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# The Value of Interest Rate Forecasts?

**By**
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**with Wen Bin Lim**

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## Introduction

This monograph brings together a collection of papers on interest rate forecasts, most of which have already appeared as separate Special Papers. In recent years there has been a developing trend whereby the Central Bank publishes a forecast of the path that it expects that the policy-determined short-term rate will follow over the forecast period, two or three years ahead. This was begun in New Zealand in 2000, and then copied in Norway in 2006 and in Sweden 2007.

This monograph begins with a discussion of the advantages and disadvantages of the three main alternative methods of making assumptions about the future path of the Central Bank's own policy-determined short-term interest rates. These are:-

a) constant from the latest level;
b) as implicitly predicted from the yield curve;
c) as chosen by the MPC.

The pros and cons of these three are then discussed at some length in this paper, 'The Interest Rate Conditioning Assumption', (DP547, October 2005).

The conclusion of this study is that, although the constant interest rate (CIR) assumption has several advantages, (notably of due humility about forecasting prowess), there are frequent occasions when it is clearly untenable. Consequently the choice lies between the latter two alternatives, at least for the first few quarters of the forecast period. In either case there will then be problems of how to deal with discrepancies between the market view, as evidenced from the money market yield curve, and official expectations.

In the subsequent three papers we turn to an empirical investigation of how accurate such forecasts have been, focussing on official New Zealand and market-implied UK forecasts. In all these papers the econometric work was carried out by Wen Bin Lim. The general conclusion of these papers is that the forecasts were not at all accurate beyond an horizon of two quarters, six months, hence.

In the first paper, 'Interest Rate Forecasts: A Pathology', (DP612, June 2008), we demonstrate that "such forecasts in NZ and UK have been excellent for the immediate forthcoming quarter, reasonable for the next quarter and useless thereafter". Perhaps even more intriguing we show that "when ex post errors are assessed depending on whether interest rates have been upwards, or downwards, trending they are shown to have been biased and, apparently inefficient". This gives rise to the commonplace diagrams, see Figures 4-7, wherein forecasts lie below subsequent out-turns during up-cycles, and above them during down-cycles: It is only because such biases cancel out over the whole period that most prior econometric studies have claimed that such forecasts have been efficient and unbiased.

In the next, third, paper in this monograph, we begin to seek for explanations of this syndrome (i.e. ex post bias and lack of forecasting value beyond two quarters ahead). Both NZ and the UK were inflation targeting countries during these years. So we first examined, 'Do Errors in Forecasting Inflation Lead to Errors in Forecasting Interest Rates?', (DP611, June 2008). The results here were rather mixed. Our hypothesis was "that, in inflation targeting countries, errors in forecasting interest rates would be positively associated with errors in forecasting inflation". Over the whole sample this was not supported, "There were, instead, periods in both countries (and in Sweden) when the relationship reversed. On inspection in both NZ and UK these latter periods were occasions when external influences may have distorted the nexus between interest rates and domestic inflationary impulses".

The fact that such interest rate forecasts were, ex post, biased and inefficient does not mean that they were ex ante either biased and inefficient. So in our fourth and final paper we turned to the question of 'Can one Forecast the Forecasters?'. In this exercise we hypothesized that, within a macro-economy that cycles around a trend, there are two main forces, a momentum element and a tendency to revert to equilibrium. At some point the cycle will come to a turning point, but the forecaster does not know when. So she always assumes a combination of auto-regressive and reversion forces. While the cycle continues upwards (downwards), the forecaster systematically under (over) estimates the future path of interest rates, but when a turning point eventually does occur, such a forecaster does much better than one who just forecasts unchanged auto-regressive momentum.

We give empirical content to this hypothesis by fitting the best, ex post, auto-regressive and reversion coefficients for our data period for our four series (UK and NZ interest rate and inflation). We compare the artificial forecasts generated by this simple assumed mechanism with the actual ex ante forecasts. We find a close fit, with one exception. The actual forecasters did not expect quite as rapid a reversion to the mean (target) values of inflation and interest rates as actually occurred in these years. Since these were the years of the Great Moderation, with unprecedented and somewhat unexpected success in achieving stable target values of macro-economic variables, such a systematic minor error is hardly surprising.

# The Interest Rate Conditioning Assumption*

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A central bank's forecast must contain some assumption about the future path for its own policy-determined short-term interest rate. I discuss the advantages and disadvantages of the three main alternatives:-

(a) constant from the latest level;

(b) as implicitly predicted from the yield curve;

(c) chosen by the Monetary Policy Committee (MPC).

Most countries initially chose alternative (a). With many central banks having planned to raise interest rates at a measured pace in the last few years, there was a shift to (b). However Norway, and now Sweden, have followed New Zealand in adopting (c), and the UK is also considering this move. So this is a lively issue.

JEL Codes: E47, E52, E58.

* My thanks are due to Peter Andrews, David Archer, Oriol Aspachs, Charlie Bean, Jarle Bergo, Hyun Shin, Lars Svensson, Bent Vale, Mike Woodford, my two refeees and to the members of the Bank of England seminar on August 3, 2005, for helpful comments. The views, and remaining errors, in this paper remain, however, my own responsibility.

## The Interest Rate Conditioning Assumption

A central bank's forecast must contain some assumption about the likely future path for its own policy-determined short-term interest rate. Most of those central banks who have publicly reported their procedures in this respect have in the past assumed that interest rates would remain unchanged from their present level, e.g. in Sweden until recently[1], in the USA (at least most of the time) (see, for Sweden, Berg, Jansson and Vredin, 2004; and Jansson and Vredin, 2003; and for the USA, Boivin, 2004; Reifschneider, Stockton and Wilcox, 1997; and Romer and Romer, 2004). The UK was amongst this group from the first Inflation Report, at the end of 1992, until May 2004; then in August 2004 it shifted to the use of the forward short rates that are implied by the money market yield curve.[2] Deputy Governor Lomax has now stated (2007) that the Bank of England is considering joining the small group, (New Zealand, Norway, Sweden) who are explicitly reporting their own expectations for the future path of interest rates. So, in this paper the focus will be on the question of how a MPC does, and should, choose (condition) a future time path for its own policy variable, the officially determined short term interest rate.

There are two main purposes for such forecasting exercises; the first is as an aid to the policy decision itself, which is to choose the current level of official short-term interest rates; the second is to communicate to the general public both an explanation of why the official rate was changed and to give an indication of how the MPC views

[1] In the Financial Times, the Lex column, January 30, 2007, reported in the article on 'Central Bank Forecasting' that Sweden has just joined the group (plus New Zealand and Norway) giving conditional forecasts of the expected future path of their own policy-determined interest rates.
[2] In fact it used both conditioning assumptions for many years before 2004, but the constant interest rate assumption was given clear precedence. Since August 2004, it has continued to use both

future economic developments. The manner in which these two purposes may be linked depends in some large part on the institutional detail of the manner in which each individual MPC has been established.

For example, prior to its being given operational independence in May 1997, the Bank of England's Inflation Forecast, (starting in 1993), was intended to be an aid to the choice of interest rates taken by the Chancellor of the Exchequer, see Goodhart (2001a). Since the decision remained with the Chancellor, however, the Bank felt that it should not be seen to be pushing the Chancellor to be following any particular path for interest rates. So its forecast was conditioned on a neutral assumption, that interest rates remained constant (in nominal terms) from whatever level they had previously reached.

In order to provide a basis for such inflation forecast(s), which then forms one of the main inputs into the current interest rate decision, the only strong requirement is that the conditioning assumption for the future path of short-term policy rates is not too patently out of line with what the decision-makers, and the markets, believe will actually happen. For simplicity most MPCs initially chose constant future policy interest rates, from the latest available level, as their main framing assumption. Occasionally, such an assumption would have been grossly at odds with perceived reality, as in the case of the USA from 2004 until early 2006, when the explicit position of the FOMC was for there to be a 'measured increase' in policy rates over time. In that case, the Green book conditioning assumption, which has also been

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conditioning assumptions, but now the money market rate curve is given the greater emphasis, see Lomax (2005).

usually[3] for constant rates, is widely believed to have been changed, but the degree of secrecy, and length of lag before publication (five years), means that we will not have confirmation of this for some time.

Of course, in addition to the basic conditioning assumption, MPC members can ask for alternative scenarios to be run, involving differing conditional time paths. There can be as many such simulations run as the resources, time and technical skills of the Bank staff allow. But, for the purposes of communication, only one forecast is generally published, albeit now often including probability distributions (fan charts). On all this, see Edey and Stone (2004).

A crucial distinction, however, lies between those MPCs which just publish a 'staff forecast' giving the forecast conditioned on the staff's own (standard) interest rate assumption, and those where the forecast is issued under the aegis of the MPC, or a decision-making Governor. Examples of the former are the ECB and FOMC; examples of the latter are the UK's MPC, Norway, Sweden and New Zealand.

Requirements for the former are less restrictive than for the latter. Thus, MPCs presenting a staff forecast need not even update that forecast to incorporate the actual subsequent decision. The publication of a staff forecast, on a standard conditioning assumption, then simply reveals a key input into the decision-making procedure. It is, in a sense, a simulation, not a true forecast, and should be interpreted as such.

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[3] But not always so. It was upwards sloping in 1994.

The situation is different when what is to be presented is a forecast for which the MPC (Governor) actually takes responsibility. This crucial change in context was not, perhaps, fully appreciated when the Bank of England was given operational independence, and the UK MPC was formed, in May 1997. Then the constant interest rate assumption, which had been appropriate in the earlier regime, was simply continued, without much consideration or public discussion.

The strongest single argument against the assumption of a constant future nominal short-term interest rate path in a proper forecast, as contrasted with a 'staff forecast' or simulation, is that this is often <u>not</u> what the central bank itself nor the money market expect to happen. The money market yield curve is only occasionally approximately flat out to the forecast horizon, (which for the purpose of this exercise we take to be eight quarters ahead).[4] Perhaps even more important, there have been periods when a central bank has been clearly signalling that it expected future changes in its policy-determined interest rates. The expectation of a `measured' rate of increase in US interest rates in 2004/05 is a case in point. But such signalling was also apparent in the UK in early 2004. It is, to say the least, inconsistent to have the central bank give one message in words, and then to base its published forecast on quite a different assumption.

Even when it is just a staff forecast, or simulation, rather than an MPC forecast, too glaring a deviation between conditioning assumption and actual expectations reduces the role of such a simulation, either as an input into policy decisions or as a means of

[4] In August 2004 the MPC in the UK extended the horizon recorded in the forecasts (for inflation and output growth) to three years, but the surrounding text tended to indicate that the two year horizon remained the chief focus of attention, again see Lomax (2005).

communication with the public. If the staff forecast should be based on a conditioning assumption for the future path of policy rates significantly different from that expected by the decision-makers, it will be harder for the latter to reach a sensible, informed view for the current decision on policy rates. It would then also be somewhat more difficult to explain that latter decision to the public in terms of expected future inflation (and output gaps), even if the staff forecast is not published. The difficulty would become much more acute, if the staff forecast was then to be published. With MPC forecasts being published, any serious deviation between the actual expectations of the MPC and the conditioning assumptions for the future path of policy rates could lead to major problems in communicating with the public.

In particular, when the policy interest rate is either cyclically high, or low, as it patently was in many countries after 2001, extrapolating the current level of interest rates into the future will give implausible results, and cannot therefore either be a sensible basis for internal decisions or a fruitful means of communication with the private sector. Adolfson, et al., (2005), used a DSGE model to simulate monetary policy in the euro-area and found out that "in the latter part of the sample (1998 Q4 – 2002 Q4)…. The constant interest rate assumption has arguably led to conditional forecasts at the two year horizon that cannot be considered economically meaningful during this period," (p. 1).

The main alternative in the academic literature, which several economists have been advocating (e.g. Svensson, 2003, 2004 and Woodford, 2004), is to base the conditioning assumption on a specific non-constant forecast made by the Bank, or by its Monetary Policy Committee (MPC). But this also has its drawbacks. While an

MPC might be quite willing to agree and to endorse a general direction of likely future change, (as in the FOMC `bias' reports or the ECB's standard vocabularly), it would generally be much less happy to commit itself to a specific, quantitative path, although this is what has been done in New Zealand, and its relatively untroubled acceptance there influenced Svensson, who wrote a Report on their procedures, (Svensson, 2001), and since 2006 in Norway, and since 2007 in Sweden. Lomax (2007) reports that the UK MPC is also considering this step.

In New Zealand the responsibility for hitting the Inflation Target rests on the Governor of the Reserve Bank personally. So he, (as yet there have been no female Governors there), can also decide upon the form and nature of the published forecast, including the conditioning assumptions. It is difficult enough for a Committee to agree on the selection of the policy rate to hold until the next meeting, when the range of feasible and sensible options is quite limited, (and that range has been greatly reduced by the implicit, but now general, convention that interest rate changes should always be in multiples of 25 basis points); it would be a quantum jump more difficult to get such a committee to agree on a single path for the next n quarters, when the potential range of feasible/sensible options widens dramatically, also see Mishkin (2004). The procedure for adopting a specific forecast future path for interest rates is made easier when a Governor has sole responsibility (New Zealand) or the relevant Committee is small as in Norway, (where the Governor usually has a decisive role) and in Sweden.

Assuming that an MPC could agree, or find a procedure for agreeing, on such a forecast for the time path of future interest rates, (Svensson has suggested taking the median of individually decided preferred paths), this would have, almost certainly, to be published. In view of the current ethos of transparency, it would hardly be acceptable to state that the forecast was based on a non-zero conditioning assumption, but that the public is not to be told what this was, (though on some occasions the Fed Staff have based their Green Book forecasts on a non-constant rate assumption without any clear indication of what that assumption was being available to the public, since such forecasts are protected from public inspection by the five year lag in publication).

If an MPC's non-constant forecast was to be published, there is a widespread view, in most central banks, that it would be taken by the public as more of a commitment, and less of a rather uncertain forecast than should be the case. That concern can, however, be mitigated by producing a fan chart of possible interest rate paths, rather than a point estimate and/or by publishing additional scenario paths. No doubt, though, measuring rulers and magnifying glasses would be used by private sector observers to extract the central tendency. Examples of recent published forecasts, for Norway and New Zealand are given in Figures 1 and 2). Once there was a published central tendency, then this might easily influence the private sector's own forecasts more than its own inherent uncertainty warranted, along lines analysed by Morris and Shin (1998, 2002, 2004).[5] Likewise when new, and unpredicted, events occurred, and made the MPC want to adjust the prior forecast path for interest rates, this might give rise to criticisms, ranging from claims that the MPC had made forecasting errors to accusations that they had reneged on a (partial) commitment.

Lars Svensson, and some other academics, respond that this worry implies that MPCs regard participants in financial markets as unsophisticated, and incapable of understanding the concept of a conditioning assumption; moreover there have been few, if any, recorded problems in New Zealand; some recent Norwegian concerns are discussed later on here. Moreover, it could be argued that having to explain the reasons why it has deviated from its prior forecast could be a good discipline on the central bank. But these countries have small financial systems, clearly dependent on international developments; reactions there may differ from those in larger countries. Be that as it may, most members of MPCs have been reluctant to move to a specific forecast for a future time path for interest rates.

One of my (anonymous) referees added that the appropriate path of the policy rate can also depend, in part, on a wide range of other financial variables (equity prices, risk spreads, currently the likelihood and effect of a 'credit crunch', and so on) or, depending on the sophistication of the model used, risk premiums on the various assets (equities on the sophistication of the model used, risk premiums on the various assets (equities, corporate bonds, and so on). Thus, to allow the public to make sense of the projected policy path the central bank might, at least at times, have to provide information on these other variables. So, for example, in the late 1990s, some of the (publicly released) Greenbooks noted that the projected path for policy was fairly flat because of an assumed levelling out in stock prices. Is that really something that the central bank would like to say publicly? Moreover, such financial variables could easily turn out differently than anticipated, (e.g. the 1987 NYSE crash, the 2007 credit market freeze), but the central bank would likely intend in such circumstances to

[5] There is a continuing debate between Svensson, and Morris, Shin and Tong on the necessary

offset the effects on the real economy by adjusting policy. So, in a sense, the policy assumption is more tentative and more subject to change than the projections for output and inflation.

A related, but reverse, argument is that it would not be the private sector, but the MPC itself that might place too much weight on an explicit forecast path. Thus having given a forward projection, an MPC might feel pressured to stick to it, even when circumstances had changed. This was the gist of an Editorial in the Financial Times (07/12/2006), p. 20, entitled 'Giving a Wrong Signal'.[6] This included the following passage:-

> "However, the market is far more interested in detecting any hints that Jean-Claude Trichet, the ECB president, might give regarding monetary policy in 2007. Mr Trichet's communication strategy has reached a level of comical transparency: a mention of "vigilance" signals a rise in the following month, while "monitoring closely" means it will happen two or three months hence.
>
> Such signposting does have some merits. But pre-announcing interest rate decisions also entails an obvious loss of flexibility. And in the increasingly uncertain global outlook of 2007 this flexibility will be needed…. The economic outlook is uncertain. Mr Trichet should make sure his language reflects this."

Caught between the lack of credibility (at least on some occasions) of a constant rate assumption, and the problems of adopting an MPC chosen time path for interest rates, the move by the UK MPC to adopt the estimated future path as estimated by the

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conditions under which transparency may, or may not, be damaging to social welfare. See Svensson (2005) and Morris, Shin and Tong (2005).

6 Ehrmann and Fratzscher (2007) report that the Fed's policy directives before 1999, when they were unpublished and for internal use only, were a much less accurate predictor of subsequent policy moves than after May 1999 when they 'were targeted at an external audience', see especially footnote 7, p. 189. While there may be several other reasons for this, such behaviour is consistent with the possibility that publication of future plans acts as a commitment device for carrying them out later. Exactly how far it is desirable for an MPC to commit itself to a future path for interest rates, in a world of uncertainty, remains uncertain. For arguments in favour of some such commitment, see Woodford (2003, Chapter 7); for arguments against see Issing (2005), as quoted by Ehrman and Fratzscher, (ibid), pp 222-3.

market for its conditioning assumption could be seen as a brilliant compromise that got around the worst features of both the other two alternatives. Given the normal assumptions of rational expectations and efficient markets, the market's forecast ought to be credible; yet its adoption in the forecasting procedure required no decision procedure in the MPC itself, and committed them to nothing; a master-stroke indeed. The change in procedure did not at the time cause much discussion, or elicit any criticism (that I saw). There may, however, be some drawbacks to this new approach, which need to be considered. One issue is the dynamic implications of adopting a market forecast; a second is how far the market forecast has had a good track record. The latter remains the subject of my further, ongoing research.

Yet another of the criticisms raised against the constant interest rate forecast is that, if maintained too long, it would lead to Wicksellian instability. Indeed in medium-run simulations at the Bank of England extending much beyond the prior two-year horizon, the constant two-year rate assumption had to be linked into a Taylor-type reaction function to prevent nonsensical trends developing as the horizon passed beyond two years. But, up to the two year horizon, there did not seem to be any practical, empirical problem with this assumption, as also noted in Edey and Stone (op. cit.).

On the other hand, the assumption of constant forward policy-determined interest rates imposed a strong discipline on the MPC that may be considered (see Goodhart, 2001b) to be strongly beneficial. Because of the UK MPC's inbuilt dislike of reporting inflation failing to come back close to target at their focus horizon of 7/8 quarters hence, this assumption virtually forced the MPC to take immediate, and sufficient, action to counter and remove any perceived threat to inflation stability, as soon as it appeared. This behavioural trait was documented in several recent papers (Goodhart 2004 and 2005). In my view the main cause of endemic inflation in earlier decades had been the syndrome of `too little, too late' in a context of great uncertainty, a trait which could be viewed as a version of time inconsistency. So any procedure that, more or less, forced the decision-makers into prompt corrective action was to be supported and encouraged.

What will be the dynamic implications for the new market-based forecasting mechanism? It is, to say the least, an incestuous exercise. The market is trying to guess what the authorities will do, and their guess is then incorporated as the conditioning assumption to the initial forecast on which, in part, the MPC bases its decision.

Clearly there are no problems when the MPC's current decision has been (largely) predicted by the market, and the resultant forecast shows inflation reverting satisfactorily to target. But what if the MPC's forecast should indicate, (given the current decision and the implied money market yield curve), that inflation would still be tending to over (under) shoot the target, especially, but not only, at the key horizon?[7] Then, emphasize the Bank of England economists, the publication of that deviation would influence expectations of market participants in the desired direction, and lead to an appropriate rise (fall) in future expected rates, and hence in longer term interest rates. Then, movements in longer term interest rates will affect the economy

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[7] Owing to lags in the transmission mechanism whereby interest rates affect the economy, any attempt to vary such rates to bring inflation back to target quickly would lead to (instrument) instability. Instead the authorities tend to focus on a crucial longer horizon for restoring inflation to target. In the UK that key horizon has been about 7 or 8 quarters from the forecast date.

more widely. Thus, goes the argument, the Bank now has effectively two instruments, its current interest rate decision, and its separate ability to influence expected future interest rates.[8] The latter is not, however, an instrument that the Bank can vary at will. If the Bank's forecast was ever suspected of being manipulated to achieve a market effect, it would lose all credibility. The Bank is forced to give its best, most truthful, forecast. Indeed, moving from a 'one instrument regime', (only operating on short term interest rates), to a 'two instruments regime', (operating on both short-term interest rates and future interest rate expectations), might allow the central bank to vary the short-term rate less than otherwise. This is a point that has been emphasized by Woodford (2003 and 2005 for example).

That is an argument that I accept, up to a point. If the resulting deviation of inflation from target, as shown in the Inflation Report, is large, especially at the key horizon of 7/8 quarters hence, and/or continuously worsening, it would raise public queries why no action had already been taken to deal with the perceived in(de)flationary threat. While it may be possible to give answers to this, the extent to which the MPC has

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[8] This is closely similar to the analysis in Gurkaynak, et al, 2005, in which they state,

> "Do central bank actions speak louder than words? We find that the answer to this question is a qualified "no." In particular, we find that viewing the effects of FOMC announcements on financial markets as driven by a single factor – changes in the federal funds rate target – is inadequate. Instead, we find that a second policy factor – one not associated with the current federal funds rate decision of the FOMC but instead with statements that it releases – accounted for more than three-fourths of the explainable variation in the movements of five- and ten-year Treasury yields around FOMC meetings.
>
> We emphasize that our findings do not imply that FOMC statements represent an *independent* policy tool. In particular, FOMC statements likely exert their effects on financial markets through their influence on financial market expectations of *future* policy actions. Viewed in this light, our results do not indicate that policy actions are secondary so much as that their influence comes earlier – when investors build in expectations of those actions in response to FOMC statements (and perhaps other events, such as speeches and testimony by FOMC members)."

been prepared to allow forecast inflation to deviate from target, especially at the crucial horizon of around 7/8 quarters, has been historically small.

However this is not an argument that the Norges Bank has found acceptable. They state[9] that the main reason for switching to a specific forecast path in 2006 was that the path of future rates implied by the market yield curve was then too flat and low to be consistent with a return to normal conditions. The Bank believed that future policy rates would, and should, be rising. Rather than publish a forecast based on market rates implying an increasing boom and incipient inflationary pressures, based on a market rate forecast, they preferred to publish a forecast of their own conditional expectations. This was an important factor in their decision to base their forecast and published Inflation Report on their own future expected path for policy rates.

Moreover, with a market based forecast, what happens if the MPC's current decision surprises the market, in the sense that it has not (or only partly) been previously expected? Clearly an unexpected change in direction will have greater impact than an unexpected change in timing. As Svensson and Woodford emphasize, e.g. Woodford (2005), it is not the overnight or one month interest rate that mainly affects the economy, but the longer term expected time path of interest rates. Surely any such surprise will affect future expected interest rates. The Bank forecasters will have to build into their forecasts some market reaction to that surprise, in order to guide the MPC whether enough has been done.

As Woodford (2005) notes:-

[9] Personal discussion, January 25, 2007.

> "Another problem with the current procedure of the Bank of England is that it is unclear how the MPC is intended to determine the correct current repo rate in the event that the interest-rate path expected by the markets is judged to imply projections inconsistent with the Bank's target criterion. Would an attempt be made to determine the current repo rate that would lead to an acceptable projection, under the assumption that *the path of the repo rate after the current month would follow the path anticipated by the markets?* This would typically require an extreme adjustment of the current repo rate, as a change in the repo rate for only one month would have to change the path of inflation over the following two years by enough to get the projected inflation rate two years in the future on track. A more sensible approach would surely involve adjusting the entire path of interest rates to one that the MPC would view as more sound, rather than acting as if the committee expected itself to behave in the future in the way currently anticipated by the markets, even though it was planning to depart substantially from the markets' expectation in the short run. But in this case, projections would have to be produced on the basis of an assumption about future policy other than the one corresponding to market expectations. The idea that the MPC would be able to avoid taking a stand (at least in its internal deliberations) on a reasonable future path of interest rates, by insisting on using the markets' forecast in its projections, is not tenable."

Most often, however, in practice markets can, and do, anticipate current policy decisions reasonably well, see especially Lildholdt and Wetherilt (2004) for the UK. So this concern may be viewed as largely hypothetical. Moreover, if the problem was perceived as serious, then it could be largely met by also publicly revealing the adjustments made by the forecasters to the money market yield curve to take account of estimated reactions.

Alternatively, and even simpler, since the Inflation Forecast is not published for a number of days after the MPC decision has been made, the forecasters could base their ex post forecast on the ex post reactions of the market to that decision. Admittedly the choice of date(s) at which to measure the ex post reaction would be arbitrary, but then so too is the choice of dates on which to estimate the ex ante future path of rates. Moreover, should the market's reaction not be what the Bank/MPC wanted, or expected, then the same argument as before, that the resulting published deviation of inflation from target should help to guide the market's expectation revisions, should presumably hold.

Even if the forecasters made no adjustments to take account of the current 'surprise' decisions, so long as that was publicly known, then the published time path of inflation in the Inflation Report would give the market some idea of how the Bank expected that they should adjust their expectations; that is if the current decision, followed by an unchanged path of future interest rates, led to inflation overshooting the target in the IR, then the market would be being guided to revise upwards its expected future time path for interest rates.

A current concern is that few commentators seem to understand exactly on what basis the money market yield curve used in the UK's Inflation Report forecast has been constructed. Indeed, I have been led to understand that the ex ante forecast, unadjusted for the surprise element in the interest rate decision, continues to be used. This is reasonable, so long as the surprise in the decision was minor, but what if it was not? Perhaps on such occasion, the Bank/MPC would give some additional guidance?

But, in any case, and as earlier noted, there are limits to the extent of such 'guidance' that the Bank of England can give by publishing a future deviation of inflation from target. In particular, a combination of a current surprise rise (fall) in the policy rate, (perhaps to influence a current asset price boom (bust) ), together with a future forecast (mean) under (over) shoot of inflation from target might be hard (but not impossible) to justify to the general public. It would probably be much harder to justify a surprise rise to offset an asset boom, than a cut during a bust, as events in the second half of 2007 indicate. The question of whether the authorities respond asymmetrically to asset price fluctuations (up and down), and whether this may matter is, however, outside the scope of this paper.

Quite how serious these potential problems might ever become, or, if they were perceived as serious, what steps might be taken in mitigation, is an issue that is beyond the scope or competence of this note. My gut feeling is that they probably would not be that serious in practice, but it does need careful watching. Be that as it may, I hope to have demonstrated that the UK MPC's current procedures on this front are not without their own inherent problems.

There are, also, somewhat similar problems with the use of a specific conditional policy forecast. How should the forecasters, for example, respond if the implied market yield curve does not then immediately move into line with the forecast set out by the MPC. The working assumption that is usually made is that the money market yield curve will exactly, indeed slavishly, adjust to the MPC's prognostications. But this need not be so. Indeed such a deviation is documented in a Chart produced by Deputy Governor Berlo in a speech presented at the Foreign Exchange Seminar of the Association of Norwegian Economists, (at Sanderstolen, Norway, on January 26, 2007, at which I was present). This is shown as Figure 3 below. When the Norges Bank interest rate projection of autumn 2006 was published, very short term market forward interest rates did fall into line, but longer ones did not.[10] Another nice issue

[10] The Deputy Governor noted that,

> "It is now almost three months since the previous *Inflation Report* was published. Since that time forward rates have increased and approached Norges Bank's interest rate path. Forward rates somewhat further out are still lower than our forecast. The reason may be that market participants have a different perception of the interest rate path that is necessary to stabilise inflation at target and to achieve stable developments in output and employment.

that has arisen in Norway is whether the Norges Bank is being time consistent in its own policy projections.  This is addressed separately in an Appendix.

There are questions about what such a discrepancy might imply, and also how, if at all, it should be fed back into the next forecast.  Should the forecasters give zero weight to the market, (which after all now has the Norges Bank's prior policy forecast in its own information set, and therefore has as much, or more, information than the MPC).  And, if not zero weight, what weighting in the MPC's forecast  should be given to the discrepant forecasts?[11]

Perhaps what the adoption of specific policy forecasts will do is to put more clearly under the academic microscope the (implicit or explicit) nature of the MPC's objective function, and its time consistency.  Academics will surely enjoy that exercise, but whether Central Bankers would also find that enjoyable is quite another question.

---

> Alternatively, the market may have the same short-term interest rate expectations as Norges Bank, but because of extraordinary conditions long-term bond prices are being pushed up and, consequently, long-term bond yields are being pushed down."

[11] This presumably depends on relative forecasting ability.  That is dire, both for the Central Bank, see the chart in the Financial Times, January 30, 2007, on the NZ record, and for the market, see for the USA (Rudebusch and Wu, 2004; also Diebold and Li, 2003; Duffee, 2002; Carriero, et al, 2003; and Rudebusch, 2002) and for Japan (D. Thornton, 2004).  Aspachs and I intend to do further work on this for the UK.  Perhaps for horizons longer than two quarters ahead, the constant interest rate assumption (CIR) is not too bad after all.

## Conclusion

The Constant Interest Rate (CIR) assumption had several beneficial aspects, one of which is an implicit humility about forecasting capabilities, (official or market). But, under the influence of the recession of 2001/2, interest rates moved to such an exceptionally low level in many countries that the only plausible forecast/expectation was that they would revert to a higher, more normal level. The discrepancy between the latter plausible expectation and the CIR effectively led to the latter becoming untenable.

So what we now have, for those MPCs which reveal the basis of their conditional forecasts, is a choice between a market-based forecast and a forecast specifically chosen by the MPC. In both cases there will be problems of how to deal with discrepancies between these two alternatives. The specific forecast of the authorities should be (slightly) more informative, but there are offsetting problems. These latter include how to reach agreement in a committee of equals and whether the perception by the private sector of the extent of commitment of the MPC to its forecast path is properly aligned. Either way what is fundamentally needed is a careful and candid description in accompanying statements and Inflation Reports of the thinking of each MPC. A picture (or graph) may paint a thousand words, but even such pictures need supporting explanations.

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## Appendix

Consider the time paths for output and inflation produced in the Norges Bank forecast (3/2006), shown in Figure 4, and then, assuming no shocks, just roll that same forecast forward to 2008 and 2009 (Figures 5 and 6), (Figures taken from the Deputy Governor's speech). In later years inflation is at target, but the output gap is still positive.

If the loss function contains the output gap as an argument, this implies a time-varying coefficient upon it. The Deputy Governor commented as follows,

> "Let us now take a closer look at our projections in the previous *Inflation Report*. The inflation gap closes gradually from below, while the output gap closes from above. According to the Bank's view, these paths provide a reasonable trade-off between the objective of stabilising inflation at target and stabilising developments in output and employment.
>
> Let us now use a time machine and travel forward to 2008. This picture, which is the same picture as the previous one but for a shorter time period, gives an impression that we place less weight on the output gap. The picture becomes even clearer if we travel forward yet another year in time to 2009.
>
> Inflation is now very near the target, while the output gap is still clearly positive. It may thus seem as if we are placing more weight on the output gap in the beginning of the period than at the end of the period. This suggests that the reference path in *Inflation Report* 3/06 is not consistent with a discretionary policy, where you make the best out of the situation in each period. Such a strategy would have involved a higher interest rate in order to provide a better balance between inflation and output towards the end of the projection period. Rather, it seems that the reference path has elements of commitment.
>
> Let us therefore assume that we follow the response pattern we have committed ourselves to earlier. In the literature, one such strategy is referred to as commitment under a timeless perspective.[12] It is possible to calculate, within the confines of our models, an optimal interest rate path based on such a strategy.

[12] See for example Woodford, M. (1999) "Commentary: How should monetary policy be conducted in an era of price stability?", Paper presented at the Jackson Hole Conference, see http://www.columbia.edu/%7Emw2230/jhole.pdf.

In this example, we have been able to reconstruct (approximately) the reference path in *Inflation Report* 3/06 by minimising a loss function under commitment in a timeless perspective. To reconstruct the reference path, the weight on the output gap in the loss function, lambda, has been set at 0.3. We also had to place a weight on changes in the interest rate in the loss function. This weight, which penalises large changes in the interest rate, can be defended based on considerations regarding robustness and financial stability."

That all sounds splendid, and academically very a la mode. The problem is that the alternative path of re-optimisation (without commitment) using the same loss function, shown in Figure 7, is extremely implausible. Would any Central Banker introduce a sharp, temporary spike in interest rates, (in this case virtually doubling them), just to get output lower more quickly, and without that having much effect on getting, and keeping, inflation back to target?

Figure 1

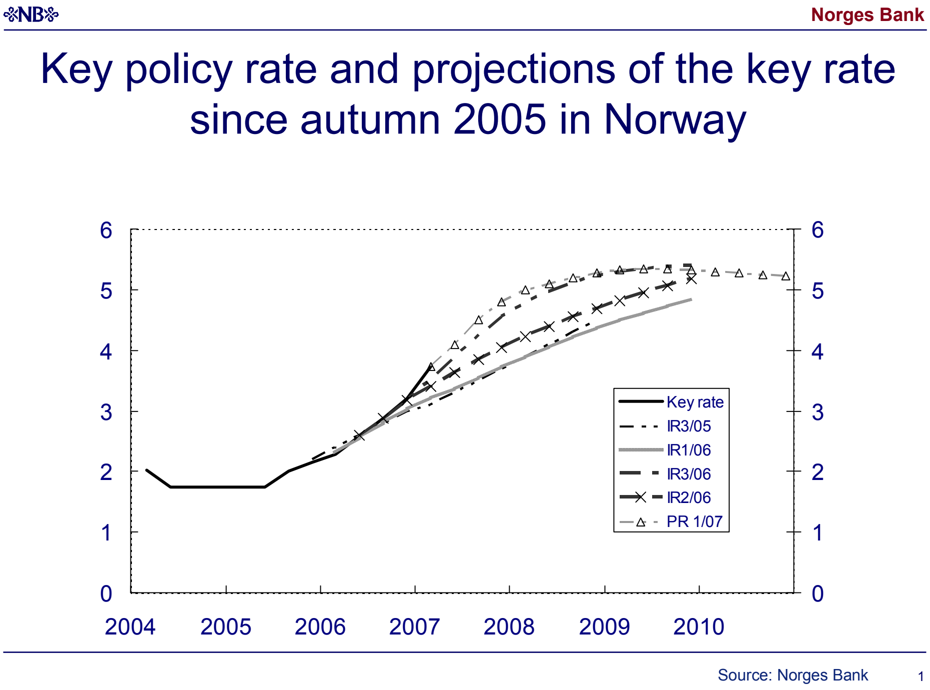
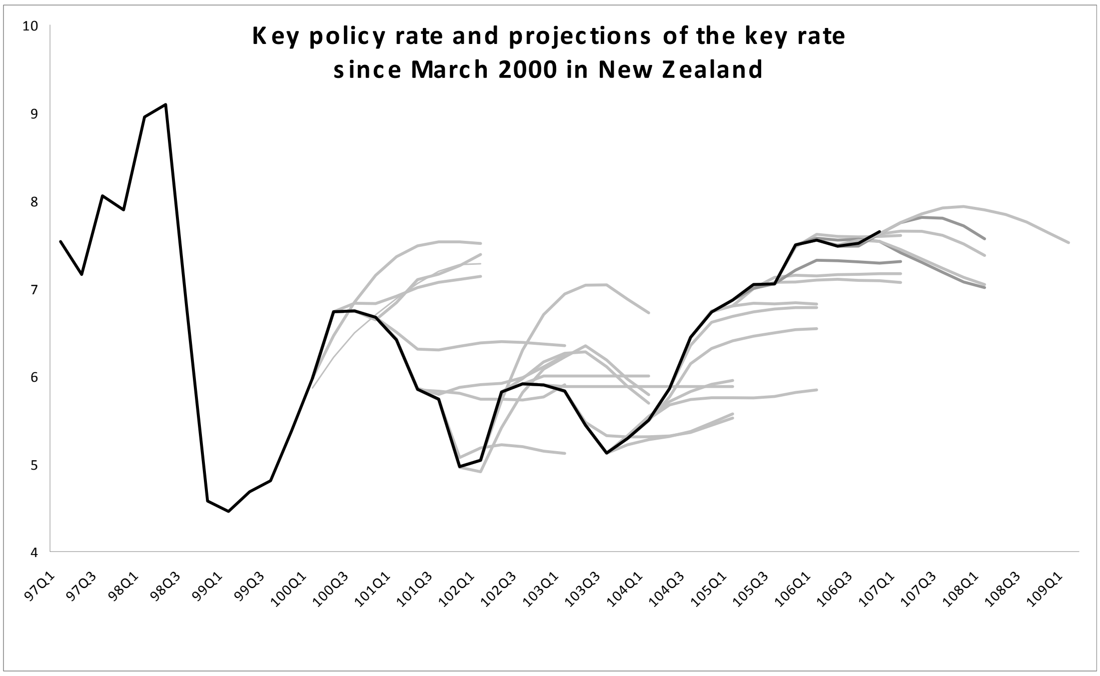



Figure 2




Source: David Archer

Figure 3

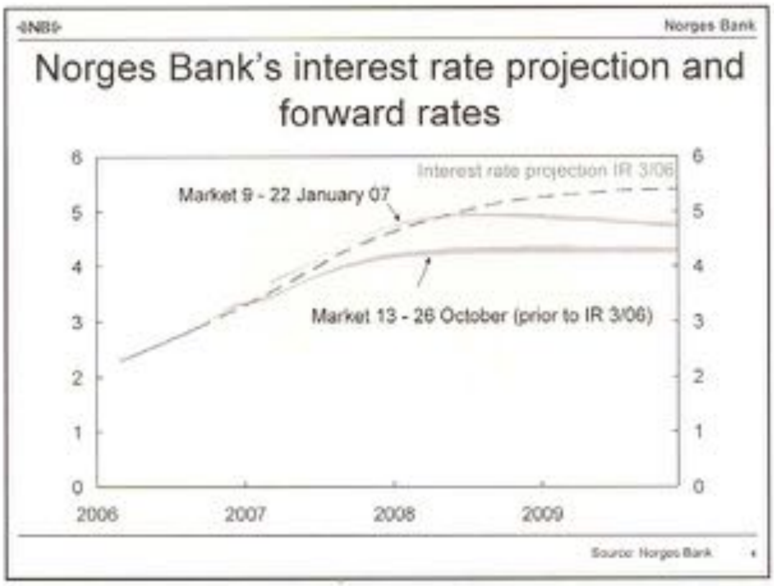



Figure 4

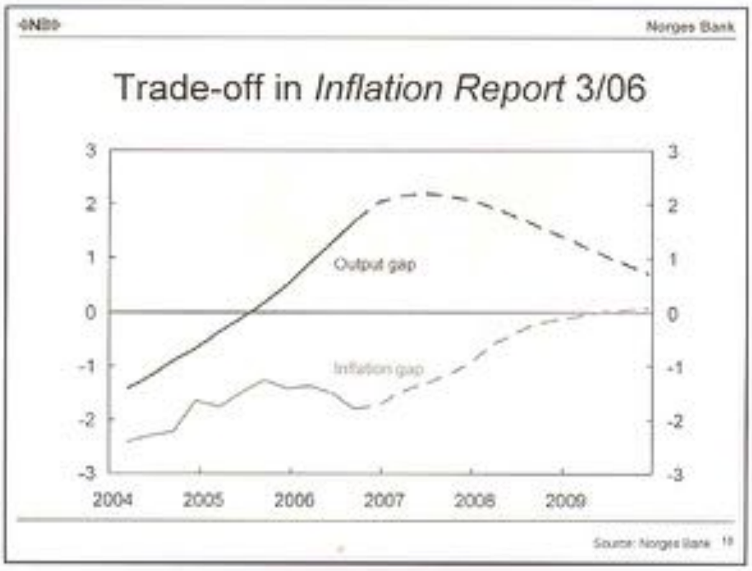


Figure 5

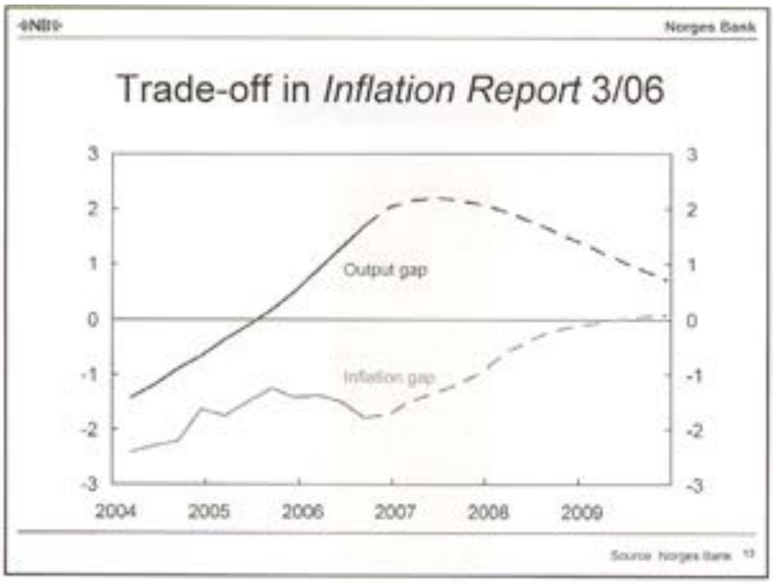



Figure 6

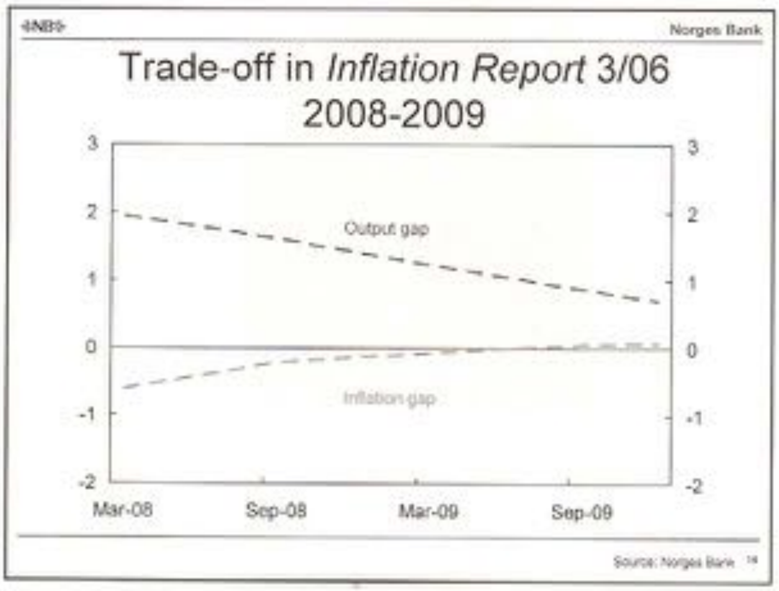
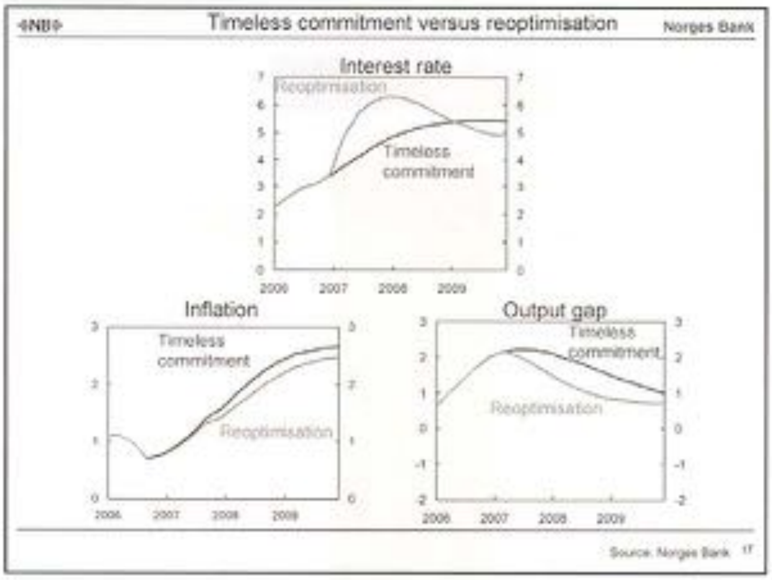


Figure 7


Timeless commitment versus reoptimisation
Norges Bank
Interest rate
Reoptimisation
Timeless commitment
Inflation
Timeless commitment
Reoptimisation
Output gap
Timeless commitment
Reoptimisation
Source: Norges Bank

# Interest Rate Forecasts:  A Pathology

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## Abstract

This is the first of three prospective papers examining how well forecasters can predict the future time path of short-term interest rates.  Most prior work has been done using US data; in this exercise we use forecasts made for New Zealand (NZ) by the Reserve Bank of New Zealand (RBNZ), and those derived from money market yield curves in the UK.  In this first exercise we broadly replicate recent US findings for NZ and UK, to show that such forecasts in NZ and UK 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 upwards, or downwards, trending, they are shown to have been biased and, apparently, inefficient.  In the second paper we shall examine whether (NZ and UK) forecasts for inflation exhibit the same syndromes, and whether errors in inflation forecasts can help to explain errors in interest rate forecasts.  In the third paper we shall set out an hypothesis to explain those findings, and examine whether the apparent ex post forecast inefficiencies may still be consistent with ex ante forecast efficiency.

Even if the forecasts may be ex ante efficient, their negligible ex post forecasting ability suggests that, beyond a six months' horizon from the forecast date, they would be better replaced by a simple 'no-change thereafter' assumption.

