

What do the RBA's forecasts imply about its preferences over inflation and output volatility?*

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Abstract

The Reserve Bank of Australia (RBA) has recently commenced publishing its forecasts of inflation and output growth in their *Quarterly Statement on Monetary Policy*. Since the RBA can potentially influence future outcomes for inflation and output through its choice of cash rate target; we examine whether the RBA's forecasts reveal useful information about its trade-off between inflation and output volatility. Our results suggest that the RBA targets a linear combination of deviations of inflation around target and output growth around potential growth – where the weight given to output growth deviations is about one-half that given to inflation deviations. If we interpret this weight as the ratio of a central bank's (relative) preference for output volatility and the slope parameter of the Phillips curve; for standard values of the latter parameter we find the RBA – while not a strict inflation targeter – gives significantly lower weight (one-third or less) to minimizing deviations in the output gap, than it does to minimizing deviations of inflation around target.

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1. Introduction

The Reserve Bank of Australia (RBA) has, since the early 1990s, employed an inflation target as the key element in its monetary policy framework. In the latest *Statement on the Conduct of Monetary Policy (2007)*, the inflation target pursued by the RBA is articulated as follows.

In pursuing the goal of medium-term price stability, both the Reserve Bank and the Government agree on the objective of keeping consumer price inflation between 2 and 3 percent, on average, over the cycle.

One way to interpret this objective is that the RBA's aim is to set the unconditional expectation of consumer price inflation somewhere between 2 and 3 percent. Such a specification for the inflation target does not rule out short-run or transitory deviations in inflation that cause it to move outside of the 2-3 percent range. The only real constraint imposed by this statement is that transitory deviations of inflation above 3 percent will need to be offset by periods when inflation is below 3 percent, while periods of inflation below 2 percent will need to be offset by periods when inflation is above 2 percent.

As the *Statement* implies there is no requirement for the RBA to achieve its 2-3 percent inflation target on, say, a quarter-by-quarter basis, so a natural question is how does the RBA implement monetary policy over short-run horizons. While its inflation target imposes a long-term constraint on the actions of the RBA, it would seem that the Bank has considerable latitude as to how it sets monetary policy in the short-run (Woodford, 2003; 2004). Suppose an exogenous and somewhat persistent shock pushes inflation above 3 percent; what is the path along which the RBA will bring inflation back into the target range in the long-run? In addition, given the RBA does not always seek to achieve its inflation target in the near-term, how does it trade-off deviations of inflation from target against any other short-term objectives it may have? These are not questions to which the RBA provides official answers.

Since its February 2008 *Quarterly Statement on Monetary Policy*, however, the RBA has published its forecasts of inflation and output growth for the subsequent 2 to 2½ year horizon.¹ Forecasts are of the annual inflation rate and annual growth rates, and are reported on a semi-annual basis. In addition to being interesting in their own right, we argue that these forecasts provide information about the RBA's preferences over inflation and output volatility. The basic idea is that if the RBA has some ability to influence future outcomes for

¹ In earlier *Quarterly Statements* the RBA published their inflation forecasts, but not their output growth forecasts.

inflation and output growth – through its choice of a cash rate target – its forecasts may reveal something about its’ desired outcomes for these two variables.

The theoretical model we use to interpret the RBA’s forecasts is based on the recent literature on forecast targeting rules (Svensson, 2003; Woodford, 2004; 2007). In this framework, a central bank is modelled as having particular objectives or targets for a set of macroeconomic variables, which they seek to achieve, using their policy instrument(s); subject to the constraints imposed by the structure of the economy. The approach models the central bank in a manner that is analogous to what is now standard for households and firms. While forecast targeting is a very general framework for studying monetary policy (Giannoni and Woodford, 2009), for certain standard central bank loss functions and economic structures, the first-order conditions from the central bank’s optimisation problem yield relatively simple forecast targeting rules or Euler equations involving inflation and some measure of economic activity.²

To date much of the work on forecast targeting rules has been concerned with establishing the normative case for their use in implementing monetary policy (Woodford, 2007). There has been relatively little work on the positive question – to what extent (if any) do simple targeting rules capture the systematic behaviour of central banks? One exception is Kuttner (2004) who analyses forecasts published by the Reserve Bank of New Zealand, the Riksbank, the Bank of England and the Federal Reserve; he finds some (modest) support for describing monetary policy in terms of forecast targeting rules. More recently, Otto and Voss (2010) find evidence that the Bank of Canada’s behaviour can also be described using forecast targeting rules based upon inflation and output growth.

In this paper we examine whether the RBA forecasts are consistent with simple targeting rules and in doing so provide a description of the implicit preferences the RBA has over inflation and economic activity. Section 2 of the paper provides a brief review of forecast targeting rules and their theoretical justification as central bank Euler equations. We also examine the testable implications of forecast targeting rules and consider the usefulness of a central bank’s forecasts in identifying its targeting rule. In Section 3 we use the forecast targeting framework and the RBA’s inflation and output forecasts to try and infer its targeting rule and to estimate the relative weight it gives to output stabilisation. Section 4 concludes.

2. Forecast Targeting Rules

² Carlin and Soskice (2006) provide a simple textbook treatment of optimal targeting rules.

Strict Inflation Targeting

Strict inflation targeting – an example of a simple targeting rule for monetary policy – is defined by Svensson (1999) as a regime where the target criteria involve only the projected path of inflation. Consider a central bank that implements monetary policy – using any policy instrument at its disposal – with the sole aim of setting the inflation rate to a particular target level. A standard way of specifying a strict inflation target is to require expected inflation equal the central bank’s target at some future horizon.³ This suggests the following targeting rule;

$$E_t \pi_{t+H} = \pi^T \quad (1)$$

where H is some specified horizon in the sequence of conditional expectations for future inflation, i.e. $E_t(\pi_t, \pi_{t+1}, \dots, \pi_{t+H}, \pi_{t+H+1}, \dots)$. This rule implies that expected inflation only has to equal the inflation target after H periods⁴. The fact that H is greater than zero is a reflection of the strong empirical support for the existence of a non-trivial lag between the timing of a change in the policy instrument and its *initial* effect on inflation. For example, suppose it takes a minimum of two quarters for a change in the policy instrument to affect inflation. Then consider a change in monetary policy at time t in response to new information about future inflation. The best outcome that could be expected of the central bank is to ensure that;

$$E_t \pi_{t+2} = \pi^T \quad (2)$$

The central bank adjusts policy at time t so that the conditional expectation (or rational forecast) for inflation in two periods (i.e. in period $t+2$) is equal to the target.

