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Forecast Rationality and Monetary Policy Frameworks: Evidence from UK Interest Rate Forecasts

Georgios Chortareas
Department of Economics
University of Athens

Boonlert Jitmaneeroj
Essex Business School
University of Essex

Andrew Wood
Essex Business School
University of Essex

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By

Georgios Chortareas [1], Boonlert Jitmaneeroj [2] and Andrew Wood [3]

Abstract

This paper explores the heterogeneity and rationality of professional forecasts at both short and long forecast horizons. We employ disaggregated survey data for forecasts of three-month inter-bank rates and ten-year gilt yields for the period 1989-2006. We find evidence of heterogeneity among forecasters. Moreover, forecasts violate both the unbiasedness and orthogonality conditions of the rational expectations hypothesis. The majority of biased forecasts underestimate the future spot rate. The rationality of forecasts varies across maturities and forecast horizons with short horizon and short maturity forecasts exhibiting more rationality. It also varies across sub-periods corresponding to different monetary policy frameworks. We produce evidence indicating that both monetary policy actions and elements of communication policy have information content regarding the rationality of forecasts. Changes in official bank rates and disagreement, as recorded in the minutes of the Monetary Policy Committee, influence the rationality of forecasts. The publication of inflation reports has no effect.

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Key words: *Rational Expectations, Heterogeneity, Survey Forecasts, Term Structure, Monetary Policy Frameworks*

[1] Department of Economics, University of Athens, 8 Pesmazoglou Street, Athens, 10559, Greece; e-mail: gchortar@econ.uoa.gr
[2] Essex Business School, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ, UK; e-mail: bjitma@essex.ac.uk
[3] ***(Corresponding author)*** Essex Business School, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ, UK; e-mail: wooda@essex.ac.uk

1. Introduction

The typical assumption permeating financial economics is that market participants form their expectations rationally.[1] Indeed, this assumption is founded on solid theoretical considerations and a powerful rationale. Nevertheless, the rationality hypothesis has been challenged both on theoretical grounds (e.g., the cognitive psychology literature that underpins behavioural finance and behavioural economics) and in terms of its empirical validity (see surveys by Frankel and Froot, 1987; Ito, 1990; Camerer *et al.*, 2004; Thaler, 1993, 2005). One approach for empirically testing the validity of the assumption of rationality relies on using survey data as a proxy for market expectations. The bulk of such studies have been applied mainly to exchange rates[2] with fewer applications to interest rates and stock prices.

Most existing survey-based studies test the rational expectations hypothesis (REH) with reference to an aggregate prediction, usually a consensus forecast as measured either by the mean or median forecast.[3] This approach, however, has a number of weaknesses. As Bonham and Cohen (2001) demonstrate, unless individual forecasters are homogeneous, the use of a consensus measure introduces an aggregation bias that conceals the heterogeneous behaviour of forecasters and can result in misleading inferences when testing the REH. Therefore a heterogeneity test constitutes a crucial pre-test to indicate whether the rationality test should use consensus or individual forecasts. Existing evidence relating to the heterogeneity of expectations is restricted to a small number of studies using foreign exchange rate data (Ito, 1990; MacDonald and Marsh, 1996; Elliott and Ito, 1999; and Bonham et al, 2006). To our knowledge, the current study is the first attempt to test for heterogeneity of interest rate expectations.

Previous studies focusing on interest rates have applied a bivariate regression to test the REH. Holden and Peel (1990), however, demonstrate that the joint hypothesis

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[1] For example, several studies test the expectations hypothesis of the term structure of interest under the REH assumption (see Mills, 1991; Hurn *et al.*,1995; Cuthbertson , 1996; Cuthbertson *et al.*, 1996 for the studies of the UK data)

[2] Tests of rationality in foreign exchange markets have been conducted by Dominguez (1986), Frankel and Froot (1987), Taylor (1989), Ito (1990), MacDonald (1990), Cavaglia *et al.* (1993, 1994), Chinn and Frankel (1994), MacDonald and Marsh (1996), Kim (1997), Elliott and Ito (1999), Verschoor and Wolff (2001) and Bonham *et al.* (2006).

[3] Of the REH studies relating to interest rates, Froot (1989), Batchelor (1991), MacDonald and MacMillan (1996), Kim (1997) and Jongen and Verschoor (2007) use a consensus measure. Only MacDonald and MacMillan (1994) use a panel of forecasts.

from a bivariate regression provides a sufficient, but not necessary, condition for unbiasedness, thereby resulting in the over-rejection of the null hypothesis of unbiasedness. For this reason we use a univariate test of biasedness since it tests for both necessary and sufficient conditions.

The ability of forecasters to minimize systematic mistakes depends in part on the available information and the costs of processing it. In recent years there has been an increasing awareness amongst both academics and policymakers of the importance of managing expectations. This has led central banks to increase the transparency and openness of their policy decisions with the implicit objective to raise the signal-to-noise ratio of policy decisions (Blinder 2004; Blinder et al. 2008). We consider explicitly the role of alternative monetary policy frameworks on the pervasiveness of interest rate forecast rationality. During the period under consideration the UK experienced three distinct monetary policy regimes along with the introduction and refinement of new channels of communication. For example, the MPC framework adopted in 1997 established the quarterly inflation report and the practice of publishing MPC minutes, thereby enhancing the transparency of UK monetary policy and giving rise to a more open central bank communication policy.

In summary, our work contributes to the limited literature on the heterogeneity and rationality of interest rate forecasts in at least four important ways. First, we consider a relatively lengthy sample period that allows us to account for differences in the monetary policy framework and test whether the institutional design of monetary policy has affected the performance of forecasters. Second, we conduct tests of rationality for both short and long maturities at both short and long forecast horizons, accounting for the possibility that forecasters may form their expectations differently depending on the maturity of interest rates and the length of the forecast horizon. Third, to our knowledge this paper is the first to apply a test of heterogeneity as a pre-test of the REH for interest rate forecasts and also the first to test the REH of interest rate forecasts by using the univariate specification for which both necessary and sufficient conditions are tested. Finally, we test both the unbiasedness and orthogonality conditions of the REH using a variety of information sets for the latter test.

The remainder of this paper is divided into five sections. Section 2 presents the analytical framework and methodology and section 3 gives a description of the data set. Section 4 reports the empirical results of heterogeneity and rationality of

forecasts. Section 5 investigates the rationality of forecasts under different institutional frameworks of monetary policy. Finally, Section 6 summarizes the results.

2. Analytical framework and methodology

As defined by Muth (1961), the REH assumes that market participants know the true economic model that generates the possible outcomes. Expectations are rational if the unbiasedness and orthogonality conditions are satisfied. The unbiasedness condition postulates that expectations errors have an unconditional mean equal to zero, implying that there is no systematic error. The orthogonality condition requires that expectations errors conditioned on the publicly available information set have a zero mean, implying that expectations are informationally efficient.

