An Essay on the Interactions between the Bank of England's Forecasts, The MPC's Policy Adjustments, and the Eventual Outcome

By C.A.E. Goodhart[1]
Financial Markets Group
London School of Economics

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1. Introduction

There are long, (and often variable), lags between a change in interest rates and its effect on real output and inflation. Hence policy should be based on forecasts, (King 2000). So the eventual out-turn, e.g. for output and inflation, is a complex combination of the skills of the forecaster, the response of the policy-makers to those forecasts (and to their other, possibly private, sources of information), and the impact of shocks, some of which will have been unforeseen at the time of the forecast. The aim of this paper is to make a start at disentangling this mixture in the particular case of the Bank of England, and thereby to seek to assess the skills of the forecasters, the adequacy of the response of the monetary authorities, and the time path of disturbances to the auto-regressive structure of the economy.

For most countries this exercise is, alas, impossible. Official forecasts are not published in many, perhaps most, cases. In other cases, where forecasts are

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published, they are described as `staff forecasts', and there is a careful distinction drawn between such `staff forecasts' and the beliefs about the future of the policy-makers themselves, e.g. in the ECB or FOMC. Fortunately these problems do not exist in the UK, at least not to the same extent. The forecasts for output and inflation are not only published, but, even though the more mechanical work in their production is done by the staff, the forecast is officially that of the Monetary Policy Committee itself.[2]

In any attempt to describe the characteristics of forecasts, there are a number of issues that need to be reviewed; these include whether the subsequent outcome data are kept constant, or are subject to revision; whether the forecasts are ex ante, i.e. made before the associated policy decision, or ex post, i.e. incorporating that policy decision; the number of forecast moments to be considered; and the nature, transparency and plausibility of the conditioning assumptions about future policies in the forecast. This list is not necessarily exhaustive, but represents a start.

One of the main problems in assessing the characteristics of the MPC's forecasts is that the actual data for output growth are subject to continuous revision for many years.[3] Indeed, in July 2005 the Chancellor, Gordon Brown, made an important revision to his fiscal platform, largely on the basis of changes in the

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[2] Of course some of the nine members may have individual reservations and qualifications, some of which are at times reported in the Inflation Report, (notably in Table 6B in previous issues of this Report).

[3] See Statistics Commission (2004), Revisions to Economic Statistics, Vols 1, 2 and 3.

dating of a business cycle which, in turn, depended on revisions to the path of output in 1997-1999! This raises the question of what generation of ex post output estimate should be compared with any particular forecast. Say that the forecast for the level of output in year XX Q2 was 100, but the estimate of the output for year XX Q2 made in year XX Q3 was 99, made in year XX+1, Q1 was 100 and made in year XX+10 was 101, should one treat the forecast error as 1, 0 or -1?

This problem is aggravated when the variable of chief interest is the output gap, since the latter depends on an estimate of the natural rate of output which is also subject to mismeasurement, sometimes as in the USA in the early 1970s and late 1990s by quite a large margin.

These problems are somewhat lessened in the UK by two factors. First the data published by the Bank of England for output relate to its growth rate, over the same quarter in the previous year. As Orphanides and Williams (2004, p. 6) note, mismeasurement of the natural rate (of unemployment or output) can be mitigated by replacing the data for the gaps by data for the growth of output/unemployment, and they further cite in support of using output growth data, (footnote 6), McCallum (1999), Orphanides (2003), Orphanides et al. (2000), and Walsh (2003).

Second, fortunately for macro-economic research workers in the UK, the Bank has now provided spread sheet (Excel) data on real output values for each generation of estimates from 1961 to 2001 Q3, (see Bank of England Quarterly Bulletin, Spring 2001, p. 42, `Building a real-time database for GDP(E)' by Castle and Ellis, and its website, www.bankofengland.co.uk/statistics/gdpdatabase). This allows the research worker to choose which generation of estimate to use, but does not resolve the question of what actually is the best choice. This choice, in some large part, relates to the question of what the forecaster is trying to forecast; is she trying to forecast the first `flash' estimate, which is known to be estimated with a large and erratic error, containing both much noise and bias; or the likely estimate after about one year; or the likely eventual estimate after some 5/10 years. In practice, early estimates have consistently tended to be revised upwards over time, but the scale of bias is unknown, and the Office for National Statistics has been trying to reduce the scale of the bias.

In contrast, the out-turn data for RPI(X), the retail price index excluding interest-related elements, e.g. mortgage payments, have not been subject to any such revisions; the first reported outcome figure remains unchanged. The target for inflation, for the MPC to hit, was set at 2.5% from May 1997 (and was implicitly at that same level from 1993 till 1997), until the index for inflation targetry was changed from RPI(X) to the Harmonised Index of Consumer Prices in November 2004, and the target rebased as 2.0%.[4] While there is some debate about which is the best index to use as a measure of inflation, e.g. how and whether to include housing costs, at least the time series itself is not continuously subject to change.

[4] That change primarily reflected the differing characteristics of the two indices, rather than any tightening of policy.

Whereas in other of my exercises making use of MPC forecasts, it has been necessary to make a stand on what generation of output outcome data to use, for the purpose of this exercise, I shall focus here primarily on the time series for the forecast and out-turn inflation where these problems do not arise. I shall only make secondary use of the output data series, and mostly for illustrative purposes.

In one such prior exercise, (Goodhart 2005a), I have sought to demonstrate that the MPC reacted strongly to deviations of forecast inflation from its target level some 7 or 8 quarters hence (the main policy horizon) in the ex ante forecasts that they were shown. These forecasts were then conditioned on an assumption that the short-term policy rate remained unchanged throughout the forecast period at the level in effect at the start of the forecasting exercise. My results suggest that the reaction was strong enough to drive inflation back to target at the policy horizon in the ex post forecasts which the MPC publishes in the Inflation Report. These are ex post in the sense that they take account of, are based on, the policy decisions taken at this latest meeting; that is that the short-term policy rate remains constant throughout the forecast horizon at the level set at this latest meeting. My findings suggested that if a researcher used ex post, rather than ex ante, forecast data to estimate reaction functions, then the estimated reaction functions, especially those relating to the longer-dated forecasts, could be severely biased.

There are, however, well-known problems with the constant interest rate assumption, (see Goodhart 2005a and b, and the references therein), and this has now been replaced, as conditioning assumption, by the use of the time path for short-term interest rates implicit in the money market yield. So long, however, as the conditioning assumption is made transparent, so that it is publicly observable, and kept unchanged throughout the forecasting process, then the combination of an ex ante forecast and the record of policy decisions should enable a researcher to explore an MPC's reaction function more accurately.

One of the problems with assessing the central bank's reaction function in both Canada and the USA is that the conditioning assumption about the future path of policy rates is not revealed, for example in the case of the U.S. Green Book forecasts, even after their five year embargo period. It is generally believed, (see Boivin, 2004; and Reifschneider, Stockton and Wilcox, 1997), that the Green Book forecasts are based on a constant interest rate assumption, except when there is good reason for the forecasters to assume a non-constant path, as in 2004/2005. But, if the researcher does not know what is the underlying interest rate conditioning assumption, how can she calibrate the reaction function by comparing the policy decision with the Green Book forecast? Indeed I do not know of any attempts to try to do so. Assume, for example, that the Green Book forecast showed stable inflation and output growth, but that the FOMC nevertheless raised interest rates. Was this because such a rising path of policy rates already formed the basis of the Green Book forecast, or because the FOMC wanted to tighten more than indicated by a forecast based on a constant interest rate assumption, or what?

In my earlier work (2005a) I sought to make use of this distinction between ex ante and ex post forecasts. I shall try to build on that further in this paper.

Finally, the Inflation Forecasts published by the MPC include estimates of the three first moments of the forecast, the mean, variance and skew. The Inflation Report itself, intentionally, does not publish point figures; instead it gives a probability distribution, which in the case of the inflation forecast is colloquially named `Rivers of Blood' from its regular red colour and river-delta shape. Of course, the associated central tendencies, the mode, median and mean exist, and after a short delay (whose objective is to focus attention on the distribution, not on the point forecast(s)), these are made publicly available by the Bank on its website (www.bankofengland.co.uk). Initially, before 1995 Q1, the distribution was assumed to be symmetrical, so all three central tendencies were identical. Thereafter, a measure of skew, (as well as of uncertainty), is reported, together with separate figures for the mean, median and mode. For this exercise we use the modal forecasts throughout. In practice, see Goodhart (2004), the skews in the forecast have been small, so there would not, we believe, be much difference if we used the mean or median instead.