A targeting rule like (1) yields a simple and easily testable prediction. Adding π_{t+H} to both sides of (1) and re-arranging gives

$$\pi_{t+H} - \pi^T = \eta_{t+H} \quad (3)$$

where $\eta_{t+H} \equiv \pi_{t+H} - E_t \pi_{t+H}$ is a rational forecast error with the property $E_t \eta_{t+H} = 0$. To test the implications of (3), consider $E_{t-H} \eta_t = 0$ and the following regression,

$$\pi_t - \pi^T = \alpha + \beta z_{t-H} + \eta_t \quad (4)$$

³ The specification of the RBA’s inflation target has a different form to equation (1). The RBA it is only required to achieve its inflation target of 2-3 percent (on average) *over the cycle*, rather than at some future horizon.

⁴ What happens to expected inflation after horizon H ? This is not an obvious question. It is natural to think that once expected inflation hits its target at horizon H , this will also be the case for expected inflation at longer horizons. Woodford (2003) argues that this may not be the case if central banks use a constant-interest rate targeting rule.

where the targeting rule implies that both α and β should be zero. If a central bank has a strict inflation target that it successfully achieves by period H , then current deviations of inflation from target should be unpredictable using any information available at time $(t-H)$ or earlier. The only restriction on the choice of z is that the variables are part of the time $(t-H)$ information set available to the central bank.

Rowe and Yetman (2002) test a condition like (1) for Canada. Using core inflation they are unable to reject the strict inflation targeting model for values of H equal to 6 or 8 quarters; at least during the Bank of Canada's announced inflation targeting regime. Rowe and Yetman's findings notwithstanding, no central bank (including the Bank of Canada) currently identifies themselves as a strict inflation targeter. At least not in the sense of equation (1) which requires using the policy instrument to bring expected inflation to target in the shortest technically feasible time – without regard for other macroeconomic economic variables. Central banks – such as the Bank of England – that have used a targeting rule like (1) in their policy framework have specified a value for H equal to 2 years (broadly consistent with Rowe and Yetman's results for Canada). Since it is likely that monetary policy can influence inflation at shorter horizons than 1½ to 2 years, it is evident that central banks have other short-run objectives about which they are concerned. We need to consider a generalisation of strict inflation targeting to allow for other variables in the targeting rule.

Flexible Targeting Rules

The simplest generalisation to a pure inflation targeting rule is to recognise that, in addition to achieving its inflation target, a central bank may have a preference for stabilising output (around potential). This suggests a targeting rule of the following form

$$E_t[(\pi_{t+h} - \pi^T) + \phi x_{t+h}] = 0 \quad h \geq H \quad (6)$$

where x is a measure of the output gap (actual less potential output). As before H reflects the lags involved in a change in the policy instrument affecting inflation and output. Assume for concreteness that $H=2$, then we can write (6) as

$$E_t[\pi_{t+2} + \phi x_{t+2}] = \pi^T \quad (7)$$

Under this flexible targeting rule, expected inflation – two periods hence – is allowed to differ from target, at least to the extent that the expected output gap is non-zero. A natural question is what determines the value of ϕ parameter. Since ϕ is the weight that is given to the output gap in a central bank's forecast targeting rule, it seems reasonable to expect that it is in some way related to the strength of a central bank's preference for stabilising output – relative to stabilising inflation. This intuition is partially correct, although it turns out not to

be the complete story. To see this we need to consider the formal derivation of targeting rules from a central bank's optimisation problem.

Optimal Monetary Policy

Consider the following loss function for a central bank.

$$\frac{1}{2} E_t \sum_{h=0}^{\infty} \beta^h [(\pi_{t+h} - \pi^T)^2 + \lambda x_{t+h}^2] \quad (8)$$

The central bank cares about two variables – inflation and the output gap. Specifically it is concerned with (expected) squared deviations of future inflation around its target and in the expected squared deviations of output around potential (i.e. the output gap). The λ parameter captures the weight the central bank gives to avoiding expected output volatility, relative to inflation volatility. In the limiting case of a strict inflation targeting central bank, $\lambda=0$.

The ability of the central bank to minimise the above loss function is constrained by the structure of the economy, in particular by the relationship between inflation and the output gap for the economy – the Phillips curve. A relatively general form for the Phillips curve is given by;

$$\pi_t = \theta E_t \pi_{t+1} + (1 - \theta) \pi_{t-1} + \kappa x_{t-j} + u_t \quad (9)$$

This model nests a number of standard Phillips curve models. When $\theta=1$ and $j=0$ we have the basic version of the New Keynesian Phillips curve (Calvo, 1983; Gali, 2008). For $0 < \theta < 1$ and $j=0$ we have a hybrid Phillips curve – hybrid in that it allows for both forward and backward-looking behaviour by the private sector (Fuhrer and Moore, 1995). Finally if we have $\theta=0$ and $j=1$ then we have a purely backward-looking (or Old Keynesian) Phillips curve (Rudebusch and Svensson, 1999; Rudd and Whelan, 2005).

A targeting rule like equation (6) can be derived by minimizing the loss function (8) with respect to a particular specification of equation (9). Optimal targeting rules can be interpreted as Euler equations for central banks and Svensson (2005) draws the analogy with consumer Euler equations. One complication is that the form of the Phillips curve has important implications for the nature of the optimal targeting rule. There are at least three cases that are worth considering.⁵ In the first two cases we use the basic specification for the New Keynesian Phillips curve $\theta=1$ and $j=0$, but compare the targeting rules that obtain if the central bank optimises in a discretionary manner, with what happens if it can achieve an outcome that is consistent with commitment. The third case is when the private sector is assumed not to display any forward-looking behaviour.

⁵ We do not consider the hybrid case since the implied targeting rule is too complicated to be identifiable with the available set of RBA forecasts.

