UK monetary policy 1972- 97: a guide using Taylor rules

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Abstract

In the period between the floating of sterling in June 1972 and the Bank of England receiving operational independence in May 1997, UK monetary policy went through several regimes, including: the early 1970s, when monetary policy was subordinate to incomes policy as the primary weapon against inflation; £M3 targeting in the late 1970s and early 1980s; moves in the late 1980s toward greater exchange rate management, culminating in UK membership of the ERM from 1990 to 1992; and inflation targeting from October 1992. This paper estimates simple interest rate reaction functions or 'Taylor rules' for different UK monetary policy regimes.

1. Introduction

In the period between the floating of the exchange rate in June 1972 and the granting of operational independence to the Bank of England in May 1997, UK monetary policy went through several regime changes. These included the period in the 1970s when monetary policy was considered subordinate to incomes policy as the government's primary weapon against inflation; an emphasis on monetary targeting in the late 1970s and early 1980s; moves from 1987 toward greater management of the exchange rate, culminating in the United Kingdom's membership of the Exchange Rate Mechanism (ERM) from 1990 to 1992; and inflation targeting from October 1992.[(1)]

In a famous paper, Taylor (1993) showed that US monetary policy after 1986 is well characterised by a rule for the Federal Reserve's interest rate instrument (the nominal Federal funds rate) whereby the interest rate responds with fixed, positive weights to inflation and the output gap.[(2)] There has subsequently been an explosion of theoretical and empirical work on Taylor rules, including econometric estimates of the Taylor rule coefficients for the United States by Clarida, Gali and Gertler (2000) and Judd and Rudebusch (1998).

This paper provides estimates for the United Kingdom of the Taylor rule for several different monetary policy regimes in the period 1972 97— prior to the Bank of England receiving independence. It is not claimed that policy-makers actually adhered to a Taylor rule during any part of this period; rather, the Taylor rule estimates provided here can be regarded as a simple (two or three parameter) characterisation of developments in UK monetary policy. Under this interpretation, changes in the estimated Taylor rule coefficients across regimes reflect different policy responses over time to inflation or to output relative to potential.[(3)]

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(1) Goodhart (1989) and Minford (1993) provide discussions of UK monetary policy covering the 1970s and 1980s.

(2) Taylor measured the output gap by detrended log real GDP.

(3) These estimates of the response coefficients do *not*, however, uncover the underlying preference or welfare function parameters of the monetary authorities. See the discussion in Section 2 below.

Previous estimates of a Taylor rule for the United Kingdom include Broadbent (1996), Clarida, Gali and Gertler (CGG) (1998), and Wright (1998). The present work departs from these studies in three major respects. First, with the exception of CGG, who modelled one regime shift, the earlier studies treated their sample period (1981 95 for Broadbent, 1961 94 for Wright) as a single policy regime. By contrast, after Section 3, which reports full-sample estimates, I split my estimation period into six distinct policy regimes, and estimate Taylor rules for each regime except the ERM period. Second, my longer sample allows a detailed examination of interest rate behaviour under inflation targeting (1992 onward). Finally, I estimate both backward-looking and forward-looking Taylor rules, and compare them as descriptions of UK policy behaviour.

For the sample periods covering the 1970s, I find that the estimated long-run response of the nominal interest rate to inflation was well below unity. Moreover, the real interest rate was permitted to be negative for most of this period. These results suggest that UK monetary policy failed to provide a nominal anchor in the 1970s. In the 1980s, control of inflation was more successful and, consistent with this, the estimates suggest a tighter monetary policy. This tightening was manifested in an increase in the average prevailing level of real interest rates, and a high degree of responsiveness to foreign interest rates, rather than in an increase in the estimated response to the domestic inflation rate. Indeed, the estimates in this paper suggest that the long-run response of nominal interest rates to inflation remained below unity until the period of inflation targeting, 1992 97. For this most recent period, the long-run estimated responses of the UK nominal interest rate to inflation and the output gap are remarkably close to the values of 1.5 and 0.5 respectively, found by Taylor (1993) to be a good description of recent US monetary policy.

2. The basic Taylor rule

Taylor (1993) showed that the behaviour of the US Federal funds rate (the nominal interest rate used by the Federal Reserve as its policy instrument) was well described by the simple formula:

$$R_t = (r^* + \ p^*) + 1.5(\ {}_4p_t - \ p^*) + 0.5\,\tilde{y}_t \qquad \textbf{(1)}$$

In equation **(1)**, the nominal interest rate R_t is annualised and expressed as a fraction, $\ {}_4p_t$ is the annual inflation rate (the fourth difference of the log price level p_t), and $\tilde{y}_t$ is the output gap (defined as $\tilde{y}_t = y_t \quad \bar{y}_t$, where y_t is log real GDP and $\bar{y}_t$ its potential level). p^* is the target for annual inflation, and r^* is the steady-state value of the real interest rate.

In empirical work, rules such as **(1)** can be thought of as a simple approximation of actual policy behaviour, attempting to represent a complex process with a small number of parameters. In theoretical and policy-simulation work, a rule like **(1)** can be compared with the performance of other policy rules, such as optimal rules, which use a wider information set. In this light, it should be emphasised that it is not essential to the logic of the rule that the coefficients in **(1)** be 1.5 and 0.5. Indeed, experiments with Taylor rules in a variety of models have generally supported higher values of one or both feedback coefficients in (**1**).[(4)] One reasonably general result is that it does seem desirable to have a (long-run) coefficient on inflation in the rule exceeding one, to ensure that the Taylor rule delivers inflation equal to its target value (p^*) on average (see Taylor (1999b)).

Taylor's original paper emphasised the graphical match of rule **(1)** with actual US interest rate behaviour. There have subsequently been attempts to fit Taylor rules to data using formal econometric procedures; Clarida, Gali and Gertler (1998, 2000) and Judd and Rudebusch (1998) do so for the United States, and Clarida, Gali and Gertler (1998) also report estimates for the United Kingdom,

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(4) See, for example, the papers in Taylor (1999a).

Japan, France, Italy, and Germany.[5] The principal departure these studies have found from equation **(1)** is strong support for a large positive coefficient on the lagged dependent variable. This coefficient can be interpreted as an interest rate 'smoothing' parameter, and an equation that includes such a term can be regarded[6] as one whose long-run solution is of the form given in equation **(1)**.

The remainder of this paper reports estimates of the UK monetary policy reaction function, starting with full-sample estimates in Section 2, and moving on to estimates for sub-samples. It is important first to note an econometric issue that affects the interpretation of the results. This issue is whether it is legitimate to interpret the coefficients in econometrically estimated versions of **(1)** as policy reaction parameters. The estimates below avoid simultaneity problems by using instrumental variables estimation whenever current or expected future values of variables appear in the estimated equations.[7] Even so, there are potential identification problems. For example, in the degenerate case where the central bank controls inflation perfectly, the resulting low variability of inflation may lead to insignificant estimates of the policy response to (expected) inflation. Fortunately, the data used in this paper do seem to provide sufficient variation in inflation and the other explanatory variables to avoid this problem. Sections 4 and 8 below provide evidence on this issue.

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(5) It should be noted that while Taylor (1993) initiated a fresh spurt of empirical work on policy reaction functions, there already existed a large literature in this field. At least in the United States, Taylor's work did contribute to a greater amount of theoretical and empirical work in which the interest rate was the policy instrument (as opposed to a monetary or reserves aggregate, as in Barro (1977), for example). In the United Kingdom, such work already had a long background; Johnson (1972, page 233) states that 'the tradition of British central banking and monetary theory… identified monetary policy with the fixing of the level of interest rates'.

(6) Provided that the smoothing coefficient is below unity.

(7) Underlying these instrumental variables estimates are first-stage regressions for inflation and the output gap. Just as I allow the estimated policy rule to vary across regimes, I also permit the parameter estimates of these first-stage regressions to vary. This reduces the danger that changes in estimated policy rule coefficients are the result of changes in the economy's aggregate demand or supply relationships instead of changes in monetary policy regime. For example, if the policy rule is $R_t = f\, E_t \; {}_4p_{t+1}$ and both the reaction coefficient f and the $E_t \; {}_4p_{t+1}$ process change from one regime to the next, the use of separate first-stage regressions for each regime helps disentangle changes in f from changes in $E_t \; {}_4p_{t+1}$.

While I argue that the estimates reported in this paper can be interpreted as policy reaction parameters — ie as partial derivatives such as $R_t / \ E_t \ {}_4p_{t+1}$, where $E_t \ {}_4p_{t+1}$ is expected inflation — the estimated coefficients do not have any straightforward link with the underlying preference parameters of the policy-makers. To illustrate this, suppose the aggregate demand relationship in the economy changed, so that larger interest rate changes were needed simply to maintain the level of inflation variability at its previous value. Then a welfare-maximising policy-maker might increase $R_t / \ E_t \ {}_4p_{t+1}$, even though there had been no change in its underlying preferences. The estimated coefficient on $E_t \ {}_4p_{t+1}$ in a regression for R_t would rise, and it would be legitimate to interpret this as indicating a stronger policy response to inflation; but it would not be legitimate to conclude that the weight on inflation variability in policy-makers' welfare function had increased. This example illustrates that the estimation of policy reaction coefficients and welfare function parameters are separate tasks; the present paper is concerned exclusively with the former.