## I. Introduction

The short-term policy interest rate has generally been adjusted in most developed countries, at least during the last 20 years or so, in a series of small steps in the same direction, followed by a pause and then a, roughly, similar series of steps in the opposite direction. Figures 1, 2 and 3 show the time-path of policy rates for New Zealand, UK and USA.

Figure 1
Official Cash Rate: Reserve Bank of New Zealand
(Source: Reserve Bank of New Zealand)

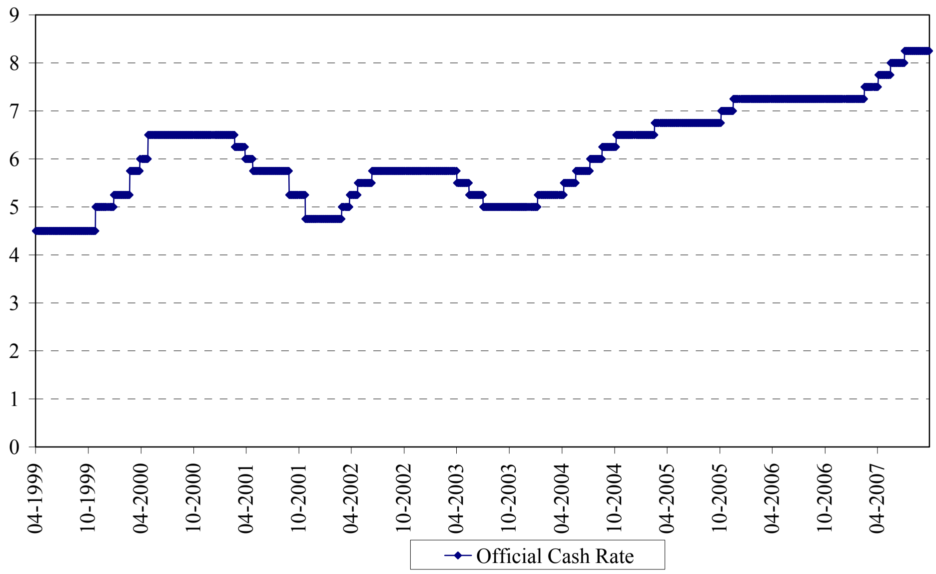


Figure 2
Official Bank Rate: Bank of England
(Source: Bank of England website)

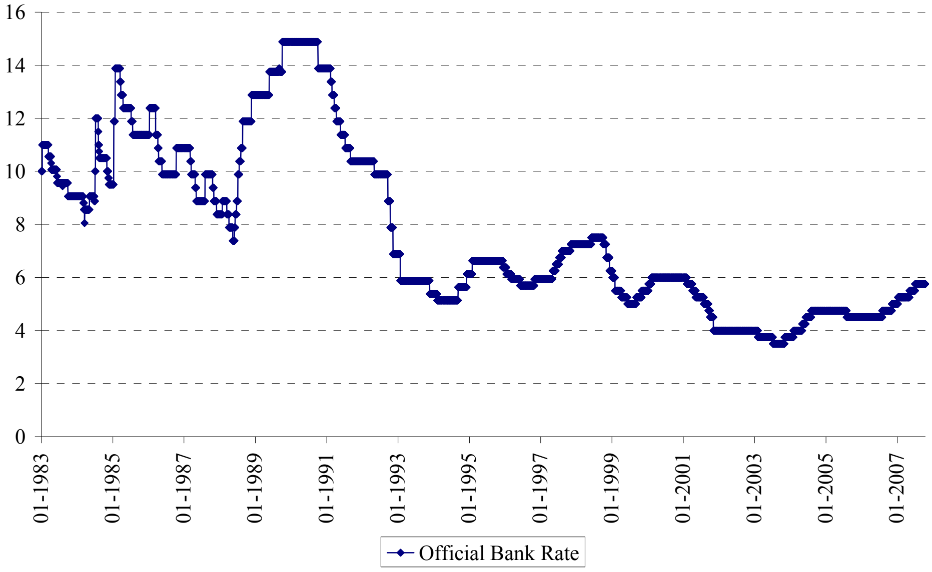
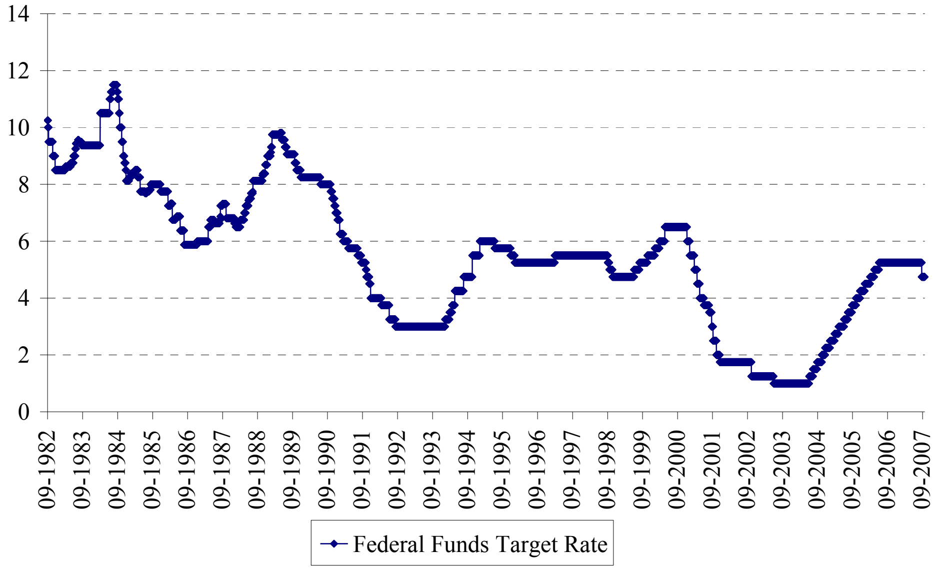



Figure 3
Federal Reserve
Federal Funds Target Rate



On the face of it, such a behavioural pattern would appear quite easy to predict. Moreover, Central Bank behaviour has typically been modelled 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 <u>not</u> 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 USA (see Rudebusch 1995 and 2002 and the literature cited there). More recently, with Central Banks having become much more transparent about their thinking, their 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, (Rudebusch, 2006, and Lange, Sack and Whitesell, 2003).

We contribute to this literature first by extending the empirical analysis to New Zealand and the UK, 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 <u>not</u> 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 (forthcoming 2008). For an analytical discussion of the effects of the relative forecasting precision on that decision, see Morris and Shin (2002) and Svensson (2006).

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 28 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 UK. We use

[1] The UK and New Zealand 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

estimates provided by the Bank of England over the period 1992 Q4 until 2004 Q4. There are two such series, one derived from the 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 choose, and subsequently use, 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 USA. 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; 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 onwards.

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 Paper 3 of this series how ex post bias can yet be consistent with ex ante efficiency in forecasting.

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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.

This bias can actually be seen clearly in a visual representation of the forecasts. The RBNZ forecasts, and outcome are shown in Figure 4 and the UK forecast derived from the short-dated Government debt yield curve in Figure 5.

Figure 4
RBNZ interest rate forecast (90days, annualized rate)
published in successive Monetary Policy Statement

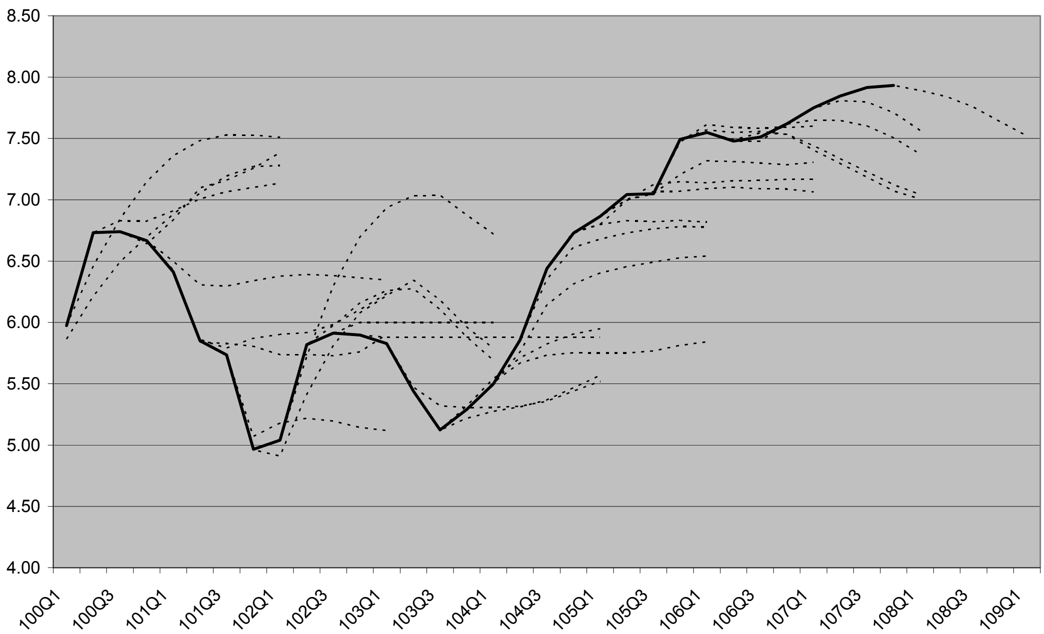
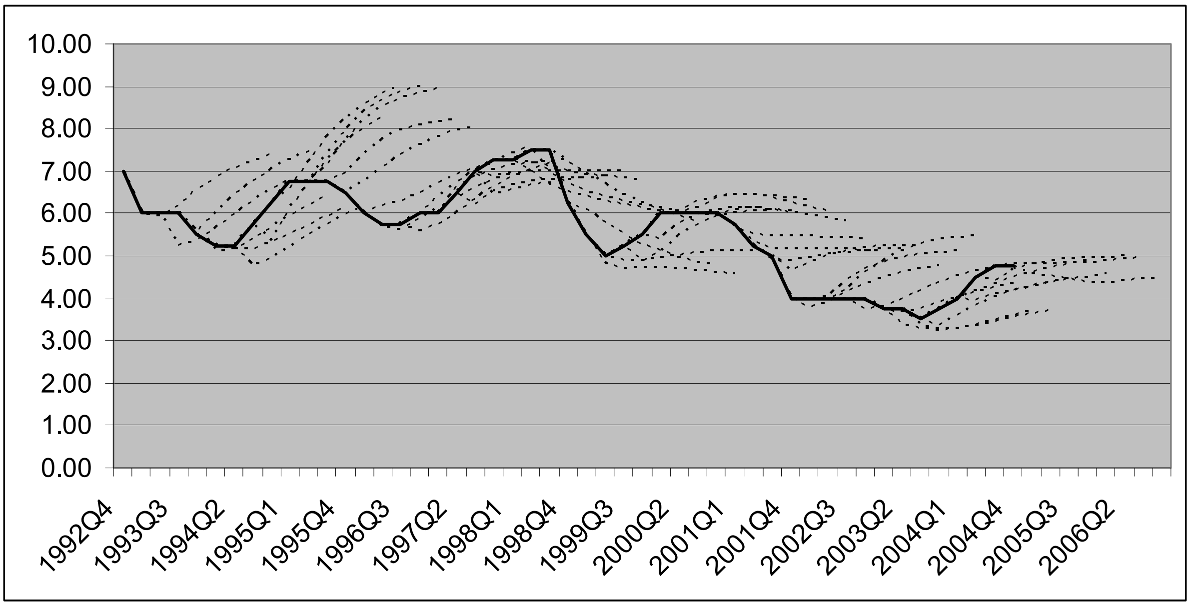


Figure 5
UK interest rate forecast (90days, annualized rate)
derived from the short dated government debt yield curve




What is apparent by simple inspection is that when interest rates are on an upwards (downwards) cyclical path, the forecast under (over) estimates the actual subsequent path of interest rates. Much the same pattern is also observable in Rudebusch, 2007, Figures 1, reproduced as Figure 6 here, for the USA and Sweden, see Adolfson, et al., 2007, reproduced as Figure 7 here. One of the reasons why this bias has not been more widely recognised is that the biases during up and down cyclical periods are almost exactly offsetting, so if an econometrician applies 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 in Paper 2, 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 not the case for short term interest rates where the, ex post, timing of turning points is relatively easier.

Figure 6
Actual and expected federal funds rate

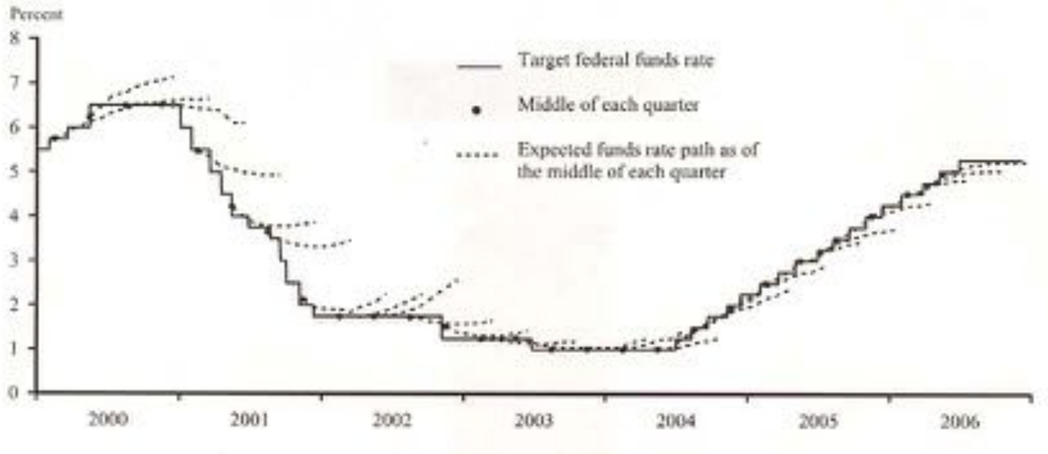
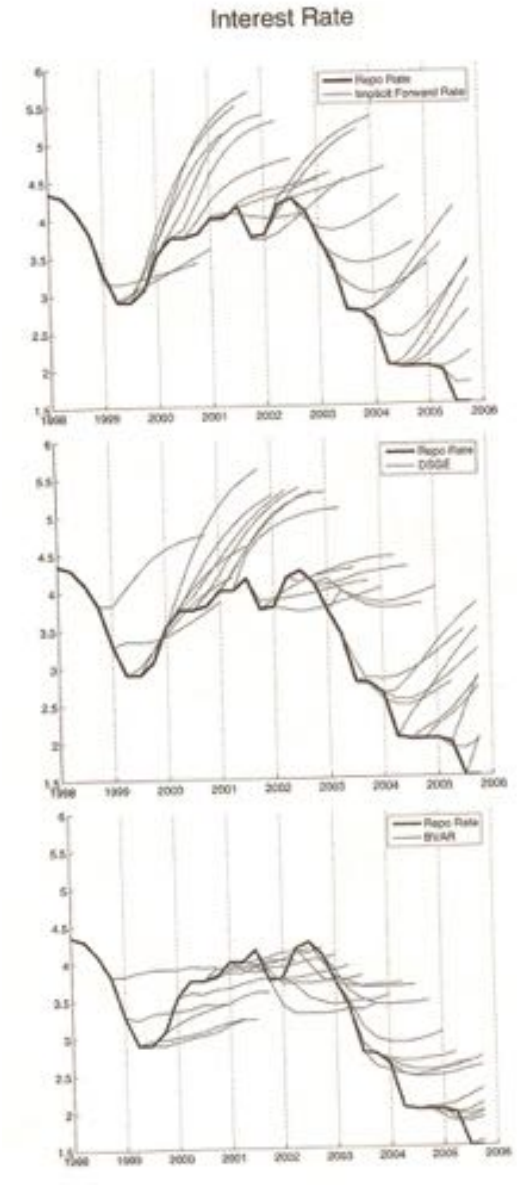


Figure 7
Sequential Forecasts of Sweden's Repo Rate, 1999:Q1 – 2005:Q5, from the Riksbank (First Row), the DSGE Model (Second Row), and the BVAR Model (Third Row)




The sequencing of this paper proceeds as follows. We report our data base in Section II. We examine the accuracy of the interest rate forecasts in Section III, and we offer some interim conclusions in Section IV. Recall that we shall continue this exercise in Paper 2, exploring whether inflation forecasts exhibit similar error patterns, which latter may help to explain the errors in the interest rate forecast; and then in Paper 3 we shall assess whether forecasts which appear ex post biased can still be ex ante efficient.

## II. The Data Base

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 Reserve Bank of New Zealand (RBNZ) in their quarterly Monetary Policy Statement. Our second country is the UK. 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 use two alternative estimates of future (forecast) policy rates.

In NZ 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, 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 Target 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.

Indeed we think that the distinction between the (forecast) path of CPI and of other measures of inflationary pressures, e.g. domestically generated CPI, may have been influential in policy decisions at certain times, as discussed further in Section 5.

In NZ the policy-determined rate is taken to be the 90 day (3 month) rate, and the forecasts are for that rate. Thus the current quarter interest rate observation contains nearly two months of actual 90 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 90 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 that data, the forecasts, and the resulting errors, for the policy rate in Appendix Tables 1A and B. 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 derived from the yield curve of short-dated government debt and that derived from the London Inter-Bank Offer Rate (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 in 2007 revealed. We do not rehearse these difficulties here; instead we simply took these data from the Bank of England website, see www.bankofengland.co.uk for more information on the procedures used to obtain such implicit forecast series, see Anderson and Sleath, (1999, 2001), Brooks, 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 had a more accurate forecast than the Libor series over our data period, 1992-2004. 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 Appendix Table 2A and B, for the government debt series, (the other series for Libor is available from the authors on request).

## III. How Accurate are the Interest Rate Forecasts?

We began our examination of this question by running four regressions both for the NZ data series and for two sets of implied market forecasts for the UK, derived from the LIBOR and Government Debt yield curve respectively. These regression equations were:-

(1) $IR(t + h) = C_1 + C_2$ Forecast (t, t + h)

(2) $IR(t + h) – IR(t) = C_1 + C_2$ (Forecast t, t + h – IRt)

(3) $IR(t + h) – IR(t + h – 1) = C_1 + C_2$ (Forecast, t, t + h – Forecast, t, t + h – 1)

(4) IR(t + h) – IR(t + h – 1) = C (Forecast, t, t + h – Forecast, t, t + h – 1).

Where: Forecast (t,t+h) = forecast of IR( t+h) made at time, t

IR(t) = actual interest rate outurn 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 expectation on both sides, $E\{IR(t+h)\} = E\ \{C_1 + C_2\ [Forecast(t,t+h)]\}$. A forecast is unbiased, i.e. E{IR(t+h)} = E{[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, focussing 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. The fourth equation just repeats equation 3, but drops the constant term.

All four regressions assess the accuracy/biasness of interest rate forecasts from slightly different angles. In the first three equations, an unbiased forecast will necessarily implies a constant term of zero, and a slope coefficient of one. In all four equations the coefficient $C_2$ should be unity. We can test whether these conditions are fulfilled with a joint hypothesis test:

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

With four equations, three data sets, and h = 0 to 5 for NZ and h = 1 to 8 for the UK series, we have some 88 regression results and statistical test scores to report. Rather than asking the reader to plough through them all, we collect these together in Appendix 2. Interpretation of regression results is somewhat subjective. We give our interpretation of them here; the sceptical reader is invited to examine Appendix 2 and make his/her own assessment.

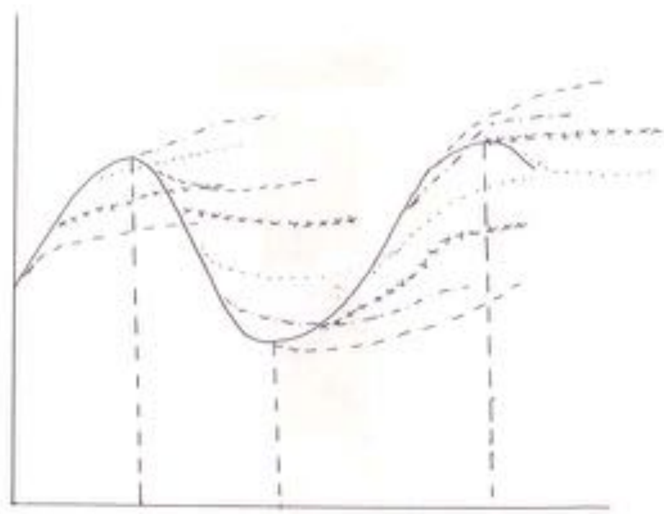
Let us start with NZ. What these results demonstrate is that the RBNZ forecast is excellent one quarter ahead, but then becomes useless in forecasting the subsequent direction, or extent, of change. Thus the coefficient $C_2$ in equation (3) becomes -0.04 at h = 2 (with a R squared of zero), and negative thereafter. Much the same is true for equation 4. When the equation is run in levels, rather than first differences, i.e. equations 1 and 2, 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.

Turning next to the UK, and starting with the 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 able also 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 Tables 3 and 4 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 onwards, the predictive ability of the Government yield forecast becomes insignificantly different from zero, but at least the coefficients have the right sign (unlike the RBNZ).

Finally for the implicit forecasts derived from the Libor yield curve these tables indicate that, over this sample period, such implicit forecasts have been comprehensively worse than those from the Government yield curve, or the RBNZ. These 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, data errors in a short sample, but it is beyond the scope of this paper to try to track them down. Instead we will focus on the forecasts implied by the government yield curve since they have a better record, at least at the short end.

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 start to answer this question, we start with a stylised fact. When one looks at most macro-economic forecasts, and notably so for interest rates, see Figures 4-7 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 8.

Figure 8



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 be tend to 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 over several quarters beyond the turning point into the next down (up)-period. Consider, for example, the final turning point in Figure 8. Three forecasts made in the earlier part of the prior upturn (---, xxx and …) have a positive Actual minus Forecast after the sign change from up to down, and three forecasts made in the latter part of the upturn (-.-.-, ---- and xxx) a negative Actual minus Forecast. 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.[2] Third, 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.

In Figures 9 and 10 we reproduce the charts for the policy rate in NZ and UK, marking the points at which we have taken the turning points to be. Given these turning points we reproduce the number of observations of errors (Actual minus Forecast) until the first sign change in up and down periods separately, and then between the first and second sign change, of all forecasts made during up and down periods respectively, together with their mean error and standard deviation, and we show the p values of such values coming from a distribution whose true underlying mean error was zero. This is shown in Table 1 for the RBNZ forecast and in Table 2 for the Government yield forecasts.

[2] 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.

Figure 9
RBNZ interest rate (3 months annualized rate)

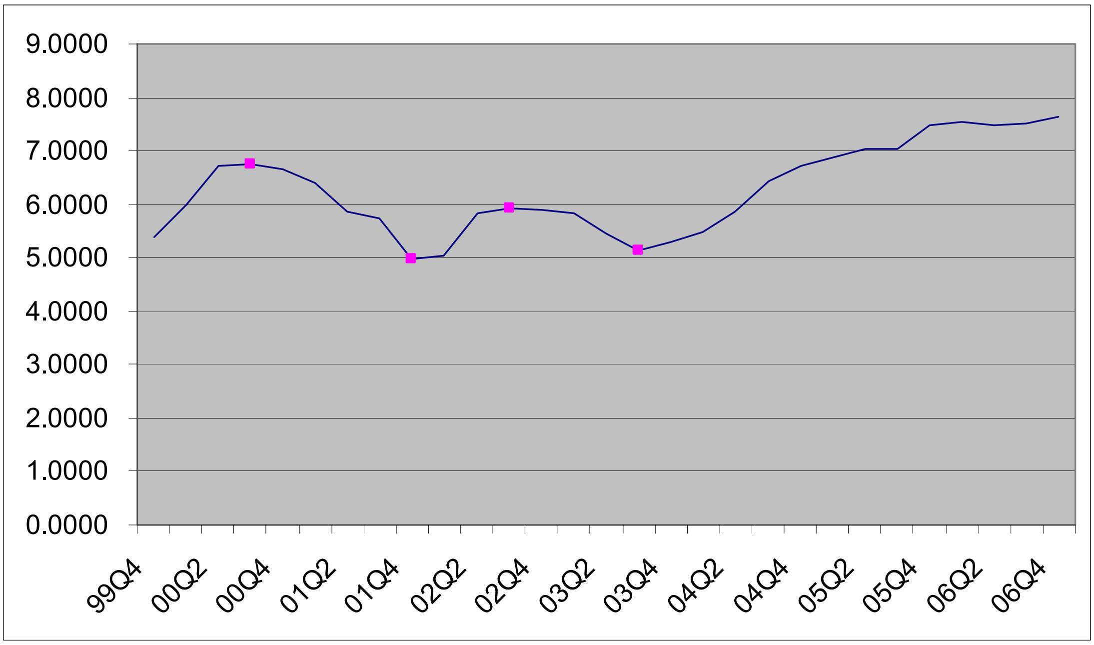
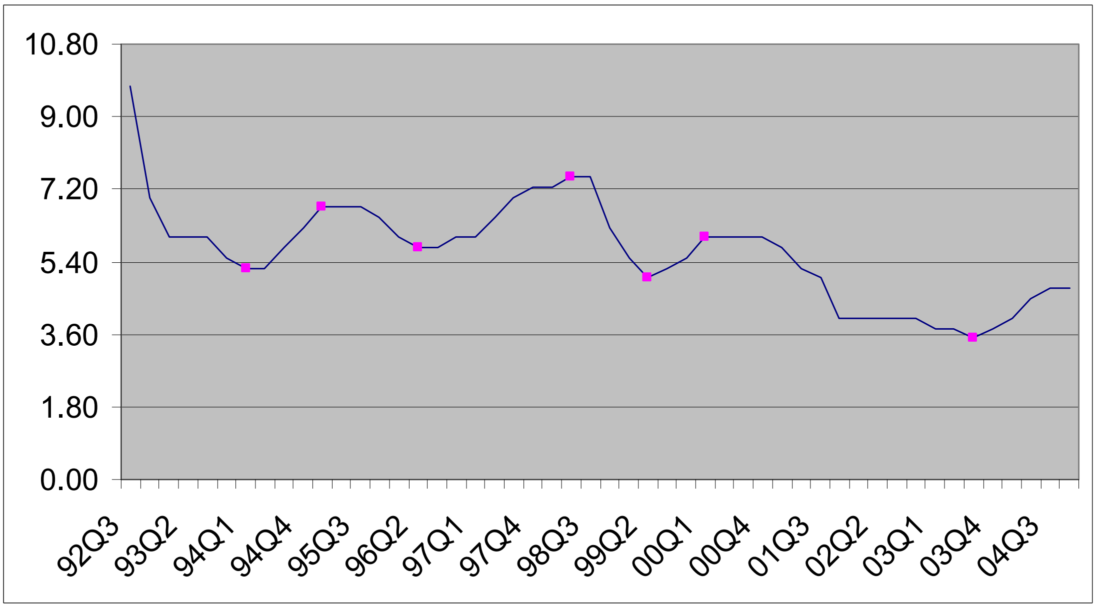



Figure 10
UK Gov curve implied forward rate (3 months annualized rate)



Let us go through the RBNZ Table 1 starting with the top left quadrant table. The top line shows that there were 19 forecasts made during up periods. Of these in their first quarter, 11 had positively signed errors (Actual > Forecast) and 8 negatively signed errors (Actual < Forecast). The mean error was a very small positive sum (0.04), with a p value of 0.06. Of these 19 forecasts, for 16 the up period of actual policy rates was still in place in their second quarter. Of these 16, 9 had a positive error and 7 a negative error. Again the mean error was small positive, insignificantly different from zero. From then on out to quarter 9, the general picture changes. There are 45 positive errors and only 4 negative errors. The mean size of the positive error rises steadily to over 100 basis points, and the mean error is statistically significantly different from zero in a couple of cases.

Table 1

RBNZ Interest Rate

Initial Sign: Up

| Up error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 19 | 11 | 8 | 0.0391 | 0.0825 | 0.0594 |
| 16 | 9 | 7 | 0.0737 | 0.2237 | 0.2213 |
| 13 | 10 | 3 | 0.1942 | 0.2150 | 0.0087 |
| 10 | 9 | 1 | 0.3628 | 0.2924 | 0.0048 |
| 9 | 9 | 0 | 0.5016 | 0.3310 | 0.0027 |
| 8 | 8 | 0 | 0.6618 | 0.3273 | 0.0011 |
| 5 | 5 | 0 | 0.7827 | 0.3559 | 0.0117 |
| 3 | 3 | 0 | 1.0812 | 0.5647 | 0.1136 |
| 1 | 1 | 0 | 1.7079 | | |
| 84 | 65 | 19 | 0.3184 | 0.4052 | 0.0000 |

Initial Sign: Down

| Down error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 9 | 3 | 6 | -0.0435 | 0.0489 | 0.0360 |
| 7 | 0 | 7 | -0.3835 | 0.2722 | 0.0136 |
| 5 | 0 | 5 | -0.7927 | 0.2824 | 0.0049 |
| 3 | 0 | 3 | -1.2244 | 0.3015 | 0.0290 |
| 1 | 0 | 1 | -2.2901 | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 25 | 3 | 22 | -0.5201 | 0.5821 | 0.0002 |

After first sign change

| Down error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 2 | 0 | 2 | -0.2104 | 0.0736 | 0.2143 |
| 4 | 0 | 4 | -0.5527 | 0.1682 | 0.0108 |
| 6 | 0 | 6 | -0.7092 | 0.4840 | 0.0221 |
| 6 | 0 | 6 | -1.0664 | 0.5457 | 0.0072 |
| 5 | 0 | 5 | -1.5902 | 0.5153 | 0.0035 |
| 3 | 0 | 3 | -1.6932 | 0.7783 | 0.0914 |
| 1 | 0 | 1 | -2.3042 | | |
| 0 | 0 | 0 | | | |
| 27 | 0 | 27 | -1.0600 | 0.6904 | 0.0000 |

After first sign change

| Up error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 2 | 1 | 1 | -0.0339 | 0.1499 | 0.8584 |
| 4 | 2 | 2 | -0.0140 | 0.6199 | 0.9712 |
| 6 | 3 | 3 | 0.0114 | 0.5816 | 0.9668 |
| 7 | 3 | 4 | -0.1149 | 0.7958 | 0.7356 |
| 7 | 3 | 4 | -0.1304 | 1.2080 | 0.8003 |
| 4 | 3 | 1 | 0.6687 | 0.8337 | 0.2590 |
| 2 | 2 | 0 | 1.0957 | 0.3509 | 0.1973 |
| 1 | 1 | 0 | 0.9847 | | |
| 33 | 18 | 15 | 0.1236 | 0.8385 | 0.4035 |

Let us next turn to the next right hand side sub-table. Here there were nine forecasts made during periods of downturn. In the first quarter of the forecast, there were three positive errors and six negative errors, the mean error was a small negative total (-0.04) with a p value of 0.04. Interest rate downturns are shorter and sharper than upturns, so no forecast originally made in a downturn had that down period of actual interest rates last beyond the fifth quarter. Once the forecast was still in a downturn (beyond the first quarter) the asymmetry becomes extreme; there are 16 negative errors and 0 positive errors. The absolute size of the negative error rises rapidly to over 100 bps by Q4, and is significantly different from zero in Qs 3 and 4.

The bottom left hand sub-table shows the outcome for forecasts made in a period when actual interest rates had been going down, but after the sign change from a down period to an up period. By definition there can be no observations in the top row. In two cases the down period of actual interest rates switched to an up period in the second quarter of the forecast. In this sub-table every single observation is again negative (Actual < Forecast), the absolute scale of the negative values rises, again to over -100 bps and several are significantly different from zero.

In the case of the bottom right hand side sub-table, the outcome is much less marked and extreme. This sub-table shows the error outcome for forecasts made initially during upturns, but after there has been a change to a downturn. In this case there is rough equality between positive and negative errors, the mean size of error is usually small and except in one case (involving only two observations) totally insignificant.

Overall upturns last longer than downturns, so more forecasts are made during upturns, and there are more error observations during upturns (117) than in downturns (52). In contrast, the extent of bias and inefficiency in errors in forecasts made initially during downturns is considerably greater than those made during upturns. So if you take the sample period as a whole, containing both periods of upturn and downturn, the biases net out. Regression analyses covering the whole sample period, therefore, tend to show that forecasts, though poor, are neither inefficient nor biased. But this obscures the finding here that there are, in fact, large, but offsetting, biases and inefficiencies in forecasts made during upturns and downturns.

Perhaps an easier and more standard 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 (C1) and one for down periods (C2). The hypothesis is that the up period indictor variable (C1) is positive (actual > forecast) and the down period indicator (C2) is negative (actual < forecast).

The results for NZ are as follows:-

Table 2

(A) Indicator variable is based on state at out-turn date (whole data set)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value |
|---|---|---|---|---|---|
| Q1 | 0.41 | 0.06 | 0.26 | -0.35 | 0.00 |
| Q2 | 0.62 | 0.15 | 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 | 0.78 |

(B) Indicator variable is based on state at out-turn 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 | -0.35 | 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 | - | - | - | - | - |

(C) Indicator variable is based on state at forecast date (whole data set)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value |
|---|---|---|---|---|---|
| Q1 | 0.41 | 0.06 | 0.26 | -0.35 | 0.00 |
| Q2 | 0.51 | 0.12 | 0.17 | -0.64 | 0.00 |
| Q3 | 0.39 | 0.16 | 0.25 | -0.76 | 0.00 |
| Q4 | 0.17 | 0.15 | 0.50 | -0.72 | 0.02 |
| Q5 | 0.05 | 0.10 | 0.72 | -0.57 | 0.13 |
| Q6 | -0.07 | -0.15 | 0.72 | -0.17 | 0.73 |
| Q7 | 0.00 | -0.49 | 0.38 | 0.41 | 0.57 |
| Q8 | -0.29 | -0.27 | 0.80 | 0.23 | 0.86 |

(D) Indicator variable is based on state at forecast date, but only includes period during which sign is unchanged

Same results as (B) above.

Turning next to the Table (Table 3) showing the results for the Government yield implied forecasts, we find in effect qualitatively identical results.

Table 3

GOV Interest Rate

Initial Sign: Up

| Up error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 13 | 11 | 2 | 0.3772 | 0.2542 | 0.0002 |
| 14 | 13 | 1 | 0.4633 | 0.3375 | 0.0003 |
| 12 | 11 | 1 | 0.5630 | 0.4362 | 0.0013 |
| 8 | 7 | 1 | 0.5728 | 0.5197 | 0.0225 |
| 5 | 4 | 1 | 0.4272 | 0.3595 | 0.0762 |
| 3 | 3 | 0 | 0.2375 | 0.2019 | 0.2381 |
| 2 | 1 | 1 | 0.1410 | 0.4474 | 0.8056 |
| 1 | 0 | 1 | -0.0761 | | |
| 58 | 50 | 8 | 0.4445 | 0.3744 | 0.0000 |

Initial Sign: Down

| Down error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 20 | 12 | 8 | -0.0289 | 0.3573 | 0.7280 |
| 24 | 6 | 18 | -0.3196 | 0.4542 | 0.0026 |
| 20 | 1 | 19 | -0.7738 | 0.4911 | 0.0000 |
| 16 | 0 | 16 | -1.1407 | 0.4963 | 0.0000 |
| 12 | 0 | 12 | -1.4608 | 0.5352 | 0.0000 |
| 9 | 0 | 9 | -1.4664 | 0.4316 | 0.0000 |
| 8 | 0 | 8 | -1.6312 | 0.4575 | 0.0000 |
| 7 | 0 | 7 | -1.7305 | 0.3724 | 0.0000 |
| 116 | 19 | 97 | -0.8578 | 0.6997 | 0.0000 |

After first sign change

| Down error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 2 | 2 | 0 | 0.5085 | 0.4241 | 0.4425 |
| 6 | 3 | 3 | -0.0752 | 0.4818 | 0.7411 |
| 9 | 4 | 5 | -0.2765 | 0.8081 | 0.3614 |
| 11 | 4 | 7 | -0.5033 | 1.1638 | 0.2014 |
| 11 | 3 | 8 | -0.8292 | 1.3532 | 0.0814 |
| 10 | 3 | 7 | -0.9444 | 1.2117 | 0.0441 |
| 9 | 2 | 7 | -1.0630 | | |
| 58 | 21 | 37 | -0.6136 | 1.0948 | 0.0001 |

After first sign change

| Up error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 4 | 4 | 0 | 0.3164 | 0.2398 | 0.1064 |
| 8 | 6 | 2 | 0.2537 | 0.4798 | 0.2046 |
| 12 | 6 | 6 | -0.0081 | 0.9716 | 0.9785 |
| 15 | 6 | 9 | -0.2285 | 1.0896 | 0.4458 |
| 16 | 5 | 11 | -0.5811 | 1.2364 | 0.0887 |
| 14 | 3 | 11 | -0.7001 | 1.1241 | 0.0427 |
| 12 | 4 | 8 | -0.7740 | 0.9715 | 0.0229 |
| 81 | 34 | 47 | 0.0151 | 0.7842 | 0.8637 |

Again we run the same, simpler, regression exercise. The results are:-

Table 4

(A) Indicator variable is based on state at out-turn date (whole data set)

| H = | R-sqr | S1 | P-value | S2 | P-value |
|---|---|---|---|---|---|
| 1 | 0.37 | 0.38 | 0.00 | -0.03 | 0.69 |
| 2 | 0.39 | 0.43 | 0.00 | -0.26 | 0.00 |
| 3 | 0.53 | 0.44 | 0.00 | -0.61 | 0.00 |
| 4 | 0.40 | 0.22 | 0.21 | -0.83 | 0.00 |
| 5 | 0.30 | -0.06 | 0.78 | -0.91 | 0.00 |
| 6 | 0.25 | -0.48 | 0.09 | -0.82 | 0.00 |
| 7 | 0.31 | -0.78 | 0.01 | -0.80 | 0.00 |
| 8 | 0.41 | -1.04 | 0.00 | -0.83 | 0.00 |

(B) Indicator variable is based on state at out-turn date,
but only includes period during which sign is unchanged

| H = | R-sqr | S1 | P-value | S2 | P-value |
|---|---|---|---|---|---|
| 1 | 0.37 | 0.38 | 0.00 | -0.03 | 0.69 |
| 2 | 0.47 | 0.46 | 0.00 | -0.32 | 0.00 |
| 3 | 0.70 | 0.56 | 0.00 | -0.77 | 0.00 |
| 4 | 0.81 | 0.57 | 0.00 | -1.17 | 0.00 |
| 5 | 0.88 | 0.43 | 0.07 | -1.46 | 0.00 |
| 6 | 0.93 | 0.24 | 0.32 | -1.47 | 0.00 |

(C) Indicator variable is based on state at forecast date (whole data set)

| H = | R-sqr | S1 | P-value | S2 | P-value |
|---|---|---|---|---|---|
| 1 | 0.37 | 0.38 | 0.00 | -0.03 | 0.69 |
| 2 | 0.38 | 0.47 | 0.00 | -0.23 | 0.01 |
| 3 | 0.34 | 0.35 | 0.02 | -0.48 | 0.00 |
| 4 | 0.27 | 0.12 | 0.57 | -0.66 | 0.00 |
| 5 | 0.22 | -0.21 | 0.45 | -0.70 | 0.00 |
| 6 | 0.24 | -0.62 | 0.05 | -0.68 | 0.01 |
| 7 | 0.32 | -0.97 | 0.00 | -0.70 | 0.00 |
| 8 | 0.44 | -1.26 | 0.00 | -0.72 | 0.00 |

(D) Indicator variable is based on state at forecast date,
but only includes period during which sign is unchanged.

Same results as (B) above.

In this latter, UK case, however, the forecasts included some sizeable 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 error tended to increase, approximately linearly, as the horizon (h) increased. This is shown in Figure 11 and Table 5 below:-

Figure 11

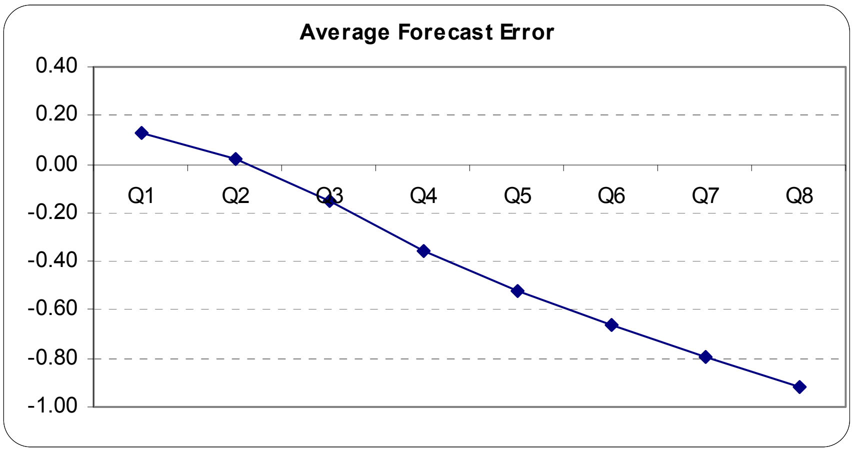



Table 5

| H= | Average Forecast Error |
|---|---|
| Q1 | 0.1311 |
| Q2 | 0.0250 |
| Q3 | -0.1552 |
| Q4 | -0.3612 |
| Q5 | -0.5240 |
| Q6 | -0.6616 |
| Q7 | -0.7939 |
| Q8 | -0.9217 |

After correcting for this average error, and re-running,[3] the results became:-

Table 6

(A) Indicator variable is based on state at out-turn date
(whole data set, with average forecast error removed)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value |
|---|---|---|---|---|---|
| Q1 | 0.27 | 0.25 | 0.01 | -0.16 | 0.03 |
| Q2 | 0.37 | 0.41 | 0.00 | -0.28 | 0.00 |
| Q3 | 0.50 | 0.59 | 0.00 | -0.46 | 0.00 |
| Q4 | 0.30 | 0.59 | 0.00 | -0.47 | 0.01 |
| Q5 | 0.12 | 0.46 | 0.06 | -0.38 | 0.08 |
| Q6 | 0.00 | 0.18 | 0.50 | -0.16 | 0.53 |
| Q7 | -0.02 | 0.01 | 0.97 | -0.01 | 0.97 |
| Q8 | -0.02 | -0.12 | 0.67 | 0.09 | 0.70 |

(B) Indicator variable is based on state at out-turn 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 | 0.27 | 0.25 | 0.01 | -0.16 | 0.03 |
| Q2 | 0.45 | 0.44 | 0.00 | -0.34 | 0.00 |
| Q3 | 0.66 | 0.72 | 0.00 | -0.62 | 0.00 |
| Q4 | 0.74 | 0.93 | 0.00 | -0.78 | 0.00 |
| Q5 | 0.79 | 0.95 | 0.00 | -0.94 | 0.00 |
| Q6 | 0.83 | 0.90 | 0.00 | -0.80 | 0.00 |
| Q7 | 0.80 | 0.93 | 0.00 | -0.84 | 0.00 |
| Q8 | 0.85 | 0.85 | 0.00 | -0.81 | 0.00 |

[3] The average forecast error in NZ was much smaller, and did not vary systematically with h. We ran similar adjusted regressions for NZ, but the results were closely similar to those shown in Table 3 above.

(C) Indicator variable is based on state at forecast date (whole data set, with average forecast error removed)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value |
|---|---|---|---|---|---|
| Q1 | 0.27 | 0.25 | 0.01 | -0.16 | 0.03 |
| Q2 | 0.37 | 0.44 | 0.00 | -0.25 | 0.00 |
| Q3 | 0.29 | 0.51 | 0.00 | -0.32 | 0.01 |
| Q4 | 0.14 | 0.48 | 0.03 | -0.29 | 0.08 |
| Q5 | 0.02 | 0.31 | 0.26 | -0.18 | 0.40 |
| Q6 | -0.02 | 0.04 | 0.91 | -0.02 | 0.93 |
| Q7 | -0.01 | -0.17 | 0.58 | 0.10 | 0.68 |
| Q8 | 0.03 | -0.34 | 0.24 | 0.20 | 0.37 |

(D) Indicator variable is based on state at forecast 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 | 0.27 | 0.25 | 0.01 | -0.16 | 0.03 |
| Q2 | 0.45 | 0.44 | 0.00 | -0.34 | 0.00 |
| Q3 | 0.66 | 0.72 | 0.00 | -0.62 | 0.00 |
| Q4 | 0.74 | 0.93 | 0.00 | -0.78 | 0.00 |
| Q5 | 0.79 | 0.95 | 0.00 | -0.94 | 0.00 |
| Q6 | 0.83 | 0.90 | 0.00 | -0.80 | 0.00 |
| Q7 | 0.80 | 0.93 | 0.00 | -0.84 | 0.00 |
| Q8 | 0.85 | 0.85 | 0.00 | -0.81 | 0.00 |

It was known before in the literature that interest rate forecasts beyond the next few months were abysmally poor, with no precision nor predictive power. What we add here is the finding is that, once one separates the data period into periods of cyclical rises (falls) in actual policy rates, they are significantly biased as well.

## VI. Conclusions

(1) 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 probably best to acknowledge this, e.g. by using a ‘no change’ thereafter assumption.

(2) 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 Papers 2 and 3.