In each case we solve the central bank's problem by using Lagrange multipliers. In cases one and two the Lagrangian is given by:

$$\Lambda_t = E_t \sum_{h=0}^{\infty} \beta^h \left\{ \frac{1}{2} [(\pi_{t+h} - \pi^T)^2 + \lambda x_{t+h}^2] + \sigma_{t+h} [\pi_{t+h} - \pi_{t+h+1} - \kappa x_{t+h} - u_{t+h}] \right\} \quad (10)$$

Case 1 is where the central bank engages in discretionary optimisation and it is unable to influence expectations of future inflation, so π_{t+h+1} is taken as given in the central bank's optimisation problem. The relevant first-order conditions for $h = 0, 1, \dots, \infty$ are

$$E_t [(\pi_{t+h} - \pi^T) + \sigma_{t+h}] = 0 \quad (11)$$

$$E_t [\lambda x_{t+h} - \kappa \sigma_{t+h}] = 0 \quad (12)$$

and upon substitution we get

$$E_t [(\pi_{t+h} - \pi^T) + \frac{\lambda}{\kappa} x_{t+h}] = 0 \quad (13)$$

which has the same form as equation (6). Again if it takes some time for the policy instrument to have an effect on inflation and the output gap, we might not expect to see (13) hold until H periods into the future. Under discretion, the optimal targeting rule for this model is for the central bank to ensure – via its policy instrument – that a linear combination of expected deviations of inflation around target and the expected output gap is equal to zero in all future periods after H . Notice that (13) implies a central bank is willing (and able) to trade-off inflation above target, if output is below potential.

Comparing (13) and (6) we see that our model implies $\phi = \frac{\lambda}{\kappa}$. The weight given to the output gap in the targeting rule depends – as expected – on the central bank preference parameter λ ; but also on the slope of the Phillips curve κ . The κ parameter indicates how responsive inflation is to a change in the output gap. Ceteris paribus, if κ is large the Phillips curve is relatively steep and large changes in inflation are associated with small changes in the output gap. Thus the weight given to the output gap in a targeting rule like (13) will be decreasing in the size of κ .

In Case 2 the central bank optimises with commitment and the relevant FOCs $h = 0, 1, \dots, \infty$ are given by:

$$E_t [(\pi_{t+h} - \pi^T) + \sigma_{t+h} - \beta^{-1} \sigma_{t+h-1}] = 0 \quad (14)$$

$$E_t [\lambda x_{t+h} - \kappa \sigma_{t+h}] = 0 \quad (15)$$

and upon substitution we get

$$E_t[(\pi_{t+h} - \pi^T) + \frac{\lambda}{\kappa}(x_{t+h} - \beta^{-1}x_{t+h-1})] = 0 \quad (16)$$

If we assume β is close to one, then the targeting rule under commitment is approximately,

$$E_t[(\pi_{t+h} - \pi^T) + \frac{\lambda}{\kappa}(x_{t+h} - x_{t+h-1})] = 0 \quad (17)$$

which is expressed in terms of the *change* in the output gap rather than the *level* of the gap.

Case 3 is an Old Keynesian model, in that the observable determinants of inflation in the Phillips curve are all lagged variables – the private sector is entirely backward-looking. In this case the Lagrangian has the following form;

$$\Lambda_t = E_t \sum_{h=0}^{\infty} \beta^h \left\{ \frac{1}{2} [(\pi_{t+h} - \pi^T)^2 + \lambda x_{t+h}^2] + \sigma_{t+h} [\pi_{t+h} - \pi_{t+h-1} - \kappa x_{t+h-1} - u_{t+h}] \right\} \quad (18)$$

The relevant FOCs $h = 0, 1, \dots, \infty$ are

$$E_t[(\pi_{t+h} - \pi^T) + \sigma_{t+h} - \beta \sigma_{t+h+1}] = 0 \quad (19)$$

$$E_t[\lambda x_{t+h} - \beta \kappa \sigma_{t+h+1}] = 0 \quad (20)$$

and upon substitution we get

$$E_t[(\pi_{t+h} - \pi^T) - \frac{\lambda}{\kappa}(x_{t+h} - \beta^{-1}x_{t+h-1})] = 0 \quad (21)$$

If we again assume β is approximately one, then the targeting rule is;

$$E_t[(\pi_{t+h} - \pi^T) - \frac{\lambda}{\kappa}(x_{t+h} - x_{t+h-1})] = 0 \quad (22)$$

where a comparison with (17) indicates that the only difference is the sign on the change in the output gap is now negative rather than positive, which arises by switching from having forward-looking inflation in the Phillips curve to having only lagged inflation (Kuttner, 2004).

Tests of Flexible Targeting Rule

The three targeting rules are given by (13), (17) and (22). From an empirical perspective an attractive feature of targeting rules (17) and (22) is that they are expressed in terms of the change – rather than the level – of the output gap. Typically, central banks report forecasts of output growth rather than the level of the output gap. In some circumstances output growth may provide a reasonable approximation to the change in the output gap. To see this note that the change in the output gap can be written as;

$$x_t - x_{t-1} = (y_t - y_{t-1}) - (y_t^p - y_{t-1}^p) \quad (23)$$

and if the change (growth) in potential is (approximately) constant, then we can write

$$x_t - x_{t-1} \approx \Delta y_t - \mu_y \quad (24)$$

We can approximate the change in the output gap by the growth rate of output (around its mean). Using (24) equation (17) can be written as a targeting rule of the following form;

$$E_t[(\pi_{t+h} - \pi^T) + \frac{\lambda}{\kappa}(\Delta y_{t+h} - \mu_y)] = 0 \quad (25)$$

which implies a negative correlation between expected deviations of inflation from target and deviations of expected output growth around its mean. If the targeting rule is derived using a purely backward-looking Phillips curve, see (22), the implied inflation-output growth correlation would be positive.

One approach to testing flexible targeting rules is to use a generalisation of the methodology employed by Rowe and Yetman (2002). If we assume rational expectations on the part of central banks, then the expected values in (25) can be replaced by observed data outcomes and a rational forecast error. This is a standard strategy for testing Euler equations and is that employed in Otto and Voss (2010). One potential difficulty with this approach is that some form of instrumental variable estimator is required to obtain consistent estimates of (at least) ϕ and in this environment weak instruments are a potential problem.

Rather than using actual data for output and inflation, we follow Kuttner (2004) and use central bank forecasts for inflation and output growth. While the use of forecasts rather than actual data avoids the problem of finding suitable instruments, it is not without its own difficulties. One issue arises when we replace the conditional expectations in (25) by the relevant central bank forecasts to obtain the following:

$$\pi_{t+h}^f - \pi^T = -\frac{\lambda}{\kappa}(\Delta y_{t+h}^f - \mu_y) \quad (26)$$

For all values of $h \geq H$ equation (26) is predicted to hold exactly – that is without any error-term. Except in the unlikely event that a central bank is actually using the forecast targeting rule (25) in setting policy, a relationship like (26) is unlikely to exactly hold for any central bank's forecasts – including those of the RBA. In our empirical analysis we include an error term in (26) and treat the relationship between the RBA's inflation and output growth forecasts as stochastic. The error term is assumed to capture random or non-systematic factors that may cause the RBA's forecasts deviate from the exact relationship given by (26).