Finally, one difference of the present study from other papers is that I do not attempt to make a structural interpretation of the intercept terms of the estimated policy rules. A standard approach in previous work has been to interpret the estimated (long-run) constant term as composed of the sum of the steady-state real interest rate, r^*, and an 'inflation target', p^*— just as it is in equation **(1)**. Typically, analysis of the constant term has proceeded by fixing the value of either r^* and p^* *a priori* and then deducing the implied inflation target or equilibrium real rate; see Judd and Rudebusch (1998, pages 7–8) for a discussion.

I do not follow this approach for two reasons. First, as I discuss further in Section 4, policy-makers in the 1970s relied heavily on devices other than monetary policy to control inflation. It is therefore unlikely that, for such periods, analysis of the estimated monetary policy rule is sufficient to deduce the policy-makers' implicit 'target' for inflation. Instead of trying to disentangle either p^* or r^* from the estimated constant term, I simply report the *ex post* real interest rate for each of the regimes for which I estimate policy rules.

The second reason why I do not attempt to interpret the intercept arises from the fact that the GDP statistics and price indices used in this study are revised data (as of 1999). Similarly, I also use detrended output series based on trends fitted to the entire 1971 98 period. The output gap and inflation data are therefore not the ‘real-time’ data that were available to policy-makers when they were making their decisions.

The analysis in Orphanides (1999) suggests that differences between the real-time and final data can have important consequences for the analysis of policy rules. In evaluating their consequences for the results in the present paper, it is important to note that Orphanides’ key finding for US data is that ‘the bulk of the problem is due to errors in the measurement of potential output. As is now evident, real-time estimates of potential output [in the 1970s] severely overstated the economy’s capacity relative to the recent estimates...’ For the United Kingdom, a similar overstatement is likely to have occurred in the 1970s. Official targets for real GDP growth were announced in the early and mid-1970s that seem, in retrospect, to reflect over-estimates of the economy’s potential growth rate and/or the amount of spare capacity in the economy. For example, the March 1972 Budget announced a 5% per annum target real GDP growth for 1971 73, and the April 1976 Budget announced a 5.5% per annum target for 1976 79.[8]

If the bulk of the difference between the final and real-time data consists of one-sided, relatively constant, and infrequently corrected, errors about the level of the output gap, then my use of final data will mainly affect the intercept terms of the policy rules that I estimate, rather than the estimated inflation and output gap responses.[9] Again, this is a reason for not giving a structural interpretation of the intercept terms, and concentrating instead on the estimated response coefficients. Estimates of UK policy rules based on real-time data, while beyond the scope of the present study, are an important area for future work.

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(8) For some periods, such as 1987 88, differences between real-time and revised GDP data are clearly important for the United Kingdom. The evidence from Stuart (1996, Chart 4) suggests, however, that the difference for 1987 88 is well approximated by a one-sided mis-measurement of the level of the output gap — similar in nature to the errors that Orphanides discusses.

(9) Note that, since I divide the 1972 97 sample period into several regimes, the mean of the output gap measurement error can change across regimes without rendering inconsistent the estimated slope coefficients in the policy rules.

3. Naïve Taylor rules: full sample estimates

Before breaking the 1972–97 sample period into separate monetary policy regimes, I present an estimated Taylor rule for the full sample. Specifically, in this section I present estimates for the United Kingdom for 1972–97 of the equation:

$$R_t = w_0 + w_1 \Delta_4 p_{t-1} + w_2 \tilde{y}_{t-1} \qquad \textbf{(2)}$$

where variables are UK counterparts of the variables discussed in Section 2. Compared with Taylor's (1993) original formulation **(1)**, the output gap appears in equation **(2)** with a one-period lag, rather than contemporaneously, reflecting a more realistic assumption about the information available to the monetary authority in period *t*. I describe the version of the Taylor rule in equation **(2)** as 'naive' to distinguish it from Taylor rules which incorporate more extensive dynamics — by including, for example, forward-looking policy behaviour (ie responses to variables such as $E_{t-1} \Delta_4 p_{t+k}$ for $k \geq 0$, instead of $\Delta_4 p_{t-1}$), further lags of $\Delta_4 p_t$ or $\tilde{y}_t$, or interest rate smoothing (via adding lags of R_t to **(2)**). Later sections will consider these more general rules; for now, **(2)** is used for an initial look at the UK experience.

The sample period is 1972 Q3–1997 Q1, a period beginning with the float of sterling (June 1972) and ending just prior to the Bank of England receiving operational independence (May 1997). Throughout this paper, R_t is measured by the Treasury bill rate[10] (expressed as an annualised fraction), p_t is measured by the log of the Retail Price Index (spliced into the RPI excluding mortgage interest payments, RPIX, from 1974 onward), and $\tilde{y}_t$ is measured empirically

(10) The actual interest rate used by the Bank of England as its instrument has varied over time, and has included Bank Rate (until September 1972), Minimum Lending Rate (1972–81), and the two-week repo rate (since 1996). The Treasury bill rate has historically moved closely with these instruments, and is available for the entire sample period. For August 1992, the only month for which no observation on the bill rate is available, a value of 9.7 is used. This figure was obtained by assuming a 20 basis point spread above the 91-day rate (the 91-day rate was 20 basis points below the bill rate in both July and September 1992).

by the residuals from a 1971 Q3 1998 Q4 regression of log real GDP, y_t, on a linear and a quadratic trend.(11) Chart 1 plots these three series. The roller-coaster behaviour of inflation in the 1970s is a dominant feature of the chart, and the disinflations of the early 1980s and early 1990s are also visible in both the inflation and output gap series. Another notable feature is that the nominal interest rate is persistently below the inflation rate until 1980, and persistently above it thereafter.

Ordinary least squares estimates of equation **(2)** on UK data appear in Table A. The estimates may be compared with the values of $w_1 = 1.5$ and $w_2 = 0.5$ found by Taylor (1993) to provide a successful description of post-1986 US monetary policy. As mentioned in Section 2, policy rules that use a value of w_1 that do not exceed 1.0 should not be expected to provide the economy with a nominal anchor. The estimates in Table A suggest that if 1972 97 is treated as a single policy regime, UK monetary policy indeed failed to provide this anchor, since the estimate of w_1 is only 0.19. The estimated output gap response is 0.27. Both these coefficients are significantly above zero according to standard t-tests.

Conclusions about policy behaviour on the basis of the estimates in Table A are difficult, because there is abundant evidence that the estimated equation is mis-specified. For one thing, it provides a poor fit, indicated by the high residual standard deviation of 258 basis points. The poor performance of the regression in capturing the dynamics of the nominal interest rate is also manifested in a high degree of autocorrelation in the estimated residuals (Durbin Watson statistic = 0.25). Finally, both formal statistical testing and recursive estimation of the model indicate that the estimated parameters are non-constant. A Chow covariance statistic, testing for breaks in the three coefficient estimates from 1979 Q2, has a value of $F(3, 93) = 28.79$, highly significant using conventional critical values (with a p value of 0.00). Chart 2 depicts the recursive estimates of the three coefficients (on the constant,

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(11) Quadratic detrending was also used in Clarida, Gali and Gertler (1998). A more desirable procedure would be to construct an output gap series that accurately takes into account non-deterministic changes in potential output. Such a procedure, however, may be quite vulnerable to errors in specifying the economy’s structure, since it requires a specification of the production technology and of private households’ preferences. See McCallum and Nelson (1999, pages 27–28) for a discussion.

inflation, and the output gap) as the sample period is extended from 1975 to 1997. All three estimated coefficients are non-constant.(12)

Chart 2 highlights the futility of treating 1972 97 as a single policy regime. In the remainder of this paper, the Taylor rule is re-estimated, now allowing for more realistic dynamics, and with the sample period divided into several regimes:(13)

> July 1972 to June 1976: from the first full month of a floating exchange rate to the end of the pre-monetary targeting period.(14)
>
> July 1976 to April 1979: from the beginning of monetary targeting to the last month prior to the election of the Conservative government.(15)
>
> May 1979 to February 1987: the period beginning with the election of the Thatcher government. This period also includes the announcement of the Medium Term Financial Strategy (MTFS) in March 1980, although the centrepiece of the initial MTFS, £M3 targeting, was abandoned in October 1985.
>
> March 1987 to September 1990: informal linking of the pound to the Deutsche Mark.
>
> October 1990 to September 1992: membership of the ERM.
>
> October 1992 to April 1997: the period of inflation targeting in the United Kingdom prior to the Bank of England receiving operational independence.

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(12) Richer dynamic specifications, such as versions of **(1)** with multiple lags of the regressors and dependent variable, exhibit similar non-constancy.

(13) In this paper, I treat both inflation and nominal interest rates as I(0) variables within each regime. Batini and Nelson (2000) present evidence that UK inflation and nominal interest rates are I(0) processes once one conditions on changes in monetary regime.

(14) The float of the exchange rate was announced on 23 June 1972 (Bank of England (1972, page 310)).

