Applied Economics Letters, 2010, **17**, 917–923

The importance of output for the monetary policy rules

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We examine the importance of variable output (Gross Domestic Product (GDP) growth rate) on the preferences of the policy makers. We do so by examining the effect of output regimes on the form of monetary policy implemented by the central banks. We use simple monetary policy rules to characterize the monetary policy of the central bank. Regime switching models are utilized to model output and monetary policy regimes separately. The importance of output is then examined for the UK and the USA by corresponding the output and monetary regimes together. We find some evidence supportive of the fact that the phase of output existent can change the preferences of the policy makers.

I. Introduction

A large number of monetary policy rules have been presented in the literature on monetary policy economics. However, none of the rules have achieved the degree of recognition which the simple rule proposed by Taylor (1993) known as the Taylor rule and its variants have achieved. A fact related to virtually all the recommended rules is that they all tend to assume constant weights on the variables in the reaction function. Taylor recommended a fixed set of weights for his rule, i.e. a weight of 1.5 on the inflationary gap and 0.5 on the output gap. And Taylor (1993, 1999) subsequently showed that his recommended rule (together with the weights) approximated the monetary policy at the Federal Reserve Bank rather well, empirically, at least for the past two decades. Therefore, an implicit assumption in nearly all the monetary policy rules recommended for practical use is the assumption of constant weights, i.e. the coefficients on the variables in the reaction functions do not change with a regime change (this is at least true for most of the simple rules).

What happens if the policy preferences of the central bank change from one regime to another? In the simplest case if a change in regime corresponds to whether the economy is in a recessionary or expansionary phase, and the preferences of the central bank change with a regime shift, do simple rules with constant weights retain any validity? However to assess the robustness of these rules we need to find out whether the preferences of the central bank change with the regime or not. The variable 'output' is an important goal variable for almost any central bank in the world. It frequently turns up as a feedback variable in virtually all the simple/optimal rules presented in the literature. It is a well-documented fact in the literature on business cycle analysis that trend growth of output frequently changes from one regime to another, i.e. from expansionary to recessionary phases of the economy. Temporary and permanent shocks to an economy frequently change the growth rate of output. But how important is this 'output' variable for the monetary policy rules? Whether a change in the growth rate of output forces the central bank to change its behaviour remains to be seen? We take an empirical approach to find the importance of output in the conduct of monetary policy. What we are doing in effect is to see whether a change in the growth rate of output, i.e. a regime change in the (growth rate of) variable output affects the (weights on the feedback variables in the) reaction function of the central bank. We assume a Taylor-type reaction function with interest rate smoothing.

Applied Economics Letters ISSN 1350–4851 print/ISSN 1466–4291 online © 2010 Taylor & Francis
http://www.informaworld.com
DOI: 10.1080/13504850802584823

In this article we use the growth rate of real Gross Domestic Product (GDP) in our analysis. This differs somewhat from the standard analysis of monetary policy rules in the literature on monetary policy in which the term output gap is used. We use the growth rate of real GDP in this article, starting on with the analysis of business cycles in Section II because the main objective of the article is to examine the influence of output regimes (recessions/expansions) on the preferences or behaviour of monetary authorities. The literature on business cycles normally utilizes the growth rate of real GDP for differentiating between the recessionary and expansionary phases of output (see, e.g. Hamilton, 1994; Kim and Nelson, 1999). We, therefore, also utilize the same measure of output for reliability and comparability of the results obtained in Section II. Further to maintain consistency with the results obtained in Section II, we decided to use the growth rate of real GDP in the monetary policy rule. The practice of using the growth rate of output in the monetary policy rule is not very unusual. The growth rate of real GDP has been utilized in some other papers on monetary policy as opposed to the output gap. Schmitt-Grohe and Uribe (2005) used the growth rate of real output in their specification of the monetary policy rules. The measurement of potential/capacity output is another problem related with the use of the term output gap.[1] McCallum (1988, 1999) has argued in favour of rules responding to nominal income growth rate as opposed to the output gap. Utilizing the growth rate of output therefore solves the problem of appropriately measuring the term output gap.

The article is organized as follows. In Section II we model the growth rate of output as regime dependent using a Markov process and figure out the recessionary and expansionary phases in the growth of output. Section III estimates a regime-dependent Taylor-type reaction function, where a regime shift changes the magnitudes of the coefficients. Section IV checks the correspondence between the output regimes and the monetary policy regimes. And Section V concludes.