Because (26) is a deterministic relationship there is no natural choice of normalization; while (26) treats inflation forecasts as the dependent variable, we could equally well re-arrange the equation so that output growth forecasts were the dependent

variable. For robustness, we present results for both normalizations of (26), which give the following two econometric specifications;

$$\pi_{t,h}^f - 2.5 = \phi(\Delta y_{t,h}^f - 3.0) + a_t + u_{t,h} \quad (27)$$

and

$$\Delta y_{t,h}^f - 3.0 = \tilde{\phi}(\pi_{t,h}^f - 2.5) + \tilde{a}_t + v_{t,h} \quad (28)$$

where $t=1..T$ represents the date when a given set of forecasts are made and $h=1..H$ is the horizon of the forecast. The variable a is a fixed-effect dummy for each set of forecasts (Feb-08, May-08 etc.). The estimate of a will provide a measure of the systematic deviation from the targeting rule for each set of forecasts. It can account for any unobserved changes in the assumed values for the inflation target ($\pi^T = 2.5$) and the potential growth rate ($g_y^T = 3.0$) that might occur across different forecasts.

3. The Trade-off Implied by the RBA's Forecasts

RBA Forecasts for Inflation and Output Growth

The RBA commenced publishing its inflation forecasts – for actual and underlying inflation – in the February 2007 *Quarterly Statement on Monetary Policy*. Twelve months later, in the February 2008 *Statement*, it began publishing forecasts for two measures of real output growth – GDP and non-farm GDP. The forecasts of inflation and output growth are reported on a 6-monthly basis – calculated as the percentage change over-the-year to the June and December quarters – for a forecast horizon of about 2-2½ years. Prior to the August 2009 *Statement*, the RBA's forecasts were based on the assumption of a constant future value for the nominal cash rate – known in the literature as constant-interest-rate-forecasts (Leitemo, 2003; Woodford, 2007). Such an approach ignores the fact, that if the RBA's forecasts for inflation and output do actually eventuate, this is likely to produce a (somewhat predictable) change in the future value of the cash rate⁶. In its August 2009 statement the RBA abandoned the reporting of constant-interest-rate-forecasts, although they do not (as yet) report their forecast path for the future cash rate.

In examining whether the RBA's forecasts of inflation and output growth are consistent with targeting rules like (17) or (22) we use non-farm GDP to measure output growth, but report results using both actual and underlying inflation forecasts. Forecasts are available for twelve *Quarterly Statements*, beginning in February 2008 and ending November

⁶ Similar technical assumptions are made for the AUD-USD exchange rate, the TWI and oil prices, but this seems more reasonable given that oil prices are exogenous to the Australian economy, while the value of the Australian dollar does not have a predictable relationship with inflation and output growth.

2010. For each *Statement* we select the forecasts corresponding to the five longest horizons. For example from the February 2010 *Statement* we use the forecasts for inflation and output growth (both year ended measures) for Jun-10, Dec-10, Jun-11, Dec-11, Jun-12. (See Figure A1 for the pattern of the forecasts across statements as used in the estimation.) We recognise that the RBA probably has only a very limited ability to influence forecast outcomes for the year-ended Jun-10 by the time of the February 2010 *Statement*, but decided – on balance – to include it to maximise our sample size.⁷

Figure 1 presents a plot of the forecasts for real output growth and underlying inflation from *Quarterly Statements* (forecasts for actual inflation are similar but omitted from the figure for clarity). In the case of output growth forecasts 3 percent is subtracted from each forecast, while 2.5 percent is subtracted from the inflation forecasts. A feature of Figure 1 is the evidence of a negative relationship between the inflation forecasts and the output growth forecasts. The negative relationship is particularly evident in the forecasts from the *Quarterly Statements* to November 2009. Interestingly, the growth and inflation forecasts from the February 2010 and later *Statements* appear to display a different pattern to the earlier forecasts, with some suggestion of a positive relationship. We also observe with these later forecasts an increase in the long horizon forecasts for output growth, from 3 to 4 percent, which explains why these later centred output growth forecasts in Figure 1 are consistently above the zero. The differences in the longer horizon forecasts are summarized in Figure A2. One possibility is that these higher forecasts reflect an increase in the RBA's view of the potential growth rate, a point we consider further below.

Basic statistics for the forecasts from all of the *Statements* are reported in Tables 1 and 2. In light of the visual evidence from Figure 1, we also report statistics for the forecasts from the first eight *Quarterly Statements* (Feb-08 to Nov-09) and also for the latest four *Statements* (Feb-10 to Nov-10). Using data for the full sample we find that both sets of inflation forecasts are on average about 1/3 of a percent above the mid-point of the RBA's target range. The average output growth forecast is about 1/3 of a percent below our assumed value for growth rate of potential of 3 percent. However this latter finding changes if we focus on the second sub-sample (Feb-10 to Nov-10), where the average forecast for output growth is now about 1/2 a percent above the assumed growth rate of potential. Comparing the standard deviations for the forecasts, we see that the growth rate forecasts are about 1½ to 2 times more volatile than the inflation forecasts.

⁷ Results using data for only the longest four forecast horizons give qualitatively similar results.

Table 2 reports sample correlations. In both the full sample and the first sub-sample (Feb-08 to Nov-09) the correlation between forecast output growth and forecast inflation is negative. Furthermore the negative correlation with output growth is stronger for the underlying inflation forecast than for the actual inflation forecast. In the case of the second sub-sample (Feb-10 to Nov-10) the correlation is strongly positive for underlying inflation (and output growth) and essentially zero for actual inflation. The statistics in Tables 1 and 2 tend to support the visual evidence in Figure 1.

Figure 2 presents a scatter-plot of the forecasts for underlying inflation (vertical axis) against the forecasts for output growth (horizontal axis) for the full sample of data. For both figures the majority of data points lie in either the north-west or south-east quadrants; this pattern is consistent with a negative correlation between the forecasts for inflation and output growth. The OLS regression line shown on the scatter-plot provides additional evidence of a negative relationship.

