In practice the use of interest rates as the main policy instrument has often taken place in conjunction with some inflation target. In other words, policymakers set an inflation target - explicitly or implicitly - and change interest rates with the aim of achieving such a target. Though, here Sims' (2003) warning should be taken heed of, that such a policy is effective only if the central bank is "actually" able to control inflation.

A rule in 'competition' to the popular Taylor rule is the McCallum rule using monetary base as the operating instrument based on nominal income targeting, which is described next.

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<sup>7</sup> See Taylor (1993b)

➤ *Nominal Income Targeting – The McCallum Rule*<sup>8</sup>

In the literature this is the only rule that propounds adjustment in the growth rate of the monetary base when the target (of nominal GDP) is not achieved. From the Quantity Theory of Money we know that:

$$Y^D = \frac{M_o}{P} V \quad [3]$$

where  $M_o$  is the exogenous money supply,  $P$  is the aggregate price level, and  $V$  the income velocity of money. The theory offers an adequate picture of reality where macroeconomic demand is markedly determined by changes in money supply.

Writing the above equation in the growth rate form we have:

$$\dot{M} + \dot{V} = \dot{Y} + \pi \quad [4]$$

and noting that nominal GDP target can be expressed in terms of growth rate we have:

$$\dot{Y}^n = \dot{Y} + \pi \quad [5]$$

where  $Y^n$  is the growth rate of the nominal GDP target<sup>9</sup>. Now, with the forecast values for growth rate of output ( $Y$ ) and velocity ( $V$ ), and the targeted inflation rate ( $\pi$ ), a target growth rate for the money stock ( $M$ ) can be calculated. Given the money multiplier ( $m$ ), the target growth rate for the monetary base can be derived from:

$$\dot{M}^* = \dot{B}^* + \dot{m}^* \quad [6]$$

At this juncture note that if fluctuations in the income velocity of circulation are ignored nominal GDP targeting may appear identical to monetary targeting. However, Bofinger (2001) argues, this is not the case. While monetary targeting results in a medium-term targeting of monetary growth, nominal GDP targeting is an activist policy leading to countercyclical fluctuations in the money

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<sup>8</sup> Made popular by Prof. Bennett McCallum of Carnegie Mellon University; See McCallum (1988, 1993, 1999)

<sup>9</sup> 'dot' on top of the variables represent (annualized) growth rates

supply growth. Also, monetary targeting cannot ensure that the (implicit) nominal target will be met unless, in the very special case, the long run trend of velocity equals the actual growth rate.

Having build the underlying premise let us look at how McCallum (1988, 1993, 1999) has translated it into a rule calling for changing in the growth rate of monetary base in advent of the nominal income target not being met. Combining equations [4] and [6] we have,

$$\dot{B} = \dot{Y} + \pi^* - \dot{V} - \dot{m} \quad [7]$$

Writing  $\dot{V}^b = \dot{V} + \dot{m}$  we can write the above equation in terms of the rate of variation of velocity of circulation of the monetary base ( $\dot{V}^b$ ). Thus,

$$\dot{B} = \dot{Y} + \pi^* - \dot{V}^b \quad [8]$$

However, McCallum does not use the rule in this form. For the velocity of circulation he uses not the actual value, but the average velocity of circulation of the monetary base for the last sixteen quarters. Also, McCallum supplements his rule by a term that takes temporary fluctuations in nominal GDP into account. He uses the difference of the logs of actual value of the nominal GDP and its trend, so that the determining equation for the monetary base is:

$$\dot{B} = \dot{Y} + \pi^* - \frac{1}{16} \sum_i \dot{V}^b_{t-i} + \lambda(\ln Y^{o*} - \ln Y^o) \quad [9]$$

where he uses the value of 0.25 for  $\lambda$ .

Thus, according to the McCallum rule, the central bank must increase the growth rate in the monetary base if the actual value of nominal GDP in the preceding period is below its target/trend value and vice versa.

McCallum (1999) has shown that for the US, his rule has agreed with the more-popular Taylor rule over many periods but differed in the case of the UK when his “...*would have called for*

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<sup>10</sup> Here  $\ln Y^o$  represents natural logarithm of nominal income

*tighter policy and Taylor's for looser.*<sup>11</sup>” He further argues that for Japan during the years 1995-1998, when understanding was that

*“...monetary policy could provide no more stimulus in Japan because interest rates were already as low as they could go...a policy rule that uses the monetary base as an essential variable would have been giving signal of this type for years, if anyone had bothered to look.”*<sup>12</sup>”

Here note that the choice of the operating target in both the rules is not sacrosanct. If there is a stable relationship between the velocity of monetary base and the short term interest rate, an analog to the McCallum rule can be cast in terms of the short term interest rate and vice versa.

It would be apparent from the description of aforementioned rules that the performance of a particular regime would crucially depend on the parameters of the rules. While monetary targeting, premised on stable demand for money function, is fairly well understood in the Indian context<sup>13</sup>, there does not seem to be any study on the estimation of monetary policy reaction functions in the Indian context. This study is an attempt to fill that gap to see if ‘rules’ offer any insights in the way RBI has conducted monetary policy in the period post liberalization.

#### **IV. Issues in the Estimation of Taylor-type Rules – The Methodology**

Although McCallum (1997) and Kozicki (1999) discuss in some detail the theoretical and practical issues respectively in the design/estimation of monetary policy rules, I delineate here the main methodological concerns. I have divided them in the following sub-categories, as:

- *Inclusion of other Macroeconomic Aggregates: Exchange Rate/Money Supply*
- *Dynamics of Adjustment: Interest Rate Smoothing*
- *Data: Measures for Output, Output Gap and Inflation*
- *Vintage of Data Used: Advanced vs. Revised Estimates?*
- *Backward Looking (OLS) vs. Forward Looking (GMM) version of the rules*
- *Unit Root Tests: Are Inflation and interest rates series stationary?*

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<sup>11</sup> McCallum *op cit.* p. 13

<sup>12</sup> McCallum *op cit.* p. 16

<sup>13</sup> Rao (1997), Jadhav (1994), and Arif (1996) are some examples



Although in the discussion that follows issues are presented with reference to rules with interest rate as the operating target, they are equally important and relevant for rules cast with monetary base as the instrument of choice.

Before discussing each of above issues in detail, to facilitate discussion, let us look at the original Taylor (1993a) rule. The original Taylor rule in estimable form can be represented as:

$$i_t^* = r^* + \pi_t + \beta(\pi_t - \pi^*) + \gamma(y_t - y_t^*) \quad [10]$$

Writing  $\alpha = r^* - \beta\pi^*$ , and  $z_t = y_t - y_t^*$  the above equation can be simplified to:

$$i_t^* = \alpha + (1 + \beta)\pi_t + \gamma z_t \quad [11]$$

where,  $i_t^*$  is the recommended short-interest rate from the rule,  $r^*$  is the long run equilibrium real rate,  $\pi^*$  is the target inflation rate,  $\pi_t$  is the average inflation rate over the past four quarters (including the contemporaneous quarter), and  $z_t = y_t - y_t^*$  is the output gap expressed as (annualized) deviation of logarithm of real GDP from the potential.

➤ *Inclusion of other Macroeconomic Aggregates: Exchange Rate/Money Supply?*

While for the U.S. interest rate serves as both the operating and the intermediate target, and Taylor rule can be interpreted as a rule for the evolution of the intermediate target, for India, it is almost an accepted ‘fact’ that till mid ‘90s, RBI, under Dr. Rangarajan, almost exclusively targeted money growth rate for whatever leeway it had in using its instruments, with effectively fully regulated financial markets. However, if official releases of RBI (various Annual Reports since 1997/98) are any indication, it is moving to a ‘multiple indicator targeting’ approach with repo rate as the chief operating instrument. Introduction of the Liquidity Adjustment Facility (LAF) in 2000 to better manage liquidity in the repo/reverse repo market is a step in that direction, and RBI is actively using its refinancing window to move the short term interest rate in the direction it deems appropriate. Although, of late RBI has declared (in Annual Reports for the years 2001-02 and 2002-03) that it is using monetary base as the official operating target.

To assess if exchange rate/money growth have been quantitatively important – during the sample under study – for the Reserve Bank of India (RBI) in its monetary policy decision making, in addition to the base line model, I estimate the rules augmented with exchange rate. To see if money is important in the event RBI's implicit intermediate target is interest rate, I experiment with growth rate and deviation of money growth from the target/projected (as announced in the monetary and credit policy) as alternative additional independent variables.

➤ *Dynamics of Adjustment: Interest Rate Smoothing*

As is well known (e.g. Goodfriend, 1991 and Svensson, 1997) most central banks using interest rate as the predominant instrument for monetary policy indulge in smoothing of interest rates. Notwithstanding the monetary conditions they refrain from drastic interest rate cuts/increases, mostly for fear of overreactions in the asset markets.

Thus, if the rule warrants a rate  $i_t^*$ <sup>14</sup>, the central bank would act as to change the rate only smoothly. An accepted way of representing such behaviour is to assume that actual rate gradually adjusts to the desired as:

$$i_t = (1 - \rho)i_t^* + \rho i_{t-1} + v_t \quad [12]$$

where  $0 \leq \rho \leq 1$  captures the observed smoothing in the value of the instrument by the bank.

In this study it is assumed that the Indian central bank indulges in smoothing of the instrument. Thus, the estimable backward looking form takes the form:

$$i_t = (1 - \rho)(\alpha + (1 + \beta)\pi_t + \gamma z_t) + \rho i_{t-1} + v_t \quad [13]$$

which can be simplified to:

$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_t + \gamma(1 - \rho)z_t + \rho i_{t-1} + v_t \quad [14]$$

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<sup>14</sup> Even though the discussion 'takes' interest rate as the instrument of choice, it is not to mean that *a priori* interest rate is the preferred instrument for the Indian central bank

Similar first-degree dynamics of adjustment has been assumed for growth rate of monetary base for use in the McCallum rule and the resulting ‘rule’ takes the form:

$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^{k-1} \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1}) + v_t$$

where,  $\alpha = (1 + \lambda)(\pi^* + \Delta y^*)$  and  $(\Delta y^* + \pi^*)$  is the target (long run) growth rate in nominal output.

➤ *Data: Measures for Output, Output Gap and Inflation*

In this study, for output I employ the quarterly output series created by Virmani and Kapoor (2003) in conjunction with the official series released by the CSO. For inflation I alternatively use four quarter average (including contemporaneous)<sup>15</sup> of annualized headline inflation rate, the Wholesale Price Index - All Commodities Index (1993-94 = 100), four quarter average of annualized 49/50 trimmed mean (see Virmani, 2003) and a proxy for “core” inflation from an unobserved components model (*UCM 3*) estimated in Virmani (2004b). See **Exhibit 1** for plots.

Estimation of output gap is one issue that has surprisingly not been given its due importance in the literature on rules. Studies working on the U.S. data either take a log linear/quadratic trend or conveniently relegate the responsibility on selecting the appropriate numeraire for output gap to “as defined by the Congressional Budget Office”. For a country like the U.S. existence of an official output gap series only adds to the simplicity associated with application of the rules. However, for a country like India, where release of the quarterly output series itself is a recent affair, estimation of output gap is a concern that needs to be addressed.

A ‘short-cut’ often found in the literature is the use of Hodrick-Prescott (1997) filter (HP) to proxy the long term trend of output. Virmani (2004b) reviews the literature on the techniques used to estimate the output gap and provides output gap estimates for India using both univariate and bivariate unobserved components models. In this study I use the estimates from the models *UCM 2* and *UCM 3* as created in that study. See **Exhibit 2** for plot of output gaps from HP, the Modified HP, *UCM 2* and *UCM 3*. See Virmani (2004b) for details.

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<sup>15</sup> For McCallum rule, however, point-to-point inflation has been used; as required by construction of the rule

➤ *Vintage of Data Used*

Orphanides (1997) was amongst the first<sup>16</sup> to recognize the consequences of delay in availability of macroeconomic data in operation of simple Taylor-type policy rules. He found that

*“...the analysis [was] based on unrealistic assumptions about the timeliness of data availability. This permits rule specifications that are not operational and ignore difficulties associated with data revisions.”<sup>17</sup>”*

He repeatedly finds that the magnitude of the errors associated with using different vintage of data used is substantial and sometimes within-year

*“...revisions in the policy recommendations are also quite large with a standard deviation exceeding that of the quarterly change of the federal funds rate.”<sup>18</sup>”*

Rather than taking his observations as a negative criticism, what is important is due appreciation of the informational problems associated with macroeconomic data like output, and inflation and end of sample sensitivity of output gap estimates. The central bank can over time observe the likely direction of data revisions based on other (high frequency) indicators (e.g. index of industrial production data, which is available monthly; rainfall estimates from the Indian Meteorological Department with which RBI does keep in touch) and incorporate that in application of the rules.

Since it is the ‘advanced’ output estimates that are available to the central bank when it has to act, it makes little sense to use the revised quarterly estimates of output. For period post 1996-97 while data on advanced estimates is available (taken to be the first releases of quarterly estimates in each issue of National Accounts Statistics released by CSO and also – now – on its website as and when the quarterly estimates are available – normally with a lag of one/two quarters), for earlier periods I use the (pro rata) imputed quarterly advance estimates for output, i.e. I take the division of revised estimates into four quarters and apply that to the ‘first’ estimate of output as announced by the CSO.

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<sup>16</sup> Since then the problem has been emphasized by Orphanides and van Norden (1999), Orphanides (2003), Orphanides et al (2000) and Nelson and Nikolov (2001) among others

<sup>17</sup> *ibid* p. 1

<sup>18</sup> *ibid* p. 1

➤ *Backward Looking (OLS) vs. Forward Looking (GMM) version of the Rules*

From the original backward looking version of the Taylor rule, specification of the rule has undergone fine tuning from the forward looking reaction function of CGG (1998, 2000) and Nelson (2000), the mixed version of Mehra (1999), to the real time analog of Orphanides (2003) which he used to conduct a historical analysis of monetary policy rules, the versions have been abounding.

If survey of the literature is any indication, while the forward looking versions of CGG are now a standard (see the *June 1999* special issue of the *Journal of Monetary Economics* which covered the *Sveriges Riksbank – IIES Conference on Monetary Policy Rules, June 1998*) with Orphanides' (1997) and Orphanides and van Norden's (1999) caveat on the importance of vintage of data used in operation of the rules.

As Estrella and Fuhrer (2002, 2003) have shown not only are backward looking rules fit the data better, they also find them to be more stable in macroeconomic models (along with suitable IS and Phillips curve specifications), especially to monetary regime shifts. In line with their finding, in this study I employ both the original Taylor rule in its estimable form (equation [15]) and in the form as used by CGG.

Specifically, the estimable form of baseline backward and forward looking Taylor and McCallum rules are given below:

- *Backward Looking Taylor Rule:*

$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_t + \gamma(1 - \rho)z_t + \rho i_{t-1} + v_t \quad [15]$$

- *Backward Looking McCallum Rule*

$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^{k-1} \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1}) + v_t \quad [16]$$

where,  $\alpha = (1 - \lambda)(\pi^* + \Delta y^*)$ ;  $\Delta y^* + \pi^*$  is the target (long run) growth rate in nominal output. A priori  $\alpha > 0$ ,  $\beta > 0$ ,  $\gamma > 0$ ,  $\rho > 0$ ,  $\lambda > 0$

The above backward looking specifications can be estimated by the ordinary least squares (*OLS*) using the heteroskedasticity and autocorrelation consistent Newey-West covariance matrix.

