Interest Rate Forecasts: A Pathology*

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This paper examines how well forecasters can predict the future time path of (policy-determined) short-term interest rates. Most prior work has been done using U.S. data; in this exercise we use forecasts made for New Zealand by the Reserve Bank of New Zealand (RBNZ) and those derived from money market yield curves in the United Kingdom. We broadly replicate recent U.S. findings for New Zealand and the United Kingdom, to show that such forecasts in New Zealand and the United Kingdom have been excellent for the immediate forthcoming quarter, reasonable for the next quarter, and useless thereafter. Moreover, when ex post errors are assessed depending on whether interest rates have been in an upward, or downward, section of the cycle, they are shown to have been biased and, apparently, inefficient. We attempt to explain those findings, and examine whether the apparent ex post forecast inefficiencies may still be consistent with ex ante forecast efficiency. We conclude, first, that the best forecast may be a hybrid containing a specific forecast for the next six months and a "no-change" assumption thereafter, and, second, that the modal forecast for interest rates, and maybe for other variables as well, is skewed, generally underestimating the likely continuation of the current phase of the cycle.

JEL Codes: C53, E17, E43, E47.

1. Introduction

The short-term policy interest rate has generally been adjusted in most developed countries, at least during the last twenty years or so, in a series of small steps in the same direction, followed by a pause

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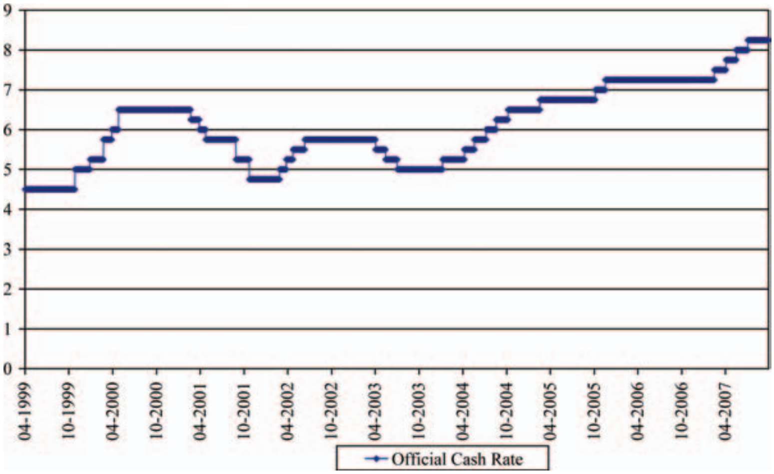
Figure 1. Official Cash Rate: Reserve Bank of New Zealand



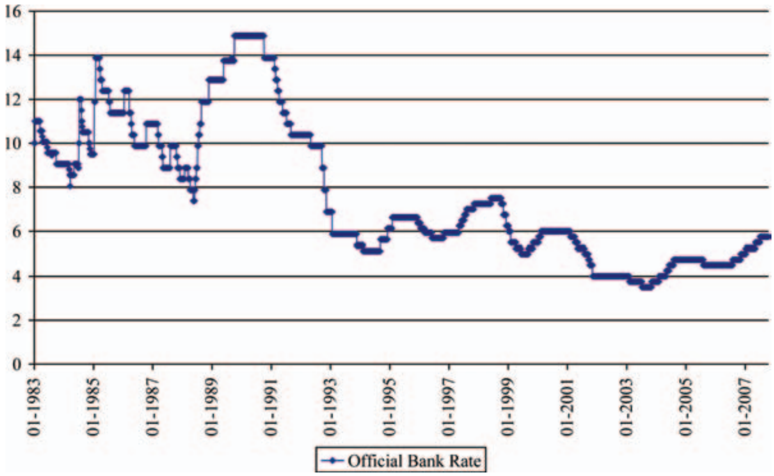
Source: Reserve Bank of New Zealand.

and then a, roughly, similar series of steps in the opposite direction. Figures 1 and 2 show the time path of policy rates for New Zealand and the United Kingdom, respectively.

On the face of it, such a behavioral pattern would appear quite easy to predict. Moreover, central bank behavior has typically been modeled by fitting a Taylor reaction function incorporating a lagged dependent variable with a large (often around 0.8 at a quarterly periodicity) and highly significant coefficient. But if this was, indeed, the reason for such gradualism, then the series of small steps should be highly predictable in advance.

The problem is that the evidence shows that they are *not* well predicted, beyond the next few months. There is a large body of, mainly American, literature to this effect, with the prime exponent being Glenn Rudebusch with a variety of co-authors; see in particular Rudebusch (1995, 2002, and 2006). Indeed, prior to the mid-1990s, there is some evidence that the market could hardly predict the likely path, or direction of movement, of policy rates over the next few months in the United States (see Rudebusch 1995 and 2002 and the literature cited there). More recently, with central banks having become much more transparent about their thinking, their

Figure 2. Official Bank Rate: Bank of England



Source: Bank of England web site.

plans, and their intentions, market forecasts of the future path of policy rates have become quite good over the immediately forthcoming quarter, and better than a random-walk (no-change) assumption over the following quarter. But thereafter they remain as bad as ever (see Lange, Sack, and Whitesell 2003 and Rudebusch 2006).

We contribute to this literature first by extending the empirical analysis to New Zealand and the United Kingdom, though some similar work on UK data has already been done by Lildholdt and Wetherilt (2004). The work on New Zealand is particularly interesting, since the forecasts are *not* those derived from the money market but those made available by the Reserve Bank of New Zealand in their Monetary Policy Statements about their current expectations for their own future policies.

One of the issues relating to the question of whether a central bank should attempt to decide upon, and then publish, a prospective future path for its own policy rate, as contrasted with relying on the expected path implicit in the money market yield curve, is the relative precision of the two sets of forecasts. A discussion of the general issues involved is provided by Goodhart (2009). For an analytical discussion of the effects of the relative forecasting precision on that decision, see Morris and Shin (2002) and Svensson

(2006). An assessment of the effects of publicly announcing the forecast on market rates is given in Andersson and Hofmann (2009) and in Ferrero and Nobili (2009).

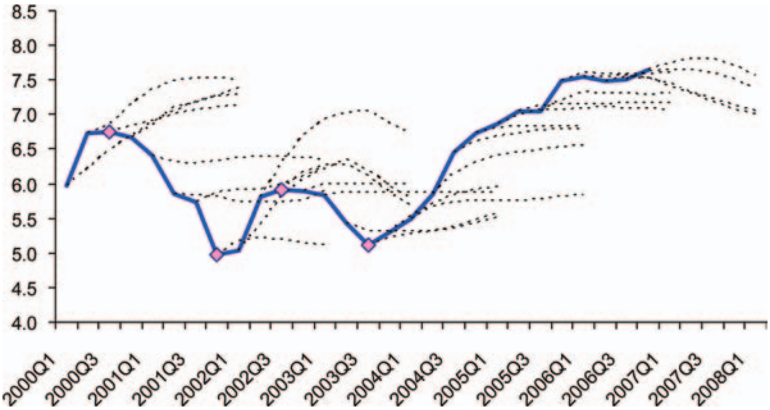
The question of the likely precision of a central bank's forecast of its own short-run policy rate is, however, at least in some large part, empirical. The Reserve Bank of New Zealand (RBNZ), a serial innovator in so many aspects of central banking, including inflation targeting and the transparency (plus sanctions) approach to bank regulation, was, once again, the first to provide a forecast of the (conditional) path of its own future policy rates. It began to do so in 2000:Q1. That gives twenty-eight observations between that date and 2006:Q4, our sample period. While still short, this is now long enough to undertake some preliminary tests to examine forecast precision.

Partly for the sake of comparison,[1] we also explore the accuracy of the implicit market forecasts of the path of future short-term interest rates in the United Kingdom. We use estimates provided by the Bank of England over the period 1992:Q4 until 2004:Q4. There are two such series, one derived from the London Interbank Offered Rate (LIBOR) yield curve and one from short-dated government debt. We base our choice between these on the relative accuracy of their forecasts. On this basis, as described in section 3, we chose, and subsequently used, the government debt series and its implied forecasts.

In the next section, section 2, we report and describe our data series. Then in section 3 of this paper we examine the predictive accuracy of these sets of interest rate forecasts. The results are closely in accord with the earlier findings in the United States.