In the absence of (much) skew, a certainty equivalence condition holds, in that the MPC makes its decision on the basis of the central tendency without regard to the estimated variance of the probability distribution. That said, Clements (2004) and Wallis (1999, 2003, 2004) have claimed that the MPC erred by presenting density forecasts that were much more widely distributed than consistent with the tight range of actual outcomes. We will not pursue issues relating to such higher moments here, but just consider the forecasting record of the MPC's modal forecasts, for inflation and to a lesser extent for output growth.

With these preliminaries concluded, the structure of the paper is as follows. In the next Section, (Section 2), we ask how the characteristics of a forecast should be judged, conditional on the forecaster not being able to influence the variable being forecast. Then in Section 3, we review how the analysis and measurement in the previous Section needs to be amended when a major purpose of the forecast is exactly to allow steps to be taken that will drive the variables being forecast in a desired direction. When such steps are then taken, there will, as a result, be a distinction between an ex ante, and an ex post, forecast, a distinction which is meaningless in a Section 2 context.

Then in Section 4 we consider the lag and auto-correlation structure of a simplified version of the economic system, including importantly that of the shocks themselves. We use this analysis to assess the likely auto-correlation of forecast errors, and of the relationship between shocks and off-setting policy measures. Section 5 concludes, and outlines a programme of future research work.

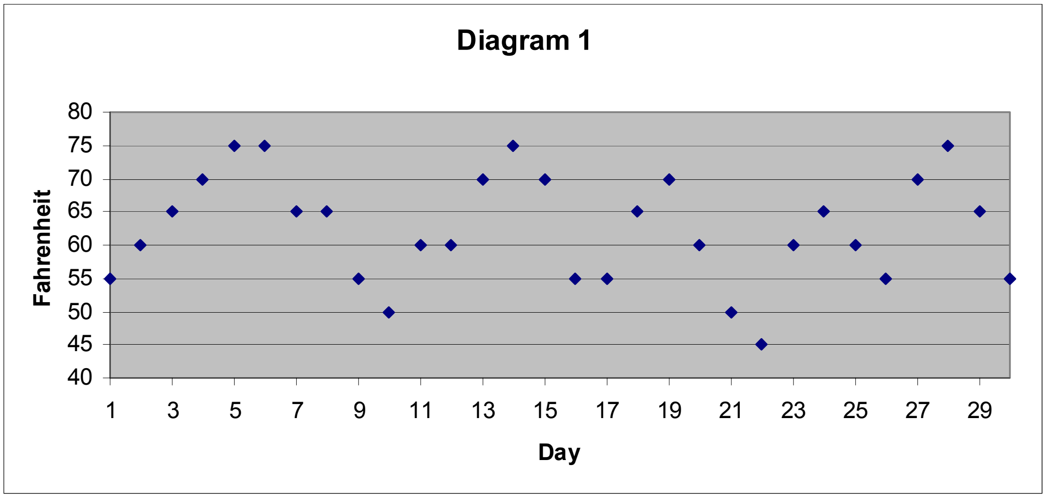
2. Forecasts when the outcome cannot be modified

Most of the forecasts that people consult are of the above form, i.e. that the forecast itself has no effect on the subsequent outcome. This is true of the weather forecast, (subject to minor qualifications about 'seeding' clouds to encourage rain), and to forecasts about other geo-physical phenomena, (earthquakes, etc.) – though again there need to be qualifications about forecasts for global warming, in so far as the forecast may (be intended to) influence policy on greenhouse gasses. Many of the components of economic forecasts, for example of growth, inflation and interest rates abroad, or of oil prices, are similar; that is there is no expectation, or intention, that policy measures could be taken, as a result of the forecast itself, that would bring about changes to the variables being forecast, (though once again, there may be some minor qualifications).

When we seek to assess the quality of forecasts, we generally have this genre of forecast in mind. What characteristics are we looking for? Two such characteristics are commonly cited and measured by the forecasters themselves, which are accuracy, for example as measured by the Mean Average Error (MAE) or Root Mean Squared Error (RMSE), and bias, i.e. the average deviation of out-turn from forecast (and the significance of such bias). These characteristics are, however, on this view, less important to most users of such forecasts than the ability to predict the fluctuations around the mean outcome, which we can term the R^2 characteristic.

In Diagram 1, for example, we draw a chart of maximum temperatures on 30 consecutive days, (the actual numbers have been made up). The average is 62.5. If a forecaster should just present a forecast for each, and every day, that the average maximum temperature will be 62.5 degrees that is some help,[5] but does not tell us what we usually want to know, which is will today/tomorrow be hotter/colder than average. Thus a forecaster who could just estimate average out-turns might be reasonably accurate and unbiased, but relatively useless for most purposes. Indeed, a forecaster who was consistently wrong by, say, five degrees (quite a large amount) in one direction, (estimating the average at 57.5), but was exactly correct in assessing the fluctuations around (deviations from) the average would, for most purposes, be more use than a forecaster who constantly repeated the (correctly estimated) average. At least a user would know which days would be relatively hot or cold, and could dress accordingly. I do not know how one might trade off these various characteristics, i.e. average error, bias and R^2, but my own preferences would be to give considerable weight to the latter.

[5] Holiday guides, for example, frequently give details of expected mean monthly temperatures, or rainfall, in a resort, and that is useful information.



As will be obvious from the diagram, I have incorporated an auto-correlative structure into my temperature time series. This is often the case in forecasts of physical phenomena. Hot days come in heat-waves; earthquakes are followed by aftershocks. So a common, basic approach is to make use of such an auto-regressive structure in the basic variable, often an AR1 structure; and thereby forecast that tomorrow will be much the same as today. A reasonable test of the forecast is whether it can improve on a mechanical auto-regressive prediction. Of course, how tough this test is depends on the richness of the auto-regressive structure employed as the comparator. The simplest test would be to compare the forecast just to a mechanical prediction based on the auto-regressive structure of the variable under consideration.

This exact test has been conducted by Campbell (2004) for the USA for forecasts of real output. Taking a break-point in 1984 Q111, which he dates as the start of the 'Great Moderation', he finds, pp 9/10, that,

> "Over the period 1969-2003, the R^2 of the quarterly SPF [Survey of Professional Forecasters] forecasts is 22.3 percent as compared to only 6.5 percent for the AR(1) forecasts.[6] While these estimates suggest that the SPF forecasts are considerably more accurate than those generated from the AR(1), examining the one-step ahead R^2 pre- and post-moderation reveals that the considerable advantage of the SPF over the AR(1) forecasts quickly deteriorated after 1984. Prior to 1984:3, the SPF forecast exhibited an R^2 of 29.95 percent with observed real output growth as compared to only 7.4 percent for the AR(1) model. After the onset of the Great Moderation, the R^2 of the AR(1) model falls slightly to 4.7 percent but the predictive accuracy of the SPF is completely eliminated. The sample estimate of the R^2 between observed and forecasted growth is -4.26 percent, indicating that professional forecasters' ability to predict future growth is dominated by the (ex post) mean growth rate.[7]
>
> The results are similar when comparing the R^2 of annual real output forecasts. The sample R^2 of SPF annual real output forecasts is 21.7 percent as compared to 0.7 percent for the AR(1) model over the entire sample period. Before the large decline in macroeconomic volatility, SPF forecasts were considerably more accurate than the AR(1) model. The R^2 between the actual and forecasted growth rates is 28.28 percent in the case of the SPF forecasts as compared with a point estimate of -4.1 percent in the case of the AR(1). After 1984:3, the roles of the SPF and AR(1) forecasts are reversed with the SPF forecasts exhibiting a negative point estimate of -16.53 percent and the predictive accuracy of the AR(1) model rising to 6.4 percent. The evidence from both these annual forecasts and the quarterly forecasts indicate that apart from a decline in volatility, the Great Moderation also ushered in a period of reduced forecastability."

Of course, the comparative test can be made tougher yet by using a broader VAR in place of a single variable autoregression. While I do have outline plans to do some collaborative research along such lines in future, for the purpose of this exercise, partly because of the short length of the data set being used, all that will be done is to examine how good, or bad, the MPC's forecasts were, using the R^2

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[6] At this point it is worth noting that use of the full-sample estimates in constructing the AR(1) forecast residuals maximizes the in-sample R^2. Hence, the population R^2 of the AR(1) model is certainly lower than 6.5 percent.

[7] Recall that the point estimate of R^2 is not constrained to lie in the unit interval since the forecast errors are not constrained to have a sample mean of zero over either subsample, or even over the entire sample in the case of the SPF forecasts.

criteria. The data series used here go up to 2003 Q3, since the initial research was done in 2004. Any subsequent revision will extend the data set as far as possible.