When using survey data to test the unbiasedness condition of the REH most researchers employ a consensus measure of the forecasts, such as the mean or median, to proxy the actual market's expectations. Moreover, it is conventional to test the unbiasedness condition of rationality by means of a bivariate regression in which the actual change in spot rate is regressed on the expected spot rate change as below,

$$(r_{t+k} - r_t) = \alpha_k + \beta_k (r^s_{t,k} - r_t) + \mu_{t,k} \quad (1)$$

where r_t and r_{t+k} are the spot rate at time *t* and *t+k* respectively, $r^s_{t,k}$ is the consensus forecast for the spot rate made at time t for *k* periods ahead, and $\mu_{t,k}$ is the disturbance term. However, Holden and Peel (1990) and Bonham *et al.* (2006) demonstrate that the joint null hypothesis (α_k=0, β_k=1) is a sufficient but not a necessary condition for unbiasedness. This implies that the bivariate regression is likely to over-reject the null hypothesis of unbiasedness. Therefore, the univariate regression specified in equation (2) emerges as an alternative testing framework. The null hypothesis of unbiasedness is that α_k is not statistically different from zero, and constitutes both a necessary and sufficient condition for unbiasedness.

$$(r_{t+k} - r^s_{t,k}) = \alpha_k + \mu_{t,k} \quad (2)$$

In addition to testing for unbiasedness, the orthogonality condition can be tested by regressing the consensus expectations error against any publicly available information set as shown in equation (3).

$$(r_{t+k} - r^{s}_{t,k}) = \alpha_k + \beta_k X_t + \mu_{t,k} \quad (3)$$

where X_t is an information set available at time t. For example, MacDonald and MacMillan (1994) use the forward premium. In the current study we use the forward premium along with the lagged spot rate changes and the past expectations errors as information sets.

The null hypothesis of the orthogonality test is that both α_k and β_k are jointly equal to zero, implying that if forecasters efficiently utilize information publicly available at the time of forecasting any components from that information set should be unrelated or orthogonal to the expectations errors.

In early tests of the REH, it was common practice to assume a representative agent by applying tests of rationality to a consensus measure of individual forecasts, as shown in equation (1) to (3). Alternatively, individual forecasts are pooled in order to increase the degrees of freedom.[4] However, Bonham and Cohen (2001) argue that heterogeneity among forecasters is a source of bias in both the consensus and pooled specifications. In the presence of heterogeneous forecasts, the REH should be separately tested for each individual forecaster. Therefore, a test of heterogeneity is a crucial pre-test to indicate whether the REH test should be conducted by consensus regressions, individual regressions or pooling over individual regressions.

In view of the concerns expressed by Bonham and Cohen we apply the heterogeneity test proposed by Ito (1990). This test has been used by MacDonald and Marsh (1996), Elliott and Ito (1999) and Bonham et al. (2006), among others. The simple form of Ito's heterogeneity test is presented in equation (4)

$$(r^{e}_{i,t,k} - r^{s}_{t,k}) = \alpha_{i,k} + \mu_{i,t,k} \quad (4)$$

where $r^{e}_{i,t,k}$ is forecaster $i's$ prediction for the spot rate made at time t for k periods ahead, $r^{s}_{t,k}$ is the consensus or mean forecast for the same spot rate, $\alpha_{i,k}$ is the individual effect (see Ito, 1990) and $\mu_{i,t,k}$ is the disturbance term. A significant individual coefficient indicates forecaster i systematically deviates from the consensus forecast and suggests heterogeneity among forecasters.

[4] Figlewski and Wachtel (1983), MacDonald (1992), Bonham and Cohen (2001) and Bonham *et al.* (2006) argue that private information exists in the current consensus forecast and that the use of consensus forecasts to test rationality is invalid. Moreover, Keane and Runkle (1990) show that the consensus measure across forecasters may aggregate out individuals' biases leading to the acceptance of the REH despite individual forecasters being irrational.

Although individual forecasters have common information sets, they may react differently to certain elements in the common information set.[5] The idiosyncratic coefficient ($\beta_{i,k}$) in equation (5) represents the different reactions to certain parts of the common information set,

$$(r^{e}_{i,t,k} - r^{s}_{t,k}) = \alpha_{i,k} + \beta_{i,k} X_t + \mu_{i,t,k} \qquad (5)$$

where X_t is a common information set, while $\alpha_{i,k}$ and $\beta_{i,k}$ correspond to the individual and idiosyncratic effects respectively. We use the forward premium, the lagged spot rate change and the lagged consensus forecast error as the common information set. This extended version of Ito's heterogeneity test as shown in equation (5) can be viewed as the orthogonality test of individual forecaster errors relative to the consensus forecast with respect to a common information set. If both individual and idiosyncratic effects are jointly significantly different from zero it is indicative of heterogeneity among forecasts.

As mentioned above, if there is convincing evidence of heterogeneity among individual forecasts, the rationality tests should be based on regressions for each individual forecast rather than the consensus forecast. Thus, the consensus forecast in equation (2) and (3) should be replaced by the individual forecasts. To test the unbiasedness and orthogonality conditions when heterogeneity exists among forecasts we use the following two specifications:

$$(r_{t+k} - r^{e}_{i,t,k}) = \alpha_{i,k} + \mu_{i,t,k} \qquad (6)$$

$$(r_{t+k} - r^{e}_{i,t,k}) = \alpha_{i,k} + \beta_{i,k} X_t + \mu_{i,t,k} \qquad (7)$$

Of course, the rational expectations assumption does not suggest that forecasts are always accurate but rather that forecasters do not make systematic mistakes. The ability to avoid making systematic mistakes depends on the available information and the costs of processing it. Accordingly, we take the analysis one step further to consider whether the monetary policy environment has affected the prevalence of rationality in interest rates forecasts.

A number of studies consider interest rate forecast rationality in relation to monetary policy. Pesando (1981) examines three sets of Canadian interest rates forecasts and finds results consistent with the efficient market approach. Friedman (1980), on the other hand, finds evidence contrary to rationality for interest rate

[5] For example, see Ito (1990), MacDonald and Marsh (1996), and Elliott and Ito (1999).

forecasts with 3 months and 6 months horizons. His findings show that survey respondents are not unbiased (especially for the longer horizon) and they do not efficiently exploit all the information contained in past interest rate movement or other macroeconomic variables, with the exception of the money stock. Simon (1989) finds that federal funds rate expectations (from March 1984 to November 1987) are biased and can outperform random walk forecasts only marginally.