[1]The United Kingdom and New Zealand (NZ) are different economies, and so one is *not* strictly comparing like with like. If one was, however, to compare the NZ implicit market forecast accuracy with that of the RBNZ forecast over the same period (a comparison which we hope that the RBNZ will do), the former will obviously be affected by the latter (and possibly vice versa). Again, if a researcher was to compare the implied accuracy of the market forecast *prior* to the introduction of the official forecast with the accuracy of the market/official forecast *after* the RBNZ had started to publish (another exercise that we hope that the RBNZ will undertake), then the NZ economy, their financial system, and the economic context may have changed over time. So one can *never* compare an implicit market forecast with an official forecast for interest rates on an exactly like-for-like basis. Be that as it may, we view the comparison of the RBNZ and the implied UK interest rate forecasts as illustrative, and not definitive in any way.

Figure 3. RBNZ Interest Rate Forecast (Ninety Days, Annualized Rate) Published in Successive Monetary Policy Statements



Notes: Turning points are marked by a diamond. The dating of these is discussed further in section 3.

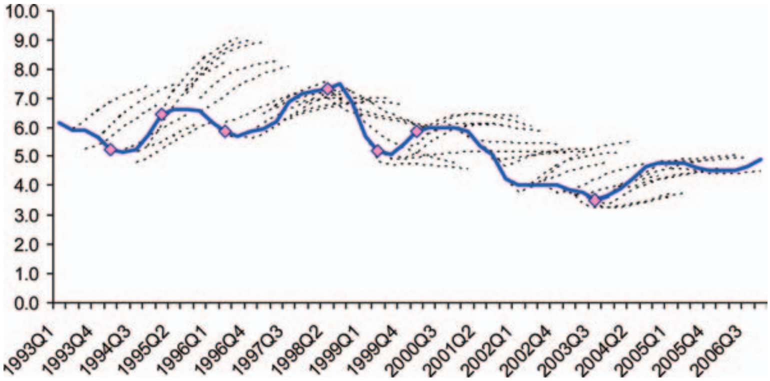
Whether the forecast comes from the central bank or from the market, the predictive ability is good, by most econometric standards, over the first quarter following the date of the forecast; it is poor, but significantly better than a no-change, random-walk forecast, over the second quarter (from end-month 3 to end-month 6), and effectively useless from that horizon onward.

Worse, however, is to come. The forecasts, once beyond the end of the first quarter, are not only without value, they are, when compared with ex post outcomes, also strongly and significantly biased. This does not, however, necessarily mean that the forecasts were ex ante inefficient. We shall demonstrate in section 5 how ex post bias can yet be consistent with ex ante efficiency in forecasting.

This bias can actually be seen clearly in a visual representation of the forecasts. The RBNZ forecasts and outcome are shown in figure 3, and the UK forecast derived from the short-dated government debt yield curve and outcome is shown in figure 4.

What is apparent by simple inspection is that when interest rates are on an upward (downward) cyclical path, the forecast underestimates (overestimates) the actual subsequent path of interest rates. Much the same pattern is also observable in the United States (see

Figure 4. UK Interest Rate Forecast (Ninety Days, Annualized Rate) Derived from the Short-Dated Government Debt Yield Curve



Rudebusch 2007) and Sweden (see Adolfson et al. 2007). One of the reasons why this bias has not been more widely recognized up till now is that the biases during up and down cyclical periods are almost exactly offsetting, so if an econometrician applies his or her tests to the complete time series (as usual) (s)he will find no aggregate sign of bias. The distinction between the bias in "up" and "down" periods is crucial. A problem with some time series—e.g., those for inflation—is that the division of the sample into "up," "down," and in some cases "flat" periods is not always easy, nor self-evident. But this is less so for short-term interest rates where the ex post timing of turning points is relatively easier.

The sequencing of this paper proceeds as follows. We report our database in section 2. We examine the accuracy of the interest rate forecasts in section 3. We continue in section 4 by assessing whether forecasts which appear ex post biased can still be ex ante efficient. Section 5 concludes.

2. The Database for Interest Rates

Our focus in this paper concerns the accuracy of forecasts for short-term policy-determined interest rates, measured in terms of unbiasedness and the magnitude of forecast error. We examine the data for two countries. We do so first for New Zealand, because this is the country with the longest available published series of official projections, as presented by the RBNZ in their quarterly Monetary Policy Statement. Our second country is the United Kingdom. In this case the Bank of England assumed unchanged future interests, from their current level, as the basis of their forecasts, until they moved onto a market-based estimate of future policy rates in November 2004. As described below, we considered the use of two alternative estimates of future (forecast) policy rates.

In New Zealand, policy announcements, and the release of projections, are usually made early in the final month of the calendar quarter, though the research work and discussions in their Monetary Policy Committee (MPC) will have mostly taken place a couple of weeks previously. Thus the Statement contains a forecast for inflation for the current quarter ($h = 0$), though that will have been made with knowledge of the outturn for the first month and some partial evidence for the second. The Policy Targets Agreement between the Treasurer and the Governor is specified in terms of the CPI, and the forecast is made in terms of the CPI. This does not, however, mean that the RBNZ focuses exclusively on the overall CPI in its assessment of inflationary pressures.

In New Zealand, the policy-determined rate is taken to be the ninety-day (three-month) rate, and the forecasts are for that rate. Thus the current-quarter interest rate observation contains nearly two months of actual ninety-day rates and just over one month of market forward one-month rates. If the MPC meeting results in a (revisable) decision to change interest rates in a way that is inconsistent with the prediction that was previously embedded in market forward interest rates, then the assumption for the current quarter can be revised to make the overall ninety-day track look consistent with the policy message. Finally, the policy interest rate can be adjusted, after the forecast is effectively completed, right up to the day before the Monetary Policy Statement; this was done in September 2001 after the terrorist attack. So, the interest rate forecast for the current quarter ($h = 0$) also contains a small extent of uncertain forecast.

The data for published official forecasts of the policy rate start in 2000:Q1. We show those data, the forecasts, and the resulting errors, for the policy rate in the appendix, tables 8 and 9. The data are shown in a format where the forecasts are shown in the same row as the actual to be forecast, so the forecast errors can be read off directly.

The British case is somewhat more complicated. In the past, during the years of our sample, the MPC used a constant forward forecast of the repo rate as the conditioning assumption for its forecasting exercise. Whether members of the MPC made any mental reservations about the forecast on account of a different subjective view about the future path of policy rates is an individual question that only they can answer personally. But it is hard to treat that constant path as a pure, most likely, forecast. At the same time, there are at least two alternative time series of implied market forecasts for future policy rates that are derived from the yield curve of short-dated government debt and from LIBOR. There are some complicated technical issues in extracting implied forecasts from market yield curves, and such yield curves can be distorted, especially the LIBOR yield curve, as experience since 2007 has clearly demonstrated. These problems relate largely to risk premia, notably credit and default risk; see Ferrero and Nobili (2009). The yield curve for government debt is (or rather has been) largely immune to such credit (default) risk, though it can be exposed to other risks, e.g., interest rate and liquidity risks.

We do not rehearse these difficulties here; instead we simply took these data from the Bank of England web site (see www.bankofengland.co.uk). For more information on the procedures used to obtain such implicit forecast series, see Anderson and Sleath (1999, 2001), Brooke, Cooper, and Scholtes (2000), and Joyce, Relleen, and Sorensen (2007). As will be reported in the next section, the government debt implicit market forecast series has had a more accurate forecast than the LIBOR series over our data period, 1992–2004, probably in part because the government series would not have incorporated a time-varying credit risk element; see Ferrero and Nobili (2009). Since the constant rate assumption was hardly a forecast, most of our work was done with the government debt implicit forecast series. This forecasts the three-month Treasury bill series. These series—actual, forecast, and errors (with the forecast lined up against the actual it was predicting)—are shown in the appendix, tables 10 and 11, for the government debt series (the other series for LIBOR is available from the authors on request).