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Appendix Table 1A: RBNZ interest rate forecast

| Date | Interest Rate | 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) |
|---|---|---|---|---|---|---|---|---|---|---|
| 00Q1 | 5.974 | 5.86 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 00Q2 | 6.732 | 6.46 | 6.21 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 00Q3 | 6.740 | 6.83 | 6.84 | 6.49 | N/A | N/A | N/A | N/A | N/A | N/A |
| 00Q4 | 6.667 | 6.64 | 6.83 | 7.15 | 6.70 | N/A | N/A | N/A | N/A | N/A |
| 01Q1 | 6.412 | 6.50 | 6.84 | 6.91 | 7.36 | 6.88 | N/A | N/A | N/A | N/A |
| 01Q2 | 5.850 | 5.84 | 6.31 | 7.10 | 7.01 | 7.48 | 7.05 | N/A | N/A | N/A |
| 01Q3 | 5.736 | 5.79 | 5.83 | 6.30 | 7.16 | 7.07 | 7.53 | 7.19 | N/A | N/A |
| 01Q4 | 4.966 | 5.07 | 5.87 | 5.81 | 6.34 | 7.26 | 7.10 | 7.53 | 7.27 | N/A |
| 02Q1 | 5.040 | 4.91 | 5.18 | 5.90 | 5.74 | 6.38 | 7.38 | 7.13 | 7.51 | 7.28 |
| 02Q2 | 5.819 | 5.72 | 5.41 | 5.22 | 5.92 | 5.74 | 6.39 | N/A | N/A | N/A |
| 02Q3 | 5.913 | 5.97 | 6.30 | 5.81 | 5.20 | 5.98 | 5.73 | 6.38 | N/A | N/A |
| 02Q4 | 5.898 | 6.00 | 6.16 | 6.70 | 6.08 | 5.14 | 6.10 | 5.76 | 6.36 | N/A |
| 03Q1 | 5.828 | 5.88 | 6.00 | 6.26 | 6.93 | 6.22 | 5.12 | 6.23 | 5.90 | 6.35 |
| 03Q2 | 5.439 | 5.47 | 5.88 | 6.00 | 6.27 | 7.03 | 6.34 | N/A | N/A | N/A |
| 03Q3 | 5.123 | 5.12 | 5.32 | 5.88 | 6.00 | 6.11 | 7.04 | 6.18 | N/A | N/A |
| 03Q4 | 5.290 | 5.32 | 5.22 | 5.31 | 5.88 | 6.00 | 5.88 | 6.87 | 5.96 | N/A |
| 04Q1 | 5.498 | 5.51 | 5.54 | 5.28 | 5.31 | 5.88 | 6.00 | 5.69 | 6.72 | 5.79 |
| 04Q2 | 5.857 | 5.76 | 5.67 | 5.71 | 5.31 | 5.32 | 5.88 | N/A | N/A | N/A |
| 04Q3 | 6.440 | 6.35 | 6.14 | 5.73 | 5.82 | 5.37 | 5.36 | 5.88 | N/A | N/A |
| 04Q4 | 6.728 | 6.74 | 6.61 | 6.31 | 5.75 | 5.90 | 5.47 | 5.44 | 5.88 | N/A |
| 05Q1 | 6.865 | 6.80 | 6.80 | 6.68 | 6.40 | 5.75 | 5.95 | 5.57 | 5.52 | 5.88 |
| 05Q2 | 7.043 | 7.00 | 7.00 | 6.83 | 6.73 | 6.45 | 5.75 | N/A | N/A | N/A |
| 05Q3 | 7.049 | 7.05 | 7.12 | 7.07 | 6.82 | 6.76 | 6.49 | 5.77 | N/A | N/A |
| 05Q4 | 7.493 | 7.47 | 7.21 | 7.15 | 7.07 | 6.83 | 6.78 | 6.53 | 5.81 | N/A |
| 06Q1 | 7.549 | 7.57 | 7.61 | 7.32 | 7.14 | 7.09 | 6.82 | 6.78 | 6.54 | 5.84 |
| 06Q2 | 7.478 | 7.49 | 7.55 | 7.59 | 7.31 | 7.15 | 7.10 | N/A | N/A | N/A |
| 06Q3 | 7.511 | 7.48 | 7.55 | 7.56 | 7.58 | 7.30 | 7.16 | 7.09 | N/A | N/A |
| 06Q4 | 7.643 | 7.62 | 7.62 | 7.53 | 7.53 | 7.59 | 7.29 | 7.17 | 7.09 | N/A |

## Appendix Table 1B

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| 00Q1 | 0.11 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| 00Q2 | 0.27 | 0.52 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| 00Q3 | -0.09 | -0.10 | 0.25 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| 00Q4 | 0.03 | -0.16 | -0.48 | -0.03 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| 01Q1 | -0.09 | -0.42 | -0.50 | -0.95 | -0.47 | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| 01Q2 | 0.01 | -0.46 | -1.25 | -1.16 | -1.63 | -1.20 | #VALUE! | #VALUE! | #VALUE! |
| 01Q3 | -0.05 | -0.09 | -0.56 | -1.42 | -1.33 | -1.79 | -1.46 | #VALUE! | #VALUE! |
| 01Q4 | -0.10 | -0.90 | -0.84 | -1.37 | -2.29 | -2.13 | -2.56 | -2.30 | #VALUE! |
| 02Q1 | 0.13 | -0.14 | -0.86 | -0.70 | -1.34 | -2.34 | -2.10 | -2.47 | -2.24 |
| 02Q2 | 0.10 | 0.41 | 0.60 | -0.10 | 0.08 | -0.57 | #VALUE! | #VALUE! | #VALUE! |
| 02Q3 | -0.06 | -0.38 | 0.10 | 0.72 | -0.07 | 0.18 | -0.47 | #VALUE! | #VALUE! |
| 02Q4 | -0.10 | -0.26 | -0.80 | -0.18 | 0.75 | -0.21 | 0.14 | -0.47 | #VALUE! |
| 03Q1 | -0.05 | -0.17 | -0.43 | -1.11 | -0.39 | 0.71 | -0.41 | -0.07 | -0.52 |
| 03Q2 | -0.03 | -0.44 | -0.56 | -0.84 | -1.59 | -0.90 | #VALUE! | #VALUE! | #VALUE! |
| 03Q3 | 0.00 | -0.20 | -0.76 | -0.88 | -0.98 | -1.91 | -1.06 | #VALUE! | #VALUE! |
| 03Q4 | -0.03 | 0.07 | -0.02 | -0.59 | -0.71 | -0.59 | -1.58 | -0.67 | #VALUE! |
| 04Q1 | -0.01 | -0.04 | 0.22 | 0.19 | -0.38 | -0.50 | -0.19 | -1.22 | -0.29 |
| 04Q2 | 0.10 | 0.19 | 0.15 | 0.55 | 0.54 | -0.02 | #VALUE! | #VALUE! | #VALUE! |
| 04Q3 | 0.09 | 0.30 | 0.71 | 0.62 | 1.07 | 1.08 | 0.56 | #VALUE! | #VALUE! |
| 04Q4 | -0.01 | 0.11 | 0.41 | 0.98 | 0.82 | 1.26 | 1.29 | 0.85 | #VALUE! |
| 05Q1 | 0.06 | 0.07 | 0.19 | 0.46 | 1.11 | 0.92 | 1.30 | 1.34 | 0.98 |
| 05Q2 | 0.04 | 0.05 | 0.21 | 0.31 | 0.59 | 1.29 | #VALUE! | #VALUE! | #VALUE! |
| 05Q3 | 0.00 | -0.07 | -0.02 | 0.23 | 0.29 | 0.56 | 1.28 | #VALUE! | #VALUE! |
| 05Q4 | 0.02 | 0.29 | 0.35 | 0.42 | 0.66 | 0.71 | 0.97 | 1.68 | #VALUE! |
| 06Q1 | -0.02 | -0.06 | 0.23 | 0.41 | 0.46 | 0.73 | 0.77 | 1.01 | 1.71 |
| 06Q2 | -0.01 | -0.07 | -0.11 | 0.17 | 0.32 | 0.38 | #VALUE! | #VALUE! | #VALUE! |
| 06Q3 | 0.03 | -0.04 | -0.05 | -0.07 | 0.21 | 0.35 | 0.42 | #VALUE! | #VALUE! |
| 06Q4 | 0.02 | 0.03 | 0.11 | 0.11 | 0.05 | 0.36 | 0.48 | 0.56 | #VALUE! |

## Appendix Table 2A

Table 1: UK interest rate forecast implied by government yield curve

| | r | 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) |
|---|---|---|---|---|---|---|---|---|---|
| **1992Q4** | 7.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q1** | 6.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q2** | 6.00 | N/A | 5.95 | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q3** | 6.00 | N/A | 5.22 | 6.18 | N/A | N/A | N/A | N/A | N/A |
| **1993Q4** | 5.50 | N/A | 5.60 | 5.36 | 6.56 | N/A | N/A | N/A | N/A |
| **1994Q1** | 5.25 | N/A | 5.12 | 6.02 | 5.66 | 6.85 | N/A | N/A | N/A |
| **1994Q2** | 5.25 | N/A | 5.14 | 5.17 | 6.43 | 5.98 | 7.07 | N/A | N/A |
| **1994Q3** | 5.75 | N/A | 4.77 | 5.17 | 5.38 | 6.76 | 6.28 | 7.24 | N/A |
| **1994Q4** | 6.25 | N/A | 5.36 | 4.94 | 5.30 | 5.65 | 7.03 | 6.56 | 7.40 |
| **1995Q1** | 6.75 | N/A | 6.55 | 6.08 | 5.21 | 5.49 | 5.92 | 7.26 | 6.81 |
| **1995Q2** | 6.75 | N/A | N/A | 7.23 | 6.73 | 5.49 | 5.71 | 6.17 | 7.47 |
| **1995Q3** | 6.75 | N/A | 7.14 | 7.42 | 7.80 | 7.27 | 5.75 | 5.93 | 6.40 |
| **1995Q4** | 6.50 | 6.49 | 6.97 | 7.73 | 7.97 | 8.24 | 7.69 | 5.98 | 6.14 |
| **1996Q1** | 6.00 | N/A | 6.76 | 7.39 | 8.20 | 8.39 | 8.57 | 8.01 | 6.18 |
| **1996Q2** | 5.75 | 5.68 | 6.16 | 7.08 | 7.73 | 8.52 | 8.68 | 8.83 | 8.26 |
| **1996Q3** | 5.75 | N/A | 5.64 | 6.29 | 7.39 | 7.95 | 8.72 | 8.88 | 9.02 |
| **1996Q4** | 6.00 | 5.60 | N/A | 5.84 | 6.50 | 7.63 | 8.09 | 8.85 | 9.00 |
| **1997Q1** | 6.00 | N/A | 5.74 | 6.42 | 6.12 | 6.71 | 7.82 | 8.18 | 8.93 |
| **1997Q2** | 6.50 | N/A | 6.63 | 6.01 | 6.74 | 6.37 | 6.90 | 7.96 | 8.24 |
| **1997Q3** | 7.00 | 6.22 | N/A | 6.88 | 6.34 | 7.01 | 6.60 | 7.06 | 8.06 |
| **1997Q4** | 7.25 | 6.87 | 6.51 | 6.43 | 7.04 | 6.62 | 7.24 | 6.80 | 7.19 |
| **1998Q1** | 7.25 | 7.26 | 6.95 | 6.67 | 6.57 | 7.13 | 6.86 | 7.43 | 6.97 |
| **1998Q2** | 7.50 | 7.00 | 7.22 | 6.99 | 6.76 | 6.66 | 7.19 | 7.04 | 7.58 |
| **1998Q3** | 7.50 | 6.94 | 6.69 | 7.10 | 6.99 | 6.80 | 6.73 | 7.23 | 7.19 |
| **1998Q4** | 6.25 | 7.21 | 6.71 | 6.51 | 7.00 | 6.98 | 6.83 | 6.78 | 7.25 |
| **1999Q1** | 5.50 | 6.10 | 6.96 | 6.53 | 6.39 | 6.93 | 6.98 | 6.85 | 6.82 |
| **1999Q2** | 5.00 | 4.80 | 5.79 | 6.69 | 6.41 | 6.30 | 6.87 | 6.98 | 6.87 |
| **1999Q3** | 5.25 | 4.89 | 4.69 | 5.51 | 6.46 | 6.31 | 6.21 | 6.82 | 6.98 |
| **1999Q4** | 5.50 | 4.89 | 4.89 | 4.71 | 5.28 | 6.26 | 6.21 | 6.13 | 6.77 |
| **2000Q1** | 6.00 | 5.37 | 5.10 | 4.94 | 4.72 | 5.10 | 6.09 | 6.13 | 6.05 |
| **2000Q2** | 6.00 | 6.07 | 5.79 | 5.45 | 5.02 | 4.70 | 4.96 | 5.93 | 6.05 |
| **2000Q3** | 6.00 | 6.14 | 6.29 | 6.00 | 5.75 | 5.08 | 4.66 | 4.86 | 5.80 |
| **2000Q4** | 6.00 | 5.95 | 6.36 | 6.40 | 6.09 | 5.93 | 5.11 | 4.61 | 4.77 |
| **2001Q1** | 5.75 | 5.65 | 6.08 | 6.44 | 6.43 | 6.13 | 6.02 | 5.13 | 4.56 |
| **2001Q2** | 5.25 | 5.34 | 5.52 | 6.12 | 6.43 | 6.43 | 6.13 | 6.06 | 5.13 |
| **2001Q3** | 5.00 | 4.90 | 5.16 | 5.47 | 6.09 | 6.36 | 6.41 | 6.10 | 6.06 |
| **2001Q4** | 4.00 | 4.66 | 4.89 | 5.14 | 5.46 | 6.03 | 6.26 | 6.38 | 6.05 |
| **2002Q1** | 4.00 | 3.77 | 4.83 | 4.95 | 5.14 | 5.46 | 5.96 | 6.15 | 6.34 |
| **2002Q2** | 4.00 | 4.01 | 3.92 | 5.01 | 5.02 | 5.15 | 5.44 | 5.89 | 6.04 |
| **2002Q3** | 4.00 | 4.17 | 4.41 | 4.14 | 5.12 | 5.08 | 5.14 | 5.42 | 5.82 |
| **2002Q4** | 4.00 | 3.74 | 4.59 | 4.68 | 4.32 | 5.19 | 5.12 | 5.13 | 5.39 |
| **2003Q1** | 3.75 | 3.72 | 3.80 | 4.90 | 4.85 | 4.47 | 5.22 | 5.14 | 5.12 |
| **2003Q2** | 3.75 | 3.38 | 3.68 | 3.98 | 5.12 | 4.97 | 4.59 | 5.24 | 5.15 |
| **2003Q3** | 3.50 | 3.34 | 3.27 | 3.76 | 4.19 | 5.27 | 5.04 | 4.69 | 5.24 |
| **2003Q4** | 3.75 | 3.36 | 3.27 | 3.24 | 3.89 | 4.37 | 5.37 | 5.09 | 4.77 |
| **2004Q1** | 4.00 | 3.96 | 3.60 | 3.28 | 3.29 | 4.02 | 4.52 | 5.44 | 5.12 |
| **2004Q2** | 4.50 | 3.95 | 4.18 | 3.84 | 3.35 | 3.38 | 4.13 | 4.64 | 5.49 |
| **2004Q3** | 4.75 | 4.42 | 4.10 | 4.35 | 4.03 | 3.44 | 3.49 | 4.24 | 4.73 |
| **2004Q4** | 4.75 | 4.80 | 4.68 | 4.19 | 4.49 | 4.18 | 3.54 | 3.60 | 4.33 |

| 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) |
|---|---|---|---|---|---|---|---|---|
| **1992Q4** | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q1** | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q2** | #VALUE! | 0.05 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q3** | #VALUE! | 0.78 | -0.18 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q4** | #VALUE! | -0.10 | 0.14 | -1.06 | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1994Q1** | #VALUE! | 0.13 | -0.77 | -0.41 | -1.60 | #VALUE! | #VALUE! | #VALUE! |
| **1994Q2** | #VALUE! | 0.11 | 0.08 | -1.18 | -0.73 | -1.82 | #VALUE! | #VALUE! |
| **1994Q3** | #VALUE! | 0.98 | 0.58 | 0.37 | -1.01 | -0.53 | -1.49 | #VALUE! |
| **1994Q4** | #VALUE! | 0.89 | 1.31 | 0.95 | 0.60 | -0.78 | -0.31 | -1.15 |
| **1995Q1** | #VALUE! | 0.20 | 0.67 | 1.54 | 1.26 | 0.83 | -0.51 | -0.06 |
| **1995Q2** | #VALUE! | #VALUE! | -0.48 | 0.02 | 1.26 | 1.04 | 0.58 | -0.72 |
| **1995Q3** | #VALUE! | -0.39 | -0.67 | -1.05 | -0.52 | 1.00 | 0.82 | 0.35 |
| **1995Q4** | 0.01 | -0.47 | -1.23 | -1.47 | -1.74 | -1.19 | 0.52 | 0.36 |
| **1996Q1** | #VALUE! | -0.76 | -1.39 | -2.20 | -2.39 | -2.57 | -2.01 | -0.18 |
| **1996Q2** | 0.07 | -0.41 | -1.33 | -1.98 | -2.77 | -2.93 | -3.08 | -2.51 |
| **1996Q3** | #VALUE! | 0.11 | -0.54 | -1.64 | -2.20 | -2.97 | -3.13 | -3.27 |
| **1996Q4** | 0.40 | #VALUE! | 0.16 | -0.50 | -1.63 | -2.09 | -2.85 | -3.00 |
| **1997Q1** | #VALUE! | 0.26 | -0.42 | -0.12 | -0.71 | -1.82 | -2.18 | -2.93 |
| **1997Q2** | #VALUE! | -0.13 | 0.49 | -0.24 | 0.13 | -0.40 | -1.46 | -1.74 |
| **1997Q3** | 0.78 | #VALUE! | 0.12 | 0.66 | -0.01 | 0.40 | -0.06 | -1.06 |
| **1997Q4** | 0.38 | 0.74 | 0.82 | 0.21 | 0.63 | 0.01 | 0.45 | 0.06 |
| **1998Q1** | -0.01 | 0.30 | 0.58 | 0.68 | 0.12 | 0.39 | -0.18 | 0.28 |
| **1998Q2** | 0.50 | 0.28 | 0.51 | 0.74 | 0.84 | 0.31 | 0.46 | -0.08 |
| **1998Q3** | 0.56 | 0.81 | 0.40 | 0.51 | 0.70 | 0.77 | 0.27 | 0.31 |
| **1998Q4** | -0.96 | -0.46 | -0.26 | -0.75 | -0.73 | -0.58 | -0.53 | -1.00 |
| **1999Q1** | -0.60 | -1.46 | -1.03 | -0.89 | -1.43 | -1.48 | -1.35 | -1.32 |
| **1999Q2** | 0.20 | -0.79 | -1.69 | -1.41 | -1.30 | -1.87 | -1.98 | -1.87 |
| **1999Q3** | 0.36 | 0.56 | -0.26 | -1.21 | -1.06 | -0.96 | -1.57 | -1.73 |
| **1999Q4** | 0.61 | 0.61 | 0.79 | 0.22 | -0.76 | -0.71 | -0.63 | -1.27 |
| **2000Q1** | 0.63 | 0.90 | 1.06 | 1.28 | 0.90 | -0.09 | -0.13 | -0.05 |
| **2000Q2** | -0.07 | 0.21 | 0.55 | 0.98 | 1.30 | 1.04 | 0.07 | -0.05 |
| **2000Q3** | -0.14 | -0.29 | 0.00 | 0.25 | 0.92 | 1.34 | 1.14 | 0.20 |
| **2000Q4** | 0.05 | -0.36 | -0.40 | -0.09 | 0.07 | 0.89 | 1.39 | 1.23 |
| **2001Q1** | 0.10 | -0.33 | -0.69 | -0.68 | -0.38 | -0.27 | 0.62 | 1.19 |
| **2001Q2** | -0.09 | -0.27 | -0.87 | -1.18 | -1.18 | -0.88 | -0.81 | 0.12 |
| **2001Q3** | 0.10 | -0.16 | -0.47 | -1.09 | -1.36 | -1.41 | -1.10 | -1.06 |
| **2001Q4** | -0.66 | -0.89 | -1.14 | -1.46 | -2.03 | -2.26 | -2.38 | -2.05 |
| **2002Q1** | 0.23 | -0.83 | -0.95 | -1.14 | -1.46 | -1.96 | -2.15 | -2.34 |
| **2002Q2** | -0.01 | 0.08 | -1.01 | -1.02 | -1.15 | -1.44 | -1.89 | -2.04 |
| **2002Q3** | -0.17 | -0.41 | -0.14 | -1.12 | -1.08 | -1.14 | -1.42 | -1.82 |
| **2002Q4** | 0.26 | -0.59 | -0.68 | -0.32 | -1.19 | -1.12 | -1.13 | -1.39 |
| **2003Q1** | 0.03 | -0.05 | -1.15 | -1.10 | -0.72 | -1.47 | -1.39 | -1.37 |
| **2003Q2** | 0.37 | 0.07 | -0.23 | -1.37 | -1.22 | -0.84 | -1.49 | -1.40 |
| **2003Q3** | 0.16 | 0.23 | -0.26 | -0.69 | -1.77 | -1.54 | -1.19 | -1.74 |
| **2003Q4** | 0.39 | 0.48 | 0.51 | -0.14 | -0.62 | -1.62 | -1.34 | -1.02 |
| **2004Q1** | 0.04 | 0.40 | 0.72 | 0.71 | -0.02 | -0.52 | -1.44 | -1.12 |
| **2004Q2** | 0.55 | 0.32 | 0.66 | 1.15 | 1.12 | 0.37 | -0.14 | -0.99 |
| **2004Q3** | 0.33 | 0.65 | 0.40 | 0.72 | 1.31 | 1.26 | 0.51 | 0.02 |
| **2004Q4** | -0.05 | 0.07 | 0.56 | 0.26 | 0.57 | 1.21 | 1.15 | 0.42 |

## Appendix 2

Regression results of running the following regressions:-

(1) $IR(t + h) = C_1 + C_2$ Forecast (t, t + h)

(2) $IR(t + h) – IR(t) = C_1 + C_2$ (Forecast t, t + h – IRt)

(3) $IR(t + h) – IR(t + h – 1) = C_1 + C_2$ (Forecast, t, t + h – Forecast, t, t + h – 1)

(4) $IR(t + h) – IR(t + h – 1) = C$ (Forecast, t, t + h – Forecast, t, t + h – 1).

The first two equations allow us to undertake the Mincer-Zarnowitz test (WBL ref) of the null hypothesis that $C_1 = 0$ and $C_2 = 1$.

The results were:-

### A. New Zealand

Equation (1)

| h = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 0 | -0.01 (0.96) | 1.00 (0.00) | 0.99 | 1.77 |
| 1 | -0.23 (0.64) | 1.02 (0.00) | 0.88 | 1.53 |
| 2 | 0.30 (0.74) | 0.93 (0.00) | 0.65 | 0.93 |
| 3 | 1.51 (0.24) | 0.74 (0.00) | 0.39 | 0.34 |
| 4 | 3.71 (0.03) | 0.40 (0.12) | 0.11 | 0.28 |
| 5 | 5.71 (0.00) | 0.09 (0.76) | 0.00 | 0.15 |

Mincer-Zarnowitz test

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

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| F-statistics | 0.7245 | 0.4351 | 0.3441 | 0.2153 | 0.0459 | 0.0095 |
| Chi-square | 0.7216 | 0.4229 | 0.3277 | 0.1934 | 0.0285 | 0.0029 |

Equation (2)

| h = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | -0.16 (0.07) | 1.60 (0.00) | 0.34 | 1.61 |
| 2 | -0.15 (0.31) | 1.02 (0.02) | 0.19 | 1.01 |
| 3 | -0.09 (0.66) | 0.72 (0.12) | 0.10 | 0.45 |
| 4 | 0.13 (0.61) | 0.10 (0.84) | 0.00 | 0.47 |
| 5 | 0.37 (0.20) | -0.38 (0.46) | 0.03 | 0.34 |

Mincer-Zarnowitz test

$IR(t + h) – IR(t) = C_1 + C_2 * \text{Forecast}(t, t + h) – IR(t)]$

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| F-statistics | 0.1886 | 0.3878 | 0.4224 | 0.1595 | 0.0327 |
| Chi-square | 0.1679 | 0.3732 | 0.4087 | 0.1356 | 0.0175 |

Equation (3)

| i = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | 0.13 (0.07) | 1.29 (0.00) | 0.43 | 2.06 |
| 2 | 0.04 (0.65) | -0.04 (0.94) | 0.00 | 1.23 |
| 3 | 0.07 (0.37) | -0.68 (0.39) | 0.03 | 1.37 |
| 4 | 0.09 (0.28) | -1.29 (0.22) | 0.07 | 1.37 |
| 5 | 0.09 (0.26) | -1.28 (0.18) | 0.08 | 1.28 |

Equation (4)

| h = | $C_1$ (P value) | R sq | DW |
|---|---|---|---|
| 1 | 0.93 (0.00) | 0.35 | 1.66 |
| 2 | 0.11 (0.79) | -0.01 | 1.26 |
| 3 | -0.31 (0.64) | -0.00 | 1.27 |
| 4 | -0.77 (0.41) | 0.02 | 1.25 |
| 5 | -0.92 (0.31) | 0.02 | 1.19 |

## B. UK Forecasts derived from the Short-term Government Yield Curve

Table 1

| h = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | 0.37 (0.22) | 0.95 (0.00) | 0.91 | 1.61 |
| 2 | 0.77 (0.06) | 0.86 (0.00) | 0.77 | 0.88 |
| 3 | 1.21 (0.02) | 0.76 (0.00) | 0.62 | 0.55 |
| 4 | 1.82 (0.01) | 0.63 (0.00) | 0.45 | 0.40 |

| | | | | |
|---|---|---|---|---|
| 5 | 2.39<br>(0.00) | 0.52<br>(0.00) | 0.32 | 0.32 |
| 6 | 2.68<br>(0.00) | 0.46<br>(0.00) | 0.26 | 0.31 |
| 7 | 2.51<br>(0.00) | 0.48<br>(0.00) | 0.27 | 0.30 |
| 8 | 2.04<br>(0.02) | 0.54<br>(0.00) | 0.33 | 0.32 |

Mincer-Zarnowitz test

$IR(t + h) = C_1 + C_2 * Forecast(t, t + h)$

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| F-statistics | 0.1130 | 0.1727 | 0.0133 | 0.0002 | 0.0000 | 0.0000 | 0.000 | 0.000 |
| Chi-square | 0.0962 | 0.1601 | 0.0085 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.000 |

Table 2

| h = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | 0.08 (0.39) | 0.73 (0.03) | 0.14 | 1.52 |
| 2 | 0.01 (0.91) | 0.90 (0.00) | 0.34 | 0.95 |
| 3 | -0.15 (0.18) | 0.88 (0.00) | 0.34 | 0.63 |
| 4 | -0.31 (0.04) | 0.73 (0.00) | 0.26 | 0.48 |
| 5 | -0.39 (0.03) | 0.58 (0.00) | 0.19 | 0.41 |
| 6 | -0.45 (0.02) | 0.48 (0.01) | 0.15 | 0.39 |
| 7 | -0.53 (0.01) | 0.48 (0.00) | 0.18 | 0.38 |
| 8 | -0.64 (0.00) | 0.51 (0.00) | 0.26 | 0.41 |

Mincer-Zarnowitz test

$IR(t + h) – IR(t) = C_1 + C_2* [Forecast (t, t + h) – IR(t)]$

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| F-statistics | 0.1120 | .08374 | 0.3063 | 0.0190 | 0.0014 | 0.0001 | 0.0000 | 0.0000 |
| Chi-square | 0.0953 | 0.8368 | 0.2965 | 0.0129 | 0.0004 | 0.0000 | 0.0000 | 0.0000 |

Table 3

| i = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | 0.08 (0.39) | 0.73 (0.03) | 0.14 | 1.51 |
| 2 | -0.14 (0.04) | 0.84 (0.01) | 0.19 | 1.52 |
| 3 | -0.10 (0.16) | 0.46 (0.10) | 0.06 | 1.12 |
| 4 | -0.07 (0.38) | 0.24 (0.42) | 0.02 | 1.01 |
| 5 | -0.08 (0.30) | 0.46 (0.21) | 0.03 | 1.05 |
| 6 | -0.07 (0.32) | 0.61 (0.15) | 0.05 | 1.05 |
| 7 | -0.05 (0.47) | 0.53 (0.30) | 0.03 | 1.03 |
| 8 | -0.05 (0.45) | 0.52 (0.38) | 0.02 | 1.00 |

Table 4

| h = | C (P value) | R sq | DW |
|---|---|---|---|
| 1 | 0.54 (0.03) | 0.12 | 1.39 |
| 2 | 0.63 (0.05) | 0.07 | 1.29 |
| 3 | 0.23 (0.32) | 0.01 | 1.05 |
| 4 | 0.07 (0.75) | -0.00 | 0.98 |
| 5 | 0.23 (0.42) | 0.01 | 1.02 |
| 6 | 0.36 (0.30) | 0.02 | 1.02 |
| 7 | 0.34 (0.44) | 0.01 | 1.00 |
| 8 | 0.31 (0.54) | 0.01 | 0.99 |

<u>C. UK Forecasts derived from the Libor Yield Curve</u>

Table 1

| h = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | 0.82 (0.08) | 0.82 (0.00) | 0.71 | 0.75 |
| 2 | 1.19 (0.03) | 0.75 (0.00) | 0.60 | 0.52 |
| 3 | 1.81 (0.01) | 0.63 (0.00) | 0.42 | 0.46 |
| 4 | 2.35 (0.01) | 0.52 (0.00) | 0.28 | 0.37 |
| 5 | 2.74 (0.00) | 0.44 (0.00) | 0.20 | 0.30 |
| 6 | 2.93 (0.00) | 0.40 (0.01) | 0.16 | 0.33 |
| 7 | 2.34 (0.02) | 0.48 (0.00) | 0.21 | 0.33 |
| 8 | 1.18 (0.25) | 0.64 (0.00) | 0.33 | 0.33 |

Mincer-Zarnowitz test

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

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| F-statistics | 0.0168 | 0.0027 | 0.0003 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chi-square | 0.0115 | 0.001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Table 2

| h = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | -0.07 (0.35) | 0.20 (0.24) | 0.03 | 1.49 |
| 2 | -0.12 (0.25) | 0.33 (0.08) | 0.07 | 0.73 |
| 3 | -0.16 (0.28) | 0.27 (0.18) | 0.04 | 0.61 |
| 4 | -0.21 (0.25) | 0.27 (0.20) | 0.04 | 0.50 |
| 5 | -0.30 (0.16) | 0.29 (0.15) | 0.05 | 0.47 |
| 6 | -0.39 (0.10) | 0.30 (0.13) | 0.05 | 0.43 |
| 7 | -0.62 (0.01) | 0.45 (0.02) | 0.14 | 0.45 |
| 8 | -0.91 (0.00) | 0.63 (0.00) | 0.29 | 0.39 |

Mincer-Zarnowitz test

$IR(t + h) – IR(t) = C_1 + C_2 * [Forecast (t, t + h) – IR(t)]$

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| F-statistics | 0.0000 | 0.0003 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Chi-square | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Table 3

| h = | $C_1$ (P value) | $C_2$ (P value) | R sq | DW |
|---|---|---|---|---|
| 1 | -0.07 (0.35) | 0.20 (0.23) | 0.03 | 1.49 |
| 2 | -0.03 (0.65) | 0.30 (0.24) | 0.03 | 2.03 |
| 3 | -0.05 (0.52) | 0.37 (0.34) | 0.02 | 2.04 |
| 4 | -0.0 (0.31) | 0.56 (0.19) | 0.04 | 2.06 |
| 5 | -0.05 (0.60) | 0.27 (0.60) | 0.01 | 2.01 |
| 6 | -0.03 (0.79) | 0.06 (0.91) | 0.00 | 2.00 |
| 7 | -0.03 (0.79) | 0.04 (0.95) | 0.00 | 2.00 |
| 8 | -0.03 (0.74) | 0.00 (1.00) | 0.00 | 2.01 |

Table 4

| h = | C (P value) | R sq | DW |
|---|---|---|---|
| 1 | 0.16 (0.33) | 0.01 | 1.51 |
| 2 | 0.27 (0.27) | 0.03 | 2.02 |
| 3 | 0.23 (0.47) | 0.01 | 2.01 |
| 4 | 0.26 (0.40) | 0.02 | 2.01 |
| 5 | 0.09 (0.78) | 0.00 | 1.99 |
| 6 | -0.04 (0.92) | -0.00 | 1.99 |
| 7 | -0.08 (0.87) | -0.00 | 1.99 |
| 8 | -0.14 (0.80) | -0.00 | 2.01 |

# Do Errors in Forecasting Inflation Lead to Errors in Forecasting Interest Rates?

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Abstract

In the first of three related, and consecutive, papers we showed that forecasts for short-term policy interest rates in NZ and UK deteriorated over the first six months to a point when they became useless, after the first two quarters. Moreover they were ex post biased, underestimating future interest rates during upturns and the reverse during downturns.

Both NZ and UK have been inflation targeters during our data period. In this second paper we ask, first whether inflation forecasts exhibit the same syndrome as the related interest rate forecasts, and whether errors in the inflation forecast may help to explain errors in the interest rate forecast. We find that the pattern of inflation forecast errors is qualitatively much the same as those for interest rates, but that the inflation forecasts are quantitatively better, both in terms of prediction error and of bias. The evidence on the relationship between inflation forecast errors and interest rate forecast errors is mixed. Over the whole time period, both in NZ and UK, there is no such relationship. But if one should strip out certain short periods, when domestic interest rates appear to have been affected by external factors, then there does seem to be such a relationship, with under (over) estimates of future inflation associated with under (over) estimates of future policy interest rates.

## Introduction

In the first of our trilogy of three papers on forecasting short-term policy-determined interest rates in New Zealand (NZ), and in the United Kingdom (UK), entitled 'Interest Rate Forecasts: A Pathology', we demonstrated that such forecasts were not only without informational content beyond two quarters hence, but that such forecasts were, ex post, biased in that such forecasts systematically underestimated interest rates during cyclical upswings in such rates, and overestimated them during downswings. In the third paper we shall see whether we can explain this ex post bias, and test whether the forecasts, despite being ex post biased, are nevertheless ex ante efficient.

In this second paper we take a slightly different tack. Both the NZ and UK Central Banks (CBs) are leading exponents of inflation targeting (IT). If inflation at the key future horizon is forecast to be above (below) target, the CB is supposed, under the Taylor principle, to raise (lower) interest rates. Thus for IT countries it would seem a reasonable hypothesis that errors in forecasting inflation should be a prime causative factor in leading to errors in forecasting interest rates.

Most prior work on the poor record of interest rate forecasts has been done for the USA, which is not an IT country. So the above hypothesis has not, to our knowledge, been previously tested, either for the USA or for any other country. Instead, the leading economist in this line of study, Glenn Rudebusch (2002 and 2006) has argued that the co-existence of the apparent slow adjustment of policy rates alongside predictive failure could be due to "various persistent factors – credit crunches, financial crises, etc., that a central bank might respond to, [and which] could be modelled as a simple first-order autoregressive process", (2006), p. 102. In his Figure 5, p. 98, (ibid) he shows how the differences between the derived desired value of a non-inertial and an inertial rule match up quite well with a number of events, besides output and inflation, to which the Fed may have reacted.

Here we take a somewhat different line of attack. Since, during these years the Central Banks in both our countries, UK and NZ, were following an Inflation Target, one possibility is that these inflation forecasts were similarly systematically (ex post) biased as we have already shown the interest forecasts to have been. So in Section 2 we apply the same tests for bias and systematic error to the inflation forecasts for NZ and for the UK that we applied in our first paper to the interest rate forecasts.

The results are not quite as stark, but do show a similar syndrome. Beyond the first quarter's (good) forecast, the tendency is for the forecast to under (over) estimate inflation during up (down) cycles of inflation. The timing of the cycles is less clearly marked than for interest rates. We do, however, have an advantage in the guise of a much longer time series, with data on UK CPI forecasts going back to 1970. This enables us to examine and compare forecasting ability in earlier decades, when inflation was much more volatile, with the present more stable period.

Our next step, in Section 3, is to see how far the (systematic) errors in predicting inflation can help to predict the (auto-correlated and inertial) errors in predicting interest rates. With inflation having been relatively stable, around its target value, during recent years, an expectation that inflation forecast errors would predict interest rate forecast errors might seem far-fetched and unlikely. And so it initially transpired. Running regressions over the full available data period, for both NZ and UK, gave no significant relationship.

However, a closer inspection of the data period showed that, both for NZ and for the UK, there were brief periods when the hypothesis, that errors in the inflation forecast would drive, similarly signed, errors in the interest rate forecast, was reversed. Thus in New Zealand in 2000/1 and in the UK in 2003/4, inflation was under-forecast (i.e. actual greater than predicted), but interest rates came out lower than earlier forecast. We tentatively attribute both occasions mainly to external pressures. When these (relatively few) observations are excluded a significant relationship between inflation forecast errors and interest rate prediction errors then does emerge.

We looked at the data to eliminate those periods when our hypothesis did not hold. This is data mining. Moreover, our residual period, both for NZ and UK, is short. So, the claim that systematic errors in forecasting inflation are responsible, some of the time, for the gradual, inertial adjustment of policy rates, and for some part of the systematic errors in forecasting interest rates does need support from further research before it may be accepted as a 'stylized fact'. Where we do feel more confident is in supporting Rudebusch's thesis that both the errors in forecasting policy interest rates and their slow inertial adjustment do not have a single cause; there is no mono-causal explanation. Instead, there are likely to be several such causes. We claim, on the basis of this research, that somewhat persistent, auto-correlated errors in predicting future inflation should be included in this set of potential causal factors.

That leads us into our Conclusion, Section 4, where we explore the implications of this work for future research, for the interpretation of past history, and for other public policy issues.

## II. Errors in Inflation Forecasts

The primary objective of most Central Banks, certainly of those with Inflation Targets, is to achieve price stability, usually defined as a low (around 2%) and stable rate of inflation. Owing to the long and variable lags in the transmission mechanism between monetary policy measures and their effect, first on output and then on inflation, policy is actually set on the basis of forecast, not current, levels of inflation.

So if forecasts of interest rates are poor, biased and inefficient, it makes sense to enquire whether this may be because the accompanying forecasts for inflation are similarly poor, biased and inefficient. Accordingly in this Section we put our forecast series for inflation through exactly the same battery of tests to which we put the interest rate forecasts.

For both UK and NZ there are several alternative inflation series. The inflation target for the UK's Monetary Policy Committee (MPC) was defined in terms of RPIX, but this series only began at the end of 1992. We use this when we compare the MPC's constant interest rate assumption errors with its RPIX inflation forecast errors. But market views of inflation may have been based on other series. We have access to a long series of CPI data, and forecasts of future CPI, thanks to the National Institute of Economic and Social Research, which provided us with these forecast data. Both because we have a much longer consistent data series for CPI forecasts, partly because it is comparable with the NZ measure, and partly because it is a justifiable measure of general inflation, we use the CPI data in our main exercises with the forecasts for interest rates derived from the government debt series, as discussed at more length in our first paper. Again we exhibit the CPI series for inflation, inflation forecasts and errors in that forecast in the same format for the shorter period, (1992 Q4 until 2004 Q4), in which we can overlap it with the forecasts and errors in the forecasts of interest rates from the government debt series, in Appendix 1. Similar data for the full available CPI data period, going back until 1970 Q1, and for the RPIX forecast data (1993 – 2004) are available from the authors on request.

The inflation forecasts, both for NZ and UK, are not quarter on quarter, but over the previous year, $Q_t – Q_{t-4}/Q_{t-4}$. There is no alternative, since that is the way that the forecasts were constructed. Moreover, given the extent of noise in individual quarters, e.g. from indirect tax changes, weather and seasonal foods, etc., some such averaging process may be beneficial. However it does mean that forecasts for the level of inflation in the current and next few quarters are only partially forecast, thus forecasts for inflation in the current quarter (h = 0) contain 3 ⅔, out of 4, known observations, for the next quarter (h = 1) 2 ⅔, for h = 2, 1 ⅔, and for h = 3, ⅔. That is bound to make such forecasts relatively more accurate. That problem can be met either by focussing on forecasts for the change in inflation, or by ignoring all forecasts of inflation levels until h = 2 or 3, or just by applying a discount to apparent measures of early forecast accuracy.

Similarly the use of annualised forecasts means that adjacent forecasts (and forecast errors) will be auto-correlated, since the forecast for h = i and h = i + 1 will share three common quarters. In so far as our forecasts go out to two years hence, h = 8, both problems can be largely met by focussing primarily on the forecasts for h = 4 and h = 8 (or h = 7, when there are no forecasts available for h = 8).

This problem did not, however, arise for the interest rate forecasts, where the forecast is for the future short-term policy rate ruling in that quarter.

In our tests for forecasting accuracy we run four regressions both for the NZ and UK data series, as we did for interest rates in our first paper. These regression equations were:-

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

(2) $\text{Inf}(t + h) - \text{Inf}(t) = C_1 + C_2\ (\text{Forecast}\ t, t + h - \text{Inf}\ t)$

(3) $\text{Inf}(t + h) - \text{Inf}(t + h - 1) = C_1 + C_2\ (\text{Forecast}, t, t + h - \text{Forecast}, t, t + h - 1)$

(4) $\text{Inf}(t + h) - \text{Inf}(t + h - 1) = C\ (\text{Forecast}, t, t + h - \text{Forecast}, t, t + h - 1)$.

Where: Forecast (t,t+h) = forecast of Inf( t+h) made at time, t

Inf(t) = actual inflation rate outurn 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 inflation rate outturn (h = 0 to n). If the forecast perfectly matches the actual inflation 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 expectation 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{[Forecast(t,t+h)]} for all t, if and only if $C_2 = 1$, and $C_1 = 0$. The second regression, by subtracting the inflation rate level from both sides, allows us to focus our attention on the performance of the forecast inflation rate difference {Inf(t + h) – Inf(t)}. It asks, as h increases, how accurately can the forecaster forecast h-quarter ahead inflation rate changes from the present level. The third regression is a slight twist on the second, focussing on one-period ahead forecasts; the regression examines the forecast performance of one-period ahead inflation rate changes {Inf(t + h) – Inf(t + h – 1)}, as h increases. The fourth equation just repeats equation 3, but drops the constant term.

All four regressions assess the accuracy/biasness of inflation rate forecasts from slightly different angles. In the first three equations, an unbiased forecast will necessarily implies a constant term of zero, and a slope coefficient of one. In all four equations the coefficient $C_2$ should be unity. We can test whether these conditions are fulfilled with a joint hypothesis test:

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

With four equations, two data sets, and h = 0 to 8 for both NZ and UK series, we have some 64 regression results and statistical test scores to report. Rather than asking the reader to plough through them all, we collect these together in Appendix 2. Interpretation of regression results is somewhat subjective. We give our interpretation of them here; the sceptical reader is invited to examine Appendix 2 and make his/her own assessment.

Let us start with NZ. The NZ data period for this sample covered 45 observations from 1995 Q4 until 2006 Q3. We also ran the same regressions over the shorter sample, 2000 Q1 – 2006 Q3, of 27 observations, that overlapped with the period for which we had data on the RBNZ interest rate forecast. The results of these latter regressions were generally quite similar to, but slightly worse than, those above. These latter regressions are available from the author(s) on request, but in the interests of conserving space are not included in Appendix 2.

These results show that the RBNZ was <u>much</u> better at forecasting inflation than at forecasting its own interest rate. Looking at the results of equations 3 and 4 in Appendix 2, it can be seen that the RBNZ did an excellent job of forecasting the quarterly <u>change</u> in inflation rates, a difficult task, up to <u>four quarters hence</u>. It is only in the second year that the forecast, of the change in inflation, is not superior to a random walk, (whereas with interest rates this predictive failure came as soon as the second quarter ahead). Given such excellent initial results using the first differences of forecasts, the forecasts in level format (Equations 1 and 2), naturally also behaved well, especially Equation 2. In Equation 2, the coefficient C2 remains very close to unity throughout, and the R squared values remain high, whereas in Equation 1, the C2 coefficient declines steadily, as does the R square.[1] Overall, and unlike the NZ interest rate forecast, the predictive ability of those forecasting inflation in the RBNZ should be described as good, perhaps excellent. A graphical illustration of the results of Equation 1 is given in Appendix 4, for Q1, Q4 and Q8.

We turn next to the UK inflation forecasts, for the CPI, taken from the NIESR. We start with the whole period sample, of 148 observations from 1970 Q1 until 2006 Q4.

---

[1] The sharp-eyed will note that the results for Equation 2, in difference format, are often better than those for Equation 1 in level format. This may be because a common variable is inserted on both sides of the equation.

The results for the UK inflation forecast (whole period) are again much better than the (separately and differently obtained) interest rate forecasts, but considerably worse than the NZ inflation forecasts. Focussing on the first difference regressions (Equations 3 and 4), the forecasts get the direction of change correct, but underestimate the scale of change progressively over the four quarters of the first year. Then in the second year, the results are no better than a random walk forecast. Given the relatively successful first difference forecasts up to four quarters ahead, the level forecasts are again good over the whole time frame, though in this case the much better results are for Equation 1 rather than Equation 2. A graphical illustration of the results of Equation 1 is given in Appendix 3, for Q1 and Q4.

The period 1970-2006 is long; it includes the disturbed and high inflation 1970s, the downwards trending but cyclical 1980s, and the stable, low inflation period since 1992. One can think of off-setting reasons why it might have been either more difficult or easier to forecast inflation in the latter stable period than in the earlier more disturbed period. In any case we wanted to compare the errors made in forecasting inflation with those made in forecasting interest rates. Since we had the latter forecasts over a sample of 48 periods, from 1992 Q4 until 2004 Q3, we re-ran the above regressions over this shorter sample as well.

The predictive ability of the NIESR inflation forecasts, according to these tests, has become significantly worse during the last 12 years of approximate price stability than it was in the earlier years of large fluctuations in inflation. One can appreciate that the latter could well have been much easier to forecast. Anyhow, on the basis of the difference forecasts, equations 3 and 4, the forecasters are, over this recent shorter period, unable even to forecast the direction of change in inflation beyond a 2 quarter horizon. As a result, the forecast in terms of levels, Equations 1 and 2 are relatively poor, especially Equation 2 where the forecasters cannot explain more than about 25% of the change in the level of inflation (from its present level) at any horizon from 1 to 7. In this respect the ability of the NIESR to forecast future inflation over the recent stable period has only been slightly better than the ability of the market to forecast UK short-term policy rates. Their record has also been worse than that of the RBNZ forecasters in NZ, perhaps because fluctuations in inflation there have been larger, and thus more easily predictable. Thus in NZ (1995 Q4 – 2006 Q4) the standard deviation of (CPI) inflation around its mean was 1.06% and the series had 8 turning points; while over a similar period (1992 Q4 – 2006 Q4) the standard deviation in the UK was less, at 0.77%, with more turning points, 11 in all.

Nevertheless, once again, as with the interest rate forecasts, there is a tendency for the inflation forecast to be rather more static than the ex post actuals. In Figures 1, 2 and 3, we show a comparison of the four quarter ahead inflation forecast with the ex post actual for both NZ and UK, the latter for both the whole period and the shorter period that overlaps with our interest rate forecast sample period.