- *Forward Looking Taylor Rule*

$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+n} + \gamma(1 - \rho)z_{t+n} + \rho i_{t-1} + \varepsilon_t \quad [17]$$

where the error terms is a combination of the forecast errors of inflation and output and the exogenous disturbance term  $\nu_t$ , i.e.

$$\varepsilon_t \equiv -(1 - \rho) \left\{ (1 + \beta)(\pi_{t+n} - E[\pi_{t+n} | I_t]) + \gamma(z_{t+n} - E[z_{t+n} | I_t]) \right\} + \nu_t \quad [18]$$

- *Forward Looking McCallum Rule*

$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^{k-1} \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) + \varepsilon_t \quad [19]$$

where, the error term  $\varepsilon_t$  in this case is given as:

$$\varepsilon_t \equiv \lambda(1 - \rho) \left( \Delta y_{t+n} + \pi_{t+n} - E[\Delta y_{t+n} + \pi_{t+n} | I_t] \right) + \nu_t \quad [20]$$

Clearly, for the forward looking versions, not only are the error terms autocorrelated (having an *MA* ( $n-1$ ) structure<sup>19</sup>), they are also correlated with explanatory variables precluding the use of *OLS* for estimation. Assuming the central bank has in its information set  $I_t$  at time  $t$ , a set of variables  $u_t$  such that  $E[\varepsilon_t | u_t] = 0$  (the orthogonality conditions) the Generalized Method of Moments (*GMM*) can be used to estimate the rules in the forward looking form.

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<sup>19</sup> Correlation arises out of the choice of the horizon; for a horizon of one year (= four quarters), three forecast errors add up over the horizon. In the event horizons for inflation and output gaps are different, representation takes the form *MA*( $q$ );  $q = \max(m, n) - 1$

Note that from the above formulations while we cannot independently determine both  $i^*$  and  $\pi^*$  in the Taylor rule, in the McCallum rule it is  $\Delta y^*$  and  $\pi^*$  that is contained in the intercept  $\alpha$ . In both cases one of them must be assumed to get the implied value of the other. As is the common practice, sample average would be used to get the equilibrium value of the nominal interest rate<sup>20</sup>. An ‘advantage’, however, in the McCallum Rule is that it does not require estimation of the unobserved output gap.

#### ➤ *Unit Root Tests*

In the equations [15] and [16] as above while the standard Dickey Fuller tests are seen to find a unit root in all the series, i.e. interest rate, inflation, output and monetary base, those tests are plagued by very low power in small samples. Relying on the study of Virmani (2004a) which compares results from modified (and importantly, more powerful) versions of Dickey-Fuller and Phillip-Perron unit root tests on Indian macroeconomic data, both interest rate and inflation series are taken to be integrated of order zero in small sample and accordingly equations [15] & [16] and [17] & [19] are treated as stationary and can be estimated using *OLS* and *GMM* respectively (after adjusting for autocorrelation and heteroskedasticity in the residual  $v_t$ ) without any fear of spurious regression.

### **V. Data and Estimation Results: 1992Q3 – 2001Q4**

In this section I present results for both backward looking and forward looking versions of Taylor and McCallum Rules. As pointed out earlier while *OLS* is used for estimation of backward looking formulations, for forward looking rules I employ *GMM*. Horizon for (short to medium term) policy making in case of forward looking version is alternatively taken to be  $n = 1$  and  $n = 4$  (quarters). For instruments, as is common practice (CGG, 1998, 2000 and Favero, 2001 are some examples), I use 1 and 4 quarter lags for each variable entering the regression and a vector of unity. In all the cases considered in the study, number of orthogonality conditions exceeds the number of parameters to be estimated. Overidentifying conditions can be tested using the  $J$

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<sup>20</sup> As CGG (1998) note, a consequence of using sample average to proxy equilibrium real rate is that in a correctly specified model implied inflation rate would never be very far from the sample average either.

statistic which is distributed as  $\chi^2$  with the degree of freedom equal to the number of 'excess' identifying conditions. Hamilton (1994) provides the details.

Rules are estimated on both the complete sample and a reduced sample with observations for four quarters removed starting the fourth quarter of 1997. The period from 1997Q3 – 1998Q4 in the Indian economy was extremely tumultuous, with an extremely volatile foreign exchange market, sanctions, slowdown in output growth combined with fears of spillovers from the South East Asian and the Russian crisis. Here is a snapshot of the economic situation then.

The South East Asian crisis started around the second quarter of 1997. Starting the second quarter of 1997, till the last quarter of 1998, not only did the Indian economy had to deal with speculative pressures in the foreign exchange market owing to the crisis, post Pokhran nuclear tests in May 1998 it also had to face unprecedented economic sanctions from the international community. The period was marked by RBI's excessive interventions in the foreign exchange market post South East Asian Crisis (around 1997Q3), Pokhran tests (May 1998), and the inflows from the Resurgent Indian Bonds (around 1998Q3), coupled by a recession and lack of aggregate demand and temporary supply shocks around the first quarter of 1998 (mostly owing to sharp price rise of a few primary articles, particularly fruits and vegetables). As RBI's 1997-98 Annual Report notes,

*“The overall growth momentum slackened in 1997-98 with agricultural sector posting a negative growth and industrial sector continuing to be sluggish. Real GDP growth in 1997-98 was placed at 5.1 per cent as per the Revised Estimates year 1997-98 was marked by a relative slowdown in real economic activity...”<sup>21</sup>”*

In such a situation, while a textbook would demand a loose monetary policy to pump-prime the economy, in reality RBI sucked the liquidity to curb speculations in the foreign exchange market. As RBI further notes,

*“...in the light of the pressures in the foreign exchange market between November 1997 and January 1998. These pressures were required to be contained by monetary policy measures that impact on the liquidity position and through it, the interest rates...Given the economic*

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<sup>21</sup> RBI 1997-98 Annual Report, “Money, Credit and Prices,” Chapter 3



*environment engendered by the currency crises in the South-East Asian region, the proposal to reduce CRR by two percentage points, envisaged in October 1997, could not materialize in full during 1997-98. On the other hand, CRR was raised with effect from December 6, 1997 and January 17, 1998 to siphon off liquidity and control the arbitrage opportunities that arose on account of relatively low call money rates and gains in the foreign exchange market. This measure was supplemented by other measures on January 16, 1998 such as a hike in both Bank Rate and repo rate by two percentage points, reduction in access to refinance facilities, and an increase in interest rate surcharge on bank credit for imports. These measures were successful in restoring orderly conditions in the forex market. With the stabilization of conditions in the foreign exchange market, the Reserve Bank could in March and April of 1998 reverse most of the January 16, 1998 measures in stages.<sup>22</sup>”*

Since the situation was indeed quite problematic, it must be checked if that period (normalcy was regained only around the third quarter of 1998, well after Pokhran tests) had any marked effects on the estimation results. Thus, I estimate the rules on the ‘truncated’ sample too.

In November 1998, Dr. Rangarajan left to give way to Dr. Bimal Jalan as the governor of the central bank. To see if change of the central banker had an effect on the stance of monetary policy (weight on arguments appearing in the rule), I introduce a (slope) dummy for data after the third quarter of 1998 against output gap (nominal income gap in case of the McCallum rule), inflation gap, and deviation of  $M_3$  from target<sup>23</sup>. This I check for both the complete and the truncated sample. Thus, in all, I estimate four versions each (full sample and truncated, both with and without dummy) of the backward and the forward looking rules. Also, for each version, I use three different numeraires for inflation, namely WPI, Trimmed Mean, and “core” inflation from UCM 3. With WPI and Trimmed Mean I use UCM 2 as the measure for potential output, and with “core” inflation, I use UCM 3 for potential output<sup>24</sup>.

To see if money is quantitatively important (anymore) for setting the value of the short term rate, I experimented with both growth rate of  $M_3$  and deviation of  $M_3$  from target, and found deviation of  $M_3$  from target to be more significant. To proxy exchange rate, I include percentage change in

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<sup>22</sup> RBI 1997-98 Annual Report, “Monetary and Economic Policy Environment,” Chapter 1

<sup>23</sup> No dummy was added to exchange rate, as with the benefit of hindsight, both the central bankers have been attentive to the external value of the Rupee.

<sup>24</sup> UCM 3 corresponds to the measure associated with CORE 3. See for Virmani (2004b) for details.

36 country trade weighted *REER* in both the Taylor and the McCallum rules. For the measure of velocity in McCallum rule I have used eight quarter moving average (including the contemporaneous quarter) of velocity of adjusted monetary base<sup>25</sup>. At this point it would be important to emphasize that in McCallum rule adjusted (for CRR) monetary base has been used applying the formula proposed by Rangarajan and Singh (1984).

All estimations have been carried out in MATLAB v. 6.5 using the Econometric Toolbox developed by Prof. James LeSage of University of Toledo, Ohio<sup>26</sup>. For GMM estimation MINZ library (prepared by Prof. Mike Cliff of Purdue University) complementing the toolbox is used. Results are presented in **Exhibits 3 to 8**. Discussion follows.

## **VI. Discussion**

In this section I evaluate econometrically and factually the results of the regressions in **Section V**. Clearly it would be futile to expend time and space on results from all the estimated versions. The idea behind using different measures was not only to check the sensitivity of rules to the numeraire, sample period and estimation strategy but also to ensure a degree of rigour in the econometric analyses.

For purpose of analysing RBI's monetary policy stance I would be discussing only those results, which bear a degree of semblance to the value of the operating target during the sample period and overall significance of the regressions. Thus, main criteria for evaluation are the ability of the rule to track the movements in the operating target (especially as it relates to 'tightening' or 'loosening'), the implied value of the target inflation rate, and last but not least, statistical and economic significance of variables appearing on the right hand side.

### ➤ *The Taylor Rule*

The first thing that becomes clear from results both forward looking and backward looking rules is the importance of exchange rate and deviation of growth rate of  $M_3$  from target in explaining the variation of the short rate over time. Also, apparent is the strong autoregressive nature of the

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<sup>25</sup> Results were insensitive to the length of the moving average used. Regressions using four, five, six and seven quarter moving averages did not lead to substantially different results

<sup>26</sup> Available for download from <http://www.spatial-econometrics.com>

movement in the short rate, suggesting that the Indian central bank does intervene to smooth changes in call rate.

However, while the sign on rate of change of *REER* is correctly negative (as the Rupee depreciates – fall in *REER* - *ceteris paribus* the central bank moves in to increase the short term interest rate) the sign on deviation of growth rate of  $M_3$  from target is wrong<sup>27</sup>. If the growth rate of  $M_3$  is higher than targeted/projected, the central bank would be expected to raise the rates to curb the growth rate of money. It is an indication that money growth is endogenous in India, and that it *responds* to changes in interest rate and demand for credit. Das and Mandal (2000) found that short term interest rates are superexogenous w.r.t parameters of the demand  $M_3$  is evidence in support. Thus, it is the reduction in rate that *leads* to a higher growth rate of money. In the light of this a rule cast in terms of monetary base would be more appropriate.

But where the forward looking versions fail both to capture the direction of movements in the call rate (the null of overidentifying restrictions in all cases is satisfied, indicating that choice of instruments is not flawed) and a reasonable value of the implied inflation target, the backward looking versions do a fairly good job of capturing the temporal evolution of the short-rate post 1996-97 (before which it is the autoregressive nature of the short-rate which seems to be predominant), and also provide a reasonable estimate of the implied inflation target. The most plausible estimates are for the case with trimmed mean used as the numeraire for inflation, with deviation of money growth from target and change in exchange rate as additional explanatory variables. Results add to the credence that RBI has been following a ‘multiple indicator targeting’ since 1996-97.

Both the value of the coefficient and the *t-statistic* on output gap indicates that RBI - at least for the sample under consideration - has not been paying much attention to the output gap *independently* of inflation. A negative  $\beta$  is a sign that the central bank ‘allows’ for persistence in inflation accommodating changes in inflation and does not let the real rate rise too much in response to decrease in expected inflation. Though, it must be pointed out that a rule with  $(1 + \beta) < 1$  when incorporated in a standard new Keynesian IS curve, Phillips curve formulation leads to instability (see CGG, 2000, McCallum and Nelson, 1999a, 1999b, and McCallum, 2001).

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<sup>27</sup> Even in regressions with growth rate of  $M_3$  as the explanatory variable the sign of the coefficient was negative

Introduction of dummy in both the full sample and the truncated sample turns out to be statistically significant. Most important change in results is significance of output gap after Dr. Jalan took over, and a drastic fall in quantitative importance of money in the reaction function (with a near zero value of the coefficient). Thus, while the backward looking Taylor rule in the truncated sample (with dummy) does provide a reasonably good representation of the evolution of call rate, parameter values (especially the value of the implied inflation target) and problems in estimating output gap in real time casts doubt on the applicability of the rule for real time policy.

➤ *The McCallum Rule*

Similar to what is seen in case of the Taylor rule, for the McCallum Rule too, it is the backward looking version (with percentage change in *REER* as additional independent variable) which comes forth as the best choice with the selection of numeraire for inflation not playing a major role here. Also, contrary to what was noticed in the case of the Taylor rule, nominal output ‘gap’<sup>28</sup> is statistically significant, and that with the correct sign<sup>29</sup>. Thus, RBI seems to have nominal income as its implicit final target while conducting monetary policy.

Another difference is that introduction of dummy in the McCallum rule turns out to be insignificant. Also, unlike for Taylor rule, both *GMM 1* and *GMM 4* versions provide a reasonably good representation of movements in adjusted monetary base in the truncated sample (overidentifying conditions are satisfied as in case of Taylor rule). But even in the forward looking versions, the forward looking *variable* is insignificant.

What is bothering, however, is the unreasonably high value of the implied inflation target in the range of 10-11%, even for a growing economy like India. This could be because a substantial portion of the sample belongs to the period when quarterly inflation was well above 5%. However, while implied inflation target is on the higher side, if we look at the implied nominal income growth rate, it comes out to be around 14-16%, which though still on the higher side, is not as disturbing given that Indian economy is still in the developing phase.

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<sup>28</sup> More correct terminology would be deviation from target; here ‘gap’ is used for ease of articulation, and to facilitate comparison with output gap as used in Taylor rule.

<sup>29</sup> Changes in *REER* with a negative sign indicates that depreciation (fall in *REER*) makes the central bank increase the short term rate inviting more capital, thereby leading to an *ex post* rise in monetary base

If we look at the full sample, for the first three quarters of 1998, where sticking to the rule would require a loosening of the economy, as noted earlier, in practice RBI increased the CRR to curb the fear of contagion in response to speculations in the foreign exchange market.

Save this period, the McCallum rule provides a reasonably good representation of the movement of monetary base. The results only seem to be validated by the recent declarations of the RBI. The central bank has declared (see Annual Reports for the years 2001-02 and 2002-03) that it is using monetary base as its operating target.

Theoretically, using monetary base as the operating target can give rise to highly volatile short term interest rates. Add to that, in presence of an unstable money multiplier it seemingly becomes a highly ineffective strategy of monetary policy if the intermediate target is some monetary aggregate (which, though, RBI has denied in its Annual Reports since 1997-98), not to mention the complications in the light of high short term capital inflows. Sticking to monetary base as the operating target is a sign that RBI believes in the strength of the credit channel of monetary transmission. As RBI in its 2002-03 Annual Report states:

*“In recent years, reserve money has become the operating target of monetary policy in the endeavor to stabilize the demand for bank reserves and, thereby, to create conditions conducive for adequate credit growth in support of industrial activity.”<sup>30</sup>*

Going only by the graphic representation, all in all, monetary base does a much better job of mimicking the action of the central bank than the Taylor rule. Since the nominal output ‘gap’ is insignificant in the forward looking rules, RBI does seem to be backward looking (which is not necessarily a bad thing, in the light of what Levin, Wieland and Williams (1997) and Estrella and Fuhrer (2002, 2003) find; that backward looking rules stabilize output and inflation better than their ‘forecast-based’ counterparts).

While the Taylor rule requires the estimate of unobserved real time (and forecasts, depending on the specification of the rule) of output gap, whose conceptualization as well as measurement is far from settled in the literature (McCallum and Nelson, 1999b), the McCallum rule poses no such problem. Also, Orphanides et al (2000) and McCallum (2001) show that a McCallum rule analog

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<sup>30</sup> RBI Annual Report 2002-03 p. 36

using short term interest rate as the operating target stabilize output and inflation reasonably well (with performance better than Taylor rule) under uncertainty. This is encouraging in the Indian context.