3. How Accurate Are the Interest Rate Forecasts?

We began our examination of this question by running three regressions both for the NZ data series and for two sets of implied market forecasts for the United Kingdom, derived from the LIBOR and government debt yield curve, respectively. These regression equations were as follows:

$$IR(t+h) = C_1 + C_2 \text{ Forecast } (t, t+h) \tag{1}$$

$$IR(t+h) - IR(t) = C_1 + C_2 \text{ [Forecast}(t, t+h) - IR(t)] \tag{2}$$

$$IR(t+h) - IR(t+h-1) = C_1 + C_2 \text{ [Forecast}(t, t+h) - \text{Forecast}(t, t+h-1)], \tag{3}$$

where

$$IR(t) = \text{actual interest rate outturn at time } t$$
$$\text{Forecast}(t, t+h) = \text{forecast of } IR(t+h) \text{ made at time } t.$$

The first equation is essentially a Mincer-Zarnowitz regression (Mincer and Zarnowitz 1969) evaluating how well the forecast can predict the actual h-period-ahead interest rate outturn ($h = 0$ to n). If the forecast perfectly matches the actual interest rate outturn for every single period, we would expect to have $C_2 = 1$ and $C_1 = 0$. This can be seen as an evaluation of the bias of the forecast. Taking expectations on both sides, $E\{IR(t+h)\} = E\{C_1 + C_2[\text{Forecast}(t, t+h)\}$. A forecast is unbiased—i.e., $E\{IR(t+h)\} = E\{[\text{Forecast}(t, t+h)]\}$ for all t—if and only if $C_2 = 1$ and $C_1 = 0$. The second regression, by subtracting the interest rate level from both sides, allows us to focus our attention on the performance of the forecast interest rate difference $\{IR(t+h) - IR(t)\}$. It asks, as h increases, how accurately can the forecaster forecast h-quarter-ahead interest rate *changes* from the present level. The third regression is a slight twist on the second, focusing on one-period-ahead forecasts; the regression examines the forecast performance of one-period-ahead interest rate changes $\{IR(t+h) - IR(t+h-1)\}$ as h increases.

All three regressions assess the accuracy/biasness of interest rate forecasts from slightly different angles. An unbiased forecast necessarily implies a constant term of zero and a slope coefficient of one. We can test whether these conditions are fulfilled with a joint hypothesis test:

$$H_0\text{: } C_1 = 0 \text{ and } C_2 = 1.$$

With three equations, three data sets, and $h = 0$ to 5 for New Zealand and $h = 1$ to 8 for the UK series, we have some eighty-five regression results and statistical test scores to report.

We found that the regression results, estimated by OLS, for the implicit forecasts derived from the LIBOR yield curve were comprehensively worse than those from the government yield curve, or the RBNZ. These LIBOR results provided poor forecasts even for the first two quarters, and useless forecasts thereafter. There are several possible reasons for such worse forecasts—e.g., time-varying risk premia (Ferrero and Nobili 2009) or data errors in a short sample—but it is beyond the scope of this paper to try to track them down. These results can be found in Goodhart and Lim (2008) and, to save space, are not reported here. That reduces the number of regression results to sixteen in table 1 for the RBNZ and twenty-four in table 2 for the UK government yield curve.

These results show that the RBNZ forecast is excellent one quarter ahead but then becomes useless in forecasting the subsequent direction, or extent, of change. Thus the coefficient C_2 in equation (3) becomes -0.04 at $h = 2$ (with an R-squared of zero), and negative thereafter. When the equation is run in levels, rather than first differences—i.e., equation (1)—the excellent first-quarter forecast feeds through into a significantly positive forecast of the *level* in the next few quarters, though it is just the first-quarter forecast doing all the work. The Mincer-Zarnowitz test results[2] are also consistent with our findings. We failed to reject the joint hypothesis H_0 for up to a three-quarters-ahead forecast for equation (1) and up to a four-quarters-ahead forecast for equation (2). We reject H_0 for the quarters thereafter.

[2]These tests are reported in Goodhart and Lim (2008) but are omitted to save space here.

Table 1. Regression Results for New Zealand

$h =$	C_1 (p-value)	C_2 (p-value)	R-squared	DW
Equation (1)				
0	−0.01 (0.93)	1.00 (0.85)	0.99	1.77
1	−0.24 (0.64)	1.03 (0.74)	0.88	1.53
2	0.30 (0.75)	0.93 (0.63)	0.65	0.93
3	1.50 (0.25)	0.74 (0.19)	0.39	0.34
4	3.71 (0.03)	0.40 (0.02)	0.11	0.28
5	5.71 (0.00)	0.09 (0.00)	0.00	0.15
Equation (2)				
1	−0.16 (0.07)	1.61 (0.18)	0.35	1.61
2	−0.15 (0.31)	1.02 (0.95)	0.20	1.02
3	−0.09 (0.66)	0.73 (0.55)	0.10	0.45
4	0.13 (0.61)	0.11 (0.10)	0.00	0.47
5	0.37 (0.20)	−0.38 (0.01)	0.03	0.34
Equation (3)				
1	0.13 (0.07)	1.30 (0.33)	0.43	2.06
2	0.04 (0.65)	−0.04 (0.06)	0.00	1.24
3	0.07 (0.38)	−0.68 (0.04)	0.03	1.38
4	0.09 (0.28)	−1.29 (0.03)	0.07	1.37
5	0.09 (0.26)	−1.30 (0.02)	0.08	1.28

Note: The corresponding p-value is evaluated against the null hypothesis, H_0: $C_1 = 0$, $C_2 = 1$.

Table 2. UK Forecasts Derived from the Short-Term Government Yield Curve

$h =$	C_1 (p-value)	C_2 (p-value)	R-squared	DW
Equation (1)				
1	0.23 (0.25)	0.98 (0.64)	0.95	1.94
2	0.60 (0.07)	0.89 (0.06)	0.84	1.03
3	0.98 (0.03)	0.79 (0.01)	0.71	0.62
4	1.56 (0.00)	0.67 (0.00)	0.55	0.43
5	2.10 (0.00)	0.56 (0.00)	0.41	0.35
6	2.43 (0.00)	0.49 (0.00)	0.34	0.31
7	2.52 (0.00)	0.47 (0.00)	0.32	0.29
8	2.42 (0.00)	0.48 (0.00)	0.35	0.28
Equation (2)				
1	0.13 (0.02)	0.94 (0.70)	0.51	1.91
2	−0.01 (0.84)	0.86 (0.31)	0.50	1.04
3	−0.16 (0.09)	0.85 (0.25)	0.47	0.67
4	−0.28 (0.03)	0.73 (0.07)	0.36	0.48
5	−0.34 (0.03)	0.60 (0.01)	0.27	0.39
6	−0.37 (0.03)	0.51 (0.00)	0.22	0.35
7	−0.39 (0.02)	0.46 (0.00)	0.21	0.31
8	−0.43 (0.00)	0.46 (0.00)	0.24	0.28

(continued)

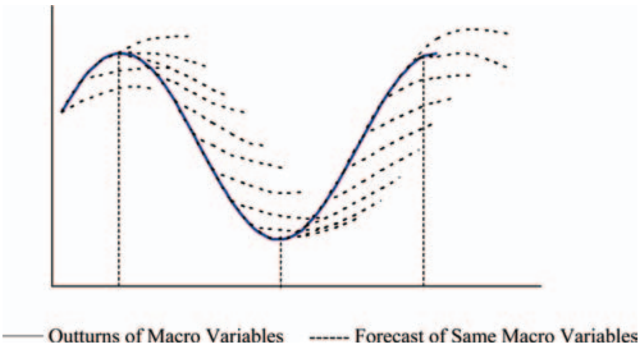
Table 2. (Continued)

$h =$	C_1 (p-value)	C_2 (p-value)	R-squared	DW
Equation (3)				
1	0.13	0.94	0.51	1.91
	(0.02)	(0.70)		
2	−0.13	0.87	0.25	1.19
	(0.02)	(0.62)		
3	−0.13	0.65	0.15	0.97
	(0.04)	(0.14)		
4	−0.09	0.43	0.05	0.83
	(0.19)	(0.03)		
5	−0.08	0.53	0.06	0.84
	(0.21)	(0.14)		
6	−0.08	0.73	0.08	0.80
	(0.18)	(0.15)		
7	−0.06	0.41	0.04	0.82
	(0.34)	(0.58)		
8	−0.05	0.58	0.03	0.76
	(0.39)	(0.41)		

Note: The corresponding p-value is evaluated against the null hypothesis, H_0: $C_1 = 0$, $C_2 = 1$.

Turning next to the United Kingdom implied forecasts from the government debt yield curve, what these tables indicate is that, in the first quarter after the forecast is made, the forecast precision of this derived forecast is mediocre (joint test for null hypothesis is rejected for $h = 3 - 8$), certainly significantly better than random walk (no change) but not nearly as good as the NZ forecast over its first quarter. However, this market-based forecast is also able to make a good forecast of the change in rates between Q1 and Q2 (whereas the RBNZ could not do that). The government yield forecast for $h = 2$ in table 2 is somewhat better than for $h = 1$. So the ability of the government yield forecast to predict the *level* of the policy rate two quarters (six months) hence is about the same or a little better than that of the RBNZ. Thereafter, from Q2 onward, the predictive ability of the government yield

Figure 5. Stylized Pattern of Relationships between Forecasts and Outturns of Macro Variables over the Cycle



forecast becomes insignificantly different from zero, but at least the coefficients have the right sign (unlike the RBNZ).