Forecasts for future inflation (RPIX) have been made in the Inflation Report by the Bank since 1993 Q1. Initially they were for the current quarter (t = 0), (remember that the forecast is completed in the middle month of each quarter), and the next six, or seven, quarters (t = 6, t = 7). Then in 1995 Q3, the forecast horizon was extended to, and has remained as, eight quarters (t = 8). As already stated, the actual data, for the RPI(X) series, taken from standard ONS series, once published are not revised. These data are shown in Table 1 below. The forecasts relating to each consecutive out-turn date are shown horizontally. Thus the forecast at t = 8 for 2003 Q3 (2.45) was made in 2001 Q3, at t = 7 (2.23) in 2001 Q4, and for t = 0 (2.85) in August 2003, and compares with the out-turn of 2.80.

Although the Bank, obviously, made forecasts of the associated predicted (growth rates of) real GDP, it did <u>not</u> publish them in its Inflation Report until it was granted operational independence in May 1997; so the first published forecasts, (for the distribution of the growth of real GDP in the Inflation Report), date from 1997 Q3. Although it may be possible at some future date for researchers to get hold of (so far) unpublished details of the Bank's internal forecasts for earlier years, in this case I have preferred to work with the existing published forecast data, despite the resulting short time series. These forecasts are shown in Table 2 in exactly the same format as for inflation, except that we also show the series for both the contemporaneous [in practice the estimate made one year later], and also the latest available (as of 2004) output data. We shall focus on the relationship between the 'contemporaneous' and the forecast output series, since that, I believe, is what the forecasters are trying to predict.

By the standard criteria, i.e. accuracy as measured by the Mean Average Error (MAE) or Root Mean Squared Error, and bias, i.e. the average error, the results are good, whether using the constant, or market rate, conditioning interest rate assumption. These are shown in Table 3.

But when we turn to examine the R^2 criteria the results change from good to bad. These are shown in Tables 4 for RPI(X) and 5 for changes in output. The R^2 values for the RPI regressions are below 0.2 at longer horizons until the forecast made at t = 1, and the b coefficient below 0.5 until t = 0. Similarly the Bank's forecast for output growth has an R^2 and b values of virtually zero until t = 1.

To put it bluntly, the Bank does not appear to be able to provide <u>any predictive guide at all</u> to the fluctuations of output growth, or inflation, around its trend over a year in advance; it is only really in the last couple of quarters before the outturn that the forecasts have any predictive value for fluctuations around the trend.

But how should we interpret such apparent predictive `failure'? Does it imply that the forecasts are just `no good' until near the outcome date; and hence that such forecasts should be abandoned, thereby saving resources? If the forecasts were forecasts for the weather, i.e. a variable whose outcome cannot be affected by the forecasters' own action, the above condemnation would stand. Forecasts at horizons greater than t = 4 would be a waste of time; it would be just as good to assume that the average weather pattern will prevail. This, however, is not the case for forecasts of output growth and inflation.

It is interesting (to me at least!) that exactly the same phenomenon appears to hold in the USA, since about 1984. As already noted, Campbell (2004) finds that the ability of professional forecasters to predict fluctuations in output since 1984 Q3 has collapsed to zero. Tulip (2005) has examined the ability of the Fed staff (in the Green Book) to predict changes in output from 1968 (four quarter forecasts) and 1980 (eight quarter forecasts) up till 2001, (more recent years cannot be used because of the five year embargo). His conclusions, pp 11 and 12, are:-

> "There are four key points evident in [the previous] charts…
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> 1. As the literature on the Great Moderation has documented, the variance of output growth declines substantially, in the sense that it has been much smaller in the last two decades than it was in the previous two decades.
> 2. In contrast, unpredictability does not show a clear trend. Although mean squared prediction errors of short-horizon forecasts tend to be larger before the early 1980s than after, the change is not large, obvious, or uniform. Moreover, the eight-quarter forecast errors seem to trend up, albeit over a shorter sample period.
> 3. The predictable component of output growth has virtually disappeared. Although output was highly variable in the 1970s and early 1980s, most of this variation was predicted. In contrast, since

the late 1980s the Fed staff seems to have been unable to predict variations in output growth.

4. Indeed, recent Mean Squared Errors have been larger than variances, particularly at longer horizons."

Finally Scott Schuh (2001) found that forecasters were unable to predict fluctuations in output and inflation at all well in recent years. He concluded, pp 54/55, that:-

> "GDP and unemployment rate forecasts and, to a lesser extent, inflation forecasts veered off track in the second half of the 1990s. Although the errors are not unusually large in historical perspective, they are economically significant and troubling – particularly from the perspective of monetary policymakers who require accurate forecasts to set interest rates appropriately. On average, macroeconomic forecasts are approximately unbiased, but they are inefficient and the forecast errors are characterized by improper correlation. These factors indicate that macroeconomic forecasts leave considerable room for improvement
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> At least with regard to the period 1996 to 2000, no individual forecasters in the SPF or WSJ predicted macroeconomic conditions accurately and consistently. However, the brief and preliminary investigation of individual forecaster performance in this study provides evidence of differential abilities among forecasters. Much more data and anlaysis are required in this area before any firm conclusions can be drawn about the best forecasters."

What these American authors note is that the large reduction in the overall volatility of the US economy, e.g. in output and inflation, has been due to the virtual disappearance of the <u>predictable</u> component of such fluctuations. Estimates of the <u>unpredictable</u> residual show no such diminution; indeed that appeared to increase in the latter half of the 1980s. My findings, above, are consistent with that having been the case in the UK also. Similarly Benati [2004] has found that (the predictable) persistence of output and inflation was high in the 1970s in the UK, but declined to historically low levels in the 1990s and early 2000s.

To some extent agents can protect themselves from predictable fluctuations in their surrounding circumstances. Since the moderation in volatility in Anglo-Saxon countries has been the result of a decline in the forecasted component of such volatility, without any apparent accompanying reduction in forecast error, the decrease in economic uncertainty has been in practice much less than one might have expected from the greater stability of recent years.

The common implication that most commentators would draw from this, and that the US writers cited above appear to make, is that the forecasters are falling down on their job. That would indeed be so if the outcomes were independent of the forecast itself, as with the weather. This, however, is not the case for MPC forecasts of output growth and inflation.

3. The characteristics of a forecast intended to influence policy and outcomes

The essential purpose of such a forecast is to inform policy-makers on how to vary their instruments, short-term interest rates in the case of the MPC, so as to drive the output gap and the deviation of inflation from target down to zero. The purpose of forecasting, certainly at the Bank and also, though perhaps to a lesser degree, among private sector forecasters, is to inform policy so as to drive output growth (or gap) and inflation back to its (desired) trend level. If this is done perfectly, then the value of R^2 at the forecast date should be zero, not unity! If the resultant policy change is overdone, the b values would be negative. The less that the forecast (correctly) induces a policy response, the closer will the expected values of R^2 and b return to unity. If there is no policy response at all to the forecast, we are back effectively to our weather forecasting simile. All this is perfectly well known in theory and in principle, (e.g. Tobin 1970; Blinder and Goldfeld 1972; Buiter 1984; Woodford 1994[8]). It is quite rare, however, to see a documented, empirical example in practice.

Why then do we see the forecasts increasingly exhibiting an ability to predict fluctuations around the trend as the horizon shortens? The answer, of course, is that lags, (which are themselves subject to uncertainty), in the transmission

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[8] Woodford (1994, p. 101) writes:-

> "The point can be illustrated by the following extremely stylized model. Suppose that inflation over the relevant horizon is determined by a relation of the form
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> (1) $\pi_{t+1} = s_t + u_t + \varepsilon_{t+1}$
>
> where π, is inflation between dates t and t + 1, s_t is an indicator observed at date t, u, is a control variable of the monetary authority chosen at date t, and ε_{t+1} is a mean-zero random variable not forecastable at date t. Equation (1) is intended to represent a causal effect of u_t on the probability distribution of possible values for π_{t+1} which is understood by the monetary authority; for simplicity, this effect is assumed to be a simple shift in the conditional mean, and the size of the effect is assumed to be independent of the value of s_t that is observed. The appearance of s_t on the right-hand side of (1) need not have a causal interpretation; s_t may simply be correlated with factors that influence inflation independently of the control variable. The realizations of s_t and ε_{t+1} are assumed to be independent of the choice of u_t, and the realization of ε_{t+1} likewise independent of s_t.
>
> It follows that the variance of π_{t+1} is minimized by a policy feedback rule of the form $u_t = -s_t$. If such a rule is followed, $\pi_{t+1} = \varepsilon_{t+1}$, and a regression of π_{t+1} on s_t will yield (asymptotically) a zero coefficient. But it would be incorrect in such a case to tell the monetary authority to stop monitoring the value of s_t before choosing the value of u_t."

mechanism make it impossible, and/or undesirable (for a variety of reasons which we will not restate here) to use interest rate policy to offset short-term shocks. <u>If interest rates could be effectively used contemporaneously and instantaneously to affect output and inflation, (as is assumed in many models), then the R^2 of forecasts should be zero at all horizons, including t = 0.</u>

The question of what one might expect for the b coefficient is more complicated.[9] Suppose that y(t) = a + bx(t) + e(t), where x is the (unconditional) forecast, y the outturn, and e an unobserved shock, so that a = 0 and b = 1 (ie these are unbiased forecasts). Now assume that policy is set in order to ensure x(t) = y*. Then indeed y(t) = y* + e(t), which might lead one to expect that a = y* and b = 0. However, notice that y(t) = a + bx(t) + e(t) with a = 0 and b = 1 should fit the data just about as well, as indeed does any linear combination of the two regressions. The point is that x(t) and the constant become almost perfectly collinear, so when b rises (falls) the coefficient a declines (rises), and the standard errors on the coefficients increase. This is almost exactly what we find in our earlier regressions.

