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

Like a number of central banks, 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.

However since its February 2008 Quarterly Statement on Monetary Policy, 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 in this paper that these forecasts may provide some information about the RBA’s preferences over inflation and output volatility. The basic idea is that if the RBA has some ability to influence

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\(^1\) In earlier Quarterly Statements the RBA published their inflation forecasts, but not their output growth forecasts.
future outcomes for 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.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 examines whether the unconditional correlations between deviations of inflation forecasts (from target) and output gap forecasts are consistent with the predictions of some simple optimal targeting rules. Kuttner finds some (modest) support for describing monetary policy in terms of targeting rules.

In this paper we examine whether the RBA forecasts are consistent with simple targeting rules. 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

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

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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. This suggests the following targeting rule:

\[ E_t \pi_{t+H} = \pi^T \]  

(1)

where \( H \) is some specified horizon in the sequence of conditional expectations for future inflation, i.e. \( E_t(\pi_t, \pi_{t+1}, ..., \pi_{t+H}, \pi_{t+H+1}, ... \) . This rule implies that expected inflation only has to equal the inflation target after \( H \) periods. 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 \textit{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;

\[ E_t \pi_{t+2} = \pi^T \]  

(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 \( \pi_{t+H} \) to both sides of (1) and re-arranging gives

\[ \pi_{t+H} - \pi^T = \eta_{t+H} \]  

(3)

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

\[ \pi_t - \pi^T = \alpha + \beta \varepsilon_{t-H} + \eta_t \]  

(4)

where the targeting rule implies that both \( \alpha \) and \( \beta \) 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

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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) \textit{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.
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 not withstanding, 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 at 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

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

(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

$$E_t[\pi_{t+2} + \phi \pi_{t+2}] = \pi^*$$

(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 $\phi$ parameter. Since $\phi$ 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.

\[
\frac{1}{2} E, \sum_{k=0}^{\infty} \beta^k [\left( \pi_{t+k} - \pi^* \right)^2 + \lambda \kappa_{t+k}^2] \tag{8}
\]

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 \( \lambda \) 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:

\[
\pi_t = \theta \pi_{t+1} + (1 - \theta) \pi_{t-1} + \kappa_{t-j} + u_t \tag{9}
\]

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. 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.

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

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

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

(11)

and upon substitution we get

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

(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 \( \lambda \); but also on the slope of the Phillips curve \( \kappa \). The \( \kappa \) parameter indicates how responsive inflation is to a change in the output gap. Ceteris paribus, if \( \kappa \) 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 \( \kappa \).

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

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

(14)

and upon substitution we get

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

(16)

If we assume \( \beta \) is close to one, then the targeting rule under commitment is approximately,
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;

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

The relevant FOCs \( h = 0, 1, \ldots, \infty \) are

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

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

and upon substitution we get

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

If we again assume \( \beta \) is approximately one, then the targeting rule is;

\[ E_t[(\pi_{t+h} - \pi^T) - \frac{\lambda}{\kappa} (x_{t+h} - x_{t+h-1})] = 0 \]  \hspace{1cm} (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. The change in sign in the targeting rule is caused by switching from having forward-looking inflation in the Phillips curve to having only lagged inflation (Kuttner, 2004).

Tests of Flexible Targeting Rules

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;

\[ x_t - x_{t-1} = (y_t - y_{t-1}) - (y_t^p - y_{t-1}^p) \]  \hspace{1cm} (23)

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

\[ x_t - x_{t-1} \approx \Delta y_t - \mu_y \]  \hspace{1cm} (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;
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 (2009). One potential difficulty with this approach is that some form of instrumental variable estimator is generally required to obtain consistent estimates of (at least) $\phi$ and estimation of targeting rules can be plagued by the problem of weak instruments. For example to estimate (25) it is necessary to find instruments that are good predictors of either $\pi_{t+H}$ or $\Delta y_{t+H}$, and this may not be straightforward.\footnote{There is also the issue of whether real-time data should be used.}

Rather than using actual data for output and inflation, the strategy we adopt in this paper is to examine whether the RBA’s forecasts for inflation and output growth are consistent with simple flexible targeting rules. While the use of forecasts rather than actual data avoids the problem of finding valid 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:

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

(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 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. Since the consistency of ordinary least squares (OLS) requires the orthogonality of the regressor and the error term, this suggests using as the regressor the variable which is least likely to be correlated with the error term. Since we believe that the potential for measurement error is probably less for the inflation target, than for the growth rate of potential output, we have a slight preference for normalizing on output growth. However as a check on the robustness of the results in the empirical analysis we present results for both normalizations of (26).