The conclusion of this set of tests is that the precision of interest forecasts beyond the next quarter or two is approximately zero, whether they are made by the RBNZ or the UK market. Given the gradual adjustments in actual policy rates, this might seem surprising. Why does it happen? In order to answer this question, we start with a stylized fact. When one looks at most macroeconomic forecasts, and notably so for interest rates (see figures 3 and 4 above), they tend to follow a pattern. When the macro variable is rising, the forecast increasingly falls below it. When the macro variable is falling, the forecast increasingly lies above it. This pattern is shown again in illustrative form in figure 5.

So, if we divide the sample period into periods of rising and falling values for the variable of concern (in this case the interest rate), during up periods Actual minus Forecast will tend to be persistently positive, and during down periods Actual minus Forecast will tend to be persistently negative. There is, however, an important caveat. A forecast made during an up (down) period may extend several quarters beyond the turning point into the next down (up) period. Once a turning point has occurred, however, a forecast that was too high (low) during the continuing down (up) cycle can rapidly then become too low (high) once the cycle has switched direction. Clearly the tendency for Actual minus Forecast to be negative in an upturn will be most marked for forecasts made in an upturn so long as that upturn *continues*, i.e., until the next sign change from up to down, or vice versa. Nevertheless, we still expect on balance that forecasts made during an upturn (downturn) will tend to have positive (negative) Actual minus Forecast outturns even after such a sign change, but the result is clearly uncertain.[3] But the forecasts made for the policy rate in the next quarter (and to a lesser extent into the second quarter) are so good, especially for the next quarter for the RBNZ, that no such bias may exist.

As can be seen from figures 1 and 2, the official rate is frequently held constant for a period of a few months before there is a reversal of direction. So the exact date of reversal is somewhat uncertain. We chose a date during these months as the best alternative on the basis of other available contemporaneous evidence, notably the concurrent time path of market rates. But we also tested for robustness by taking the first and last dates of each flat period and rerunning the exercises. The latter made no difference; the results are available on request from the authors.

Perhaps the easiest way of demonstrating this result, suggested to us by Andrew Patton, is to run a regression of the forecast error, at various horizons, against two indicator variables, one for up periods (C_1) and one for down periods (C_2):[4]

$$[IR(t+h) - \text{Forecast}(t, t+h)] = C_1 \mathrm{I}_{up}(t+h) + C_2 \mathrm{I}_{down}(t+h), \tag{4}$$

where

$IR(t)$ = actual interest rate outturn at time t

$\text{Forecast}(t, t+h)$ = forecast of $IR(t+h)$ made at time t

$\mathrm{I}_{up}(t+h)$ is a dummy variable = 1 if time, $t+h$, is an "up" period; else 0

$\mathrm{I}_{down}(t+h)$ is a dummy variable = 1 if time, $t+h$, is a "down" period; else 0.

[3]When interest rates are volatile, and sign changes are more frequent, nothing useful can be said about the likely outcomes of Actual minus Forecast after a second sign change.

[4]In our original paper (Goodhart and Lim 2008), we did some additional and more complicated statistical exercises, looking at the number of errors of a particular sign, in "up" and "down" phases, their mean, standard deviation, and p-values. They are omitted here to save space.

Table 3. Results for New Zealand

A. Indicator Variable Is Based on State in NZ at Outturn Date (Whole Data Set)					
$H =$	Adj. R-sqr.	C_1	p-value	C_2	p-value
Q1	0.41	0.06	0.26	−0.34	0.00
Q2	0.61	0.14	0.07	−0.69	0.00
Q3	0.58	0.23	0.06	−0.88	0.00
Q4	0.36	0.23	0.23	−0.99	0.00
Q5	0.27	0.24	0.33	−1.06	0.01
Q6	0.20	0.23	0.49	−1.07	0.05
Q7	0.03	0.13	0.79	−0.95	0.27
Q8	−0.30	0.04	0.97	−0.52	0.79
B. Indicator Variable Is Based on State in NZ at Outturn Date, but only Includes Period during Which Sign Is Unchanged					
$H =$	Adj. R-sqr.	C_1	p-value	C_2	p-value
Q1	0.41	0.06	0.26	−0.34	0.00
Q2	0.76	0.22	0.00	−0.70	0.00
Q3	0.87	0.41	0.00	−1.13	0.00
Q4	0.81	0.56	0.00	−1.53	0.00
Q5	0.86	0.73	0.00	−2.13	0.00
Q6	—	—	—	—	—
Q7	—	—	—	—	—
Q8	—	—	—	—	—

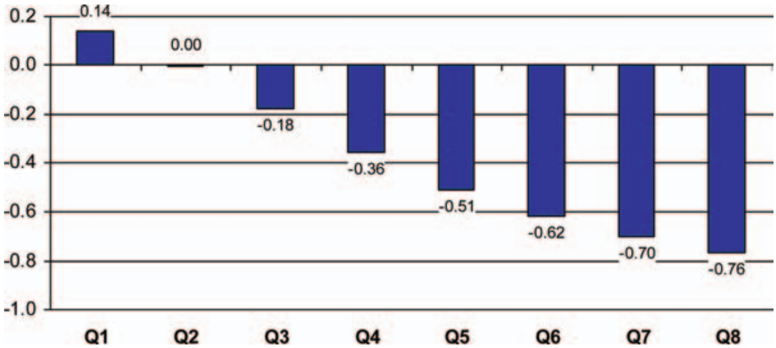
Note: The corresponding p-value is evaluated against the null hypothesis, H_0: $C_1 = 0$, $C_2 = 0$.

The hypothesis is that the up-period indicator (C_1) is positive (actual > forecast) and the down-period indicator (C_2) is negative (actual < forecast).

The results for New Zealand are shown in table 3.

Turning next to the results for the UK government yield implied forecasts, we found similar results. In this case, however, the forecasts included some sizable *average* errors, whereby the forecasts implied that interest rates would tend to become higher than was the case in the historical event (actual < forecast). This average

Figure 6. Average UK Interest Rate Forecast Error



error tended to increase, approximately linearly, as the horizon (h) increased. This is shown in figure 6.

After correcting for this average error[5] and rerunning,[6] the results were as shown in table 4.

One of our referees kindly directed our attention to a related recent article, Ferrero and Nobili (2009). In this they regress excess returns (x), defined as forecast less actual ex post outcomes, for interest rates (futures) as a function of a business-cycle indicator (growth of output or employment expectations) and the current level of the futures rate, so that in their equation (4), p. 116,

$$x_{t+n}^{(n)} = a^{(n)} + \beta_n z_t + \gamma^n f_t^{(n)} + \varepsilon_{t+n}^{(n)},$$

where z_t is the business-cycle indicator, f_t is the level of the current futures rate, and β and γ are coefficients. In their table 2 (p. 118), table 5 (p. 127), and table 7 (p. 131), they find β to be negative, often significantly so, and γ to be usually significantly positive.

These authors cannot explain their own findings: "A theoretical analysis of the reasons behind the presence of forecast errors that are predictable and significantly countercyclical only in the United

[5]The tables using the unadjusted data—i.e., without correcting for the average error—are available on request from the authors.

[6]The average forecast error in New Zealand was much smaller and did not vary systematically with h. We ran similar adjusted regressions for New Zealand, but the results were closely similar to those shown in table 4.

Table 4. Results for United Kingdom, with Average Error Removed

A. Indicator Variable Is Based on State in UK at Outturn Date (Whole Data Set, with Average Forecast Error Removed)					
***H* =**	**Adj. R-sqr.**	C_1	**p-value**	C_2	**p-value**
Q1	0.14	0.12	0.10	−0.08	0.16
Q2	0.25	0.26	0.01	−0.19	0.02
Q3	0.41	0.45	0.00	−0.38	0.00
Q4	0.22	0.41	0.02	−0.39	0.02
Q5	0.07	0.27	0.24	−0.30	0.17
Q6	0.01	0.04	0.89	−0.13	0.60
Q7	0.00	−0.19	0.50	−0.03	0.91
Q8	0.03	−0.40	0.16	0.01	0.97
B. Indicator Variable Is Based on State in UK at Outturn Date, but only Includes Period during Which Sign Is Unchanged, with Average Forecast Error Removed					
***H* =**	**Adj. R-sqr.**	C_1	**p-value**	C_2	**p-value**
Q1	0.14	0.12	0.10	−0.08	0.16
Q2	0.32	0.28	0.01	−0.25	0.00
Q3	0.63	0.57	0.00	−0.55	0.00
Q4	0.70	0.79	0.00	−0.72	0.00
Q5	0.76	0.85	0.00	−0.88	0.00
Q6	0.81	0.76	0.00	−0.80	0.00
Q7	0.76	0.76	0.03	−0.89	0.00
Q8	0.67	0.52	0.23	−0.95	0.00

States lies beyond the scope of this paper" (Ferrero and Nobili 2009, p. 130). Our analysis here enables us to explain these findings; they are exactly what we would have expected given the ex post biases in forecasting over the cycle phases. As shown illustratively in figure 5, during the up (down) phases of the cycle, forecasts understate (overstate) ex post actuals systematically; hence β will be negative, though we too cannot explain why the euro zone exhibits less of this effect. Similarly, the expected futures rate will tend to be highest (lowest) at the top (bottom) of the cycle. As figure 5 again shows, this is when the forecast bias has forecast greater (less) than actual, so γ should be positive. The explanation of the Ferrero/Nobili results is, in our view, not due to time-varying risk premia, but to systematic ex post biases in the forecasting process over cycle phases. We are particularly grateful for having been given the chance to relate our work here to another strand in the literature.