One basic message is that the shorter (longer) the lag before the instrument affects the objective variable, the shorter (longer) is the horizon over which deviations from trend should become reasonably predictable.

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[9] I am indebted to C. Bean for this analysis.

The normal empirical finding is that the lag before interest rates affect output is shorter than that for inflation. So, what we should see is that longer horizon forecasts for inflation are rather better, by our criteria of R^2 and b coefficient closer to unity, than for output growth. Whilst the differences between the forecasting characteristics (for inflation and output growth) are not strong, they do tend in the direction hypothesized. With the Bank forecasts, all the coefficients for inflation, out to t = 8, are positive, and most are weakly significantly different from zero. In the output forecast, the coefficients on the output forecast, b, are mostly negative after t = 2. Similarly the R^2 values for inflation are low, around 0.1 until t = 2, (but this at least is better than the value of less than 0.1 for output until t = 1).

So, the traditional measures of forecasting accuracy, e.g. MAE, RMSE, unbiassedness, can be met well enough, especially during periods of stability, by forecasting that the relevant variables will return to their average trend. This is, in effect, what the forecasters at the Bank did at the longer horizons since 1993, because policy was set, explicitly in the case of RPI(X), to drive that variable back to target at the forecast horizon. If one instead, as here, examines the more testing criteria, whether the forecasters could predict the fluctuations around the trend, the results demonstrate virtually zero ability to do so, until the horizons become rather short, t = 3 or lower, too late to take countervailing action.

But that latter qualification is crucial. If no countervailing action is possible, (as with forecasts of weather, earthquakes, etc.), then failure to forecast fluctuations is pure failure. But if counter-vailing action is possible, then the initial (ex ante, prior to the MPC decision) forecast has the key role of informing policy actions. Those policy actions should offset deviations from target (desired trend), eliminating predicted deviations, until the lags in the transmission mechanism make that impossible; so that the ex post forecasts (prepared after the resulting MPC decision), which is what are published in the Inflation Report, and what we show here, should, at the longer horizons, show no correlation between current fluctuations (from target) in output growth and inflation and prior longer-term predictions of those same variables. Thus our results in this Section, of R^2 and b coefficients of approximately zero for output growth until t = 3, and low for inflation forecasts until short horizons could be seen as evidence of the optimal inter-play of forecasting and policy response, not as evidence of lousy forecasting ability. As Blinder and Goldfeld note (1972, p. 588),

> "Typically, an authority that is conducting an effective stabilization program will appear to have a very small (and statistically insignificant) multiplier in simple reduced form experiments, and, conversely, an ineffective authority will get a large (and statistically significant) multiplier."

The objective of policy should, surely, be to reduce the predictable component of fluctuations in inflation, or output to zero. There is no reason to believe that inherently unpredictable shocks to the (world) economy should have an (upwards or downwards) trend. Thus the finding that the predictable component of fluctuations has declined to zero whereas the predictable component has remained constant is, on this view, consistent with an optimal combination of forecast and policy.

There are, however, other explanations of the 'Great Moderation', in particular that it is due to good luck rather than good policy. Thus Benati and Mumtaz (2005), using a Bayesian time-varying parameterised structural VAR conclude that, p. 1 (and p. 19):-

> "Our evidence points towards a dominant role played by good luck in fostering the more stable macroeconomic environment of the last two decades. Results from counterfactual simulations, in particular, show that (1) if the volatility of non-policy shocks had been, over the entire sample period, the same as that over the most recent years, the Great Inflation would have never happened; and (2) 'bringing the *Monetary Policy Committee* back in time' would have affected macroeconomic outcomes only to a minor extent."

To reach a similar result by a rather simpler route, note that the scale of interest changes made by the MPC since 1993 have been quite small, in comparison with those made in the previous 30 years. Our best estimates of the transmission mechanism (see Monetary Policy Committee, 1999) indicates that such policy moves will only have shifted output and inflation slightly from their prior course. So, that prior course must itself have been quite stable, in order to enable the ex post time path of inflation and output to be as stable as it has been.

There are some potential responses to this.[10] First, many of the shocks affecting an open economy, such as the UK, originate abroad. So, if good (monetary) policies abroad make the world outside more stable, then the UK will benefit. Thus UK policy may not have needed to be so active in the last twenty years because Volcker and Greenspan have stabilised the US economy. The Benati/Mumtaz exercise treats the UK as a closed economy, concentrating on a three variable VAR for output, inflation and interest rates, without specific consideration of external shocks.

Second, some large part of the auto-regressive structure of the economy depends on forward-looking expectations. In so far as these expectations are transformed in a stabilising manner by a systematic shift in monetary policy (n.b. the impulse response functions to monetary policy shocks will by definition miss any such effect, as Rudebusch [1996] noted in his critique of the VAR approach), then that policy will have had an extra stabilising effect on the economy. Such an effect might well be difficult to pick up in a VAR approach

Third, if 'good luck' is held to account for the reduction in volatility, why should it have impacted solely on the predictable component of volatility, and not at all on the unpredicted? Would not one have expected 'good luck' to reduce the unpredicted shocks as much as the predictable element? What is the special nature

[10] Also Cecchetti, et al., (2004), in their Working Paper on 'Has monetary policy become more efficient? A cross country analysis' reach diametrically opposite conclusions, finding that monetary policy improvements have been the major cause of the greater stability.

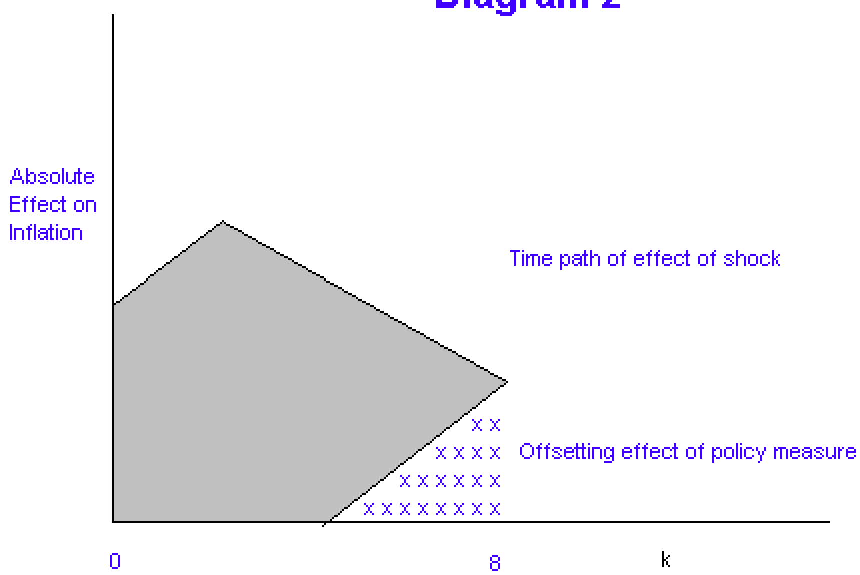
of this 'good luck' that has this pattern of effects? Thus the very nature of the pattern of reduction in overall volatility, as between the predicted and unpredicted elements, goes to support the hypothesis that what has been happening has been due to improvements in the forecasting/policy mix.

4. The interaction of the lag structure of shocks, forecasts, policy and outcomes

The transmission mechanism of monetary policy involves long lags. If shocks only had a very short-lived transitory effect on the economy, then there would be no point in using monetary policy to try to offset them, since their effect would have disappeared before policy measures could be brought to bear. It follows that the shocks to the economy that matter for policy purposes are those with some considerable persistence. Indeed, the shocks that concern policy-makers, such as the 1997/98 Asian crisis, oil price shocks, asset price booms and busts (such as housing), the impact of the Olympic games, technology shocks, etc., etc., do have effects on an economy that can be expected to persist for many quarters, even though they will eventually die away. Often their peak effect may come several quarters after they are first observed.