## VII. Conclusion

From the results it seems that RBI has been conducting its monetary policy as if it were targeting nominal income. The McCallum rule based on nominal income targeting does explain the behaviour of reserve money fairly closely.

One final exercise I do is to assess the out-of-sample ‘performance’<sup>31</sup> of the rule (backward looking, in truncated sample and using WPI as the measure for inflation) to see how well the parameter estimates from the backward looking rule (in both truncated and full ‘sample’) hold.

### ➤ *Out – of – Sample Results: Are changes in Net Foreign Exchange Assets Important?*

Since growth rate of monetary base explains the stance of monetary policy fairly well over the ‘90s, it would be interesting to see if inclusion of changes in net foreign exchange assets (NFA) of the RBI adds to the explanatory power of the rule. To see this, I estimate the backward looking McCallum rule on the truncated dataset with an additional variable as percentage changes in (contemporaneous) NFA of the RBI. Results are presented in **Exhibit 9**<sup>32</sup>. While inclusion is statistically significant, quantitatively the effect is only marginal. An indication that while short term capital inflows have a marginally positive effect on the growth rate of monetary base, RBI has been quite successful in sterilizing the effect of inflows.

Out-of-sample results from both the truncated and full sample<sup>33</sup> backward looking McCallum rule (including NFA as an additional variable) for the eight quarters after the sample in the study ends are presented in **Exhibit 10**. Results reveal high volatility of monetary base resulting from the increased OMOs of the RBI in the year 2002-03, mostly arising out of increased short term capital flows during the period. As RBI reports,

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<sup>31</sup> It may not be altogether to call ‘performance’ of the rule; rather it should be what the rule calls for against how RBI actually acted

<sup>32</sup> Even when included in full sample, results were similar, i.e. while inclusion was statistically significant, quantitatively it was no different than when included in the truncated sample.

<sup>33</sup> Only for the sake of comparison; differences are only marginal

*“Excess supply conditions in the foreign exchange market were reflected in continuous purchases of foreign exchange by the Reserve Bank and accretions to the Reserve Bank’s foreign currency assets. The primary liquidity generated by this substantial accretion to the net foreign assets (NFA) was sterilized through active recourse to open market sales and repos under the liquidity adjustment facility (LAF).<sup>34</sup>”*

Since parameter estimates are based on data which includes period before the introduction of WMA and the launch of LAF, as more data becomes available, going by the results in the study, McCallum rule should become a choice of monetary policy reaction function, given that RBI has declared monetary base as its official operating target.

To conclude, performance of McCallum rule augurs well for the conduct of monetary policy in the Indian context. This study was exploratory in nature, attempting to operationalise the rules, rather than a statement in favour of a particular rule. It would be worth looking at the performance of McCallum rule in detail. If indeed velocity of monetary base has a stable relation with short term interest rate (as should be the case in the light of RBI’s new found favour for reserve money, else meeting the reserve money target would entail potentially infinite variance of the short term rate) then a complete model based evaluation of the rule specified with the short term rate as the numeraire along with an IS and a supply curve would be very insightful as to how well it can stabilize inflation and output.

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<sup>34</sup> RBI Annual Report 2002-03, *ibid*, p. 36

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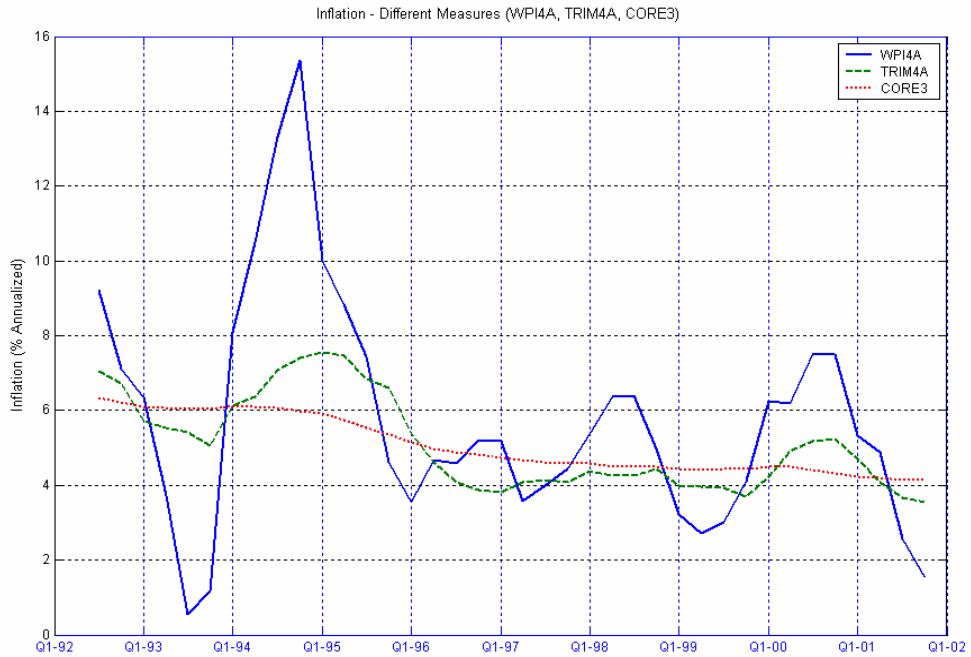
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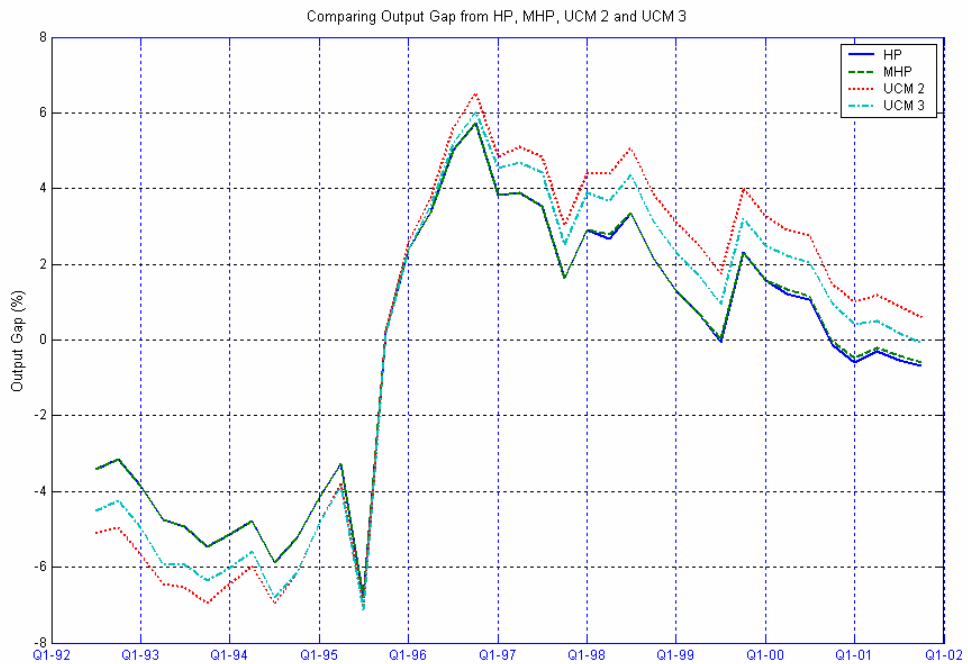
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**Exhibit 1**  
[Inflation – Different Measures]



**Exhibit 2**  
[Output Gap – Different Measures]



**Exhibit 3**  
[Backward Looking Taylor Rule]

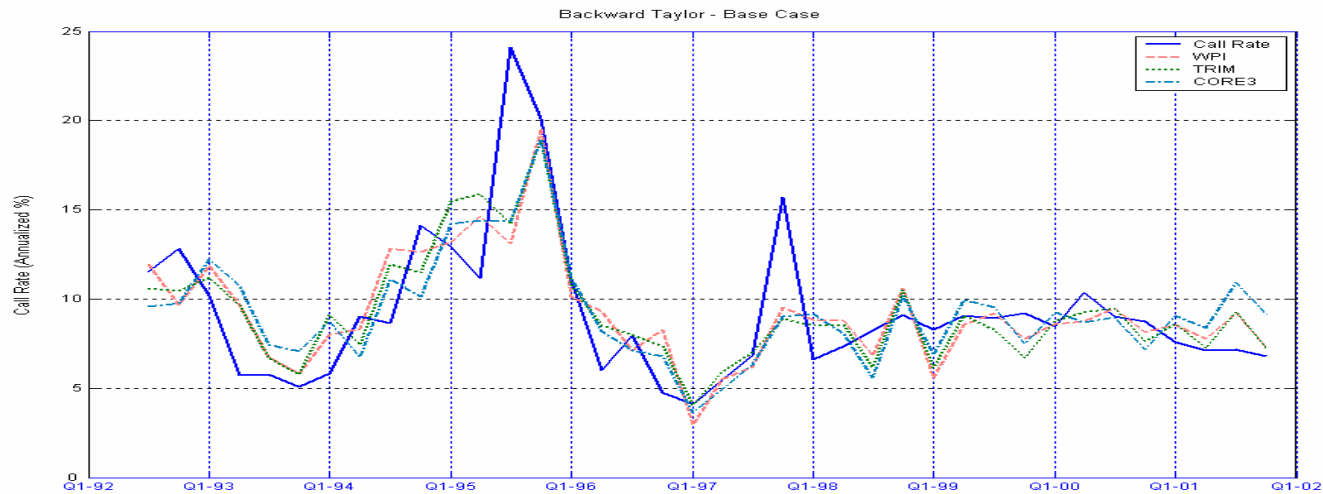
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_t + \gamma(1 - \rho)z_t + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

*Base Case*

Case	$\alpha$	$\beta$	$\gamma$	$\rho$	$\delta_1$	$\delta_2$	$\bar{R}^2$	$r^*$	$\pi^*$
<i>WPI</i>	0.077 <b>(3.12)</b>	-0.57 <b>(2.53)</b>	-0.41 <b>(-1.91)</b>	0.37 <b>(4.09)</b>	-0.22 <b>(-2.22)</b>	-0.54 <b>(-3.09)</b>	0.47	0.0412	<b>0.0637</b>
<i>TRIM</i>	0.008 <b>(0.18)</b>	0.82 <b>(2.16)</b>	-0.04 <b>(-0.2)</b>	0.24 <b>(2.95)</b>	-0.19 <b>(-2.47)</b>	-0.40 <b>(-3.14)</b>	0.48	0.0467	<b>0.0477</b>
<i>CORE3</i>	0.12 <b>(1.16)</b>	-1.39 <b>(-0.19)</b>	-0.66 <b>(-1.48)</b>	0.39 <b>(3.87)</b>	-0.22 <b>(-2.43)</b>	-0.52 <b>(-2.92)</b>	0.43	0.0457	<b>0.0538</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Base Case w. Dummy

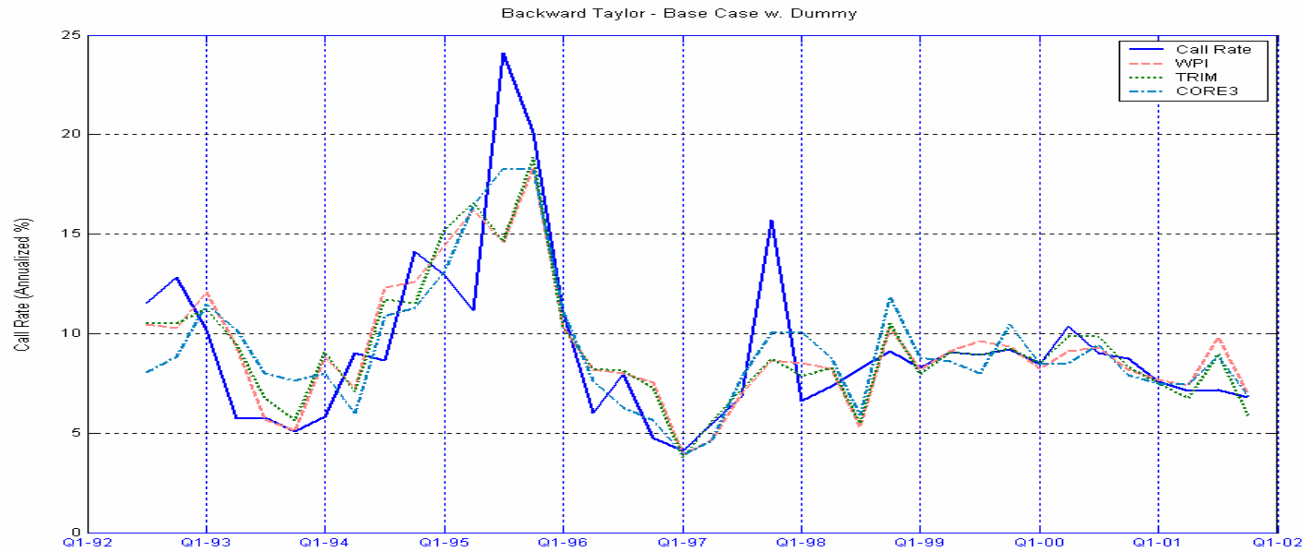
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_t + (1 + \beta)(1 - \rho)\pi_t D_1 + \gamma(1 - \rho)z_t + \gamma(1 - \rho)z_t D_2 + \dots$$

$$\dots + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} D_3 + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\beta_P$	$\gamma$	$\gamma_P$	$\rho$	$\delta_1$	$\delta_2$	$\delta_{2P}$	$\bar{R}^2$	$r^*$	$r^*_P$	$\pi^*$	$\pi^*_P$
WPI	0.077 <b>(3.12)</b>	-0.57 <b>(2.53)</b>	-1.97 <b>(-3.27)</b>	-0.44 <b>(-2.33)</b>	0.57 <b>(5.75)</b>	0.35 <b>(4.15)</b>	-0.21 <b>(-2.22)</b>	-0.69 <b>(-3.61)</b>	-0.09 <b>(2.93)</b>	0.45	0.0399	0.0436	<b>0.0678</b>	<b>0.0174</b>
TRIM	0.02 <b>(0.36)</b>	0.63 <b>(1.8)</b>	-0.8 <b>(-1.82)</b>	-0.14 <b>(-0.49)</b>	0.97 <b>(4.54)</b>	0.22 <b>(2.87)</b>	-0.19 <b>(-2.66)</b>	-0.51 <b>(-3.1)</b>	-0.13 <b>(2.25)</b>	0.46	0.0484	0.0424	<b>0.0444</b>	<b>-0.0278</b>
CORE3	0.53 <b>(2.33)</b>	-10.34 <b>(-5.41)</b>	-14.55 <b>(-2.46)</b>	-1.87 <b>(-2.72)</b>	2.51 <b>(2.96)</b>	0.42 <b>(3.96)</b>	-0.15 <b>(-1.76)</b>	-0.78 <b>(-3.00)</b>	-0.07 <b>(2.58)</b>	0.52	0.0481	0.0409	<b>0.0465</b>	<b>0.0336</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