Regression Results

Estimates of equations (27) and (28) – which we refer to as direct and indirect estimates respectively – are reported in Tables 3 and 4. Each equation is estimated using OLS with standard errors adjusted for the presence of heteroscedasticity and serial correlation (Newey and West, 1987). Table 3 reports the direct estimates. The first three columns are based on underlying inflation, while the latter three use headline inflation. Column (1) reports the estimates of equation (27), but with the fixed-effects dummies excluded (and including a constant). This equation corresponds to the simple regression line for Figure 2. The estimated slope coefficient is negative (-0.19) and statistically significant, but the Durbin-Watson (*DW*) statistic for this regression is relatively low and points to some problems with the regression. Column (2) reports the results obtained when the fixed-effect dummies are included in the model. This leads to a marked increase in the size of the DW statistic and also in the (absolute) magnitude of the slope coefficient to (-0.38). The fixed-effects dummies are jointly significant and it would appear that their omission produces a biased estimate of the slope coefficient in the targeting rule. Column (3) reports the estimates obtained if we omit the forecasts for the Feb-10 and Nov-10 *Statements*. In fact their omission makes relatively little qualitative difference to the estimate of ϕ (-0.41 compared to -0.38).

Columns (4) to (6) of Table 3 show the results obtained using headline inflation. The results are qualitatively similar, although use of headline (rather than underlying) inflation yields estimates of ϕ that are slightly smaller in absolute value (-0.31 compared to -0.38).

Table 4 reports the estimates obtained from the indirect regression model (28). The pattern of results is broadly similar to those for the direct regression. Once again the slope coefficient is estimated to be negative and statistically significant. For the full sample, the estimate of $\tilde{\phi}$ is (-1.6) for underlying inflation and (-1.4) for headline inflation. The values of ϕ implied by these estimates are (-0.63) and (-0.71) respectively, which are both larger in absolute value than the direct estimates in Table 3. If equation (26) held without error, these pairs of estimates would be identical. While this is not the case, the two sets of estimates are not wildly different and both provide support for the flexible inflation target rule. We have a slight preference for direct estimates simply because they are more precisely estimated. But a careful interpretation of these results would be that the coefficient appears to be somewhere in the range of (-0.3) to (-0.7) with the coefficient for headline inflation being systematically larger in absolute value than that for underlying inflation.

The estimated fixed effects, also reported in Table 3 and 4, are also of some interest. These effects capture systematic deviations from the targeting rule; when the effect is positive, the inflation forecasts are systematically above target for that *Statement* and systematically below target when negative. To explore this further, Figure 3 shows the estimates of a based on Column (2) in Table 3 (estimates from Table 4 provide similar patterns). We also present a set of fixed effects adjusted for possible changes in the potential growth rate. As noted previously, the Bank's forecasts of output growth at the longest horizon (2 to 2 ½ years) have increased in recent years, possibly reflecting a belief that the potential growth rate has increased. We use these long horizon forecasts, as summarized in Figure A2, for the adjustment. Finally, since the RBA has a target range of 2-3 percent rather than an actual point target of 2.5 percent, we are really only interested in fixed effects greater than 0.5 percent (in absolute value).

Inspection of Figure 3 identifies two particular periods where we see fixed effects in excess of the target boundaries. The first three statements of 2008 have positive estimates so that inflation is above the target, though the departure is not too large. This is also true for the 2010 statements but once these are adjusted for changes in long run output growth the estimated effects are within the bounds. The second episode occurs with the statements in 2009, in particular the May 2009 *Statement*, where inflation is well below the target.

One explanation for both of these departures is that the model is missing important features of the Bank's behaviour. With respect to the May 2009 *Statement*, where the forecasts are well below the target bounds, one might expect this to be the case as the Bank was dealing with the events of the 2008 financial crisis and its after effects. At this point in time, the Bank may have recognized that it faced an economy with inflation and output growth well below normal but with little that could be done.

An alternative explanation is that we are assuming that the Bank has more ability to control inflation and output than it does, in particular at the near horizon. To address this, we re-estimated the model but excluded the nearest term forecast for each statement so that we are left with four forecasts per statement. The results, however, are largely unchanged suggesting that this is not the case. On balance, then, we are left with the conclusion that the fixed effects do indicate some important systematic departures from the simple targeting rules, the largest of which can be rationalized by the financial crisis of 2008/2009.

What is RBA's weight on output gap stabilization?

While estimates of ϕ can be obtained from the RBA's forecasts and the flexible targeting rule, the theoretical prediction that $\phi = \frac{\lambda}{\kappa}$ (the ratio of the RBA's preference for stabilizing the output gap to the slope of the Phillips curve) does not allow us to identify λ . Nevertheless we can draw some inferences from our estimates of ϕ . Since ϕ is non-zero, it must be the case that λ is non-zero – so the RBA is giving some weight to output gap stabilisation.⁸ Secondly since ϕ is a fraction it must be the case that $\lambda < \kappa$. However to go further we need an estimate of κ ; the slope of the New Keynesian Phillips curve for Australia.

There are a number of studies that estimate New Keynesian Phillips curves for Australia (Buncic and Melecky, 2007; Kuttner and Robinson, 2008; Hodge, Robinson and Stuart, 2008). In practice these estimates cannot be used in a naïve manner as some consideration must be given to units of measurement. Our estimate of ϕ is obtained from an equation in which both variables are measured in annualised percentage changes. In equation (24), the right-hand-side variables are in annual percentage changes, and this implies that the left-hand-side variables should also be in the same units – so the output gap x should measure the annualised (percentage) deviation between actual and potential output. Given the units of measurement of the variables that are used to estimate ϕ , the empirical specification for the Phillips curve model should relate the annual inflation rate to the annualised output gap; in

⁸ This assumes that κ is finite, which seems reasonable.

which case κ measures the marginal response of the annual inflation rate to a one unit (say one hundred percentage point) change in the annualised output gap.

Hodge, Robinson and Stuart (2008) estimate (by Bayesian methods) a New Keynesian Phillips curve that includes a measure of the output gap.⁹ Both inflation and the output gap are measured in quarterly percentage changes – so the values of κ should be unchanged if we consider mapping annualised inflation to the annualised output gap. Hodge *et. al.* assume a prior mean for κ of 0.4 and obtain a posterior mean of 0.68. These figures suggest that a reasonable value of κ for Australia is around 0.5; implying that a 100 percentage point increase in the (annualised) output gap raises annual inflation by a half a percent. To allow for the possibility that this number is a little high, we consider values for κ in the range [0 to 0.5).