Existing research suggests that variations in the monetary policy framework can affect expectations of monetary phenomena. For example, Ball (2000) considers the implications of alternative monetary regimes associated with different degrees of inflation persistence for inflation expectations (the period with no persistence, 1879 to 1914, and the post-1960 period of persistent inflation). Although our sample period is relatively short, the monetary policy regime is not homogeneous but is characterised by significant institutional changes. The most important change is the adoption of the inflation targeting framework, which brings changes in the communications policy of the central bank and enhances the transparency of monetary policy.[6] The enhanced transparency of inflation targeting has two dimensions. First the assignment of the central bank is cast in explicit terms. Second, monetary policy becomes more of an "economist's job" rather than a "politician's job" which means that the central bank needs to produce and disseminate relevant information (e.g., inflation report, forecasts and projections, statements, etc.). As in the UK the adoption of inflation targeting typically goes hand in hand with a central bank communication policy characterized by a high degree of transparency.

An emerging question then is whether the degree of information released by the central bank to the public affects the functioning and efficiency of financial markets and their ability to process information. In this paper we consider whether the different institutional frameworks under which monetary policy operated in the UK affects the prevalence or violation of the rationality hypothesis.

Some relevant recent evidence exists mainly for US interest rates where the move to a more transparent policy has been less discernible when compared to changes in the UK. For example, Lange *et al.* (2003) find that since the late 1980s the Treasury bill yield has been more successful in predicting changes in the federal funds rate. In a study of the US and six other industrialized countries Tomljanovich (2007) finds that

[6] We also note the brief period of UK's participation into the EMS since a fixed exchange rates system implies a high degree of transparency by itself (e.g., Herrendorf, 1999).

during the 1990s the forecast error for interest rates has decreased across maturities and that the expectations hypothesis performs better at the short end of the yield curve. Swanson's (2006) results show that private sector forecasters' ability to forecast the federal funds rate has improved and forecast uncertainty has decreased. This finding is valid even when one takes into account the decline in macroeconomic volatility.

3. The data

Consensus Economics has collected survey forecast data since October 1989. Each month Consensus Economics contacts professional forecasters from the business and academic sectors asking for their end of month forecasts for a range of macro variables, including three-month inter-bank rates and ten-year gilt yields, for the three months and twelve months hence. For example, during the first week of January forecasters are asked for their predictions for the end of April and the end of the following January. Based on the combinations of maturities and forecast horizons, the forecasts of interest rates used in our study can be classified into four categories: SMSH (Short Maturity – Short Horizon); SMLH (Short Maturity – Long Horizon); LMSH (Long Maturity – Short Horizon) and LMLH (Long Maturity – Long Horizon).

Our sample covers the period from October 1989 to July 2006. In addition to an analysis of this full sample, we also study sub-periods that allow focusing on the different monetary policy regimes experienced in the UK during the last two decades. The three sub-periods correspond to the period of exchange rate targeting (1st October 1989 – 15th September 1992); inflation targeting with interest rates set by the UK government (16th September 1992 – 5th May 1997); and inflation targeting with the Bank of England enjoying "economic independence" and interest rates set by the Monetary Policy Committee (MPC) (6th May 1997 –31st July 2006).

We include forecasters who provide at least 30 observations during the period in question. Based on this criterion, there are a total of 54 forecasters included in the whole sample period, with 20 forecasters in sub-period 1, 30 in sub-period 2 and 31 in sub-period 3 respectively.

Our information set includes past forecast errors, past changes in spot rates, and the forward premium. Actual spot rate data of three-month inter-bank rates is obtained

from the British Bankers' Association (BBA) while ten-year gilt yields are derived from Datastream Advance. The survey forecast horizon, however, does not correspond precisely with three month and twelve month horizons. To remedy for this inconsistency when constructing the forward premium we apply the widely-used cubic-spline technique to interpolate the non-standard interest rates on the basis of actual/365 day count convention.

Hansen and Hodrick (1980) show that the expectations errors will be serially correlated when the forecast horizon is longer than the survey frequency. Since the actual forecast horizons of our survey data set are not exactly k months (k=3 or 12) but k months plus a few weeks, we assume a moving average process of order k for the monthly k- month ahead expectations errors. This overlapping data problem is overcome by utilizing OLS estimates with Newey-West corrections for heteroscedasticity and autocorrelation, unless otherwise specified.

4. Empirical results: heterogeneity and rationality

4.1 Heterogeneity

Table 1 reports a summary of the results for the heterogeneity tests as specified in equations (4) and (5).[7] In each case, we report the number and percentage of forecasters whose forecasts are statistically different from the consensus forecasts.[8] In other words, it is the number and percentage of rejections of the null hypothesis of homogeneity. The percentage of heterogeneous forecasts is at least as high as 50% in 52 of the 56 cases reported in Table 1. The rejection rate for the other 4 cases, all to be found in the sub-sample range of SMSH, is only marginally less than 50%.

TABLE 1 around here

To confirm that forecasts as a whole are heterogeneous, we use the binomial test suggested by McNees (1978). If individual regressions are assumed to be independent, each individual regression can be regarded as a trial with two mutually exclusive and exhaustive outcomes: rejection of the null hypothesis or failure to reject the null hypothesis. For our purposes, the probability of each outcome is 0.05 and

[7] Throughout this paper, we only present a summary of results due to space limitations. The results of individual regressions can be requested from the authors.
[8] Unless otherwise specified, the level of significance is 5 percent throughout this paper.

0.95 respectively provided that the null hypothesis of individual regression is tested at 5% level of significance. Under these assumptions we can apply binomial tests for each category of forecast to evaluate the null hypothesis that forecasts as a whole are homogeneous. We report the p-values of binomial tests in Table 1. For all cases, we find that the probability of the rejections occurring as a result of chance alone is less than 0.05 which leads us to conclude that heterogeneity exists in all cases. Therefore, the rationality test should be performed at the individual level in order to avoid the heterogeneity bias.

4.2 Rationality

The results of the test for unbiasedness, as defined in equation (6), are reported in Table 2. As with the heterogeneity tests, we perform binomial tests with the null hypothesis that forecasts as a whole are unbiased. The proportion of forecasters with biased forecasts, as signified by significant alphas, is significant at the 1% level for the whole sample for three of the four combinations of maturity and horizon and is significant at the 10% level (with a p-value of 0.052) for the remaining combination. It is noteworthy that the evidence of biased forecasts is generally more robust for the long horizon forecasts, with a significant number of forecasters demonstrating bias in five of the six sub-samples.

TABLE 2 around here

FIGURE 1 around here

A closer analysis of the individual results reveals that across all combinations of maturities and forecast horizons the majority of forecasts underestimated the future spot rate.[9] Of the 130 biased forecasts across all periods, 94% are associated with significantly negative alphas. The distribution of alphas reported in Figures 1 illustrates this finding. The majority of alphas are negative and the distribution of alphas is apparently unimodal. As the forecast horizon increases, the distribution of alphas not only tends to move to the left and away from zero but its variance also becomes larger.