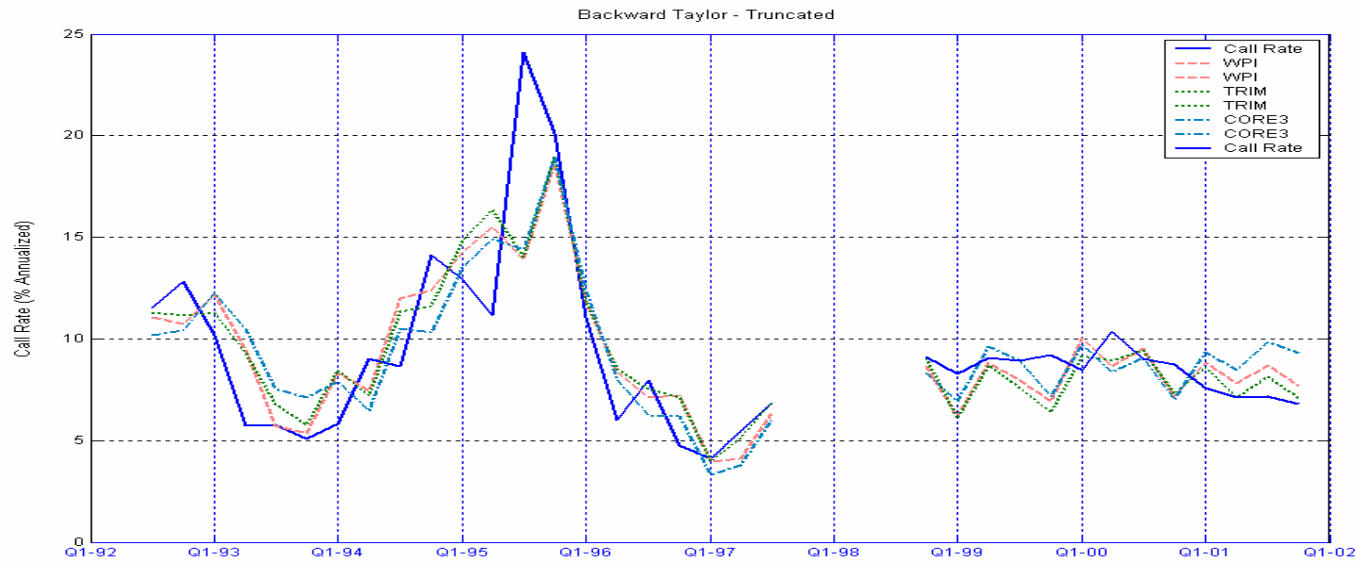
*Truncated*

$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_t + \gamma(1 - \rho)z_t + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\gamma$	$\rho$	$\delta_1$	$\delta_2$	$\bar{R}^2$	$r^*$	$\pi^*$
WPI	0.068 <b>(2.82)</b>	-0.47 <b>(2.89)</b>	-0.49 <b>(-1.71)</b>	0.46 <b>(8.37)</b>	-0.17 <b>(-1.69)</b>	-0.65 <b>(-2.54)</b>	0.55	<b>0.0377</b>	<b>0.0643</b>
TRIM	-0.004 <b>(0.08)</b>	0.98 <b>(2.16)</b>	-0.11 <b>(-0.32)</b>	0.33 <b>(6.07)</b>	-0.14 <b>(-2.00)</b>	-0.48 <b>(-2.58)</b>	0.56	<b>0.0421</b>	<b>0.0471</b>
CORE3	0.15 <b>(1.16)</b>	-2.14 <b>(-0.52)</b>	-0.94 <b>(-1.75)</b>	0.50 <b>(7.15)</b>	-0.17 <b>(-1.87)</b>	-0.66 <b>(-2.49)</b>	0.52	<b>0.0412</b>	<b>0.0522</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Truncated w. Dummy

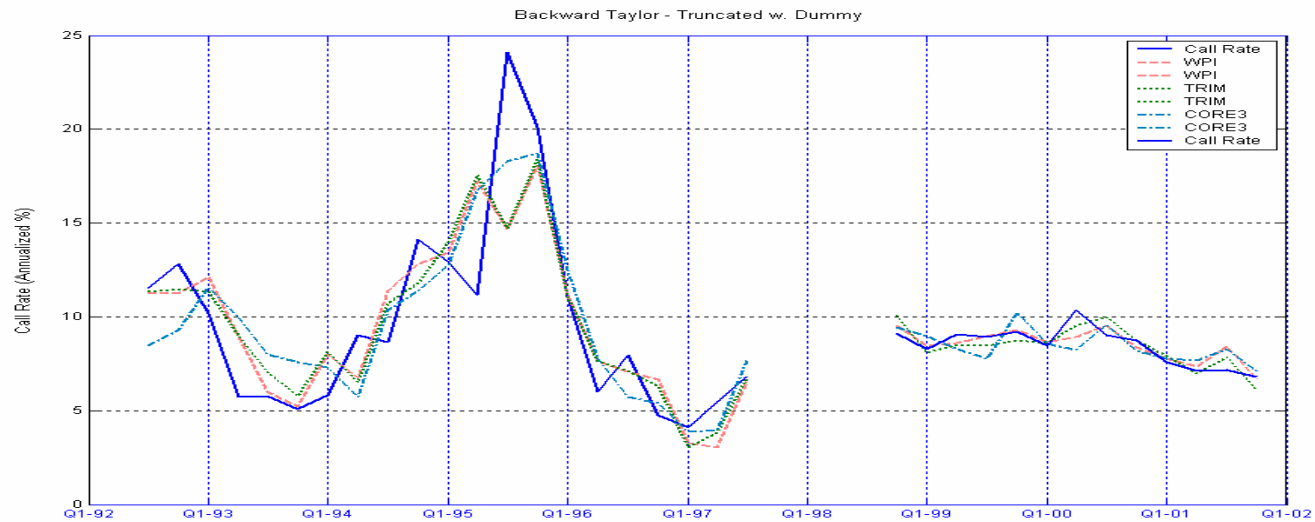
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_t + (1 + \beta)(1 - \rho)\pi_t D_1 + \gamma(1 - \rho)z_t + \gamma(1 - \rho)z_t D_2 + \dots$$

$$\dots + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} D_3 + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\beta_P$	$\gamma$	$\gamma_P$	$\rho$	$\delta_1$	$\delta_2$	$\delta_{2P}$	$\bar{R}^2$	$r^*$	$r^*_P$	$\pi^*$	$\pi^*_P$
WPI	0.066 <b>(3.48)</b>	-0.5 <b>(2.99)</b>	-1.88 <b>(-3.42)</b>	-0.66 <b>(-2.86)</b>	0.71 <b>(5.62)</b>	0.44 <b>(10.06)</b>	-0.14 <b>(-1.53)</b>	-0.96 <b>(-3.09)</b>	-0.05 <b>(2.93)</b>	0.56	<b>0.0342</b>	<b>0.0436</b>	<b>0.0635</b>	<b>0.0119</b>
TRIM	0.02 <b>(0.03)</b>	0.77 <b>(1.78)</b>	-0.44 <b>(-0.84)</b>	-0.31 <b>(-0.95)</b>	0.79 <b>(3.94)</b>	0.33 <b>(5.55)</b>	-0.12 <b>(-1.86)</b>	-0.72 <b>(-2.79)</b>	-0.09 <b>(2.52)</b>	0.56	<b>0.0418</b>	<b>0.0424</b>	<b>0.0516</b>	<b>-0.093</b>
CORE3	0.64 <b>(1.48)</b>	-13.34 <b>(-1.28)</b>	-18.3 <b>(-1.51)</b>	-2.38 <b>(-2.13)</b>	2.8 <b>(2.12)</b>	0.53 <b>(6.63)</b>	-0.1 <b>(-1.23)</b>	-0.94 <b>(-1.83)</b>	-0.03 <b>(1.71)</b>	0.60	<b>0.0413</b>	<b>0.0409</b>	<b>0.0447</b>	<b>0.032</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



**Exhibit 4**  
[Backward Looking McCallum Rule]

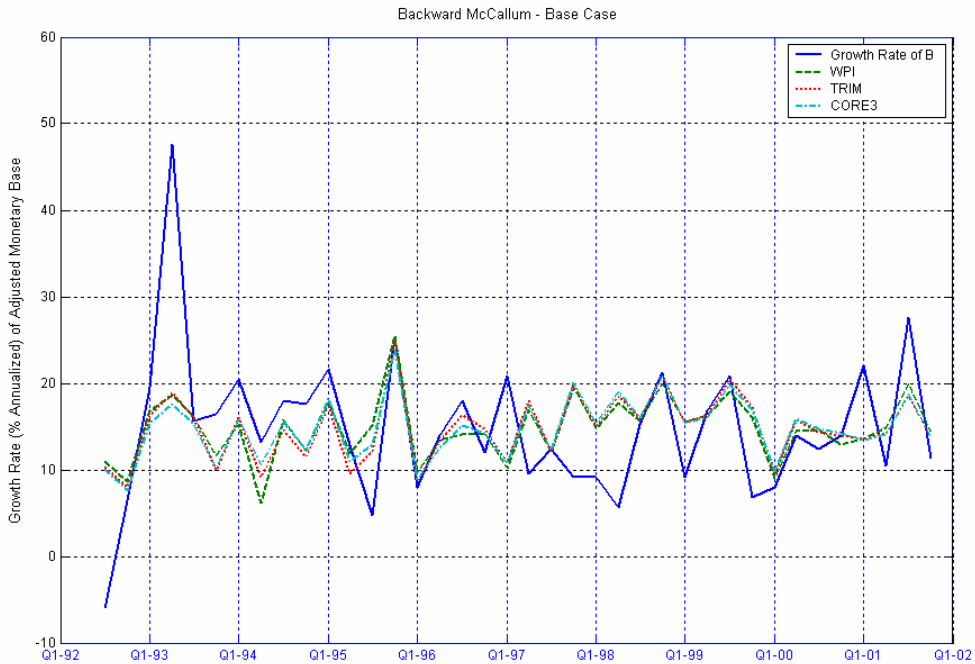
*Base Case*

$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1}) + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0607$$

Case	$\alpha$	$\beta$	$\lambda$	$\rho$	$\delta$	$\bar{R}^2$	$\pi^*$
<i>WPI</i>	0.186 <b>(7.34)</b>	-0.35 (0.67)	0.19 <b>(-2.11)</b>	0.07 (0.84)	-0.36 <b>(2.31)</b>	0.09	<b>0.0967</b>
<i>TRIM</i>	0.21 <b>(5.53)</b>	-0.83 (1.19)	0.19 <b>(-2.00)</b>	0.06 <b>(0.8)</b>	-0.35 <b>(-2.25)</b>	0.10	<b>0.1124</b>
<i>CORE3</i>	0.196 (5.32)	-0.62 (0.92)	0.16 <b>(-1.83)</b>	0.07 <b>(0.86)</b>	-0.36 <b>(-2.25)</b>	0.08	<b>0.1079</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]





Base Case w. Dummy

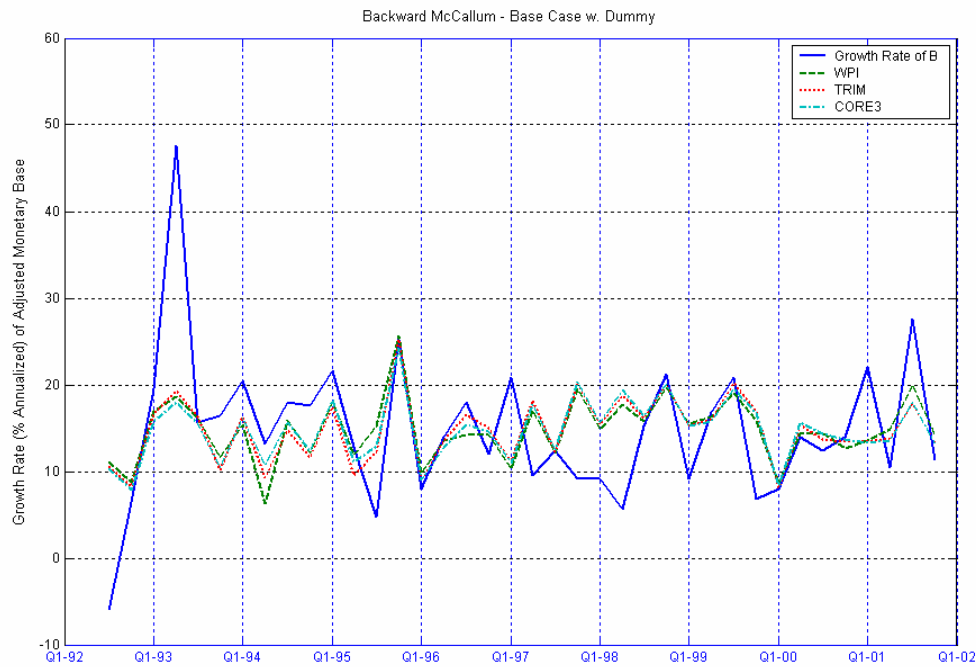
$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1}) - \dots$$

$$\dots - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1})D + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0694; \Delta y^*_p = 0.0439$$

Case	$\alpha$	$\beta$	$\lambda$	$\lambda_p$	$\rho$	$\delta$	$\bar{R}^2$	$\pi^*$	$\pi^*_p$
WPI	0.187 <b>(6.59)</b>	-0.35 (0.68)	0.19 <b>(-2.13)</b>	0.21 (-0.14)	0.07 (0.84)	-0.37 <b>(-2.3)</b>	0.06	<b>0.0886</b>	<b>0.1108</b>
TRIM	0.21 <b>(4.77)</b>	-0.86 (1.21)	0.20 <b>(-1.95)</b>	0.29 (-0.39)	0.06 (0.79)	-0.35 <b>(-2.22)</b>	0.08	<b>0.1065</b>	<b>0.1194</b>
CORE3	0.20 <b>(4.15)</b>	-0.66 (0.89)	0.17 <b>(-1.81)</b>	0.26 (-0.35)	0.07 (0.84)	-0.36 <b>(-2.22)</b>	0.05	<b>0.1029</b>	<b>0.1156</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



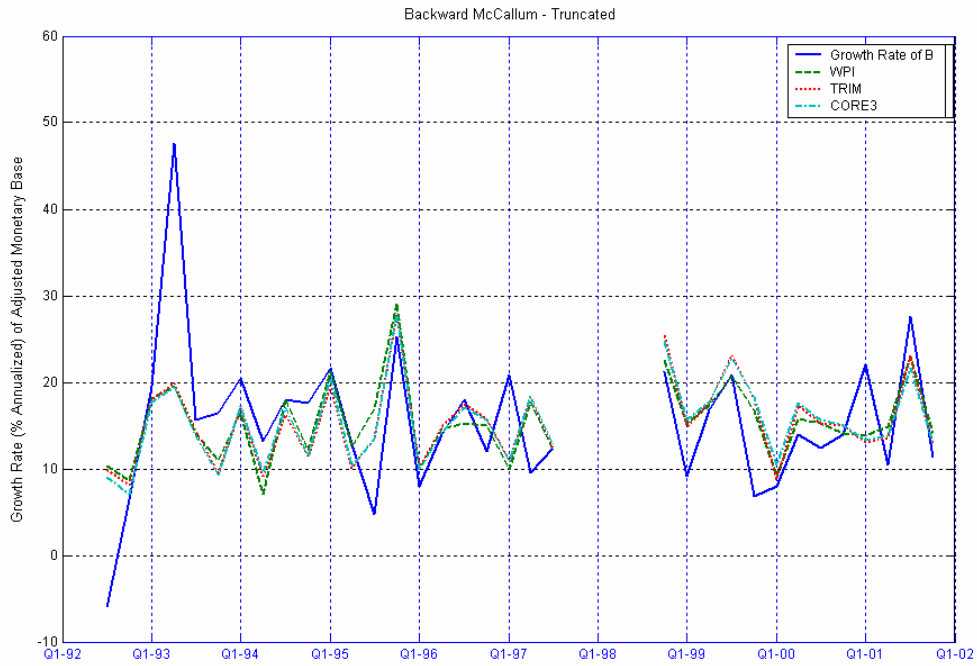
*Truncated*

$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1}) + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0625$$

Case	$\alpha$	$\beta$	$\lambda$	$\rho$	$\delta$	$\bar{R}^2$	$\pi^*$
WPI	0.194 <b>(9.31)</b>	-0.32 (0.69)	0.15 <b>(-1.89)</b>	0.04 (0.41)	-0.47 <b>(-3.34)</b>	0.18	<b>0.1064</b>
TRIM	0.21 <b>(7.37)</b>	-0.87 (1.31)	0.13 <b>(-1.28)</b>	0.03 (0.32)	-0.44 <b>(-2.72)</b>	0.21	<b>0.1249</b>
CORE3	0.21 <b>(6.45)</b>	-0.91 (1.45)	0.11 <b>(-1.21)</b>	0.02 (0.22)	-0.47 <b>(-3.6)</b>	0.2	<b>0.1313</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Truncated w. Dummy

