The effect of official interest rate changes on market rates since 1987

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Abstract

It is widely accepted that a central bank, such as the Bank of England, has the ability to control short-term interest rates. Moreover, a number of studies have documented the very close relationship between Bank administered rates and their market analogues. What has not been investigated, however, is the influence of official rates - stemming from the markets' expectations about the future path of short rates - over interest rates more generally. This influence is analysed by considering the response of market interest rates to the thirty policy changes, as signalled by movements in official rates, since 1987.

I Introduction

'It is widely believed that the monetary authority can most directly control short-term interest rates, but that aggregate demand depends primarily on long-term interest rates. If this conviction is correct, the monetary transmission mechanism relies on the behaviour of the term structure of interest rates' (Mankiw and Summers 1984).

Conventional wisdown holds that, as the monopoly supplier of base money, the Bank of England has the ability to control - or at least have a strong influence over - very short-term interest rates (eg Goodhart 1989, Dow and Saville 1988). Moreover, a number of studies have documented the very close relationship between Bank administered rates and their market analogues (Llewellyn 1990, Dow and Saville 1988). What has not been investigated, however, is the extent to which the official rate, via the markets' expectations about the future path of short rates, is able to influence market interest rates more generally.

As suggested by Mankiw and Summers (1984), it is widely believed that the impact of monetary policy on the real economy depends on a wide range of interest rates maturities, including longer rates. Thus, the authorities' influence over longer-term interest rates may be a key parameter in determining the effectiveness of monetary policy. Similarly, the likely reaction of longer interest rates to changes in the Bank's desired level of short-term interest rates is potentially an important consideration in the conduct and transmission mechanism of monetary policy. This paper, by analysing the reaction of market interest rates to the changes in the Bank's official interest rate since 1987, investigates the UK authorities' influence over longer interest rates. In this respect, the paper follows closely the approach of Cook and Hahn (1989) which investigated the reaction of US interest rates to changes in the Federal Funds rate target in the 1970s.

II Methodology and Data

The time-series relationship between shorter interest rates, including sometimes the official interest rate, and longer market rates has been the subject of extensive work both in the United Kingdom and the United States. However, this type of approach raises a number of problems when considering the monetary authorities' influence over longer rates. First, time-series studies of this type cannot be used to measure the speed with which changes in the authorities' desired level of interest rates may effect a change in market rates - an important consideration in the conduct and transmission mechanism of monetary policy. Moreover, there may also be a reverse causality problem associated with analysing time-series relationships: the level of official interest rates may, in part, depend on the level and term structure of market rates. The approach employed in this paper is able largely to circumvent these problems by concentrating on the reaction of market rates in the days immediately surrounding official interest rate changes.(1)

This methodology rests, however, on the monetary authorities providing a clear signal about changes in their desired level of interest rates. This contrasts with the basis of monetary policy formulation and execution adopted in the United Kingdom in the early 1980s, which was deliberately designed to avoid market interest rates being driven by signals generated by the authorities. While an official objective for interest rates continued to be set, it was both imprecise and unrevealed, taking the form of an 'unpublished interest rate band'. This led, for example, to significant diversity, at times, in the base rates adopted by clearing banks.

However, due in part to the period of overfunding (and the size of the associated money market shortages) in the mid 1980s, it did not take long for much greater fixity to be attached to the rates at which the Bank conducted the bill purchases in its money market operations. The Bank quickly became the

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(1) The time-series properties of market rates, and their relationship with official rates do, however, provide a useful benchmark (in the form of an upper-bound) for this influence - see below.

de facto rate setter, and changes in the Bank's dealing rates became in turn a clear signal about changes in the authorities' desired level of interest rates. In particular, since the latter half of the 1980s, the Bank has tended to indicate changes in its interest rate objective by altering the minimum rate (the 'stop rate') at which it is willing to discount Band 1 and Band 2 bills from the discount market.(2)

Reflecting the imprecision of the authorities' influence in the early-to-mid 1980s, this paper focuses on the signals given by the thirty movements in the Bank's Band 1 stop rate between the beginning of 1987 and July 1991. To assess the reaction of market interest rates, the movements of interest rates at seven different maturities (1, 3, 6 and 12-months and 5, 10 and 20-years) in the days surrounding these policy changes are considered. A full description of the data and their sources is given in Appendix 1. The time-series properties of the various interest rates over the sample period are summarised in Appendix 2.

Approaching the reaction of market interest rates to policy changes as an econometric exercise suggests an equation of the form:

$$\Delta MR(i)_n = \beta(i)\, \Delta Stop_n + \epsilon_{in} \qquad (1)$$

where:

$\Delta MR(i)_n$ is the change in the market rate of maturity (i) on the day of the n'th change.

$\Delta Stop_n$ is the n'th change in the Bank of England's Band 1 stop rate.

i = 1, 3, 6, 12, 60, 120 and 240-months

n = 1, 2, 3 30

ϵ_n is an error term.

The problem with estimating an equation such as (1) is that the reaction of market interest rates to policy changes is likely to depend on a whole array of

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(2) Band 1 and Band 2 bills refer to eligible bills with less than 14 days and between 15 and 33 days to maturity respectively.

factors, such as market sentiment, the extent to which the change in official rates was anticipated, the degree to which the change contained information about future policy changes etc. The omission of such variables implies that the response parameter $\beta(i)$ is likely to be 'event-specific'.