(15) The £M3 growth rate target for the financial year 1976/77 was announced by Chancellor Healey on 22 July 1976 (Bank of England, 1976, page 296). The Conservative government was elected on 3 May 1979 and took office the following day.

4. Estimates of the Taylor rule 1972 Q3- 1976 Q2

In this section I report estimated policy rules for the 1972 76 regime. The first specification which I estimate is a backward-looking Taylor rule with lags of inflation, the output gap, and the interest rate:

$$R_t = \quad + S_{i=1}^{j} a_i \quad {}_4 p_{t \; i} + S_{i=1}^{j} b_i \; \tilde{y}_{t \; i} + S_{i=1}^{j} c_i R_{t \; i} + e_t \qquad \textbf{(3)}$$

In equation **(3)**, e_t is a white noise disturbance. The equation allows, via the inclusion of lags of R_t, for central bank interest rate smoothing. Consequently, the parameters in **(3)** that correspond to w_0, w_1 and w_2 in **(2)** are the long-run response coefficients: $w_0 = \quad / (1 \quad S_{i=1}^{j} c_i)$, $w_1 \quad (S_{i=1}^{j} a_i) / (1 \quad S_{i=1}^{j} c_i)$ and $w_2 \quad (S_{i=1}^{j} b_i) / (1 \quad S_{i=1}^{j} c_i)$. Rule **(3)** is 'backward-looking', as it does not allow explicitly for responses by the monetary authorities to expected current or future values of variables. I will also estimate a forward-looking alternative to this rule.

My sample for estimating equation **(3)** consists of only 16 observations, which on the surface might appear insufficient to produce reliable estimates of the parameters. However, the information content provided by a data set depends not only on its length but also on the in-sample variation of the explanatory variables. Chart 3 displays the 16-quarter moving standard deviations from 1974 Q4 to 1998 Q4 of annual inflation, the output gap and the nominal interest rate — the three variables appearing on the right-hand side of **(3)**. The highest standard deviation of inflation is for the four years ending in 1976 Q1, while output gap variability and interest rate variability are also close to their full-sample peaks in 1976. This exceptional volatility of the explanatory variables implies that the 1972 76 sample contains more information than the small number of observations would suggest, and explains why the estimates of **(3)** given in Table B below are precise and interpretable.

Estimates of equation **(3)**, using the lag length of j = 2 quarters, are presented as the first regression in Table B; the second regression in Table B shows a more parsimonious version of the same model that results from deleting the least significant variables. The long-run estimated response to inflation is 0.14; while this is significantly above zero, it is very low in relation to Taylor's (1993) coefficient of 1.5. Indeed, if one uses $R_t \quad {}_4 p_{t \; 1}$ as a rough guide to the real interest rate $R_t \quad 4E_t \quad p_{t+1}$, the estimate suggests that policy-makers permitted each 1 percentage point increase in the inflation rate to reduce the real interest rate by more than 80 basis points. In addition, the output gap response coefficient is large (0.59) and highly significant.

These results are consistent with other descriptions of macroeconomic policy during this period (see Campbell (1993, page 471)). 1972 was the year of the Heath government's 'U-turn' in macroeconomic policy. The government maintained that it could stimulate output and employment through expansionary monetary and fiscal policies, while holding down inflation through statutory wage and price controls.(16) This reflected a view, initially shared by the Labour government when it was elected in March 1974, that the break-out of inflation in the 1970s largely reflected autonomous wage and price movements, and that the appropriate policy response was to take actions that exerted downward pressure on the prices of particular products, rather than to focus on a monetary policy response.(17) Examples of the non-monetary attempts to control inflation over this period include the statutory incomes policy announced by the Heath government in November 1972 and the voluntary incomes policy pursued by the Labour government from 1974; the extension of food subsidies in the March 1974 Budget (which were intended to reduce the Retail Price Index by 1.5%); and cuts in indirect taxation in the July 1974 mini-Budget (Bank of England (1974a, 1974b)).

In the final column of Table B, I estimate a forward-looking version of the Taylor rule, under which monetary policy responds to the estimated contemporaneous values of the output gap and inflation, and to expected annual inflation one quarter, two quarters, three quarters, and (as in Clarida, Gali and Gertler (1998)) one year ahead:

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(16) From 1973 to 1980, the government periodically used the Supplementary Special Deposits Scheme (the 'Corset') as a quantitative control on the expansion of banks' balance sheets and therefore of the £M3 monetary aggregate. However, it is likely that this served principally as a device for restricting artificially the measured growth of £M3 without changing monetary base growth or interest rates, rather than as a genuinely restrictive monetary policy measure. The Bank of England (1982) acknowledged that the Corset 'tended to encourage the diversion of banking business into other channels'. See also Minford (1993, page 423).

(17) In keeping with this view, Sir Edward Heath has argued in his autobiography that 'Our policy of expanding demand was essential to growth and employment and, therefore, broadly non-inflationary, on which basis inflation resulted largely from wage settlements' (Heath (1998, page 405)).

$$R_t = \quad + a_0 \, \mathrm{E}_{t\ 1} \ \ {}_4p_t + a_{\ 1} \, \mathrm{E}_{t\ 1} \ \ {}_4p_{t+1} + a_{\ 2} \, \mathrm{E}_{t\ 1} \ \ {}_4p_{t+2} + a_{\ 3} \, \mathrm{E}_{t\ 1} \ \ {}_4p_{t+3} \qquad \textbf{(4)}$$
$$+ a_{\ 4} \, \mathrm{E}_{t\ 1} \ \ {}_4p_{t+4} + b_0 \, \mathrm{E}_{t\ 1} \, \tilde{y}_{\ t} + \mathrm{S}_{i=1}{}^{j} c_i \, R_{t\ i} + e_t$$

Estimation is by instrumental variables.[18] In contrast to the backward-looking specification, no coefficient is significant. If the forward-looking terms in **(4)** are added to the backward-looking specification, none of these additional variables is significant, and their inclusion leaves the other coefficients basically unchanged at their previously estimated values. Thus, in the 1972 76 period monetary policy-makers appear to have moved the short-term interest rate reacted mainly in response to past behaviour of the output gap and, to a very limited extent, inflation. Conditional on those reactions, they do not appear to have responded to the current gap or to current or expected inflation.

5. July 1976 to April 1979

The next regime begins with the announcement of targets for the monetary aggregate, £M3, in July 1976, and finishes with April 1979, the last month prior to the election of the Conservative government.

Quarterly estimation is inhibited by the fact that there are only eleven quarterly data points and the specifications to be estimated contain at least four parameters. Instead, I use monthly data, and measure the output gap by the quadratically detrended log of industrial production.[19]

As before, I therefore estimate both a purely backward-looking Taylor rule, equation **(3)**, as well as a forward-looking Taylor rule with interest rate smoothing, analogous to equation **(4)**:[20]

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(18) The inclusion of regressors dated later than t+1 should in principle introduce moving-average error processes into the error term of the equation; however, serial correlation in the estimated residuals for this equation (as well as in similar equations reported in this paper for other sample periods) does not appear to be significant.

(19) Quarterly averages of this series have a correlation of 0.90 with the detrended output series over 1971 Q1 1998 Q4, and of 0.77 over 1976 Q3 1979 Q1. An alternative monthly output gap measure is retail sales volume (again, in quadratically detrended log form). This is a poorer indicator of GDP movements, as its correlation on quarterly data with detrended GDP is 0.75 for 1971 Q1 1998 Q4 and 0.60 for 1976 Q3 1979 Q1.

(20) But, in both cases, with ${}_{12}p_t$ instead of ${}_4p_t$ as the inflation variable, reflecting the use of monthly data.

$$R_t = \quad + a_0 \mathrm{E}_{t\ 1}\ {}_{12}p_t + a_{\ 3}\, \mathrm{E}_{t\ 1}\ {}_{12}p_{t+6} + a_{\ 6}\, \mathrm{E}_{t\ 1}\ {}_{12}p_{t+9} \qquad \textbf{(5)}$$

$$+ a_{\ 12}\, \mathrm{E}_{t\ 1}\ {}_{12}p_{t+12} + b_0 \mathrm{E}_{t\ 1}\, \tilde{y}_{\ t} + \mathrm{S}_{i=1}^{j} c_i R_{t\ i} + e_t.$$

The first regression in Table C provides estimates of equation **(3)**, with lag length $j = 3$ months. It delivers insignificant and wrongly signed coefficients on both inflation and the output gap. The forward-looking rule, **(5)**, is estimated in unrestricted form as the second regression in Table C. While there are many insignificant coefficients due to the large number of parameters being estimated, the long-run response to (current and expected future) inflation is now positively signed. Deleting the insignificant coefficients on $\mathrm{E}_{t\ 1}\,\tilde{y}_{\ t}$, $\mathrm{E}_{t\ 1}\ {}_{12}p_t$, and $R_{t\ 3}$ produces the third regression in Table C. Of the coefficients on inflation in this regression, that on $\mathrm{E}_{t\ 1}\ {}_{12}p_{t+9}$ is the largest, and is retained in the final, restricted regression of Table C.