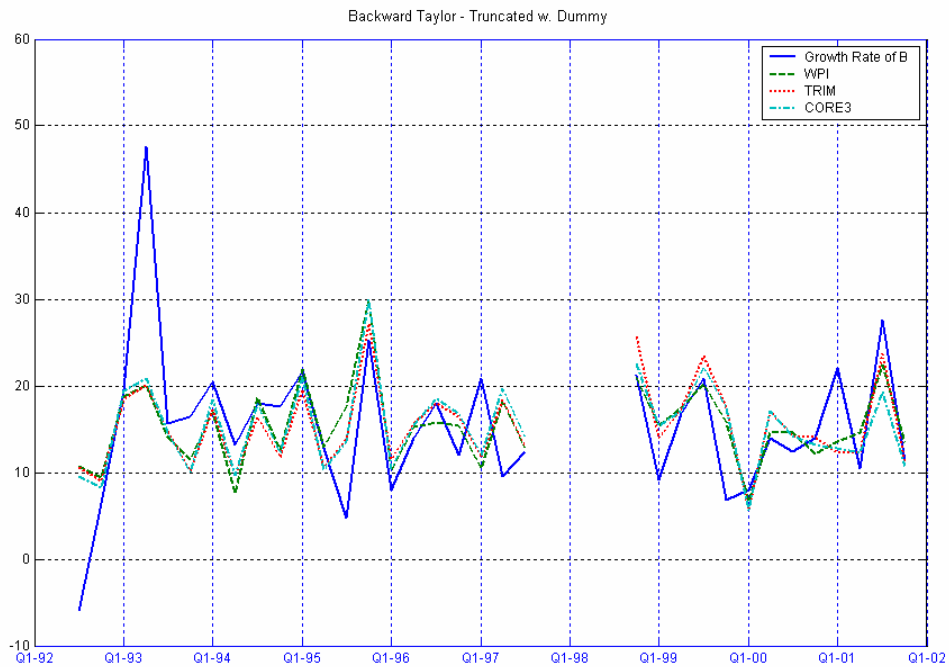
$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1}) - \dots$$

$$\dots - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1})D + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0735; \Delta y^*_p = 0.0439$$

Case	$\alpha$	$\beta$	$\lambda$	$\lambda_p$	$\rho$	$\delta$	$\bar{R}^2$	$\pi^*$	$\pi^*_p$
WPI	0.19 <b>(8.38)</b>	-0.29 (0.69)	0.15 <b>(-1.85)</b>	0.31 (-1.06)	0.02 (0.25)	-0.47 <b>(-3.19)</b>	0.16	<b>0.0997</b>	<b>0.1082</b>
TRIM	0.21 <b>(8.2)</b>	-0.88 (1.39)	0.11 (-1.12)	0.26 (-1.34)	0.01 (0.18)	-0.41 <b>(-2.28)</b>	0.19	<b>0.1189</b>	<b>0.1246</b>
CORE3	0.23 <b>(6.56)</b>	-1.1 <b>(1.74)</b>	0.12 <b>(-1.81)</b>	0.43 (-1.45)	-0.01 (-0.16)	-0.48 <b>(-3.37)</b>	0.21	<b>0.1348</b>	<b>0.119</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



### Exhibit 5

[Forward Looking Taylor Rule;  $n = 1$ ]

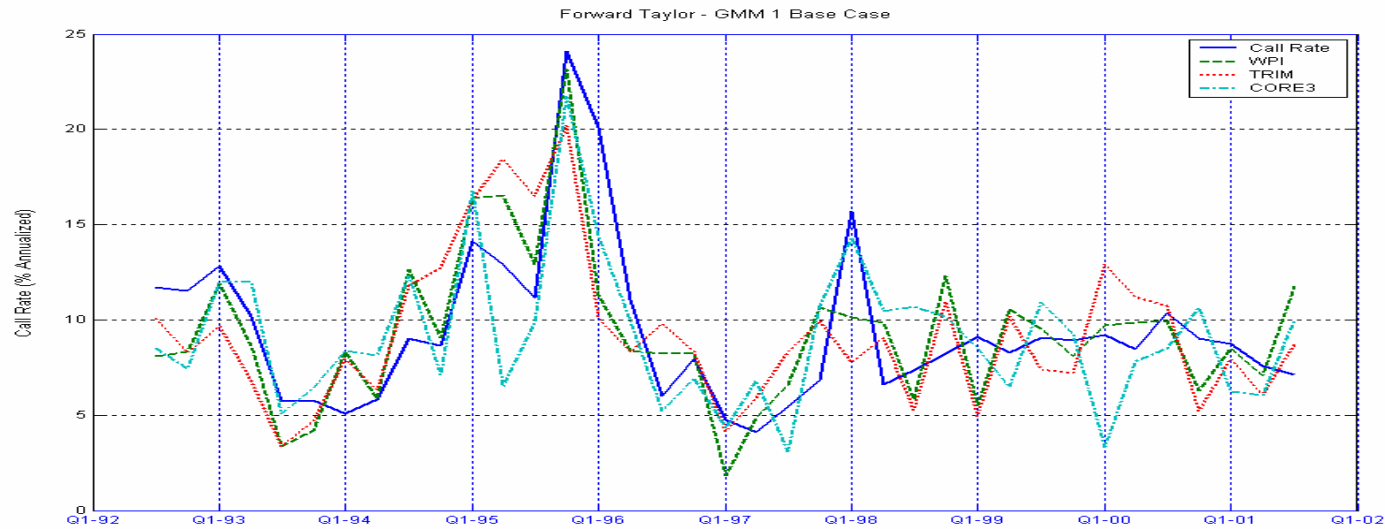
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+n} + \gamma(1 - \rho)z_{t+n} + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \rho i_{t-1} + \varepsilon_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Base Case ( $n = 1$ )

Case	$\alpha$	$\beta$	$\gamma$	$\rho$	$\delta_1$	$\delta_2$	$P[\psi^2 > 4]$	$r^*$	$\pi^*$
WPI	0.087 <b>(2.62)</b>	-0.51 (1.3)	-0.39 <b>(-1.39)</b>	0.49 <b>(4.04)</b>	-0.53 (-1.57)	-0.96 (-1.35)	0.73	0.0412	<b>0.0895</b>
TRIM	-0.05 (-0.82)	2.14 <b>(2.31)</b>	0.28 (0.82)	0.25 (1.52)	-0.23 (-1.35)	-0.88 (-1.37)	0.69	0.0467	<b>0.0495</b>
CORE3	0.05 (0.31)	-0.33 (0.17)	0.1 (0.21)	0.63 <b>(3.28)</b>	-0.51 <b>(-1.04)</b>	1.16 <b>(0.62)</b>	0.43	0.0457	<b>0.0142</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Base Case w. Dummy ( $n = 1$ )

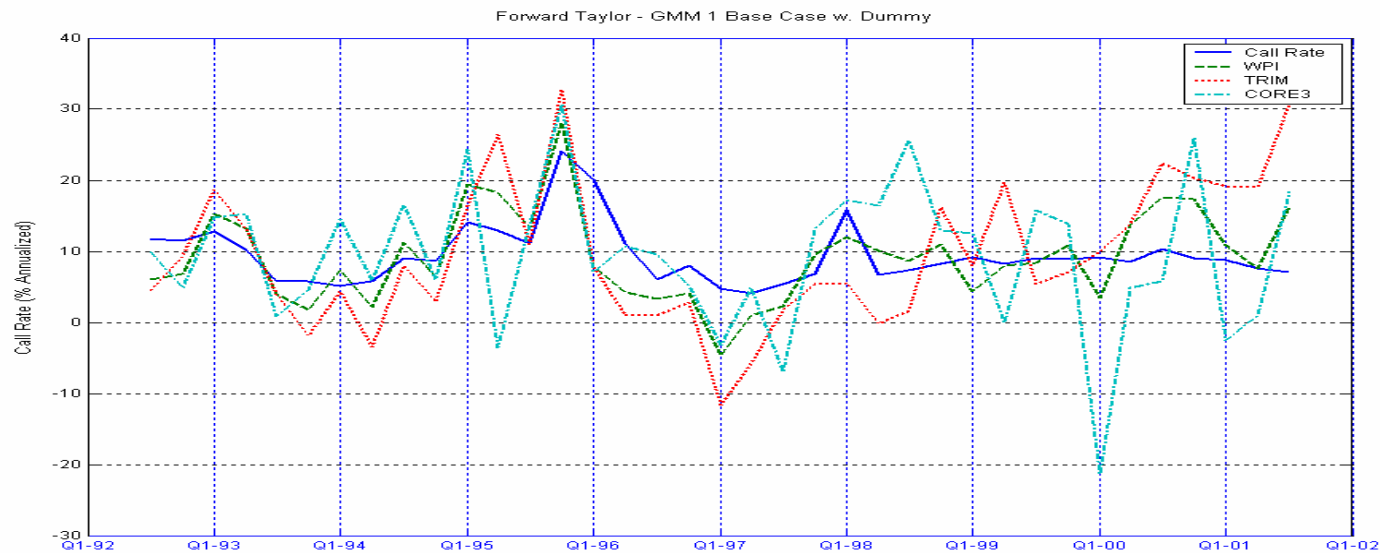
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+1} + (1 + \beta)(1 - \rho)\pi_{t+1}D_1 + \gamma(1 - \rho)z_{t+1} + \gamma(1 - \rho)z_{t+1}D_2 + \dots$$

$$\dots + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1}D_3 + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\beta_P$	$\gamma$	$\gamma_P$	$\rho$	$\delta_1$	$\delta_2$	$\delta_{2P}$	$P[\psi^2 > 1]$	$r^*$	$\pi^*$	$r^*_P$	$\pi^*_P$
WPI	0.05 (0.89)	-1.51 (-0.36)	2.78 (0.72)	-1.9 (-1.4)	-8.48 (-0.84)	0.62 (1.58)	-1.24 (-1.45)	-1.49 (-0.69)	2.42 (0.76)	0.61	0.0399	<b>0.0084</b>	0.0436	<b>-0.0031</b>
TRIM	0.14 (0.47)	75.3 (-0.37)	-64.5 (0.58)	45.89 (-0.69)	190.8 (-0.61)	1.03 (0.83)	15.65 (-0.83)	37.19 (-0.51)	15.95 (0.39)	0.95	0.0484	<b>-0.001</b>	0.0424	<b>0.0015</b>
CORE3	-1.02 (-0.63)	24.62 (0.64)	30.27 (0.77)	2.64 (0.74)	-4.86 (-0.87)	0.28 (0.3)	-0.96 (-0.74)	0.34 (0.1)	4.23 (0.7)	0.60	0.0481	<b>0.0436</b>	0.0409	<b>0.0335</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



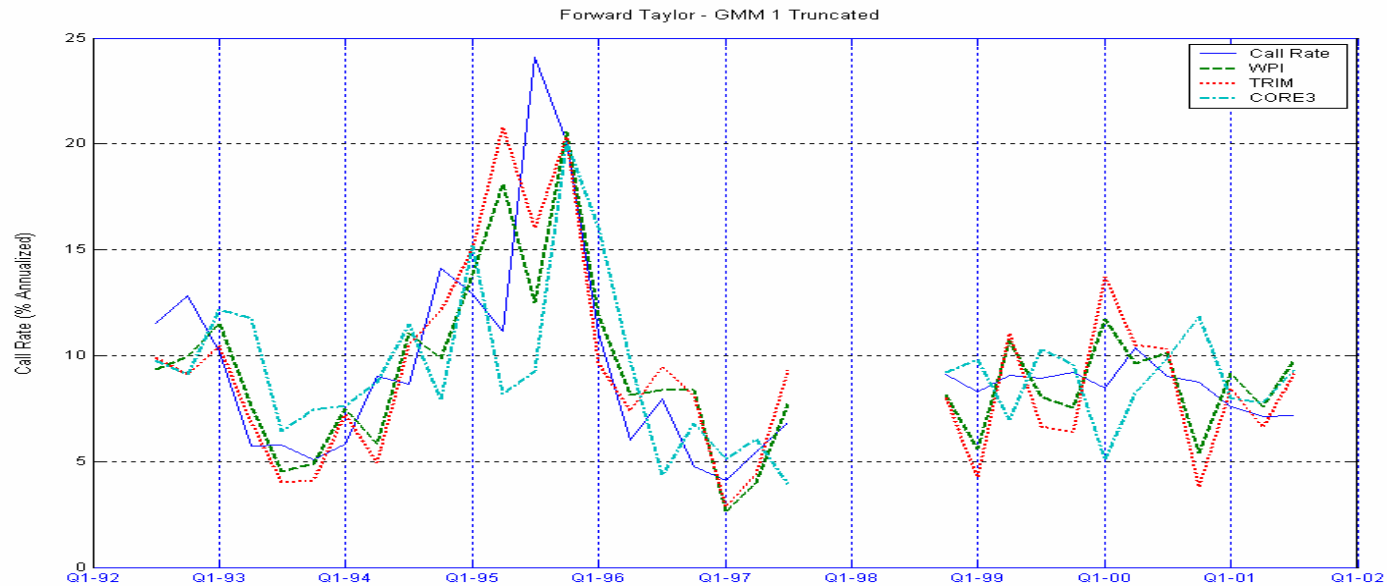
Truncated ( $n = 1$ )

$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+n} + \gamma(1 - \rho)z_{t+n} + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \rho i_{t-1} + \varepsilon_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\gamma$	$\rho$	$\delta_1$	$\delta_2$	$P[\psi^2 > 4]$	$r^*$	$\pi^*$
WPI	0.079 <b>(2.88)</b>	-0.51 <b>(1.79)</b>	-0.45 <b>(-1.68)</b>	0.49 <b>(5.41)</b>	-0.30 <b>(-1.42)</b>	-1.23 <b>(-2.62)</b>	0.59	0.0377	<b>0.0821</b>
TRIM	-0.02 <b>(-0.4)</b>	1.55 <b>(2.39)</b>	-0.009 <b>(-0.03)</b>	0.29 <b>(2.73)</b>	-0.24 <b>(-1.67)</b>	-1.23 <b>(-2.15)</b>	0.65	0.0421	<b>0.0417</b>
CORE3	0.28 <b>(1.3)</b>	-5.03 <b>(-0.8)</b>	-0.55 <b>(-0.68)</b>	0.73 <b>(2.72)</b>	-0.27 <b>(-0.68)</b>	1.55 <b>(0.59)</b>	0.79	0.0412	<b>0.0483</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Truncated w. Dummy ( $n = 1$ )