What all these results show is as follows:

(i) The official and market forecasts of interest rates that we have studied here have significant predictive power over the next two quarters, but virtually none thereafter. When forecast precision is effectively zero, as after two quarters hence, it is perhaps best to acknowledge this, e.g., by the central bank using either a "no-change" thereafter assumption, or the implied market forecast, for the more distant forecasts.[7]

(ii) These interest rate forecasts are systematically biased, underestimating future policy rates during upturns and overestimating them during downturns. We shall now proceed to explore reasons why this might have been so in sections 4 and 5.

4. Can One Forecast the Forecasters?

In the preceding sections, we have shown that interest rate forecasts in the United Kingdom and New Zealand during this time period systematically underpredicted the time series during cyclical phases of upward movement, and similarly overpredicted during downswings.

In this section we seek to address the question of why these (most?) forecasts exhibit this tendency.[8] The answer that we propose is that (most) macroeconomic variables are expected (by most

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[7]The choice may depend on the confidence with which the official forecasters hold their longer-dated forecasts. There is, however, a danger that the official forecasters have excessive confidence in their own forecasting abilities *and* that private-sector forecasters likewise place excessive weight on such official forecasts (Morris and Shin 2002). However, the finding by Ferrero and Secchi (2009) that long-term expectations on future interest rates react significantly only to short-term central bank interest rate forecasts, and not to their longer-term projections, suggests that market agents may well realize that such longer-term projections rarely contain any valuable information.

[8]In our original work we extended our research to cover inflation forecasts as well. These also exhibited the same syndrome. In order to save space and to enhance focus, we have, however, omitted those results from this paper. A more extended version of this paper, which explores not only the (errors in the) inflation forecasts in New Zealand and the United Kingdom but also the relationships between the errors in the inflation forecasts and those in the interest rate forecasts, is given in Goodhart and Lim (2009).

economists[9]) to revert to some longer-term equilibrium, ceteris paribus. Indeed, it is hard to see how forecasting could be done in the absence of a concept of (long-run) equilibrium. But at any particular point of time, macroeconomic variables will be subject to momentum, whose current force is quite difficult to assess accurately and which will be subject to unforeseeable future shocks. Thus we posit that these (most) forecasts will be subject to two main elements, an autoregressive component and a mean-reverting (back to equilibrium) component. Such a combination is bound to give us the general pattern that we have found in practice. So long as the phase remains upward (downward), the mean-reverting element in the forecast will tend to pull the forecast below (above) the actual track of the variable, but, of course, as the eventual turning point draws closer, it will predict far better than a pure autoregressive forecast.

During the periods under examination, an inflation-targeting regime was in operation in both New Zealand and the United Kingdom, so the equilibrium to which the inflation rate would revert would have been close to target, and about $2\frac{1}{2}$ percent above that for the nominal interest rate, assuming an equilibrium real interest rate of $2\frac{1}{2}$ percent. But for our purposes here, we do not assume to know what the equilibrium interest rate is, and have simply taken the arithmetic average of the study period as an estimation of the "mean-reverting" point.[10] The nature of the autoregressive process for each series, and the coefficients for combining the autoregressive and the mean-reverting components into an implied forecast are unknown and for determination. Initially we shall assume that the forecasters make an efficient, unbiased prediction of both factors. Thus we estimate for each series

$$IR(t+1) - IR(t) = B_1 * [IR(t) - IR(t-1)] + B_2 * [IR(t) - \overline{IR}], \quad (5)$$

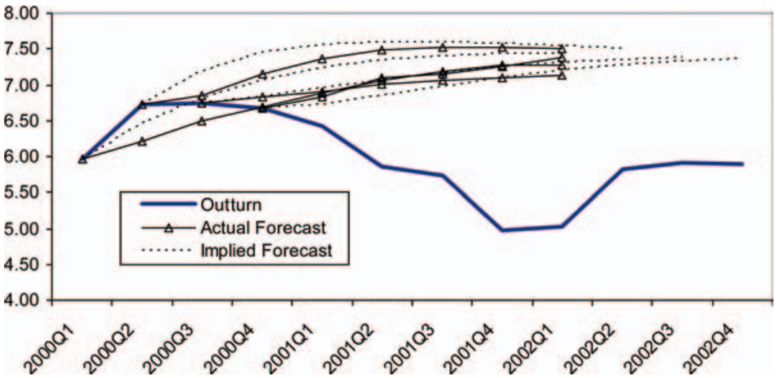
[9]Not all economists have such expectations. A few, "heterodox," economists challenge whether equilibria necessarily exist, notably Paul Davidson and Basil Moore.

[10]We tested this by trying values of the mean-reverting point with +1 percent and −1 percent of the average, and it made no significant difference to the coefficients for B_1 and B_2, as well as for the results in table 6 and table 7. These results are available on request from the authors.

Table 5. Estimated Coefficients

Equation (1)	B_1			B_2			Regression Statistics		
	Coef.	t-stats	p-value	Coef.	t-stats	p-value	Adj. R-sqr.	SE	Obs.
UK Interest Rate	0.66	6.30	0.00	−0.09	−2.54	0.01	0.4175	0.2539	54
NZ Interest Rate	0.49	4.90	0.00	−0.13	−3.58	0.00	0.3403	0.6326	66

Figure 7. NZ Interest Rate: Comparison between Outturn, Actual and Implied Forecast



where

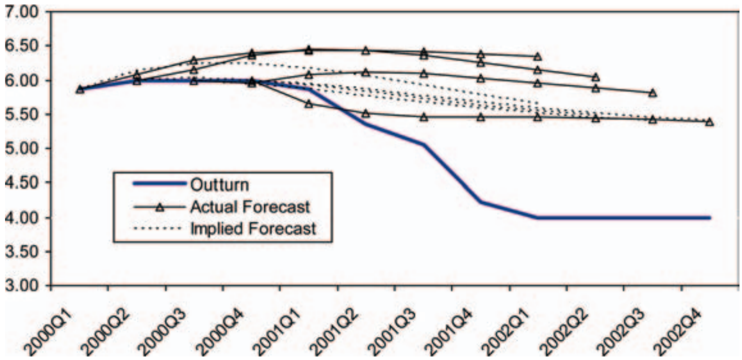
$$IR(t) = \text{actual interest rate outturn at time } t$$

$$\overline{IR} = \text{average interest rate outturn over the study period.}$$

The estimated coefficients are shown in table 5, where B_1 can be understood as the autoregressive coefficient, and B_2 as the mean-reversion coefficient.

Now we have a simplified model of how forecasts are done. The next step is to compare it with the actual forecasts. We do this first diagrammatically. For illustration, we have provided the diagrammatical comparison for the period between 2000:Q1 and 2002:Q4. The diagrams, figure 7 for New Zealand and figure 8 for the United

Figure 8. UK Interest Rate: Comparison between Outturn, Actual and Implied Forecast



Kingdom, show quite a close relationship between the actual and our implied (from our simple model) forecast. Quarters beyond $t+1$ are estimated recursively.

We then evaluate the implied forecast *changes* against the actual forecast *changes* via regression analysis over the whole study period:

$$\begin{aligned} &\text{Actual Forecast } (t, t+h) - IR(t) \\ &\quad = C_1 + C_2[\text{Implied Forecast } (t, t+h) - IR(t) \\ &\quad\; i = 1 - 8. \end{aligned} \tag{6}$$

The hypothesis is that $C_1 = 0$ and $C_2 = 1$. The t-stats for C_2 in table 6 for New Zealand and table 7 for the United Kingdom relate to the coefficient's deviation from unity, *not* from zero.