Figure 1
NZ inflation forecast (1995-2006)

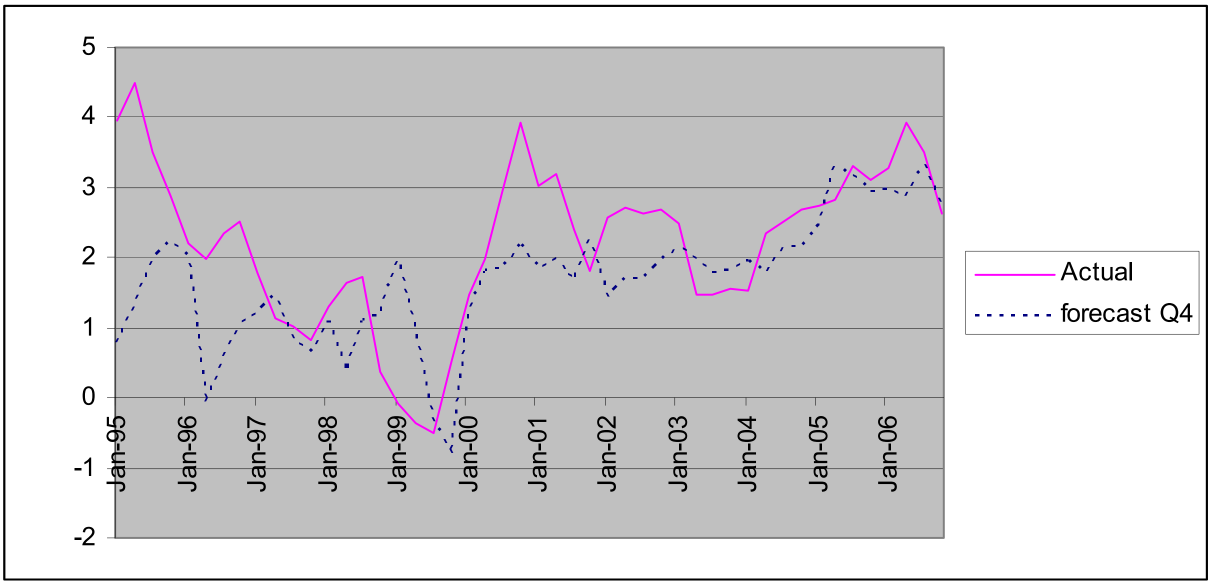



Figure 2
UK Π forecast (whole period)
UK Inflation Forecast (whole period)

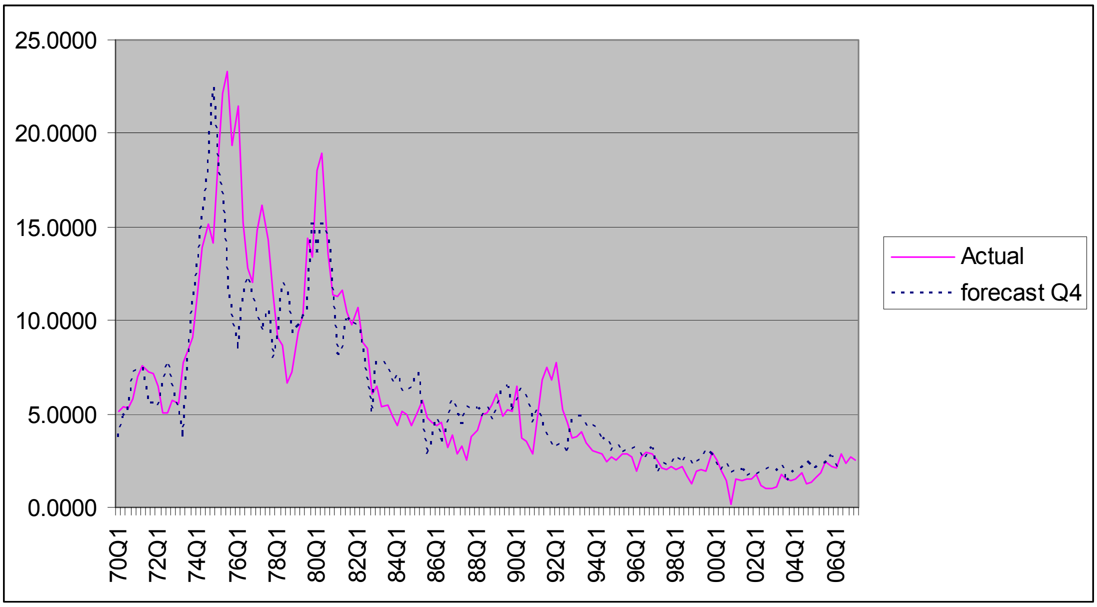
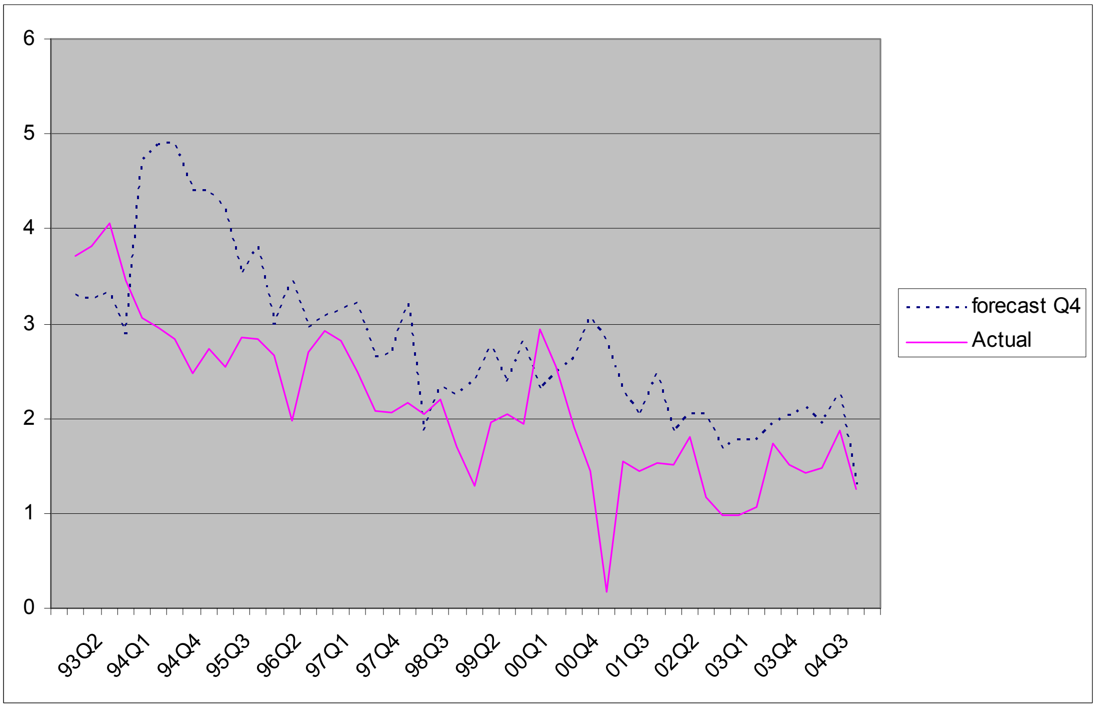


Figure 3
UK inflation forecast comparison (overlapping period)




The fact that the inflation forecasts appeared to have been better, in the light of our regression exercises, than those of interest rate forecasts, particularly in the NZ case (less so in the UK case, especially when using the shorter overlapping period), does not, however, necessarily mean that they are also unbiased and fully efficient. In this sub-section we apply the same tests that we ran for interest rates, to explore whether there are signs of systemic bias during periods in which the inflation rate is on an upwards path, as compared with when it is on a downwards path.

Choosing periods of upwards, and downwards, movements in inflation is, however, more complicated than in the case of interest rates, especially during the recent period of stable inflation. There were, during these years of the Great Moderation, certain short periods which we could not allocate to 'up', or 'down', phases with any confidence. Figures 4, 5 and 6 show the actual, ex post, inflation data for NZ, over the period 1995 Q4 to 2006 Q3, for the UK over the period 1970 Q1 to 2006 Q4, and also for the UK over the shorter, overlapping period, 1992 Q4 until 2004 Q3. In these figures the chosen turning points and flat periods are marked.

Figure 4

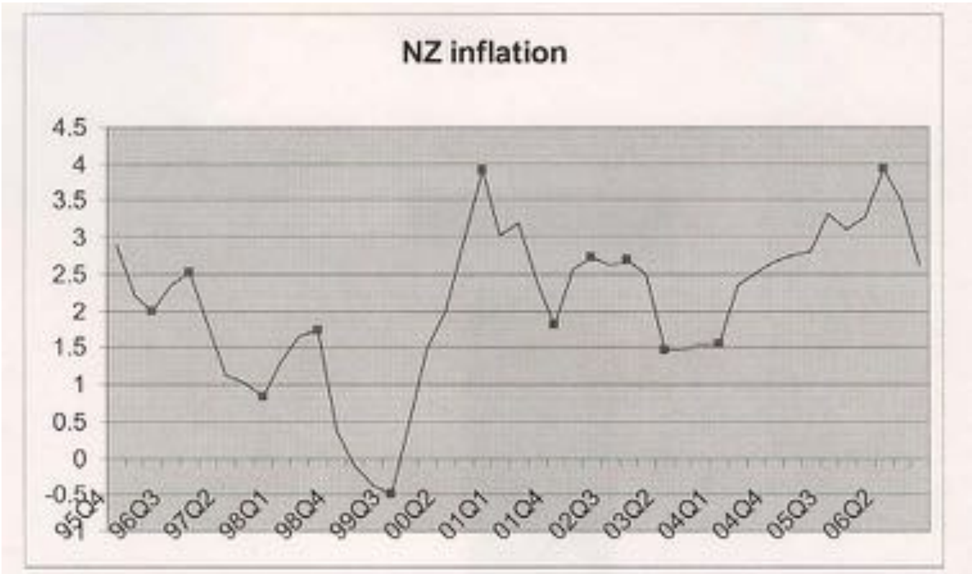



Figure 5
<u>UK inflation: Whole period</u>

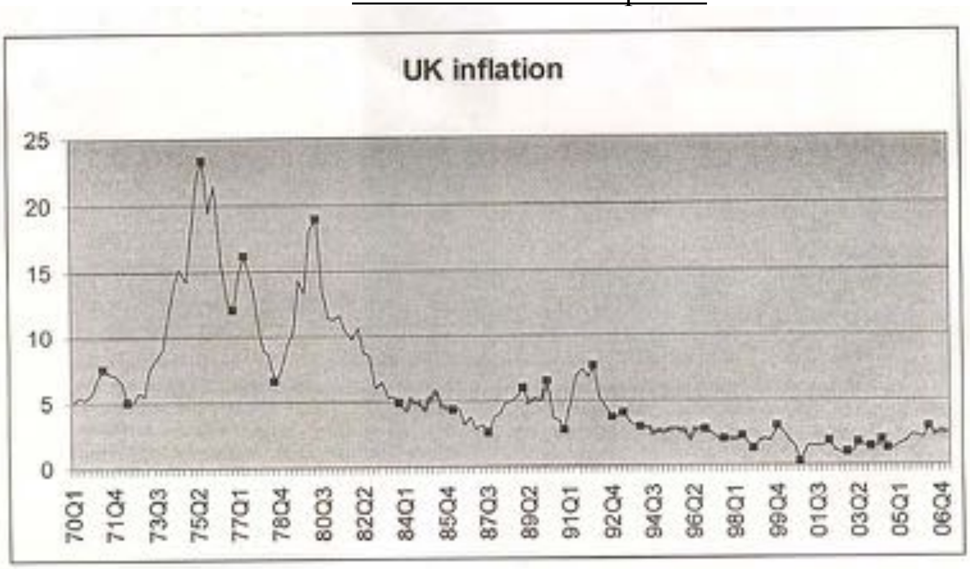
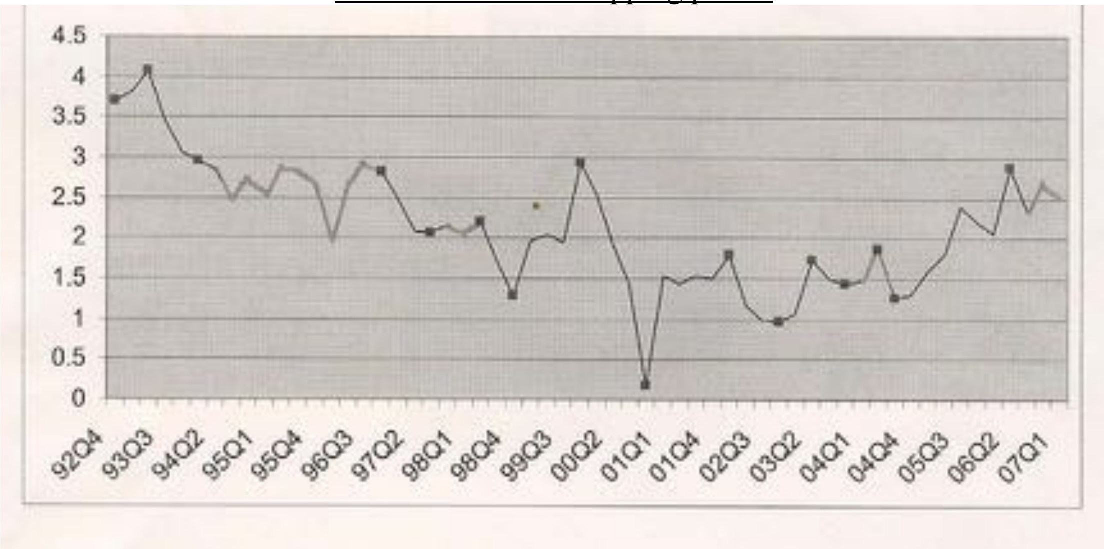
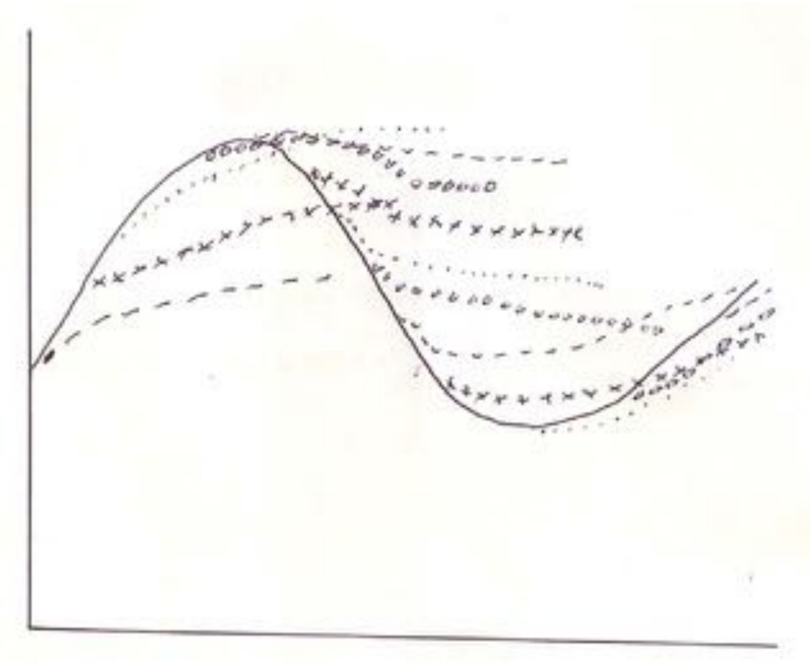


Figure 6
UK inflation: Overlapping period




We can explore this tendency towards cyclical bias more carefully by examining the sign and scale of errors in forecasts undertaken during periods when inflation is rising (up periods) or falling (down periods). These forecasts are generally made out to an 8 quarter horizon. Frequently the cycle will change before the full 8 quarters are finished. For the reasons described in our first paper, we distinguish between forecasts initially made during an up (down) period which at the out-turn date are still in the same cyclical up (down) phase, and those where the sign of the cycle has changed (once again, we ignore observations with two sign changes). We expect the bias to be greater when the forecasts remain within the same initial cycle phase. A diagram may again make this easier to understand. Assume that forecasts all are subject to mean reversion; then the errors will be more mixed in sign/scale after a cyclical sign change.

Figure 7



This leaves the question of how to handle flat periods. If there is no clear cyclical reversal, then the mean reversion of forecasts should make the systematic bias continue. So, we treated a flat period following an up (down) period as being essentially a continuation of the up (down) period. We have, however, shown the up/flat and down/flat periods separately in the tables below.

We turn first to New Zealand. The relevant table, of exactly the same format as described in our first paper, for the whole period, of 45 actual observations and 134 forecast quarters, is shown below. The table for the shorter overlapping period of observations is again left out for reasons of space, since it is so similar to that for the longer period, but it is available from the author(s) on request. Given that the inflation forecasts in NZ are good, as already reported, one might expect any residual bias to be less than for interest rate forecasts, and this is what Table 1 indicates. The signs of up errors, and up/flat errors, (both before and after the first sign change) tend to be more often positive than negative, and vice versa for down, and down/flat errors, but the results are no longer as overwhelming in numbers, nor as statistically significant, as in the case of the NZ interest rate forecast.  Thus there are some slight signs of bias, but these are mild and somewhat tentative.

Table 1

**NZ Inflation**

Initial sign: Up

**Up error till first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 21 | 10 | 11 | -0.0571 | 0.3514 | 0.4761 |
| 16 | 6 | 10 | 0.0720 | 0.5099 | 0.5927 |
| 11 | 6 | 5 | 0.1450 | 0.7035 | 0.5293 |
| 8 | 6 | 2 | 0.3028 | 0.6503 | 0.2577 |
| 6 | 5 | 1 | 0.4933 | 0.7851 | 0.2190 |
| 4 | 4 | 0 | 0.3282 | 0.4307 | 0.2785 |
| 3 | 3 | 0 | 0.4303 | 0.4937 | 0.3429 |
| 2 | 2 | 0 | 0.7453 | 0.4085 | 0.3192 |
| 1 | 1 | 0 | 1.4166 | | |
| 72 | 43 | 29 | 0.2016 | 0.5885 | 0.0052 |

**Up/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 2 | 1 | 1 | 0.0030 | 0.1286 | 0.9850 |
| 2 | 1 | 1 | -0.1374 | 0.2029 | 0.6210 |
| 2 | 0 | 2 | -0.1433 | 0.1663 | 0.5473 |
| 1 | 1 | 0 | 0.0034 | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 7 | 3 | 4 | -0.0788 | 0.1418 | 0.2222 |

Initial sign: Down

**Down error till first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 19 | 5 | 14 | -0.1328 | 0.1754 | 0.0048 |
| 13 | 4 | 9 | -0.1926 | 0.5186 | 0.2226 |
| 7 | 4 | 3 | 0.1655 | 0.5150 | 0.4611 |
| 4 | 2 | 1 | 0.2514 | 0.4019 | 0.3580 |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 43 | 15 | 27 | -0.1258 | 0.3881 | 0.0417 |

**Down/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 3 | 1 | 2 | -0.0907 | 0.3951 | 0.7763 |
| 3 | 1 | 2 | -0.1212 | 0.3421 | 0.6661 |
| 3 | 0 | 3 | -0.2422 | 0.1897 | 0.2127 |
| 2 | 0 | 2 | -0.1374 | 0.0293 | 0.1337 |
| 1 | 0 | 1 | -0.4012 | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 12 | 2 | 10 | -0.1699 | 0.2552 | 0.0494 |

After first sign change

**Down error after first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 5 | 1 | 4 | -0.2250 | 0.3321 | 0.2469 |
| 10 | 3 | 7 | -0.2670 | 0.5893 | 0.2071 |
| 12 | 5 | 7 | -0.1454 | 0.7633 | 0.5404 |
| 13 | 7 | 6 | -0.0370 | 0.9166 | 0.8911 |
| 10 | 6 | 4 | 0.0536 | 0.9711 | 0.8722 |
| 6 | 3 | 3 | 0.1873 | 0.9217 | 0.6686 |
| 4 | 3 | 1 | 0.2739 | 0.5140 | 0.4241 |
| 3 | 2 | 1 | 0.2584 | 0.4439 | 0.4970 |
| 63 | 30 | 33 | 0.2050 | 0.6139 | 0.0108 |

**Down/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 1 | 0 | 1 | -0.3424 | | |
| 2 | 0 | 2 | -0.2894 | 0.0255 | 0.0559 |
| 3 | 0 | 3 | -0.3643 | 0.2037 | 0.1272 |
| 3 | 0 | 3 | -0.3380 | 0.1295 | 0.0662 |
| 2 | 0 | 2 | -0.4267 | 0.2172 | 0.2998 |
| 1 | 0 | 1 | -0.3405 | | |
| 12 | 0 | 12 | -0.3518 | 0.1295 | 0.0000 |

After first sign change

**Up error after first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 5 | 0 | 5 | -0.2806 | 0.3466 | 0.1808 |
| 10 | 5 | 5 | 0.0170 | 0.4398 | 0.9103 |
| 13 | 8 | 5 | 0.3385 | 0.4937 | 0.0351 |
| 14 | 14 | 0 | 0.7426 | 0.4665 | 0.0001 |
| 12 | 12 | 0 | 1.0251 | 0.7504 | 0.0009 |
| 9 | 9 | 0 | 1.0272 | 0.8451 | 0.0089 |
| 7 | 7 | 0 | 0.9930 | 1.0722 | 0.0638 |
| 6 | 6 | 0 | 0.8933 | 0.9983 | 0.1018 |
| 76 | 61 | 15 | 0.6161 | 0.7966 | 0.0000 |

**Up/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 1 | 1 | 0 | 0.4411 | | |
| 2 | 2 | 0 | 0.8431 | 0.1288 | 0.0965 |
| 2 | 2 | 0 | 1.1700 | 0.0837 | 0.0454 |
| 2 | 2 | 0 | 1.4811 | 0.4133 | 0.1733 |
| 1 | 1 | 0 | 1.6420 | | |
| 0 | 0 | 0 | | | |
| 8 | 8 | 0 | 1.1340 | 0.4384 | 0.0002 |

Again we also provide a simpler demonstration of the same syndrome, using the following regression equation:-

Infl Forecast Error = C1 + C2 + C3 + C4 + u

where:-

C1 = a constant taking the value 1 in up periods;

C2 = a constant taking the value 1 in both up and succeeding flat periods;

C3 = a constant taking the value 1 in down periods;

C4 = a constant taking the value 1 in both down and succeeding flat periods;

u = a residual.

The results are shown in Table 2

Table 2

(A) Indicator variable is based on state at out-turn (whole data set)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | -0.01 | 0.91 | -0.14 | 0.68 | -0.20 | 0.08 | -0.12 | 0.66 |
| Q2 | -0.04 | 0.08 | 0.50 | -0.14 | 0.72 | -0.09 | 0.52 | -0.24 | 0.46 |
| Q3 | 0.05 | 0.32 | 0.02 | 0.22 | 0.60 | -0.06 | 0.67 | -0.21 | 0.55 |
| Q4 | 0.22 | 0.67 | 0.00 | 0.84 | 0.09 | -0.07 | 0.69 | -0.33 | 0.41 |
| Q5 | 0.25 | 0.83 | 0.00 | 1.17 | 0.03 | 0.02 | 0.91 | -0.36 | 0.40 |
| Q6 | 0.24 | 0.85 | 0.00 | 1.48 | 0.01 | 0.07 | 0.72 | -0.34 | 0.45 |
| Q7 | 0.20 | 0.87 | 0.00 | 1.37 | 0.03 | 0.02 | 0.92 | -0.24 | 0.63 |
| Q8 | 0.12 | 0.86 | 0.00 | 1.14 | 0.09 | 0.05 | 0.84 | -0.05 | 0.93 |

(B) Indicator variable is based on state at out-turn,
but only includes periods during which sign is unchanged

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | -0.01 | 0.91 | -0.14 | 0.68 | -0.20 | 0.08 | -0.12 | 0.66 |
| Q2 | -0.05 | 0.08 | 0.58 | -0.14 | 0.73 | -0.13 | 0.44 | -0.24 | 0.47 |
| Q3 | -0.06 | 0.22 | 0.15 | 0.22 | 0.53 | 0.09 | 0.65 | -0.21 | 0.48 |
| Q4 | 0.16 | 0.55 | 0.03 | 0.75 | 0.24 | -0.13 | 0.71 | -0.34 | 0.45 |
| Q5 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Q6 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Q7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Q8 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

(C) Indicator variable is based on state at forecast date (whole data set)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | -0.01 | 0.91 | -0.14 | 0.68 | -0.20 | 0.08 | -0.12 | 0.66 |
| Q2 | -0.05 | 0.05 | 0.70 | 0.01 | 0.97 | -0.11 | 0.41 | 0.05 | 0.88 |
| Q3 | -0.04 | 0.09 | 0.53 | -0.25 | 0.58 | 0.24 | 0.13 | 0.17 | 0.64 |
| Q4 | 0.00 | 0.22 | 0.21 | -0.41 | 0.46 | 0.50 | 0.01 | 0.48 | 0.29 |
| Q5 | 0.07 | 0.21 | 0.28 | -0.28 | 0.64 | 0.78 | 0.00 | 0.49 | 0.30 |
| Q6 | 0.08 | 0.27 | 0.18 | -0.38 | 0.53 | 0.87 | 0.00 | 0.40 | 0.43 |
| Q7 | -0.06 | 0.43 | 0.08 | -0.02 | 0.97 | 0.64 | 0.01 | 0.43 | 0.46 |
| Q8 | -0.07 | 0.66 | 0.02 | 0.48 | 0.51 | 0.38 | 0.15 | 0.49 | 0.42 |

(D) Indicator variable is based on state at forecast date,
but only includes periods during which sign is unchanged

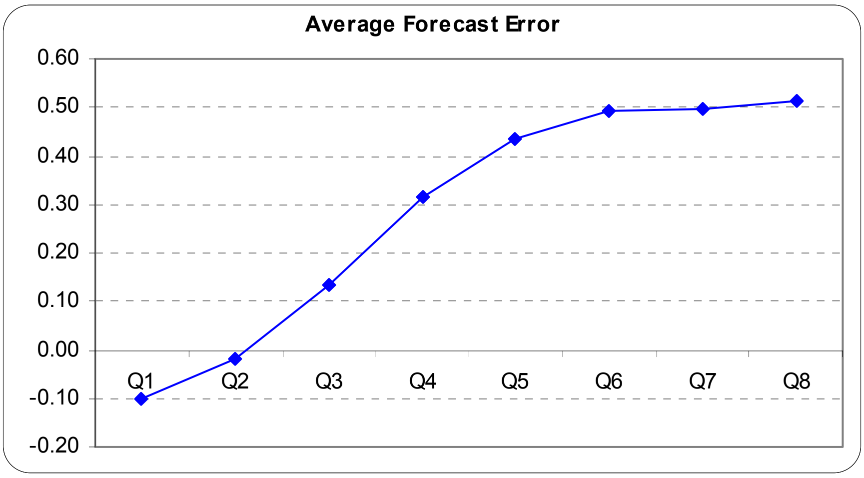
| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | -0.01 | 0.91 | -0.14 | 0.68 | -0.20 | 0.08 | -0.12 | 0.66 |
| Q2 | -0.06 | 0.06 | 0.67 | -0.03 | 0.96 | -0.15 | 0.36 | -0.16 | 0.69 |
| Q3 | 0.01 | 0.22 | 0.11 | N/A | N/A | 0.01 | 0.97 | N/A | N/A |
| Q4 | 0.29 | 0.57 | 0.01 | N/A | N/A | -0.22 | 0.41 | N/A | N/A |
| Q5 | 0.08 | 0.66 | 0.14 | N/A | N/A | -0.54 | 0.58 | N/A | N/A |
| Q6 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Q7 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Q8 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

The forecasters from the RBNZ, however, tended to underestimate inflation on average, increasingly so at longer forecasting horizons, as h increases, see Table 3 and Figure 8.

Table 3

| H= | Average Forecast Error |
|---|---|
| Q1 | -0.1027 |
| Q2 | -0.0177 |
| Q3 | 0.1342 |
| Q4 | 0.3163 |
| Q5 | 0.4342 |
| Q6 | 0.4917 |
| Q7 | 0.4963 |
| Q8 | 0.5153 |

Figure 8




When the forecasts are re-adjusted to remove the effects of this average error, and the regressions re-run, the results are shown in Table 4, below:-

Table 4

(A) Indicator variable is based on state at out-turn
(whole data set, with average forecast error removed)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | 0.09 | 0.38 | -0.03 | 0.92 | -0.10 | 0.38 | -0.02 | 0.95 |
| Q2 | -0.04 | 0.10 | 0.41 | -0.13 | 0.75 | -0.07 | 0.60 | -0.22 | 0.49 |
| Q3 | 0.05 | 0.19 | 0.15 | 0.09 | 0.84 | -0.20 | 0.19 | -0.34 | 0.33 |
| Q4 | 0.22 | 0.35 | 0.03 | 0.53 | 0.28 | -0.38 | 0.03 | -0.64 | 0.11 |
| Q5 | 0.25 | 0.40 | 0.02 | 0.74 | 0.17 | -0.41 | 0.03 | -0.80 | 0.07 |
| Q6 | 0.24 | 0.36 | 0.05 | 0.99 | 0.08 | -0.42 | 0.04 | -0.83 | 0.07 |
| Q7 | 0.20 | 0.37 | 0.07 | 0.87 | 0.16 | -0.47 | 0.05 | -0.73 | 0.15 |
| Q8 | 0.12 | 0.34 | 0.12 | 0.62 | 0.35 | -0.46 | 0.08 | -0.56 | 0.31 |

(B) Indicator variable is based on state at out-turn, but only includes periods
during which sign is unchanged, with average forecast error removed

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | 0.09 | 0.38 | -0.03 | 0.92 | -0.10 | 0.38 | -0.02 | 0.95 |
| Q2 | -0.05 | 0.10 | 0.50 | -0.13 | 0.76 | -0.11 | 0.51 | -0.22 | 0.50 |
| Q3 | -0.06 | 0.09 | 0.57 | 0.09 | 0.80 | -0.04 | 0.84 | -0.34 | 0.25 |
| Q4 | 0.16 | 0.23 | 0.31 | 0.44 | 0.49 | -0.45 | 0.23 | -0.65 | 0.16 |
| Q5 | N/A | | | | | | | | |
| Q6 | N/A | | | | | | | | |
| Q7 | N/A | | | | | | | | |
| Q8 | N/A | | | | | | | | |

(C) Indicator variable is based on state at forecast date
(whole data set, with average forecast error removed)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | 0.09 | 0.38 | -0.03 | 0.92 | -0.10 | 0.38 | -0.02 | 0.95 |
| Q2 | -0.05 | 0.07 | 0.60 | 0.03 | 0.94 | -0.10 | 0.49 | 0.07 | 0.84 |
| Q3 | -0.04 | -0.05 | 0.72 | -0.38 | 0.39 | 0.11 | 0.50 | 0.04 | 0.92 |
| Q4 | 0.00 | -0.10 | 0.57 | -0.72 | 0.19 | 0.18 | 0.35 | 0.17 | 0.71 |
| Q5 | 0.07 | -0.23 | 0.24 | -0.71 | 0.23 | 0.35 | 0.10 | 0.06 | 0.90 |
| Q6 | 0.08 | -0.22 | 0.28 | -0.88 | 0.15 | 0.37 | 0.09 | -0.10 | 0.85 |
| Q7 | -0.06 | -0.06 | 0.80 | -0.52 | 0.46 | 0.14 | 0.56 | -0.07 | 0.90 |
| Q8 | -0.07 | 0.14 | 0.59 | -0.03 | 0.96 | -0.13 | 0.61 | -0.03 | 0.96 |

(D) Indicator variable is based on state at forecast date, but only includes periods during which sign is unchanged, with average forecast error removed

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | -0.03 | 0.09 | 0.38 | -0.03 | 0.92 | -0.10 | 0.38 | -0.02 | 0.95 |
| Q2 | -0.06 | 0.08 | 0.59 | -0.01 | 0.99 | -0.13 | 0.42 | -0.15 | 0.72 |
| Q3 | 0.00 | 0.09 | 0.52 | | | -0.13 | 0.46 | | |
| Q4 | 0.29 | 0.25 | 0.20 | | | -0.53 | 0.06 | | |
| Q5 | 0.08 | 0.23 | 0.57 | | | -0.98 | 0.34 | | |
| Q6 | N/A | | | | | | | | |
| Q7 | N/A | | | | | | | | |
| Q8 | N/A | | | | | | | | |

Largely because the RBNZ was able to forecast inflation so well, apart from the average error, there is relatively little systematic cyclical bias in the errors. The signs of the coefficients tend to take the expected values, see panels B and D of Table 4 above, but they are not significant.

When we turn to examine the UK results (whole period) for bias and inefficiency, we get much stronger results, much more akin to the bias in the interest rate forecasts. Only in one sub-set (up/flat error, up till first sign change) is the hypothesis, (that up period errors will be overwhelmingly positive (actual less forecast) and down period errors equivalently negative), not strongly supported. Once again note that the scale of the up and down period errors is approximately offsetting, so if one should take the time period as a whole, (not divided into ‘up’ and ‘down’ periods), the forecasts appear unbiased and efficient.

Table 5

**UK inflation**

Initial sign: Up

| Up error till first sign change | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 59 | 32 | 27 | 0.1144 | 0.8924 | 0.3332 |
| 48 | 30 | 18 | 0.5173 | 1.4212 | 0.0162 |
| 37 | 29 | 8 | 1.0219 | 1.7063 | 0.0010 |
| 29 | 25 | 4 | 2.0559 | 2.3367 | 0.0001 |
| 21 | 18 | 3 | 3.7508 | 3.2799 | 0.0001 |
| 11 | 11 | 0 | 6.5127 | 4.0058 | 0.0004 |
| 2 | 2 | 0 | 9.5821 | 0.0511 | 0.0034 |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 207 | 147 | 60 | 1.4424 | 2.5664 | 0.0000 |

| Up/Flat error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 7 | 3 | 4 | -0.0710 | 0.6185 | 0.7881 |
| 7 | 4 | 3 | -0.1388 | 0.5691 | 0.5719 |
| 7 | 3 | 4 | -0.1522 | 0.6064 | 0.5613 |
| 7 | 3 | 4 | -0.0491 | 0.3226 | 0.7220 |
| 7 | 4 | 3 | 0.2322 | 0.4429 | 0.2464 |
| 5 | 1 | 4 | -0.1284 | 0.3051 | 0.4474 |
| 5 | 2 | 3 | -0.2956 | 0.5016 | 0.3038 |
| 3 | 1 | 2 | -0.0951 | 0.3906 | 0.7635 |
| 1 | 0 | 1 | -0.4112 | | |
| 49 | 21 | 28 | -0.0830 | 0.4794 | 0.2361 |

Initial sign: Down

| Down error till first sign change | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 58 | 14 | 44 | -0.5542 | 0.8739 | 0.0000 |
| 48 | 12 | 36 | -0.6822 | 1.1658 | 0.0002 |
| 38 | 12 | 26 | -0.8502 | 1.3930 | 0.0007 |
| 29 | 7 | 22 | -0.8695 | 1.4700 | 0.0041 |
| 24 | 6 | 18 | -0.9968 | 1.7308 | 0.0111 |
| 18 | 3 | 15 | -1.3615 | 1.3418 | 0.0006 |
| 13 | 1 | 12 | -1.6650 | 1.0620 | 0.0002 |
| 7 | 0 | 7 | -2.0600 | 0.9625 | 0.0019 |
| 2 | 0 | 2 | -2.2565 | 0.3927 | 0.1097 |
| 237 | 55 | 182 | -0.8641 | 1.0596 | 0.0000 |

| Down/Flat error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 24 | 9 | 15 | -0.0655 | 0.5431 | 0.5685 |
| 25 | 11 | 14 | -0.1912 | 0.5964 | 0.1293 |
| 25 | 6 | 19 | -0.6113 | 0.7854 | 0.0039 |
| 24 | 3 | 21 | -0.9327 | 0.9122 | 0.0001 |
| 22 | 1 | 21 | -1.3591 | 1.0136 | 0.0000 |
| 18 | 2 | 16 | -1.3053 | 0.8371 | 0.0000 |
| 11 | 1 | 10 | -1.2842 | 0.9599 | 0.0017 |
| 7 | 0 | 7 | -1.5317 | 0.6901 | 0.0016 |
| 2 | 0 | 2 | -1.4695 | 0.4535 | 0.1906 |
| 158 | 33 | 125 | -0.7766 | 0.9388 | 0.0000 |

After first sign change

| Down error after first sign change | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 10 | 4 | 6 | -0.9020 | 1.2577 | 0.0599 |
| 20 | 3 | 17 | -0.9738 | 1.5901 | 0.0152 |
| 26 | 6 | 20 | -0.9413 | 1.5343 | 0.0061 |
| 28 | 8 | 20 | -0.9043 | 1.8723 | 0.0184 |
| 25 | 6 | 19 | -1.1857 | 1.9481 | 0.0065 |
| 17 | 2 | 15 | -1.2825 | 2.5065 | 0.0575 |
| 9 | 3 | 6 | -0.8650 | 2.4956 | 0.3556 |
| 2 | 1 | 1 | 0.0020 | 3.4421 | 0.9996 |
| 137 | 33 | 104 | -1.0038 | 1.8667 | 0.0000 |

| Down/Flat error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 1 | 0 | 1 | -0.8990 | | |
| 3 | 0 | 3 | -0.9767 | 0.9421 | 0.2803 |
| 3 | 0 | 3 | -1.5235 | 1.2001 | 0.2145 |
| 2 | 0 | 2 | -2.3061 | 0.2610 | 0.0717 |
| 1 | 0 | 1 | -2.3118 | | |
| 0 | 0 | 0 | | | |
| 10 | 0 | 10 | -1.5323 | 0.9343 | 0.0008 |

After first sign change

| Up error after first sign change | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 10 | 3 | 7 | -0.1798 | 1.2986 | 0.6877 |
| 20 | 7 | 13 | -0.1517 | 1.2553 | 0.6056 |
| 27 | 9 | 18 | 0.0012 | 1.1570 | 0.9957 |
| 31 | 13 | 18 | 0.3336 | 1.7776 | 0.3122 |
| 26 | 12 | 14 | 0.5785 | 2.5349 | 0.2646 |
| 15 | 9 | 6 | 1.0678 | 2.3974 | 0.1178 |
| 7 | 4 | 3 | 0.2156 | 1.5842 | 0.7502 |
| 2 | 0 | 2 | -0.0605 | 0.8401 | 0.5759 |
| 138 | 57 | 81 | -0.1849 | 0.8877 | 0.0160 |

| Up/Flat error | | | | | |
|---|---|---|---|---|---|
| # | + ve | - ve | Mean | SD | P-value |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | #DIV/0! | #DIV/0! | #DIV/0! |

We did exactly the same exercise for the UK for the shorter, overlapping period; the equivalent Table is shown below. As is evident, the same extent, scale and significance of the bias reappears on the down side. On the 'up' side, however, the results are much weaker, and indeed are incorrectly signed after the first sign change.

Table 6

**UK inflation (overlapping period)**

Initial sign: Up

**Up error till first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 14 | 7 | 7 | 0.1098 | 0.3632 | 0.2955 |
| 10 | 6 | 4 | 0.1619 | 0.3713 | 0.2233 |
| 6 | 3 | 3 | 0.1242 | 0.4677 | 0.5786 |
| 4 | 3 | 1 | 0.1678 | 0.4226 | 0.5410 |
| 2 | 0 | 2 | -0.1445 | 0.1587 | 0.5297 |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 36 | 19 | 17 | 0.1190 | 0.3695 | 0.0650 |

**Up/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | #DIV/0! | #DIV/0! | #DIV/0! |

After first sign change

**Down error after first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 4 | 2 | 2 | -0.3902 | 0.6561 | 0.3787 |
| 8 | 0 | 8 | -0.6662 | 0.6067 | 0.0228 |
| 9 | 0 | 9 | -0.8689 | 0.6939 | 0.0076 |
| 8 | 1 | 7 | -1.1548 | 0.8520 | 0.0089 |
| 6 | 0 | 6 | -1.4186 | 0.9306 | 0.0191 |
| 4 | 0 | 4 | -1.6510 | 0.7302 | 0.0296 |
| 2 | 0 | 2 | -1.8701 | 0.4173 | 0.1398 |
| 0 | 0 | 0 | | | |
| 41 | 3 | 38 | -1.0440 | 0.8033 | 0.0000 |

**Down/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 1 | 0 | 1 | -0.8900 | | |
| 3 | 0 | 3 | -0.9767 | 0.9421 | 0.2803 |
| 3 | 0 | 3 | -1.5235 | 1.2001 | 0.2145 |
| 2 | 0 | 2 | -2.3061 | 0.2610 | 0.0717 |
| 1 | 0 | 1 | -2.3118 | | |
| 0 | 0 | 0 | | | |
| 10 | 0 | 10 | -1.5323 | 0.9343 | 0.0008 |

Initial sign: Down

**Down error till first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 19 | 3 | 16 | -0.3600 | 0.3807 | 0.0008 |
| 14 | 2 | 12 | -0.5321 | 0.5422 | 0.0036 |
| 10 | 2 | 8 | [illegible] | 0.5517 | 0.0039 |
| 7 | 1 | 6 | -0.8278 | 0.7184 | 0.0303 |
| 6 | 0 | 6 | -0.6066 | 0.3366 | 0.0100 |
| 4 | 0 | 4 | -0.9359 | 0.2395 | 0.0066 |
| 3 | 0 | 3 | -1.0449 | 0.4327 | 0.0761 |
| 1 | 0 | 1 | -1.0162 | | |
| 0 | 0 | 0 | | | |
| 64 | 8 | 56 | -0.6048 | 0.5077 | 0.0000 |

**Down/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 15 | 6 | 9 | -0.0485 | 0.3943 | 0.6524 |
| 16 | 9 | 7 | -0.0599 | 0.4229 | 0.5913 |
| 16 | 5 | 11 | -0.3476 | 0.6266 | 0.0484 |
| 15 | 3 | 12 | -0.5419 | 0.6675 | 0.0089 |
| 13 | 1 | 12 | -0.8039 | 0.6985 | 0.0018 |
| 9 | 2 | 7 | -0.7799 | 0.6824 | 0.0120 |
| 5 | 1 | 4 | -0.8302 | 0.6015 | 0.0508 |
| 3 | 0 | 3 | -1.4041 | 0.3907 | 0.0382 |
| 0 | 0 | 0 | | | |
| 92 | 27 | 65 | -0.4479 | 0.6592 | 0.0000 |

After first sign change

**Up error after first sign change**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 5 | 0 | 5 | -0.5090 | 0.2942 | 0.0258 |
| 9 | 0 | 9 | -0.6683 | 0.3249 | 0.0004 |
| 11 | 0 | 11 | -0.5300 | 0.2241 | 0.0000 |
| 13 | 1 | 12 | -0.4146 | 0.4203 | 0.0051 |
| 10 | 2 | 8 | -0.4269 | 0.4359 | 0.0165 |
| 6 | 2 | 4 | -0.3204 | 0.6645 | 0.3302 |
| 3 | 2 | 1 | -0.2406 | 0.6824 | 0.6677 |
| 0 | 0 | 0 | | | |
| 57 | 7 | 50 | -0.4683 | 0.4100 | 0.0000 |

**Up/Flat error**

| # | + ve | - ve | Mean | SD | P-value |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | | | |
| 0 | 0 | 0 | #DIV/0! | #DIV/0! | #DIV/0! |

Again the simpler regression results, both for the whole and for the shorter periods, give the following results (Table 7):-

Table 7

(A) Indicator variable is based on state at out-turn (whole data set)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 0.40 | 0.01 | -0.14 | 0.76 | -0.72 | 0.00 | -0.19 | 0.42 |
| Q2 | 0.17 | 0.61 | 0.00 | -0.15 | 0.78 | -0.89 | 0.00 | -0.51 | 0.07 |
| Q3 | 0.23 | 1.07 | 0.00 | -0.05 | 0.94 | -0.88 | 0.00 | -0.93 | 0.01 |
| Q4 | 0.24 | 1.60 | 0.00 | 0.23 | 0.78 | -0.85 | 0.00 | -1.31 | 0.00 |
| Q5 | 0.23 | 2.10 | 0.00 | -0.13 | 0.91 | -1.00 | 0.01 | -1.34 | 0.02 |
| Q6 | 0.13 | 1.39 | 0.01 | -0.30 | 0.80 | -0.95 | 0.02 | -1.44 | 0.05 |
| Q7 | 0.01 | 0.12 | 0.85 | -0.10 | 0.94 | -0.64 | 0.17 | -1.63 | 0.04 |
| Q8 | | | | | | | | | |

(B) Indicator variable is based on state at out-turn,
but only includes periods during which sign is unchanged

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 0.40 | 0.01 | -0.14 | 0.76 | -0.72 | 0.00 | -0.19 | 0.42 |
| Q2 | 0.22 | 0.83 | 0.00 | -0.15 | 0.78 | -0.93 | 0.00 | -0.51 | 0.08 |
| Q3 | 0.33 | 1.67 | 0.00 | -0.05 | 0.94 | -1.00 | 0.00 | -0.93 | 0.01 |
| Q4 | 0.45 | 3.04 | 0.00 | 0.23 | 0.77 | -1.12 | 0.01 | -1.35 | 0.00 |
| Q5 | 0.57 | 5.04 | 0.00 | -0.13 | 0.90 | -1.48 | 0.00 | -1.36 | 0.01 |
| Q6 | 0.72 | 7.04 | 0.00 | -0.30 | 0.67 | -1.85 | 0.00 | -1.35 | 0.00 |
| Q7 | | | | | | | | | |
| Q8 | | | | | | | | | |

(C) Indicator variable is based on state at forecast date (whole data set)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 0.40 | 0.01 | -0.14 | 0.76 | -0.72 | 0.00 | -0.19 | 0.42 |
| Q2 | 0.16 | 0.58 | 0.00 | -0.45 | 0.44 | -0.90 | 0.00 | -0.38 | 0.18 |
| Q3 | 0.16 | 0.88 | 0.00 | -0.87 | 0.26 | -0.79 | 0.00 | -0.64 | 0.07 |
| Q4 | 0.15 | 1.28 | 0.00 | -1.72 | 0.14 | -0.68 | 0.03 | -0.83 | 0.07 |
| Q5 | 0.10 | 1.39 | 0.00 | -2.90 | 0.08 | -0.42 | 0.30 | -1.03 | 0.10 |
| Q6 | 0.02 | 0.12 | 0.83 | -2.95 | 0.13 | -0.14 | 0.76 | -1.20 | 0.09 |
| Q7 | 0.06 | -0.62 | 0.23 | -2.96 | 0.16 | 0.17 | 0.75 | -1.51 | 0.03 |
| Q8 | | | | | | | | | |

(D) Indicator variable is based on state at forecast date,
but only includes periods during which sign is unchanged

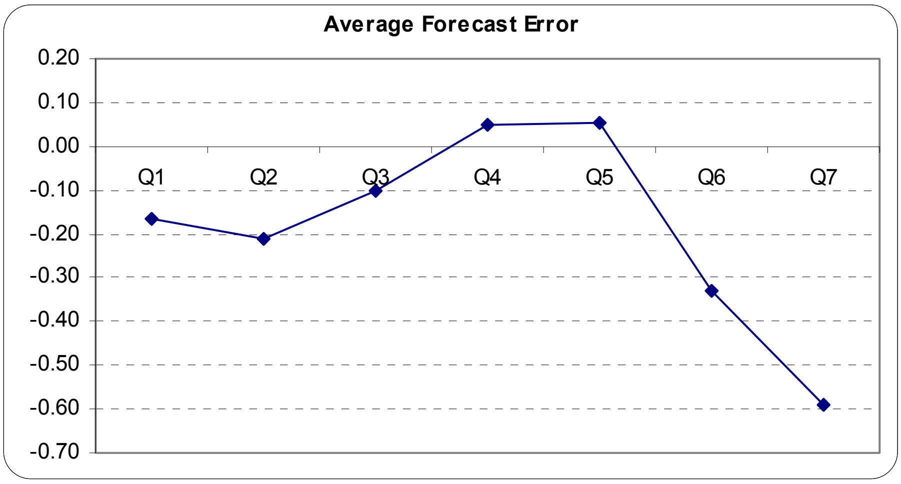
| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 0.40 | 0.01 | -0.14 | 0.76 | -0.72 | 0.00 | -0.19 | 0.42 |
| Q2 | 0.22 | 0.79 | 0.00 | -0.13 | 0.84 | -0.99 | 0.00 | -0.38 | 0.18 |
| Q3 | 0.32 | 1.49 | 0.00 | -0.02 | 0.99 | -1.18 | 0.00 | -0.64 | 0.07 |
| Q4 | 0.40 | 2.52 | 0.00 | 1.14 | 0.61 | -1.47 | 0.00 | -0.87 | 0.07 |
| Q5 | 0.43 | 3.75 | 0.00 | | | -1.72 | 0.00 | | |
| Q6 | 0.27 | 2.46 | 0.01 | | | -1.91 | 0.01 | | |
| Q7 | -1.48 | -0.10 | 0.92 | | | -1.62 | 0.03 | | |
| Q8 | | | | | | | | | |

Unlike NZ there is no systematic trend in the average errors. These are small, and flat, until the longest forecast horizon (h = 6/7), see Table 8 and Figure 9.