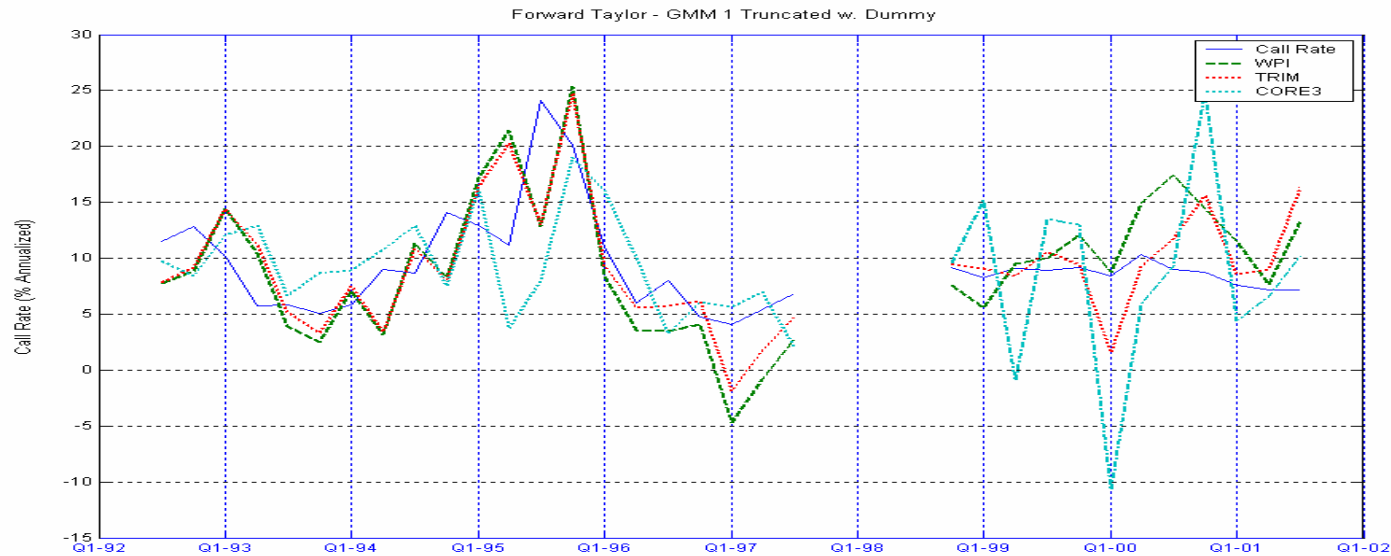
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+1} + (1 + \beta)(1 - \rho)\pi_{t+1}D_1 + \gamma(1 - \rho)z_{t+1} + \gamma(1 - \rho)z_{t+1}D_2 + \dots$$

$$\dots + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1}D_3 + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\beta_P$	$\gamma$	$\gamma_P$	$\rho$	$\delta_1$	$\delta_2$	$\delta_{2P}$	$P[\psi^2 > 1]$	$r^*$	$\pi^*$	$r^*_P$	$\pi^*_P$
WPI	0.027 (0.55)	-0.85 (0.11)	2.9 (0.63)	-2.25 (-1.47)	-5.43 (-0.28)	0.66 <b>(1.7)</b>	-1.02 (-1.41)	-2.37 (-0.88)	0.02 (0.31)	0.67	0.0342	<b>-0.008</b>	0.0436	<b>0.006</b>
TRIM	0.07 (0.47)	-1.71 (-0.09)	-0.31 (0.41)	-1.51 (-0.63)	-3.94 (-0.28)	0.57 (1.21)	-0.76 (-1.04)	-1.69 (-0.55)	1.36 (0.59)	0.63	0.0418	<b>0.0153</b>	0.0424	<b>0.0839</b>
CORE3	0.05 (0.03)	-2.59 (-0.02)	-1.86 (0.1)	-0.09 (-0.01)	-3.16 (-0.19)	0.69 (0.4)	-0.27 (-0.11)	2.66 (0.15)	8.38 (0.47)	0.68	0.0413	<b>0.0023</b>	0.0409	<b>0.0034</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



### Exhibit 6

[Forward Looking Taylor Rule;  $n = 4$ ]

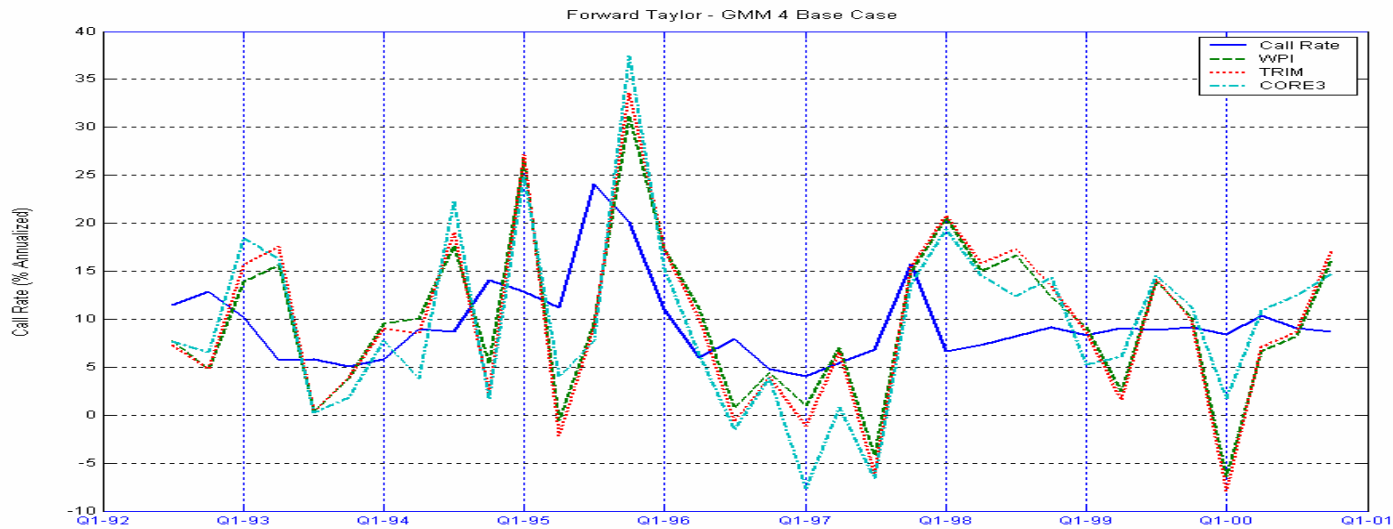
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+n} + \gamma(1 - \rho)z_{t+n} + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \rho i_{t-1} + \varepsilon_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Base Case ( $n = 4$ )

Case	$\alpha$	$\beta$	$\gamma$	$\rho$	$\delta_1$	$\delta_2$	$P[\psi^2 > 4]$	$r^*$	$\pi^*$
WPI	-0.32 (0.07)	11.46 (-0.62)	-3.56 (0.12)	1.02 (1.45)	23.72 (-1.11)	-74.95 (1.08)	0.97	0.0412	<b>0.0318</b>
TRIM	0.48 (0.47)	11.14 (-0.58)	2.56 (-0.42)	1.09 <b>(1.84)</b>	5.24 (-1.6)	-14.2 (0.89)	0.99	0.0467	<b>0.0471</b>
CORE3	-0.43 (0.76)	9.13 (-0.62)	2.76 (-0.78)	1.47 (-1.16)	1.32 (-1.16)	-0.91 (0.32)	0.85	0.0457	<b>0.0523</b>

[*t*-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]





Base Case w. Dummy (n = 4)

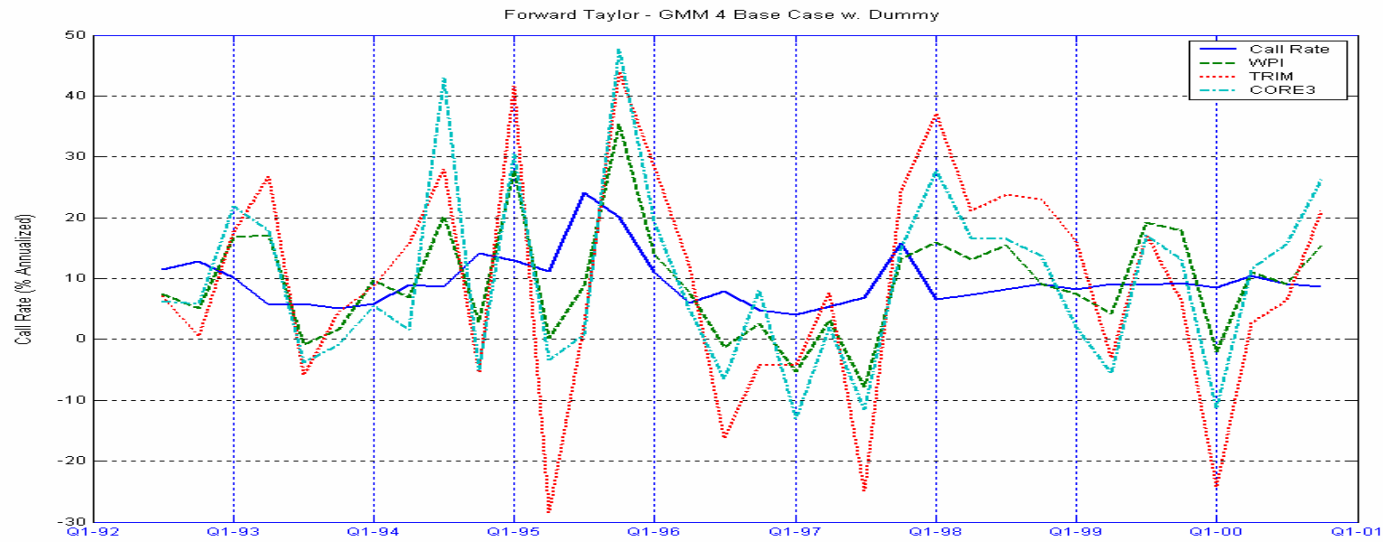
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+1} + (1 + \beta)(1 - \rho)\pi_{t+1}D_1 + \gamma(1 - \rho)z_{t+1} + \gamma(1 - \rho)z_{t+1}D_2 + \dots$$

$$\dots + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1}D_3 + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\beta_P$	$\gamma$	$\gamma_P$	$\rho$	$\delta_1$	$\delta_2$	$\delta_{2P}$	$P[\psi^2 > 1]$	$r^*$	$\pi^*$	$r^*_P$	$\pi^*_P$
WPI	-0.01 (-0.05)	0.2 (-0.3)	-11.24 (0.6)	2.47 (-0.39)	18.92 (-0.49)	1.17 (0.82)	3.79 (-1.34)	-5.86 (0.26)	-7.2 (0.1)	0.93	0.0399	<b>0.2658</b>	0.0436	<b>-0.0051</b>
TRIM	0.06 (0.11)	2.48 (-0.23)	2.65 (-0.1)	0.23 (-0.16)	-3.47 (0.17)	2.06 (0.46)	0.62 (-0.7)	-4.24 (0.26)	-2.51 (-0.16)	0.88	0.0484	<b>-0.006</b>	0.0424	<b>-0.008</b>
CORE3	2.33 (0.19)	19.45 (-0.19)	22.28 (-0.17)	3.32 (-0.24)	0.45 (0.12)	2.4 (0.28)	0.68 (-0.81)	-0.57 (0.09)	-0.76 (0.18)	0.83	0.0481	<b>-0.118</b>	0.0409	<b>-0.103</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



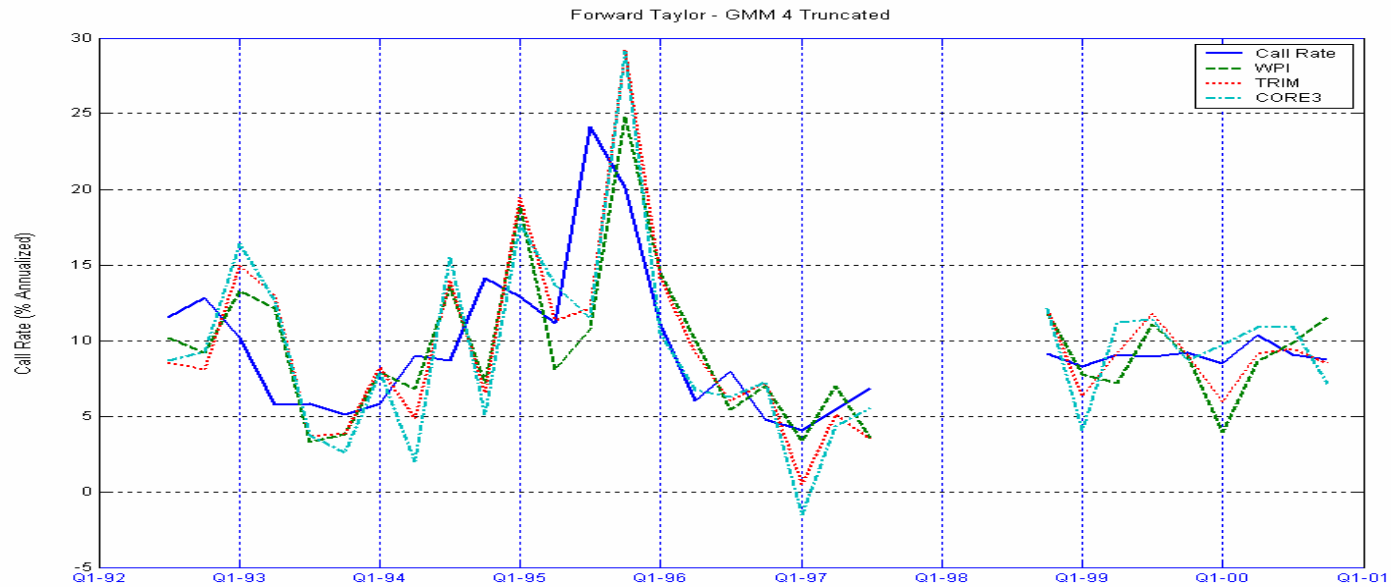
Truncated ( $n = 4$ )

$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+n} + \gamma(1 - \rho)z_{t+n} + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \rho i_{t-1} + \varepsilon_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\gamma$	$\rho$	$\delta_1$	$\delta_2$	$P[\psi^2 > 4]$	$r^*$	$\pi^*$
WPI	0.159 (1.13)	-1.84 (-1.35)	-0.56 (-0.43)	0.72 <b>(1.78)</b>	-0.97 (-1.11)	1.08 (0.33)	0.88	0.0377	<b>0.0661</b>
TRIM	0.14 (0.7)	-0.35 (0.14)	-1.39 (-0.78)	0.82 <b>(3.17)</b>	-2.08 <b>(-2.28)</b>	-0.5 (-0.11)	0.91	0.0421	<b>0.272</b>
CORE3	0.45 (0.5)	-6.35 (-0.22)	-3.78 (-0.91)	0.78 (1.1)	-2.15 <b>(-3.05)</b>	-2.81 (-0.52)	0.95	0.0412	<b>0.0646</b>

[*t*-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Truncated w. Dummy ( $n = 4$ )

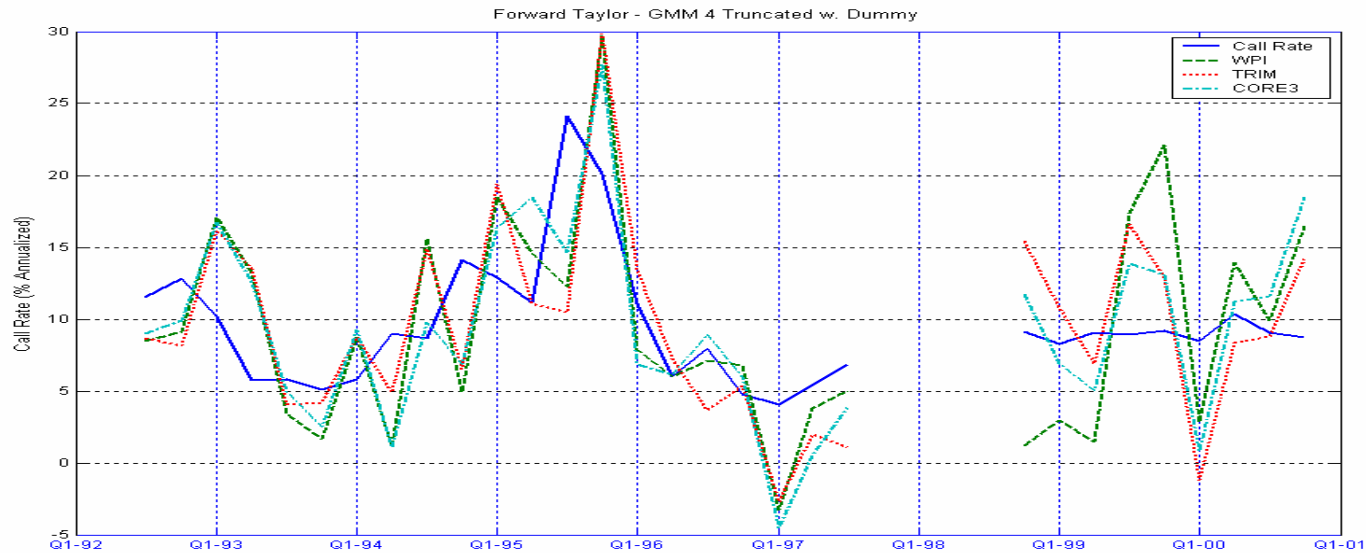
$$i_t = \alpha(1 - \rho) + (1 + \beta)(1 - \rho)\pi_{t+1} + (1 + \beta)(1 - \rho)\pi_{t+1}D_1 + \gamma(1 - \rho)z_{t+1} + \gamma(1 - \rho)z_{t+1}D_2 + \dots$$

$$\dots + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1} + \delta_2(1 - \rho)\Delta m_{t-1}D_3 + \rho i_{t-1} + v_t$$

$$\alpha \equiv r^* - \beta\pi^*$$

Case	$\alpha$	$\beta$	$\beta_P$	$\gamma$	$\gamma_P$	$\rho$	$\delta_1$	$\delta_2$	$\delta_{2P}$	$P[\psi^2 > 1]$	$r^*$	$\pi^*$	$r^*_P$	$\pi^*_P$
WPI	0.089 (0.85)	-1.09 (-0.06)	5.45 (0.56)	-2.13 (-0.95)	-20.68 (-0.56)	0.64 (0.97)	-1.58 <b>(-1.79)</b>	-2.2 (-0.37)	3.19 (0.69)	0.44	0.0342	<b>0.05</b>	0.0436	<b>-0.008</b>
TRIM	-0.06 (-0.41)	203.47 (0.52)	260.55 (0.04)	-80.04 (-0.62)	71.14 (0.05)	0.996 (1.6)	-88.01 <b>(-2.13)</b>	-41.14 (-0.09)	223.47 (0.53)	0.8421	0.0418	<b>0.0005</b>	0.0424	<b>0.0004</b>
CORE3	-0.43 (0.04)	11.15 (0.31)	14.33 (0.49)	0.16 (0.03)	-6.56 (-0.59)	0.42 (0.25)	-0.81 (-2.89)	-1.9 (-0.5)	1.56 (0.79)	0.74	0.0413	<b>0.0425</b>	0.0409	<b>0.033</b>