The most satisfactory solution to this problem would be to include these additional variables in the regression. This approach is investigated in section VI. However, since many of these market variables are unobservable, this solution is necessarily incomplete. In terms of the bivariate regression, the most efficient form of estimation would be to estimate (1) allowing $\beta(i)$ to be 'event-varying'. Estimation of this form, however, is limited by the fact there are only 30 observations in the sample. Hence, in practice, estimation of the bivariate regression is limited to simple OLS on (1).

However, if we are only concerned with a bivariate equation, OLS estimation will not provide any additional information to that which could be gained by considering the moments of a series reflecting the proportional movements of the different interest rates *vis-à-vis* the changes in the Band 1 stop rate.(3) This property is attractive in the sense that it implies that it is possible to work with simple means and variances. Nevertheless, it should be recognised that such a methodology does not avoid the problems inherent in the estimation of (1). By using the means of the proportional series to draw inferences about $\beta(i)$, it is still being assumed implicitly that $\beta(i)$ is constant.

III Expectations Theory of the Term Structure

The proposition that the current level of official rates may influence longer-term interest rates is clearly related to the expectations theory of the term structure. Although the expectations theory can take a variety of forms, its essential message is that long-term interest rates will be a weighted average of present and expected future short-term rates. Appealing to such a relationship,

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(3) It is easy to show that the means of these proportional movement series are very similar to OLS estimates of $\beta(i)$ from (1).

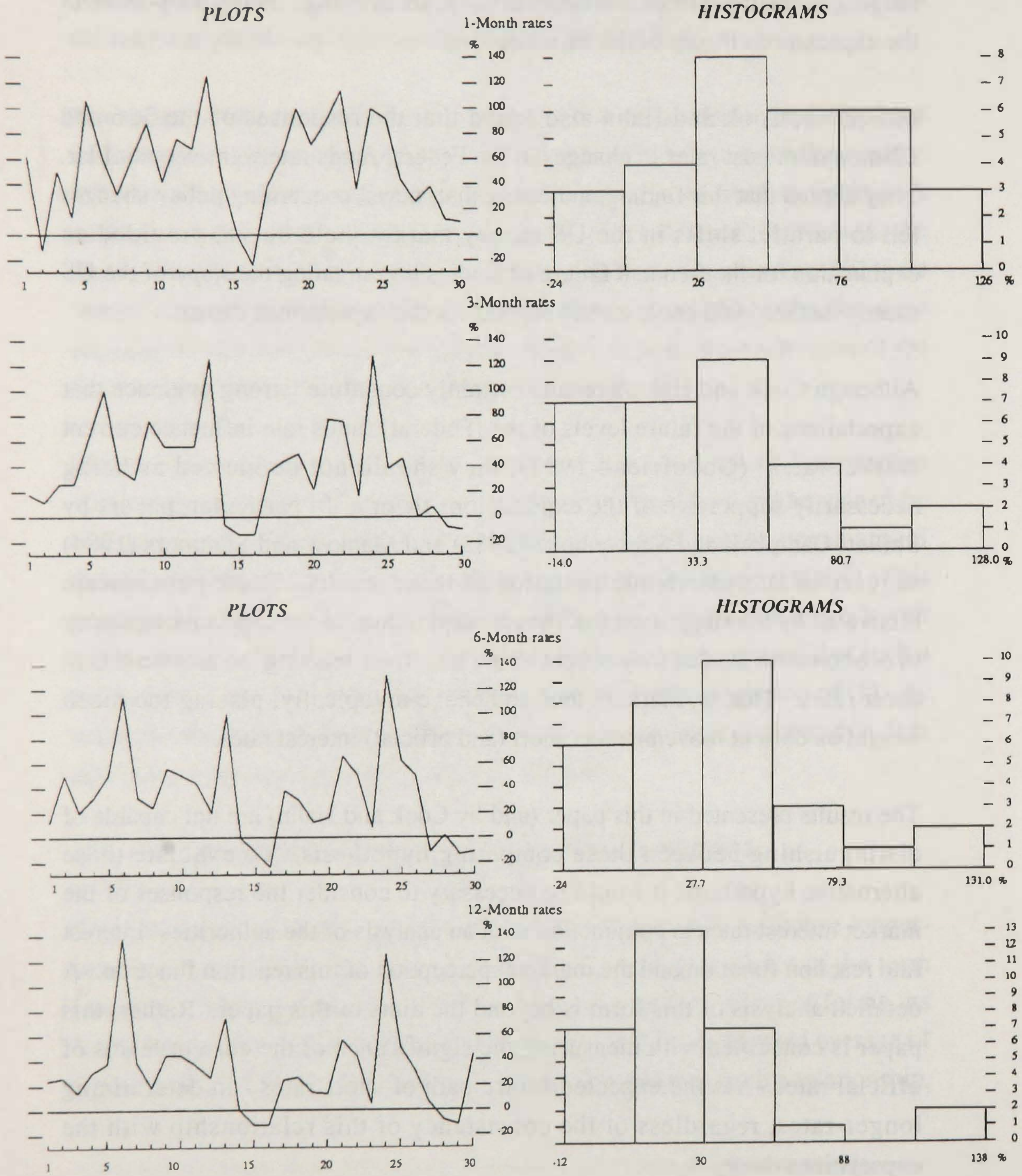
Cook and Hahn (1989) interpreted their finding that changes in the Federal Funds target led to declining, but significant, reactions in US interest rates ranging in maturity from 3-months to 20-years as being 'highly supportive of the expectations theory of the term structure'.