Table 8

| H= | Average Forecast Error |
|---|---|
| Q1 | -0.1654 |
| Q2 | -0.2099 |
| Q3 | -0.1015 |
| Q4 | 0.0507 |
| Q5 | 0.0527 |
| Q6 | -0.3307 |
| Q7 | -0.5911 |

Figure 9




Adjusting the forecasts for such average errors and re-running the regressions gives the following results:-

Table 9

(A) Indicator variable changes is based on state at out-turn
(whole data set, with average forecast error removed)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 0.56 | 0.00 | 0.03 | 0.95 | -0.55 | 0.00 | -0.03 | 0.91 |
| Q2 | 0.17 | 0.82 | 0.00 | 0.06 | 0.91 | -0.68 | 0.00 | -0.30 | 0.29 |
| Q3 | 0.23 | 1.17 | 0.00 | 0.05 | 0.93 | -0.78 | 0.00 | -0.83 | 0.01 |
| Q4 | 0.24 | 1.55 | 0.00 | 0.18 | 0.83 | -0.90 | 0.00 | -1.36 | 0.00 |
| Q5 | 0.23 | 2.05 | 0.00 | -0.18 | 0.88 | -1.06 | 0.01 | -1.39 | 0.02 |
| Q6 | 0.13 | 1.72 | 0.00 | 0.04 | 0.98 | -0.62 | 0.14 | -1.11 | 0.12 |
| Q7 | 0.01 | 0.72 | 0.27 | 0.50 | 0.69 | -0.05 | 0.91 | -1.04 | 0.17 |
| Q8 | | | | | | | | | |

(B) Indicator variable is based on state at out-turn, but only includes periods during which sign is unchanged, with average forecast error removed

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 0.56 | 0.00 | 0.03 | 0.95 | -0.55 | 0.00 | -0.03 | 0.91 |
| Q2 | 0.22 | 1.04 | 0.00 | 0.06 | 0.92 | -0.72 | 0.00 | -0.30 | 0.30 |
| Q3 | 0.33 | 1.77 | 0.00 | 0.05 | 0.94 | -0.90 | 0.00 | -0.83 | 0.02 |
| Q4 | 0.45 | 2.99 | 0.00 | 0.18 | 0.82 | -1.17 | 0.00 | -1.40 | 0.00 |
| Q5 | 0.57 | 4.98 | 0.00 | -0.18 | 0.86 | -1.54 | 0.00 | -1.41 | 0.01 |
| Q6 | 0.72 | 7.37 | 0.00 | 0.04 | 0.96 | -1.52 | 0.00 | -1.02 | 0.03 |
| Q7 | | | | | | | | | |
| Q8 | | | | | | | | | |

(C) Indicator variable is based on state at forecast date (whole data set, with average forecast error removed)

| H = | Adj R-sqr | C(1) | P-value | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 0.56 | 0.00 | 0.03 | 0.95 | -0.55 | 0.00 | -0.03 | 0.91 |
| Q2 | 0.16 | 0.79 | 0.00 | -0.24 | 0.68 | -0.69 | 0.00 | -0.18 | 0.54 |
| Q3 | 0.16 | 0.98 | 0.00 | -0.77 | 0.32 | -0.69 | 0.00 | -0.54 | 0.12 |
| Q4 | 0.15 | 1.23 | 0.00 | -1.77 | 0.13 | -0.73 | 0.02 | -0.88 | 0.06 |
| Q5 | 0.10 | 1.33 | 0.00 | -2.95 | 0.08 | -0.47 | 0.24 | -1.08 | 0.09 |
| Q6 | 0.02 | 0.45 | 0.40 | -2.62 | 0.18 | 0.19 | 0.68 | -0.87 | 0.22 |
| Q7 | 0.06 | -0.03 | 0.95 | -2.37 | 0.26 | 0.76 | 0.15 | -0.92 | 0.17 |
| Q8 | | | | | | | | | |

(D) Indicator variable is based on state at forecast date, but only includes periods during which sign is unchanged, with average forecast error removed

| H = | Adj R-sqr | 0.56256 | 0.0004 | C(2) | P-value | C(3) | P-value | C(4) | P-value |
|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0.13 | 1.00 | 0.00 | 0.03 | 0.95 | -0.55 | 0.00 | -0.03 | 0.91 |
| Q2 | 0.22 | 1.59 | 0.00 | 0.08 | 0.91 | -0.78 | 0.00 | -0.18 | 0.54 |
| Q3 | 0.32 | 2.15 | 0.00 | 0.08 | 0.93 | -1.08 | 0.00 | -0.54 | 0.13 |
| Q4 | 0.40 | 3.69 | 0.00 | 0.77 | 0.73 | -1.84 | 0.00 | -1.24 | 0.01 |
| Q5 | 0.43 | 2.79 | 0.00 | | | -1.78 | 0.00 | | |
| Q6 | 0.31 | 0.50 | 0.50 | | | -1.57 | 0.02 | | |
| Q7 | -0.50 | | | | | -1.03 | 0.06 | | |
| Q8 | | | | | | | | | |

To recapitulate, in this Section we have examined whether the inflation forecasts in NZ and the UK exhibited the same syndrome as the interest rate forecasts, that is ex post cyclical inefficiency and bias, in that actuals systematically exceed forecasts during ‘up’ periods, and decline below forecasts during ‘down’ periods. For the NIESR inflation forecasts for the UK, the answer was generally ‘yes’. In NZ over this period the RBNZ forecasts of inflation were remarkably good, and similarly their cyclical (up/down) bias was much less, with only a slight tendency in that direction.

## III. Could Errors in Forecasting Inflation have been Partly Responsible for Errors in Forecasting Future Policy Interest Rates and for Inertial Adjustments in Actual Policy Rates?

The primary responsibility of Central Banks nowadays is to maintain price stability, generally in the guise of low, but positive, inflation targets. Since interest rates only affect inflation after long, and variable, lags, the decision to adjust the policy rate has to be, and normally is, taken on the basis of an inflation forecast.

In the previous Section we examined whether the inflation forecasts, for which we had data, exhibited systematic errors. We concluded that they had such a tendency, mildly in the case of the RBNZ inflation forecast, markedly so in the case of the NIESR UK forecast. So, in this Section we explore whether the errors in the inflation forecast are associated with, and perhaps cause, the errors in the inflation forecast. This is quite a demanding test, to attempt to find the error in one forecast associated with the error in another forecast.

This is especially so in the case of NZ, where the RBNZ inflation forecasts were so comparatively good. We start by noting that in NZ there was a close over-lap between periods of rising/falling interest rates and periods of rising/falling inflation between 2001 Q1 and 2006 Q4. Over these seven years (28 quarters) in only six quarters were the signs different, and in three of these inflation was basically flat, rather than moving in the opposite direction. But, while consistent with the hypothesis above, it is also consistent with the hypothesis that the RBNZ planned to raise/lower interest rates gradually in order to bring inflation back onto track.

So the test we employ is whether the error in the forecast for inflation for $Q_{t+i}$ made at time t significantly affects the error in the forecast for interest rates for $Q_{t+i}$ at time t, i.e.,

$$Ei_{t+i,t} = a + bE\pi_{t+i,t}$$

Because of concerns about potential simultaneity, we also run the same equation with the forecast for inflation, $\pi_{t+i,t}$ instrumented by the forecast for the t + i quarter made in the previous quarter, t – 1.

The initial results for New Zealand showed <u>no support</u> for our hypothesis. These are shown in Table 10 below:

Table 10

Data period 2000Q1-2006Q4

| h = | Contemporaneous | | | | Instrumented | | | |
|---|---|---|---|---|---|---|---|---|
| | C1 (P value) | C2 (P value) | R sq. | DW | C1 (P value) | C2 (P value) | R sq. | DW |
| 0 | 0.0034<br>0.8253 | -0.1466<br>0.0667 | 0.1235 | 1.6293 | 0.0087<br>0.5917 | -0.0067<br>0.8548 | 0.0014 | 1.7071 |
| 1 | -0.074<br>0.2162 | -0.0055<br>0.9674 | 0.0001 | 1.4769 | -0.1017<br>0.0821 | 0.0527<br>0.6162 | 0.0106 | 1.4922 |
| 2 | -0.1464<br>0.1686 | 0.0403<br>0.8346 | 0.0019 | 1.0005 | -0.1427<br>0.2284 | -0.0633<br>0.7568 | 0.0043 | 0.9674 |
| 3 | -0.1808<br>0.2676 | 0.0475<br>0.8663 | 0.0013 | 0.4609 | -0.1723<br>0.3417 | -0.0081<br>0.9763 | 0.0000 | 0.4029 |
| 4 | -0.2318<br>0.3265 | 0.1591<br>0.6538 | 0.0093 | 0.4909 | -0.2287<br>0.3776 | 0.1514<br>0.6684 | 0.0089 | 0.4231 |
| 5 | -0.1724<br>0.5645 | 0.0312<br>0.9393 | 0.0003 | 0.4706 | -0.1554<br>0.6171 | 0.1001<br>0.8156 | 0.0028 | 0.4770 |
| 6 | -0.1429<br>0.7053 | -0.0287<br>0.9552 | 0.0002 | 0.3014 | -0.1498<br>0.7091 | 0.1832<br>0.7529 | 0.0073 | 0.2365 |
| 7 | -0.1718<br>0.7479 | 0.0304<br>0.9677 | 0.0002 | 0.1091 | 0.1983<br>0.7499 | -0.2979<br>0.7396 | 0.0146 | 0.1682 |

Further careful examination of the errors for NZ inflation and interest rates, with the NZ interest rate errors reported in Appendix 1 of our first paper, and the inflation errors in Appendix 1 here, however, reveals that part of the answer for this failure may have lain in the somewhat anomalous and unusual behaviour in the sub-period 2000 Q1 until 2001 Q3. During this sub-period (excluding the forecasts for Q0 and Q1 as so close to the outturn as to be unbiased), all the 49 inflation forecast errors, except for 5, are positive (actual greater than forecast), and on quite a large scale (e.g. 1%+), whereas of the 40 interest rate errors, no less than 36 are negative (actual below forecast), and some are again substantial in size. So, during this period inflation (as measured by CPI) consistently exceeded forecasts, yet interest rates were set in practice below their previously forecast rate.

If we exclude this anomalous period, and re-run the same equations, from 2001 Q4 to 2006 Q3, we get a relatively strong relationship between errors in the inflation forecast and errors in the interest rate forecast, as shown in the table below:-

Table 11

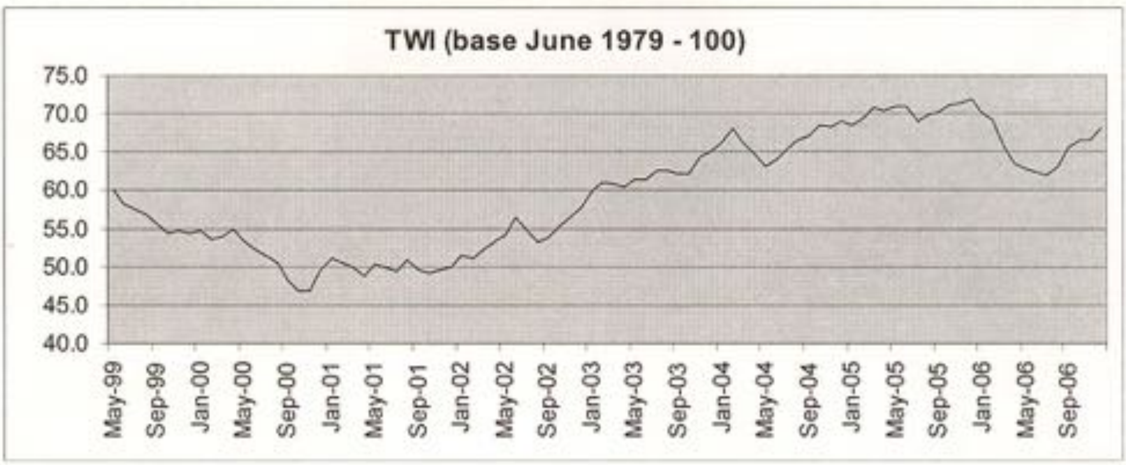
NZ regression:
Data period 2001Q4-2006Q4

| | Contemporaneous | | | | Instrumented | | | |
|---|---|---|---|---|---|---|---|---|
| h = | C1 (P value) | C2 (P value) | R sq. | DW | C1 (P value) | C2 (P value) | R sq. | DW |
| 0 | -0.0009 | -0.1029 | 0.0977 | 1.3848 | 0.0120 | -0.0134 | 0.0077 | 0.9686 |
| | 0.9521 | 0.1678 | | | 0.4066 | 0.7134 | | |
| 1 | -0.0192 | -0.0022 | 0.0000 | 1.6973 | -0.0113 | 0.1299 | 0.0781 | 1.3601 |
| | 0.7158 | 0.9866 | | | 0.8257 | 0.2465 | | |
| 2 | 0.0288 | 0.0793 | 0.0084 | 0.9162 | -0.0406 | 0.5390 | 0.2165 | 1.0249 |
| | 0.7715 | 0.7091 | | | 0.6517 | 0.0517 | | |
| 3 | 0.0264 | 0.8285 | 0.2389 | 0.9868 | -0.0290 | 0.4830 | 0.1360 | 0.5968 |
| | 0.8385 | 0.0395 | | | 0.8434 | 0.1452 | | |
| 4 | 0.0072 | 1.0290 | 0.3746 | 0.8441 | -0.0450 | 0.9564 | 0.3351 | 0.5130 |
| | 0.9642 | 0.0090 | | | 0.7985 | 0.0188 | | |
| 5 | 0.0519 | 1.2294 | 0.4192 | 1.0550 | 0.0222 | 1.2560 | 0.3159 | 1.2565 |
| | 0.7838 | 0.0067 | | | 0.9207 | 0.0292 | | |
| 6 | 0.1804 | 2.0348 | 0.6508 | 2.0261 | 0.1338 | 1.3616 | 0.3485 | 1.3993 |
| | 0.3612 | 0.0027 | | | 0.6346 | 0.0559 | | |
| 7 | 0.4064 | 2.0341 | 0.7464 | 0.6972 | 0.0506 | 2.0264 | 0.4763 | 1.1087 |
| | 0.1292 | 0.0122 | | | 0.9003 | 0.0861 | | |

So what is going on? Adding to the problem is the fact that a recent critique of RBNZ policy, (by Rodney Dickens, 2007), claims that the period of excessively lax policy began in September 2002 after Alan Bollard was appointed Governor. But, unless there is an implicit suggestion that the RBNZ inflation forecasts were biased downwards from September 2002 onwards, our data suggest that policy followed a standard path whereby under (over) estimates of CPI inflation led to under (over) estimates of future interest rates. In contrast, in our data series, the problematical time period is 2000/2001 at the end of Don Brash's period in office.

What is noticeable, however, is that Dickens expresses his critique in terms of non-tradeables inflation whereas our data are for overall CPI inflation. As shown in Figure 10 for the NZ exchange rate, Trade Weighted Index (1979 = 100) from May 1999 until December 2006, the NZ $ depreciated quite strongly from May 1999 until the end of 2000, remained roughly constant then until end 2001, and then appreciated strongly until end 2005. In so far as Dickens (and Brash?) believes that non-tradeables inflation is a better measure of (core) inflation than GDP inflation, the underestimate of inflation in 2000/1 could be dismissed as being due to exogenous external influences, which were less relevant for the policy decision than the continued control over non-tradeables inflation (see Dickens Figure 1, p. 72). Equivalently the sharp rise in non-tradeables inflation, after Bollard's appointment, was masked by the exchange rate appreciation.

Figure 10




So, the assessment of NZ monetary policy must depend in some considerable part on what was held to be the appropriate measure of inflation. But if the appropriate measure was held, by some, to be non-tradeables inflation, then surely the Policy

Target Agreement should have been framed in the same terms. The monetary authorities must abide by their publicly-set target, until it is changed. It is not helpful to have a private target measure that differs from that publicly set.

Turning next to the UK, our initial results for the UK were equally unsupportive. Here we initially related the errors implicit in the market forecast against the errors in the National Institute forecast for inflation. The results, not shown here but available from the authors, provided no evidence of any significant relationship. A possibility that immediately occurred to us was that, during this period, the official target was RPIX, not CPI, and that the basis of the MPC's forecast was an unchanged interest rate. So we switched to an examination of the MPC's errors in forecasting RPIX as a potential explanation of the errors in predicting interest rates, from the unchanged assumption. The basic data are also included in Appendix 1.

But the first results remained just about as unpromising, see Table 12 below.

Table 12

Data period: 1993Q1 – 2004Q1

| | Contemporaneous | | | | Instrumented | | | |
|---|---|---|---|---|---|---|---|---|
| h = | C1 (P value) | C2 (P value) | R sq. | DW | C1 (P value) | C2 (P value) | R sq. | DW |
| 1 | -0.0685<br>0.0360 | 0.2018<br>0.0292 | 0.1083 | 0.9486 | -0.0701<br>0.0434 | 0.0967<br>0.2271 | 0.0354 | 1.0683 |
| 2 | -0.1227<br>0.1329 | 0.3092<br>0.1070 | 0.0621 | 0.6699 | -0.1192<br>0.1654 | 0.1057<br>0.5380 | 0.0096 | 0.6687 |
| 3 | -0.1721<br>0.1615 | 0.3278<br>0.1855 | 0.0434 | 0.4783 | -0.1702<br>0.1857 | 0.1388<br>0.5617 | 0.0087 | 0.4683 |
| 4 | -0.2146<br>0.1705 | 0.3238<br>0.2683 | 0.0313 | 0.3911 | -0.2156<br>0.1891 | 0.0410<br>0.9001 | 0.0004 | 0.3944 |
| 5 | -0.2601<br>0.1547 | 0.1717<br>0.6367 | 0.0059 | 0.3399 | -0.2762<br>0.1470 | -0.1305<br>0.7365 | 0.0031 | 0.3488 |
| 6 | -0.3168<br>0.1127 | -0.0433<br>0.9150 | 0.0003 | 0.3107 | -0.3899<br>0.0696 | -0.1650<br>0.7376 | 0.0033 | 0.3257 |
| 7 | -0.4379<br>0.0432 | -0.1604<br>0.7450 | 0.0032 | 0.2939 | -0.4108<br>0.1666 | 0.6524<br>0.3813 | 0.0308 | 0.3024 |

An examination of the errors in forecasting RPIX inflation, and the implied errors from the constant interest rate assumption, revealed, however, that there were two periods when the expected positive relationship between the two sets of errors was reversed. The first comes at the start of the period. In 1994/95 the policy rate was rising above the levels reached in 1992/93 (so the implicit forecast was too low, actual greater than forecast) at a time when the RPIX forecast was coming in below predicted levels (actual less than forecast). Interest rates had been brought down sharply in 1992/93 because of the recession then, especially in the housing market. The lower than forecast inflation rate was largely due to the much less than expected pass-through onto domestic prices from the large devaluation in 1992. So the lower RPI, than expected, in 1994/95 was not taken as a sign of lower domestic inflationary pressures. As in NZ external factors were disguising perceived relationships between domestic inflation and interest rates.

The second period when the hypothesis of a positive relationship between errors in inflation forecast and errors in interest rate forecasts clearly breaks down is at the end of the period in 2003/4. At this time interest rates were declining, (so the forecast error was actual less than forecast) whereas inflation was picking up (actual greater than forecast). Again we tentatively attribute this to external factors, i.e. the worldwide decline in nominal and real interest rates in the years following the collapse of the equity bubble.

If we exclude these two periods, thereby cutting the sample period by about one quarter for h = 5 – 8, the (positive) relationship between errors in inflation forecasts and in interest rate forecasts does re-emerge, see Table 13, though its strength, and the significance of the coefficient is limited rather than strong.[2]

Table 13

| | Contemporaneous | | | | Instrumented | | | |
|---|---|---|---|---|---|---|---|---|
| h = | C1 (P value) | C2 (P value) | R sq. | DW | C1 (P value) | C2 (P value) | R sq. | DW |
| 1 | -0.0805<br>0.0514 | 0.2464<br>0.1030 | 0.0785 | 0.9326 | -0.0756<br>0.0703 | 0.1439<br>0.2197 | 0.0453 | 1.0701 |
| 2 | -0.1961<br>0.0473 | 0.4976<br>0.0726 | 0.0972 | 0.7315 | -0.1749<br>0.0779 | 0.2973<br>0.2027 | 0.0502 | 0.7433 |
| 3 | -0.3100<br>0.0311 | 0.6508<br>0.0536 | 0.1150 | 0.5601 | -0.2939<br>0.0428 | 0.5277<br>0.1102 | 0.0802 | 0.5452 |
| 4 | -0.3943<br>0.0485 | 1.1954<br>0.0208 | 0.1959 | 0.5418 | -0.3429<br>0.1112 | 0.7971<br>0.2419 | 0.0544 | 0.4380 |
| 5 | -0.3761<br>0.1039 | 1.3558<br>0.0690 | 0.1262 | 0.5092 | -0.3832<br>0.1332 | 0.4736<br>0.5438 | 0.0149 | 0.3972 |
| 6 | -0.3532<br>0.1740 | 0.9605<br>0.2335 | 0.0563 | 0.4502 | -0.3826<br>0.1829 | 0.3781<br>0.6223 | 0.0099 | 0.3423 |
| 7 | -0.3260<br>0.2465 | 0.5958<br>0.4317 | 0.0249 | 0.3531 | 0.2783<br>0.5592 | 2.2049<br>0.0612 | 0.1724 | 0.6037 |

We turn, finally, to a purely visual, graphical example taken from the paper by Adolfson, et al., in the IJCB (December 2007). Figures 1(a) and (b) show charts (reproduced below) for the relationship between Riksbank (Swedish) forecasts and outturns for inflation and interest rates. Between 2002 Q2 and 2005 there is an apparent positive correlation between the errors in the two series, but this was patently not there between 1999 and 2002 Q2. During this latter period, policy interest rates were apparently forecast to rise sharply to around 5%, or above, despite inflation being predicted, as largely turned out to be the case, to remain around 2/2 ½ %. Why there was some expectation that in Sweden real rates would rise to 3%, while they were in sharp decline everywhere else in the world, is not an issue covered further here.

2 We examined whether any such relationship re-emerged also when using the government debt/CPI error series over this same shortened period.

Figure 11

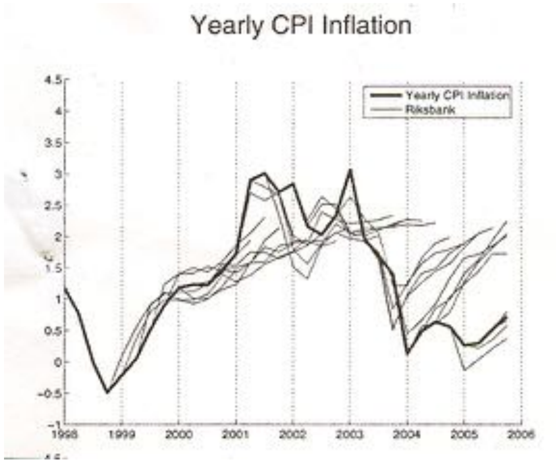
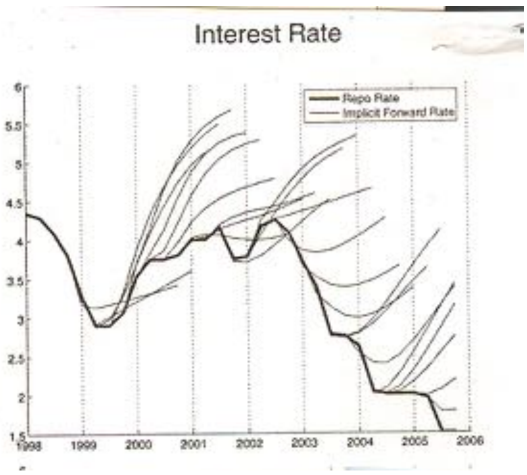



Figure 12




What is germane is that this is a further example of a country where during some periods errors in forecasting inflation and in forecasting interest rates seem to have a reasonably strong positive association, but in other, perhaps briefer, periods they do not. In the case of both NZ and the UK, two open economies, the periods when this relationship does not hold appear to be associated with external influences affecting the course either of inflation, or of interest rates, or both, in ways that may have distorted the direct domestic inflation/interest rate nexus.

## IV. Conclusions

(1) The inflation forecasts, both official and private sector, that we studied here were rather better than the interest rate forecasts, especially in NZ. They were rather good over the next year, and had some, but not much, value over the second year.

(2) Nevertheless both the inflation and interest rate forecasts were, ex post, inefficient and biased. This may have been caused by forecasters generally assuming a quicker reversion to some equilibrium level than actually occurs in up, and down, cycles, a hypothesis that we shall examine in our third, and final, paper of this trilogy. Since this bias is offsetting between up, and down, phases it does not appear in whole sample econometric tests.

(3) Our hypothesis was that, in inflation targeting countries, errors in forecasting interest rates would be positively associated with errors in forecasting inflation. Over our complete sample periods, this was not supported. It was, however, supported over the larger part of our periods in both NZ and UK. There were, instead, periods in both countries (and in Sweden) when the relationship reversed. On inspection in both NZ and UK these latter periods were occasions when external influences may have distorted the nexus between interest rates and domestic inflationary impulses.

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Appendix 1: Table 1: UK inflation forecast, measured in terms of CPI

| Date | CPI | 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) |
|---|---|---|---|---|---|---|---|---|---|
| **1992Q1** | 7.7039 | 7.3485 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **1992Q2** | 5.1939 | 5.1207 | 4.6188 | N/A | N/A | N/A | N/A | N/A | N/A |
| **1992Q3** | 4.552 | 4.3134 | 4.3197 | 3.6023 | N/A | N/A | N/A | N/A | N/A |
| **1992Q4** | 3.7062 | 4.4191 | 3.5436 | 3.617 | 3.2764 | N/A | N/A | N/A | N/A |
| **1993Q1** | 3.8136 | 3.8787 | 4.507 | 3.1535 | 3.2959 | 3.2463 | N/A | N/A | N/A |
| **1993Q2** | 4.0645 | 4.2747 | 4.123 | 4.3902 | 2.9903 | 3.3403 | 3.3637 | N/A | N/A |
| **1993Q3** | 3.4513 | 4.1696 | 4.656 | 4.5045 | 4.7685 | 2.8946 | 3.3816 | 3.4771 | N/A |
| **1993Q4** | 3.0586 | 3.5933 | 4.1982 | 4.8143 | 4.7358 | 4.7099 | 2.9432 | 3.3539 | 3.5172 |
| **1994Q1** | 2.9514 | 3.3015 | 3.9029 | 4.2206 | 5.034 | 4.888 | N/A | N/A | N/A |
| **1994Q2** | 2.8424 | 2.8424 | 3.3621 | 4.0517 | 4.1751 | 4.9059 | 4.8993 | N/A | N/A |
| **1994Q3** | 2.4829 | 3.0796 | 3.0796 | 3.7671 | 4.3627 | 4.4029 | 4.8473 | 4.9735 | N/A |
| **1994Q4** | 2.7341 | 2.5554 | 3.3163 | 3.4014 | 4.0782 | 4.3993 | 4.5575 | 4.8556 | 5.0459 |
| **1995Q1** | 2.5402 | 2.7895 | 2.5359 | 3.5413 | 3.457 | 4.2052 | N/A | N/A | N/A |
| **1995Q2** | 2.8595 | 2.439 | 2.9387 | 2.605 | 3.6851 | 3.5176 | 4.3369 | N/A | N/A |
| **1995Q3** | 2.8404 | 3.0075 | 2.5063 | 3.172 | 2.7569 | 3.8174 | 3.5685 | 4.4554 | N/A |
| **1995Q4** | 2.6677 | 2.99 | 3.2392 | 2.6578 | 3.314 | 2.99 | 3.9506 | 3.6184 | 4.4898 |
| **1996Q1** | 1.9769 | 2.6359 | 1.8946 | 3.2152 | 2.8076 | 3.4539 | N/A | N/A | N/A |
| **1996Q2** | 2.6961 | 1.8018 | 2.6144 | 3.1122 | 3.1889 | 2.9557 | 3.5889 | N/A | N/A |
| **1996Q3** | 2.9221 | 2.6786 | 1.8745 | 3.0106 | 3.0869 | 3.0819 | 2.8525 | 3.7217 | N/A |
| **1996Q4** | 2.8235 | 2.9863 | 2.6634 | 2.0276 | 3.1528 | 3.1452 | 2.9767 | 2.7508 | 3.8492 |
| **1997Q1** | 2.486 | 2.56 | 2.8823 | 2.48 | 2.3425 | 3.2103 | N/A | N/A | N/A |
| **1997Q2** | 2.075 | 2.2293 | 2.224 | 3.1873 | 2.6253 | 2.6549 | 3.3439 | N/A | N/A |
| **1997Q3** | 2.0586 | 1.9002 | 1.8942 | 1.9716 | 2.9968 | 2.6877 | 2.8 | 3.3965 | N/A |
| **1997Q4** | 2.1622 | 2.4467 | 2.131 | 1.9623 | 1.9608 | 3.2132 | 2.9874 | 3.0207 | 3.5266 |
| **1998Q1** | 2.0424 | 2.1978 | 2.4314 | 2.2799 | 2.1909 | 1.8721 | N/A | N/A | N/A |
| **1998Q2** | 2.1926 | 2.036 | 2.3438 | 2.8974 | 2.3456 | 2.3364 | 2.0979 | N/A | N/A |
| **1998Q3** | 1.6949 | 2.0202 | 1.7871 | 2.2481 | 2.4825 | 2.2533 | 2.4787 | 2.2428 | N/A |
| **1998Q4** | 1.2915 | 1.4019 | 2.0849 | 1.7761 | 2.6255 | 2.3883 | 2.2411 | 2.5404 | 2.3077 |
| **1999Q1** | 1.9626 | 1.8709 | 2.0561 | 2.6194 | 2.0785 | 2.765 | N/A | N/A | N/A |
| **1999Q2** | 2.0465 | 2.2326 | 1.8605 | 2.3277 | 2.7586 | 2.3791 | 2.9008 | N/A | N/A |
| **1999Q3** | 1.9481 | 2.1257 | 2.1257 | 2.037 | 2.3148 | 2.818 | 2.5191 | 2.881 | N/A |
| **1999Q4** | 2.9464 | 1.7479 | 2.2059 | 2.2059 | 2.3063 | 2.3041 | 2.8744 | 2.5038 | 2.784 |
| **2000Q1** | 2.5501 | 2.3636 | 2.2957 | 2.844 | 2.6581 | 2.4793 | N/A | N/A | N/A |
| **2000Q2** | 1.9056 | 2.0758 | 1.8902 | 2.7473 | 3.0082 | 2.6388 | 2.5571 | N/A | N/A |
| **2000Q3** | 1.4453 | 1.9874 | 1.8834 | 2.3381 | 2.7298 | 3.0769 | 2.8054 | 2.4501 | N/A |
| **2000Q4** | 0.17937 | 1.5274 | 2.0665 | 1.875 | 2.2321 | 2.8029 | 3.4173 | 2.8777 | 2.3445 |
| **2001Q1** | 1.5413 | 1.4493 | 1.9766 | 2.5112 | 1.865 | 2.3091 | N/A | N/A | N/A |
| **2001Q2** | 1.4467 | 1.3562 | 1.7179 | 2.1505 | 2.4043 | 2.0336 | 2.4735 | N/A | N/A |
| **2001Q3** | 1.5343 | 1.3514 | 1.3514 | 1.9856 | 1.959 | 2.4801 | 2.1127 | 2.5483 | N/A |
| **2001Q4** | 1.5044 | 1.2579 | 1.0743 | 1.2534 | 1.8834 | 1.8584 | 2.4648 | 2.2787 | 2.5328 |
| **2002Q1** | 1.7969 | 1.7986 | 1.435 | 1.25 | 1.5179 | 2.0536 | N/A | N/A | N/A |
| **2002Q2** | 1.167 | 1.2478 | 1.1576 | 1.3381 | 1.5152 | 2.0517 | 2.2222 | N/A | N/A |
| **2002Q3** | 0.98655 | 1.6129 | 1.1535 | 1.1535 | 1.4222 | 1.6889 | 2.3111 | 2.3894 | N/A |
| **2002Q4** | 0.97778 | 1.6158 | 1.6129 | 1.5058 | 1.3274 | 1.7746 | 1.8601 | 2.4757 | 2.5528 |
| **2003Q1** | 1.0657 | 0.62389 | 1.5179 | 2.3194 | 1.677 | 1.7668 | N/A | N/A | N/A |
| **2003Q2** | 1.7396 | 1.7778 | 1.1597 | 2.0536 | 2.2183 | 1.9366 | 2.0246 | N/A | N/A |
| **2003Q3** | 1.5078 | 1.778 | 2.1277 | 1.5138 | 2.0426 | 2.0282 | 2.193 | 2.3684 | N/A |
| **2003Q4** | 1.4346 | 1.3297 | 1.7345 | 2.4757 | 1.8667 | 2.1201 | 1.8405 | 2.356 | 2.5328 |
| **2004Q1** | 1.4736 | 1.4432 | 1.397 | 1.4996 | 2.3726 | 1.9486 | N/A | N/A | N/A |
| **2004Q2** | 1.8791 | 1.9336 | 1.766 | 1.4962 | 1.2277 | 2.2707 | 2.0282 | N/A | N/A |
| **2004Q3** | 1.2614 | 1.8946 | 1.941 | 1.9119 | 1.5365 | 1.3123 | 2.0833 | 2.0175 | N/A |
| **2004Q4** | 1.3094 | 1.4374 | 2.1801 | 2.0354 | 1.9458 | 1.7 | 1.5136 | 1.9845 | 2.007 |

| 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) |
|---|---|---|---|---|---|---|---|---|
| **1992Q1** | 0.355 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1992Q2** | 0.073 | 0.575 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1992Q3** | 0.239 | 0.232 | 0.950 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1992Q4** | -0.713 | 0.163 | 0.089 | 0.430 | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q1** | -0.065 | -0.693 | 0.660 | 0.518 | 0.567 | #VALUE! | #VALUE! | #VALUE! |
| **1993Q2** | -0.210 | -0.059 | -0.326 | 1.074 | 0.724 | 0.701 | #VALUE! | #VALUE! |
| **1993Q3** | -0.718 | -1.205 | -1.053 | -1.317 | 0.557 | 0.070 | -0.026 | #VALUE! |
| **1993Q4** | -0.535 | -1.140 | -1.756 | -1.677 | -1.651 | 0.115 | -0.295 | -0.459 |
| **1994Q1** | -0.350 | -0.952 | -1.269 | -2.083 | -1.937 | #VALUE! | #VALUE! | #VALUE! |
| **1994Q2** | 0.000 | -0.520 | -1.209 | -1.333 | -2.064 | -2.057 | #VALUE! | #VALUE! |
| **1994Q3** | -0.597 | -0.597 | -1.284 | -1.880 | -1.920 | -2.364 | -2.491 | #VALUE! |
| **1994Q4** | 0.179 | -0.582 | -0.667 | -1.344 | -1.665 | -1.823 | -2.122 | -2.312 |
| **1995Q1** | -0.249 | 0.004 | -1.001 | -0.917 | -1.665 | #VALUE! | #VALUE! | #VALUE! |
| **1995Q2** | 0.421 | -0.079 | 0.255 | -0.826 | -0.658 | -1.477 | #VALUE! | #VALUE! |
| **1995Q3** | -0.167 | 0.334 | -0.332 | 0.083 | -0.977 | -0.728 | -1.615 | #VALUE! |
| **1995Q4** | -0.322 | -0.572 | 0.010 | -0.646 | -0.322 | -1.283 | -0.951 | -1.822 |
| **1996Q1** | -0.659 | 0.082 | -1.238 | -0.831 | -1.477 | #VALUE! | #VALUE! | #VALUE! |
| **1996Q2** | 0.894 | 0.082 | -0.416 | -0.493 | -0.260 | -0.893 | #VALUE! | #VALUE! |
| **1996Q3** | 0.244 | 1.048 | -0.089 | -0.165 | -0.160 | 0.070 | -0.800 | #VALUE! |
| **1996Q4** | -0.163 | 0.160 | 0.796 | -0.329 | -0.322 | -0.153 | 0.073 | -1.026 |
| **1997Q1** | -0.074 | -0.396 | 0.006 | 0.144 | -0.724 | #VALUE! | #VALUE! | #VALUE! |
| **1997Q2** | -0.154 | -0.149 | -1.112 | -0.550 | -0.580 | -1.269 | #VALUE! | #VALUE! |
| **1997Q3** | 0.158 | 0.164 | 0.087 | -0.938 | -0.629 | -0.741 | -1.338 | #VALUE! |
| **1997Q4** | -0.285 | 0.031 | 0.200 | 0.201 | -1.051 | -0.825 | -0.859 | -1.364 |
| **1998Q1** | -0.155 | -0.389 | -0.238 | -0.149 | 0.170 | #VALUE! | #VALUE! | #VALUE! |
| **1998Q2** | 0.157 | -0.151 | -0.705 | -0.153 | -0.144 | 0.095 | #VALUE! | #VALUE! |
| **1998Q3** | -0.325 | -0.092 | -0.553 | -0.788 | -0.558 | -0.784 | -0.548 | #VALUE! |
| **1998Q4** | -0.110 | -0.793 | -0.485 | -1.334 | -1.097 | -0.950 | -1.249 | -1.016 |
| **1999Q1** | 0.092 | -0.093 | -0.657 | -0.116 | -0.802 | #VALUE! | #VALUE! | #VALUE! |
| **1999Q2** | -0.186 | 0.186 | -0.281 | -0.712 | -0.333 | -0.854 | #VALUE! | #VALUE! |
| **1999Q3** | -0.178 | -0.178 | -0.089 | -0.367 | -0.870 | -0.571 | -0.933 | #VALUE! |
| **1999Q4** | 1.199 | 0.741 | 0.741 | 0.640 | 0.642 | 0.072 | 0.443 | 0.162 |
| **2000Q1** | 0.187 | 0.254 | -0.294 | -0.108 | 0.071 | #VALUE! | #VALUE! | #VALUE! |
| **2000Q2** | -0.170 | 0.015 | -0.842 | -1.103 | -0.733 | -0.652 | #VALUE! | #VALUE! |
| **2000Q3** | -0.542 | -0.438 | -0.893 | -1.285 | -1.632 | -1.360 | -1.005 | #VALUE! |
| **2000Q4** | -1.348 | -1.887 | -1.696 | -2.053 | -2.624 | -3.238 | -2.698 | -2.165 |
| **2001Q1** | 0.092 | -0.435 | -0.970 | -0.324 | -0.768 | #VALUE! | #VALUE! | #VALUE! |
| **2001Q2** | 0.091 | -0.271 | -0.704 | -0.958 | -0.587 | -1.027 | #VALUE! | #VALUE! |
| **2001Q3** | 0.183 | 0.183 | -0.451 | -0.425 | -0.946 | -0.578 | -1.014 | #VALUE! |
| **2001Q4** | 0.247 | 0.430 | 0.251 | -0.379 | -0.354 | -0.960 | -0.774 | -1.028 |
| **2002Q1** | -0.002 | 0.362 | 0.547 | 0.279 | -0.257 | #VALUE! | #VALUE! | #VALUE! |
| **2002Q2** | -0.081 | 0.009 | -0.171 | -0.348 | -0.885 | -1.055 | #VALUE! | #VALUE! |
| **2002Q3** | -0.626 | -0.167 | -0.167 | -0.436 | -0.702 | -1.325 | -1.403 | #VALUE! |
| **2002Q4** | -0.638 | -0.635 | -0.528 | -0.350 | -0.797 | -0.882 | -1.498 | -1.575 |
| **2003Q1** | 0.442 | -0.452 | -1.254 | -0.611 | -0.701 | #VALUE! | #VALUE! | #VALUE! |
| **2003Q2** | -0.038 | 0.580 | -0.314 | -0.479 | -0.197 | -0.285 | #VALUE! | #VALUE! |
| **2003Q3** | -0.270 | -0.620 | -0.006 | -0.535 | -0.520 | -0.685 | -0.861 | #VALUE! |
| **2003Q4** | 0.105 | -0.300 | -1.041 | -0.432 | -0.686 | -0.406 | -0.921 | -1.098 |
| **2004Q1** | 0.030 | 0.077 | -0.026 | -0.899 | -0.475 | #VALUE! | #VALUE! | #VALUE! |
| **2004Q2** | -0.055 | 0.113 | 0.383 | 0.651 | -0.392 | -0.149 | #VALUE! | #VALUE! |
| **2004Q3** | -0.633 | -0.680 | -0.651 | -0.275 | -0.051 | -0.822 | -0.756 | #VALUE! |
| **2004Q4** | -0.128 | -0.871 | -0.726 | -0.636 | -0.391 | -0.204 | -0.675 | -0.698 |