But the regressions, and a closer inspection of the diagrams, indicated a systematic problem, separating the implied from the actual forecast. This was that the "true" coefficient of mean reversion during these years was greater than that used by the actual forecasters; i.e., the implied forecast flattened out near the equilibrium level faster than the actual forecasters expected. An indicative diagram for the six-quarters-ahead implied forecast for the UK interest rate showing this is given in figure 9.[11]

[11] Similar figures for NZ interest rates and for the UK series, both inflation and interest rates, are available in Goodhart and Lim (2009).

Table 6. NZ Interest Rate: Evaluation of Implied Forecast and Actual Forecast

	C_1			C_2			Regression Statistics		
h	**Coef.**	***t*-stats**	**p-value**	**Coef.**	***t*-stats**	**p-value**	**Adj. R-sqr.**	**SE**	**Obs.**
1	0.05	1.76	0.09	0.48	−4.99	0.00	0.44	0.10	28
2	0.01	0.14	0.89	0.57	−3.87	0.00	0.48	0.17	28
3	−0.03	−0.41	0.69	0.52	−4.20	0.00	0.43	0.24	28
4	−0.04	−0.40	0.69	0.44	−4.95	0.00	0.35	0.30	28
5	−0.05	−0.44	0.66	0.40	−5.35	0.00	0.30	0.35	28
6	−0.13	−0.81	0.43	0.43	−4.36	0.00	0.33	0.38	21
7	−0.21	−1.02	0.33	0.48	−3.22	0.01	0.38	0.41	14
8	−0.31	−0.91	0.41	0.50	−2.12	0.09	0.36	0.48	7

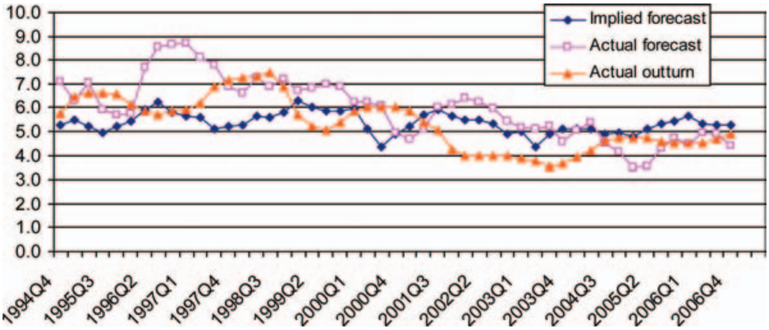
Table 7. UK Interest Rate: Evaluation of Implied Forecast and Actual Forecast

	C_1			C_2			Regression Statistics		
h	**Coef.**	***t*-stats**	**p-value**	**Coef.**	***t*-stats**	**p-value**	**R-sqr.**	**SE**	**Obs.**
1	−0.16	−5.51	0.00	0.89	−0.93	0.36	0.65	0.17	34
2	−0.03	−0.49	0.63	0.81	−1.33	0.19	0.42	0.39	44
3	0.17	1.96	0.06	0.70	−1.84	0.07	0.28	0.59	47
4	0.31	2.82	0.01	0.59	−2.42	0.02	0.20	0.75	47
5	0.43	3.27	0.00	0.50	−2.92	0.01	0.14	0.89	47
6	0.51	3.52	0.00	0.44	−3.33	0.00	0.11	0.99	47
7	0.58	3.66	0.00	0.40	−3.64	0.00	0.09	1.07	47
8	0.63	3.74	0.00	0.37	−3.86	0.00	0.08	1.14	47

Incidentally, the implied forecasts often did better in predicting the outturns than the actual forecasts. The results are available from the authors on request. This is not, however, so surprising since the implied forecasts are obtained by finding the coefficients that best explained the ex post outturns, i.e., data mining. So we place no emphasis on this finding.

The actual forecasters placed less weight on mean reversion than appeared to be the case in our constructed implied forecasts. That

Figure 9. UK Interest Rate, Six-Quarters-Ahead Forecast



forecasters should have underestimated the speed of reversion to the mean is itself both plausible and understandable during these years. This was, after all, the period of the Great Moderation. A possible definition of such a Great Moderation is a period when the key macroeconomic time series revert to their (desired) equilibrium somewhat faster than in the past or than currently expected.

Most macro variables are cyclical, but, as any forecaster knows only too well, it is extraordinarily difficult to predict turning points. Hence a forecast which combines a weighted average of autoregressive continuation and mean reversion is likely to be optimal. It should minimize the likelihood of a really big error, and will be unbiased over the medium and longer run. So the behavior of the forecasters in seeking to estimate the likely mean outturn is, we would argue, appropriate.

Where our findings do indicate that there is a need for improvement is with the fan chart, or probability distribution, of future outcomes. This is usually shown as a symmetric single-peaked distribution, often akin to a normal distribution with mode, mean, and median at the same point.

Our results show that this will *generally not* be the case. The most probable outcome is that the cyclical phase will continue. Hence in an upturn (downturn), the most probable outcome is that (inflation and) interest rates will turn out to be systematically above (below) the mean forecast. But this is balanced by a smaller probability that the cycle will turn within this interval. But if there should be such a turning point, following an upturn (downturn) phase, then the forecasts will considerably overstate (understate) the subsequent downward (upward) movement.

5. Conclusions

In this paper we have demonstrated that, in the two countries and short data periods studied, the forecasts of interest rates had little or no informational value when the horizon exceeded two quarters (six months), though they were good in the next quarter and reasonable in the second quarter out. Moreover, all the forecasts were ex post and, systematically, inefficient, underestimating (overestimating) future outturns during up (down) cycle phases. The main reason for this is that forecasters cannot predict the timing of cyclical turning points, and hence predict future developments as a convex combination of autoregressive momentum and a reversion to equilibrium.

There are, perhaps, two main conclusions that can be drawn from this. The first is that official interest rate forecasts should probably be presented in hybrid form. MPCs and markets can make reasonable forecasts of interest rates up to two (at an extreme pinch, three) quarters hence. These should, indeed, be the basis of forecasts. Beyond that horizon, they are rarely able to do so, and that too should be acknowledged. Unless the authorities have a particular reason for exhibiting confidence in their own longer-dated forecasts, those same (longer-dated) forecasts should be presented in a specifically formulaic manner, e.g., constant or based on implied forward market rates.

The second conclusion is that the resulting interest (and inflation) forecast is generally *not* modal. It is biased, underestimating (overestimating) in upturns (downturns), because the forecaster is protecting himself or herself against extreme errors by assuming a (roughly constant) small probability of a turning point in the cycle occurring in each quarter. Consequently the *most likely* outturn in any expansionary phase is that output, inflation, and interest rates will turn out *above* forecast (vice versa in a downturn). The conclusion that we would draw from this is that policy needs to be normally somewhat more aggressive than the mean forecast would indicate (raising rates in booms, cutting rates in recessions), but that the policymakers need to be alert to (unpredictable) turning points and therefore to the occasional need to reverse course abruptly.

Appendix

Table 8. RBNZ Interest Rate Forecast

Date	Interest Rate	State[a]	$r(t,t)$	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
2000:Q1	5.97	1	5.86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2000:Q2	6.73	1	6.46	6.21	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2000:Q3	6.74	1	6.83	6.84	6.49	N/A	N/A	N/A	N/A	N/A	N/A
2000:Q4	6.67	−1	6.64	6.83	7.15	6.70	N/A	N/A	N/A	N/A	N/A
2001:Q1	6.42	−1	6.50	6.84	6.91	7.36	6.88	N/A	N/A	N/A	N/A
2001:Q2	5.85	−1	5.84	6.31	7.10	7.01	7.48	7.05	N/A	N/A	N/A
2001:Q3	5.74	−1	5.79	5.83	6.30	7.16	7.07	7.53	7.19	N/A	N/A
2001:Q4	4.97	−1	5.07	5.87	5.81	6.34	7.26	7.10	7.53	7.27	N/A
2002:Q1	5.03	1	4.91	5.18	5.90	5.74	6.38	7.38	7.13	7.51	7.28
2002:Q2	5.82	1	5.72	5.41	5.22	5.92	5.74	6.39	N/A	N/A	N/A
2002:Q3	5.91	1	5.97	6.30	5.81	5.20	5.98	5.73	6.38	N/A	N/A
2002:Q4	5.90	−1	6.00	6.16	6.70	6.08	5.14	6.10	5.76	6.36	N/A
2003:Q1	5.83	−1	5.88	6.00	6.26	6.93	6.22	5.12	6.23	5.90	6.35
2003:Q2	5.44	−1	5.47	5.88	6.00	6.27	7.03	6.34	N/A	N/A	N/A
2003:Q3	5.12	−1	5.12	5.32	5.88	6.00	6.11	7.04	6.18	N/A	N/A
2003:Q4	5.29	1	5.32	5.22	5.31	5.88	6.00	5.88	6.87	5.96	N/A
2004:Q1	5.49	1	5.51	5.54	5.28	5.31	5.88	6.00	5.69	6.72	5.79
2004:Q2	5.86	1	5.76	5.67	5.71	5.31	5.32	5.88	N/A	N/A	N/A
2004:Q3	6.44	1	6.35	6.14	5.73	5.82	5.37	5.36	5.88	N/A	N/A