If monetary policy over this period is to be described using a Taylor rule, the best characterisation seems to be that interest rates responded to expected annual inflation nine months ahead, with interest rate smoothing and no separate response to the output gap. The long-run response to inflation is estimated at 0.62 (more than four times the estimated response for 1972 76), significantly above zero, but also significantly below unity.

The specifications estimated in Table C can be thought of as the 'implied Taylor rule representation' of a policy regime which reacted to monetary growth and to the exchange rate, whose depreciation in 1976 was a major factor in triggering a tighter monetary policy. This interpretation is consistent with Taylor (1999c), who argues that monetary targeting and exchange rate targeting imply particular parameterisations of the Taylor rule. But Clarida, Gali and Gertler (1998) find in their studies of several industrial countries that occasionally money growth and the exchange rate enter their estimated policy rules separately, even after conditioning on the output gap and expected inflation. This is the case also for the United Kingdom for the 1976 79 period.(21) Adding money growth and exchange rates to the final regression in

(21) And, as shown below, the 1987 90 period, for which the foreign nominal interest rate enters the policy rule.

Table C, I found that both lagged £M3 annual growth ($_{12}£m3_{t\ \ 1}$) relative to target[22] and the log of the current trade-weighted nominal exchange rate (s_t) mattered. The following estimates are representative of these findings:[23]

$$R_t = \underset{(0.175)}{0.697} + \underset{(0.052)}{0.337}\ E_{t\ \ 1}\ \ {}_{12}p_{t+9} + \underset{(0.026)}{0.084}\ (\ \ {}_{12}£m3_{t\ \ 1}\quad [\ \ {}_{12}£m3]^{tar})\quad \underset{(0.037)}{0.147}\ s_t \qquad \textbf{(6)}$$

$$+ \underset{(0.136)}{0.688}\ R_{t\ \ 1}\quad \underset{(0.106)}{0.239}\ R_{t\ \ 2}$$

SEE = 0.0051, DW = 2.13,

with long run solution:

$$R_t = \underset{(0.292)}{1.266} + \underset{(0.044)}{0.611}\ E_{t\ \ 1}\ \ {}_{12}p_{t+9} + \underset{(0.048)}{0.152}\ (\ \ {}_{12}£m3_{t\ \ 1}\quad [\ \ {}_{12}£m3]^{tar})\quad \underset{(0.062)}{0.267}\ s_t \qquad \textbf{(7)}$$

These equations imply that an exchange rate depreciation or an increase in money growth prompted an increase in nominal interest rates. The inclusion of these new terms leaves the coefficient on inflation basically unaltered, although their presence in the equation might suggest a tighter policy than suggested by the size of the estimated coefficient on inflation alone.

Nevertheless, it is important not to over-emphasise the tightness of monetary policy in 1976 79. One reason why I find that the inflation response is larger in 1976 79 than previously is that the nominal interest rate was cut aggressively (by more than 900 basis points from late 1976 to early 1978) ahead of a fall in inflation from mid-1977 to late 1978.[24] In retrospect, this easing appears to have reversed much of the progress achieved in reducing inflation. Reflecting the easier monetary policy, monetary base (M0) growth, which had fallen into single digits in late 1977, rose sharply and peaked at more than 17% in July 1978; inflation troughed at 7.6% in October 1978 and continued to rise until May 1980 (when it stood at 21%).

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(22) For the observations relevant to this estimation period, the values of this target are 11.0% (May 1976 to April 1978) and 10% (May 1978 to April 1979). These are the mid-points of the successive targets announced for annual £M3 growth.

(23) In these equations, s_t is treated as endogenous and six lags of s_t are added to the instrument list.

(24) The significance of the exchange rate term in the estimated policy rule is consistent with one reason for the 1977 78 policy easing being a desire to restrain the exchange rate appreciation that occurred during that period.

Another reason for doubting the tightness of policy in 1976–79 is the average *level* of interest rates. From July 1976 to April 1979, the nominal Treasury bill rate averaged 9.32%. Since inflation responds sluggishly to monetary policy changes, central banks' control over nominal interest rates gives them considerable leeway in the short run in affecting the behaviour of real interest rates. If one measures the real interest rate by $R_t - \Delta_{12} p_{t-1}$ — the Treasury bill rate minus the most recent annual inflation rate — the real interest rate did not become positive until June 1978; if one measures it by the *ex post* real interest rate, this also only became positive in that month, and it averaged −3.14% over 1976–79.[25] While this is higher than the −5.72% ex post real rate observed in 1972–76,[26] it indicates a continuing tendency by policy-makers until 1978 to hold nominal interest rates well below the actual and prospective inflation rate.[27]

6. May 1979 to February 1987

The next regime begins with the election of the Conservative government in May 1979 and concludes with the Louvre Accord on exchange rates in February 1987. I treat this period as a single regime as, throughout, domestic monetary policy emphasised control of inflation, and the exchange rate was largely permitted to float freely. Arguably, the sample should begin in March 1980 with the announcement of the Medium Term Financial Strategy (MTFS) and end in October 1985 with the abandonment of £M3 targeting. Large misses of the £M3 target were permitted as early as mid-1980, however, and the MTFS was heavily revised in 1982. It was also clear prior to 1985 that key policy-makers and advisers did not regard overshoots of the £M3 target as intolerable, provided that other measures of monetary conditions, such as monetary base growth or interest rates, were not indicating that monetary

(25) The annualised rate of monthly RPIX inflation from October 1976 to July 1979 averaged 1200*E[Δp] = 12.45%.

(26) The mean of 1200*[Δp] from October 1972 to September 1976 was 15.53, while that of the nominal Treasury bill rate from July 1972 to June 1976 was 9.81%, implying the *ex post* real interest rate was −5.72%.

(27) Judd and Rudebusch (1998, Table A) report an average real interest rate of 2 basis points for the United States for the 1970–78 period, so the phenomenon of low or negative real interest rates in the 1970s was more pronounced in the United Kingdom than in the United States.

policy was loose.[28] For these reasons it may be satisfactory to treat 1979 87 as one regime rather than subdivide it according to the priority placed on the £M3 target.[29]

The estimation period is 1979 Q2 1987 Q1, although I check quarterly results with estimates on monthly data from May 1979 to February 1987. I first estimate a purely backward-looking Taylor rule, equation **(3)**. OLS estimates of **(3)**, for lag length $j = 1$, appear in the first column of estimates in Table D.[30] The long-run response of the nominal interest rate to inflation is estimated at 0.34, significantly different from zero but also significantly below unity. The long-run output gap response is 0.26.

In the second regression in Table D, the forward-looking version of the Taylor rule, equation **(4)**, is estimated. This specification produces long-run estimates of the output gap response parameter of 0.16 and the inflation response parameter of 0.31 — close to the estimates from the backward-looking specification. The estimate of the interest rate smoothing parameter is also similar, at 0.33, compared with 0.34 in the previous regression.

If the regressors from the backward and forward-looking specification are all included in a single equation, the current values of inflation and the output gap appear to be the most important, and the remaining regressors ($\tilde{y}_{t\ 1}$, ${}_4p_{t\ 1}$, $E_{t\ 1}\ {}_4p_{t+1}$, $E_{t\ 1}\ {}_4p_{t+2}$, $E_{t\ 1}\ {}_4p_{t+3}$, and $E_{t\ 1}\ {}_4p_{t+4}$) can be deleted.[31] This produces the final regression of Table D. It appears that the 1979 87 period is best characterised by a Taylor rule with long-run coefficients of 0.38 and 0.15 on inflation and the output gap respectively, and that the interest rate was moved in response to estimated current inflation rather than to expectations of

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(28) See, for example, the discussions of this period in Goodhart (1989, page 303) and Minford (1993, pages 409–12).

(29) As a check on this approach, I added the lagged deviation of annual £M3 growth from target as a regressor to the preferred specification (the final regression) in Table D below, re-estimating over the sub-sample for which £M3 targeting was officially in force (1979 Q2 1985 Q3). The £M3 target deviations variable had long-run coefficient 0.159, standard error 0.114, and the other long run coefficients were $w_0 = 0.087$ (0.009), $w_1 = 0.331$ (0.084), and $w_2 = 0.239$ (0.181), all similar to the estimates in Table D.

(30) The restriction on lag length is not rejected against the alternative of a two-lag specification by an F test: F(3, 25) = 0.99 [p value = 0.41].

(31) An F test for the restriction that these variables have zero coefficients produces F(6, 22) = 0.39 [p value = 0.88].

future inflation. The output gap response is not statistically significant[32] but its sign and magnitude in the equation are supported by monthly estimates of the same regression.[33]

Table D leaves us with an apparent anomaly. Inflation fell during much of the 1979 87 period, particularly in the first five years, when twelve-month growth in the RPIX fell from 21.0% in May 1980 to 4.0% in September 1984. In the last month of the sample period, February 1987, inflation had fallen to 3.7%. The results in Table D indicate that this disinflation was accomplished under a regime which can be described by a Taylor rule with a less than one-for-one long-run response of the nominal interest rate to inflation (and, indeed, one where the long-run response was smaller than in 1976 79). Yet analysis of historical periods using the Taylor rule approach, such as that in Clarida, Gali and Gertler's (2000) discussion of the US experience, typically characterises episodes of disinflation as periods during which the long-run inflation response exceeded unity.