Table 2: UK interest rate forecast (taken as constant forecast from official bank rate)

| | Official Bank Rate | 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) |
|---|---|---|---|---|---|---|---|---|---|---|
| **1993Q1** | 6.13 | 6.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q2** | 5.88 | 6.00 | 6.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q3** | 5.88 | 6.00 | 6.00 | 6.00 | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q4** | 5.66 | 5.50 | 6.00 | 6.00 | 6.00 | N/A | N/A | N/A | N/A | N/A |
| **1994Q1** | 5.22 | 5.25 | 5.50 | 6.00 | 6.00 | 6.00 | N/A | N/A | N/A | N/A |
| **1994Q2** | 5.13 | 5.25 | 5.25 | 5.50 | 6.00 | 6.00 | 6.00 | N/A | N/A | N/A |
| **1994Q3** | 5.24 | 5.75 | 5.25 | 5.25 | 5.50 | 6.00 | 6.00 | 6.00 | N/A | N/A |
| **1994Q4** | 5.75 | 6.25 | 5.75 | 5.25 | 5.25 | 5.50 | 6.00 | 6.00 | 6.00 | N/A |
| **1995Q1** | 6.45 | 6.75 | 6.25 | 5.75 | 5.25 | 5.25 | 5.50 | 6.00 | 6.00 | 6.00 |
| **1995Q2** | 6.63 | 6.75 | 6.75 | 6.25 | 5.75 | 5.25 | 5.25 | 5.50 | 6.00 | 6.00 |
| **1995Q3** | 6.63 | 6.75 | 6.75 | 6.75 | 6.25 | 5.75 | 5.25 | 5.25 | 5.50 | 6.00 |
| **1995Q4** | 6.58 | 6.50 | 6.75 | 6.75 | 6.75 | 6.25 | 5.75 | 5.25 | 5.25 | 5.50 |
| **1996Q1** | 6.13 | 6.00 | 6.50 | 6.75 | 6.75 | 6.75 | 6.25 | 5.75 | 5.25 | 5.25 |
| **1996Q2** | 5.87 | 5.75 | 6.00 | 6.50 | 6.75 | 6.75 | 6.75 | 6.25 | 5.75 | 5.25 |
| **1996Q3** | 5.69 | 5.75 | 5.75 | 6.00 | 6.50 | 6.75 | 6.75 | 6.75 | 6.25 | 5.75 |
| **1996Q4** | 5.86 | 6.00 | 5.75 | 5.75 | 6.00 | 6.50 | 6.75 | 6.75 | 6.75 | 6.25 |
| **1997Q1** | 5.94 | 6.00 | 6.00 | 5.75 | 5.75 | 6.00 | 6.50 | 6.75 | 6.75 | 6.75 |
| **1997Q2** | 6.20 | 6.50 | 6.00 | 6.00 | 5.75 | 5.75 | 6.00 | 6.50 | 6.75 | 6.75 |
| **1997Q3** | 6.87 | 7.00 | 6.50 | 6.00 | 6.00 | 5.75 | 5.75 | 6.00 | 6.50 | 6.75 |
| **1997Q4** | 7.15 | 7.25 | 7.00 | 6.50 | 6.00 | 6.00 | 5.75 | 5.75 | 6.00 | 6.50 |
| **1998Q1** | 7.25 | 7.25 | 7.25 | 7.00 | 6.50 | 6.00 | 6.00 | 5.75 | 5.75 | 6.00 |
| **1998Q2** | 7.33 | 7.50 | 7.25 | 7.25 | 7.00 | 6.50 | 6.00 | 6.00 | 5.75 | 5.75 |
| **1998Q3** | 7.50 | 7.50 | 7.50 | 7.25 | 7.25 | 7.00 | 6.50 | 6.00 | 6.00 | 5.75 |
| **1998Q4** | 6.86 | 6.25 | 7.50 | 7.50 | 7.25 | 7.25 | 7.00 | 6.50 | 6.00 | 6.00 |
| **1999Q1** | 5.69 | 5.50 | 6.25 | 7.50 | 7.50 | 7.25 | 7.25 | 7.00 | 6.50 | 6.00 |
| **1999Q2** | 5.20 | 5.00 | 5.50 | 6.25 | 7.50 | 7.50 | 7.25 | 7.25 | 7.00 | 6.50 |
| **1999Q3** | 5.07 | 5.25 | 5.00 | 5.50 | 6.25 | 7.50 | 7.50 | 7.25 | 7.25 | 7.00 |
| **1999Q4** | 5.40 | 5.50 | 5.25 | 5.00 | 5.50 | 6.25 | 7.50 | 7.50 | 7.25 | 7.25 |
| **2000Q1** | 5.87 | 6.00 | 5.50 | 5.25 | 5.00 | 5.50 | 6.25 | 7.50 | 7.50 | 7.25 |
| **2000Q2** | 6.00 | 6.00 | 6.00 | 5.50 | 5.25 | 5.00 | 5.50 | 6.25 | 7.50 | 7.50 |
| **2000Q3** | 6.00 | 6.00 | 6.00 | 6.00 | 5.50 | 5.25 | 5.00 | 5.50 | 6.25 | 7.50 |
| **2000Q4** | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 5.50 | 5.25 | 5.00 | 5.50 | 6.25 |
| **2001Q1** | 5.86 | 5.75 | 6.00 | 6.00 | 6.00 | 6.00 | 5.50 | 5.25 | 5.00 | 5.50 |
| **2001Q2** | 5.36 | 5.25 | 5.75 | 6.00 | 6.00 | 6.00 | 6.00 | 5.50 | 5.25 | 5.00 |
| **2001Q3** | 5.05 | 4.75 | 5.25 | 5.75 | 6.00 | 6.00 | 6.00 | 6.00 | 5.50 | 5.25 |
| **2001Q4** | 4.23 | 4.00 | 4.75 | 5.25 | 5.75 | 6.00 | 6.00 | 6.00 | 6.00 | 5.50 |
| **2002Q1** | 4.00 | 4.00 | 4.00 | 4.75 | 5.25 | 5.75 | 6.00 | 6.00 | 6.00 | 6.00 |
| **2002Q2** | 4.00 | 4.00 | 4.00 | 4.00 | 4.75 | 5.25 | 5.75 | 6.00 | 6.00 | 6.00 |
| **2002Q3** | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.75 | 5.25 | 5.75 | 6.00 | 6.00 |
| **2002Q4** | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.75 | 5.25 | 5.75 | 6.00 |
| **2003Q1** | 3.85 | 3.75 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.75 | 5.25 | 5.75 |
| **2003Q2** | 3.75 | 3.75 | 3.75 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.75 | 5.25 |
| **2003Q3** | 3.53 | 3.50 | 3.75 | 3.75 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.75 |
| **2003Q4** | 3.65 | 3.75 | 3.50 | 3.75 | 3.75 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| **2004Q1** | 3.91 | 4.00 | 3.75 | 3.50 | 3.75 | 3.75 | 4.00 | 4.00 | 4.00 | 4.00 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **1993Q1** | 0.13 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q2** | -0.12 | -0.12 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q3** | -0.12 | -0.12 | -0.12 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q4** | 0.16 | -0.34 | -0.34 | -0.34 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1994Q1** | -0.03 | -0.28 | -0.78 | -0.78 | -0.78 | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1994Q2** | -0.12 | -0.12 | -0.37 | -0.87 | -0.87 | -0.87 | #VALUE! | #VALUE! | #VALUE! |
| **1994Q3** | -0.51 | -0.01 | -0.01 | -0.26 | -0.76 | -0.76 | -0.76 | #VALUE! | #VALUE! |
| **1994Q4** | -0.50 | 0.00 | 0.50 | 0.50 | 0.25 | -0.25 | -0.25 | -0.25 | #VALUE! |
| **1995Q1** | -0.30 | 0.20 | 0.70 | 1.20 | 1.20 | 0.95 | 0.45 | 0.45 | 0.45 |
| **1995Q2** | -0.12 | -0.12 | 0.38 | 0.88 | 1.38 | 1.38 | 1.13 | 0.63 | 0.63 |
| **1995Q3** | -0.12 | -0.12 | -0.12 | 0.38 | 0.88 | 1.38 | 1.38 | 1.13 | 0.63 |
| **1995Q4** | 0.08 | -0.17 | -0.17 | -0.17 | 0.33 | 0.83 | 1.33 | 1.33 | 1.08 |
| **1996Q1** | 0.13 | -0.37 | -0.62 | -0.62 | -0.62 | -0.12 | 0.38 | 0.88 | 0.88 |
| **1996Q2** | 0.12 | -0.13 | -0.63 | -0.88 | -0.88 | -0.88 | -0.38 | 0.12 | 0.62 |
| **1996Q3** | -0.06 | -0.06 | -0.31 | -0.81 | -1.06 | -1.06 | -1.06 | -0.56 | -0.06 |
| **1996Q4** | -0.14 | 0.11 | 0.11 | -0.14 | -0.64 | -0.89 | -0.89 | -0.89 | -0.39 |
| **1997Q1** | -0.06 | -0.06 | 0.19 | 0.19 | -0.06 | -0.56 | -0.81 | -0.81 | -0.81 |
| **1997Q2** | -0.30 | 0.20 | 0.20 | 0.45 | 0.45 | 0.20 | -0.30 | -0.55 | -0.55 |
| **1997Q3** | -0.13 | 0.37 | 0.87 | 0.87 | 1.12 | 1.12 | 0.87 | 0.37 | 0.12 |
| **1997Q4** | -0.10 | 0.15 | 0.65 | 1.15 | 1.15 | 1.40 | 1.40 | 1.15 | 0.65 |
| **1998Q1** | 0.00 | 0.00 | 0.25 | 0.75 | 1.25 | 1.25 | 1.50 | 1.50 | 1.25 |
| **1998Q2** | -0.17 | 0.08 | 0.08 | 0.33 | 0.83 | 1.33 | 1.33 | 1.58 | 1.58 |
| **1998Q3** | 0.00 | 0.00 | 0.25 | 0.25 | 0.50 | 1.00 | 1.50 | 1.50 | 1.75 |
| **1998Q4** | 0.61 | -0.64 | -0.64 | -0.39 | -0.39 | -0.14 | 0.36 | 0.86 | 0.86 |
| **1999Q1** | 0.19 | -0.56 | -1.81 | -1.81 | -1.56 | -1.56 | -1.31 | -0.81 | -0.31 |
| **1999Q2** | 0.20 | -0.30 | -1.05 | -2.30 | -2.30 | -2.05 | -2.05 | -1.80 | -1.30 |
| **1999Q3** | -0.18 | 0.07 | -0.43 | -1.18 | -2.43 | -2.43 | -2.18 | -2.18 | -1.93 |
| **1999Q4** | -0.10 | 0.15 | 0.40 | -0.10 | -0.85 | -2.10 | -2.10 | -1.85 | -1.85 |
| **2000Q1** | -0.13 | 0.37 | 0.62 | 0.87 | 0.37 | -0.38 | -1.63 | -1.63 | -1.38 |
| **2000Q2** | 0.00 | 0.00 | 0.50 | 0.75 | 1.00 | 0.50 | -0.25 | -1.50 | -1.50 |
| **2000Q3** | 0.00 | 0.00 | 0.00 | 0.50 | 0.75 | 1.00 | 0.50 | -0.25 | -1.50 |
| **2000Q4** | 0.00 | 0.00 | 0.00 | 0.00 | 0.50 | 0.75 | 1.00 | 0.50 | -0.25 |
| **2001Q1** | 0.11 | -0.14 | -0.14 | -0.14 | -0.14 | 0.36 | 0.61 | 0.86 | 0.36 |
| **2001Q2** | 0.11 | -0.39 | -0.64 | -0.64 | -0.64 | -0.64 | -0.14 | 0.11 | 0.36 |
| **2001Q3** | 0.30 | -0.20 | -0.70 | -0.95 | -0.95 | -0.95 | -0.95 | -0.45 | -0.20 |
| **2001Q4** | 0.23 | -0.52 | -1.02 | -1.52 | -1.77 | -1.77 | -1.77 | -1.77 | -1.27 |
| **2002Q1** | 0.00 | 0.00 | -0.75 | -1.25 | -1.75 | -2.00 | -2.00 | -2.00 | -2.00 |
| **2002Q2** | 0.00 | 0.00 | 0.00 | -0.75 | -1.25 | -1.75 | -2.00 | -2.00 | -2.00 |
| **2002Q3** | 0.00 | 0.00 | 0.00 | 0.00 | -0.75 | -1.25 | -1.75 | -2.00 | -2.00 |
| **2002Q4** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.75 | -1.25 | -1.75 | -2.00 |
| **2003Q1** | 0.10 | -0.15 | -0.15 | -0.15 | -0.15 | -0.15 | -0.90 | -1.40 | -1.90 |
| **2003Q2** | 0.00 | 0.00 | -0.25 | -0.25 | -0.25 | -0.25 | -0.25 | -1.00 | -1.50 |
| **2003Q3** | 0.03 | -0.22 | -0.22 | -0.47 | -0.47 | -0.47 | -0.47 | -0.47 | -1.22 |
| **2003Q4** | -0.10 | 0.15 | -0.10 | -0.10 | -0.35 | -0.35 | -0.35 | -0.35 | -0.35 |
| **2004Q1** | -0.09 | 0.16 | 0.41 | 0.16 | 0.16 | -0.09 | -0.09 | -0.09 | -0.09 |

Table 3: UK inflation forecast, measured in terms of RPIX

| | RPIX | I(t,t) | I(t-1,t) | I(t-2,t) | I(t-3,t) | I(t-4,t) | I(t-5,t) | I(t-6,t) | I(t-7,t) | I(t-8,t) |
|---|---|---|---|---|---|---|---|---|---|---|
| **1993Q1** | **3.4** | 3.50 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q2** | **2.8** | 3.40 | 3.40 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q3** | **3.1** | 2.90 | 3.40 | 3.00 | N/A | N/A | N/A | N/A | N/A | N/A |
| **1993Q4** | **2.7** | 3.30 | 3.00 | 3.20 | 3.10 | N/A | N/A | N/A | N/A | N/A |
| **1994Q1** | **2.7** | 2.80 | 3.60 | 3.20 | 3.20 | 3.40 | N/A | N/A | N/A | N/A |
| **1994Q2** | **2.4** | 2.70 | 3.00 | 3.50 | 3.30 | 3.50 | 3.40 | N/A | N/A | N/A |
| **1994Q3** | **2.2** | 2.30 | 2.90 | 3.10 | 3.50 | 3.30 | 3.60 | 3.40 | N/A | N/A |
| **1994Q4** | **2.3** | 2.10 | 2.60 | 3.00 | 3.20 | 3.40 | 3.30 | 3.70 | 3.30 | N/A |
| **1995Q1** | **2.7** | 2.90 | 1.90 | 2.70 | 3.10 | 3.40 | 3.40 | 3.50 | N/A | N/A |
| **1995Q2** | **2.7** | 2.70 | 2.80 | 2.00 | 3.00 | 3.40 | 3.30 | 3.40 | 3.60 | N/A |
| **1995Q3** | **2.9** | 2.90 | 3.00 | 3.10 | 2.30 | 3.20 | 3.40 | 3.20 | N/A | N/A |
| **1995Q4** | **2.9** | 3.20 | 3.00 | 3.10 | 3.20 | 2.40 | 3.20 | 3.30 | 3.20 | N/A |
| **1996Q1** | **2.9** | 2.80 | 3.30 | 3.20 | 3.40 | 2.70 | 2.80 | 3.40 | 3.30 | N/A |
| **1996Q2** | **2.8** | 2.70 | 2.60 | 3.50 | 3.50 | 3.80 | 2.70 | 2.40 | 3.10 | N/A |
| **1996Q3** | **2.9** | 2.70 | 2.60 | 2.30 | 3.20 | 3.40 | 3.70 | 2.60 | 2.40 | N/A |
| **1996Q4** | **3.2** | 3.10 | 2.40 | 2.40 | 2.10 | 3.00 | 3.20 | 3.40 | 2.50 | N/A |
| **1997Q1** | **2.9** | 2.80 | 2.90 | 2.40 | 2.30 | 2.10 | 2.70 | 2.90 | 3.00 | N/A |
| **1997Q2** | **2.6** | 2.60 | 2.40 | 2.90 | 2.40 | 2.30 | 2.20 | 2.70 | 2.80 | N/A |
| **1997Q3** | **2.8** | 2.65 | 2.50 | 2.30 | 2.70 | 2.60 | 2.50 | 2.30 | 2.70 | 2.80 |
| **1997Q4** | **2.8** | 2.60 | 2.32 | 2.40 | 2.30 | 2.40 | 2.70 | 2.60 | 2.50 | 2.70 |
| **1998Q1** | **2.6** | 2.60 | 2.51 | 2.19 | 2.40 | 2.40 | 2.60 | 2.80 | 2.70 | 2.60 |
| **1998Q2** | **2.9** | 2.83 | 2.63 | 2.42 | 2.06 | 2.40 | 2.70 | 2.70 | 2.90 | 2.80 |
| **1998Q3** | **2.5** | 2.51 | 2.35 | 2.42 | 2.27 | 1.99 | 2.50 | 2.80 | 2.90 | 3.00 |
| **1998Q4** | **2.5** | 2.54 | 2.56 | 2.35 | 2.41 | 2.19 | 2.08 | 2.60 | 2.90 | 3.10 |
| **1999Q1** | **2.5** | 2.49 | 2.57 | 2.69 | 2.41 | 2.44 | 2.18 | 2.24 | 2.80 | 3.00 |
| **1999Q2** | **2.3** | 2.48 | 2.53 | 2.71 | 2.82 | 2.37 | 2.39 | 2.25 | 2.36 | 2.90 |
| **1999Q3** | **2.2** | 2.31 | 2.40 | 2.55 | 2.74 | 2.86 | 2.30 | 2.47 | 2.37 | 2.50 |
| **1999Q4** | **2.2** | 2.20 | 2.28 | 2.36 | 2.61 | 2.59 | 2.77 | 2.26 | 2.55 | 2.42 |
| **2000Q1** | **2.1** | 1.93 | 2.12 | 2.09 | 2.20 | 2.52 | 2.56 | 2.69 | 2.27 | 2.64 |
| **2000Q2** | **2.1** | 1.88 | 1.98 | 2.06 | 1.99 | 2.23 | 2.49 | 2.51 | 2.56 | 2.35 |
| **2000Q3** | **2.1** | 2.38 | 1.93 | 1.95 | 2.02 | 1.88 | 2.25 | 2.47 | 2.48 | 2.47 |
| **2000Q4** | **2.1** | 2.36 | 2.28 | 2.10 | 2.05 | 1.84 | 1.92 | 2.23 | 2.47 | 2.45 |
| **2001Q1** | **1.9** | 1.94 | 2.33 | 2.26 | 2.20 | 2.32 | 1.72 | 2.08 | 2.35 | 2.56 |
| **2001Q2** | **2.3** | 1.90 | 1.92 | 2.22 | 2.39 | 2.47 | 2.48 | 1.81 | 2.28 | 2.43 |
| **2001Q3** | **2.4** | 2.31 | 1.90 | 1.87 | 2.19 | 2.48 | 2.53 | 2.53 | 2.19 | 2.59 |
| **2001Q4** | **2** | 2.00 | 2.17 | 1.91 | 1.87 | 2.19 | 2.62 | 2.53 | 2.56 | 2.53 |
| **2002Q1** | **2.4** | 2.14 | 2.03 | 2.17 | 1.91 | 2.09 | 2.18 | 2.68 | 2.53 | 2.58 |
| **2002Q2** | **1.9** | 2.02 | 1.87 | 1.85 | 1.91 | 1.94 | 2.18 | 2.37 | 2.70 | 2.56 |
| **2002Q3** | **2** | 1.84 | 2.08 | 1.96 | 2.06 | 1.96 | 2.03 | 2.27 | 2.46 | 2.72 |
| **2002Q4** | **2.6** | 2.64 | 2.25 | 2.24 | 2.11 | 2.06 | 2.13 | 2.16 | 2.42 | 2.56 |
| **2003Q1** | **2.9** | 2.77 | 2.73 | 2.25 | 2.18 | 2.13 | 2.08 | 2.32 | 2.39 | 2.55 |
| **2003Q2** | **2.9** | 3.09 | 2.90 | 2.72 | 2.25 | 2.05 | 2.13 | 2.15 | 2.41 | 2.53 |
| **2003Q3** | **2.8** | 2.85 | 2.90 | 2.98 | 2.72 | 2.31 | 2.09 | 2.18 | 2.23 | 2.45 |
| **2003Q4** | **2.6** | 2.72 | 2.58 | 2.63 | 2.78 | 2.41 | 2.29 | 2.26 | 2.28 | 2.36 |
| **2004Q1** | **2.3** | 2.32 | 2.55 | 2.30 | 2.40 | 2.70 | 2.38 | 2.31 | 2.39 | 2.34 |

| Forecast Error | I(t,t) | I(t-1,t) | I(t-2,t) | I(t-3,t) | I(t-4,t) | I(t-5,t) | I(t-6,t) | I(t-7,t) | I(t-8,t) |
|---|---|---|---|---|---|---|---|---|---|
| **1993Q1** | -0.10 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q2** | -0.60 | -0.60 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q3** | 0.20 | -0.30 | 0.10 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1993Q4** | -0.60 | -0.30 | -0.50 | -0.40 | #VALUE! | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1994Q1** | -0.10 | -0.90 | -0.50 | -0.50 | -0.70 | #VALUE! | #VALUE! | #VALUE! | #VALUE! |
| **1994Q2** | -0.30 | -0.60 | -1.10 | -0.90 | -1.10 | -1.00 | #VALUE! | #VALUE! | #VALUE! |
| **1994Q3** | -0.10 | -0.70 | -0.90 | -1.30 | -1.10 | -1.40 | -1.20 | #VALUE! | #VALUE! |
| **1994Q4** | 0.20 | -0.30 | -0.70 | -0.90 | -1.10 | -1.00 | -1.40 | -1.00 | #VALUE! |
| **1995Q1** | -0.20 | 0.80 | 0.00 | -0.40 | -0.70 | -0.70 | -0.80 | #VALUE! | #VALUE! |
| **1995Q2** | 0.00 | -0.10 | 0.70 | -0.30 | -0.70 | -0.60 | -0.70 | -0.90 | #VALUE! |
| **1995Q3** | 0.00 | -0.10 | -0.20 | 0.60 | -0.30 | -0.50 | -0.30 | #VALUE! | #VALUE! |
| **1995Q4** | -0.30 | -0.10 | -0.20 | -0.30 | 0.50 | -0.30 | -0.40 | -0.30 | #VALUE! |
| **1996Q1** | 0.10 | -0.40 | -0.30 | -0.50 | 0.20 | 0.10 | -0.50 | -0.40 | #VALUE! |
| **1996Q2** | 0.10 | 0.20 | -0.70 | -0.70 | -1.00 | 0.10 | 0.40 | -0.30 | #VALUE! |
| **1996Q3** | 0.20 | 0.30 | 0.60 | -0.30 | -0.50 | -0.80 | 0.30 | 0.50 | #VALUE! |
| **1996Q4** | 0.10 | 0.80 | 0.80 | 1.10 | 0.20 | 0.00 | -0.20 | 0.70 | #VALUE! |
| **1997Q1** | 0.10 | 0.00 | 0.50 | 0.60 | 0.80 | 0.20 | 0.00 | -0.10 | #VALUE! |
| **1997Q2** | 0.00 | 0.20 | -0.30 | 0.20 | 0.30 | 0.40 | -0.10 | -0.20 | #VALUE! |
| **1997Q3** | 0.15 | 0.30 | 0.50 | 0.10 | 0.20 | 0.30 | 0.50 | 0.10 | 0.00 |
| **1997Q4** | 0.20 | 0.48 | 0.40 | 0.50 | 0.40 | 0.10 | 0.20 | 0.30 | 0.10 |
| **1998Q1** | 0.00 | 0.09 | 0.41 | 0.20 | 0.20 | 0.00 | -0.20 | -0.10 | 0.00 |
| **1998Q2** | 0.07 | 0.27 | 0.48 | 0.84 | 0.50 | 0.20 | 0.20 | 0.00 | 0.10 |
| **1998Q3** | -0.01 | 0.15 | 0.08 | 0.23 | 0.51 | 0.00 | -0.30 | -0.40 | -0.50 |
| **1998Q4** | -0.04 | -0.06 | 0.15 | 0.09 | 0.31 | 0.42 | -0.10 | -0.40 | -0.60 |
| **1999Q1** | 0.01 | -0.07 | -0.19 | 0.09 | 0.06 | 0.32 | 0.26 | -0.30 | -0.50 |
| **1999Q2** | -0.18 | -0.23 | -0.41 | -0.52 | -0.07 | -0.09 | 0.05 | -0.06 | -0.60 |
| **1999Q3** | -0.11 | -0.20 | -0.35 | -0.54 | -0.66 | -0.10 | -0.27 | -0.17 | -0.30 |
| **1999Q4** | 0.00 | -0.08 | -0.16 | -0.41 | -0.39 | -0.57 | -0.06 | -0.35 | -0.22 |
| **2000Q1** | 0.17 | -0.02 | 0.01 | -0.10 | -0.42 | -0.46 | -0.59 | -0.17 | -0.54 |
| **2000Q2** | 0.22 | 0.12 | 0.04 | 0.11 | -0.13 | -0.39 | -0.41 | -0.46 | -0.25 |
| **2000Q3** | -0.28 | 0.17 | 0.15 | 0.08 | 0.22 | -0.15 | -0.37 | -0.38 | -0.37 |
| **2000Q4** | -0.26 | -0.18 | 0.00 | 0.05 | 0.26 | 0.18 | -0.13 | -0.37 | -0.35 |
| **2001Q1** | -0.04 | -0.43 | -0.36 | -0.30 | -0.42 | 0.18 | -0.18 | -0.45 | -0.66 |
| **2001Q2** | 0.40 | 0.38 | 0.08 | -0.09 | -0.17 | -0.18 | 0.49 | 0.02 | -0.13 |
| **2001Q3** | 0.09 | 0.50 | 0.53 | 0.21 | -0.08 | -0.13 | -0.13 | 0.21 | -0.19 |
| **2001Q4** | 0.00 | -0.17 | 0.09 | 0.13 | -0.19 | -0.62 | -0.53 | -0.56 | -0.53 |
| **2002Q1** | 0.26 | 0.37 | 0.23 | 0.49 | 0.31 | 0.22 | -0.28 | -0.13 | -0.18 |
| **2002Q2** | -0.12 | 0.03 | 0.05 | -0.01 | -0.04 | -0.28 | -0.47 | -0.80 | -0.66 |
| **2002Q3** | 0.16 | -0.08 | 0.04 | -0.06 | 0.04 | -0.03 | -0.27 | -0.46 | -0.72 |
| **2002Q4** | -0.04 | 0.35 | 0.36 | 0.49 | 0.54 | 0.47 | 0.44 | 0.18 | 0.04 |
| **2003Q1** | 0.13 | 0.17 | 0.65 | 0.72 | 0.77 | 0.82 | 0.58 | 0.51 | 0.35 |
| **2003Q2** | -0.19 | 0.00 | 0.18 | 0.65 | 0.85 | 0.77 | 0.75 | 0.49 | 0.37 |
| **2003Q3** | -0.05 | -0.10 | -0.18 | 0.08 | 0.49 | 0.71 | 0.62 | 0.57 | 0.35 |
| **2003Q4** | -0.12 | 0.02 | -0.03 | -0.18 | 0.19 | 0.31 | 0.34 | 0.32 | 0.24 |
| **2004Q1** | -0.02 | -0.25 | 0.00 | -0.10 | -0.40 | -0.08 | -0.01 | -0.09 | -0.04 |

Table 4: NZ inflation forecast

| | NZ CPI | 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) |
|---|---|---|---|---|---|---|---|---|---|---|
| 00Q1 | 1.477676 | 1.7141 | 2.4854 | 2.0948 | 1.7582 | 1.1822 | -0.8155 | 0.0915 | 0.8099 | 0.1788 |
| 00Q2 | 1.986044 | 2.1262 | 2.0698 | 2.9753 | 2.2734 | 1.8014 | 1.3606 | -0.0900 | 0.6371 | 0.9883 |
| 00Q3 | 2.958595 | 2.5660 | 2.2882 | 2.0794 | 2.6521 | 1.8400 | 1.5252 | 1.2645 | 0.5472 | 1.0906 |
| 00Q4 | 3.919932 | 3.7594 | 2.8568 | 2.4139 | 2.2133 | 2.1684 | 1.5146 | 1.4694 | 1.2600 | 1.0018 |
| 01Q1 | 3.032903 | 3.1241 | 3.7636 | 2.6445 | 2.0240 | 1.8314 | 1.9732 | 1.3922 | 1.4570 | 1.4363 |
| 01Q2 | 3.203955 | 3.2419 | 3.0331 | 3.6606 | 2.3186 | 1.9715 | 1.7234 | 1.7227 | 1.3969 | 1.4197 |
| 01Q3 | 2.401206 | 2.4314 | 2.4693 | 2.2198 | 2.8568 | 1.6776 | 1.8220 | 1.6831 | 1.6280 | 1.4270 |
| 01Q4 | 1.807237 | 1.8107 | 1.8709 | 1.7194 | 1.2038 | 2.2560 | 1.4703 | 1.8146 | 1.6606 | 1.5528 |
| 02Q1 | 2.561823 | 2.9384 | 2.5619 | 2.4740 | 2.2363 | 1.4365 | 1.9250 | 1.3555 | 1.7493 | 1.6575 |
| 02Q2 | 2.726831 | 2.8198 | 2.8164 | 2.3110 | 1.9379 | 1.7054 | 1.0832 | 1.7063 | 1.4234 | 1.7467 |
| 02Q3 | 2.619137 | 2.7070 | 2.9000 | 2.8800 | 2.1780 | 1.6849 | 1.5083 | 0.8458 | 1.5191 | 1.5269 |
| 02Q4 | 2.696539 | 2.6026 | 2.6905 | 2.7222 | 2.6931 | 1.9445 | 1.4674 | 1.5077 | 1.0545 | 1.5166 |
| 03Q1 | 2.498789 | 2.4986 | 2.3092 | 2.4447 | 2.5935 | 2.1414 | 1.7127 | 1.4154 | 1.5472 | 1.2881 |
| 03Q2 | 1.471712 | 1.8360 | 2.0185 | 1.7495 | 1.8695 | 1.9786 | 1.8464 | 1.4216 | 1.4484 | 1.5414 |
| 03Q3 | 1.464979 | 1.8293 | 1.8276 | 1.8655 | 1.8074 | 1.7724 | 1.8732 | 1.7092 | 1.3258 | 1.4683 |
| 03Q4 | 1.546299 | 1.1840 | 1.8176 | 1.5783 | 1.7044 | 1.8177 | 1.6885 | 2.0321 | 1.8194 | 1.3391 |
| 04Q1 | 1.540704 | 1.8107 | 1.2704 | 1.8348 | 1.6574 | 1.9419 | 2.0831 | 1.8248 | 2.1210 | 1.8812 |
| 04Q2 | 2.347878 | 2.4407 | 2.4407 | 1.8704 | 2.3551 | 1.7897 | 2.0267 | 2.1637 | 1.8138 | 2.1123 |
| 04Q3 | 2.515281 | 2.4225 | 2.6953 | 2.5476 | 1.8814 | 2.1573 | 1.8777 | 2.3423 | 2.1963 | 1.7874 |
| 04Q4 | 2.67416 | 2.4973 | 2.4972 | 2.8403 | 2.3834 | 2.1453 | 2.2085 | 2.0637 | 2.4610 | 2.1991 |
| 05Q1 | 2.752336 | 2.9241 | 2.8397 | 2.8849 | 3.3014 | 2.4700 | 2.3729 | 2.5342 | 2.2222 | 2.4288 |
| 05Q2 | 2.817762 | 2.8178 | 2.8969 | 2.8147 | 2.9418 | 3.2924 | 2.5493 | 2.4609 | 2.7189 | 2.3306 |
| 05Q3 | 3.319554 | 3.4061 | 2.8870 | 2.9072 | 2.8832 | 3.1742 | 3.2743 | 2.6599 | 2.6682 | 2.7794 |
| 05Q4 | 3.119725 | 3.3764 | 3.5475 | 2.7392 | 2.7981 | 2.9335 | 3.0968 | 3.0416 | 2.7335 | 2.6908 |
| 06Q1 | 3.276246 | 3.2762 | 3.3619 | 3.8220 | 3.0060 | 2.9748 | 2.9781 | 3.0581 | 2.8198 | 2.6145 |
| 06Q2 | 3.923916 | 3.8395 | 3.1638 | 3.3144 | 3.8700 | 2.8741 | 2.9773 | 2.9294 | 2.8898 | 2.5073 |
| 06Q3 | 3.499348 | 3.7977 | 3.6308 | 2.6297 | 2.8415 | 3.3424 | 2.8950 | 3.0752 | 2.9330 | 2.7951 |
| 06Q4 | 2.616393 | 2.7157 | 3.7723 | 3.8618 | 2.7085 | 2.7091 | 3.0109 | 2.8858 | 3.0069 | 2.8000 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| 00Q1 | -0.236 | -1.008 | -0.617 | -0.281 | 0.295 | 2.293 | 1.386 | 0.668 | 1.299 |
| 00Q2 | -0.140 | -0.084 | -0.989 | -0.287 | 0.185 | 0.625 | 2.076 | 1.349 | 0.998 |
| 00Q3 | 0.393 | 0.670 | 0.879 | 0.306 | 1.119 | 1.433 | 1.694 | 2.411 | 1.868 |
| 00Q4 | 0.161 | 1.063 | 1.506 | 1.707 | 1.752 | 2.405 | 2.451 | 2.660 | 2.918 |
| 01Q1 | -0.091 | -0.731 | 0.388 | 1.009 | 1.202 | 1.060 | 1.641 | 1.576 | 1.597 |
| 01Q2 | -0.038 | 0.171 | -0.457 | 0.885 | 1.232 | 1.481 | 1.481 | 1.807 | 1.784 |
| 01Q3 | -0.030 | -0.068 | 0.181 | -0.456 | 0.724 | 0.579 | 0.718 | 0.773 | 0.974 |
| 01Q4 | -0.003 | -0.064 | 0.088 | 0.603 | -0.449 | 0.337 | -0.007 | 0.147 | 0.254 |
| 02Q1 | -0.377 | 0.000 | 0.088 | 0.326 | 1.125 | 0.637 | 1.206 | 0.813 | 0.904 |
| 02Q2 | -0.093 | -0.090 | 0.416 | 0.789 | 1.021 | 1.644 | 1.021 | 1.303 | 0.980 |
| 02Q3 | -0.088 | -0.281 | -0.261 | 0.441 | 0.934 | 1.111 | 1.773 | 1.100 | 1.092 |
| 02Q4 | 0.094 | 0.006 | -0.026 | 0.003 | 0.752 | 1.229 | 1.189 | 1.642 | 1.180 |
| 03Q1 | 0.000 | 0.190 | 0.054 | -0.095 | 0.357 | 0.786 | 1.083 | 0.952 | 1.211 |
| 03Q2 | -0.364 | -0.547 | -0.278 | -0.398 | -0.507 | -0.375 | 0.050 | 0.023 | -0.070 |
| 03Q3 | -0.364 | -0.363 | -0.401 | -0.342 | -0.307 | -0.408 | -0.244 | 0.139 | -0.003 |
| 03Q4 | 0.362 | -0.271 | -0.032 | -0.158 | -0.271 | -0.142 | -0.486 | -0.273 | 0.207 |
| 04Q1 | -0.270 | 0.270 | -0.294 | -0.117 | -0.401 | -0.542 | -0.284 | -0.580 | -0.340 |
| 04Q2 | -0.093 | -0.093 | 0.477 | -0.007 | 0.558 | 0.321 | 0.184 | 0.534 | 0.236 |
| 04Q3 | 0.093 | -0.180 | -0.032 | 0.634 | 0.358 | 0.638 | 0.173 | 0.319 | 0.728 |
| 04Q4 | 0.177 | 0.177 | -0.166 | 0.291 | 0.529 | 0.466 | 0.610 | 0.213 | 0.475 |
| 05Q1 | -0.172 | -0.087 | -0.133 | -0.549 | 0.282 | 0.379 | 0.218 | 0.530 | 0.324 |
| 05Q2 | 0.000 | -0.079 | 0.003 | -0.124 | -0.475 | 0.268 | 0.357 | 0.099 | 0.487 |
| 05Q3 | -0.087 | 0.433 | 0.412 | 0.436 | 0.145 | 0.045 | 0.660 | 0.651 | 0.540 |
| 05Q4 | -0.257 | -0.428 | 0.381 | 0.322 | 0.186 | 0.023 | 0.078 | 0.386 | 0.429 |
| 06Q1 | 0.000 | -0.086 | -0.546 | 0.270 | 0.301 | 0.298 | 0.218 | 0.456 | 0.662 |
| 06Q2 | 0.084 | 0.760 | 0.610 | 0.054 | 1.050 | 0.947 | 0.995 | 1.034 | 1.417 |
| 06Q3 | -0.298 | -0.131 | 0.870 | 0.658 | 0.157 | 0.604 | 0.424 | 0.566 | 0.704 |
| 06Q4 | -0.099 | -1.156 | -1.245 | -0.092 | -0.093 | -0.394 | -0.269 | -0.391 | -0.184 |

## Appendix 2

We apply exactly the same four equations used earlier to assess the predictive abilities of interest rate forecasts. To recap, these are:-

(1) $\Pi(t + h) = C_1 + C_2$ Forecast (t, t + h)

(2) $\Pi(t + h) – \Pi(t) = C_1 + C_2$ (Forecast (t, t + h) – $\Pi_t$)

(3) $\Pi(t + h) – \Pi(t + h - 1) = C_1 + C_2$ (Forecast, t, t + h – Forecast, t, t + h – 1)

(4) $\Pi(t + h) – \Pi(t + h - 1) = C$ (Forecast, t, t + h – Forecast, t, t + h – 1)

### A. New Zealand

Equation (1)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 0 | -0.1391<br>0.1783 | 1.0231<br>0.0000 | 0.9310 | 2.0267 |
| 1 | -0.0862<br>0.6248 | 0.9924<br>0.0000 | 0.8120 | 1.6955 |
| 2 | 0.0944<br>0.6433 | 0.9463<br>0.0000 | 0.7384 | 1.4151 |
| 3 | 0.2126<br>0.3375 | 0.9595<br>0.0000 | 0.6893 | 1.1257 |
| 4 | 0.5161<br>0.0627 | 0.8857<br>0.0000 | 0.5154 | 0.8608 |
| 5 | 0.7117<br>0.0157 | 0.8286<br>0.0000 | 0.4362 | 0.7280 |
| 6 | 0.7607<br>0.0160 | 0.8285<br>0.0000 | 0.3933 | 0.5368 |
| 7 | 0.8159<br>0.0273 | 0.7988<br>0.0003 | 0.3056 | 0.5343 |
| 8 | 0.8368<br>0.0487 | 0.7989<br>0.0017 | 0.2484 | 0.5281 |

Mincer-Zarnowitz test

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| F-statistics | 0.1045 | 0.3521 | 0.8132 | 0.3496 | 0.0326 | 0.0059 | 0.0039 | 0.0075 | 0.0096 |
| Chi - square | 0.0924 | 0.3429 | 0.8123 | 0.3399 | 0.0237 | 0.0028 | 0.0016 | 0.0036 | 0.0049 |

Equation (2)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 1 | -0.0696<br>0.2780 | 0.6567<br>0.0000 | 0.4941 | 1.7563 |
| 2 | -0.0103<br>0.9005 | 0.8232<br>0.0000 | 0.6571 | 1.4428 |
| 3 | 0.1286<br>0.1796 | 0.9126<br>0.0000 | 0.7147 | 1.1201 |
| 4 | 0.3184<br>0.0149 | 1.0095<br>0.0000 | 0.6659 | 0.9486 |
| 5 | 0.4567<br>0.0026 | 1.0698<br>0.0000 | 0.6589 | 0.8457 |
| 6 | 0.5065<br>0.0018 | 1.0439<br>0.0000 | 0.6370 | 0.5965 |
| 7 | 0.5010<br>0.0039 | 1.0159<br>0.0000 | 0.5966 | 0.5903 |
| 8 | 0.5218<br>0.0041 | 1.0249<br>0.0000 | 0.5865 | 0.6008 |

Mincer-Zarnowitz test

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| F-statistics | 0.0025 | 0.1725 | 0.2402 | 0.0458 | 0.0094 | 0.0061 | 0.0122 | 0.0136 |
| Chi - square | 0.0010 | 0.1596 | 0.2280 | 0.0354 | 0.0051 | 0.0028 | 0.0068 | 0.0077 |

Equation (3)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 1 | -0.0137<br>0.8208 | 0.9277<br>0.0000 | 0.5309 | 1.9732 |
| 2 | 0.0537<br>0.4221 | 0.8646<br>0.0000 | 0.4478 | 1.8140 |
| 3 | 0.1050<br>0.1557 | 0.8361<br>0.0000 | 0.3947 | 1.6199 |
| 4 | 0.1729<br>0.0595 | 0.9784<br>0.0004 | 0.2817 | 1.5413 |
| 5 | 0.0651<br>0.5227 | 0.5960<br>0.1406 | 0.0562 | 1.4585 |
| 6 | 0.0254<br>0.7901 | 0.2647<br>0.5409 | 0.0102 | 1.4985 |
| 7 | 0.0237<br>0.8131 | 0.2867<br>0.5812 | 0.0085 | 1.5198 |
| 8 | 0.0292<br>0.7756 | 0.2907<br>0.6016 | 0.0079 | 1.4960 |

Equation (4)

| h = | C1 (P value) | R sq. | DW |
|---|---|---|---|
| 1 | 0.9272<br>0.0000 | 0.5303 | 1.9705 |
| 2 | 0.8506<br>0.0000 | 0.4390 | 1.7795 |
| 3 | 0.7786<br>0.0000 | 0.3630 | 1.5161 |
| 4 | 0.7461<br>0.0021 | 0.2122 | 1.4245 |
| 5 | 0.4902<br>0.1785 | 0.0459 | 1.4263 |
| 6 | 0.2570<br>0.5468 | 0.0083 | 1.4938 |
| 7 | 0.3216<br>0.5135 | 0.0070 | 1.5240 |
| 8 | 0.3322<br>0.5315 | 0.0055 | 1.4965 |

UK, Full period, 1970 Q1 – 2006 Q4 (148 observations)

Equation (1)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 0 | 0.1444<br>0.1800 | 0.9468<br>0.0000 | 0.9714 | 1.9374 |
| 1 | 0.1022<br>0.5373 | 0.9566<br>0.0000 | 0.9348 | 1.5251 |
| 2 | -0.0344<br>0.8706 | 0.9718<br>0.0000 | 0.9001 | 0.9948 |
| 3 | -0.2441<br>0.3598 | 1.0233<br>0.0000 | 0.8548 | 0.7655 |
| 4 | -0.3719<br>0.3170 | 1.0709<br>0.0000 | 0.7508 | 0.6540 |
| 5 | -0.3672<br>0.4987 | 1.0688<br>0.0000 | 0.6306 | 0.4664 |
| 6 | -0.4295<br>0.4969 | 1.0163<br>0.0000 | 0.6259 | 0.4724 |
| 7 | -0.5799<br>0.4217 | 0.9981<br>0.0000 | 0.6796 | 0.4895 |

Mincer-Zarnowitz test

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| F-statistics | 0.0000 | 0.0349 | 0.1571 | 0.6508 | 0.3799 | 0.6529 | 0.5630 | 0.2081 |
| Chi - square | 0.0000 | 0.0322 | 0.1534 | 0.6500 | 0.3774 | 0.6519 | 0.5606 | 0.1957 |

Equation (2)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 1 | -0.1098<br>0.2629 | 0.6228<br>0.0000 | 0.3178 | 1.6409 |
| 2 | -0.1801<br>0.1604 | 0.8278<br>0.0000 | 0.4805 | 0.9595 |
| 3 | -0.0962<br>0.5364 | 0.8812<br>0.0000 | 0.5285 | 0.7048 |
| 4 | 0.0234<br>0.9084 | 0.7873<br>0.0000 | 0.4067 | 0.5236 |
| 5 | -0.0320<br>0.9076 | 0.7631<br>0.0000 | 0.3413 | 0.3876 |
| 6 | -0.4646<br>0.1316 | 0.7543<br>0.0000 | 0.4335 | 0.4276 |
| 7 | -0.8177<br>0.0089 | 0.7292<br>0.0000 | 0.6658 | 0.7168 |

Mincer-Zarnowitz test

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| F-statistics | 0.0000 | 0.0158 | 0.1900 | 0.0296 | 0.0581 | 0.0295 | 0.0014 |
| Chi -square | 0.0000 | 0.0140 | 0.1864 | 0.0271 | 0.0542 | 0.0249 | 0.0004 |

Equation (3)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 1 | 0.0126<br>0.8957 | 0.8252<br>0.0000 | 0.3296 | 2.1921 |
| 2 | -0.0390<br>0.6950 | 0.8202<br>0.0000 | 0.2947 | 2.0793 |
| 3 | 0.0495<br>0.6592 | 0.5421<br>0.0000 | 0.1310 | 1.9386 |
| 4 | 0.0462<br>0.6958 | 0.3937<br>0.0000 | 0.0645 | 1.8729 |
| 5 | -0.1459<br>0.2873 | 0.2147<br>0.3507 | 0.0075 | 1.6207 |
| 6 | -0.3097<br>0.0252 | 0.7101<br>0.0307 | 0.0600 | 2.1630 |
| 7 | -0.4859<br>0.0165 | 0.3647<br>0.3127 | 0.0249 | 1.9474 |

Equation (4)

| h = | C1 (P value) | R sq. | DW |
|---|---|---|---|
| 1 | 0.8248<br>0.0000 | 0.3295 | 2.1918 |
| 2 | 0.8191<br>0.0000 | 0.2939 | 2.0770 |
| 3 | 0.5353<br>0.0000 | 0.1298 | 1.9353 |
| 4 | 0.3845<br>0.0021 | 0.0635 | 1.8694 |
| 5 | 0.2489<br>0.2751 | -0.0023 | 1.6110 |
| 6 | 0.8267<br>0.0135 | -0.0045 | 2.0228 |
| 7 | 0.7160<br>0.0458 | -0.1239 | 1.6468 |

UK, Short period, 1992 Q4 – 2004 Q3 (48 observations)

Equation (1)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 1 | 0.4218<br>0.0348 | 0.7224<br>0.0000 | 0.6478 | 1.2704 |
| 2 | 0.4671<br>0.0383 | 0.4671<br>0.0000 | 0.5680 | 1.1885 |
| 3 | 0.5502<br>0.0112 | 0.5548<br>0.0000 | 0.5580 | 1.3074 |
| 4 | 0.5573<br>0.0210 | 0.5169<br>0.0000 | 0.4900 | 1.1480 |
| 5 | 0.5482<br>0.1080 | 0.4851<br>0.0001 | 0.3792 | 0.8582 |
| 6 | 0.2578<br>0.5884 | 0.5415<br>0.0021 | 0.3849 | 1.0940 |
| 7 | -0.2306<br>0.7366 | 0.6643<br>0.0103 | 0.5367 | |

Mincer-Zarnowitz test

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| F-statistics | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0003 |
| Chi - square | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Equation (2)

| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 1 | -0.1131<br>0.0862 | 0.3723<br>0.0034 | 0.1716 | 2.0092 |
| 2 | -0.2818<br>0.0035 | 0.4803<br>0.0009 | 0.2192 | 1.2290 |
| 3 | -0.4209<br>0.0005 | 0.5700<br>0.0007 | 0.2343 | 1.0293 |
| 4 | -0.5604<br>0.0002 | 0.6299<br>0.0013 | 0.2161 | 0.9151 |
| 5 | -0.4121<br>0.0229 | 0.2147<br>0.3211 | 0.0318 | 0.9234 |
| 6 | -0.5459<br>0.0302 | 0.1980<br>0.4929 | 0.0238 | 0.9077 |
| 7 | -1.0318<br>0.0270 | 0.7196<br>0.0966 | 0.2765 | |

Mincer-Zarnowitz test

Null hypothesis: $C_1 = 0$ and $C_2 = 1$

| H | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| F-statistics | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0008 |
| Chi - square | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

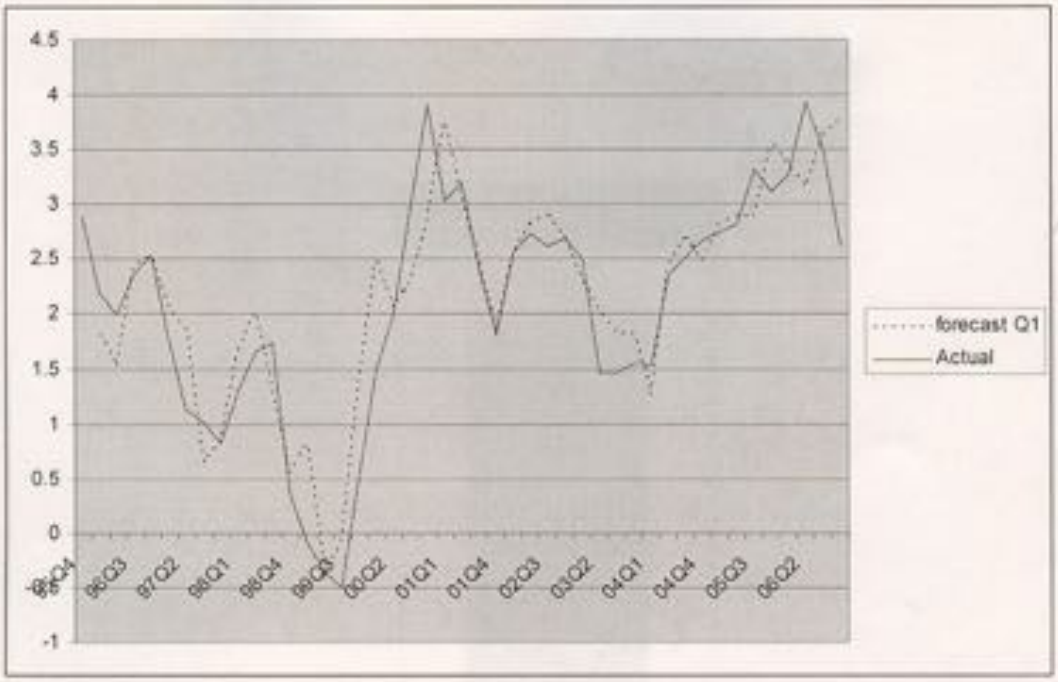
Equation (3)