[9] Earlier research (e.g., Theil 1966; Zarnowitz 1967, 1985; Stekler 1968, 1975; Smyth; 1981) finds that forecasters are likely to underestimate macroeconomic variables, such as GNP and inflation. One of the most likely explanations is that underestimation might be caused by the actual changes being more variable than the expected changes.

We provide the results of the orthogonality tests for informational efficiency in Table 3. Overall, we find substantially higher percentages of irrational forecasts for the orthogonality tests in comparison to the unbiasedness tests reported in Table 2. This evidence suggests that although some consensus forecasts are unbiased, they do not efficiently reflect publicly available information. Binomial tests indicate that the null hypothesis that forecasts as a whole are informational efficient is rejected for 38 out of 40 cases. The orthogonality results reported in Table 3 represent a stronger rejection of the REH than the unbiasedness results reported in Table 2, implying that while a substantial number of forecasters were statistically unbiased, they were nevertheless informationally inefficient.

TABLE 3 around here

4.3 The degree of rationality across sub-periods, maturities and forecast horizons

A visual inspection of Tables 2 and 3 suggests the degree of both the bias and orthogonality aspects of rationality varies across the sub-periods. Broadly speaking, the number of forecasters revealed to be biased is at its lowest during sub-period 2 while the results for sub-period 1 depends on whether the focus is on short forecast horizons, which are associated with low levels of bias, or long horizons, for which there is a substantially higher proportion of biased forecasts.[10] To formally test whether the proportion of biased or non-orthogonal forecasts varies across all three sub-periods we present results of Fisher's exact test based on 2 x 3 contingency tables.[11] The results reported in the last column of Table 4 indicate that both measures of irrationality vary across time for SMLH, LMSH and LMLH, but not for SMSH. Turning to the tests for differences between individual periods, the first three columns in Table 4 report the percentage difference in rationality between each pairing of sub-periods along with the p-value from Fisher's exact test for the corresponding 2 x 2 contingency table. We test the null hypothesis of equal percentage of forecasts violating the rationality assumption against the one-sided

[10] All results for period 1 were re-estimated excluding outliers due to sterling's exit from the ERM; subsequent results were qualitatively unchanged.

[11] Since some expected value of each cell in the contingency tables are less than 5, it is appropriate to use Fisher's exact test, rather than a Chi-square test, when dealing with small samples.

alternative hypothesis. Although there are significant differences between each combination of sub-periods for SMLH, LMSH and LMLH, it is nevertheless difficult to discern a pattern. The findings are mixed and depend on the sub-periods, the maturities, the forecast horizons, and the type of rationality tested.

While the bias tends to be lower in the second sub-period, table 4 does not support the presence of a clearcut overall pattern. One would expect that the third (post 1997) sub-period should display a lower bias given the improved monetary policy communication framework in the context of inflation targeting. One possible explanation for our not finding a lower bias post-97 may be that other factors, in addition to and pre-dating the adoption of inflation targeting, underpin the apparent success of the expectations anchoring during the pre and post-97 period. Such an interpretation is consistent with recent empirical findings showing that while the adoption of inflation targeting is associated with low inflation, inflation had begun its downward trend well before the introduction of the given framework (Angeriz and Arestis, 2007, 2008). Of course this does not refute the contribution of inflation targeting in 'locking in' low inflation rates.

TABLE 4 around here

The results reported in Tables 2 and 3 also suggest that the degree to which the rationality assumption is violated varies across maturities and horizons. To find out the possible influence of these two dimensions on the degree of rationality, we again construct 2 x 2 contingency tables and apply Fisher's exact test. Table 5 presents the percentage differences in the non-rational forecasts and p-values from Fisher's exact test under the null hypothesis of equal percentage of the non-rational forecasts against the one-sided alternative hypothesis. In panels 1 and 2 of Table 5 we measure the effect of an increase in forecast horizon on the non-rationality of forecasts and in panels 3 and 4 we compare the degree of non-rationality of forecasts for long maturity interest rates in comparison to short maturity. The results for the whole period indicate that as both forecast horizons and interest maturities increase the level of irrationality increases. This finding is more pronounced in the orthogonality tests as compared to the unbiasedness tests. For the sub-periods, the majority of p-values indicate statistical significance, particularly for tests of orthogonality, suggesting that the degree of rationality is likely to depend on the horizon and maturity.

TABLE 5 around here

5. The impact of monetary policy implementation on the rational behaviour of forecasters

The previous sections present persuasive evidence of changes in the level of rationality of forecasts across different monetary policy frameworks. It is, therefore, of interest to further explore whether the UK's monetary policy implementation has any impact on the rationality of forecasts. To this end, we select three measures relating to the implementation of monetary policy: the announcement of a change in the bank rate, the publication of the inflation report, and the disagreement between members of the MPC.[12]

Announcements of a change (or no change) in the bank rate constitute the actual monetary policy decisions. The inflation report and the publication of the MPC minutes (which records the dissenting votes) constitute aspects of the current inflation targeting framework. These features of the Bank of England's institutional design are considered to enhance the transparency of monetary policy and facilitate central bank communication in order to anchor inflation expectations.

The inflation report is published quarterly and provides a detailed economic analysis along with an assessment of the UK inflation prospects over a two-year horizon. It was first published in 1993 but has been published in its current form since 1997. The analysis provided in the inflation report provides the rationale on which the MPC interest rate decisions are based. Moreover, its presentation is followed by a press conference where financial journalists have the opportunity to ask the Bank's Governor[13] thorny questions. Thus, the publication of the inflation report should have some information content for financial market participants.

The minutes of the MPC have been published since 1997. They are published two weeks after the MPC meetings,[14] this being a relatively short period of delay as compared to the practice of other central banks. The issue of whether the publication of voting records makes monetary policy more transparent has been the subject of some debate, especially in the context of the European Central Bank's (ECB)

[12] Since the results of the orthogonality condition of rationality might be varied by the selected common information set, we only focus on the unbiasedness condition of rationality in this section. Therefore, the term rationality in this section refers to the unbiasedness dimension and not to the orthogonality dimension.

[13] In the past the Deputy Governor has played this role.

[14] More specifically, the minutes are published on the Wednesday of the second week after the meetings take place. This practice has been adopted since 1998.

institutional design.[15] For the UK, Gerlach-Kristen (2004) finds that the publication of the MPC's voting records can help forecast future policy changes but this information does not appear to be used by market participants when they form their expectations of future changes to interest rates.

Table 6 presents the results of the effect of the monetary policy signal on the unbiasedness condition of rationality. We report the results for the number of forecasters providing biased forecasts for each combination of maturity and horizon according to whether the forecast was made in the absence of a policy signal (group 1) or following a signal (group 2). The signal takes the form of: a change in bank rates; the publication of the inflation report; or disagreement reported in the MPC minutes, occurring during the month prior to the survey date.