Why, in that case, were the interest rates in force in the United Kingdom during this period consistent with disinflation? The answer appears to lie in the high level of real interest rates. The Taylor rule approach often takes for granted that the average real interest rate over a given sample period is not in excess of its long-run equilibrium level, where the latter is normally assumed to lie in the 2% 4% range. For 1979 87, however, this position seems untenable since *ex post* real rates averaged 4.66% per annum, approximately 750 basis points higher than their 1976 79 level.[34] Thus while the *movements* of the nominal interest rate to inflation over 1979 87 were not indicative of an aggressively

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[32] If added to this specification, the lagged output gap enters less significantly than the contemporaneous output gap.

[33] On monthly data from May 1979 to February 1987, the preferred IV estimates are:

$$R_t = 0.023 + 0.097\, E_{t\ 1}\ {}_{12}p_t + 0.036\, E_{t\ 1}\, \tilde{y}_t + 0.729\, R_{t\ 1}$$

(0.006) (0.032) (0.021) (0.072)

SEE = 0.0078, DW = 1.93, p value for LM test for first to twelfth-order autocorrelation = 0.41.

Six lags of each variable plus a constant served as instruments. The long-run response parameters are: $w_0 = 0.088$ (0.007), $w_1 = 0.359$ (0.062), and $w_2 = 0.133$ (0.081).

[34] The average of the nominal Treasury bill rate from May 1979 to February 1987 was 11.60%; the average annualised RPIX inflation from August 1979 to May 1987 was 6.95%.

anti inflationary policy, the average prevailing *level* of interest rates was consistent with a restrictive monetary policy. This is recognised by Clarida, Gali and Gertler (1998, page 1,054) who observe: 'Monetary policy boiled down to keep[ing] real rates steadily high over this period, even when inflation was low during the mid-1980s'.

7. March 1987 to September 1990

The next regime, 1987 90, largely consisted of informal linking of the pound to the Deutsche Mark. This includes not only the 'shadowing' of the Mark in 1987 1988, but also the subsequent period (1988 90), during which UK monetary policy continued to follow German policy closely. For example, in October 1989 the United Kingdom 'immediately followed' the Bundesbank's 100 basis point increase in short-term interest rates with an increase of the same amount (Lawson (1992, page 951)).

I estimate two models, in both of which, as in Clarida, Gali and Gertler (1998), the UK nominal interest rate responds to the German day-to-day nominal interest rate R_t^G, annual inflation, and the output gap. The backward-looking version of this specification, to be estimated on monthly data from March 1987 to September 1990, is:

$$R_t = \quad + \quad {}_G R_t^G + S_{i=1}^{j} a_i \quad {}_{12}p_{t\ \ i} + S_{i=1}^{j} b_i\ \tilde{y}_{t\ \ i} + S_{i=1}^{j} c_i R_{t\ \ i} + e_t \qquad \textbf{(8)}$$

and the forward-looking version is:

$$R_t = \quad + \quad {}_G R_t^G + a_0 \mathrm{E}_{t\ \ 1} \quad {}_{12}p_t + a_{\ 3} \mathrm{E}_{t\ \ 1} \quad {}_{12}p_{t+3} + a_{\ 6} \mathrm{E}_{t\ \ 1} \quad {}_{12}p_{t+6} \qquad \textbf{(9)}$$

$$+ a_{\ 9} \mathrm{E}_{t\ \ 1} \quad {}_{12}p_{t+9} + a_{\ 12} \mathrm{E}_{t\ \ 1} \quad {}_{12}p_{t+12} + b_0 \mathrm{E}_{t\ \ 1} \tilde{y}_t + S_{i=1}^{j} c_i R_{t\ \ i} + e_t$$

Due to the presence of R_t^G in both equations, instrumental variables estimation is used throughout.

The first regression reported in Table E contains the estimates of **(6)**, with lag length of $j = 1$ month.[35] These estimates indicate a very sizable effect of the German nominal interest rate. There is also considerable interest rate smoothing (over and above any smoothing implied by following German interest rates) and a strong and statistically significant response to the output gap. The responses to domestic inflation, however, are wrongly signed and insignificant; the second regression in Table E re-estimates **(6)** after restricting the inflation terms to have zero coefficients.[36] This is the preferred specification, as the estimates of **(7)** (the final regression in Table E) indicate no evidence that expected future inflation was important.

The results in Table E therefore suggest that from 1987 to 1990, the Bundesbank's monetary policy, rather than a domestic variable, served as UK monetary policy's nominal anchor. But domestic factors continued to be a consideration, as indicated by the significant degree of domestic interest rate smoothing, and by the positive coefficient on the output gap.

The estimates of the preferred model suggest that the long-run response of UK to German rates was 1.11. This is not significantly above unity, but is nearly double the estimate in Clarida, Gali and Gertler (1998), who found that, conditional on domestic factors, the UK nominal interest rate responded to the German day-to-day nominal interest rate R_t^G with a long-run coefficient of 0.60. Their sample period, however, was 1979 90, so their smaller estimate may be a result of combining a regime in which German monetary policy was not a major factor in UK policy formation (1979 87) with one in which Bundesbank (or European Monetary System) policy became a dominant consideration (1987 90). Consistent with this possibility, re-estimating equation **(6)** over the sample period May 1979 September 1990 produces a long-run coefficient on R_t^G of 0.578 (standard error 0.268), while R_t^G is not significant if **(8)** is estimated over 1979 87.

The results in Table E raise intriguing questions about the behaviour of UK inflation in the late 1980s. Judged by the interest rate, UK monetary policy appears to have been 'tight' on average in this period: the real interest rate was

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(35) A test of this restriction on equation **(6)** against the alternative of a two-lag specification produces an insignificant statistic of F(3, 35) = 1.19 [p value = 0.33] .

(36) The current output gap is insignificant if added to this specification.

high (5.76% *ex post*), and nominal interest rates were on average about 6% higher than the German rates which they closely tracked. Consistent with this, Stuart (1996, Chart 4) finds that the UK nominal interest rate was below that recommended by Taylor's (1993) original version of the Taylor rule for only two quarters in the 1986–88 period. Yet RPIX inflation rose by more than 5 percentage points from late 1987 to late 1990. One possible explanation is that both money growth and interest rates matter for aggregate demand, and that the outbreak of inflation was partly due to high rates of monetary growth.(37) Consistent with this, measures of monetary policy stance based on base money growth suggest that monetary policy was loose over 1986–88 (Stuart (1996, Chart 3)).(38) This proposed explanation is, however, speculative, and a fuller analysis of the question would require a complete model of the economy and of the monetary transmission mechanism.

8. October 1992 to April 1997

The next regime for which a policy rule is estimated is 1992–97, the period beginning with the October 1992 announcement of the new policy of inflation targeting (following the United Kingdom's departure from the Exchange Rate Mechanism in September) to the Bank of England receiving operational independence in May 1997.

Quarterly data from 1992 Q4 to 1997 Q1 are used to estimate the Taylor rule both in its backward-looking form (equation **(3)**) and forward-looking form (equation **(4)**). The first set of estimates in Table F is for equation **(3)**, with lag length $j = 1$.(39) The inflation responses are wrongly signed and insignificant. Far more plausible are the estimates of the forward-looking rule **(4)** — the second regression in Table F. This equation implies a long-run inflation response of 1.77, which, unlike the estimates in the previous section, exceeds unity. The final regression imposes valid restrictions on the preceding regression by retaining only one of the inflation terms (expected annual inflation one quarter ahead). The long-run estimated coefficients on inflation

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(37) In Nelson (2000), I find that real money base growth has significant effects on aggregate demand in both the United States and the United Kingdom, even after controlling for the effect of the short-term real interest rate.

(38) An alternative explanation is that the outbreak of inflation in the late 1980s reflects rapid *broad* money growth in 1985–86 (Congdon (1992)).

(39) The test statistic for excluding a second lag of each variable is F(3, 11) = 1.71 [p value = 0.22].

and the output gap are 1.27 and 0.47, respectively, which are remarkably close to the (1.5, 0.5) combination used by Taylor (1993) to characterise US monetary policy.

As a check on these results, I estimated the corresponding specification on monthly data, starting with equation **(5)** with lag length $j = 3$ months, then successively deleting the insignificant terms. This procedure led to a restricted specification similar to the preferred quarterly regression in Table F, with long-run response parameters of $w_1 = \ 1.472$ (standard error 0.424) to expected inflation and $w_2 = \ 0.301$ (0.068) to the output gap.[40]

Mervyn King, who was a monetary policy maker during this sample period, made comments at a February 1999 press conference that shed light on the results in Table F:

'…[T]he Taylor rule is no more in a sense than a restatement of the obvious, which is that if inflation looks to be higher, either now or in prospect, than the target, then you're likely to want to raise interest rates, and if it looks as if it's falling, and is likely to be lower than the target, then you'll cut interest rates. It's common sense, but that's why probably most central banks that have been successful appear ex post to have been following a Taylor rule, even if they'd never heard of that concept when they were actually making the decisions.'[41]

Thus, the results in Table F do not imply that policy-makers *literally* followed a Taylor rule over 1992 97.