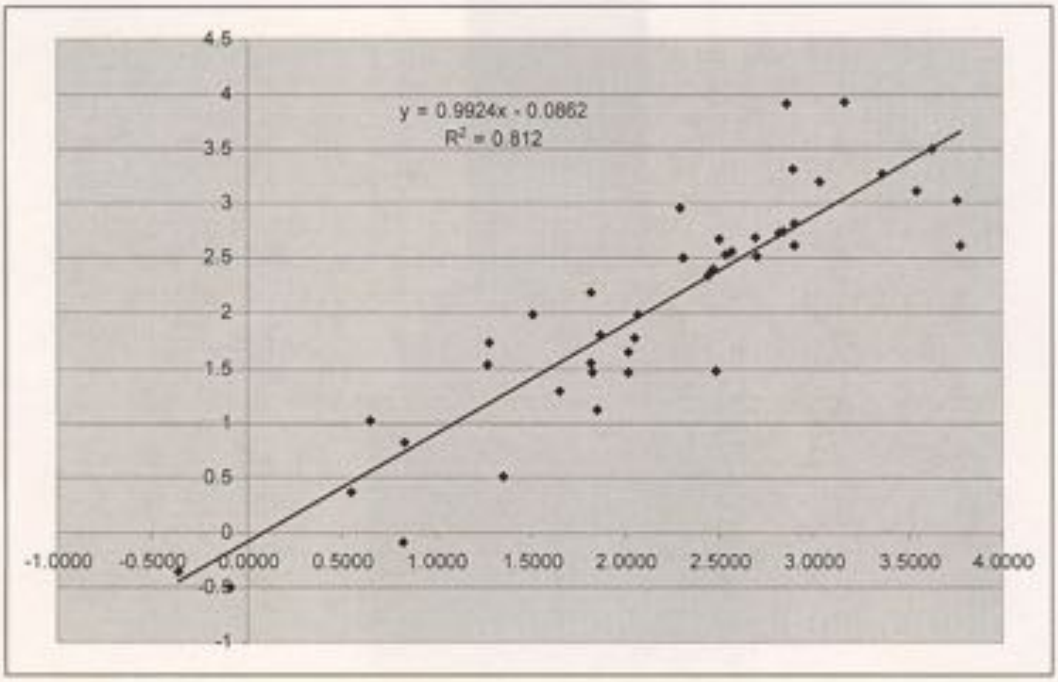
| h = | C1 (P value) | C2 (P value) | R sq. | DW |
|---|---|---|---|---|
| 1 | -0.0823<br>0.1796 | 0.6925<br>0.0010 | 0.2120 | 2.3528 |
| 2 | -0.1662<br>0.0526 | 0.5282<br>0.0353 | 0.0947 | 2.3269 |
| 3 | -0.0377<br>0.6305 | -0.2351<br>0.5331 | 0.0089 | 2.3709 |
| 4 | -0.0433<br>0.6138 | -0.0425<br>0.9285 | 0.0002 | 2.4105 |
| 5 | -0.0653<br>0.5173 | -0.0587<br>0.9230 | 0.0003 | 1.4393 |
| 6 | -0.1186<br>0.2969 | -0.1259<br>0.8818 | 0.0011 | 1.4319 |
| 7 | -0.0807<br>0.6820 | 0.4471<br>0.8132 | 0.0065 | |

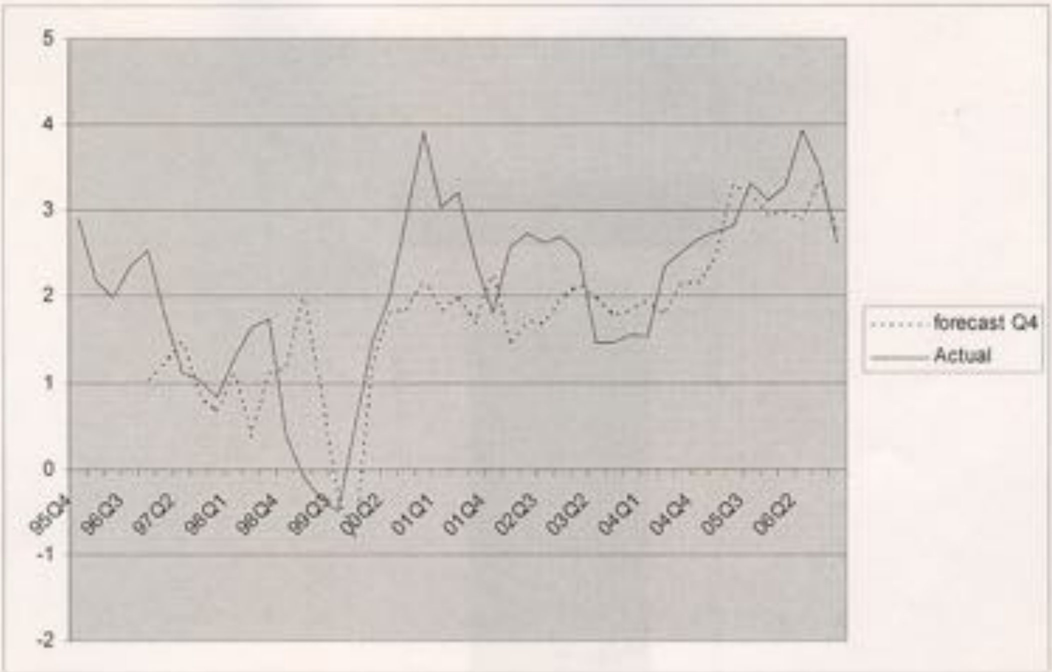
Equation (4)

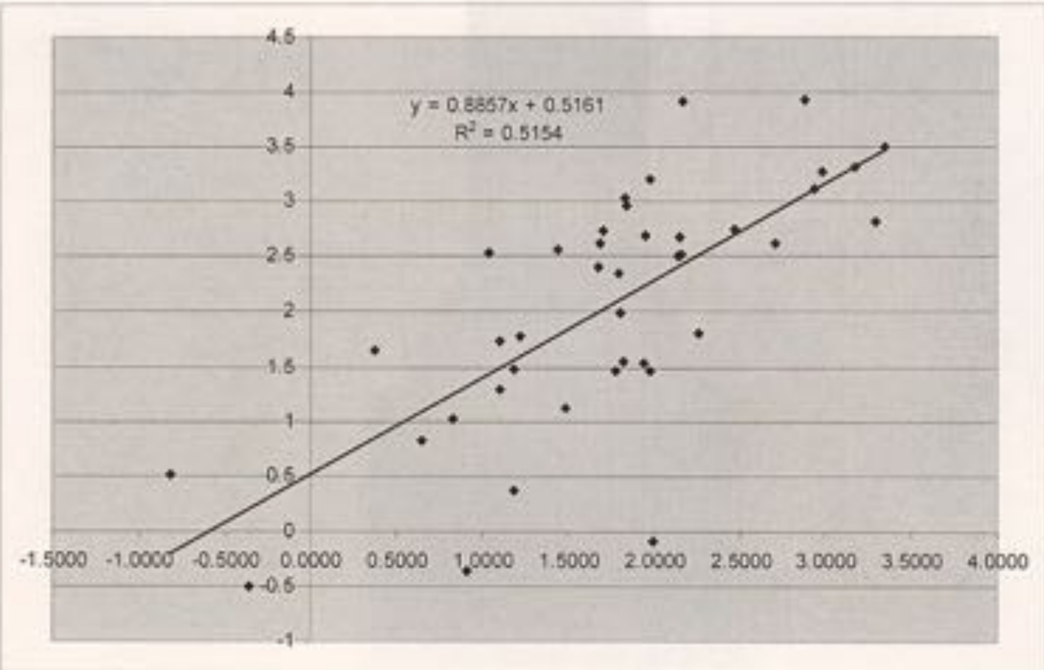
| h = | C1 (P value) | R sq. | DW |
|---|---|---|---|
| 1 | 0.6517<br>0.0017 | 0.1802 | 2.2717 |
| 2 | 0.2261<br>0.2556 | 0.0150 | 2.2619 |
| 3 | -0.3172<br>0.3429 | 0.0036 | 2.3681 |
| 4 | -0.1778<br>0.6469 | -0.0058 | 2.3914 |
| 5 | -0.3076<br>0.5109 | -0.0135 | 1.5044 |
| 6 | -0.6360<br>0.3665 | -0.0562 | 1.3005 |
| 7 | 0.0871<br>0.9566 | -0.0132 | |

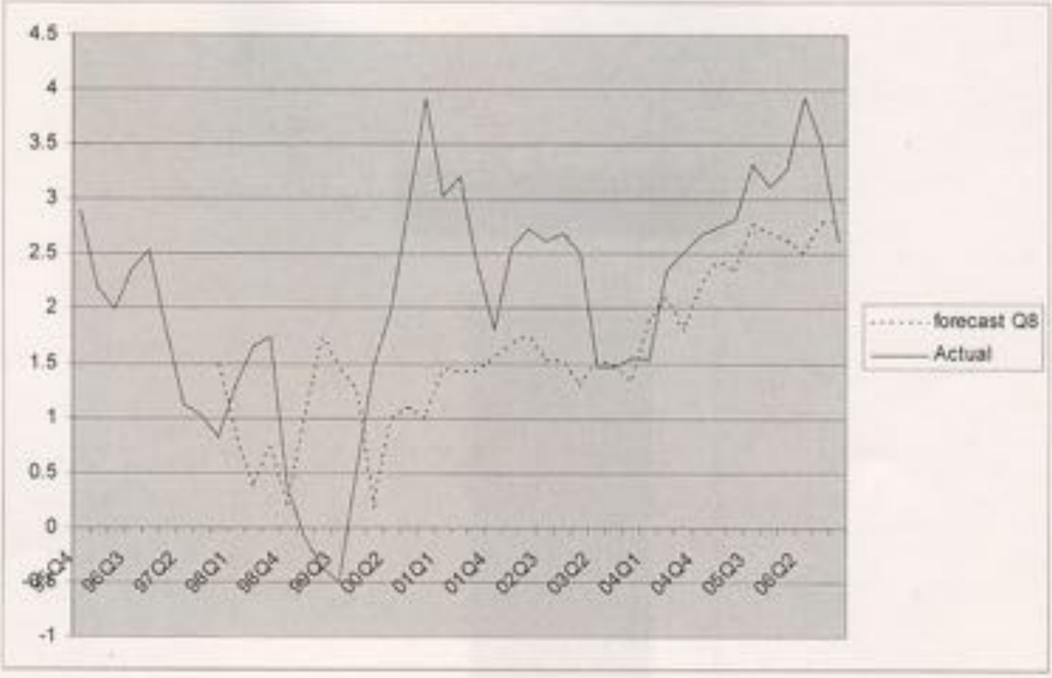
# Appendix 3



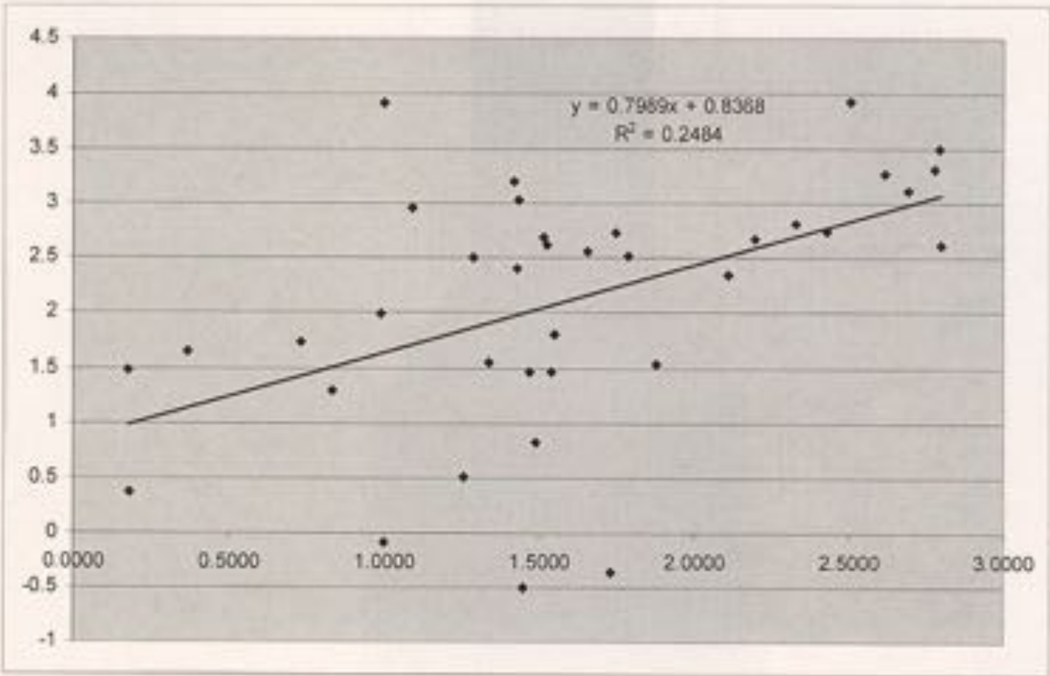




5
4
3
2
1
0
-1
-2
95Q4
96Q3
97Q2
98Q1
98Q4
99Q3
00Q2
01Q1
01Q4
02Q3
03Q2
04Q1
04Q4
05Q3
06Q2
forecast Q4
Actual

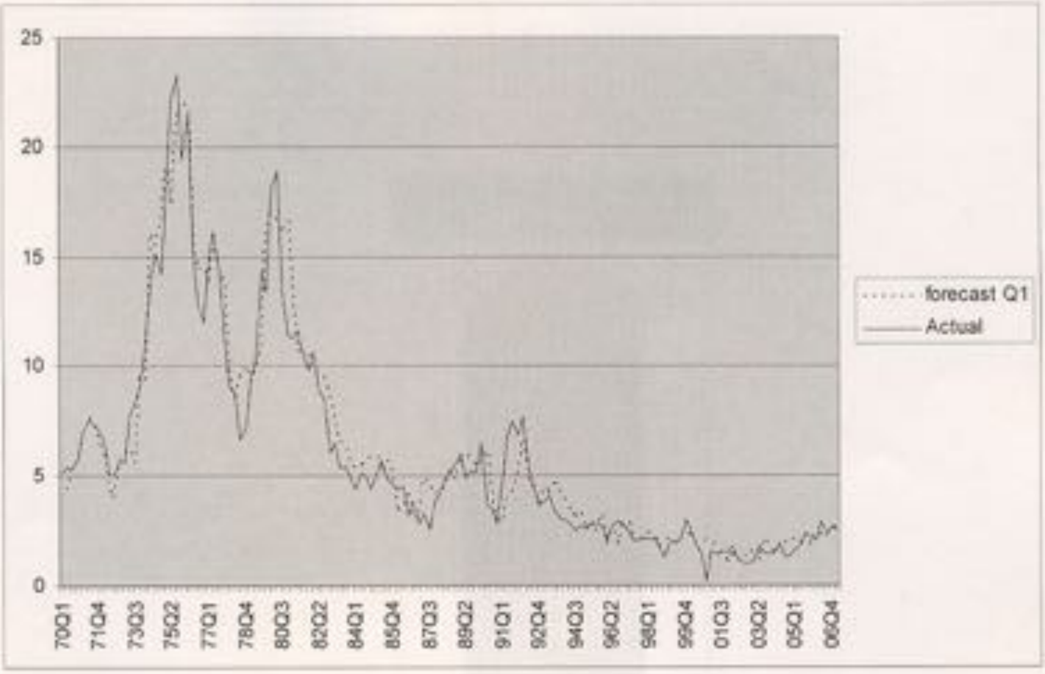

y = 0.8857x + 0.5161
R2 = 0.5154
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5000
-1.0000
-0.5000
0.0000
0.5000
1.0000
1.5000
2.0000
2.5000
3.0000
3.5000
4.0000



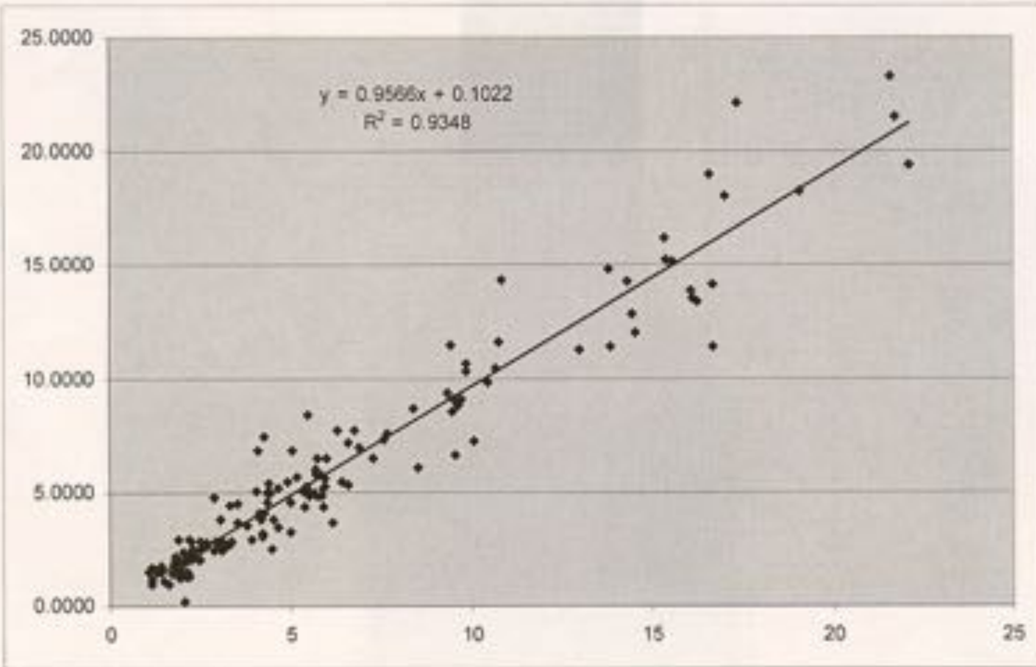
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-1
96Q3
97Q2
98Q1
98Q4
99Q3
00Q2
01Q1
01Q4
02Q3
03Q2
04Q1
04Q4
05Q3
06Q2
forecast Q8
Actual

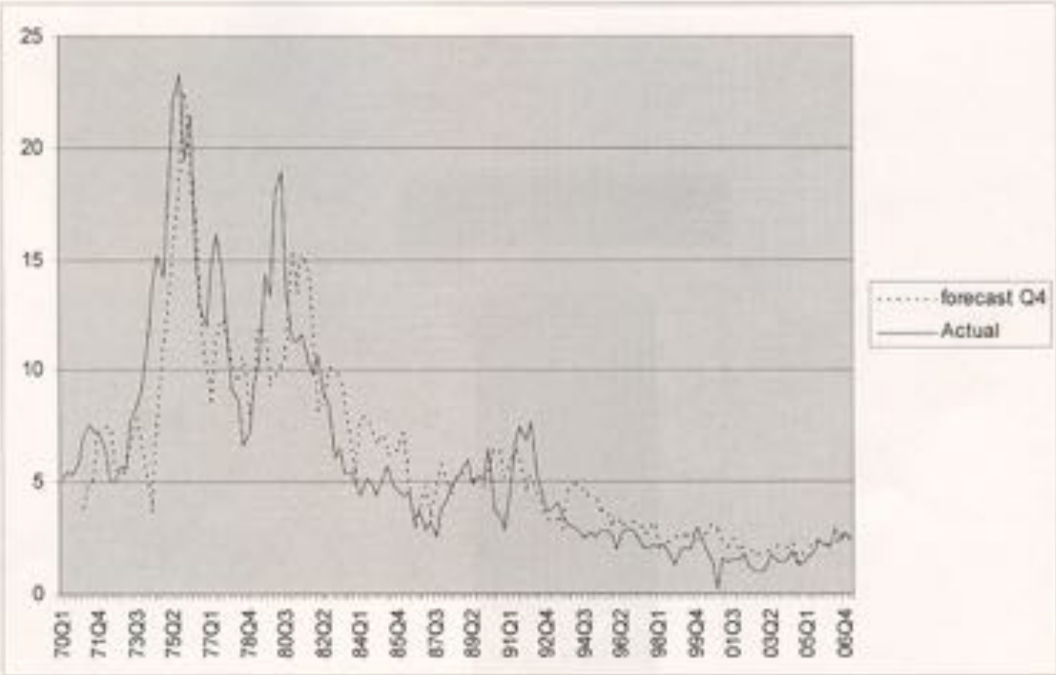
y = 0.7989x + 0.8368
R² = 0.2484
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0.0000
0.5000
1.0000
1.5000
2.0000
2.5000
3.0000



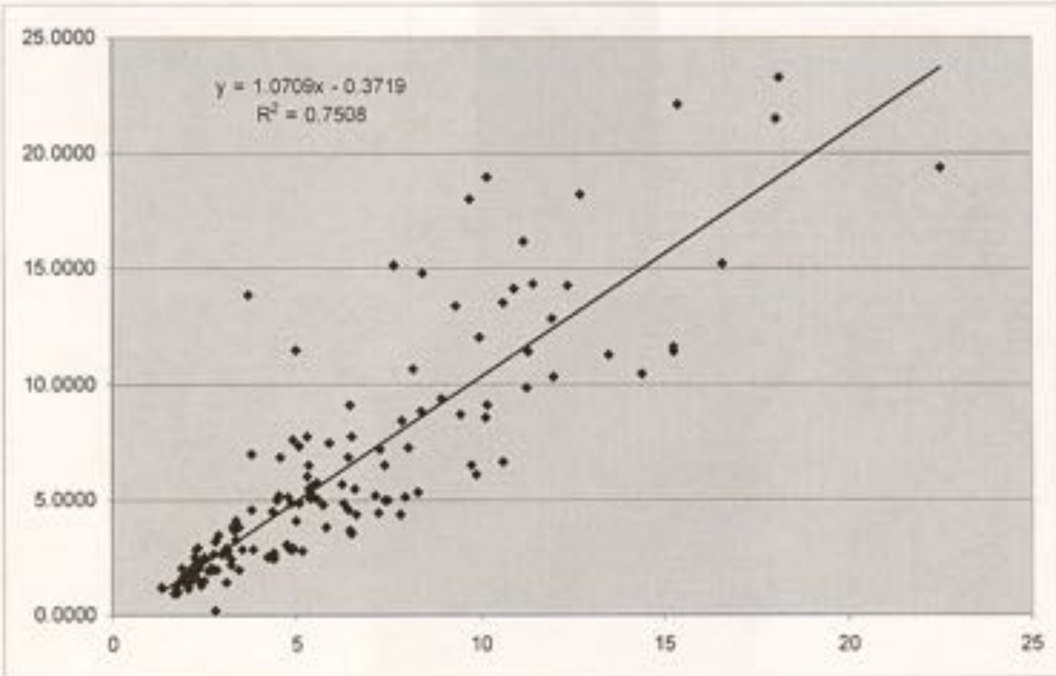
25
20
15
10
5
0
forecast Q1
Actual
70Q1
71Q4
73Q3
75Q2
77Q1
78Q4
80Q3
82Q2
84Q1
85Q4
87Q3
89Q2
91Q1
92Q4
94Q3
96Q2
98Q1
99Q4
01Q3
03Q2
05Q1
06Q4

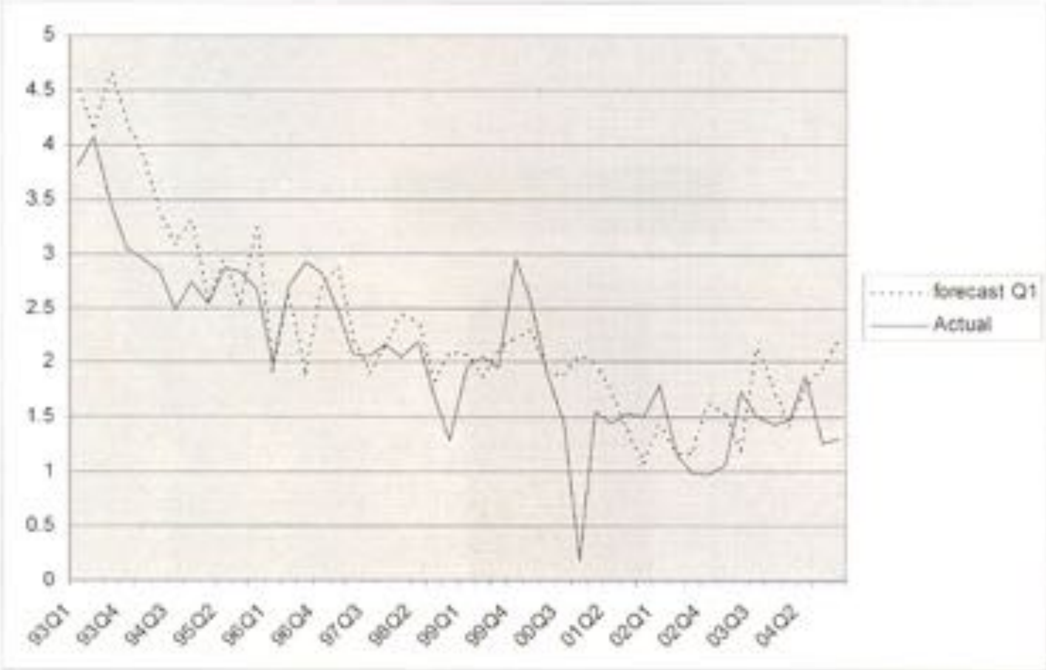
y = 0.9566x + 0.1022
R² = 0.9348
25.0000
20.0000
15.0000
10.0000
5.0000
0.0000
0
5
10
15
20
25



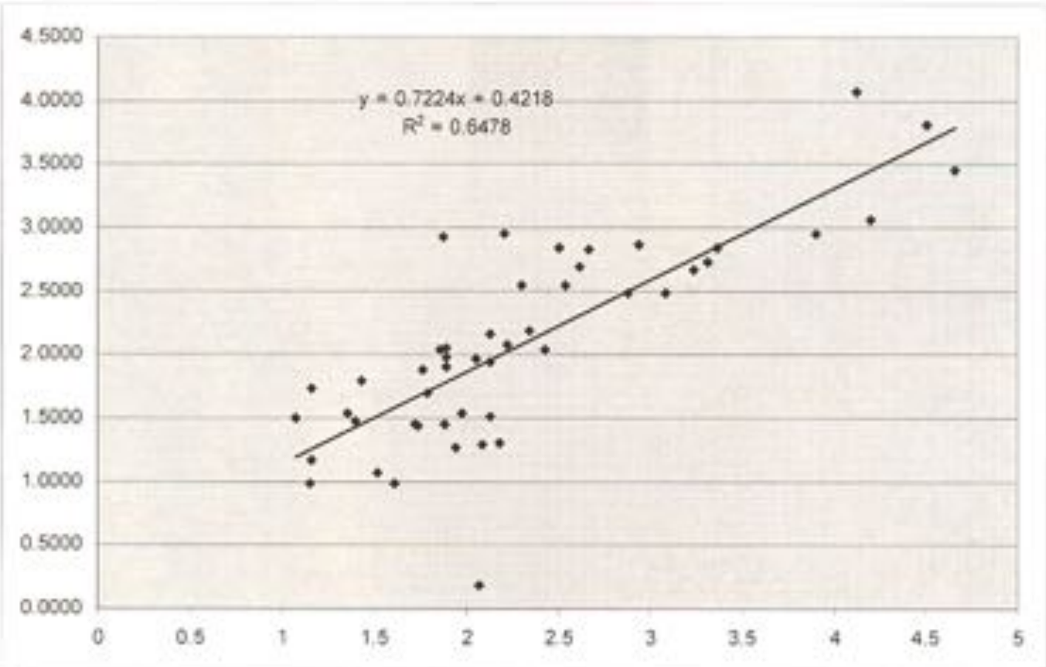
25
20
15
10
5
0
70Q1
71Q4
73Q3
75Q2
77Q1
78Q4
80Q3
82Q2
84Q1
85Q4
87Q3
89Q2
91Q1
92Q4
94Q3
96Q2
98Q1
99Q4
01Q3
03Q2
05Q1
06Q4
forecast Q4
Actual

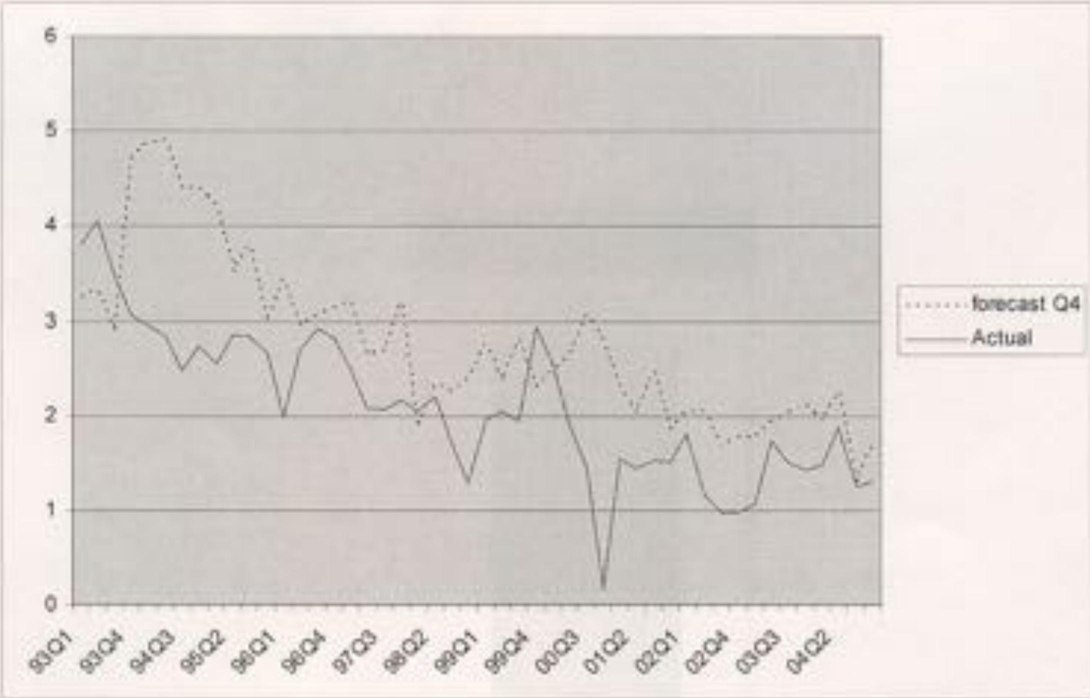
y = 1.0709x - 0.3719
R² = 0.7508
25.0000
20.0000
15.0000
10.0000
5.0000
0.0000
0
5
10
15
20
25



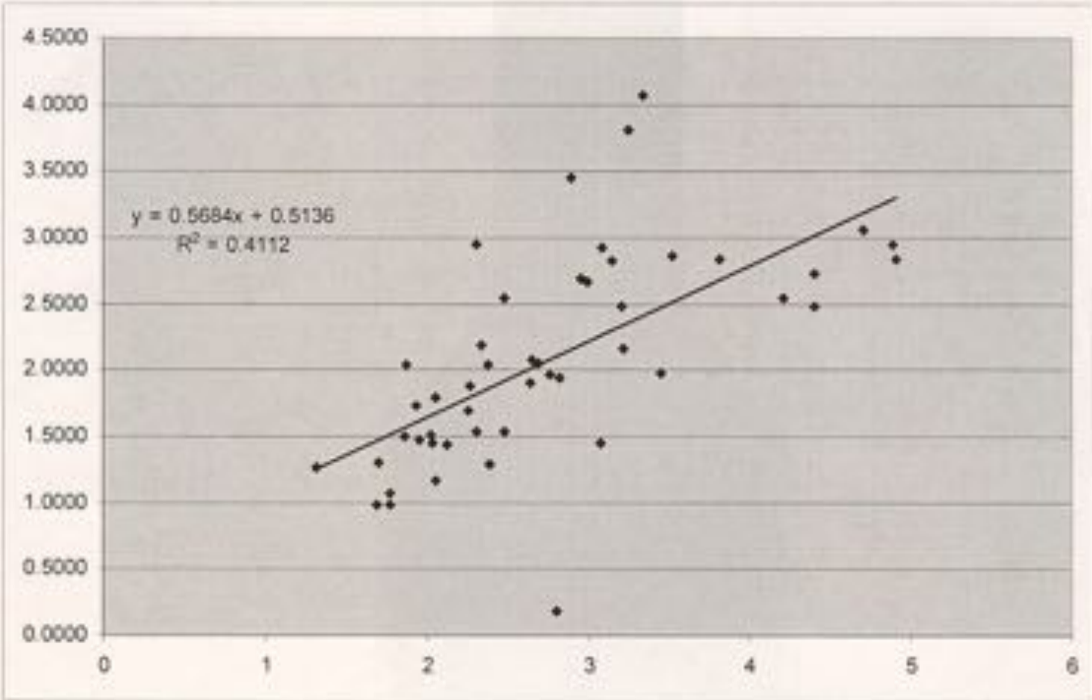
forecast Q1
Actual

y = 0.7224x + 0.4218
$R^2$ = 0.6478



6
5
4
3
2
1
0
93Q1
93Q4
94Q3
95Q2
96Q1
96Q4
97Q3
98Q2
99Q1
99Q4
00Q3
01Q2
02Q1
02Q4
03Q3
04Q2
forecast Q4
Actual

4.5000
4.0000
3.5000
3.0000
2.5000
2.0000
1.5000
1.0000
0.5000
0.0000
y = 0.5684x + 0.5136
R² = 0.4112
0
1
2
3
4
5
6

# Can one Forecast the Forecasters?

By Wen Bin Lim and Charles Goodhart

## 1. Introduction

In our first two papers in this series, entitled 'Interest Rate Forecasts: A Pathology' and 'Do Errors in Forecasting Inflation Lead to Errors in Forecasting Interest Rates', we demonstrated that, in the four time series that we examined, forecasts systematically under-predicted the time series during cyclical phases of upwards movement, and similarly over-predicted during downswings. These series were for inflation in the UK and New Zealand, and for official short term interest rates in these same two countries. Because the forecast errors in the two cyclical phases cancel out, if an econometrician takes the whole time series, the forecasts appear unbiased. While we only establish this for these series, and time periods, we cannot be sure whether this syndrome applies more widely, but we conjecture that it often does.

In order to refresh the memory, diagrams for forecasts and outturns for the four series are shown below:-

Figure 1
NZ inflation, forecast and Out-turn

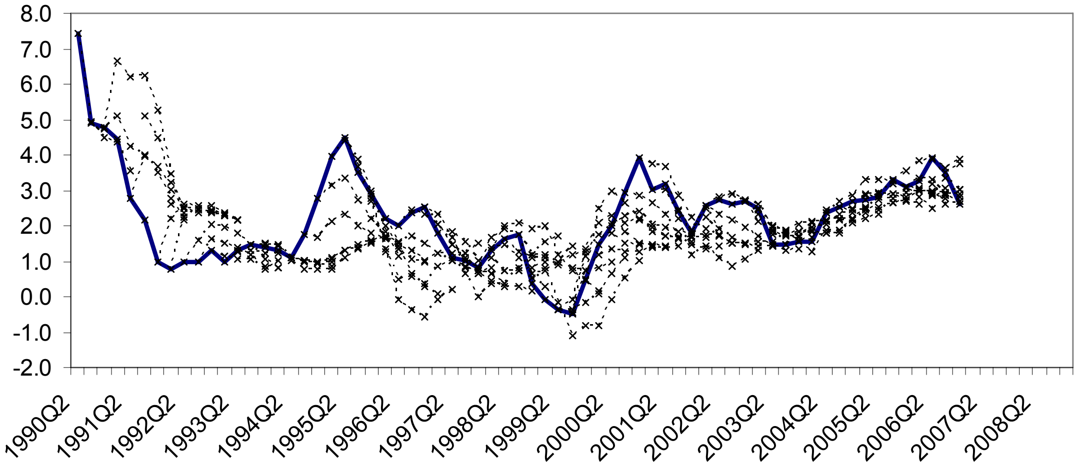



Figure 2
NZ interest rate, forecast and Out-turn

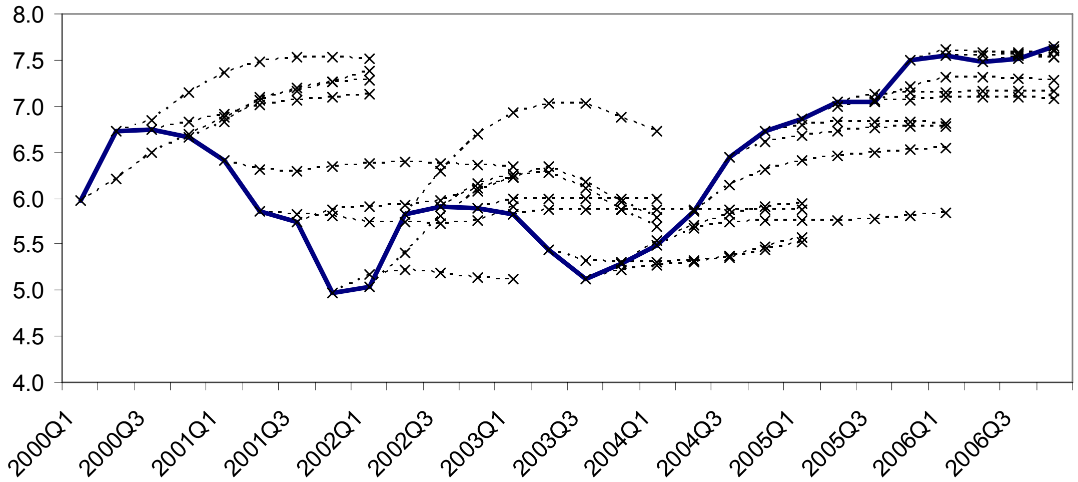



Figure 3
UK inflation, forecast and Out-turn

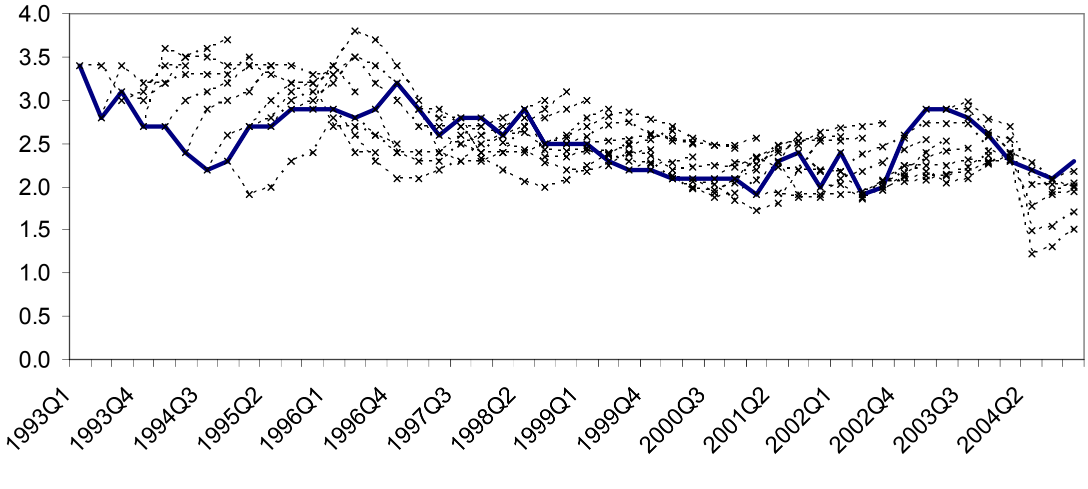
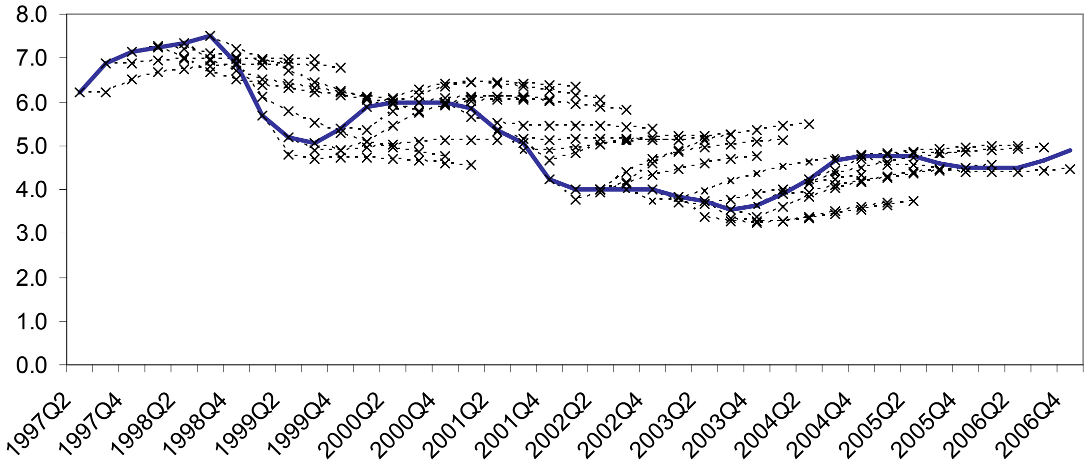


Figure 4
UK interest rate, forecast and Out-turn




Source: UK interest rate charts 2008-09-15

In this paper we seek to address the question why these (most?) forecasts exhibit this tendency. The answer that we propose is that (most) macro-economic variables are expected (by most economists[1]) 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, macro-economic 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 auto-regressive 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 upwards (downwards), 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 auto-regressive forecast.

[1] Not all economists. A few, 'heterodox', economists challenge whether equilibria necessarily exist, notably Paul Davidson and Basil Moore.

How does a forecaster assess the equilibrium value of a variable? Fortunately this is not such a difficult task in the four series that we have investigated. Both New Zealand and the UK were subject to an inflation target during the period studied, so the target value will have been the equilibrium towards which the system will be driven by the monetary regime. Next, nobody knows what is the true value of the equilibrium real interest rate, so the usual assumption is that it will be constant (and roughly around 2%). So if inflation gets driven back to its target value (of around 2½%), in the medium, and longer, term, the official short-term interest rate should also revert to an equilibrium level of about 4½%.

In the second part of this paper we explore empirically how far these forecasts can be explained by an extremely simple two-part model, with an auto-regressive and a mean-reverting component. [We also examine how well such a simple model can also fit the actual outturns, but this is a by-product, and not the focus of this exercise.] Then in the final, third part we consider the public policy implications of such behaviour. We note, in passing, that there is relatively little literature on this particular issue, in some large part because of the mistaken belief that forecasts are generally unbiased estimates of the actual outturns.

## 2. Empirical Estimation

During the periods under examination, an inflation target regime was in operation, so the equilibrium to which the inflation rate would revert would have been close to target, and about 2% above that for the interest rate. The nature of the auto-regressive process for each series, and the co-efficients for combining the auto-regressive 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:-

Out-turn (t+1) - Out-turn (t) = B1 * [Out-turn (t) - Out-turn (t-1)]

+ B2 * [Out-turn (t) – Equilibrium Level] (Equation 1)

In the four time series, a first order auto-regressive model provided a satisfactory fit for three of them. The exception was UK inflation series, where we expanded the model to include one additional lagged quarter.

Out-turn (t+1) - Out-turn (t) =

B1 * {0.5*[Out-turn (t) - Out-turn (t-1)] +0.5*[Out-turn (t-1) - Out-turn (t-2)]}

+ B2 * [Out-turn (t) – Equilibrium Level] (Equation 2)

The estimated coefficient of B1 and B2 are shown in the table below:-

Table 1

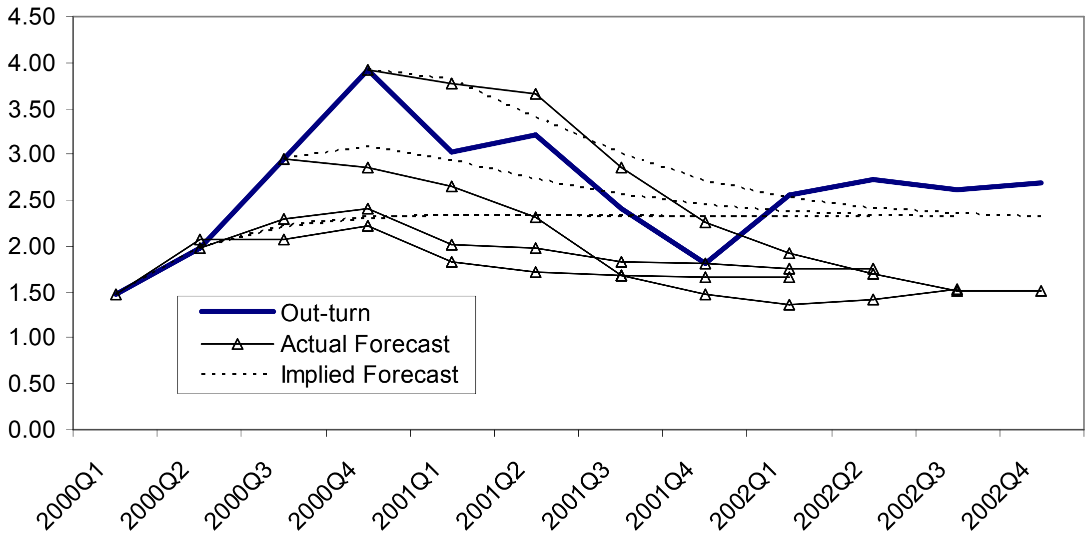
| **Equation 1** | **B1** | | | **B2** | | | **Regression Statistics** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef | t-stats | P-value | Coef | t-stats | P-value | Adj R-Sqr | SE | Obs |
| UK Interest Rate | 0.66 | 6.30 | 0.00 | -0.09 | -2.54 | 0.01 | 0.4175 | 0.2539 | 54 |
| NZ Inflation | 0.30 | 2.89 | 0.01 | -0.25 | -4.75 | 0.00 | 0.2829 | 0.5724 | 66 |
| NZ Interest Rate | 0.49 | 4.90 | 0.00 | -0.13 | -3.58 | 0.00 | 0.3403 | 0.6326 | 66 |

| **Equation 2** | **B1** | | | **B2** | | | **Regression Statistics** | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef | t-stats | P-value | Coef | t-stats | P-value | Adj R-Sqr | SE | Obs |
| UK Inflation | 0.24 | 1.09 | 0.28 | -0.27 | -2.48 | 0.02 | 0.0710 | 0.2402 | 53 |

Source: Results summary 2008-08-04.xls

Now we have a simplified model of how forecasts are done. The next step is to compare it with the actual forecasts[2]. We do this first diagrammatically. For illustration, we have provided the diagrammatical comparison for period between 2000 Q1– 2002 Q4. The diagrams show quite a close relationship between the actual and our implied (from our simple model) forecast. Quarters beyond t+1 are estimated recursively.