We embed the targeting rules (17) and (22) in the following two econometric specifications;

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

and

\begin{equation}
\Delta y_{t,h}^{f} - 3.0 = \mu + \tilde{\phi} (\pi_{t,h}^{f} - 2.5) + \tilde{a}_t + \nu_{t,h}
\end{equation}

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. We assume that \( \pi^{r} = 2.5 \) and \( g^{r} = 3.0 \), although this is not a restrictive assumption since the regression includes a constant term. The variable \( a \) is a fixed-effect dummy for each set of forecasts (Feb-08, May-08 etc.). If the RBA behaves in a manner that is consistent with a targeting rule like (17) we would expect to see a negative relationship between its forecasts for inflation and output growth, (\( \phi \) and \( \tilde{\phi} \) both less than zero).

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 rate. 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 ten Quarterly Statements, beginning in February 2008 and ending May 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 the (year-ended) Jun-10, Dec-10, Jun-11, Dec-11, Jun-12. 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.

Figure 1 presents a plot of the forecasts for real output growth and actual and underlying inflation, obtained from the various Quarterly Statements. In the case of output growth forecasts 3 percent is subtracted from each forecast, while 2.5 percent is subtracted from both types of 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 however, the growth and inflation forecasts from the February and May 2010 Statements appear to display a different pattern to the earlier forecasts, with some suggestion of a positive relationship.

Basic statistics for the forecasts are reported in Tables 1 and 2. In light of the visual evidence from Figure 1 – in addition to using the full data sample of forecasts – we compute statistics for the forecasts from the first eight Quarterly Statements (Feb-08 to Nov-09) and also for the latest two Statements (Feb-10 to May-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 ½ 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 May-10), where the average forecast for output growth is now about ½ a percent above the assumed growth rate of

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7 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.

8 A similar issue arises with the August 2010 Statement, as we include forecasts for year-to Dec-10. Results using data for only the longest four forecast horizons give qualitatively similar results.
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.

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 May-10) the correlation is strongly positive for underlying inflation (and output growth) and almost zero for actual inflation. While the second sub-sample contains only ten observations, the statistics in Tables 1 and 2 tend to confirm the visual evidence in Figure 1.

Figures 2 and 3 present scatter-plots of the inflation forecasts (underlying and actual respectively) against the growth rate forecasts. Following the standard textbook representation we place inflation on the y-axis and output on the x-axis. 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.

In Figure 4 (which uses underlying inflation) we have separately identified the data for the two sub-samples on the scatter-plot. To emphasise the apparent differences between the observations we have reported the simple OLS regression line for each sub-sample. For the forecasts from the Feb-08 to Nov-09 Quarterly Statements the regression line has a negative slope, however for the forecasts from the Feb-10 and May-10 Statements there is evidently a positive 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 ordinary least squares, however the standard errors are 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 actual inflation. Column (1) reports the estimates of equation (27), but with the fixed-effects dummies excluded. This equation corresponds to the simple regression line for Figure 2. The estimated slope coefficient is negative (-0.24) and statistically significant, but the Durbin-Watson (DW) statistic for this regression is relatively low and points to some problems with
the regression\(^9\). Column (2) reports the results obtained when the fixed-effects 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 (-0.39). The fixed-effects dummies are jointly significant and it would appear that their omission leads to 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 May-10 Statements. In fact their omission makes relatively little qualitative difference to the estimate of \(\phi\) (-0.41 compared to -0.39).

Columns (4) to (6) of Table 3 show the results obtained using actual inflation. The use of actual rather than underlying inflation yields estimates of \(\phi\) that are slightly smaller (negative) numbers (e.g. -0.31 compared to -0.39).

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 (-1.7) for underlying inflation and (-1.4) for actual inflation. The values of \(\phi\) implied by these estimates are (-0.59) and (-0.71) respectively. Comparing estimates of \(\phi\) across the two models: for underlying inflation we get -0.41 and -0.59 and for actual inflation we get -0.39 and -0.71. If equation (26) held without error, these pairs of estimates would be identical and it is worth noting that the differences are smaller for underlying inflation than for actual inflation.