Moreover, Cook and Hahn also found that the responses of the 3, 6 and 12-month interest rates to changes in the Federal funds rate were very similar. They argued that this finding, indicating that 'news' concerning policy changes led to parallel shifts in the US money market yield curve, provided an explanation for the frequent failure of studies investigating the *slope* of the US money market yield curve to find support for the expectations theory.

Although Cook and Hahn's results certainly constitute 'strong evidence that expectations of the future levels of the [Federal] funds rate influence current market rates' (Goodfriend 1991), they should not be viewed as being necessarily supportive of the expectations theory. In particular, papers by Shiller, Campbell and Schoenholtz (1983) and Mankiw and Summers (1984) suggest an alternative interpretation of these results. These papers were motivated by the suggestion that the repeated failure of the expectations theory in econometric studies may reflect long rates 'over-reacting' to movements in short rates. That is, markets tend to behave myopically, placing too much weight on current movements in short (and official) interest rates.

The results presented in this paper (and by Cook and Hahn) are not capable of distinguishing between these competing hypothesis. To evaluate these alternative hypothesis it would be necessary to consider the responses of the market interest rates in conjunction with an analysis of the authorities' interest rate reaction function and the markets' perception of this reaction function. A detailed analysis of this form is beyond the aims of this paper. Rather, this paper is concerned with measuring the significance of the current levels of official rates - via the expected future path of short-rates - in determining longer-rates, regardless of the consistency of this relationship with the expectations theory.

Figure 1 1, 3, 6 and 12-month rates



IV Bivariate Results

Figures 1 and 2 illustrate the plots and histograms of the proportional series for the seven interest rate maturities across the thirty policy changes. The proportional movements (shown on the vertical axis of the plots) have been converted to percentages, such that a movement of 100% implies that the market rate moved exactly in line with the change in the stop rate, a movement of 50% implies that the market rate moved by only half as much as the stop rate and so on.

The plots of the proportional series highlight the sharp fluctuations in the reactions of the market interest rates across the different policy changes. These reactions range from small negative movements (ie the market rates moved in the opposite direction to the change in the stop rate),(4) to small 'overshoots' for the shorter term interest rates (ie the market rates moved by more than the official rates). Such 'overshooting' may reflect the markets perceiving that the policy change contained information about further impending changes in official rates. The histograms suggest that the distribution of interest rate reactions tend to be slightly skewed, with long right-hand-side tails reflecting the occasional large (or even 'overshooting') interest rate response.

The means of the proportional series are reported in Table 1. As would be expected, the means of the series decline monotonically across the interest rate maturities. The results suggests that a 1% point change in the Bank's Band 1 stop rate leads to a 0.54% point movement in the 1-month rate on the day of the change, falling to between 0.40-0.30% point movements in the 3 to 12-month rates and declining to less than 0.05% point movements in the 20-year rate.(5) The size of the standard deviations associated with the mean responses

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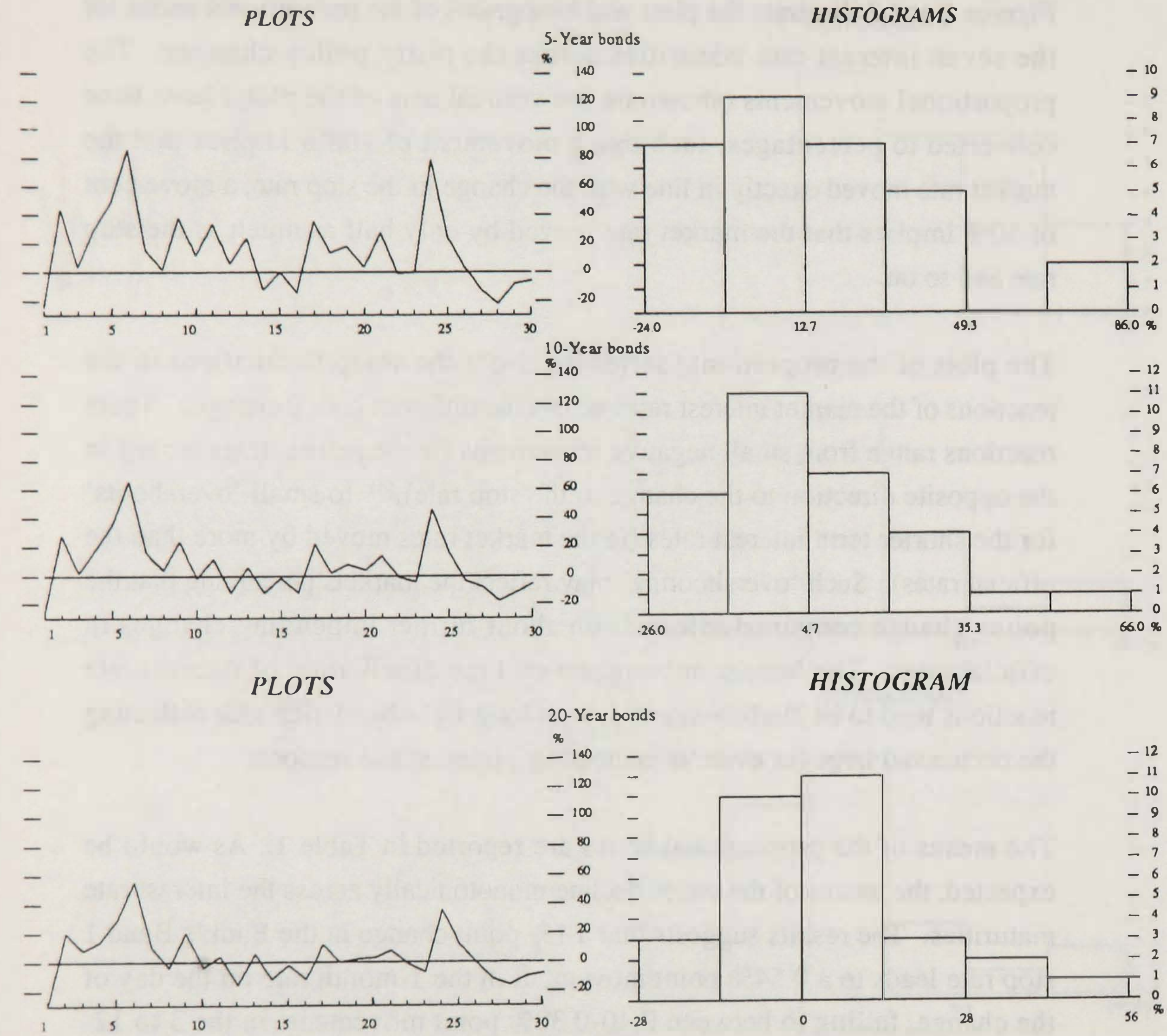
(4) This may reflect the change in official rates being smaller than that already discounted by the markets.