II. Regime Switching Models

A simple regime switching process allows the growth rate of output to be dependent on the state of the economy. Hamilton (1989) models the business cycle asymmetry by allowing the growth rate of real output to be governed by an unobserved Markov-switching state variable. His results characterize the economy as being in one of the two states: positive growth (expansion) or negative growth (recession). Following Hamilton (1989), we also model the mean of the growth rate in real GDP to evolve according to a two-state Markov-switching process, thus allowing the dynamics of recessions to be qualitatively distinct from those of expansions. Growth in real GDP is modelled as an AR(2) process for the UK and as an AR(4) process for the USA:[2]

$$\begin{aligned}(\Delta y_t - \mu_{s_t}) = {} & \varphi_1(\Delta y_{t-1} - \mu_{s_t-1}) \\ & + \varphi_2(\Delta y_{t-2} - \mu_{s_t-2}) \\ & + \cdots + \varphi_4(\Delta y_{t-4} - \mu_{s_t-4}) + \varepsilon_t\end{aligned} \tag{1}$$

$$\varepsilon_t \sim \text{i.i.d.} N(0, \sigma^2) \tag{2}$$

$$\Pr(s_t = j / s_{t-1} = i) = p_{ij} \tag{3}$$

where y_t is the log of real GDP. The term Δy_t is the growth rate of real GDP in quarter t: $100(y_t - y_{t-1})$, s_t an unobserved state variable that evolves according to a first-order Markov process and for the UK the last two autoregressive (AR) terms in Equation 1 are assumed to be zero. The regime indicator $s_t = 1$ if the economy is in a recession in quarter t and $s_t = 2$ otherwise. Regime 1 therefore corresponds to a recession and regime 2 corresponds to an expansion. The change in regime is itself a random variable.

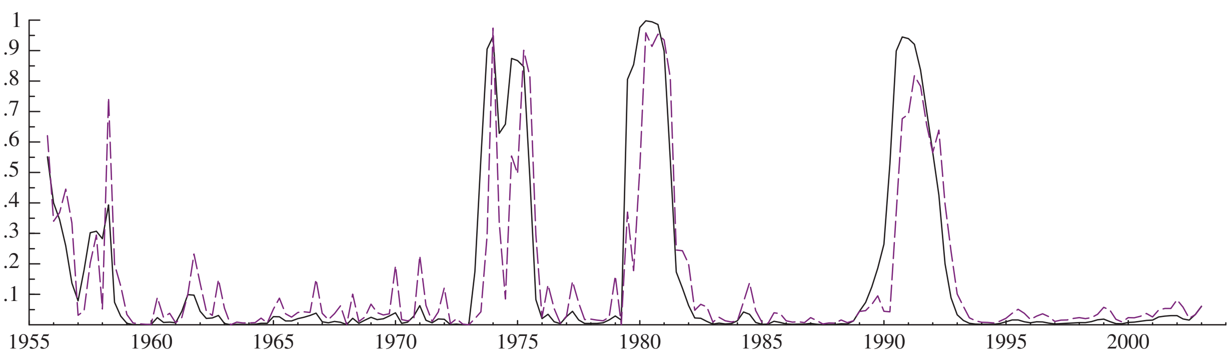
We apply the above mentioned model to real GDP of the UK and the USA for the sample period 1955 : 1 to 2003 : 1, respectively.[3] Parameter estimates of the model are shown in Table 1 for both the countries. The lower part of the table shows the transition matrix and the expected duration of the regimes. Figures 1 and 2 show the filtered and smoothed probabilities of a recession, with both closely spiraling around each other, for the UK and the USA, respectively. The filtered and smoothed probabilities for the USA (till 1984) are in close agreement with the probabilities reported in Hamilton (1989) and Kim and Nelson (1999) and hence with the National Bureau of Economic Research (NBER) dating of recessions.[4] The model however misses a small recessionary period in the late 1980s and the early 1990s for the USA, which is probably because

[1] As McCallum (2000) argues that reliance of a policy rule upon any output gap measure is risky for different measures give quite different values and there is no professional consensus on an appropriate measure or even the concept itself.
[2] The AR(2) process for the UK (as opposed to AR(4)) was selected on the basis of various diagnostic test statistics, including Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC) and the significance of the t- and F-statistics.
[3] The data utilized in the study have been extracted from DataStream International.
[4] Filtered probabilities refer to inferences about s_t conditional on information up to t ($\Pr[s_t = j|\psi_t]$), whereas smoothed probabilities refer to inferences about s_t conditional on all information in the sample ($\Pr[s_t = j|\psi_T]$).