**What is RBA’s weight on output gap stabilization?**

While estimates of \(\phi\) can be obtained from the RBA’s forecasts and the flexible targeting rule, the fact 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 separately identify \(\lambda\). Nevertheless we can draw some inferences from our estimates of \(\phi\). Since \(\phi\) is non-zero, it must be the case that \(\lambda\) is non-zero – so the RBA is giving some weight to output gap stabilisation.\(^{10}\) Secondly since \(\phi\) is a fraction it must be the case that \(\lambda < \kappa\). However to go further we need an estimate of \(\kappa\); the slope of the New Keynesian Phillips curve for Australia.

\(^9\) Since the DW statistic is approximately \(2(1 - \rho)\), where \(\rho\) is first-order serial correlation coefficient for the errors, it must be the case that \(\rho > 0\) (there is positive serial correlation) for the DW to be less than 2.

\(^{10}\) This assumes that \(\kappa\) is finite, which seems reasonable.
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 since some consideration must be given to units of measurement. Our estimate of $\phi$ 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 $\phi$, the empirical specification for the Phillips curve model should relate the annual inflation rate to the annualised output gap; in which case $\kappa$ measures the marginal response of the annual inflation rate to a one unit (say one 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. Both inflation and the output gap are measured in quarterly percentage changes – so the values of $\kappa$ should be unchanged if we consider mapping annualised inflation to the annualised output gap. Hodge et. al. assume a prior mean for $\kappa$ of 0.4 and obtain a posterior mean of 0.68. These figures suggest that a reasonable value of $\kappa$ for Australia is around 0.5; implying that a 1 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 little high, we consider values for $\kappa$ in the range [0 to 0.5).

Table 5 reports implied values of $\lambda$ based on the range of our estimates of $\phi$ and some selected values for $\kappa$. 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 $\lambda$ 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.

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11 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 $\kappa$ 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 $\pi$ 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 simple cases.
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). 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.

Within the optimal targeting rule framework, 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. A negative correlation is not guaranteed by optimising behaviour by the central bank, witness equation (22), but depends on the structure of the economy. More specifically the negative correlation implies that the RBA believes that the private sector is forward-looking in their price-setting behaviour. This is consistent with the New Keynesian Phillips curve (as opposed to the Old Keynesian view of regressive (or adaptive) expectations).

The RBA reports forecasts of real output growth not forecasts of the output gap. While there may be a number of reasons for this, including the difficulty in estimating and forecasting potential output; nevertheless concern with the growth rate of output does induce a certain history-dependence into the objectives of their targeting rule. Given the RBA’s belief in forward-looking behaviour by the private sector; the fact that they report forecasts in terms on output growth – which might be viewed as an approximation to the change in the output gap – rather than in terms of the level of the output gap implies some attempt to seek the gains obtainable through commitment. It suggests an attempt to implement a monetary policy that is consistent with commitment rather than with a purely discretionary approach. In practice the RBA does spend time and effort seeking to influence private expectations about future inflation; if this is to be more than cheap talk it cannot just engage in purely discretionary (opportunistic) behaviour.
Table 1: Sample Mean and Standard Deviation

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std</th>
<th>Mean</th>
<th>Std</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Underlying)</td>
<td></td>
<td></td>
<td>(Actual)</td>
<td></td>
<td>(Non-Farm)</td>
<td></td>
</tr>
<tr>
<td>Full Sample</td>
<td>0.33</td>
<td>0.6033</td>
<td>0.33</td>
<td>0.6575</td>
<td>-0.54</td>
<td>1.1215</td>
</tr>
<tr>
<td>Feb-08 to Nov-09</td>
<td>0.35</td>
<td>0.6679</td>
<td>0.33</td>
<td>0.7277</td>
<td>-0.79</td>
<td>1.1015</td>
</tr>
<tr>
<td>Feb-10 to May-10</td>
<td>0.23</td>
<td>0.1845</td>
<td>0.35</td>
<td>0.2415</td>
<td>0.48</td>
<td>0.4158</td>
</tr>
</tbody>
</table>