(5) The analysis assumes implicitly that the average daily change in the market interest rates, in days other than those surrounding policy changes, is zero. Tests on the interest rate series across the entire sample period supports this assumption (see Appendix 3).

Figure 2 5, 10 and 20-year rates



suggests that the changes in the stop rate induce statistically significant interest rate reactions across the maturities up to the 5-year rate. These monotonically declining, but significant, interest rate reactions are supportive of the proposition that longer market rates are influenced by the current level of (and changes in) the official interest rate.

Table 1: Mean responses on the day of the policy change

Maturity (months)	1	3	6	12	60	120	240
Mean (%)	54.35	39.08	33.18	31.46	15.10	6.78	3.59
(St. Deviation)	(6.95)	(7.20)	(6.82)	(6.29)	(4.86)	(3.59)	(3.12)

As with Cook and Hahn, the mean responses of the 3, 6 and 12-month market rates are similar, suggesting that movements in official rates tend to induce parallel shifts in this section of the money market yield curve.(6) This result is indicative of the markets attaching similar (weighted) probabilities to the new official interest rate being maintained over the different time-horizons.

In addition, we also investigated whether the mean changes in market rates on the day of a policy change were significantly different from the everyday movements in interest rates observed across the sample period. These tests, calculated for the four different types of policy changes (±0.5pp and ±1.0pp), suggest similar conclusions to those drawn from Table 1. Changes in official interest rates lead to significantly different movements in market rates up to a maturity of around 5-years. The form of these tests and the results are reported in Appendix 3.

V Dynamics about the Policy Change

This type of statistical analysis can also be used to consider the dynamics of the market rate responses in the days surrounding the official interest rate

(6) This suggestion is supported by the very high correlations between the 3, 6 and 12-month proportional movement series: Corr(3,6)=0.92, corr(6,12)=0.91, corr(3,12)=0.83.

changes. To what extent are policy changes reflected in the reaction of market rates in the days leading up to (and following) the change? In particular, if the markets anticipate the timing of policy changes it may lead to systematic movements in market rates in the days leading up to the change. In addition, Cook and Hahn found evidence of significant movements in United States interest rates in the day following changes in the Federal Funds target. The explanation for this finding in the United States stems from the recognition that the Federal Reserve does not announce explicitly a target level for the Federal Funds rate and hence the markets in the United States have to 'learn' about changes in the target. Although the operation of policy in the United Kingdom is such that changes in policy are more easily discernible, learning effects of this sort may still be apparent. It may take time for the markets to learn about the significance of the policy change, the commitment of the authorities to the new interest rate level, etc.

As suggested above, this analysis is based on the assumption that the direction of causality runs solely from changes in the Bank's stop rate to changes in market interest rates. This is justified to the extent that the decision to change official rates is not determined by changes in market rates on the day of its implementation. This assumption about the direction of causality becomes less clear, however, when considering the days leading up to a policy change. It is quite possible that the authorities' decision about the timing of interest rate changes may be influenced by movements in market rates.

When investigating the existence of these anticipation and learning effects, observations 13 and 14 (the 0.5% point increases in interest rates on 2 and 6 June 1988 respectively) were omitted since they were only 3 working days apart. The remaining 28 changes were at least 4 working days apart. The mean responses recorded on the actual day of the change were not materially affected by the omission of these two observations.