Figure 5
NZ inflation, comparison between Out-turn, Actual and Implied Forecast




[2] Actual forecast refers to the forecast published by an official source. For NZ interest (and inflation?) rate, this is taken from RBNZ; UK inflation is from Bank of England and UK interest rate is from government curve. Implied forecast refers to the forecast implied by our simple two-part model.

Figure 6
NZ interest rate, comparison between Out-turn, Actual and Implied Forecast

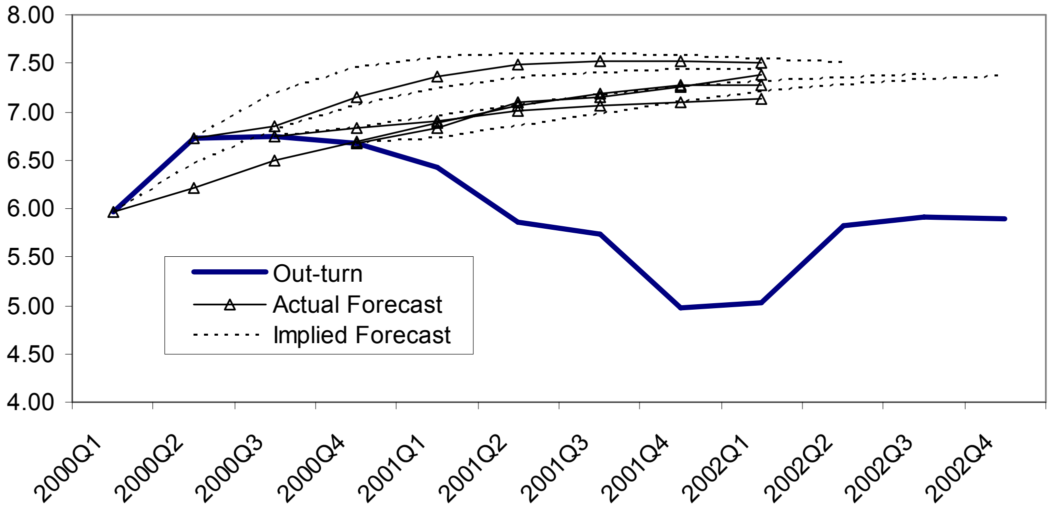



Figure 7
UK inflation, comparison between Out-turn, Actual and Implied Forecast

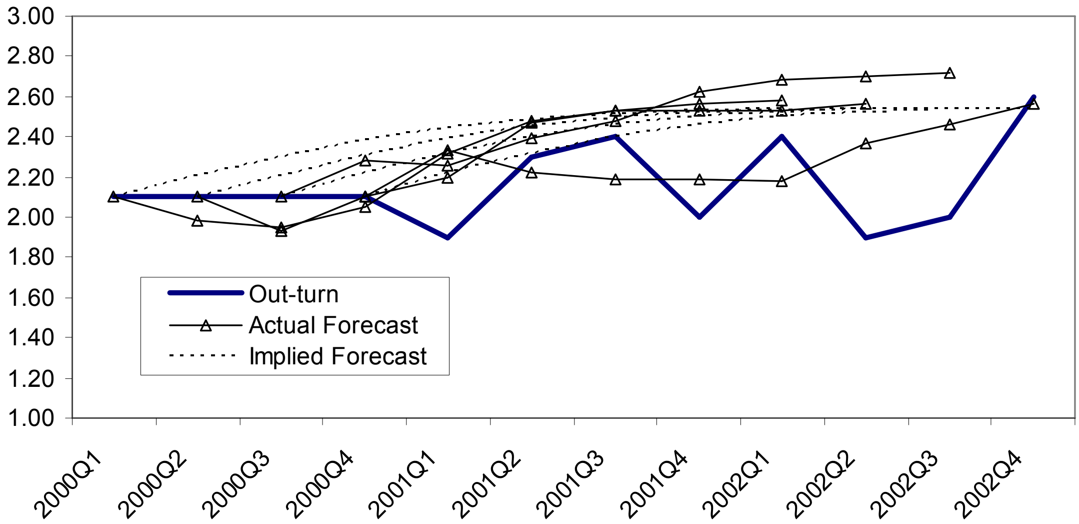
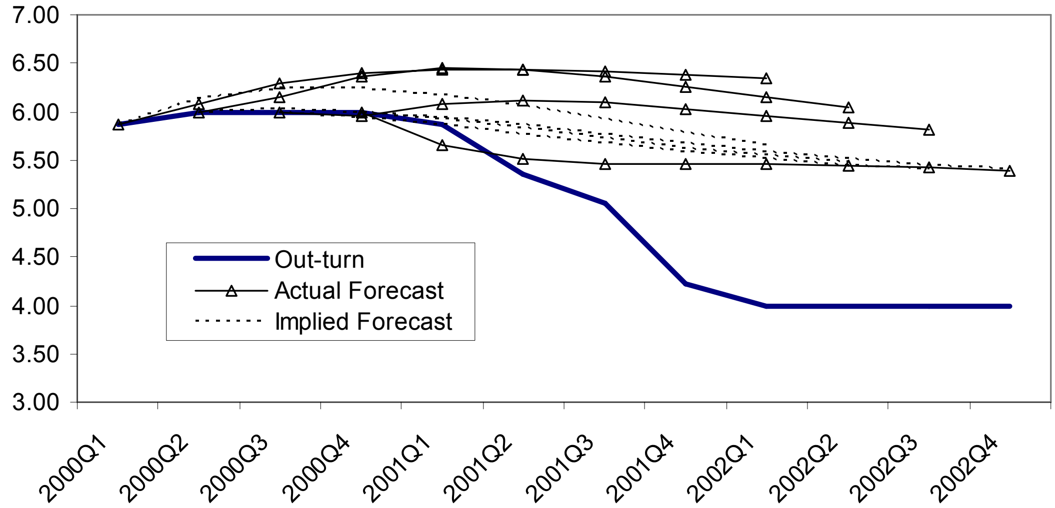


Figure 8
UK interest rate, comparison between Out-turn, Actual and Implied Forecast




We then evaluate the implied forecast <u>changes</u> against the actual forecast <u>changes</u> via regression analysis over the whole study period:-

$$\text{Actual Forecast}_{t,t+i} - \text{Out-turn}_t = C(1) + C(2) * \text{Implied Forecast}_{t,t+i} - \text{Out-turn}_t$$

$i = 1\text{-}8$ (Equation 3)

The hypothesis is that C(1) = 0 and C(2) = 1. The t-stats for C(2) in the Tables relates to the coefficient's deviation from unity, <u>not</u> from zero.

Table 2
NZ inflation, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | |
|---|---|---|---|---|---|---|---|---|---|
| **I** | Coef | t-stats | P-value | Coef | t-stats | P-value | Adj R-Sqr | SE | Obs |
| **1** | 0.12 | 1.40 | 0.17 | 0.78 | -0.93 | 0.36 | 0.15 | 0.69 | 61 |
| **2** | 0.03 | 0.32 | 0.75 | 0.69 | -2.07 | 0.04 | 0.24 | 0.85 | 65 |
| **3** | -0.17 | -1.44 | 0.15 | 0.72 | -2.32 | 0.03 | 0.34 | 0.94 | 64 |
| **4** | -0.43 | -3.67 | 0.00 | 0.77 | -2.28 | 0.03 | 0.47 | 0.92 | 63 |
| **5** | -0.62 | -5.46 | 0.00 | 0.83 | -1.64 | 0.11 | 0.52 | 0.87 | 60 |
| **6** | -0.75 | -6.57 | 0.00 | 0.91 | -0.85 | 0.40 | 0.60 | 0.84 | 56 |
| **7** | -0.78 | -6.97 | 0.00 | 0.98 | -0.17 | 0.86 | 0.66 | 0.78 | 51 |
| **8** | -0.80 | -7.29 | 0.00 | 1.07 | 0.72 | 0.47 | 0.72 | 0.72 | 46 |

Table 3
NZ interest rate, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | |
|---|---|---|---|---|---|---|---|---|---|
| **i** | Coef | t-stats | P-value | Coef | t-stats | P-value | Adj R-Sqr | SE | Obs |
| **1** | 0.04 | 1.57 | 0.13 | 0.49 | -4.78 | 0.00 | 0.44 | 0.10 | 27 |
| **2** | -0.03 | -0.47 | 0.65 | 0.63 | -3.09 | 0.00 | 0.51 | 0.17 | 26 |
| **3** | -0.11 | -1.08 | 0.29 | 0.62 | -2.74 | 0.01 | 0.44 | 0.24 | 25 |
| **4** | -0.08 | -0.50 | 0.62 | 0.48 | -3.23 | 0.00 | 0.25 | 0.32 | 24 |
| **5** | 0.00 | -0.02 | 0.99 | 0.36 | -3.58 | 0.00 | 0.12 | 0.39 | 23 |
| **6** | -0.03 | -0.12 | 0.91 | 0.36 | -2.94 | 0.01 | 0.10 | 0.42 | 17 |
| **7** | 0.06 | 0.15 | 0.88 | 0.30 | -2.37 | 0.02 | 0.00 | 0.46 | 11 |
| **8** | -0.24 | -0.25 | 0.82 | 0.45 | -0.95 | 0.35 | -0.11 | 0.59 | 5 |

Table 4
UK inflation, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | |
|---|---|---|---|---|---|---|---|---|---|
| **i** | Coef | t-stats | P-value | Coef | t-stats | P-value | Adj R-Sqr | SE | Obs |
| **1** | -0.04 | -0.94 | 0.35 | 0.69 | -0.57 | 0.57 | 0.01 | 0.31 | 45 |
| **2** | -0.07 | -1.20 | 0.24 | 0.49 | -1.33 | 0.19 | 0.01 | 0.39 | 44 |
| **3** | -0.08 | -1.11 | 0.27 | 0.64 | -1.06 | 0.29 | 0.05 | 0.49 | 43 |
| **4** | -0.07 | -0.88 | 0.39 | 0.70 | -1.02 | 0.31 | 0.10 | 0.52 | 42 |
| **5** | -0.04 | -0.53 | 0.60 | 0.71 | -1.17 | 0.25 | 0.15 | 0.48 | 41 |
| **6** | 0.02 | 0.24 | 0.81 | 0.67 | -1.64 | 0.11 | 0.21 | 0.42 | 39 |
| **7** | 0.07 | 1.23 | 0.23 | 0.66 | -2.13 | 0.04 | 0.32 | 0.33 | 36 |
| **8** | 0.08 | 2.27 | 0.03 | 0.71 | -2.88 | 0.01 | 0.65 | 0.18 | 27 |

Table 5
UK interest rate, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | |
|---|---|---|---|---|---|---|---|---|---|
| **i** | Coef | t-stats | P-value | Coef | t-stats | P-value | Adj 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 |

Source: Regression results (regressed coefficient) 2008-10-07

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 above that used by the actual forecasters, i.e. the implied forecast flattened out near the equilibrium level faster than the actual forecasters expected. Indicative diagrams for 6 quarters ahead implied forecast showing this are given below.

Figure 9
NZ inflation, six quarter ahead forecast

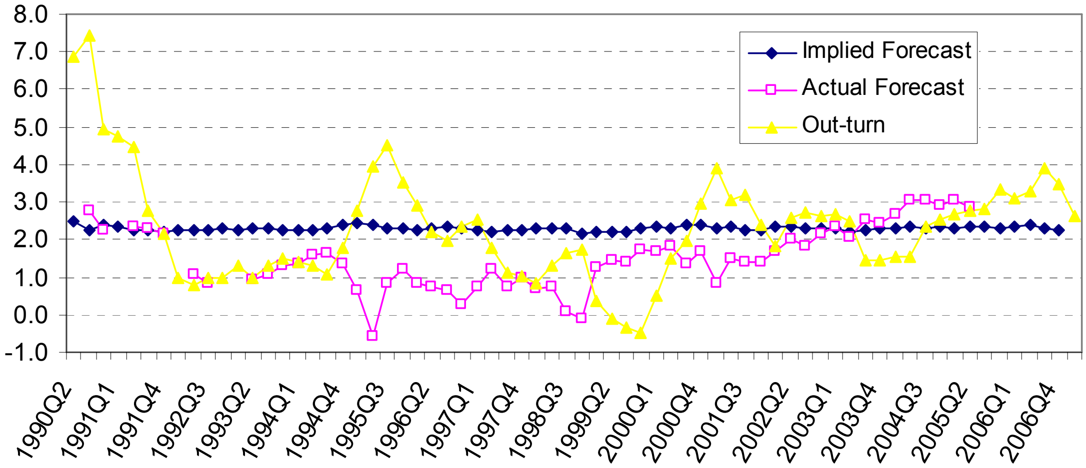


Figure 10
NZ interest rate[3], six quarter ahead forecast

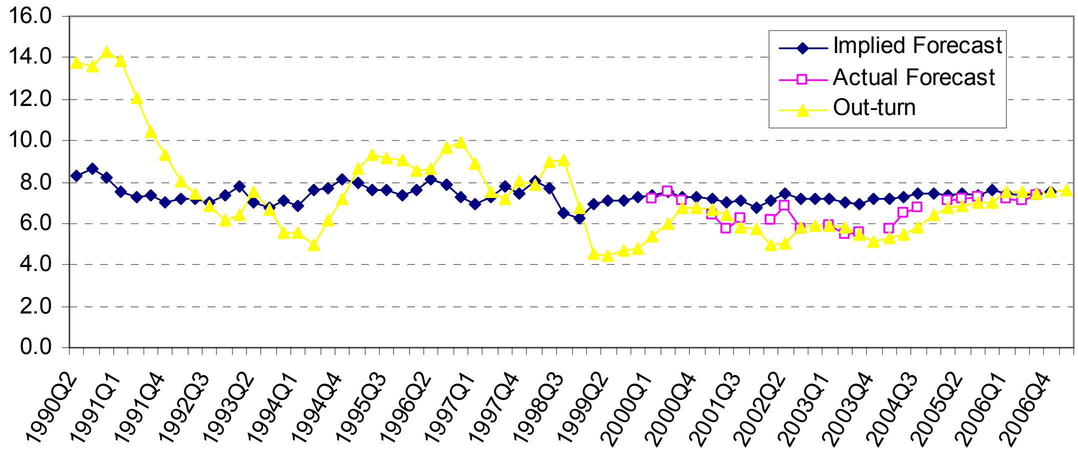
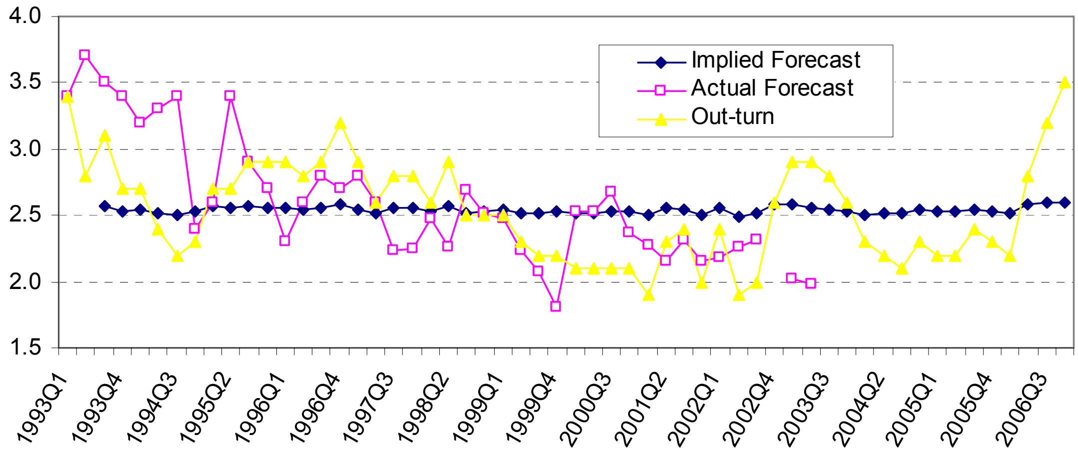
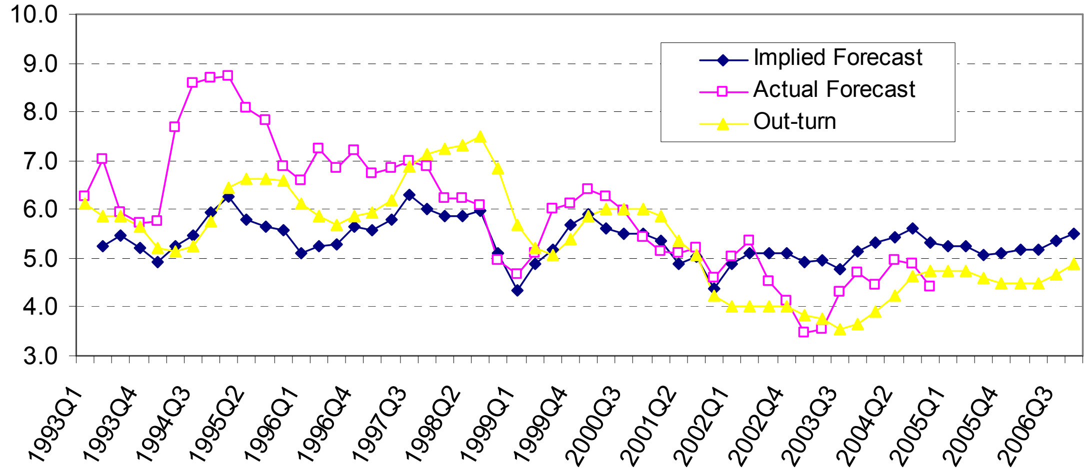



Figure 11
UK inflation, six quarter ahead forecast




[3] Data for RBNZ interest rate forecast is only available from 2001 Q1

Figure 12
UK interest rate, six quarter ahead forecast




Source: UK interest rate regression 2008-10-06 v2

Incidentally, the implied forecasts often did better in predicting the outturns than the actual forecasts. This is not, however, so surprising since the implied forecasts are obtained by data-mining, i.e. finding the coefficients that best explained the out-turns. We show the regression data in the footnote below,[4] but we place no emphasis on it.

Since the actual forecasters placed less weight on mean-reversion, than appeared to be the case in our series, our next step was to explore what was the weight on mean reversion that brought the implied forecast most closely into line with the actual

---

[4] We evaluate the forecasts in predicting actual Out-turn via the following regression:-

$$\text{Out-turn}_{t+i} - \text{Out-turn}_t = C(1) + C(2) * \text{Implied Forecast}_{t,t+i} - \text{Out-turn}_t \quad i = 1\text{-}8 \qquad \text{(Equation 4)}$$

$$\text{Out-turn}_{t+i} - \text{Out-turn}_t = C(1) + C(2) * \text{Actual Forecast}_{t,t+i} - \text{Out-turn}_t \quad i = 1\text{-}8 \qquad \text{(Equation 5)}$$

The estimated coefficient of C(1) and C(2) of each of the four series is summarised in the tables below. Again, the hypothesis is that C(1) = 0 and C(2) = 1:

Table 6: Implied Forecast Vs Out-turn (Equation 4)

| | NZ inflation | | | NZ interest rate | | | UK inflation | | | UK interest rate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| i | C(1) | C(2) | R-Sqr | C(1) | C(2) | R-Sqr | C(1) | C(2) | R-Sqr | C(1) | C(2) | R-Sqr |
| 1 | -0.08 | 1.00 | 0.31 | -0.06 | 0.99 | 0.36 | 0.00 | 1.00 | 0.11 | 0.00 | 1.00 | 0.45 |
| 2 | -0.13 | 0.93 | 0.39 | -0.16 | 0.98 | 0.37 | -0.01 | 1.06 | 0.21 | -0.01 | 0.91 | 0.33 |
| 3 | -0.18 | 0.99 | 0.50 | -0.29 | 1.03 | 0.48 | -0.02 | 1.06 | 0.30 | -0.03 | 0.80 | 0.25 |
| 4 | -0.25 | 1.11 | 0.59 | -0.39 | 1.04 | 0.55 | -0.03 | 1.04 | 0.36 | -0.04 | 0.69 | 0.20 |
| 5 | -0.28 | 1.13 | 0.64 | -0.47 | 1.03 | 0.61 | -0.02 | 0.96 | 0.38 | -0.05 | 0.61 | 0.18 |
| 6 | -0.30 | 1.16 | 0.67 | -0.53 | 1.02 | 0.67 | -0.02 | 0.89 | 0.37 | -0.06 | 0.54 | 0.18 |
| 7 | -0.29 | 1.18 | 0.69 | -0.57 | 1.01 | 0.70 | -0.03 | 0.93 | 0.41 | -0.08 | 0.50 | 0.18 |
| 8 | -0.28 | 1.21 | 0.72 | -0.59 | 1.03 | 0.72 | -0.03 | 1.00 | 0.44 | -0.11 | 0.48 | 0.20 |

Source: Regression results (regressed coefficient) 2008-10-07

Table 7: Actual Forecast Vs Out-turn (Equation 5)

| | NZ inflation | | | NZ interest rate | | | UK inflation | | | UK interest rate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| i | C(1) | C(2) | R-Sqr | C(1) | C(2) | R-Sqr | C(1) | C(2) | R-Sqr | C(1) | C(2) | R-Sqr |
| 1 | -0.11 | 0.55 | 0.40 | -0.16 | 1.61 | 0.35 | -0.02 | 0.21 | 0.06 | 0.13 | 0.94 | 0.51 |
| 2 | -0.14 | 0.62 | 0.34 | -0.15 | 1.02 | 0.20 | -0.02 | 0.23 | 0.08 | -0.01 | 0.86 | 0.50 |
| 3 | -0.03 | 0.72 | 0.38 | -0.09 | 0.73 | 0.10 | -0.04 | 0.26 | 0.12 | -0.16 | 0.85 | 0.47 |
| 4 | 0.17 | 0.86 | 0.45 | 0.13 | 0.11 | 0.00 | -0.05 | 0.33 | 0.17 | -0.28 | 0.73 | 0.36 |
| 5 | 0.37 | 0.95 | 0.51 | 0.37 | -0.38 | 0.03 | -0.07 | 0.44 | 0.25 | -0.34 | 0.60 | 0.27 |
| 6 | 0.53 | 0.93 | 0.53 | 0.44 | -0.47 | 0.04 | -0.08 | 0.47 | 0.25 | -0.37 | 0.51 | 0.22 |
| 7 | 0.54 | 0.94 | 0.58 | 0.82 | -1.05 | 0.17 | -0.10 | 0.67 | 0.31 | -0.39 | 0.46 | 0.21 |
| 8 | 0.53 | 0.95 | 0.65 | 0.80 | -0.82 | 0.14 | -0.21 | 0.98 | 0.45 | -0.43 | 0.46 | 0.24 |

forecast. Thus we varied B2 in equation 1 until the weighted average squared residuals[5] in equation 1 were minimised (the same is done for UK inflation but with equation 2). The values of B2 that resulted were:-

Table 7
Summary comparison of estimated mean reversion coefficient ("B2")

| | B2 | |
|---|---|---|
| | Best fit | 'True' |
| **Equation 1** | | |
| UK Interest Rate | -0.031 | -0.085 |
| NZ Inflation | -0.167 | -0.249 |
| NZ Interest Rate | -0.032 | -0.130 |
| **Equation 2** | | |
| UK Inflation | -0.173 | -0.269 |

Source: Database (optimised coefficient) 2008-11-16 v2

The results seem plausible. Armed with the best coefficients for B2 we then re-ran:

$$\text{Actual Forecast}_{t,t+i} - \text{Out-turn}_t = C(1) + C(2) * \text{Implied Forecast}_{t,t+i} - \text{Out-turn}_t$$

$i = 1\text{-}8$ (Equation 3)

The regressions, and diagrams, are shown below.

[5] A linearly declining weighting is applied to the squared residuals, with heavier weight applied to nearer term forecast

Figure 13
NZ inflation forecast comparison

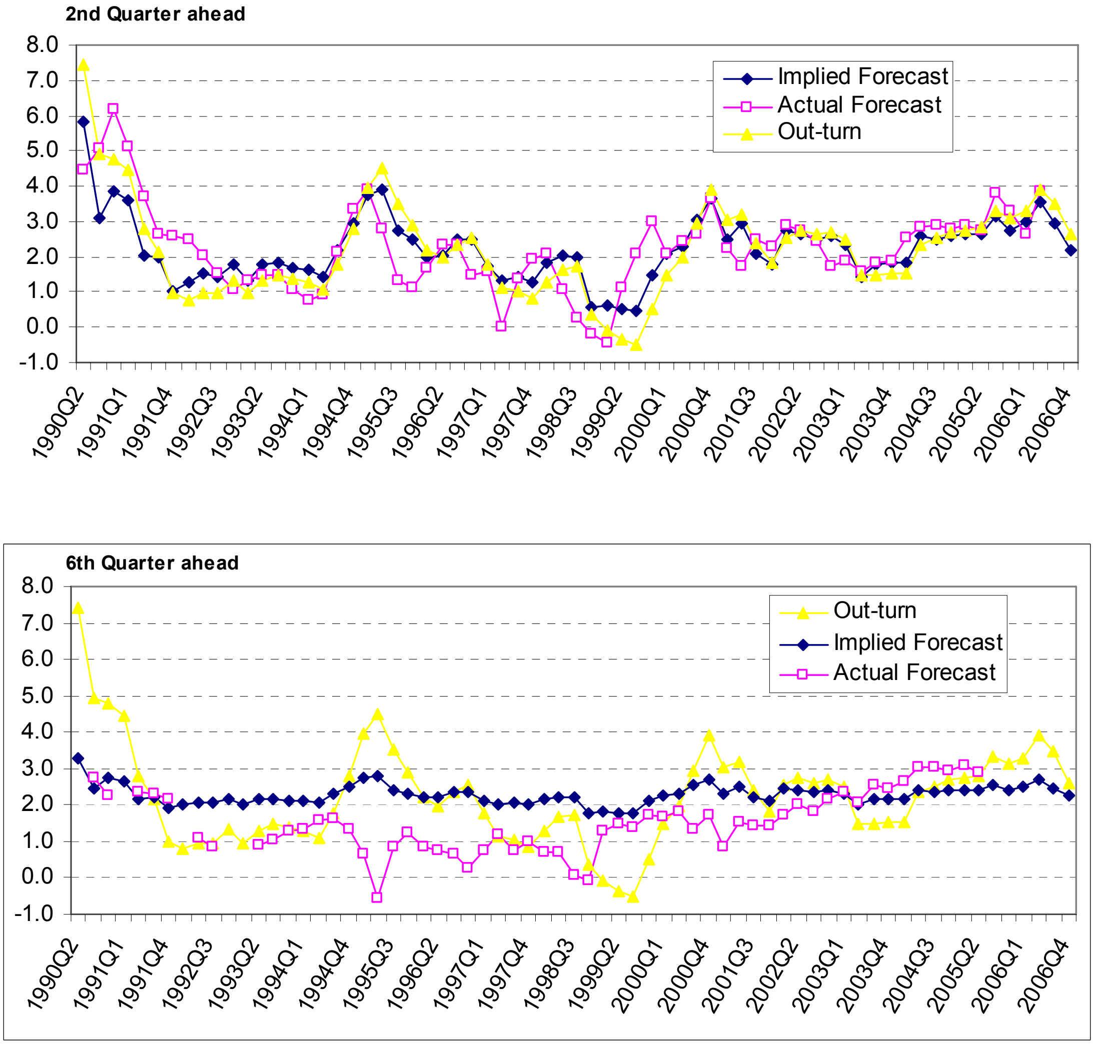
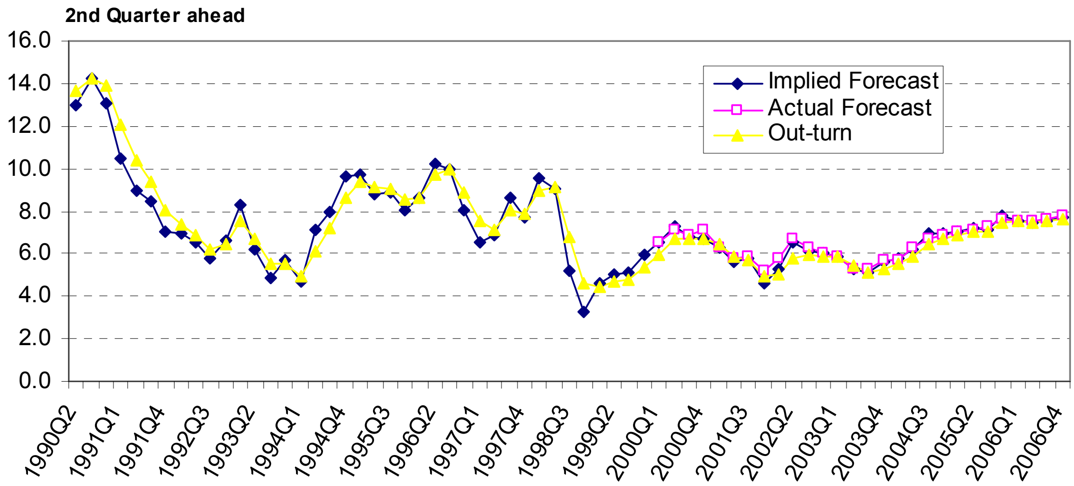



Figure 14
NZ interest rate forecast comparison



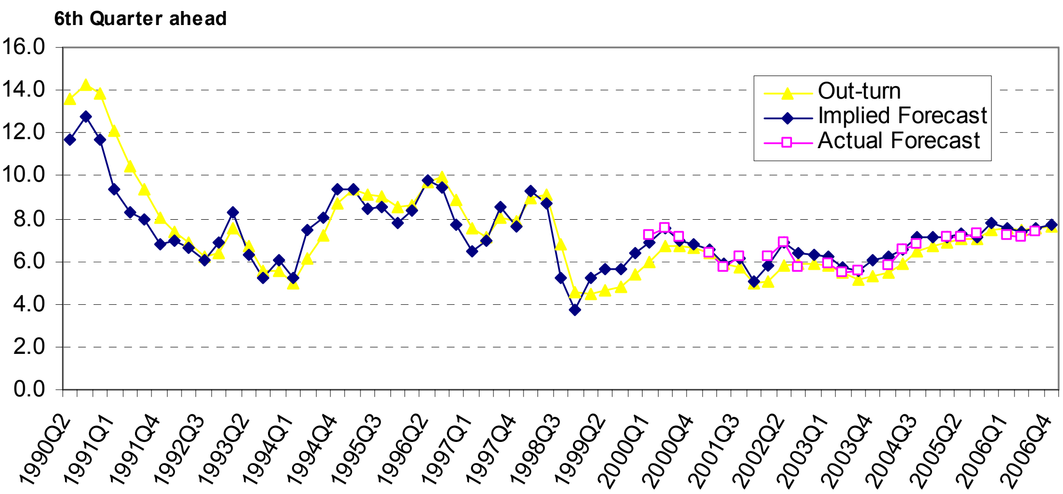
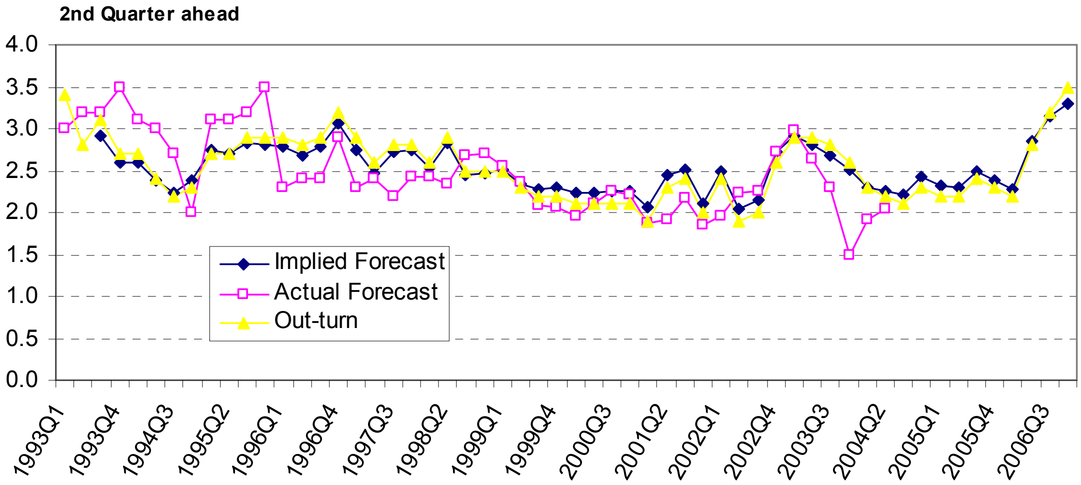



Figure 15
UK inflation forecast comparison



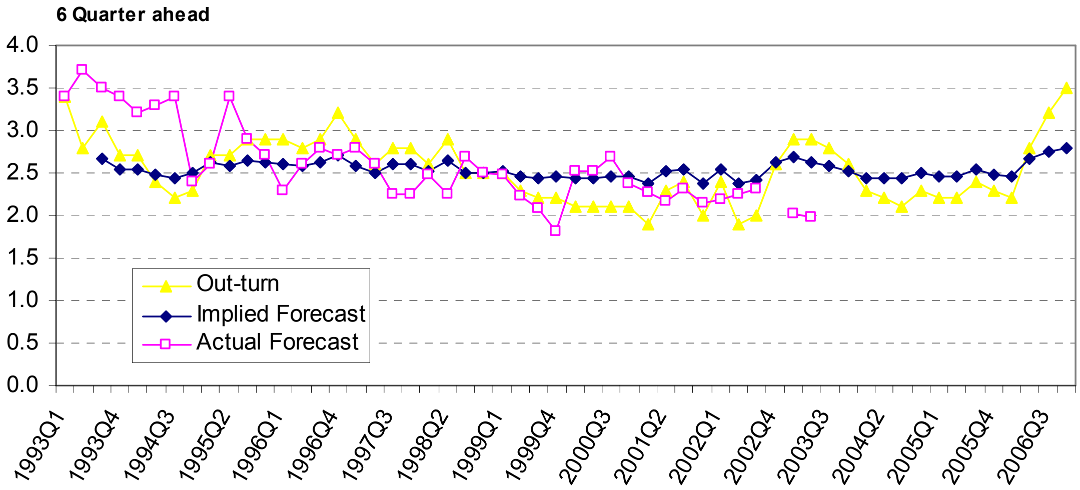
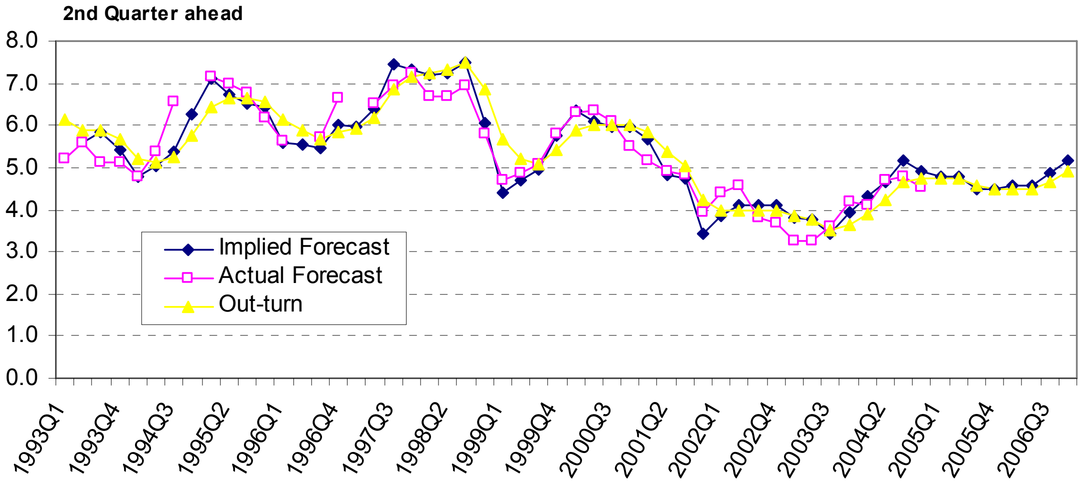



Figure 16
UK interest rate forecast comparison



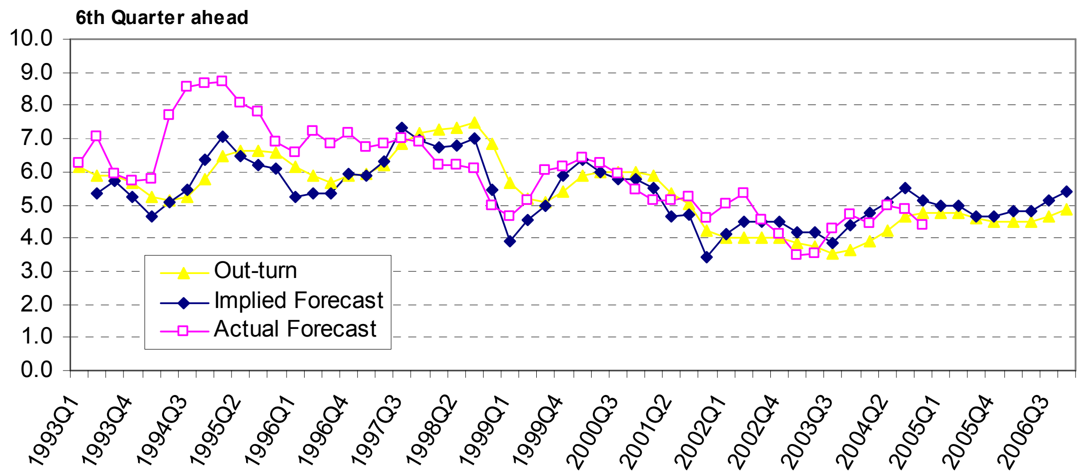




Table 9
NZ inflation, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| i | Coef | t-stats | P-value | Coef | t-stats | P-value | R-Sqr | Adj R-Sqr | SE | Obs |
| 1 | 0.13 | 1.41 | 0.17 | 0.87 | -0.44 | 0.67 | 0.12 | 0.10 | 0.71 | 61 |
| 2 | 0.04 | 0.38 | 0.70 | 0.91 | -0.45 | 0.66 | 0.23 | 0.22 | 0.86 | 65 |
| 3 | -0.16 | -1.37 | 0.17 | 0.96 | -0.26 | 0.79 | 0.35 | 0.34 | 0.94 | 64 |
| 4 | -0.42 | -3.58 | 0.00 | 0.98 | -0.17 | 0.87 | 0.47 | 0.46 | 0.93 | 63 |
| 5 | -0.62 | -5.35 | 0.00 | 1.01 | 0.08 | 0.94 | 0.52 | 0.51 | 0.88 | 60 |
| 6 | -0.74 | -6.42 | 0.00 | 1.07 | 0.55 | 0.58 | 0.60 | 0.59 | 0.85 | 56 |
| 7 | -0.78 | -6.85 | 0.00 | 1.11 | 0.93 | 0.36 | 0.66 | 0.65 | 0.79 | 51 |
| 8 | -0.80 | -7.25 | 0.00 | 1.18 | 1.65 | 0.11 | 0.72 | 0.72 | 0.72 | 46 |

Table 10
NZ interest rate, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| i | Coef | t-stats | P-value | Coef | t-stats | P-value | R-Sqr | Adj R-Sqr | SE | Obs |
| 1 | 0.10 | 4.49 | 0.00 | 0.41 | -4.71 | 0.00 | 0.31 | 0.28 | 0.11 | 27 |
| 2 | 0.14 | 3.22 | 0.00 | 0.62 | -2.50 | 0.02 | 0.42 | 0.39 | 0.19 | 26 |
| 3 | 0.11 | 1.74 | 0.09 | 0.81 | -1.11 | 0.27 | 0.50 | 0.48 | 0.23 | 25 |
| 4 | 0.05 | 0.67 | 0.51 | 0.93 | -0.36 | 0.72 | 0.54 | 0.52 | 0.26 | 24 |
| 5 | 0.00 | -0.03 | 0.97 | 1.01 | 0.04 | 0.97 | 0.51 | 0.49 | 0.29 | 23 |
| 6 | -0.16 | -1.13 | 0.28 | 1.15 | 0.59 | 0.56 | 0.59 | 0.56 | 0.29 | 17 |
| 7 | -0.23 | -1.44 | 0.18 | 1.18 | 0.76 | 0.45 | 0.74 | 0.71 | 0.25 | 11 |
| 8 | -0.52 | -1.16 | 0.33 | 1.42 | 0.70 | 0.49 | 0.66 | 0.54 | 0.38 | 5 |

Table 11
UK inflation, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| i | Coef | t-stats | P-value | Coef | t-stats | P-value | R-Sqr | Adj R-Sqr | SE | Obs |
| 1 | -0.04 | -0.89 | 0.38 | 0.91 | -0.11 | 0.91 | 0.03 | 0.00 | 0.31 | 45 |
| 2 | -0.07 | -1.17 | 0.25 | 0.69 | -0.54 | 0.59 | 0.03 | 0.01 | 0.39 | 44 |
| 3 | -0.08 | -1.08 | 0.28 | 0.89 | -0.21 | 0.83 | 0.07 | 0.05 | 0.50 | 43 |
| 4 | -0.07 | -0.86 | 0.40 | 0.91 | -0.22 | 0.82 | 0.11 | 0.09 | 0.52 | 42 |
| 5 | -0.04 | -0.52 | 0.61 | 0.88 | -0.38 | 0.71 | 0.16 | 0.14 | 0.49 | 41 |
| 6 | 0.02 | 0.26 | 0.80 | 0.79 | -0.82 | 0.42 | 0.21 | 0.19 | 0.42 | 39 |
| 7 | 0.07 | 1.22 | 0.23 | 0.76 | -1.25 | 0.22 | 0.32 | 0.30 | 0.33 | 36 |
| 8 | 0.08 | 2.27 | 0.03 | 0.80 | -1.73 | 0.09 | 0.66 | 0.64 | 0.18 | 27 |

Table 12
UK interest rate, evaluation of implied forecast and actual forecast

| | C(1) | | | C(2) | | | Regression Statistics | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| i | Coef | t-stats | P-value | Coef | t-stats | P-value | R-Sqr | Adj R-Sqr | SE | Obs |
| 1 | -0.16 | -5.27 | 0.00 | 0.92 | -0.66 | 0.51 | 0.64 | 0.63 | 0.17 | 34 |
| 2 | -0.03 | -0.59 | 0.56 | 0.85 | -0.95 | 0.35 | 0.41 | 0.40 | 0.39 | 44 |
| 3 | 0.16 | 1.89 | 0.07 | 0.83 | -0.93 | 0.36 | 0.32 | 0.30 | 0.58 | 47 |
| 4 | 0.31 | 2.89 | 0.01 | 0.81 | -0.93 | 0.36 | 0.25 | 0.24 | 0.73 | 47 |
| 5 | 0.43 | 3.44 | 0.00 | 0.80 | -0.87 | 0.39 | 0.22 | 0.20 | 0.86 | 47 |
| 6 | 0.53 | 3.76 | 0.00 | 0.80 | -0.82 | 0.42 | 0.20 | 0.18 | 0.95 | 47 |
| 7 | 0.60 | 3.94 | 0.00 | 0.80 | -0.80 | 0.43 | 0.18 | 0.17 | 1.03 | 47 |
| 8 | 0.65 | 4.04 | 0.00 | 0.79 | -0.82 | 0.42 | 0.17 | 0.15 | 1.10 | 47 |

In contrast to the previous Tables (Tables 2-5) reporting the relationship between the actual and out implied forecasts, in only a handful of cases in this revised version (Tables 9-12) does the coefficient C2 differ significantly from unity: These cases related to forecasts for NZ interest rates, where the RBNZ forecasters had some inside knowledge in the first couple of quarters, see our first two papers.

So, after adjusting for a slower expected, than actual ex post facto, reversion to the mean, our simple model of forecasting tracks the actual forecast in these four cases rather well. That 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 macro-economic time series revert to their (desired) equilibrium rather faster than in the past or than currently expected.

## 3. Implications and Conclusions

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 auto-regressive continuation and mean reversion is likely to be optimal. It should minimise the likelihood of a really big error, and will be unbiased over the medium and longer run. So the behaviour of the forecasters in seeking to estimate the likely mean out-turn 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 (generally) 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. If so, in an upturn (downturn) phase, the forecasts will considerably overstate (understate) the subsequent upwards (downwards) movement.

What does this mean for policy? It means, for example, that the mean forecast will very rarely be correct. We would also argue that, assuming that the policy maker has no more expertise in predicting turning-points than the forecaster, policy should be somewhat more aggressive than the mean forecast would suggest, since this will usually be the right move, but that the policy maker should be ready to reverse the direction of policy both sharply and quickly as soon as a turning point appears.

Our results provide yet another reason why Brainard caution and interest rate smoothing are sub-optimal for policy-makers.

# Conclusions

In this set of four papers 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, under (over) estimating future outturns during up (down) trends. 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 auto-regressive momentum and of 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 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 be the basis of forecasts. Beyond that horizon, they cannot do so, and that too should be acknowledged, by applying a constant interest rate assumption beyond that date.

The second conclusion is that the resulting interest (and inflation) forecast is generally not modal. It is biased, under (over) estimating in up (down) turns, because the forecaster is protecting 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 policy makers need to be alert to (unpredictable) turning points, and therefore to the occasional need to reverse course abruptly.