Table 5 reports implied values of λ based on the range of our estimates of ϕ and some selected values for κ . What the figures in Table 5 suggest is that the RBA does not give equal weight to minimising inflation and output volatility. The largest numbers in Table 5 estimate that RBA's preference for reducing output volatility is at most 1/3 of that given to reducing inflation volatility. If such a figure seems too low then one way to increase the size of λ is to be willing to accept that inflation is very response to changes in the size of the output gap; i.e. a relatively steep Phillips curve .

4. Conclusion

How do we interpret our results? It is certainly not the case that the RBA precisely follows a simple forecast targeting rule of the type advocated by Woodford (2004) or Svensson (2003). Nevertheless an examination of the RBA's forecasts for inflation and output growth indicates that they tend to display a negative relationship. The Bank does appear to trade-off inflation against output growth, in a reasonably systematic manner. The optimal policy models of Woodford (2007) typically imply this is a good strategy, particularly if you believe that the private sector is forward-looking and if the Bank wishes to influence their expectations of future inflation.

⁹ In theory the New Keynesian Phillips curve includes the marginal supply cost and the output gap is simply a proxy for this unobserved variable. Recent empirical work by Gali, Gertler and Lopez-Salido (2005) suggests that the labour share of income is a better proxy for marginal cost than conventional measures of the output gap. Kuttner and Robinson (2008) use the labour share and report estimates for κ in the range of (0.001 to 0.004). These numbers are estimates of the marginal effect, $\Delta\pi = \kappa\Delta mc$, where mc is log marginal cost and π is quarterly inflation (in percentages?). While there should be a relationship between the output gap and labour share, and therefore between the coefficients in the two specifications of the NKPC, the form of this relationship is not obvious – except in relatively simple cases.

Within the optimal targeting rule framework we presented, the negative relationship that we observe in the RBA's forecasts for inflation and output growth is generated by two factors. One of these is a forward-looking Phillips curve and the second is optimisation with commitment. Our results suggest that this is not an entirely unreasonable framework within which to consider the RBA's behaviour, either for theoretical modelling or for further empirical work.

Table 1: Sample Statistics of Forecasts

	Underlying Inflation		Actual Inflation		Non-Farm Output Growth	
	$\pi_{t,h}^f - 2.5$		$\pi_{t,h}^f - 2.5$		$\Delta y_{t,h}^f - 3.0$	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
All Statements	0.33	0.55	0.35	0.61	-0.33	1.13
Feb-08 to Nov-09	0.35	0.67	0.33	0.73	-0.79	1.10
Feb-10 to Nov-10	0.23	0.18	0.40	0.22	0.59	0.37

Table 2: Sample Correlations

	Underlying Inflation $Corr(\pi_{t,h}^f, \Delta y_{t,h}^f)$	Actual Inflation $Corr(\pi_{t,h}^f, \Delta y_{t,h}^f)$
All Statements	-0.387	-0.198
Feb-08 to Nov-09	-0.480	-0.298
Feb-10 to Nov-10	0.768	-0.008

Table 3: Direct Estimates of Flexible Targeting Rule

$$\pi_{t,h}^f - 2.5 = \mu + \phi(\Delta y_{t,h}^f - 3.0) + a_t + u_{t,h}^f$$

	Underlying Inflation			Headline Inflation		
	(1)	(2)	(3)	(4)	(5)	(6)
μ	0.2645 (0.116)	na	na	0.3151 (0.126)	na	na
ϕ	-0.1900 (0.062)	-0.3774 (0.042)	-0.4104 (0.043)	-0.1061 (0.086)	-0.3084 (0.061)	-0.3118 (0.064)
a	no	yes	yes	no	yes	yes
P -value	na	0.00	0.00	na	0.00	0.00
DW	0.574	2.116	2.091	0.641	2.015	2.054
\bar{R}^2	0.135	0.762	0.834	0.022	0.704	0.717
$Nobs$	60	60	40	60	60	40

Notes: Newey-West standard errors with lags = 4 (Newey and West, 1987). P-value is for a test of the joint significance of the fixed-effect dummy variables.

Table 4: Indirect Estimates of Flexible Targeting Rule

$$\Delta y_{t,h}^f - 3.0 = \tilde{\mu} + \tilde{\phi}(\pi_{t,h}^f - 2.5) + \tilde{\alpha}_t + v_{t,h}^f$$

	Underlying Inflation			Headline Inflation		
	(1)	(2)	(3)	(4)	(5)	(6)
$\tilde{\mu}$	-0.0715 (0.239)	na	na	-0.2004 (0.258)	na	na
$\tilde{\phi}$	-0.7811 (0.174)	-1.6413 (0.291)	-1.7845 (0.276)	-0.3678 (0.222)	-1.3683 (0.397)	-1.4094 (0.430)
$\tilde{\alpha}$	no	yes	yes	no	yes	yes
<i>P-value</i>	na	0.00	0.00	na	0.00	0.00
<i>DW</i>	0.577	1.872	1.792	0.774	1.933	1.919
\bar{R}^2	0.135	0.751	0.734	0.022	0.622	0.443
<i>Nobs</i>	60	60	40	60	60	40

Notes: Newey-West standard errors with lags = 4 (Newey and West, 1987). P-value is for a test of the joint significance of the fixed-effect dummy variables.

Table 5: Implied Values for RBA Weight on Output Volatility

	κ				
	0.01	0.1	0.25	0.4	0.5
Underlying Inflation					
ϕ			λ		
0.38	0.0038	0.038	0.095	0.152	0.190
0.61	0.0061	0.061	0.153	0.244	0.305
Headline Inflation					
ϕ			λ		
0.31	0.0031	0.031	0.078	0.124	0.155
0.73	0.0073	0.073	0.183	0.292	0.365

Figure 1: RBA Forecasts of Non-Farm Output Growth, Underlying and Headline Inflation: (Feb 2008 – Nov 2010)