Any anticipation and learning effects for the longer maturities (ie 5-years and over) were both small and ill-defined, hence only results for the money market interest rates are reported. An examination of the means of the proportional series reflecting the responses of market rates in the days surrounding the changes suggests there are sizeable interest rate movements in the two days leading up to the change and the day immediately following the change. These mean responses are reported in Table 2.

Table 2: Mean responses in the days surrounding the policy change (%)[(a)]

	2 days before	1 day before	Day of change	1 day after	Total
1-month rate	5.89 (3.15)	13.60 (6.67)	52.17 (6.69)	7.78 (3.59)	79.44
3-month rate	8.74 (4.30)	8.80 (4.30)	37.58 (7.10)	10.04 (4.18)	65.16
6-month rate	14.18 (3.75)	8.24 (4.11)	31.98 (6.80)	9.14 (4.30)	63.54
12-month rate	10.76 (4.02)	7.04 (3.79)	31.06 (6.47)	6.96 (4.02)	55.82

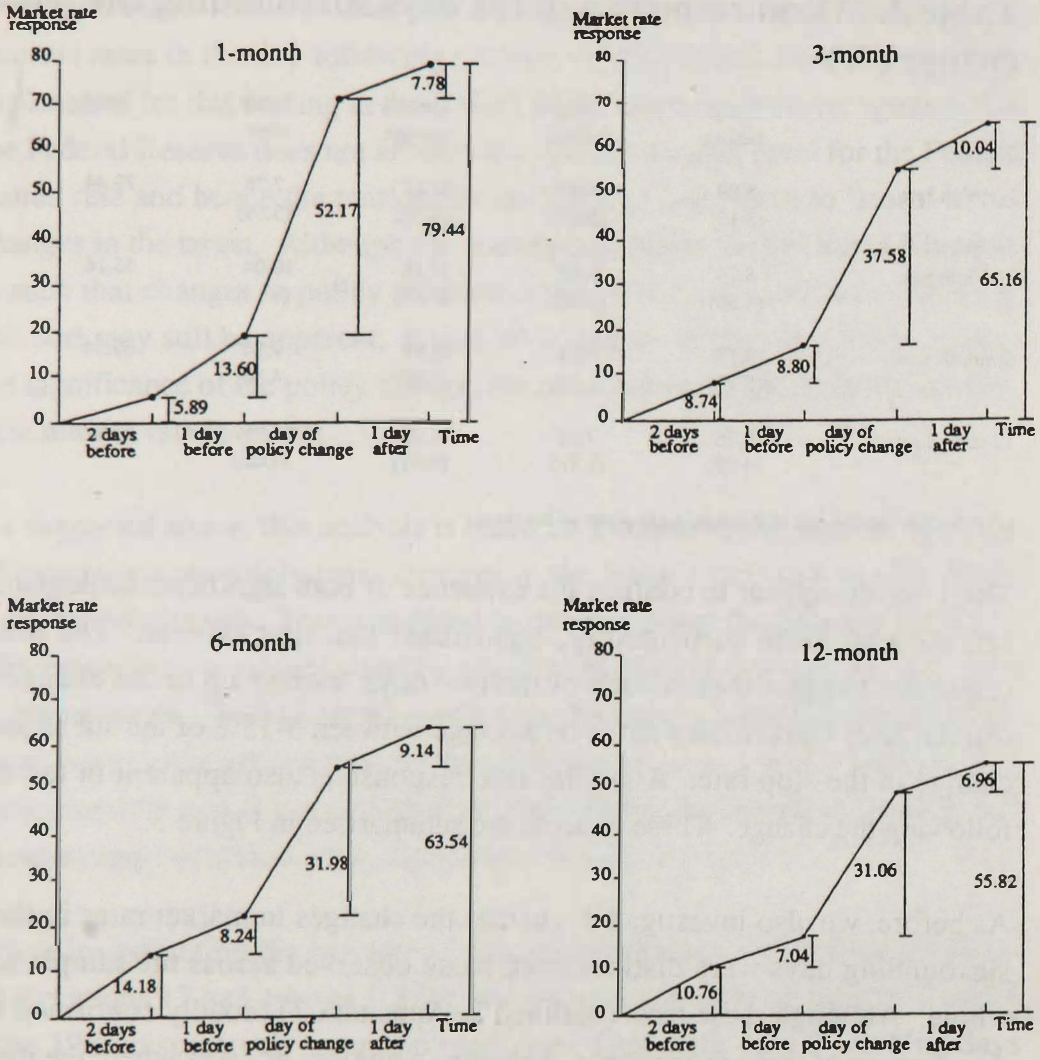
(a) Standard deviations of the means are given in brackets.

These results appear to confirm the existence of both significant anticipatory effects and, more surprisingly, significant learning effects. The mean responses suggest that in each of the two days leading up to the change in official rates market rates move on average between 5-15% of the subsequent change in the stop rate. A similar size response is also apparent in the day following the change. These patterns are summarised in Figure 3.

As before, we also investigated whether the changes in market rates in these surrounding days were distinct from those observed across the sample as a whole. Although these tests (outlined in Appendix 3) broadly confirmed the significance of these movements, there was a number of cases where the mean changes were not significantly different to the everyday movements observed in the various interest rates across the sample period.