[*t*-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



### Exhibit 7

[Forward Looking McCallum Rule;  $n = 1$ ]

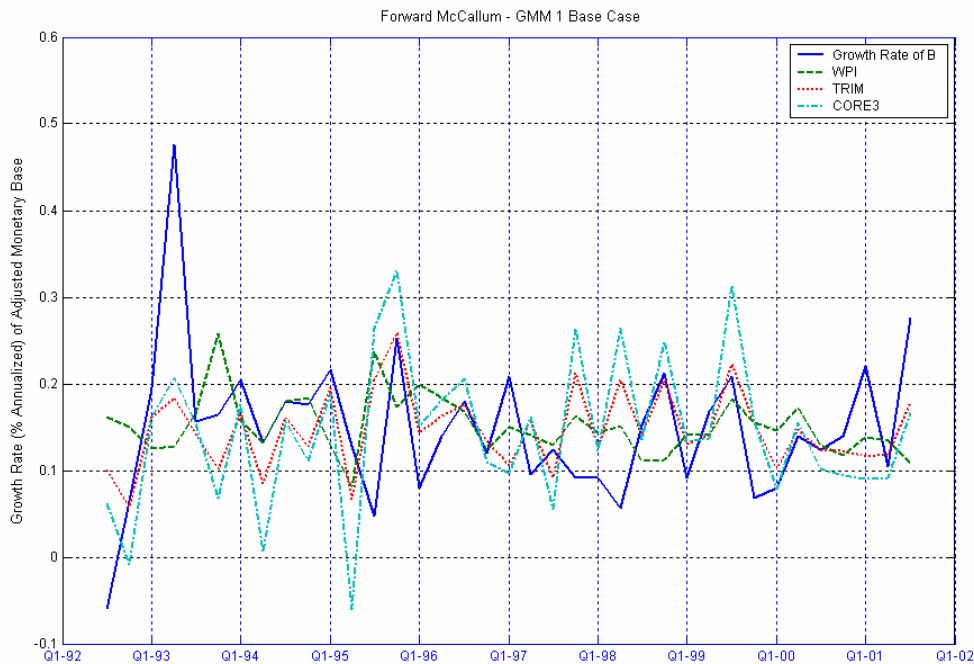
Base Case ( $n = 1$ )

$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) + \delta(1 - \rho)\Delta e_{t-1} + \varepsilon_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0607$$

Case	$\alpha$	$\beta$	$\lambda$	$\rho$	$\delta$	$P[\psi^2 > 4]$	$\pi^*$
WPI	0.11 <b>(2.56)</b>	-0.35 (0.72)	-0.39 (1.24)	-0.02 (-0.27)	0.09 (0.36)	0.87	<b>0.1249</b>
TRIM	0.16 <b>(2.76)</b>	-0.98 (0.95)	-0.28 (0.75)	0.05 (0.87)	-0.4 (-1.54)	0.69	<b>0.1612</b>
CORE3	0.16 <b>(2.56)</b>	-2.36 (1.08)	-0.75 (1.17)	0.04 (0.38)	-0.57 <b>(-2.16)</b>	0.55	<b>0.5579</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Base Case w. Dummy ( $n = 1$ )

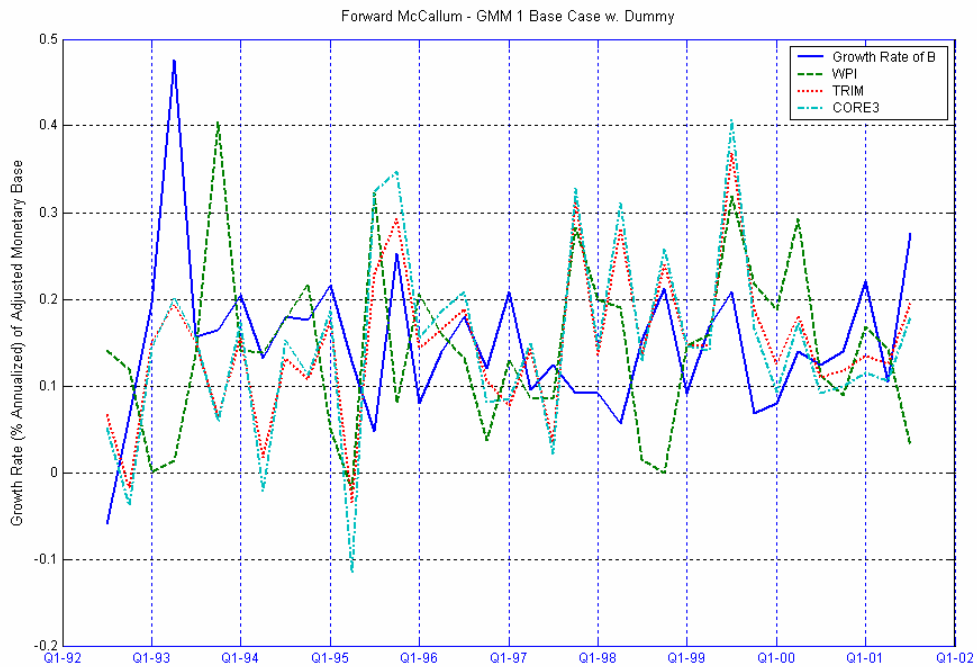
$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) - \dots$$

$$\dots - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n})D + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0694; \Delta y^*_p = 0.0439$$

Case	$\alpha$	$\beta$	$\lambda$	$\lambda_p$	$\rho$	$\delta$	$P[\psi^2 > 3]$	$\pi^*$	$\pi^*_p$
WPI	-0.005 (-0.04)	0.06 (-0.07)	-0.91 (0.96)	-0.07 (0.71)	-0.03 (-0.15)	0.43 (0.82)	0.89	<b>-0.127</b>	<b>-0.05</b>
TRIM	0.14 <b>(1.87)</b>	-2.16 (0.96)	-0.63 (1.03)	0.02 (1.07)	0.1 (0.79)	-0.56 <b>(-1.89)</b>	0.42	<b>0.3123</b>	<b>0.095</b>
CORE3	0.122 <b>(1.24)</b>	-2.7 (0.95)	-1.07 (1.22)	-0.67 (0.66)	0.06 (0.44)	-0.61 <b>(-2.02)</b>	0.05	<b>-1.845</b>	<b>0.32</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



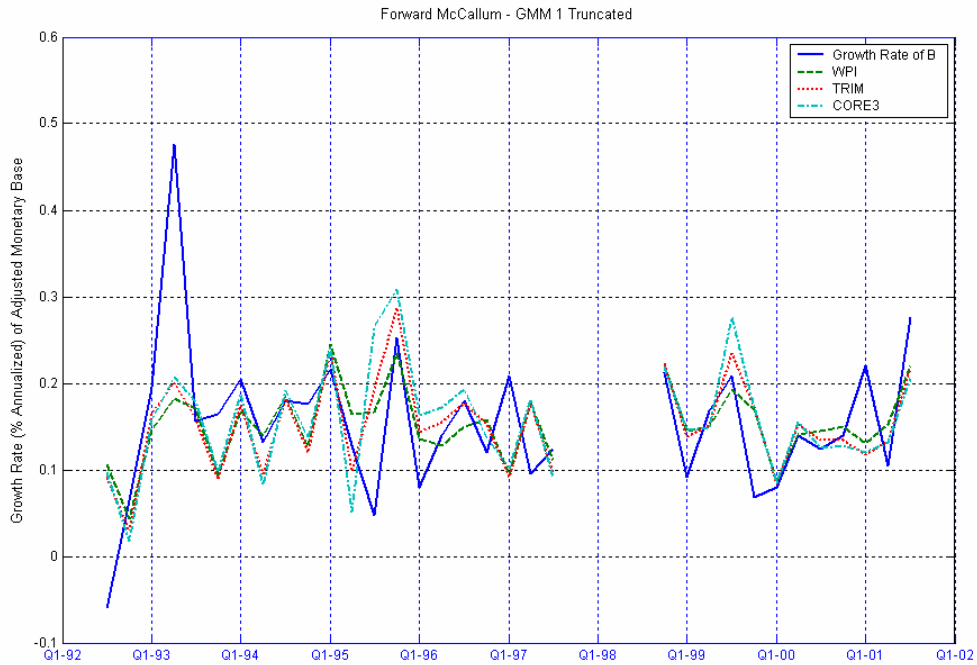
Truncated ( $n = 1$ )

$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) + \delta(1 - \rho)\Delta e_{t-1} + \varepsilon_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0625$$

Case	$\alpha$	$\beta$	$\lambda$	$\rho$	$\delta$	$P[\psi^2 > 4]$	$\pi^*$
WPI	0.175 <b>(2.22)</b>	0.07 (-0.16)	0.05 (-0.13)	0.23 (1.11)	-0.59 <b>(-2.45)</b>	0.59	<b>0.1042</b>
TRIM	0.18 <b>(2.19)</b>	-0.9 (1.02)	-0.18 (0.54)	0.15 (0.5)	-0.64 <b>(-2.39)</b>	0.51	<b>0.1618</b>
CORE3	0.16 <b>(1.72)</b>	-1.27 (0.99)	-0.55 (0.95)	0.17 (0.5)	-0.63 <b>(-2.27)</b>	0.46	<b>0.30</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Truncated w. Dummy ( $n = 1$ )

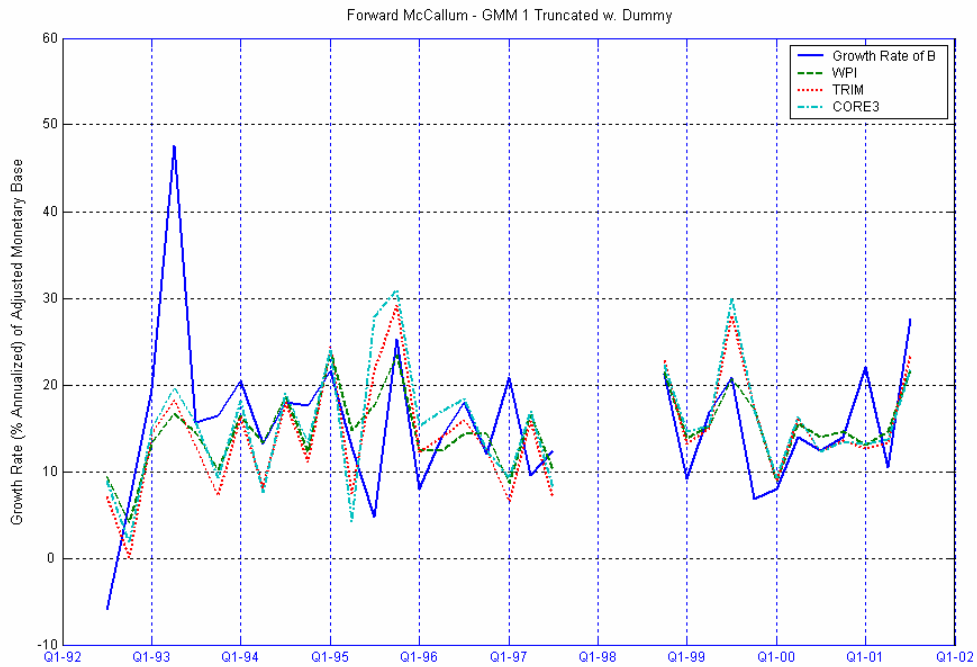
$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) - \dots$$

$$\dots - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n})D + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0735; \Delta y^*_p = 0.0439$$

Case	$\alpha$	$\beta$	$\lambda$	$\lambda_p$	$\rho$	$\delta$	$P[\psi^2 > 3]$	$\pi^*$	$\pi^*_p$
WPI	0.155 <b>(2.21)</b>	0.14 (-0.3)	-0.02 (0.06)	0.1 (0.19)	0.19 (0.73)	-0.56 <b>(-2.49)</b>	0.45	<b>0.0842</b>	<b>0.0961</b>
TRIM	0.15 (1.56)	-0.7 (0.73)	-0.3 (0.56)	0.04 (-1.34)	0.16 (0.46)	-0.72 <b>(-2.42)</b>	0.34	<b>0.1364</b>	<b>0.0973</b>
CORE3	0.14 (1.35)	-1.1 (0.85)	-0.58 (0.79)	-0.39 (0.3)	0.14 (0.37)	-0.62 <b>(-2.0)</b>	0.3	<b>0.27</b>	<b>0.1887</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



### Exhibit 8

[Forward Looking McCallum Rule;  $n = 4$ ]

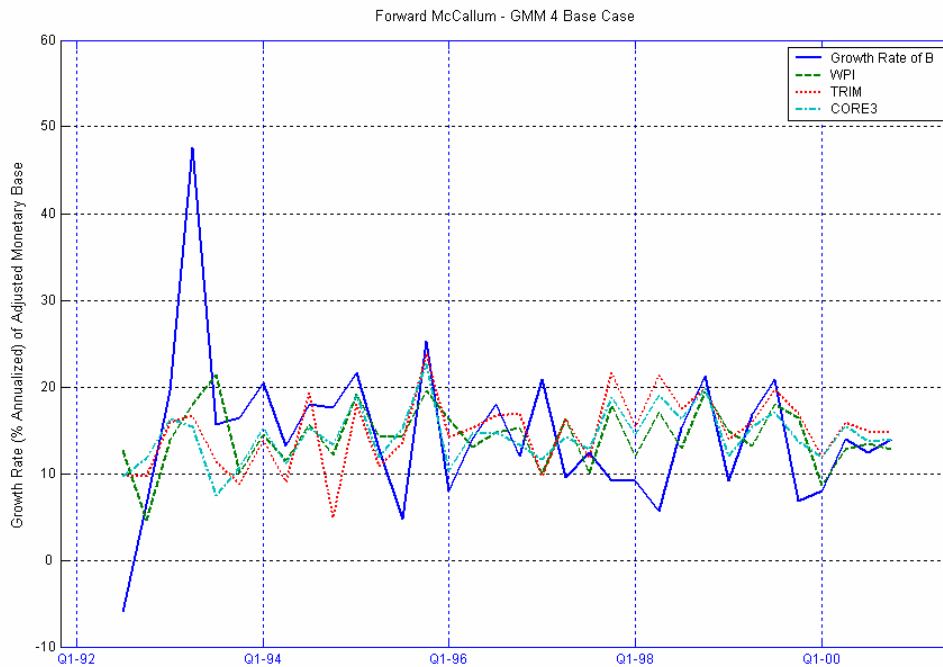
Base Case ( $n = 4$ )