Table 1. Estimates of regime switching model for growth rate of output

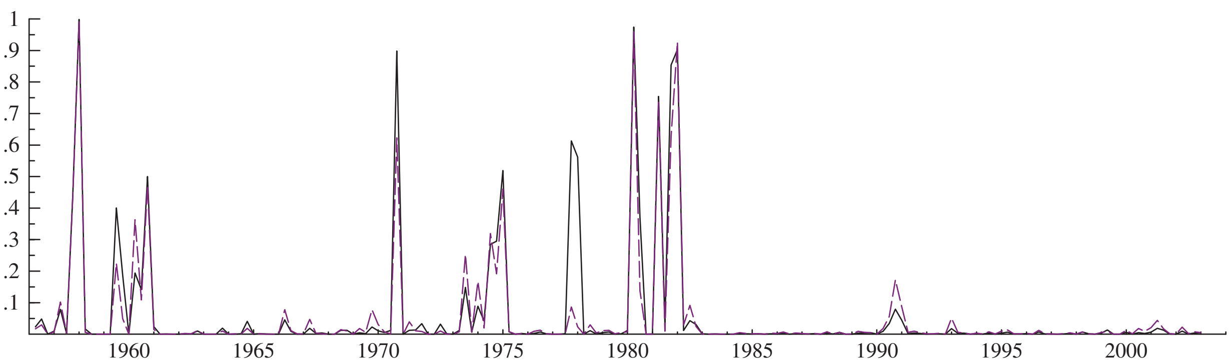
	UK			USA		
φ_1	−0.1653 (0.07)			0.3176 (0.07)		
φ_2	−0.0490 (0.06)			0.1714 (0.07)		
φ_3	–			−0.0740 (0.06)		
φ_4	–			−0.0530 (0.07)		
μ_1	−0.3556 (0.30)			−1.0761 (0.42)		
μ_2	0.7642 (0.10)			0.9242 (0.16)		
Log-likelihood	−265.6656			−238.5447		
		Regime 1	Regime 2		Regime 1	Regime 2
	Regime 1	0.7982	0.2018	Regime 1	0.3183	0.6817
	Regime 2	0.0316	0.9684	Regime 2	0.0431	0.9569
	Duration: Regime 1 = 4.96			Duration: Regime 1 = 1.47		
	Regime 2 = 31.63			Regime 2 = 23.19		

Note: SEs are in parentheses.



(smoothed probability——, filtered probability– – –) US

Fig. 1. Probabilities for a recession



(smoothed probability——, filtered probability– – –) US

Fig. 2. Probabilities for a recession

of the fact that the model assumes that the average growth rate of output during a boom or a recession is the same over the entire sample, i.e. the recessions arise from only one source: a switch in the common growth component (see Kim and Nelson, 1999 for further details). The average growth rate for the UK is –0.36% per quarter during recession and 0.76% per quarter during expansion. For the USA the figures are –1.08% per quarter and 0.92% per quarter, respectively.

III. Regime-Dependent Policy Rules

We assume that the central bank follows a Taylor-type reaction function for the conduct of monetary policy, the difference however is that the coefficients of the reaction function change with a change in the regime. And as in Section II, the change in regime is itself modelled as a random variable. The parameters of the reaction function are therefore not assumed to be constant throughout the sample; they are assumed to be regime specific. We specify the following reaction function for the two central banks:

$$i_t = c_s + \beta_s(\pi_t - \pi_t^*) + \lambda_s \Delta y_t + \gamma_s i_{t-1} + \varepsilon_t \quad (4)$$