The final column in Table 2 calculates the total proportional movement in market rates once these additional effects are included. The 'total' responses have similar characteristics to the static (same day) reactions, declining monotonically across the interest rate maturities, and with the total reactions of

Figure 3 - mean responses: dynamics about the day of the policy change



the 3, 6 and 12-month rates being fairly similar. This 'total' response estimate is based on the assumption that the movements in market rates in the days leading up to the official rate change are due purely to the anticipation of the change, rather than being instrumental in inducing the policy change. Hence, to this extent, the 'total' movement represents an upper bound on the overall influence of the monetary authorities in these surrounding days. The time-series properties of the money market rates reported in Appendix 2 suggest that changes in official rates tend to be reflected completely in market rates in the long-run. A comparison of the 'total' response in these three days with this long-run property provides a measure of the additional response in market rates occurring in days other than those immediately surrounding the timing of the policy change, together with any reverse causality effects stemming from the influence of market rates on the operation of monetary policy.

VI Additional Explanatory Variables

From the plots of the proportional movements, it is clear that some of the 'extreme' responses present in the data are common across all the interest rate maturities. In particular, there are clearly discernible peaks in the plots at observations 6, 13 and 24, while there appears to be a common 'trough' in the interest rate responses around observations 14, 15 and 16. These common patterns can be used to provide some guidance as to further possible explanatory variables:

Turning Points: The policy changes at observations 6, 13 and 24 all constitute 'turning points' in the direction of the official interest rate changes. For example, the 0.5% point rise in the Band 1 stop rate on 2 June 1988 (observation 13) was the first increase in interest rates following three successive reductions.[7] These common peaks suggest that the authorities may generate a greater (proportional) reaction in market interest rates when switching the direction of official interest rate changes. This effect is most

(7) The other turning points in the sample are at observations 5, 9 and 10.

readily explained by the recognition that when the direction of interest rate changes has just switched, the probability attached to this change being 'reversed' may be less. Although there is no reason to expect the frequency of interest rate changes to be less (ie the persistence of any given interest rate level to be greater), it is more likely that the subsequent changes will be in the same direction. Such an expectation would encourage rates to adjust by a fuller amount or even 'overshoot'. This explanation is consistent with the observation that the size of the movements in the longer maturity interest rates in response to 'turning points' is much closer to those of the shorter maturities than the mean response levels would indicate. Indeed, the responses of the longer rates often exceed those of the shorter maturities.

Frequency: The very low (and often negative) interest rate reactions around observations 14, 15 and 16 are associated with a period in 1988 during which official interest rates were changed five times between 2 June and 4 July. This finding raises the possibility that the sensitivity of market interest rates to changes in official rates diminishes during periods of frequent interest rate adjustments. A possible rationalisation of this proposition is that episodes of frequent interest rate changes may be characterised by periods in which the current level of official interest rates has become clearly out of line with the authorities' 'desired' level. In such a situation, market rates may discount the eventual movement to this 'desired' level and hence become less sensitive to the timing of subsequent interest rate changes. It is not that the specific timing of interest rate changes is easier to anticipate during periods of frequent interest changes, but rather that the effect of the change has already been discounted by the market. The most obvious example of such an episode is the sequence of interest rate reductions in 1991 once it seemed that the UK's membership of the ERM had been established (observations 26-30).

Trying to gauge the individual significance of these different effects necessitates some form of regression analysis. Such an analysis also provides an insight into the importance of the remaining omitted variables (ie unobservable market variables) once these additional explanatory variables are included. As such, we estimate a model (using OLS) of the form:

$$\Delta MR(i)_n = \beta(i)\,\Delta Stop_n + \gamma(i)\,X_n + \omega_{in} \quad (2)$$

where: X is a vector of additional explanatory variables (including a constant)

ω is an error term

To test the 'turning point' effect we included a dummy variable equal to 1 for the six turning point observations and 0 elsewhere.(8) The 'frequency' effect was initially investigated by including a variable indicating how many weeks had passed since the last official change in interest rates. In addition, the proposed rationalisation of the 'frequency' effect was considered more directly by constructing a variable designed to measure the extent to which market rates, during episodes of frequent policy changes, are able to discount future policy moves. In the absence of interest rate speculation, 3-month market rates will fluctuate around the level of clearing banks' base rates. Hence, the degree of discounting can be proxied by the 'spread' between 3-month market rates the day before policy changes and the base rate level associated with the new (ie following the policy change) Band 1 stop rate.(9)

Dummy variables were also included to test for asymmetries in terms of the direction of interest rate changes (ie interest rate cuts vis-a-vis interest rate rises), and for non-linearities in relation to the size of interest rate changes (ie 1% point changes as opposed to 0.5% point changes). An analysis of the individual significance of these effects was hindered by the interest rate change coinciding with the UK's entry into the ERM: this observation represented a turning point, a 1% point change in official rates, and the longest interval

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(8) The dummy variable was specified such that turning points associated with official interest rate increases or decreases had a symmetric effect on the magnitude of the market rate response. Hence, the dummy variable, in fact, took a value of +1 when the turning point corresponded to a rise in official rates and a value of -1 when it coincided with a reduction.

(9) The correlation coefficient between this 'spread' variable and the frequency variable was 0.54%.

between changes in official rates contained in the sample. A dummy variable was included to control for this observation.

The only variable found to have a statistically significant effect was the 'turning point' variable. The results from these regressions are reported in Table 3. The regressions passed tests for normality, functional form and heteroscedasticity.