In Goodhart (2005a) I sought to demonstrate that the MPC has reacted to a (perceived) shock to expected inflation by adjusting interest rates so that forecast inflation is driven back to target inflation at its main policy horizon of 7/9 quarters hence. If so, that (perceived) shock will lead to an expected divergence between inflation and target at all shorter horizons, with the gap depending on the margin between the persistent time path of the shock, (as perceived at time t), and the increasing effect of the countervailing policy measure. This is shown in Diagram 2, where the time path of the effect of the shock has been arbitrarily selected.

Diagram 2



Area marked by grey tone shows the intermediate effect of shock on inflation.

Area marked by x x shows the offset to a shock, fully offset at t=8, which is offset by policy in the intermediate quarters.

As the diagram shows, the combination of the persistence of shocks, the lags in the effect of monetary policy and the (implicit) choice of a policy horizon at about 7/8 quarters hence, has the following implications. First, the variance of forecast inflation will be considerably higher at intermediate horizons (4 or 5 quarters hence for example) than at the policy horizon. Second, since shocks are, by definition, unpredictable, but once occurred persistent, the errors in forecasting will be auto-correlated. So, if at time t, the forecaster made an error in forecasting inflation at time t+i, that same signed error is likely to recur at time t+i+1. So the first order autocorrelation of forecast errors, going horizontally, ought to be high. We record the actual experience of forecast errors in inflation in Table 6.

If the scale and persistence of the shocks was perfectly perceived, then the error at time t in forecasting inflation at time t+i, should not be correlated with the error at time t+1 in forecasting inflation at time t+i; that is the first order auto-correlation of forecast errors, going downwards ought, in principle, to be zero. In practice, it is usually hard to perceive at the outset which shocks will become large in effect and persistent. So there is quite likely to be initial underestimates of the scale of the major shocks. Thus we may expect some positive first-order auto-correlation of forecast errors, but its scale should be much lower than that of the horizontal auto-correlation of forecast errors.

Third, and contrary to some theoretical expectations, if the effect of shocks should rise to a peak a few quarters after it is first observed, as in the case shown in Diagram 2, the standard deviation of the forecast errors will themselves be likely to be hump-shaped, with the position of the hump dependent on the (average) time paths of shocks and their policy counter-measures.

Fourth, and finally, given the time paths of the persistence of the shock and the lags in the effect of policy, then, with a policy horizon at t = 8, only a relatively small proportion of the effect of a shock will be offset in the intermediate period. This is also shown in Diagram 2.

We can demonstrate that all four hypotheses hold in the case of the UK for inflation, for our data set running from 1993 Q1 to 2003 Q3. First, the average variance of forecasts of inflation, (constant interest rate, modal forecast), is as shown below:-

Inflation Report
RPI(X)

	Out-turn	Forecast at Horizon								
		t = 0	1	2	3	4	5	6	7	8
Mean	2.5	2.6	2.5	2.5	2.5	2.6	2.6	2.6	2.6	2.6
Standard Deviation	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.3	0.2

The errors in the forecasts for inflation are shown in Table 6. From this table, it is simple to extract the first order auto-correlations, and the standard deviations of the errors, which are as follows:-

First order auto-correlations Bank RPIX

First order auto-correlations of the forecast errors going downwards:

T=	8	7	6	5	4	3	2	1	0
	0.434	0.356	0.530	0.626	0.686	0.583	0.551	0.306	-0.162

First order auto-correlations of forecast errors going horizontally:

T=	8/7	7/6	6/5	5/4	4/3	3/2	2/1	1/0
	0.882	0.850	0.818	0.838	0.857	0.829	0.833	0.666

As hypothesized the auto-correlation of forecasting errors going horizontally is high, and much higher than the auto-correlation going downwards.

Interestingly, and contrary to theoretical expectations (see Benati 2003b, Section 5.1), the standard deviations of the forecasting errors themselves are hump-shaped, rising from t = 0 to t = 4 and then declining again until t = 8 for both output and inflation.

Standard deviations of the forecast errors:

T=	0	1	2	3	4	5	6	7	8
	0.26	0.41	0.47	0.53	0.57	0.53	0.51	0.42	0.38

Both the variances in inflation forecasts and in the errors in such forecasts would be hump-shaped on the assumption that disturbances may build over time and offsetting policy measures are slow to take effect. Equally the horizontal auto-correlation of forecast errors is high, as must be the case if shocks are persistent; and such auto-correlations are much higher than those going downwards, though these latter in turn are higher than might have been expected if the first estimate of the shock/disturbance was accurate.

Finally we review how far policy has offset shocks at intermediate dates between t = 8, where we rely on Goodhart (2005a) to the effect that the offset was forecast to be complete (100%) at t = 8, so that the subsequent deviation of inflation from target is entirely due to later shocks, unforeseen at the time of the initial forecast eight quarters previously. Here we have the advantage that in 1999 the Monetary Policy Committee authorised a publication on 'The Transmission Mechanism of Monetary Policy', (largely prepared by the staff), showing diagrammatically on page 12 the effect of a 1% change in interest rates, maintained for one year and then reversed, on both output and inflation on the basis of two alternative simulations. Since there seemed few grounds for choosing between these, I took the average, mean, of the two, and translated that, by eye, into numerical estimates.

For my purposes, however, I want a rule of thumb for a change in interest rates maintained over two years, until t = 8, not just one. For inflation there is no problem, since the lags are so long that the results are equivalent.[11] Moreover, interest rate changes are not made only in the forecasting (Inflation Report, IR) month, but in the two preceding months as well, (though the frequency of making such adjustments, for some fairly obvious reasons, is higher in the IR month than in the other (not IR) months). So we need to take account of these as well.

Be that as it may, the rule-of-thumb adjustments to be made to the forecasts of inflation for interest rate changes are shown in Table 7, and the actual historical changes in interest rates, and the resulting implied changes in the inflation forecasts are shown in Table 8. Note that a change in interest rates in say Q1 1999 will affect output in Q2 1999, Q3 1999, etc., so the way that we have set up the tables, the effects run diagonally downwards from left to right in Table 8.

Taking advantage of the finding (Goodhart 2005a) that the MPC drove forecast inflation back close to target (2.5%) at the horizon of t = 8 at all times, I can then take the deviation between the inflation outcome and the forecast for that same quarter eight quarters previously as the sum of intermediate (unforeseen) shocks and (offsetting) policy effects. So I can then calculate how much policy has offset such shocks in the intermediate period (up to the policy horizon at t = 8). This is reported in Table 9.

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[11] The Bank of England has introduced a new quarterly model, (BEQM, see News Release on April 22, 2004), in which the responses to interest rate changes of inflation (somewhat quicker) and of output (somewhat larger) are slightly different from those used in this paper. See the article on `The new Bank of England Quarterly Model', accompanying the News Release, and available on its website, especially Charts 1 and 2, p. 5.

A positive value for ‘policy change’ implies that the sum of the effects of interest rate changes between t = 8 and t = 0 was expansionary on inflation. We show, in column 2, the difference between the outcome, for RPIX (Table 9) and the concurrent forecast at t = 0. For inflation the difference between the concurrent forecast in the middle month of the quarter and the end-quarter outcome at t = 0 was on average tiny, and randomly distributed. Then we show the difference between the forecasts at t = 8 and t = 0. This difference has a strong first-order positive auto-correlation (0.51, p = 0.004). We can then decompose this into the accumulated policy response (as estimated) and therefore the residual forecast change, primarily from intervening unforeseen shocks. Again both the policy responses, and the unforeseen shocks, show strong first-order positive autocorrelation.

The initial forecast (t = 8) for RPIX has, however, been on average very slightly above the outcome, both over the full period and since operational independence in 1997 Q2, as already reported in Goodhart (2004a). The outcomes, however, have closely matched the target value of 2.5%; so the average value of column 5 has been negative (-0.25, S.E. 0.4 over full period, F.P.; -0.22, S.E. 0.36 since operational independence, OI). Inflation was probably initially overestimated, until Q2 1996, because of an expectation of a greater pass-through (than actually occurred) onto domestic prices of the sharp devaluation of end 1992. The other main period, when prospective inflation was initially over-forecast, was between

1998 Q3 and 1999 Q2. This reflected a feeling in 1996 and early 1997 (before OI) that Chancellor Clarke had failed to raise interest rates enough. With a combination of a subsequent strong rise in rates (note that the negative policy response in these quarters exceeds the unanticipated shocks) and the deflationary effect of the Asian crisis, this mini-surge in inflation was halted.