where $\varepsilon_t \sim$ i.i.d.$N(0, \sigma^2)$. The term i_t is the short-term nominal interest rate: the instrument of the central bank, π_t the quarterly inflation rate measured as 100(ln P_t − ln P_{t-1}) (P_t being the consumer price index), π_t^* the inflation target which for simplicity we assume to be equal to zero and Δy_t the quarterly growth rate in the real GDP measured as 100(ln y_t – ln y_{t-1}).[5] The last term in the reaction function is the interest rate smoothing term. As specified the coefficients (and the constant) in the reaction function are regime dependent. Beside the regime-specific coefficients in the reaction function, the rule includes the growth rate of real GDP as the second feedback variable as opposed to output gap in the Taylor rule and also includes an interest rate smoothing term compared to the simple Taylor rule. The interest rate smoothing term is included to capture the behavioural tendency of the central bank to smooth interest rate adjustments (empirically). See Clarida *et al.* (1998, 2000), Rudebusch (2002) and the references therein on the importance and significance of the interest rate smoothing term in the actual monetary policy making at the Federal Reserve Bank and the Bank of England. The real GDP growth compared to the more frequently used output gap variable is included mainly for consistency with the model estimated in the previous section. Also see the discussion in Section I.

The monetary policy rule as specified is thus a three-state Markov-switching process for the UK and a four-state Markov-switching process for the USA. We assume three regimes (states) for the UK as recent empirical evidence suggests that the Bank of England has followed at least three different forms of monetary policy regimes during the span of our sample period (1975 : 1 to 2003 : 1) with Exchange Rate Mechanism (ERM) and the inflation-targeting regime of the Bank of England being the prime examples, see Nelson (2000) for a more detailed discussion. We assume four regimes for the USA, again four regimes for the USA are close enough to provide an accurate description of the monetary policy making process at the Federal Reserve Bank. Recent empirical analysis of the US monetary policy corresponding to our sample period (1971 : 1 to 2003 : 1) suggests that the Federal Reserve Bank has followed at least four different forms of monetary policy regimes during this period, roughly divided into 1972 to 1979, 1979 to 1982, 1982 to 1988 and 1988 to present. The last regime from 1988 to present corresponds to the implicit inflation-targeting regime of the Federal Reserve Bank (see, e.g. Clarida *et al.*, 2000; Walsh, 2003 for a detailed discussion).[6] We however do not precisely define the regimes for each country at this stage.

The parameter estimates of the reaction function specified above for the UK and the USA are shown in Table 2. The smoothed probabilities of the regimes are shown in Figs 3 and 4 for the UK and the USA, respectively. For the UK, regime 1 which is the most recent regime as well, i.e. prevailing from 1993 to 2003 corresponds to the inflation-targeting regime (the Bank of England adopted the inflation-targeting

Table 2. Estimates of regime dependent monetary policy rules

	Regime 1	Regime 2	Regime 3	Regime 4
UK (1975 to 2003)				
c	3.3695 (1.00)	8.7381 (2.58)	11.2377 (2.50)	–
β	0.8380 (0.25)	−0.1875 (0.48)	0.1756 (0.32)	–
λ	0.1491 (0.62)	−0.2518 (0.56)	−1.5577 (0.59)	–
γ	0.2425 (0.14)	−0.0021 (0.44)	0.1106 (0.16)	–
US (1971 to 2003)				
c	0.2451 (0.26)	0.4952 (0.25)	3.2848 (0.48)	0.1606 (0.91)
β	0.3590 (0.17)	0.4322 (0.08)	1.5780 (0.22)	2.2652 (0.20)
λ	0.0848 (0.13)	0.0028 (0.07)	−1.1518 (0.23)	1.7103 (0.22)
γ	0.7528 (0.05)	0.8772 (0.03)	0.3545 (0.05)	0.6853 (0.07)

Note: SEs are in parentheses.

[5] The interest rate used for the UK is the interbank overnight interest rate and for the USA is the Federal Funds Rate. The data on the interbank overnight interest rate for the UK are only available from 1975 onwards in the Organization for Economic Co-operation and Development (OECD) database, therefore the estimation sample for the reaction function is different from the sample utilized in the previous section. The same is true for the USA as well.

[6] In Ox the software used in the estimation of Markov-switching processes, models such as Equation 4 are characterized as 'MSIA' i.e. Markov-switching process in intercept term and autoregressive parameters. See Krolzig, H. M. (1998) Econometric modelling of Markov-switching vector autoregressions using MSVAR for Ox, Working Paper, Oxford University.