TABLE 6 around here

First, we examine the effect of monthly changes in official bank rates on the biasedness of forecasts. For short maturity, short horizon forecasts there is an insignificant reduction in the proportion of forecasts that are biased, from six (11.1%) in group 1 to five (9.3%) in group 2. For all other combinations of maturity and forecast horizon the signal of a change in the bank rate is associated with a significant reduction in the percentage of forecasters whose forecasts are biased. This finding is quite intuitive because the timing and magnitude of changes to official bank rates influences both longer maturity rates and future short and long term rates, as financial market participants adjust their expectations.

Second, we investigate whether the publication of inflation reports are associated with a reduction of the number of biased forecasts. The results presented in Table 6 suggest that the publication of the inflation report does not help reduce the biasedness of forecasts. At first glance, this finding may be surprising since the inflation report is regarded as an example of good practice in central bank communication (Blinder 2004; Blinder et al. 2008). Financial market participants generally pore over the Bank of England's inflation reports since they provide useful insights to the bank's thinking and hints on the likely direction of interest rates. A probable explanation for our counter-intuitive finding is that most information in the inflation report is already

[15] See Buiter (1999) and Issing (1999) for two conflicting views on this issue.

absorbed by market participants prior to its quarterly publication. The interest rate decision usually takes place within less than two weeks before the publication of the inflation report and it may be that financial market participants extract limited information content at the margin. Moreover, they can get similar information from the minutes of MPC monthly meetings or from other sources during the quarter.

Lastly, we explore the effect of the disagreement between members of the MPC at each MPC monthly meeting.[16] The evidence presented in Table 6 exhibits a similar pattern to the impact of official bank rate changes. Disagreement amongst the MPC is associated with a significant reduction in the level of biasedness of forecasts for long maturity rates over both short and long forecast horizons. For short maturity interest rates, voting disagreement within the MPC does not impact on the biasedness of forecasts at the short horizon whereas forecasts over the long horizon are less biased when there is discord within the MPC.

These findings may appear to be counter intuitive. If disagreement amongst the MPC is considered to be a measure of uncertainty of the direction of future monetary policy, the level of unbiasedness of forecasts may be expected to decrease. However, as Blinder (2004) notes, while on the one hand the individualistic nature of the Bank of England's MPC with its occasionally "fractious" post-meeting statements may give rise to uncertainty, on the other hand, the announcement of the committee's vote does convey real information. Indeed, a possible explanation for our results is that disagreement within the MPC tends to precede a change in rates and hence gives some helpful hints of the future course of interest rates so the forecasts is less biased when there is the disagreement between the MPC.

In conclusion, our evidence indicates that the disagreement and changes in the official bank rate, but not the publication of inflation report, assist market participants to produce less biased forecasts for ten year rates over the short term forecast horizon and for both three month and ten year rates over the longer forecast horizon. But none of our monetary policy signals has a significant influence on the biasedness of forecasts for the three month rate over the short forecast horizon.

6. Conclusion

[16]During our sample period, there are 65 out of 108 MPC meetings in which at least one member votes for the higher or lower official bank rate.

We explore the heterogeneity and rationality of forecasts of the three-month inter-bank rate and the ten-year gilt yield over three and twelve-month forecast horizons, focusing on the behaviour of individual forecasters. We investigate the unbiasedness and orthogonality conditions of the REH over the period 1989-2006 as well as specific sub-periods corresponding to different monetary policy frameworks. We consider the implications of changes in the transparency of the monetary policy on the unbiasedness of expectations.

Our main findings can be summarised as follows: First, conducting the heterogeneity test as a pre-test of the REH, we find there exists significant variation across individual forecasts resulting from both individual and idiosyncratic effects. The most important implication of this finding is that the test for the REH should be performed at the individual level in order to avoid aggregation and heterogeneity biases. Second, the univariate tests for unbiasedness reveal that forecasts as a whole are biased and the degree of bias increases as the forecast horizon or maturity increases with forecasts tending to underestimate the future spot rate. Third, we investigate the orthogonality condition of rationality with reference to the different information sets. The findings from the orthogonality tests vary depending on the selected information set. Both unbiasedness and orthogonality conditions provide fairly consistent results even though the evidence of rationality from the unbiasedness test is not as strong as that from the orthogonality test. Fourth, changes in the official bank rate and the MPC's disagreement, as reflected in the MPC voting record, significantly reduces the number of unbiased forecasts in SMLH, LMSH and LMLH, but not SMSH. The publication of the inflation report, however, does not help improve the unbiasedness in any case. Finally, there is convincing evidence that the rationality of forecasts displays differences over different monetary policy frameworks.

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Table 1 Summary of the heterogeneity tests

	SH (Short horizon)				LH (Long horizon)			
	Sub-period 1	Sub-period 2	Sub-period 3	Whole period	Sub-period 1	Sub-period 2	Sub-period 3	Whole period
Total No. of forecasters	20	30	31	54	20	30	31	54
Panel 1 : SM (Short maturity)	SMSH				SMLH			
Individual effect								
No. of heterogeneous forecasts	9	15	13	27	11	24	21	35
(Percentage)	(45.00%)	(50.00%)	(41.49%)	(50.00%)	(55.00%)	(80.00%)	(67.74%)	(64.81%)
p-value	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Individual & idiosyncratic effect								
Forward premium								
No. of heterogeneous forecasts	11	15	18	33	Na	Na	Na	Na
(Percentage)	(55.00%)	(50.00%)	(58.06%)	(61.11%)	(Na)	(Na)	(Na)	(Na)
p-value	0.000**	0.000**	0.000**	0.000**	Na	Na	Na	Na
Lagged spot rate change								
No. of heterogeneous forecasts	9	15	15	34	11	23	26	44
(Percentage)	(45.00%)	(50.00%)	(48.39%)	(62.96%)	(55.00%)	(76.67%)	(83.87%)	(81.48%)
p-value	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Lagged consensus forecast error								
No. of heterogeneous forecasts	15	22	24	46	17	29	31	52
(Percentage)	(75.00%)	(73.33%)	(77.42%)	(85.19%)	(85.00%)	(96.67%)	(100.00%)	(96.30%)
p-value	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Panel 2 : LM (Long maturity)	LMSH				LMLH			
Individual effect								
No. of heterogeneous forecasts	13	15	17	31	10	16	18	31
(Percentage)	(65.00%)	(50.00%)	(54.84%)	(57.41%)	(50.00%)	(53.33%)	(58.06%)	(57.41%)
p-value	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Individual & idiosyncratic effect								
Forward premium								
No. of heterogeneous forecasts	13	18	22	40	Na	Na	Na	Na
(Percentage)	(65.00%)	(60.00%)	(70.97%)	(74.07%)	(Na)	(Na)	(Na)	(Na)
p-value	0.000**	0.000**	0.000**	0.000**	Na	Na	Na	Na
Lagged spot rate change								
No. of heterogeneous forecasts	12	17	18	34	10	16	18	33
(Percentage)	(60.00%)	(56.67%)	(58.06%)	(62.96%)	(50.00%)	(53.33%)	(58.06%)	(61.11%)
p-value	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Lagged consensus forecast error								
No. of heterogeneous forecasts	15	22	28	49	16	30	30	52
(Percentage)	(75.00%)	(73.33%)	(90.32%)	(90.74%)	(80.00%)	(100.00%)	(96.77%)	(96.30%)
p-value	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