There is, as one might hope to find, a negative association between the policy response and the unanticipated subsequent shocks, but it is not particularly pronounced; the signs are opposite 23x, similar 11x, and zero 2x, over FP; (opposite 14x, similar 9x, zero 2x, under OI).

A regression,

$$\text{Policy Change}_t = a + b \text{ Forecast Change}_t,$$

does, however, show a significant offsetting effect: Thus

a = 0.01 (0.76)	b = -0.16 (0.06)	$R^2 = 0.10$	FP
a = 0.01 (0.83)	b = -0.26 (0.07)	$R^2 = 0.14$	OI

The strength of the correct counter-vailing policy response has, apparently, increased since OI. The difficulty of forecasting shocks, that need offsetting, may well be the explanation of the low R^2. Moreover a given subsequent change in forecast inflation, unanticipated at t = 8, only produces a policy offset somewhere about one fifth of the former’s size. But this should not be surprising. Given the long lags in putting offsetting monetary policy into action, this is, as Diagram 2 shows graphically, what one should have expected in the first place. When a subsequent shock occurs near to the out-turn date, say within a year, there is nothing that the MPC can, or should try to, do about it.

5. Conclusions

The record of the Bank forecasters in predicting output growth and inflation is good by the standard criteria of MAE, RMSE and unbiassedness. Looking at this more closely, however, reveals that, since 1993, this has been because these forecasters have predicted that these variables would remain close to trend/target, and this has been broadly what has occurred. If, instead, the criterion is whether the forecasters can predict deviations around the average trend/target, then the results have been dire. In equations of the form Outcome = a + b Forecast, the values of R^2 and of b have been approximately zero (rather than one) until the horizon has become fairly short (two, or three, quarters, or less).

Superficially this may seem to represent forecast failure, but this would only be so if the forecasting process could not itself influence policy, which then drives the variables back to their desired target. Indeed long-horizon values of R^2 of zero may reflect an optimal forecast/policy procedure. Only when the lag length is such as to make it impossible/undesirable to use the instrument to drive the objectives back to target should we see the values of R^2 and b returning towards one.

Since the transmission mechanism of monetary policy has long lags, only persistent shocks will be of concern to the monetary authorities. Earlier work (Goodhart 2005a) suggests that in the UK the MPC has attempted to offset the effect of inflationary shocks at t = 7/8. Given this, and depending on the actual time paths of auto-correlated (i.e. persistent) shocks and of the transmission mechanism of monetary policy, both the variance of (ex post) inflation forecasts and of errors in that inflation forecast will tend to be hump-shaped; the (horizontal) auto-correlation in forecast errors will be high, and much higher than the vertical auto-correlation; the proportion of unforeseen shocks offset by policy measures between t = 8 (when the offset is complete) and t = 0 will appear low, even in those cases when forecasting is optimal and policy succeeds completely in its chosen purpose (i.e. to return inflation to target at t = 8). We show that the data for inflation forecasts and outcomes between 1993 and 2003 are consistent with all these hypotheses.

There are several further channels of research that this line of work suggests. First, there is the question of whether the ‘Great Moderation’ in (predictable) volatility was due to good luck or to good policy. There are arguments to be advanced on both sides of that question, and analytical complications in addressing this question, several of which were briefly mentioned in Section 3. I hope to work further with Benati on this question. Then there is the question of why money markets yield curves have been such poor predictors of future short-term interest rates. I intend to examine whether errors in interest rate forecasts are correlated with errors made (by the MPC) in forecasts of output and inflation. Finally there is the issue of why, if shocks are random in arrival (and the MPC attempts to offset them fully at t = 8), the time path of interest rate changes is nonetheless one of small, same-signed, consecutive changes in interest rates. This issue is closely akin to the question of why there is positive, first-order vertical auto-correlation in forecast errors. Having tended to under (over) estimate inflation at t + i at time t, why is there a tendency for forecasters to make the same signed under/over) estimate for inflation at t + i at time t + 1? When a big shock does come, there has seemed to be some tendency for forecasters to under-estimate its true virulence initially, and to need time to assess its full scale. Is this a common problem in forecasting? If so, why?

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Table 1
Bank Forecast of RPIX

		Forecast t =								
	RPIX (% change over 12 months)	0	1	2	3	4	5	6	7	8
1993 Q1	3.50	3.50								
Q2	2.80	3.40	3.40							
Q3	3.30	2.90	3.40	3.00						
Q4	2.70	3.30	3.00	3.20	3.10					
1994 Q1	2.40	2.80	3.60	3.20	3.20	3.40				
Q2	2.40	2.70	3.00	3.50	3.30	3.50	3.40			
Q3	2.00	2.30	2.90	3.10	3.50	3.30	3.60	3.40		
Q4	2.50	2.10	2.60	3.00	3.20	3.40	3.30	3.70	3.30	
1995 Q1	2.80	2.90	1.90	2.70	3.10	3.40	3.40	3.50		
Q2	2.80	2.70	2.80	2.00	3.00	3.40	3.30	3.40	3.60	
Q3	3.10	2.90	3.00	3.10	2.30	3.20	3.40	3.20		
Q4	3.00	3.20	3.00	3.10	3.20	2.40	3.20	3.30	3.20	
1996 Q1	2.90	2.80	3.30	3.20	3.40	2.70	2.80	3.40	3.30	
Q2	2.80	2.70	2.70	3.50	3.50	3.80	2.70	2.40	3.10	
Q3	2.90	2.70	2.50	2.40	3.20	3.40	3.70	2.60	2.40	
Q4	3.10	3.10	2.40	2.30	2.20	3.00	3.20	3.40	2.50	
1997 Q1	2.70	2.70	2.90	2.30	2.30	2.30	2.70	2.90	3.00	
Q2	2.70	2.60	2.40	2.80	2.30	2.20	2.30	2.70	2.80	
Q3	2.70	2.65	2.40	2.20	2.70	2.40	2.40	2.30	2.70	2.80
Q4	2.70	2.60	2.32	2.20	2.20	2.40	2.50	2.40	2.40	2.70
1998 Q1	2.60	2.60	2.51	2.19	2.20	2.30	2.40	2.60	2.40	2.40
Q2	2.80	2.83	2.63	2.42	2.06	2.20	2.50	2.50	2.70	2.50
Q3	2.50	2.51	2.35	2.42	2.27	1.99	2.30	2.70	2.60	2.80
Q4	2.60	2.54	2.56	2.35	2.41	2.19	2.08	2.50	2.80	2.70
1999 Q1	2.70	2.49	2.56	2.69	2.41	2.44	2.18	2.24	2.70	2.90
Q2	2.20	2.48	2.53	2.71	2.82	2.37	2.39	2.25	2.36	2.90
Q3	2.10	2.31	2.40	2.55	2.74	2.86	2.30	2.47	2.37	2.50
Q4	2.20	2.20	2.28	2.36	2.61	2.59	2.77	2.26	2.55	2.42
2000 Q1	2.00	1.93	2.12	2.09	2.20	2.52	2.56	2.69	2.27	2.64
Q2	2.20	1.88	1.98	2.06	1.99	2.23	2.49	2.51	2.56	2.35
Q3	2.20	2.38	1.93	1.95	2.02	1.88	2.25	2.47	2.48	2.47
Q4	2.00	2.36	2.28	2.10	2.05	1.84	1.92	2.23	2.47	2.45
2001 Q1	1.90	1.94	2.33	2.26	2.20	2.32	1.72	2.08	2.35	2.56
Q2	2.40	1.90	1.92	2.22	2.39	2.47	2.48	1.80	2.28	2.43
Q3	2.30	2.31	1.90	1.87	2.19	2.48	2.53	2.53	2.19	2.59
Q4	1.90	2.00	2.17	1.91	1.87	2.19	2.62	2.53	2.56	2.53
2002 Q1	2.30	2.14	2.03	2.17	1.91	2.09	2.18	2.68	2.53	2.58
Q2	1.50	2.02	1.87	1.85	1.91	1.94	2.18	2.37	2.70	2.56
Q3	2.10	1.84	2.08	1.96	2.06	1.96	2.03	2.27	2.46	2.72
Q4	2.70	2.64	2.25	2.24	2.11	2.06	2.13	2.16	2.42	2.56
2003 Q1	3.00	2.77	2.73	2.25	2.18	2.13	2.08	2.32	2.39	2.55
Q2	2.80	3.09	2.90	2.72	2.25	2.05	2.13	2.15	2.41	2.53
Q3	2.80	2.85	2.90	2.98	2.72	2.31	2.09	2.18	2.23	2.45