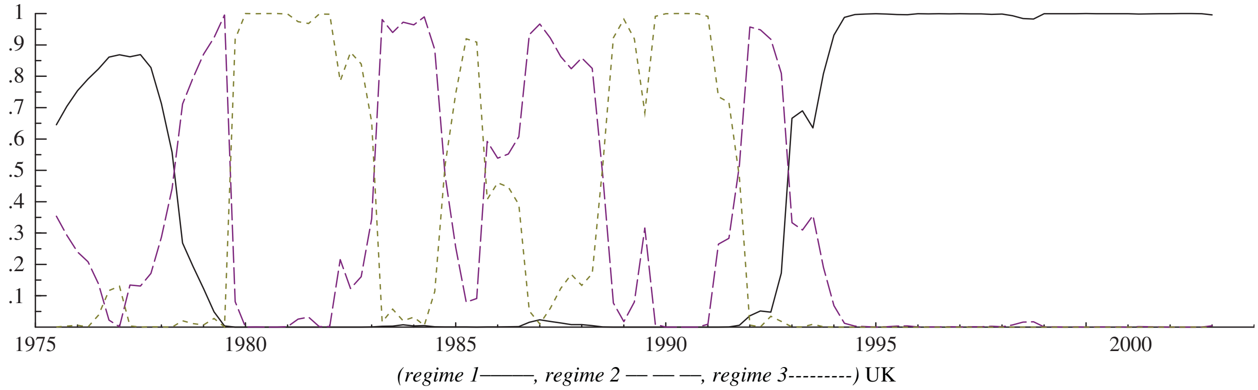


Fig. 3. Probabilites for monetary policy regimes

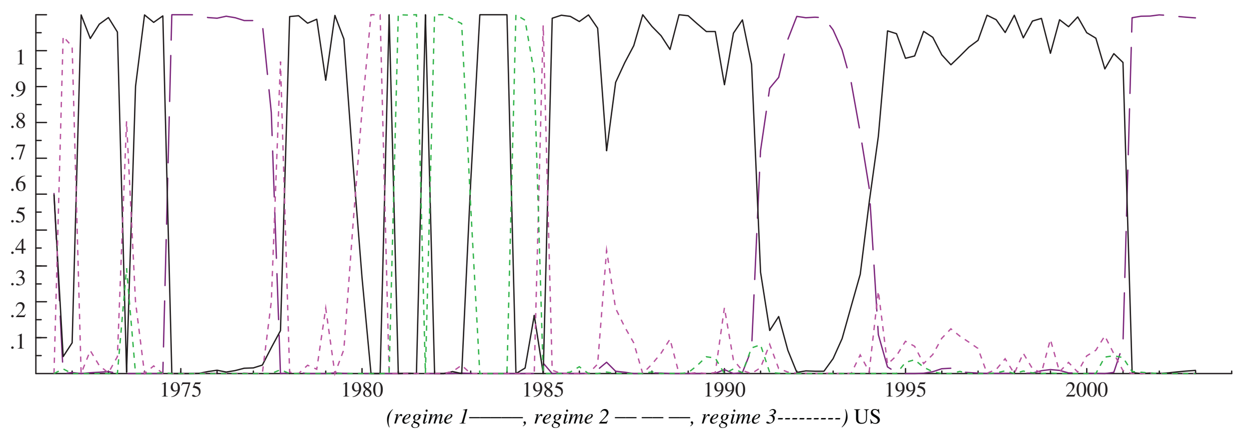


Fig. 4. Probabilites for monetary policy regimes

regime from 1992 onwards). The increased weight on inflation during this regime also provides evidence in favour of the inflation-targeting regime during this period.[7] For regimes 2 and 3 there is some form of misspecification. The extremely high values of constant for these two regimes suggest that the simple monetary policy rule specified above does not accurately depict the conduct of monetary policy during these regimes.

For the USA, regime 2 which prevailed for most of the 1990s and from mid-1980s onwards, the long-run coefficient on inflation is greater than 1.5 (the weight in the original Taylor rule), there is also a significant weight on the real GDP growth variable, however much lower than the weight of 0.5 recommended by Taylor for the output gap variable. The interest rate smoothing term for regime 2 is also highly significant.[8] Regime 4 has even more greater weights on all the feedback variables compared to regime 2 but empirically persists only for some few short and brief time periods. Regimes 1 and 2 have the greatest (and significant) weight on the interest rate smoothing term with the earlier prevailing for some part of the early 1990s and for the latest 6–7 quarters of the sample period. Regime 2 which persists for most of time from 1985 onwards (and for few quarters before that) has a long-run coefficient (weight) in excess of 1 on the inflationary gap, which accords well with the finding of Taylor (1999) and Clarida *et al.* (2000). There is also a large weight on the lagged interest in this regime consistent with the findings reported in the literature.