Table 3: Additional Explanatory Variables(a)

$$\Delta MR(i)_n = \beta(i)\, \Delta Stop_n + \gamma(i)\, X_n + \omega_{in}$$

$\Delta MR(i)$	$\beta(i)$	$\gamma(i)$	SER	R^2
1-month rate (i=1)	0.561 (8.04)	0.179 (1.72)	0.21	0.80
3-month rate (i=3)	0.317 (5.63)	0.288 (3.44)	0.17	0.81
6-month rate (i=6)	0.242 (4.61)	0.275 (3.53)	0.16	0.81
12-month rate (i=12)	0.218 (4.70)	0.248 (3.60)	0.14	0.82
5-year rate (i=60)	0.083 (2.09)	0.208 (3.54)	0.12	0.70
10-year rate (i=120)	0.027 (0.86)	0.147 (3.20)	0.09	0.56
20-year rate (i=240)	-0.000 (0.03)	0.136 (3.44)	0.08	0.52

t-statistics are given in brackets.

(a) The χ_n vector included 3 variables: a constant, the turning point dummy and an ERM entry dummy. The γ_i parameter records the coefficient of the turning point dummy. The parameter estimates for the constant and the 'ERM entry' dummy are not reported.

The estimates of the response parameter $\beta(i)$ are, not surprisingly, slightly lower than the simple means considered earlier. However, the two estimates, particularly for the money market rates, do not appear to be significantly different. The results continue to suggest that changes in official UK rates have a systematic influence on interest rate maturities up to 5-years. The monotonic decline in the response parameter across the maturities is still apparent, as is the similarity of the parameter estimates for the 3, 6 and 12-month rates.

The parameter estimates of the turning point variable indicate that a switch in the direction of official interest rate changes may result in an additional response in the market interest rates of between 0.1 and 0.3 percentage points. The comparative uniformity of the parameter estimates across the different interest rate maturities suggests that this effect is proportionately more important when considering the response of longer-term interest rates. This is consistent with the hypothesis that a switch in the direction of official interest rate changes is interpreted as containing information about the likely direction of subsequent interest rate changes.

VII Conclusions

The impact of monetary policy on the real economy is likely to depend on a wide range of interest rate maturities. It is widely accepted that a central bank, such as the Bank of England, has the ability to exert a significance influence over very short-term interest rates. This paper, by considering the response of market interest rates to changes in the authorities' target level of interest rates, has sought to investigate the authorities' influence over longer-term interest rates.

A number of conclusions can be drawn from the study. The results suggest that changes in the Bank of England's Band 1 stop rate lead to significant responses in market interest rates ranging in maturity from 1-month to 5-years. These findings are supportive of the proposition that longer market rates are influenced by expectations of the future path of short rates, and hence by the current level of official rates. Moreover, it appears that changes in official rates may result in a parallel shift in the money market yield curve between 3-months and 1-year. This result is indicative of the markets attaching similar probabilities to the interest rate changes being reversed over the different time-horizons. This finding may have important implications for studies investigating the expectations theory of the term structure based on the *slope* of the UK money market yield curve.

In addition, there was evidence of systematic movements in money market interest rates in both the days leading up to the policy change and, more surprisingly, the day immediately following the changes. The possible market inefficiency highlighted by this latter result may be worthy of further research. Finally, preliminary estimates suggest that the reaction of market rates increases when the change in interest rates coincides with a switch in the direction of these official changes. This probably reflects the markets' recognition that when the direction of interest rate changes has just switched, the probability that this change will be reversed in the near future is lessened.

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Appendix 1: Data

The thirty changes in the Band 1 stop rate are detailed in Table 4:

Table 4: Changes in the Bank's Band 1 stop rate between 1987 and July 1991

Obs	Date	Δ in stop rate[(a)] (% points)	'old' Band 1 stop rate (%)	'new' Band 1 stop rate (%)
1	10 March 1987	-0.5	10.875	10.375
2	18 March 1987	-0.5	10.375	9.875
3	28 April 1987	-0.5	9.875	9.375
4	8 May 1987	-0.5	9.375	8.875
5	6 August 1987	+1.0	8.875	9.875
6	23 October 1987	-0.5	9.875	9.375
7	4 November 1987	-0.5	9.375	8.875
8	3 December 1987	-0.5	8.875	8.375
9	1 February 1988	+0.5	8.375	8.875
10	17 March 1988	-0.5	8.875	8.375
11	8 April 1988	-0.5	8.375	7.875
12	17 May 1988	-0.5	7.875	7.375
13	2 June 1988	+0.5	7.375	7.875
14	6 June 1988	+0.5	7.875	8.375
15	22 June 1988	+0.5	8.375	8.875
16	28 June 1988	+0.5	8.875	9.375
17	4 July 1988	+0.5	9.375	9.875
18	18 July 1988	+0.5	9.875	10.375
19	8 August 1988	+0.5	10.375	10.875
20	25 August 1988	+1.0	10.875	11.875
21	25 November 1988	+1.0	11.875	12.875
22	24 May 1989	+1.0	12.875	13.875
23	5 October 1989	+1.0	13.875	14.875
24[(b)]	5 October 1990	-1.0	14.875	13.875
25	13 February 1991	-0.5	13.875	13.375
26	27 February 1991	-0.5	13.375	12.875
27	22 March 1991	-0.5	12.875	12.375
28	12 April 1991	-0.5	12.375	11.875
29	24 May 1991	-0.5	11.875	11.375
30	12 July 1991	-0.5	11.375	10.875

(a) On some occasions the change in the authorities' interest rate objective was signalled via '2.30 lending', rather than by changes in the stop rates. On such occasions, the (implicit) change in the Band 1 stop rate is inferred from the stop rates observed in subsequent days. Further information about the Bank of England's operations in the money market is contained in Bank of England (1982,1988).