The results in this section may be contrasted with those of Kuttner and Posen (KP) (1999). Estimating on monthly data for October 1992 December 1997, a sample period similar to that in this section, they find a coefficient of essentially zero on inflation. The main differences between their specification

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[40] On monthly data from October 1992 to April 1997, the preferred IV estimates are:

$R_t = 0.007 + 0.620\, E_{t\ 1}\ {}_{12}p_{t+3} + 0.127\, E_{t\ 1}\, \tilde{y}_t + 0.579\, R_{t\ 1}$

(0.005) (0.263) (0.031) (0.091)

SEE = 0.0027, DW = 1.69, p value for LM test for first to twelfth-order autocorrelation = 0.81. Six lags of each variable and a constant served as instruments, and the test statistic for the validity of this specification as a restriction on **(5)** was $F(6, 45) = 0.56$ [p value = 0.76].

[41] Remarks at *Inflation Report* press conference, 10 February 1999, Bank of England; author's verbatim transcript.

and the final regression in Table F are: (*a*) KP's estimation is on monthly data; (*b*) their output gap proxy is the unemployment rate; (*c*) the inflation variable in their regressions is the annualised monthly inflation rate (12× p); (*d*) they use lagged inflation, 12× $p_{t\ 1}$, as their proxy for expected future inflation, instead of instrumenting for the latter variable.[(42)] Differences (*a*) and (*b*) are not critical in explaining the discrepancies between my results and KP's, while (*c*) and (*d*) are more important. This is illustrated by the fact that if one estimates by IV a specification of the form $R_t = a_1 12\times \mathrm{E}_{t\ 1}\ p_{t+3} + b_1\ \mathrm{E}_{t\ 1}\,\tilde{y}_t +$ $c_1 R_{t\ 1}$, on monthly data from October 1992 to April 1997, the results are:[(43)]

$a_1 =$ 0.007 (0.020), b_1 = 0.081 (0.023), and c_1 = 0.747 (0.054),

which agrees with KP's finding of a zero long-run inflation response. However, if one simply changes the inflation variable in the estimated rule from one quarter ahead expected monthly inflation ($12\times \mathrm{E}_{t\ 1}\ p_{t+3}$) to one quarter ahead expected *annual* inflation ($\mathrm{E}_{t\ 1}\ \ _{12}\ p_{t+3}$), without making any alterations to the instrument list, the results change dramatically to:[(44)]

a_1 = 0.670 (0.268), b_1 = 0.131 (0.032), and c_1 = 0.565 (0.092),

which implies long-run responses of w_1 = 1.54 (0.413) to inflation and w_2 = 0.302 (0.067) to the output gap, in line with the estimates in Table F. Thus, the use of annual inflation in the estimated rule is crucial for the results in this section. But one can argue for the use of this inflation variable on *a priori* grounds, since the United Kingdom's inflation target has always been expressed in terms of the annual (year-ended) inflation rate, rather than the monthly inflation rate.

The difference in results outlined above sheds light on an argument advanced by KP that under a successful policy of controlling inflation, expected future inflation should always be constant, leading to unforecastable inflation

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(42) Another difference is that they use seasonally adjusted RPIX, while the regressions in this paper use (yearly growth in) the not seasonally adjusted RPIX.

(43) The seasonally adjusted monthly log-change in the RPIX; detrended industrial production; and the Treasury bill rate measure inflation, the output gap, and the interest rate respectively. Six lags of each variable and a constant serve as instruments.

(44) This regression differs from that reported in footnote 40 above only in its use of monthly instead of annual inflation in the instrument list.

behaviour, and to the absence of an observed inflation/interest rate relationship.[45] If empirically valid, this argument would cast doubt on the interpretation — made in this paper and others in the Taylor rule literature — of coefficients in estimated Taylor rules as policy response coefficients. However, on UK data, KP's argument does not appear to be empirically valid, especially once the annual inflation rate is used. The R^2s of the first-stage regressions for one quarter ahead expected future annual inflation used in the instrumental variables estimates in this section are 0.78 for the 1992 97 quarterly regression and 0.62 0.68 for the monthly regressions, so inflation targeting has not made inflation unpredictable.

Finally, the average value of the *ex post* real interest rate over 1992 97 deserves comment, as it was 2.99%, well below 1980s levels. To a considerable extent this must reflect factors other than monetary policy, such as a global fall in the equilibrium real interest rate in the 1990s. But it is also possible that the move to inflation targeting reduced *ex post* real interest rates by lowering the risk that a sudden outbreak of inflation due to loose monetary policy would occur. If so, then it may be possible to control inflation without resort to real interest rates as high as those in the 1980s.

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(45) This is a special case of the identification issue discussed in Section 2 above.

9. Conclusion

This paper attempted to characterise UK monetary policy from 1972 to 1997 by a Taylor rule with smoothing. Estimation took place for five separate policy regimes — on quarterly data for regimes of four years or more in length, and on monthly data otherwise.[46] The results by regime are summarised in Table G.

In some respects, the results are in keeping with standard analysis of the properties of the Taylor rule under different settings of the inflation response parameter. For example, the 1972 76 period of extremely high inflation is characterised by a near-zero response of nominal interest rates to the inflation rate, in keeping with the results of Clarida, Gali and Gertler (2000), Judd and Rudebusch (1998), and Taylor (1999b), who suggest that inflation is more reliably controlled when this response parameter exceeds unity. As their analysis also would suggest, the low-inflation period from 1992 is characterised by a Taylor rule with a response parameter above unity.

On the other hand, a major contrast with the standard analysis is that periods of relatively restrictive monetary policy are *not* necessarily characterised by a greater than one-for-one long-run response of the nominal interest rate to inflation. Rather, the tightening of policy is sometimes manifested in a sharp increase in the *average level* of the real interest rate. While changes in the level of the real interest rate in the long run tend to be due to changes in the structure of the economy which alter the steady-state real interest rate, monetary policy can influence the real rate heavily in the short run, due to inflation inertia. In particular, tighter monetary policy from 1979 to 1987 led to an increase in the average *ex post* real interest rate of 750 basis points compared with 1976 79. This tightening was reflected in an increase in (a component of) the intercept of the estimated Taylor rule, rather than in an increase in the estimated inflation response parameter. This contrasts with US studies, such as those by Judd and Rudebusch (1998) and Clarida, Gali and Gertler (2000); there, the disinflation of the early 1980s is associated with an increase in the estimated inflation response parameter, compared with estimates based on data up to 1979.

The results in this paper also provide evidence for the United Kingdom relevant to the debate between Rudebusch (1998) and Sims (1998) on the treatment of

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[46] No policy rule was estimated for a sixth regime, the United Kingdom's membership of the Exchange Rate Mechanism from 1990 to 1992.

monetary policy regime shifts in VAR analysis. Rudebusch criticises the VAR literature for largely ignoring breaks in the US monetary policy rule, while Sims argues that non-constancy in the policy rule is ‘of modest quantitative importance’. For the United Kingdom, the estimates in this paper suggest that it is untenable to treat the monetary policy rule as relatively constant over the sample period 1972 97. But restricting a VAR’s sample period to a single regime would imply a very small number of observations; while estimating the VAR over a longer period, and allowing for changes in both intercept and response coefficients in the policy rule, would make the VAR non-linear in parameters. A reasonable compromise would be to estimate the VAR over a long period, but incorporate intercept-shift dummies for each of the six different UK policy regimes into which I have divided 1972 97. This would preserve the VAR’s essential linearity, but would recognise the major shifts in the mean of the real interest rate across regimes.

Table A: OLS estimates of equation (2)
Sample period: 1972 Q3 to 1997 Q1

	Coefficient
Constant	0.0824 (0.0046)
$_{4}p_{t\;1}$	0.1922 (0.0442)
$\tilde{y}_{t\;1}$	0.2725 (0.0877)
R^2	0.226
Standard error of estimate (SEE)	0.0258
DW	0.25

Note: numbers in parentheses are standard errors.

Table B: Taylor rule estimates for the United Kingdom
Sample period: 1972 Q3 to 1976 Q2

	Estimation method		
	OLS	OLS	IV[a]
	0.054 (0.014)	0.053 (0.012)	0.033 (0.023)
w_0[b]	0.074 (0.015)	0.072 (0.009)	0.230 (1.452)
a_1	0.088 (0.183)	0.102 (0.050)	—
a_2	0.002 (0.170)	—	—
w_1	0.124 (0.077)	0.138 (0.049)	1.746 (7.605)
b_0	—	—	0.126 (0.332)
b_1	0.047 (0.204)	—	—
b_2	0.458 (0.203)	0.437 (0.135)	—
w_2[e]	0.570 (0.198)	0.591 (0.132)	0.866 (4.844)
c_1	0.224 (0.267)	0.260 (0.174)	0.649 (0.599)
c_2	0.050 (0.245)		0.493 (0.599)
Sc_I	0.274 (0.213)	0.260 (0.174)	1.142 (0.843)
Additional coefficients[f] on:			
$E_{t\ 1}\ {}_4p_t$	—	—	1.063 (5.984)
$E_{t\ 1}\ {}_4p_{t+1}$	—	—	0.779 (5.687)
$E_{t\ 1}\ {}_4p_{t+2}$	—	—	3.461 (21.42)
$E_{t\ 1}\ {}_4p_{t+3}$	—	—	2.394 (16.99)
$E_{t\ 1}\ {}_4p_{t+4}$	—	—	0.971 (3.49)
SEE	0.0106	0.0092	0.0169
DW	2.20	2.19	2.03
LM test for first to fourth-order serial correlation [p value]	0.56	0.64	0.29

a. Instruments: constant, and lags 1 4 of R_t, ${}_4p_t$, and $\tilde{y}_t$.
b. $w_0 = \ / (1 \ c_1)$.
c. $w_1 = (a_1 + a_2) / (1 \ c_1)$.
d. Sum of long-run coefficients on current and future inflation.
e. $w_2 = (S_{i=0}^{j} b_i) / (1 \ c_1)$.
f. Long-run coefficients.