[7] The coefficient on the inflationary gap should theoretically be much greater than one for an inflation-targeting central bank and at least this is what we expect for an inflation-targeting regime like the Bank of England. A coefficient of less than 1 on inflationary gap is, however, also reported in some other empirical studies for the UK as well. See, for instance, Clarida *et al.* (1998).

[8] For some of the regimes, for the two countries, the coefficient of the output growth variable is negative which is intuitively a bit hard to digest. It is, however, plausible if the central bank has a target growth rate of real GDP or it could be because of the inflationary bias inherent in the discretionary monetary policy, as documented in the literature.

IV. Correspondence Between the Regimes

The real GDP growth variable does enter significantly in the reaction function of the USA and the UK for some of the regimes (mainly for the USA). The question we, however, seek to answer is, 'Does a change in the growth rate (regime/phase) of real GDP alter the conduct of monetary policy by the central bank, i.e. change the coefficients of the reaction function?' We examine the correspondence between the regimes of the GDP and of the reaction function coefficients.

Starting with the UK, the most visible correspondence is between the expansionary phase of the real GDP beginning (approx.) at the end of 1992 and the adoption of regime 1 (which corresponds to an inflation-targeting regime) for the conduct of monetary policy by the Bank of England. The recessionary phase of the real GDP in the late 1970s and early 1980s and especially from 1990 to 1992 (the time of ERM) correspond to regime 3 of the reaction function coefficients with a concern for the output highly visible in the form of a considerable weight on the GDP growth variable. Another expansionary phase (regime) of GDP from 1975 to 1979 (approx.) corresponds to the reaction function of regime 1, but a long expansionary phase identified by the model in Section II from the early 1980s to late 1980s, however, corresponds randomly to the reaction function coefficients of regimes 2 and 3, respectively, which slightly diminishes the importance of output in the conduct of monetary policy, i.e. as far as the attitude of the central bank is concerned.

For the USA, compared to UK, it is slightly more difficult to present any solid hypothesis of linkages between the regimes. Periods of recessions and expansions correspond to different regimes of monetary policy making and as such it seems virtually impossible to single out any unique monetary policy regime before the mid-1980s corresponding to a specific expansion or recession. The final long lasting period of expansion (in our sample) for the US economy does however is dominated by the regime 2 reaction function (for most of quarters) with an increased concern of inflation.[9] Majority of the periods of recessions before the 1980s correspond to regimes 1 and 3 reaction function coefficients in the conduct of monetary policy, which together with result of regime 2 being the dominant regime for monetary policy over the last expansionary phase, identified by the model: 1984 to 2003 approximately does however give due importance to the output variable. The (implicit) inflation stabilization objective of the Federal Reserve Bank from the mid-1980s onwards shows up remarkably well over the last expansionary regime in our sample. The increased concern for inflation, i.e. the dominance of the regime 2 reaction function from the mid-1980s onwards is consistent with the findings of Taylor (1993, 1999). See also Walsh (2003) and the references therein. Even if the growth rate of output does not show up significantly in the reaction function, it does appear to influence the preferences of the policy makers.[10]

V. Conclusion

Monetary policy can change simply because of a change in the preferences of the central bank independent of the concern for the phase of output (existent). There is, however, some evidence to suggest that the phase of the output (existent) can on its own change the preferences of the central bank and this being true for both the Bank of England and the Federal Reserve Bank. The commencement of inflation-targeting regime (explicitly announced) at the Bank of England and the increased weight on inflationary gap to stabilize inflation by the Federal Reserve Bank, corresponding to the expansionary output regimes in the two economies, respectively, stand out most clearly. Even if the output growth does not enter with considerable weight in the reaction function, it does appear to have some influence on the preferences of the central bank in conducting its monetary policy. The evidence over the past two decades is at least quite supportive of this finding. As a future research area, it would be interesting to evaluate the gains (if any) from following a constant coefficients policy rule as opposed to a regime-dependent policy rule.

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[9] The early 1990s correspond to a regime 1 reaction function, however as mentioned earlier our model for the business cycle misses a small recessionary period in the early 1990s as well.

[10] One possible explanation for insignificant coefficients on the output for some regimes in the reaction functions could be the use of growth rate of output as opposed to output gap.

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