Notes: The range of each period is as follows: whole period (1/10/1989 – 31/07/2006), sub-period 1 (1/10/1989 – 15/09/1992), sub-period 2 (16/09/1992 – 5/05/1997), sub-period 3 (6/05/1997 – 31/07/2007). The p-value is for the binomial test under the null hypothesis that forecasts as a whole are homogeneous. ** and * signify statistical significance at 5 and 10 percent respectively. Due to the limit to maturity of the yield curve, we do not compute the forward premium at the long forecast horizon. Thus, "Na" indicates that the relevant test cannot be performed since the information set is unavailable.

Table 2 Summary results on the unbiasedness condition of rationality

	SH (Short horizon)				LH (Long horizon)			
	Sub-period 1	Sub-period 2	Sub-period 3	Whole period	Sub-period 1	Sub-period 2	Sub-period 3	Whole period
Total No. of forecasters	20	30	31	54	20	30	31	54
Panel 1 : SM (Short maturity)	SMSH				SMLH			
No. of biased forecasts	1	2	5	6	11	4	5	12
(Percentage)	(5.00%)	(6.67%)	(16.13%)	(11.11%)	(55.00%)	(13.33%)	(16.13%)	(22.22%)
p-value	0.642	0.446	0.018**	0.052*	0.000**	0.061*	0.018**	0.000**
No. of underestimating forecasts	20	5	18	36	20	20	23	45
(Percentage)	(100.00%)	(16.67%)	(58.06%)	(66.67%)	(100.00%)	(66.67%)	(74.19%)	(83.33%)
p-value	0.642	0.446	0.018**	0.052*	0.000**	0.061*	0.018**	0.000**
No. of Significant underestimating forecasts	1	0	3	3	11	3	5	12
(Percentage)	(100.00%)	(0.00%)	(60.00%)	(50.00%)	(100.00%)	(75.00%)	(100.00%)	(100.00%)
Panel 2 : LM (Long maturity)	LMSH				LMLH			
No. of biased forecasts	2	2	12	13	16	3	15	21
(Percentage)	(10.00%)	(6.67%)	(38.71%)	(24.07%)	(80.00%)	(10.00%)	(48.39%)	(38.89%)
p-value	0.264	0.446	0.000**	0.000**	0.000**	0.188	0.000**	0.000**
No. of underestimating forecasts	17	21	30	47	20	28	28	50
(Percentage)	(85.00%)	(70.00%)	(96.77%)	(87.04%)	(100.00%)	(93.33%)	(90.32%)	(92.59%)
No. of significant underestimating forecasts	2	2	12	13	16	3	15	21
(Percentage)	(100.00%)	(100.00%)	(100.00%)	(100.00%)	(100.00%)	(100.00%)	(100.00%)	(100.00%)

Notes: The range of each period is as follows: whole period (1/10/1989 – 31/07/2006), sub-period 1 (1/10/1989 – 15/09/1992), sub-period 2 (16/09/1992 – 5/05/1997), sub-period 3 (6/05/1997 – 31/07/2007). The p-value is for the binomial test provided that the null hypothesis of individual regression is tested at 5% significance level. The null hypothesis of binomial test is that forecasts as a whole are unbiasedness. ** and * signify statistical significance at 5 and 10 percent respectively. In each panel, the percentage of significant underestimating forecasts is calculated with respect to the number of biased forecasts.

Table 3 Summary results on the orthogonality condition of rationality

	SH(Short horizon)				LM (Long horizon)			
	Sub-period 1	Sub-period 2	Sub-period 3	Whole period	Sub-period 1	Sub-period 2	Sub-period 3	Whole period
Total No. of forecasters	20	30	31	54	20	30	31	54
Panel 1 : SM (Short maturity)	SMSH				SMLH			
Forward premium								
No. of inefficient forecasts	3	8	13	25	Na	Na	Na	Na
(Percentage)	(15.00%)	(26.67%)	(41.94%)	(46.30%)	(Na)	(Na)	(Na)	(Na)
p-value	0.075*	0.000**	0.000**	0.000**	Na	Na	Na	Na
Lagged spot rate change								
No. of inefficient forecasts	3	12	6	10	11	29	11	23
(Percentage)	(15.00%)	(40.00%)	(19.35%)	(18.52%)	(55.00%)	(96.67%)	(35.48%)	(42.59%)
p-value	0.075*	0.000**	0.004**	0.000**	0.000**	0.000**	0.000**	0.000**
Lagged forecast error								
No. of inefficient forecasts	1	7	7	14	10	28	14	24
(Percentage)	(5.00%)	(23.33%)	(22.58%)	(25.30%)	(50.00%)	(93.33%)	(45.16%)	(44.44%)
p-value	0.642	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Panel 2 : LM (Long Maturity)	LMSH				LMLH			
Forward premium								
No. of inefficient forecasts	6	2	15	17	Na	Na	Na	Na
(Percentage)	(30.00%)	(6.67%)	(48.39%)	(31.48%)	(Na)	(Na)	(Na)	(Na)
p-value	0.000**	0.446	0.000**	0.000**	Na	Na	Na	Na
Lagged spot rate change								
No. of inefficient forecasts	18	4	13	20	19	20	27	41
(Percentage)	(90.00%)	(13.33%)	(41.94%)	(37.04%)	(95.00%)	(66.67%)	(87.10%)	(75.93%)
p-value	0.000**	0.061*	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Lagged forecast error								
No. of inefficient forecasts	10	6	11	22	19	21	26	45
(Percentage)	(50.00%)	(20.00%)	(35.48%)	(40.74%)	(95.00%)	(70.00%)	(83.87%)	(83.33%)
p-value	0.000**	0.003**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

Notes: The range of each period is as follows: whole period (1/10/1989 – 31/07/2006), sub-period 1 (1/10/1989 – 15/09/1992), sub-period 2 (16/09/1992 – 5/05/1997), sub-period 3 (6/05/1997 – 31/07/2007). The p-value is for the binomial test provided that the null hypothesis of individual regression is tested at 5% significance level. The null hypothesis of binomial test is that forecasts as a whole are informational efficiency. ** and * signify statistical significance at 5 and 10 percent respectively. Due to the limit to maturity of the yield curve, we do not compute the forward premium at the long forecast horizon. Thus, "Na" indicates that the relevant test cannot be performed since the information set is unavailable.