Table C: Taylor rule estimates for the United Kingdom
Sample period: July 1976 to April 1979

	Estimation method			
	OLS	IV[a]	IV[a]	IV[a]
	0.057 (0.013)	0.043 (0.026)	0.022 (0.012)	0.007 (0.005)
W_0[b]	0.277 (0.063)	0.056 (0.055)	0.060 (0.047)	0.018 (0.011)
a_1	0.074 (0.213)	—	—	—
a_2	0.046 (0.315)	—	—	—
a_3	0.268 (0.185)	—	—	—
w_1	1.157[c] (.419)	0.284[d] (0.422)	0.275[d] (0.379)	0.620[d] (0.088)
b_0	—	0.108 (0.187)	—	—
b_1	0.098 (0.074)	—	—	—
b_2	0.067 (0.068)	—	—	—
b_3	0.176 (0.069)	—	—	—
W_2[e]	1.646 (0.557)	0.139 (0.173)	—	—
c_1	1.015 (0.186)	1.119 (0.360)	0.994 (0.210)	1.095 (0.156)
c_2	0.425 (0.264)	0.862 (0.746)	0.354 (0.303)	0.475 (0.130)
c_3	0.204 (0.171)	0.031 (0.312)	—	—
Sc_I	0.793 (0.069)	0.225 (0.522)	0.641 (0.186)	0.620 (0.095)
Additional coefficients[f] on:				
$E_{t\ 1}\ {}_{12}p_t$	—	0.430 (0.391)	—	—
$E_{t\ 1}\ {}_{12}p_{t+3}$	—	0.036 (0.359)	0.594 (0.471)	—
$E_{t\ 1}\ {}_{12}p_{t+6}$	—	0.888 (0.493)	0.386 (0.722)	—
$E_{t\ 1}\ {}_{12}p_{t+9}$	—	0.042 (0.675)	0.917 (1.090)	0.620 (0.088)
$E_{t\ 1}\ {}_{12}p_{t+12}$	—	0.180 (0.484)	0.436 (0.644)	—
SEE	0.0074	0.0114	0.0079	0.0071
DW	2.22	1.07	1.80	2.09
LM test for autocorrelation, lags 1 to 12 [p value]	0.59	0.53	0.76	0.65

a. Instruments: constant, and lags 1 6 of R_t, ${}_{12}p_t$, and $\tilde{y}_t$.
b. $w_0 = \ / (1 \ \ S_{i=1}^{j} c_i)$.
c. $w_1 = (S_{i=1}^{j} a_i) / (1 \ \ S_{i=1}^{j} c_i)$.
d. Sum of long-run coefficients on current and future inflation.
e. $w_2 = (S_{i=0}^{j} b_i) / (1 \ \ S_{i=1}^{j} c_i)$.
f. Long-run coefficients.

Table D: Taylor rule estimates for the United Kingdom
Sample period: 1979 Q2 to 1987 Q1

	Estimation method		
	OLS	IV[a]	IV[a]
	0.060 (0.018)	0.060 (0.017)	0.054 (0.014)
w_0[b]	0.090 (0.007)	0.089 (0.007)	0.086 (0.006)
a_1	0.227 (0.086)		—
w_1	0.342[c] (0.063)	0.308[d] (0.080)	0.380[d] (0.058)
b_0	—	0.109 (0.098)	0.091 (0.071)
b_1	0.171 (0.079)	—	—
w_2[e]	0.258 (0.124)	0.164 (0.143)	0.145 (0.122)
c_1	0.337 (0.199)	0.333 (0.183)	0.373 (0.156)
Additional coefficients[f] on:			
$E_{t\ 1}\ \ _4p_t$	—	0.220 (0.311)	0.380 (0.058)
$E_{t\ 1}\ \ _4p_{t+1}$	—	0.296 (0.434)	—
$E_{t\ 1}\ \ _4p_{t+2}$	—	0.179 (0.415)	—
$E_{t\ 1}\ \ _4p_{t+3}$	—	0.136 (0.411)	—
$E_{t\ 1}\ \ _4p_{t+4}$	—	0.251 (0.375)	—
SEE	0.0112	0.0099	0.0099
DW	1.63	1.93	1.76
p value for LM test for first to fourth-order serial correlation	0.22	0.84	0.68

a. Instruments: constant, and lags 1 4 of R_t, $_4p_t$, and $\tilde{y}_t$.

b. $w_0 = \ / (1 \ \ c_1)$.

c. $w_1 = a_1 / (1 \ \ c_1)$.

d. Sum of long-run coefficients on current and future inflation.

e. $w_2 = (S_{i=0}^{j} b_i) / (1 \ \ c_1)$.

f. Long-run coefficients.

Table E: Taylor rule estimates for the United Kingdom
Sample period: March 1987 to September 1990

	Estimation method		
	IV[a]	IV[a]	IV[a]
	0.017 (0.006)	0.017 (0.005)	0.014 (0.014)
w_0[b]	0.036 (0.006)	0.036 (0.005)	0.031 (0.019)
^{G}	0.548 (0.180)	0.530 (0.147)	0.538 (0.538)
Long-run response to R_t^G	1.136 (0.184)	1.109 (0.088)	1.177 (0.718)
a_1	0.018 (0.105)	—	—
w_1	0.036[c] (0.217)	—	0.040[d] (1.027)
b_0	—	—	0.197 (0.122)
b_1	0.218 (0.048)	0.217 (0.047)	—
w_2[e]	0.453 (0.120)	0.454 (0.119)	0.430 (0.174)
c_1	0.518 (0.118)	0.522 (0.115)	0.543 (0.210)
Additional coefficients[f] on:			
$E_{t\ 1}\ \ {}_{12}p_t$	—	—	0.283 (0.843)
$E_{t\ 1}\ \ {}_{12}p_{t+3}$	—	—	0.618 (0.752)
$E_{t\ 1}\ \ {}_{12}p_{t+6}$	—	—	0.647 (0.624)
$E_{t\ 1}\ \ {}_{12}p_{t+9}$	—	—	0.579 (0.480)
$E_{t\ 1}\ \ {}_{12}p_{t+12}$	—	—	0.307 (0.540)
SEE	0.0041	0.0041	0.0050
DW	1.71	1.71	1.88
p value for LM test for first to twelfth-order serial correlation	0.16	0.16	0.33

a. Instruments: constant, and lags 1 6 of R_t^G, R_t, $\ {}_{12}p_t$, and $\tilde{y}_t$.

b. $w_0 = \ \ / (1 \ \ c_1)$.

c. $w_1 = a_1 / (1 \ \ c_1)$.

d. Sum of long-run coefficients on current and future inflation.

e. $w_2 = (S_{i=0}^{j} b_i) / (1 \ \ c_1)$.

f. Long-run coefficients.

Table F: Taylor rule estimates for the United Kingdom
Sample period: 1992 Q4 to 1997 Q1

	Estimation method		
	OLS	IV[a]	IV[a]
	0.038 (0.004)	0.010 (0.019)	0.019 (0.008)
w_0[b]	0.072 (0.016)	0.012 (0.024)	0.027 (0.013)
a_1	0.169 (0.282)	—	
w_1	0.323 (0.525)	1.765[d] (0.852)	1.267[d] (0.468)
b_0	—	0.321 (0.146)	0.335 (0.072)
b_1	0.280 (0.094)	—	—
w_2[e]	0.534 (0.138)	0.386 (0.218)	0.470 (0.131)
c_1	0.475 (0.109)	0.168 (0.222)	0.288 (0.116)
Additional coefficients[f] on:			
$E_{t\ 1}\ {}_4p_t$	—	0.373 (0.678)	—
$E_{t\ 1}\ {}_4p_{t+1}$	—	1.100 (0.968)	1.267 (0.468)
$E_{t\ 1}\ {}_4p_{t+2}$	—	0.371 (0.675)	—
$E_{t\ 1}\ {}_4p_{t+3}$	—	0.483 (1.185)	—
$E_{t\ 1}\ {}_4p_{t+4}$	—	0.180 (0.695)	—
SEE	0.0025	0.0035	0.0029
DW	1.38	1.50	1.55
p value for LM test for first to fourth-order serial correlation	0.29	0.54	0.45

a. Instruments: constant, and lags 1 4 of R_t, ${}_4p_t$, and $\tilde{y}_t$.

b. $w_0 = \ / (1 \ c_1)$.

c. $w_1 = a_1 / (1 \ c_1)$.

d. Sum of long-run coefficients on current and future inflation.

e. $w_2 = (S_{i=0}{}^{j} b_i) / (1 \ c_1)$.

f. Long-run coefficients.