(continued)

Table 8. (Continued)

Date	Interest Rate	State[a]	$r(t,t)$	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
2004:Q4	6.73	1	6.74	6.61	6.31	5.75	5.90	5.47	5.44	5.88	N/A
2005:Q1	6.86	1	6.80	6.80	6.68	6.40	5.75	5.95	5.57	5.52	5.88
2005:Q2	7.04	1	7.00	7.00	6.83	6.73	6.45	5.75	N/A	N/A	N/A
2005:Q3	7.05	1	7.05	7.12	7.07	6.82	6.76	6.49	5.77	N/A	N/A
2005:Q4	7.49	1	7.47	7.21	7.15	7.07	6.83	6.78	6.53	5.81	N/A
2006:Q1	7.55	1	7.57	7.61	7.32	7.14	7.09	6.82	6.78	6.54	5.84
2006:Q2	7.48	1	7.49	7.55	7.59	7.31	7.15	7.10	N/A	N/A	N/A
2006:Q3	7.51	1	7.48	7.55	7.56	7.58	7.30	7.16	7.09	N/A	N/A
2006:Q4	7.64	1	7.62	7.62	7.53	7.53	7.59	7.29	7.17	7.09	N/A

[a] "+1" indicates an "up" period, i.e., a period of rising interest rate; "−1" indicates a "down" period, i.e., a period of declining interest rate.
Source: The NZ data are taken from their quarterly Monetary Policy Statements. For more detail, see section 2.

Table 9. RBNZ Interest Rate Forecast Error (Table Updated)

Forecast Error	$r(t, t)$	$r(t-1, t)$	$r(t-2, t)$	$r(t-3, t)$	$r(t-4, t)$	$r(t-5, t)$	$r(t-6, t)$	$r(t-7, t)$	$r(t-8, t)$
2000:Q1	0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2000:Q2	0.27	0.52	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2000:Q3	−0.09	−0.10	0.25	N/A	N/A	N/A	N/A	N/A	N/A
2000:Q4	0.03	−0.16	−0.48	−0.03	N/A	N/A	N/A	N/A	N/A
2001:Q1	−0.08	−0.42	−0.49	−0.94	−0.47	N/A	N/A	N/A	N/A
2001:Q2	0.01	−0.46	−1.25	−1.16	−1.63	−1.20	N/A	N/A	N/A
2001:Q3	−0.05	−0.09	−0.56	−1.42	−1.33	−1.79	−1.46	N/A	N/A
2001:Q4	−0.10	−0.90	−0.84	−1.37	−2.29	−2.13	−2.56	−2.30	N/A
2002:Q1	0.12	−0.15	−0.87	−0.70	−1.34	−2.35	−2.10	−2.48	−2.25
2002:Q2	0.10	0.41	0.60	−0.10	0.08	−0.57	N/A	N/A	N/A
2002:Q3	−0.06	−0.38	0.10	0.72	−0.07	0.18	−0.47	N/A	N/A
2002:Q4	−0.10	−0.26	−0.80	−0.18	0.75	−0.21	0.14	−0.47	N/A
2003:Q1	−0.05	−0.17	−0.43	−1.11	−0.39	0.71	−0.41	−0.07	−0.52
2003:Q2	−0.03	−0.44	−0.56	−0.84	−1.59	−0.90	N/A	N/A	N/A
2003:Q3	0.00	−0.20	−0.76	−0.88	−0.98	−1.91	−1.06	N/A	N/A
2003:Q4	−0.03	0.07	−0.02	−0.59	−0.71	−0.59	−1.58	−0.67	N/A
2004:Q1	−0.02	−0.05	0.22	0.19	−0.39	−0.51	−0.20	−1.23	−0.29
2004:Q2	0.10	0.19	0.15	0.55	0.54	−0.02	N/A	N/A	N/A

(continued)

Table 9. (Continued)

Forecast Error	$r(t,t)$	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
2004:Q3	0.09	0.30	0.71	0.62	1.07	1.08	0.56	N/A	N/A
2004:Q4	−0.01	0.11	0.41	0.98	0.82	1.26	1.29	0.85	N/A
2005:Q1	0.06	0.06	0.18	0.46	1.11	0.91	1.29	1.34	0.98
2005:Q2	0.04	0.05	0.21	0.31	0.59	1.29	N/A	N/A	N/A
2005:Q3	0.00	−0.07	−0.02	0.23	0.29	0.56	1.28	N/A	N/A
2005:Q4	0.02	0.29	0.35	0.42	0.66	0.71	0.97	1.68	N/A
2006:Q1	−0.02	−0.06	0.23	0.41	0.46	0.73	0.77	1.01	1.71
2006:Q2	−0.01	−0.07	−0.11	0.17	0.32	0.38	N/A	N/A	N/A
2006:Q3	0.03	−0.04	−0.05	−0.07	0.21	0.35	0.42	N/A	N/A
2006:Q4	0.02	0.03	0.11	0.11	0.05	0.36	0.48	0.56	N/A

Note: Error is Actual minus Forecast.

Table 10. UK Interest Rate Forecast Implied by Government Yield Curve

Date	Interest Rate	State[a]	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
1993:Q1	6.13	−1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1993:Q2	5.88	−1	N/A	5.95	N/A	N/A	N/A	N/A	N/A	N/A
1993:Q3	5.88	−1	N/A	5.22	6.18	N/A	N/A	N/A	N/A	N/A
1993:Q4	5.66	−1	N/A	5.60	5.36	6.56	N/A	N/A	N/A	N/A
1994:Q1	5.22	−1	N/A	5.12	6.02	5.66	6.85	N/A	N/A	N/A
1994:Q2	5.13	1	N/A	5.14	5.17	6.43	5.98	7.07	N/A	N/A
1994:Q3	5.24	1	N/A	4.77	5.17	5.38	6.76	6.28	7.24	N/A
1994:Q4	5.75	1	N/A	5.36	4.94	5.30	5.65	7.03	6.56	7.40
1995:Q1	6.45	1	N/A	6.55	6.08	5.21	5.49	5.92	7.26	6.81
1995:Q2	6.63	−1	N/A	N/A	7.23	6.73	5.49	5.71	6.17	7.47
1995:Q3	6.63	−1	N/A	7.14	7.42	7.80	7.27	5.75	5.93	6.40
1995:Q4	6.58	−1	6.49	6.97	7.73	7.97	8.24	7.69	5.98	6.14
1996:Q1	6.13	−1	N/A	6.76	7.39	8.20	8.39	8.57	8.01	6.18
1996:Q2	5.87	−1	5.68	6.16	7.08	7.73	8.52	8.68	8.83	8.26
1996:Q3	5.69	1	N/A	5.64	6.29	7.39	7.95	8.72	8.88	9.02
1996:Q4	5.86	1	5.60	N/A	5.84	6.50	7.63	8.09	8.85	9.00
1997:Q1	5.94	1	N/A	5.74	6.42	6.12	6.71	7.82	8.18	8.93
1997:Q2	6.20	1	N/A	6.63	6.01	6.74	6.37	6.90	7.96	8.24
1997:Q3	6.87	1	6.22	N/A	6.88	6.34	7.01	6.60	7.06	8.06
1997:Q4	7.15	1	6.87	6.51	6.43	7.04	6.62	7.24	6.80	7.19
1998:Q1	7.25	1	7.26	6.95	6.67	6.57	7.13	6.86	7.43	6.97

(continued)

Table 10. (Continued)