Table 4 The difference in irrational forecasts between sub-periods

Panel	Maturity & horizon	Type of rationality test	Sub-period 2 - Sub-period 1	Sub-period 3 - Sub-period 2	Sub-period 3 - Sub-period 1	Among all sub-periods
1	SMSH	Unbiasedness condition	+1.67%	+9.46%	+11.13%	
		p-value	0.651	0.226	0.230	0.444
		Orthogonality condition				
		Forward premium	+11.67%	+15.27%	+26.94%	
		p-value	0.269	0.162	0.041**	0.122
		Lagged spot rate change	+25.00%	-20.65%	+4.35%	
		p-value	0.055*	0.068*	0.499	0.098*
		Lagged individual forecast error	+18.33%	-0.75%	+17.58%	
		p-value	0.087*	0.592	0.095*	0.207
2	SMLH	Unbiasedness condition	-41.67%	+2.80%	-38.87%	
		p-value	0.002**	0.522	0.005**	0.003**
		Orthogonality condition				
		Forward premium	Na	Na	Na	
		p-value	Na	Na	Na	Na
		Lagged spot rate change	+41.67%	-61.18%	-19.52%	
		p-value	0.001**	0.000**	0.139	0.000**
		Lagged individual forecast error	+43.33%	-48.17%	-4.84%	
		p-value	0.001**	0.000**	0.479	0.000**
3	LMSH	Unbiasedness condition	-3.33%	+32.04%	+28.71%	
		p-value	0.528	0.003**	0.024**	0.004**
		Orthogonality condition				
		Forward premium	-23.33%	+41.72%	+18.39%	
		p-value	0.036**	0.000**	0.156	0.001**
		Lagged spot rate change	-76.67%	+28.60%	-48.06%	
		p-value	0.000**	0.013**	0.001**	0.000**
		Lagged individual forecast error	-30.00%	+15.48%	-14.52%	
		p-value	0.028**	0.144	0.230	0.087*
4	LMLH	Unbiasedness condition	-70.00%	+38.39%	-31.61%	
		p-value	0.000**	0.001**	0.023**	0.000**
		Orthogonality condition				
		Forward premium	Na	Na	Na	
		p-value	Na	Na	Na	Na
		Lagged spot rate change	-28.33%	+20.43%	-7.90%	
		p-value	0.018**	0.055*	0.340	0.032**
		Lagged individual forecast error	-25.00%	+13.87%	-11.13%	
		p-value	0.031**	0.163	0.230	0.081*

Notes: The p-value is for Fisher's exact test. ** and * signify statistical significance at 5 and 10 percent significance level respectively. The p-value in last column is for Fisher's exact test of 2 x 3 contingency table based on the null hypothesis that the percentage of irrational forecasts among three sub-period is indifferent. The alternative hypothesis is that there is at least one sub-period in which its percentage of irrational forecasts is different from any other sub-period. The p-value in the first three column is for Fisher's exact test of 2 x 2 consistency table based on the null hypothesis of no difference in the percentage of irrational forecasts between two sub-periods. The null hypothesis is tested against one-sided alternative hypothesis. The positive (negative) difference in percentage implies that the percentage of irrational forecasts at the later sub-period is greater (less) than that at the previous sub-period. For example, the positive (negative) sign in the first column means that the percentage of irrational forecasts in sub-period 2 is greater (less than) than that in sub-period 1. Due to the limit to maturity of the yield curve, we do not compute the forward premium at the long forecast horizon. Thus, "Na" indicates that the relevant test cannot be performed since the information set is unavailable.

Table 5 Effect of maturity and horizon on rationality

Panel	Description	Type of rationality test	Sub-period 1	Sub-period 2	Sub-period 3	Whole period
1	The Difference in irrational forecasts of SMLH relative to SMSH	Unbiasedness	+50.00%	+6.67%	0.00%	+11.11%
		p-value	0.001**	0.335	0.634	0.098*
		Orthogonality				
		Lagged spot rate change	+40.00%	+56.67%	+16.13%	+24.07%
		p-value	0.009**	0.000**	0.127	0.006**
		Lagged individual forecast error	+45.00%	+70.00%	+22.58%	+18.52%
		p-value	0.002**	0.000**	0.053*	0.035**
2	The Difference in irrational forecasts of LMLH relative to LMSH	Unbiasedness	+70.00%	+3.33%	+9.68%	+14.81%
		p-value	0.000**	0.681	0.304	0.073*
		Orthogonality				
		Lagged spot rate change	+5.00%	+53.33%	+45.16%	+38.89%
		p-value	0.500	0.000**	0.000**	0.000**
		Lagged individual forecast error	+45.00%	+50.00%	+48.39%	+42.59%
		p-value	0.002**	0.000**	0.000**	0.000**
3	The Difference in irrational forecasts of LMSH relative to SMSH	Unbiasedness	+5.00%	0.00%	+22.58%	+12.96%
		p-value	0.500	0.694	0.043**	0.064*
		Orthogonality				
		Lagged spot rate change	+75.00%	-26.67%	+22.58%	+18.52%
		p-value	0.002**	0.020**	0.049**	0.026**
		Lagged individual forecast error	+45.00%	-3.33%	+12.90%	+14.81%
		p-value	0.002**	0.500	0.201	0.076*
4	The Difference in irrational forecasts of LMLH relative to SMLH	Unbiasedness	+25.00%	-3.33%	+32.26%	+16.67%
		p-value	0.088*	0.500	0.007**	0.052*
		Orthogonality				
		Lagged spot rate change	+40.00%	-30.00%	+51.61%	+33.33%
		p-value	0.004**	0.003**	0.000**	0.000**
		Lagged individual forecast error	+45.00%	-23.33%	+38.71%	+38.89%
		p-value	0.002**	0.021**	0.002**	0.000**