(b) The change in official rates on 5 October 1990, coinciding with the announcement of sterling's entry into the ERM, was signalled by the temporary re-introduction of the MLR. Hence, although the Band 1 stop rate did not actually change until the 8 October - the day sterling entered the ERM - the policy change is assumed to have occurred on 5 October.

The money market interest rates (ie 1, 3, 6 and 12-month rates) are close of business interbank rates taken from the Bank of England's dealers' pads. The longer rates (ie 5, 10 and 20-year rates) are proxied by par-yields taken from the Bank's yield curve model. Details of this model are provided in Bank of England (1990). The Bank of England's Band 1 *dealing* rates up to October 1991 were quoted in the statistical annex of the Bank of England Quarterly Bulletin. More recent data are available in the monthly "Money Market Statistics" press notice issued by the Bank. It is possible to deduce the stop rates from the quoted dealing rates.

Appendix 2: Time-Series Properties of the Interest Rates

The time-series properties of the band 1 stop rate and the various market rates were considered using daily data from January 1987 to July 1991. The time-series relationship between these rates was investigated by considering the cointegration properties of the stop rate with each of the market rates.

Conventional DF and ADF tests indicated that both the official rate and the market interest rates were I(1) over the sample period. The cointegration properties of the various market rates with the stop rate were investigated using the Johansen maximum likelihood procedure (Table 5).

Table 5: Johansen Estimation (VAR=8)

	Coeff on stop rate[a]	H_0: Vector does not cointegrate[b],[c]		H_0:Coeff on stop rate = 1[d]	
1-Month	1.0238	58.1264	**	8.7742	
3-Month	0.9828	42.9465	**	1.4834	++
6-Month	0.9540	27.3967	**	1.9746	++
12-Month	0.8744	20.1194	**	4.3464	+
5-Year	0.4329	9.5094			
10-Year	0.3180	5.5631			
20-Year	0.2150	5.2695			

(a) Coefficient on band 1 stop rate when the vector is normalised on the market rate.
(b) Test statistic based on the maximum eigenvalue of the stochastic matrix. The critical values for the rejection of the null hypothesis are 14.0690 and 12.0710 at 95% and 90% probabilities respectively. (** and * imply rejection of the null hypothesis at 95% and 90% respectively.)
(c) Similar tests confirmed the existence of a unique cointegrating vector for each of the money market rates.
(d) Test statistic based on $\chi^2(1)$ test. The critical values for acceptance of the null hypothesis are 3.84 and 5.02 at 95% and 97.5% respectively. (++ and + imply acceptance of the null hypothesis at 95% and 97.5% respectively.)

The tests appear to confirm the existence of bivariate cointegration relationships between each of the money market rates (ie interest rates of 12-month maturity or less) and the stop rate. The failure of the longer maturity rates to cointegrate with the official rate is perhaps not surprising given the relative importance of other factors (such as inflation expectations and the supply of government debt) in the determination of long rates.

The use of the Johansen procedure allows hypothesis testing on the parameter estimates in the cointegrating vectors. In particular, it is possible to test whether the parameter estimates on the stop rate are significantly different from unity: are changes in official rates fully reflected in money market rates in the long run? This hypothesis is not rejected for the 3, 6 and 12-month rates and hence provides a useful benchmark when considering the responses recorded in the days immediately surrounding the change.

Appendix 3: Testing the Significance of the Interest Rate Responses

It is possible to test the significance of the interest rate changes in the samples defined by the various days immediately surrounding official interest rate changes by comparing them with those observed across the entire sample.(10) The mean change in interest rates across the entire sample period was (approximately) equal to zero for all interest rate maturites.

The test statistic was calculated separately for the three types of policy changes observed in the sample: increases of 0.5% points and 1.0% points and a decrease of 0.5% points. Since a reduction of 1.0% points in official rates only occurred once in the sample, the significance of the interest rate responses coinciding with this policy change was consider using a conventional test of significance.

The test statistic values for the interest rate changes on the day of the policy change are reported in Table 6. These values can be compared with conventional significance levels drawn from a standard normal distribution. For brevity, the values for the changes in the days either side of the policy change are not reported here.

Table 6: Test Statistic Values for the Day of the Official Rate Change

Maturity (months)	1	3	6	12	60	120	240
0.5pp increase	3.03	2.15	1.75	0.73	1.83	0.93	0.45
1.0pp increase	6.98	2.03	1.28	3.30	1.63	0.59	0.99
0.5pp decrease	6.07	4.28	3.59	3.77	1.71	0.84	0.33
1.0pp decrease	7.47	8.56	9.97	9.84	8.74	5.81	4.97

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(10) Details of the test statistic for comparing the equality of two means can be found in Kmenta (1971)

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