Date	Interest Rate	State[a]	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
1998:Q2	7.33	1	7.00	7.22	6.99	6.76	6.66	7.19	7.04	7.58
1998:Q3	7.50	−1	6.94	6.69	7.10	6.99	6.80	6.73	7.23	7.19
1998:Q4	6.86	−1	7.21	6.71	6.51	7.00	6.98	6.83	6.78	7.25
1999:Q1	5.69	−1	6.10	6.96	6.53	6.39	6.93	6.98	6.85	6.82
1999:Q2	5.20	−1	4.80	5.79	6.69	6.41	6.30	6.87	6.98	6.87
1999:Q3	5.07	1	4.89	4.69	5.51	6.46	6.31	6.21	6.82	6.98
1999:Q4	5.40	1	4.89	4.89	4.71	5.28	6.26	6.21	6.13	6.77
2000:Q1	5.87	1	5.37	5.10	4.94	4.72	5.10	6.09	6.13	6.05
2000:Q2	6.00	−1	6.07	5.79	5.45	5.02	4.70	4.96	5.93	6.05
2000:Q3	6.00	−1	6.14	6.29	6.00	5.75	5.08	4.66	4.86	5.80
2000:Q4	6.00	−1	5.95	6.36	6.40	6.09	5.93	5.11	4.61	4.77
2001:Q1	5.86	−1	5.65	6.08	6.44	6.43	6.13	6.02	5.13	4.56
2001:Q2	5.36	−1	5.34	5.52	6.12	6.43	6.43	6.13	6.06	5.13
2001:Q3	5.05	−1	4.90	5.16	5.47	6.09	6.36	6.41	6.10	6.06
2001:Q4	4.23	−1	4.66	4.89	5.14	5.46	6.03	6.26	6.38	6.05
2002:Q1	4.00	−1	3.77	4.83	4.95	5.14	5.46	5.96	6.15	6.34
2002:Q2	4.00	−1	4.01	3.92	5.01	5.02	5.15	5.44	5.89	6.04
2002:Q3	4.00	−1	4.17	4.41	4.14	5.12	5.08	5.14	5.42	5.82

(continued)

Table 10. (Continued)

Date	Interest Rate	State[a]	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
2002:Q4	4.00	−1	3.74	4.59	4.68	4.32	5.19	5.12	5.13	5.39
2003:Q1	3.85	−1	3.72	3.80	4.90	4.85	4.47	5.22	5.14	5.12
2003:Q2	3.75	−1	3.38	3.68	3.98	5.12	4.97	4.59	5.24	5.15
2003:Q3	3.53	−1	3.34	3.27	3.76	4.19	5.27	5.04	4.69	5.24
2003:Q4	3.65	1	3.36	3.27	3.24	3.89	4.37	5.37	5.09	4.77
2004:Q1	3.91	1	3.96	3.60	3.28	3.29	4.02	4.52	5.44	5.12
2004:Q2	4.22	1	3.95	4.18	3.84	3.35	3.38	4.13	4.64	5.49
2004:Q3	4.65	1	4.42	4.10	4.35	4.03	3.44	3.49	4.24	4.73
2004:Q4	4.75	1	4.80	4.68	4.19	4.49	4.18	3.54	3.60	4.33

[a] "+1" indicates an "up" period, i.e., a period of rising interest rate; "−1" indicates a "down" period, i.e., a period of declining interest rate.
Source: The UK data are taken from the Bank of England web site, www.bankofengland.co.uk. For more detail, see section 2.

Table 11. Implied Error from UK Government Yield Forecast (Table Updated)

Forecast Error	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
1993:Q1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1993:Q2	N/A	N/A	−0.07	N/A	N/A	N/A	N/A	N/A
1993:Q3	N/A	N/A	0.66	−0.30	N/A	N/A	N/A	N/A
1993:Q4	N/A	N/A	0.06	0.30	−0.90	N/A	N/A	N/A
1994:Q1	N/A	N/A	0.10	−0.80	−0.44	−1.63	N/A	N/A
1994:Q2	N/A	N/A	−0.01	−0.04	−1.30	−0.85	−1.94	N/A
1994:Q3	N/A	N/A	0.47	0.07	−0.14	−1.52	−1.04	−2.00
1994:Q4	N/A	N/A	0.39	0.81	0.45	0.10	−1.28	−0.81
1995:Q1	N/A	N/A	−0.10	0.37	1.24	0.96	0.53	−0.81
1995:Q2	N/A	N/A	N/A	−0.60	−0.10	1.14	0.92	0.46
1995:Q3	N/A	N/A	−0.51	−0.79	−1.17	−0.64	0.88	0.70
1995:Q4	N/A	0.09	−0.39	−1.15	−1.39	−1.66	−1.11	0.60
1996:Q1	N/A	N/A	−0.63	−1.26	−2.07	−2.26	−2.44	−1.88
1996:Q2	N/A	0.19	−0.29	−1.21	−1.86	−2.65	−2.81	−2.96
1996:Q3	N/A	N/A	0.05	−0.60	−1.70	−2.26	−3.03	−3.19
1996:Q4	N/A	0.26	N/A	0.02	−0.64	−1.77	−2.23	−2.99
1997:Q1	N/A	N/A	0.20	−0.48	−0.18	−0.77	−1.88	−2.24
1997:Q2	N/A	N/A	−0.43	0.19	−0.54	−0.17	−0.70	−1.76
1997:Q3	N/A	0.65	N/A	−0.01	0.53	−0.14	0.27	−0.19
1997:Q4	N/A	0.28	0.64	0.72	0.11	0.53	−0.09	0.35
1998:Q1	N/A	−0.01	0.30	0.58	0.68	0.12	0.39	−0.18

(continued)

Table 11. (Continued)

Forecast Error	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
1998:Q2	N/A	0.33	0.11	0.34	0.57	0.67	0.14	0.29
1998:Q3	N/A	0.56	0.81	0.40	0.51	0.70	0.77	0.27
1998:Q4	N/A	−0.35	0.15	0.35	−0.14	−0.12	0.03	0.08
1999:Q1	N/A	−0.41	−1.27	−0.84	−0.70	−1.24	−1.29	−1.16
1999:Q2	N/A	0.40	−0.59	−1.49	−1.21	−1.10	−1.67	−1.78
1999:Q3	N/A	0.18	0.38	−0.44	−1.39	−1.24	−1.14	−1.75
1999:Q4	N/A	0.51	0.51	0.69	0.12	−0.86	−0.81	−0.73
2000:Q1	N/A	0.50	0.77	0.93	1.15	0.77	−0.22	−0.26
2000:Q2	N/A	−0.07	0.21	0.55	0.98	1.30	1.04	0.07
2000:Q3	N/A	−0.14	−0.29	0.00	0.25	0.92	1.34	1.14
2000:Q4	N/A	0.05	−0.36	−0.40	−0.09	0.07	0.89	1.39
2001:Q1	N/A	0.21	−0.22	−0.58	−0.57	−0.27	−0.16	0.73
2001:Q2	N/A	0.02	−0.16	−0.76	−1.07	−1.07	−0.77	−0.70
2001:Q3	N/A	0.15	−0.11	−0.42	−1.04	−1.31	−1.36	−1.05
2001:Q4	N/A	−0.43	−0.66	−0.91	−1.23	−1.80	−2.03	−2.15
2002:Q1	N/A	0.23	−0.83	−0.95	−1.14	−1.46	−1.96	−2.15

(continued)

Table 11. (Continued)

Forecast Error	$r(t-1,t)$	$r(t-2,t)$	$r(t-3,t)$	$r(t-4,t)$	$r(t-5,t)$	$r(t-6,t)$	$r(t-7,t)$	$r(t-8,t)$
2002:Q2	N/A	−0.01	0.08	−1.01	−1.02	−1.15	−1.44	−1.89
2002:Q3	N/A	−0.17	−0.41	−0.14	−1.12	−1.08	−1.14	−1.42
2002:Q4	N/A	0.26	−0.59	−0.68	−0.32	−1.19	−1.12	−1.13
2003:Q1	N/A	0.13	0.05	−1.05	−1.00	−0.62	−1.37	−1.29
2003:Q2	N/A	0.37	0.07	−0.23	−1.37	−1.22	−0.84	−1.49
2003:Q3	N/A	0.19	0.26	−0.23	−0.66	−1.74	−1.51	−1.16
2003:Q4	N/A	0.29	0.38	0.41	−0.24	−0.72	−1.72	−1.44
2004:Q1	N/A	−0.05	0.31	0.63	0.62	−0.11	−0.61	−1.53
2004:Q2	N/A	0.27	0.04	0.38	0.87	0.84	0.09	−0.42
2004:Q3	N/A	0.23	0.55	0.30	0.62	1.21	1.16	0.41
2004:Q4	N/A	−0.05	0.07	0.56	0.26	0.57	1.21	1.15

Note: Error is Actual minus Forecast.

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