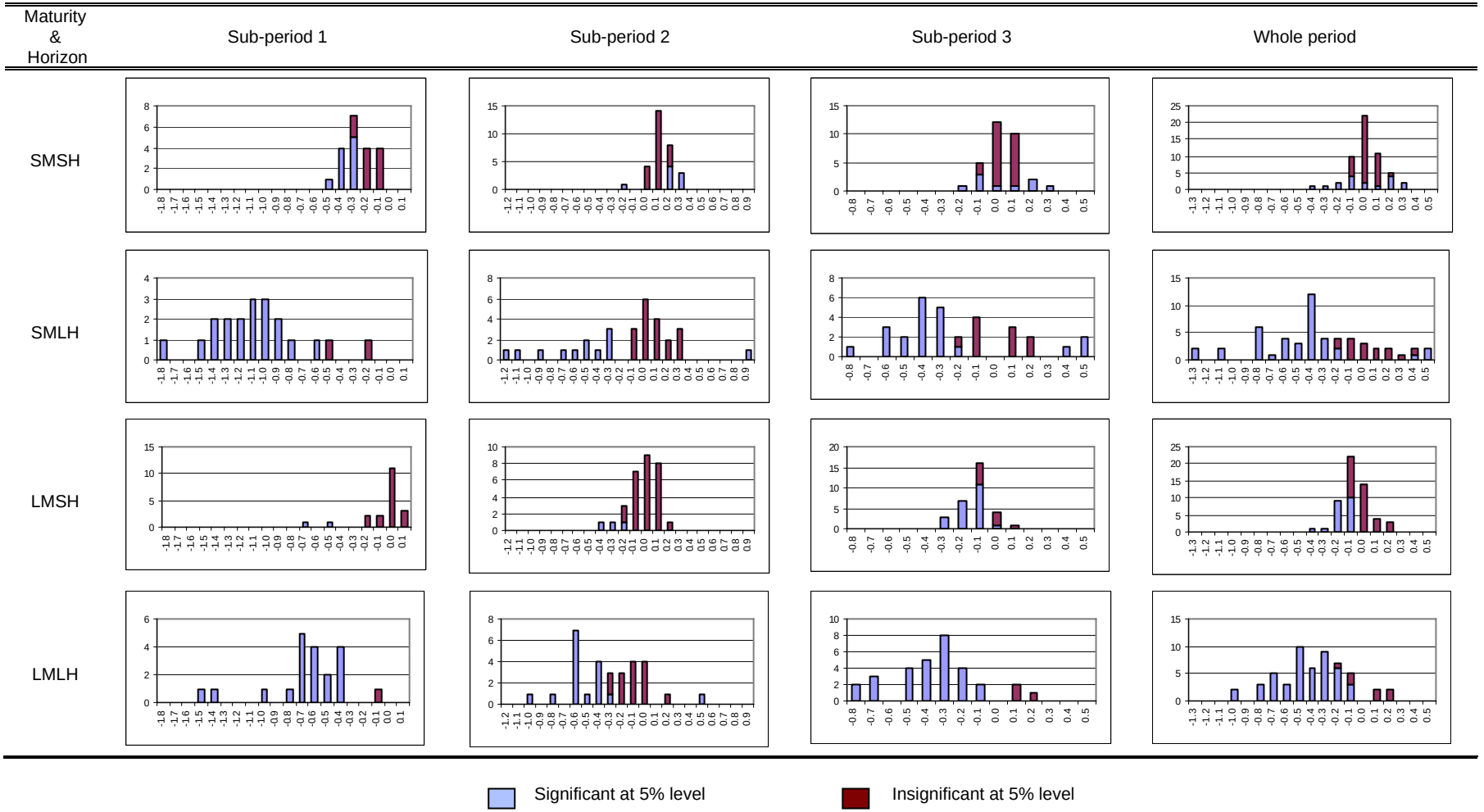
Notes: The range of each period is as follows: whole period (1/10/1989 – 31/07/2006), sub-period 1 (1/10/1989 – 15/09/1992), sub-period 2 (16/09/1992 – 5/05/1997), sub-period 3 (6/05/1997 – 31/07/2007). The p-value is for Fisher's exact test. For panels 1 and 2, the null hypothesis is that the increase in forecast horizon has no impact on the number of irrational forecasts. For panels 3 and 4, the null hypothesis is that the increase in maturity has no impact on the number of irrational forecasts. The null hypothesis is tested against one-sided alternative hypothesis.. ** and * signify statistical significance at 5 and 10 percent respectively. The positive (negative) percentage difference implies that the percentage of irrational forecasts increases (decreases) when the forecast horizon increases in panels 1 and 2 or when the maturity increases in panels 3 and 4.

Table 6 Summary of the effect of monetary policy signals on the unbiasedness condition of rationality

Monetary policy signals	SH (Short horizon)			LH (Long horizon)		
	Group 1	Group 2	Difference	Group 1	Group 2	Difference
Panel 1 : SM (Short maturity)		SMSH			SMLH	
Official bank rate change						
No. of biased forecasts	6	5	-1	16	5	-11
(Percentage)	(11.11%)	(9.26%)	(-1.85%)	(29.63%)	(9.26%)	(-20.37%)
p-value	0.052*	0.132	0.500	0.000**	0.132	0.007**
Publication of the inflation report						
No. of biased forecasts	7	12	+5	2	7	+5
(Percentage)	(14.89%)	(25.53%)	(+10.64%)	(4.25%)	(14.89%)	(+10.64%)
p-value	0.008**	0.000**	0.152	0.688	0.008**	0.079*
Disagreement amongst MPC						
No. of biased forecasts	3	3	0	13	3	-10
(Percentage)	(9.68%)	(9.68%)	(0.00%)	(41.94%)	(9.68%)	(-32.26%)
p-value	0.201	0.201	0.664	0.000**	0.201	0.004**
Panel 2 : LM (Long maturity)		LMSH			LMLH	
Official bank rate change						
No. of biased forecasts	14	3	-11	20	11	-9
(Percentage)	(25.93%)	(5.56%)	(-20.37%)	(37.04%)	(20.37%)	(-16.67%)
p-value	0.000**	0.511	0.003**	0.000**	0.000**	0.044**
Publication of the inflation report						
No. of biased forecasts	10	5	-5	14	12	-2
(Percentage)	(21.28%)	(10.64%)	(-10.64%)	(29.79%)	(25.53%)	(-4.26%)
p-value	0.000**	0.085*	0.130	0.000**	0.000**	0.409
Disagreement amongst MPC						
No. of biased forecasts	23	3	-20	24	9	-15
(Percentage)	(74.19%)	(9.68%)	(-64.51%)	(77.42%)	(29.03%)	(-48.39%)
p-value	0.000**	0.201	0.000**	0.000**	0.000**	0.000**

Notes: The p-value in column named "Group 1" and "Group 2" is for the binomial test provided that the null hypothesis of individual regression is tested at 5% significance level. The null hypothesis of binomial test is that forecasts as a whole are unbiasedness. The p-value in column named "Difference" is for Fisher's exact test under the null hypothesis of no difference in the number of irrational forecasts between two groups. The null hypothesis is tested against one-sided alternative hypothesis. ** and * signify statistical significance at 5 and 10 percent respectively. The study period and the number of forecasters for each test of monetary policy signal are as follows: the disagreement amongst the MPC: August 1997 – July 2006 (31 forecasters), the Publication of the inflation report: Jan 1993 – July 2006 (47 forecasters), the announcement of a change in bank rate: October 1989 – July 2006 (54 forecasters).

Figure 1 The distribution of bias coefficient



Notes: This figure shows the distribution of alphas estimated by equation (6).