Table G: Summary of Taylor rule estimates

Regime	Long-run inflation response	Long-run output gap response	Smoothing parameter	*Ex post* real interest rate %
1972 76	0.14	0.59	0.26	5.72
1976 79	0.62	0.00	0.62	3.14
1979 87	0.38	0.15	0.29	4.66
1987 90 [(1)]	0.00	0.45	0.52	5.76
1992 97	1.27	0.47	0.29	2.99

(1) German short-term interest rate enters rule with long-run coefficient 1.11.

Chart 1: Annual inflation ($\Delta_4 p_t$), output gap ($\tilde{y}_t$), and nominal interest rate (R_t) , 1972 Q1–1997 Q1

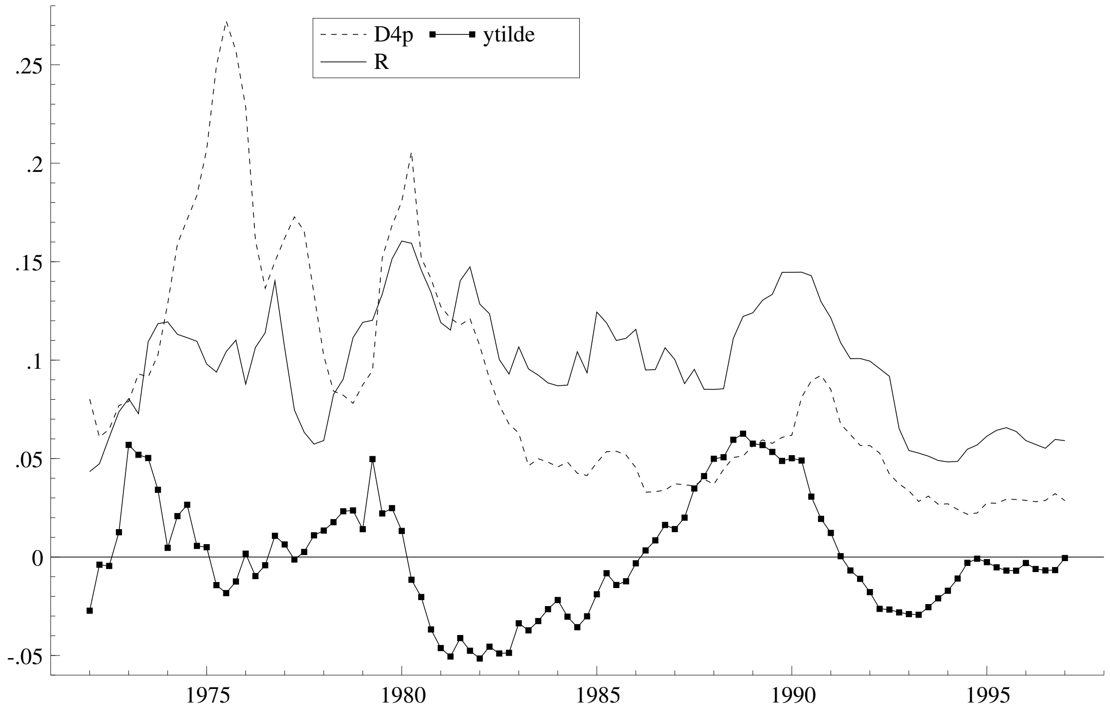


Chart 2: Recursive estimates for equation (2)

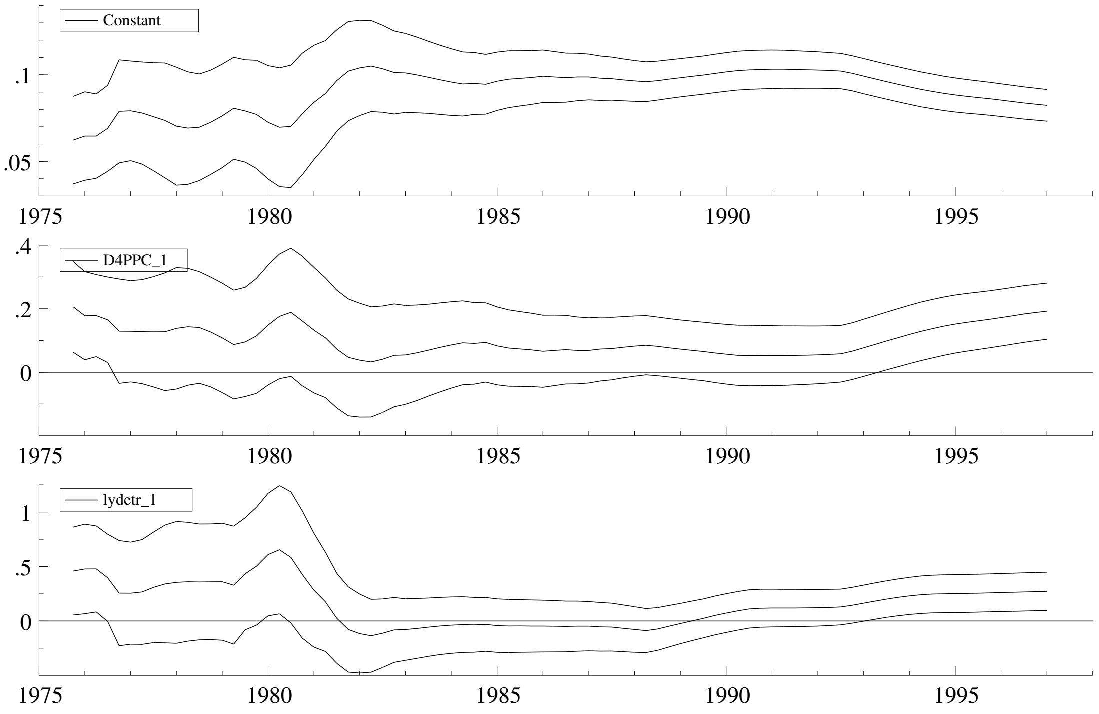
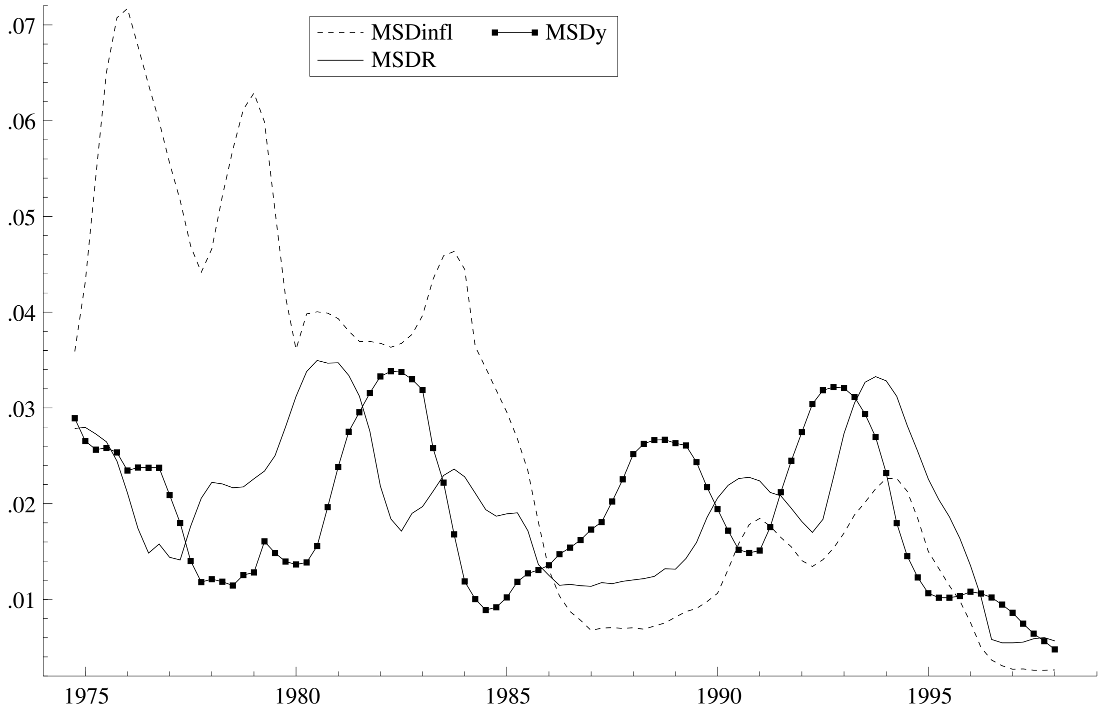


Chart 3: 16-quarter moving standard deviations of annual inflation ($\Delta_4 p_t$), output gap ($\tilde{y}_t$), and nominal interest rate (R_t), 1974 Q4–1998 Q4



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