Table 2
Bank Forecast of GDP

	Forecast t =										
	Output (% growth) 2003 estimate	Output (% growth) contemp-oraneous	0	1	2	3	4	5	6	7	8
1997 Q3	3.19	3.89	3.39								
Q4	3.36	3.93	4.02	2.82							
1998 Q1	3.38	2.88	3.04	3.54	2.37						
Q2	2.79	2.47	2.41	2.33	2.84	1.85					
Q3	3.51	2.40	1.99	1.86	1.76	2.11	1.80				
Q4	2.82	2.02	1.95	1.66	1.71	1.64	1.33	1.83			
1999 Q1	2.72	1.70	1.16	1.28	1.41	1.76	1.59	1.41	2.03		
Q2	2.61	1.64	0.79	0.77	1.00	1.19	1.83	1.79	1.64	2.38	
Q3	2.60	2.30	1.32	0.99	0.68	0.84	1.29	2.11	2.15	1.93	2.63
Q4	3.26	2.75	2.50	1.90	1.20	0.83	1.01	1.54	2.27	2.41	2.33
2000 Q1	3.96	3.11	2.92	2.82	2.41	1.49	1.36	1.33	1.69	2.39	2.61
Q2	4.30	3.36	2.94	2.70	2.80	2.58	1.72	1.82	1.65	2.09	2.56
Q3	3.94	2.98	2.56	2.58	2.47	2.51	2.73	1.99	2.24	2.02	2.44
Q4	2.93	2.72	2.73	2.48	2.45	2.24	2.42	2.80	2.58	2.61	2.48
2001 Q1	2.56	3.01	2.86	2.76	2.50	2.57	2.27	2.61	2.92	2.97	2.83
Q2	2.23	2.65	2.25	2.30	2.39	2.51	2.61	2.35	2.70	3.01	3.11
Q3	1.80	2.24	1.62	2.03	2.07	2.31	2.53	2.65	2.38	2.82	3.02
Q4	1.95	1.71	2.09	1.82	2.46	2.22	2.40	2.63	2.70	2.39	2.83
2002 Q1	1.44	1.37	1.37	1.92	1.98	2.68	2.10	2.48	2.81	2.74	2.39
Q2	1.55	1.75	1.35	1.48	1.97	2.26	2.72	2.37	2.51	2.79	2.70
Q3	1.93	2.26	1.82	1.62	1.78	2.05	2.42	2.71	2.62	2.50	2.76
Q4	1.99	2.31	2.29	2.34	2.32	2.43	2.27	2.33	2.48	2.81	2.48
2003 Q1	1.84	2.10	2.53	3.06	2.91	2.95	2.76	2.49	2.24	2.42	2.89
Q2	1.98	1.84	2.38	2.58	3.18	2.75	2.95	2.79	2.66	2.15	2.42
Q3	1.89	1.89	1.59	2.00	2.33	3.17	2.94	3.15	2.69	2.70	2.11

Table 3
RPIX Inflation Errors

	Average Error	Average Absolute Error	Sample Size
One-year-ahead errors			
Constant rate mode	0.1	0.3	20
Constant rate mean	0.0	0.3	20
Market rate mode	0.0	0.3	18
Market rate mean	0.0	0.3	18
Two-year-ahead errors			
Constant rate mode	-0.3	0.4	16
Constant rate mean	-0.4	0.5	16
Market rate mode	-0.3	0.4	14
Market rate mean	-0.3	0.4	14

Table 4
Predictive Ability of Forecasts for RPI

Bank : Regression: Actual = a + bForecast(t+i)

i=	a (p-value) St. Er.	b (p-value) St. Er.	R^2	DW	Time Period
0	0.488 (0.04) 0.232	0.801 (0.00) 0.089	0.66	2.20	1993:Q1 2003:Q3
1	1.31 (0.00) 0.300	0.47 (0.00) 0.116	0.29	1.20	1993:Q2 2003:Q3
2	1.61 (0.00) 0.311	0.36 (0.00) 0.121	0.18	0.80	1993:Q3 2003:Q3
3	1.92 (0.00) 0.302	0.22 (0.06) 0.117	0.08	0.79	1993:Q4 2003:Q3
4	1.96 (0.00) 0.289	0.20 (0.07) 0.111	0.08	0.66	1994:Q1 2003:Q3
5	1.83 (0.00) 0.311	0.25 (0.03) 0.118	0.11	0.71	1994:Q2 2003:Q3
6	1.77 (0.00) 0.355	0.27 (0.04) 0.133	0.10	0.68	1994:Q3 2003:Q3
7	1.40 (0.00) 0.439	0.41 (0.01) 0.163	0.11	0.82	1994:Q4 2003:Q3
8	1.52 (0.25) 1.297	0.32 (0.52) 0.501	0.01	0.87	1997:Q3 2003:Q3

Data set: Bank RPI Forecast

Table 5
Predictive Ability of Forecasts for GDP

GDPActual = a + b Forecast (t+i)

.i=	a (p-value) St. Er.	b (p-value) St Er.	R^2	DW	Time Period
0	0.71 (0.00) 0.21	0.77 (0.00) 0.09	0.75	1.09	1997:3 2003:3
1	1.15 (0.00) 0.35	0.57 (0.00) 0.15	0.38	0.84	1997:4 2003:3
2	1.81 (0.00) 0.39	0.24 (0.19) 0.18	0.07	0.47	1998:1 2003:3
3	2.41 (0.00) 0.42	-0.05 (0.77) 0.19	0.00	0.43	1998:2 2003:3
4	2.71 (0.00) 0.46	-0.19 (0.35) 0.20	0.04	0.43	1998:3 2003:3
5	2.95 (0.00) 0.58	-0.29 (0.25) 0.25	0.07	0.45	1998:4 2003:3
6	3.23 (0.00) 0.82	-0.39 (0.26) 0.34	0.07	0.45	1999:1 2003:3
7	3.03 (0.01) 1.10	-0.28 (0.53) 0.43	0.02	0.46	1999:2 2003:3
8	1.90 (0.21) 1.45	0.17 (0.75) 0.55	0.00	0.35	1999:3 2003:3

Table 6

Differential between RPIX and forecast

	RPIX (% change over 12)	0	1	2	3	4	5	6	7	8
1993	3.5	0								
Q2	2.8	-0.6	-0.6							
Q3	3.3	0.4	-0.1	0.3						
Q4	2.7	-0.6	-0.3	-0.5	-0.4					
1994 Q1	2.4	-0.4	-1.2	-0.8	-0.8	-1				
Q2	2.4	-0.3	-0.6	-1.1	-0.9	-1.1	-1			
Q3	2	-0.3	-0.9	-1.1	-1.5	-1.3	-1.6	-1.4		
Q4	2.5	0.4	-0.1	-0.5	-0.7	-0.9	-0.8	-1.2	-0.8	
1995 Q1	2.8	-0.1	0.9	0.1	-0.3	-0.6	-0.6	-0.7		
Q2	2.8	0.1	0	0.8	-0.2	-0.6	-0.5	-0.6	-0.8	
Q3	3.1	0.2	0.1	0	0.8	-0.1	-0.3	-0.1		
Q4	3	-0.2	0	-0.1	-0.2	0.6	-0.2	-0.3	-0.2	
1996 Q1	2.9	0.1	-0.4	-0.3	-0.5	0.2	0.1	-0.5	-0.4	
Q2	2.8	0.1	0.1	-0.7	-0.7	-1	0.1	0.4	-0.3	
Q3	2.9	0.2	0.4	0.5	-0.3	-0.5	-0.8	0.3	0.5	
Q4	3.1	0	0.7	0.8	0.9	0.1	-0.1	-0.3	0.6	
1997 Q1	2.7	0	-0.2	0.4	0.4	0.4	0	-0.2	-0.3	
Q2	2.7	0.1	0.3	-0.1	0.4	0.5	0.4	0	-0.1	
Q3	2.7	0.05	0.3	0.5	0	0.3	0.3	0.4	0	-0.1
Q4	2.7	0.1	0.38	0.5	0.5	0.3	0.2	0.3	0.3	0
1998 Q1	2.6	0	0.09	0.41	0.4	0.3	0.2	0	0.2	0.2
Q2	2.8	-0.03	0.17	0.38	0.74	0.6	0.3	0.3	0.1	0.3
Q3	2.5	-0.01	0.15	0.08	0.23	0.51	0.2	-0.2	-0.1	-0.3
Q4	2.6	0.06	0.04	0.25	0.19	0.41	0.52	0.1	-0.2	-0.1
1999 Q1	2.7	0.21	0.14	0.01	0.29	0.26	0.52	0.46	0	-0.2
Q2	2.2	-0.28	-0.33	-0.51	-0.62	-0.17	-0.19	-0.05	-0.16	-0.7
Q3	2.1	-0.21	-0.3	-0.45	-0.64	-0.76	-0.2	-0.37	-0.27	-0.4
Q4	2.2	0	-0.08	-0.16	-0.41	-0.39	-0.57	-0.06	-0.35	-0.22
2000 Q1	2	0.07	-0.12	-0.09	-0.2	-0.52	-0.56	-0.69	-0.27	-0.64
Q2	2.2	0.32	0.22	0.14	0.21	-0.03	-0.29	-0.31	-0.36	-0.15
Q3	2.2	-0.18	0.27	0.25	0.18	0.32	-0.05	-0.27	-0.28	-0.27
Q4	2	-0.36	-0.28	-0.1	-0.05	0.16	0.08	-0.23	-0.47	-0.45
2001 Q1	1.9	-0.04	-0.43	-0.36	-0.3	-0.42	0.18	-0.18	-0.45	-0.66
Q2	2.4	0.5	0.48	0.18	0.01	-0.07	-0.08	0.6	0.12	-0.03
Q3	2.3	-0.01	0.4	0.43	0.11	-0.18	-0.23	-0.23	0.11	-0.29
Q4	1.9	-0.1	-0.27	-0.01	0.03	-0.29	-0.72	-0.63	-0.66	-0.63
2002 Q1	2.3	0.16	0.27	0.13	0.39	0.21	0.12	-0.38	-0.23	-0.28
Q2	1.5	-0.52	-0.37	-0.35	-0.41	-0.44	-0.68	-0.87	-1.2	-1.06
Q3	2.1	0.26	0.02	0.14	0.04	0.14	0.07	-0.17	-0.36	-0.62
Q4	2.7	0.06	0.45	0.46	0.59	0.64	0.57	0.54	0.28	0.14
2003 Q1	3	0.23	0.27	0.75	0.82	0.87	0.92	0.68	0.61	0.45
Q2	2.8	-0.29	-0.1	0.08	0.55	0.75	0.67	0.65	0.39	0.27
Q3	2.8	-0.05	-0.1	-0.18	0.08	0.49	0.71	0.62	0.57	0.35