Table 2: Sample Correlation

<table>
<thead>
<tr>
<th></th>
<th>Corr((\pi_{t,h}^f), (\Delta\pi_{t,h}^f))</th>
<th>Corr((\pi_{t,h}^f), (\Delta y_{t,h}^f))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Sample</td>
<td>-0.4399</td>
<td>-0.2522</td>
</tr>
<tr>
<td>Feb-08 to Nov-09</td>
<td>-0.4804</td>
<td>-0.2983</td>
</tr>
<tr>
<td>Feb-10 to May-10</td>
<td>0.7152</td>
<td>-0.0415</td>
</tr>
</tbody>
</table>

Table 3: Direct Estimates of Flexible Targeting Rule

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

<table>
<thead>
<tr>
<th></th>
<th>Underlying Inflation</th>
<th>Headline Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>(\mu)</td>
<td>n.a.</td>
<td>0.2008</td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
<td></td>
</tr>
<tr>
<td>(\phi)</td>
<td>-0.3937</td>
<td>-0.2367</td>
</tr>
<tr>
<td></td>
<td>(0.042)</td>
<td>(0.070)</td>
</tr>
<tr>
<td>(a)</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>(P)-value</td>
<td>0.00</td>
<td>na</td>
</tr>
<tr>
<td>(DW)</td>
<td>2.116</td>
<td>0.472</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.803</td>
<td>0.177</td>
</tr>
<tr>
<td>(Nobs)</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Notes: Newey-West standard errors. Lags = 4. P-value is for test of the joint significance of the fixed-effect dummy variables.
### Table 4: Indirect Estimates of Flexible Targeting Rule

\[ \Delta y_{i,h}^f - 3.0 = \tilde{\mu} + \tilde{\phi} (\pi_{i,h}^f - 2.5) + \tilde{a}_i + \nu_{i,h}^f \]

<table>
<thead>
<tr>
<th></th>
<th>Underlying Inflation</th>
<th>Headline Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Underlying Inflation</td>
<td>(2) Headline Inflation</td>
<td>(3) (4) (5) (6)</td>
</tr>
<tr>
<td>$\tilde{\mu}$</td>
<td>n.a.</td>
<td>-0.2673 (0.232)</td>
</tr>
<tr>
<td>$\tilde{\phi}$</td>
<td>-1.730 (0.280)</td>
<td>-0.8176 (0.164)</td>
</tr>
<tr>
<td>$\tilde{a}$</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>$P$-value</td>
<td>0.00</td>
<td>na</td>
</tr>
<tr>
<td>$DW$</td>
<td>1.853</td>
<td>0.662</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.750</td>
<td>0.177</td>
</tr>
<tr>
<td>$Nobs$</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Notes: Newey-West standard errors. Lags = 4. P-value is for test of the joint significance of the fixed-effect dummy variables.

### Table 5: Implied Values for RBA Weight on Output Volatility

<table>
<thead>
<tr>
<th>$\kappa$</th>
<th>0.01</th>
<th>0.1</th>
<th>0.25</th>
<th>0.4</th>
<th>0.5</th>
</tr>
</thead>
</table>

#### Underlying Inflation

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.41</td>
<td>0.0041</td>
</tr>
<tr>
<td>0.59</td>
<td>0.0059</td>
</tr>
</tbody>
</table>

#### Actual Inflation

<table>
<thead>
<tr>
<th>$\phi$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.39</td>
<td>0.0039</td>
</tr>
<tr>
<td>0.71</td>
<td>0.0071</td>
</tr>
</tbody>
</table>
Figure 1: RBA Forecasts of Non-Farm Output Growth, Actual Inflation and Underlying Inflation: Feb 2008 – May 2010

Figure 2: RBA Forecasts for Underlying Inflation and Non-Farm Output Growth (Feb 2008 – May 2010)
Figure 3: RBA Forecasts for Actual Inflation and Non-Farm Output Growth (Feb 2008 – May 2010)

![Chart showing RBA forecasts for actual inflation and non-farm output growth from February 2008 to May 2010.](image)

Figure 4: RBA Forecasts for Underlying Inflation and Non-Farm Output Growth

Sub-sample (Feb 08 to Nov 09)
Sub-sample (Feb 10 to May 10)

![Chart showing RBA forecasts for underlying inflation and non-farm output growth with regression lines and R-squared values.](image)