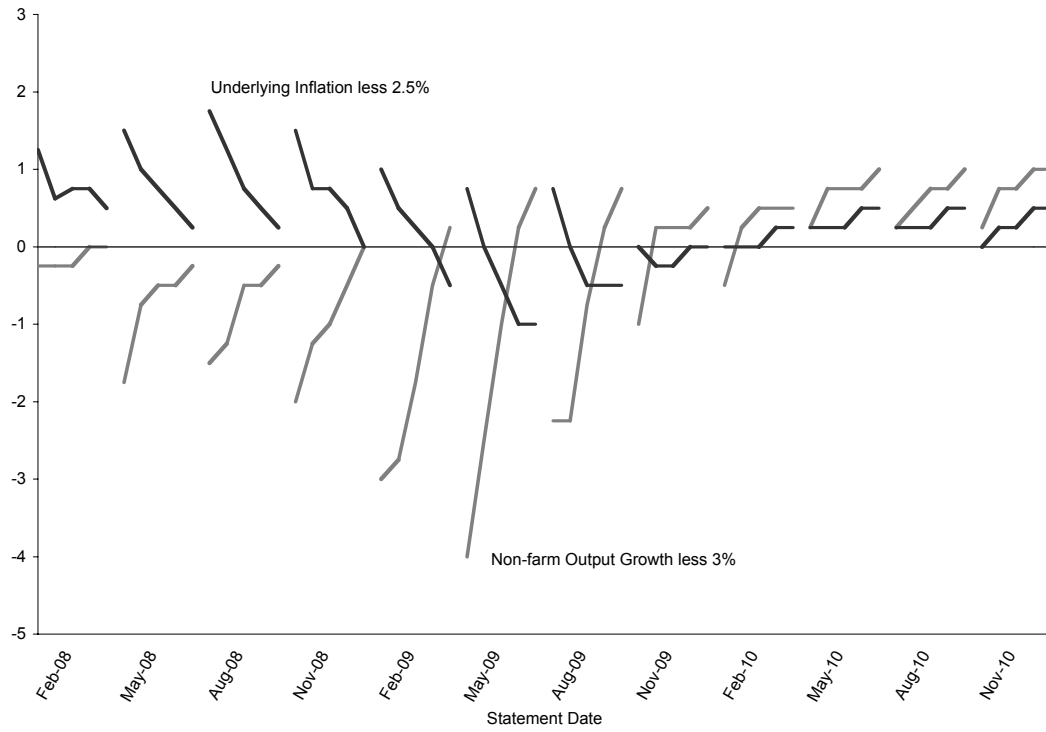


Figure 2: RBA Forecasts for Underlying Inflation and Non-Farm Output Growth (Feb 2008 – Nov 2010)

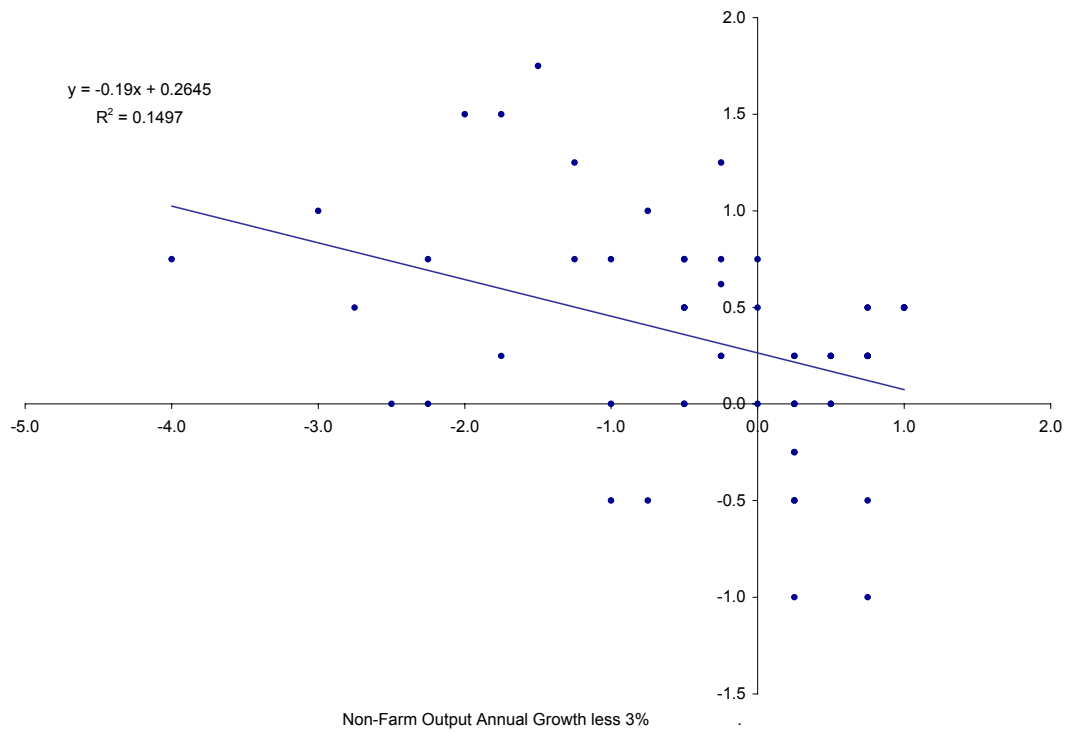
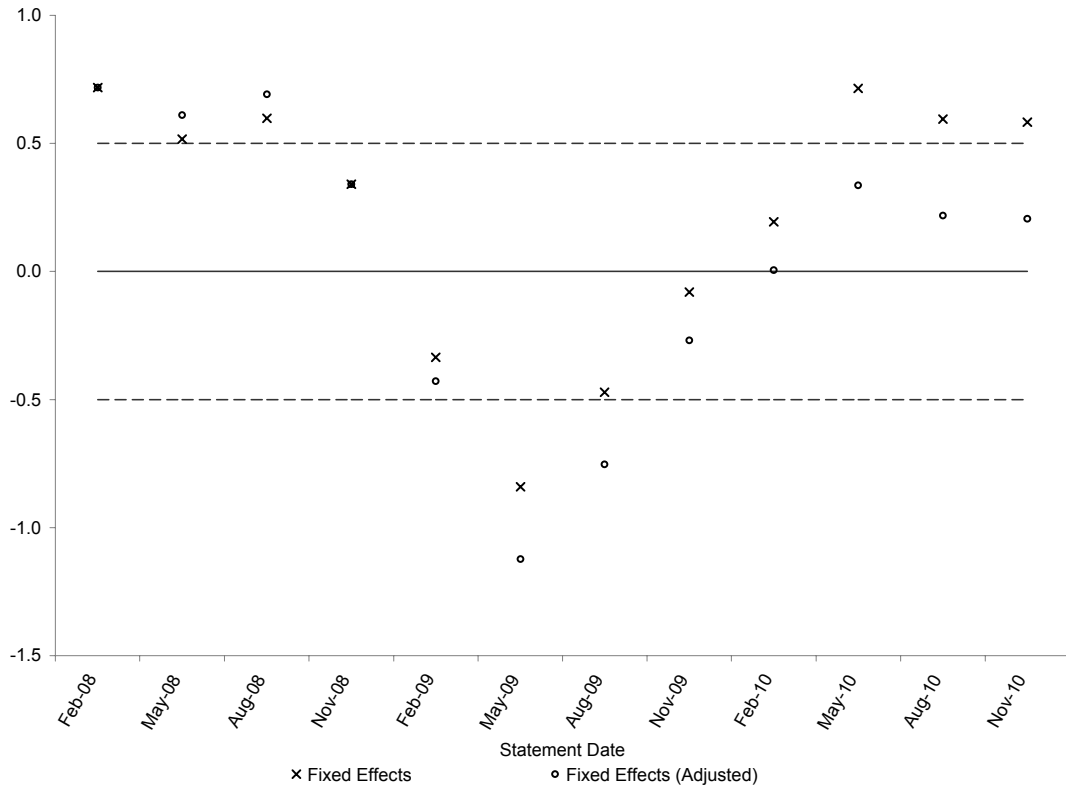