$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k V_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) + \delta(1 - \rho)\Delta e_{t-1} + \varepsilon_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0607$$

Case	$\alpha$	$\beta$	$\lambda$	$\rho$	$\delta$	$P[\psi^2 > 4]$	$\pi^*$
WPI	0.16 <b>(2.38)</b>	-0.49 (0.64)	0.02 (-0.15)	0.29 (1.05)	-0.43 <b>(-2.03)</b>	0.56	<b>0.1021</b>
TRIM	0.2 <b>(2.86)</b>	-0.52 (0.93)	0.21 (-0.5)	-0.02 (-0.12)	-0.37 <b>(-1.83)</b>	0.42	<b>0.1035</b>
CORE3	0.15 <b>(2.71)</b>	-0.23 (0.45)	-0.06 (0.22)	-0.11 (-0.75)	-0.27 <b>(-1.72)</b>	0.33	<b>0.1006</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]





Base Case w. Dummy (n = 4)

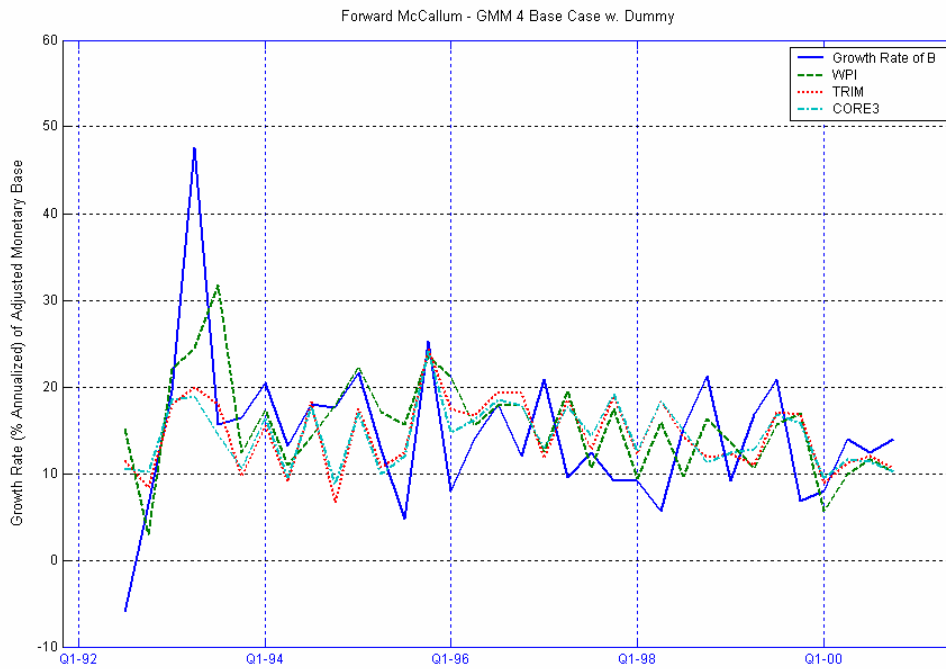
$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) - \dots$$

$$\dots - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n})D + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0694; \Delta y^*_p = 0.0439$$

Case	$\alpha$	$\beta$	$\lambda$	$\lambda_p$	$\rho$	$\delta$	$P[\psi^2 > 3]$	$\pi^*$	$\pi^*_p$
WPI	0.21 <b>(2.99)</b>	-1.74 (1.05)	-0.28 (0.6)	-1.13 (-1.06)	0.46 (1.33)	-0.7 <b>(-2.09)</b>	0.53	<b>0.227</b>	<b>-1.69</b>
TRIM	0.24 <b>(3.26)</b>	-1.18 (1.47)	0.19 (-0.42)	-0.42 (-0.61)	0.07 (0.4)	-0.39 <b>(-1.99)</b>	0.64	<b>0.1279</b>	<b>0.3599</b>
CORE3	0.22 <b>(3.33)</b>	-1.03 (1.6)	0.11 (-0.28)	-0.48 <b>(-1.77)</b>	-0.04 (-0.31)	-0.32 <b>(-2.07)</b>	0.69	<b>0.1273</b>	<b>0.371</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



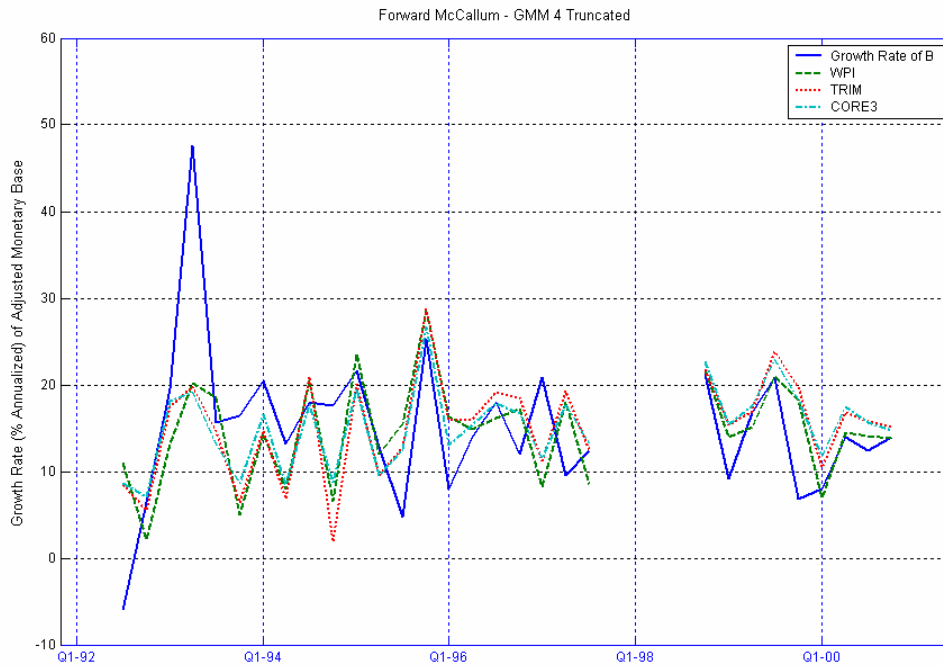
Truncated ( $n = 4$ )

$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) + \delta(1 - \rho)\Delta e_{t-1} + \varepsilon_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0625$$

Case	$\alpha$	$\beta$	$\lambda$	$\rho$	$\delta$	$P[\psi^2 > 4]$	$\pi^*$
WPI	0.21 <b>(3.56)</b>	-0.81 (0.75)	0.19 <b>(-0.49)</b>	0.26 (1.09)	-0.85 <b>(-2.35)</b>	0.53	<b>0.1169</b>
TRIM	0.25 <b>(3.25)</b>	-1.14 <b>(1.79)</b>	0.3 (-0.62)	0.06 (0.32)	-0.61 <b>(-3.47)</b>	0.57	<b>0.1271</b>
CORE3	0.21 <b>(3.25)</b>	-1.07 <b>(1.94)</b>	0.06 (-0.17)	-0.01 (-0.1)	-0.46 <b>(-3.9)</b>	0.5	<b>0.1381</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



Truncated w. Dummy ( $n = 4$ )

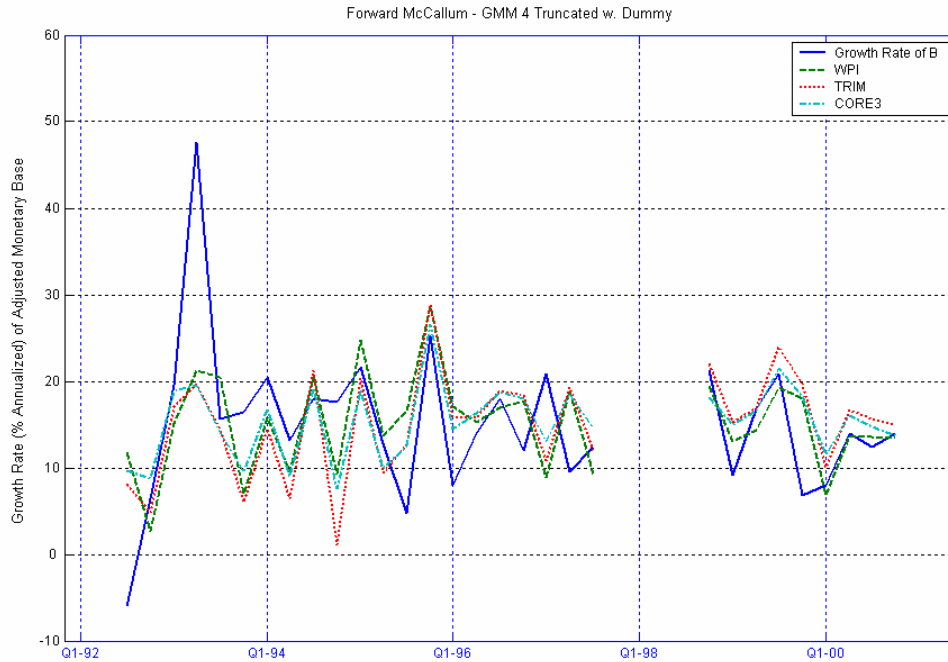
$$\dot{B}_t = \alpha(1 - \rho) - \frac{(1 - \rho)}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n}) - \dots$$

$$\dots - \lambda(1 - \rho)(\Delta y_{t+n} + \pi_{t+n})D + \delta(1 - \rho)\Delta e_{t-1} + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0735; \Delta y^*_p = 0.0439$$

Case	$\alpha$	$\beta$	$\lambda$	$\lambda_p$	$\rho$	$\delta$	$P[\psi^2 > 3]$	$\pi^*$	$\pi^*_p$
WPI	0.22 <b>(3.35)</b>	-0.79 (0.66)	0.13 <b>(-0.28)</b>	-0.11 (-0.35)	0.29 (1.2)	-0.85 <b>(-2.02)</b>	0.39	<b>0.1213</b>	<b>0.2042</b>
TRIM	0.25 <b>(3.09)</b>	-1.13 <b>(1.73)</b>	0.32 (-0.64)	0.34 (0.03)	0.07 (0.47)	-0.64 <b>(-3.28)</b>	0.4	<b>0.1136</b>	<b>0.1415</b>
CORE3	0.23 <b>(3.29)</b>	-1.06 <b>(1.96)</b>	0.13 <b>(-0.33)</b>	-0.22 (-0.72)	-0.03 (-0.21)	-0.42 <b>(-3.01)</b>	0.41	<b>0.1267</b>	<b>0.2039</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



**Exhibit 9**  
[Backward Looking McCallum Rule]

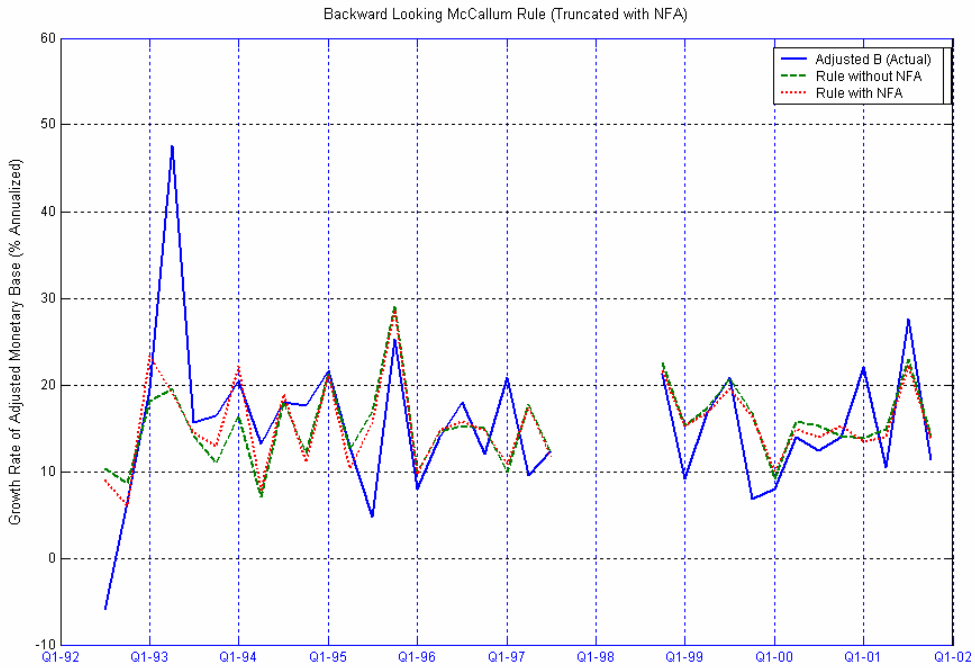
*Truncated with NFA*  
[WPI as the measure for inflation]

$$\dot{B}_t = \alpha(1 - \rho) - \beta(1 - \rho) \frac{1}{k} \sum_{j=0}^k \dot{V}_{t-j}^b + \rho \dot{B}_{t-1} - \lambda(1 - \rho)(\Delta y_{t-1} + \pi_{t-1}) + \delta_1(1 - \rho)\Delta e_{t-1} + \delta_2(1 - \rho)\Delta nfa_t + v_t$$

$$\alpha \equiv (1 + \lambda)(\Delta y^* + \pi^*); \Delta y^* = 0.0625$$

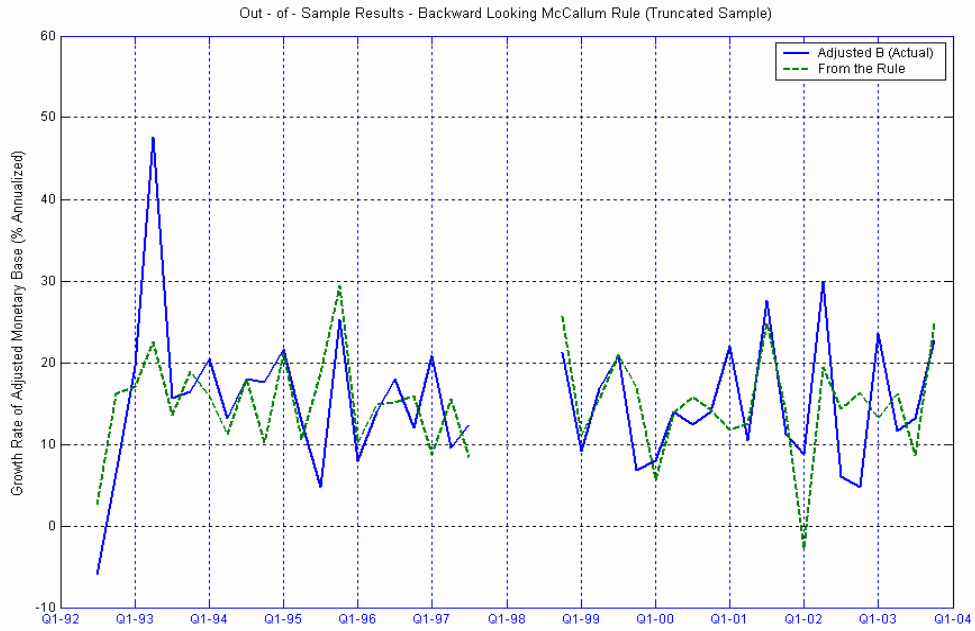
$\alpha$	$\beta$	$\lambda$	$\rho$	$\delta_1$	$\delta_2$	$\bar{R}^2$	$\pi^*$
0.171 <b>(7.7)</b>	-0.47 <b>(1.01)</b>	0.06 <b>(-1.13)</b>	0.05 <b>(0.41)</b>	-0.61 <b>(-3.00)</b>	0.07 <b>(3.41)</b>	0.27	<b>0.097</b>

[t-values given in parentheses correspond to the coefficients as they appear in the regression and not the parameters]



**Exhibit 10**  
[Out - of - Sample Results]

*Truncated Sample*



*Full Sample*