Table 7

Assumed Effects of Interest Rate Changes on

RPI

Quarters after Change

0	1	2	3	4	5	6	7	8	
0	0	0	0.04	0.11	0.18	0.25	0.32	0.30	1% change*
0	0	0	0.01	0.03	0.05	0.06	0.08	0.07	¼% change

Interest Rate Changes in Months applied to Quarters

Dec – Feb	Q1
Mar – May	Q2
June – Aug	Q3
Sept B Nov	Q4

* The effect of an increase in interest rates being a reduction in inflation (and vice versa). The effects are assumed to be symmetrical.

Table 8
Effect on RPIX

Effect on										
Date	Interest Change	0	1	2	3	4	5	6	7	8
1993 Q1	-1.00									
Q2										
Q3										
Q4	-0.50									
1994 Q1	-0.25									
Q2										
Q3					-0.02			-0.25		
Q4	0.50				-0.01	-0.06			-0.30	
1995 Q1	0.50					-0.03	-0.10			-0.30
Q2							-0.05	-0.12		
Q3					0.02			-0.06	-0.15	
Q4	-0.25				0.02	0.06			-0.08	-0.15
1996 Q1	-0.25					0.06	0.10			-0.08
Q2							0.10	0.12		
Q3	-0.25				-0.01			0.12	0.15	
Q4	0.25				-0.01	-0.03			0.15	0.15
1997 Q1						-0.03	-0.05			0.15
Q2	0.25				-0.01		-0.05	-0.06		
Q3	0.75				0.01	-0.03		-0.06	-0.08	
Q4	0.25					0.03	-0.05		-0.08	-0.08
1998 Q1					0.01		0.05	-0.06		-0.08
Q2					0.03	0.03		0.06	-0.08	
Q3	0.25				0.01	0.08	0.05		0.08	-0.08
Q4	-0.75					0.03	0.14	0.06		0.08
1999 Q1	-1.25						0.05	0.18	0.08	
Q2	-0.25				0.01			0.06	0.24	0.08
Q3	-0.25				-0.03	0.03			0.08	0.24
Q4	0.50				-0.05	-0.08	0.05			0.08
2000 Q1	0.50				-0.01	-0.14	-0.14	0.06		
Q2					-0.01	-0.03	-0.23	-0.18	0.08	
Q3					0.02	-0.03	-0.05	-0.31	-0.24	0.08
Q4					0.02	0.06	-0.05	-0.06	-0.38	-0.24
2001 Q1	-0.25					0.06	0.09	-0.06	-0.08	-0.38
Q2	-0.50						0.09	0.12	-0.08	-0.08
Q3	-0.25							0.12	0.16	-0.08
Q4	-1.00				-0.01				0.16	0.16
2002 Q1					-0.02	-0.03				0.16
Q2					-0.01	-0.06	-0.05			
Q3					-0.04	-0.03	-0.09	-0.06		
Q4						-0.11	-0.05	-0.12	-0.08	
2003 Q1	-0.25						-0.18	-0.06	-0.16	-0.08
Q2								-0.25	-0.08	-0.16
Q3	-0.25								-0.32	-0.08

Table 9
RPIX Summary Statistics

RPI							
Date	Actual	Dif	Fcast t=0	Dif	Fcast t=7/8	Policy change	Fcast change
1994 Q3	2.00	-0.30	2.30				
Q4	2.50	0.40	2.10	-1.20	3.30	0.07	-1.27
1995 Q1	2.80	-0.10	2.90	-0.60	3.50	0.13	-0.73
Q2	2.80	0.10	2.70	-0.90	3.60	0.17	-1.07
Q3	3.10	0.20	2.90	-0.30	3.20	0.04	-0.34
Q4	3.00	-0.20	3.20	0.00	3.20	-0.08	0.08
1996 Q1	2.90	0.10	2.80	-0.50	3.30	-0.16	-0.34
Q2	2.80	0.10	2.70	-0.40	3.10	0.22	-0.62
Q3	2.90	0.20	2.70	0.30	2.40	-0.11	0.41
Q4	3.10	0.00	3.10	0.60	2.50	0.04	0.56
1997 Q1	2.70	0.00	2.70	-0.30	3.00	0.08	-0.38
Q2	2.70	0.10	2.60	-0.20	2.80	0.12	-0.32
Q3	2.70	0.05	2.65	-0.15	2.80	0.16	-0.31
Q4	2.70	0.10	2.60	-0.10	2.70	0.13	-0.23
1998 Q1	2.60	0.00	2.60	0.20	2.40	0.00	0.20
Q2	2.80	-0.03	2.83	0.33	2.50	-0.04	0.37
Q3	2.50	-0.01	2.51	-0.29	2.80	-0.22	-0.07
Q4	2.60	0.06	2.54	-0.16	2.70	-0.23	0.07
1999 Q1	2.70	0.21	2.49	-0.41	2.90	-0.31	-0.10
Q2	2.20	-0.28	2.48	-0.42	2.90	-0.31	-0.11
Q3	2.10	-0.21	2.31	-0.19	2.50	-0.08	-0.11
Q4	2.20	0.00	2.20	-0.22	2.42	0.08	-0.30
2000 Q1	2.00	0.07	1.93	-0.71	2.64	0.23	-0.94
Q2	2.20	0.32	1.88	-0.47	2.35	0.37	-0.84
Q3	2.20	-0.18	2.38	-0.09	2.47	0.61	-0.70
Q4	2.00	-0.36	2.36	-0.09	2.45	0.41	-0.50
2001 Q1	1.90	-0.04	1.94	-0.61	2.56	-0.01	-0.60
Q2	2.40	0.50	1.90	-0.53	2.43	-0.13	-0.40
Q3	2.30	-0.01	2.31	-0.28	2.59	-0.28	0.00
Q4	1.90	-0.10	2.00	-0.53	2.53	-0.15	-0.38
2002 Q1	2.30	0.16	2.14	-0.44	2.58	0.05	-0.49
Q2	1.50	-0.52	2.02	-0.54	2.56	0.12	-0.66
Q3	2.10	0.26	1.84	-0.88	2.72	0.22	-1.10
Q4	2.70	0.06	2.64	0.08	2.56	0.36	-0.28
2003 Q1	3.00	0.23	2.77	0.22	2.55	0.40	-0.18
Q2	2.80	-0.29	3.09	0.56	2.53	0.33	0.23
Q3	2.80	-0.05	2.85	0.40	2.45	0.32	0.08