Figure 3: Fixed Effects for Quarterly Statements and Cumulative Changes in Cash Rate



Appendix Figures

Figure A1: Structure of Forecasts based on Statement Date

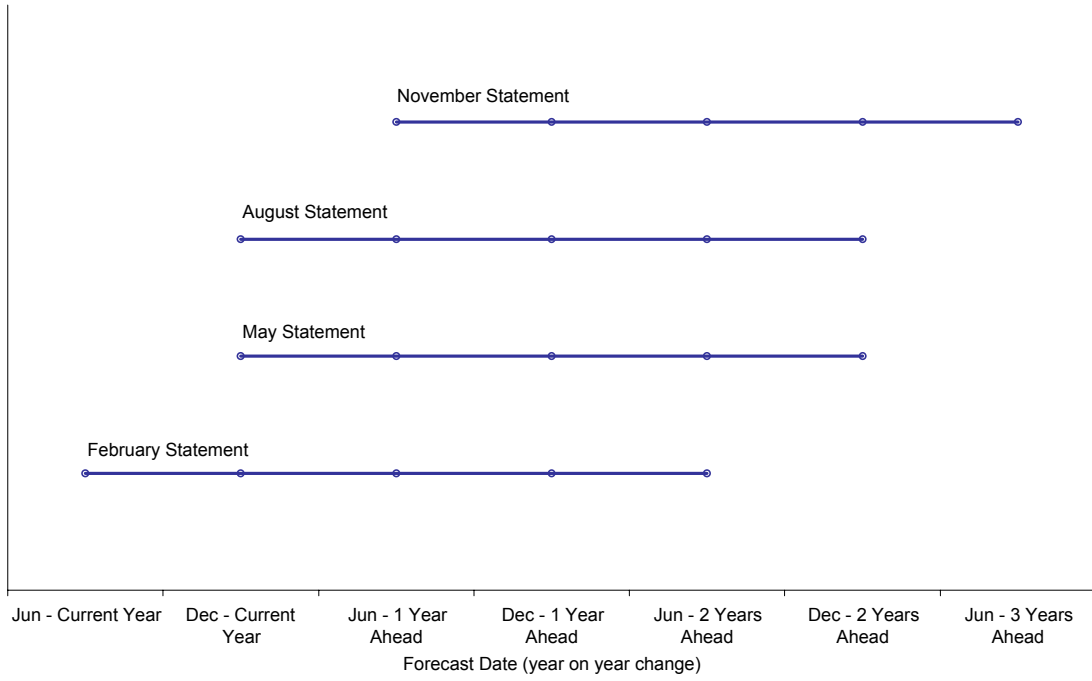
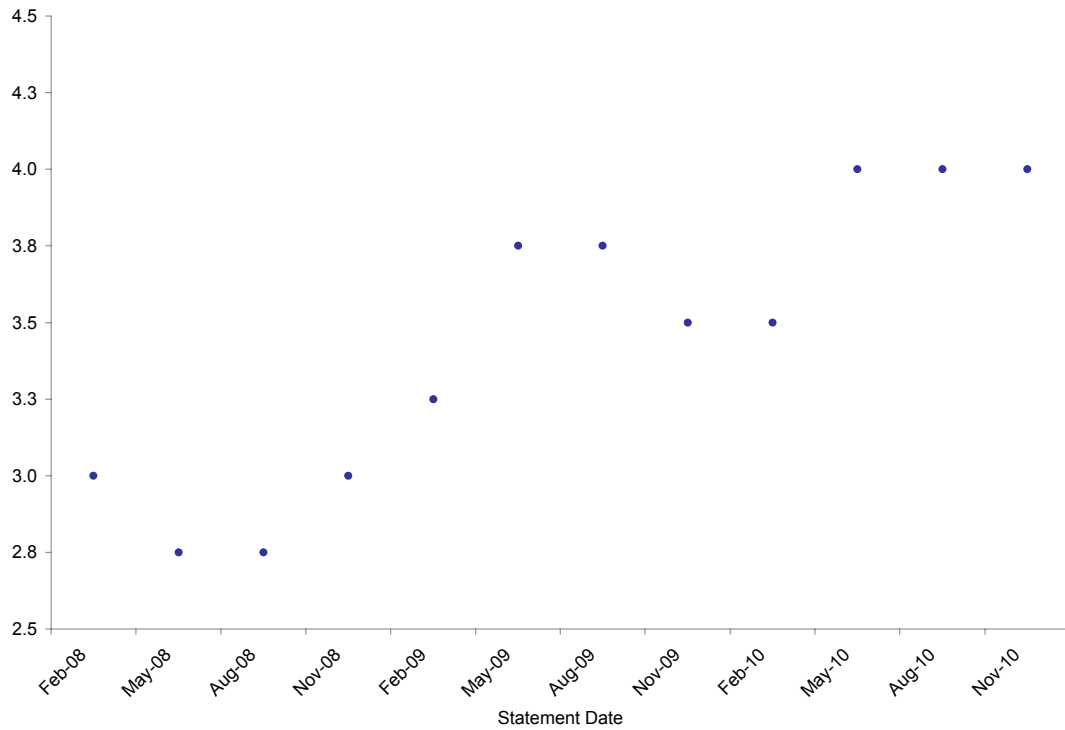


Figure A2: Longest Horizon Forecasts of Non-Farm Output Growth



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