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Strict and Flexible Inflation Forecast Targets: An Empirical Investigation

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Abstract

We examine whether standard theoretical models of inflation forecast targeting are consistent with the observed behaviour of the central banks of Australia, Canada, and the United States. The target criteria from these models restrict the conditionally expected paths of variables targeted by the central bank, in particular inflation and the output gap. We estimate various moment conditions, providing a description of monetary policy for each central bank under different maintained hypotheses. We then test whether these estimated conditions satisfy the predictions of models of optimal monetary policy. The overall objective is to examine the extent to which and the manner in which these central banks successfully balance inflation and output objectives over the near term.

For all three countries, we obtain reasonable estimates for both the strict and flexible inflation forecast targeting models, though with some qualifications. Most notably, for Australia and the United States there are predictable deviations from forecasted targets, which is not consistent with models of inflation targeting. In contrast, the results for Canada lend considerable support to simple models of flexible inflation forecast targeting.

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1. Introduction

Inflation targeting, the practice of specifying a numerical target for inflation and implementing forward-looking policy decisions to achieve the target, was initially developed by central banks as a transparent means of implementing credible monetary policy.[1] Subsequent theoretical work by Svensson (1997, 1999), Woodford (2003, 2004), Svensson and Woodford (2005), and Woodford and Giannoni (2005), recasts inflation targeting as an optimal targeting rule, that is as the outcome of a central bank setting monetary policy to minimize social welfare losses. A key emphasis of this theoretical work is inflation *forecast* targeting, where the central bank uses its policy instrument to ensure that the bank's projections or forecasts for its target variables satisfy criteria consistent with minimizing social welfare loss.[2]

In this paper, we use inflation forecast targeting framework as a means of investigating the actual behaviour of three central banks, those of Australia, Canada, and the United States. The target criteria from this framework provide restrictions on the conditionally expected paths of variables targeted by the central bank; they are in fact the Euler conditions from the linear quadratic optimization problem for the central bank. We estimate these conditions, providing a description of monetary policy for each central bank under the maintained hypothesis that monetary policy has been implemented as if they were operating within the inflation forecast targeting framework. General specification tests then allow us to determine whether the conditions are satisfied. A distinct advantage of the approach is that we need not concern ourselves with how the policy instrument is adjusted to achieve these conditions, which would require a structural representation of the entire economy.

Australia and Canada, as two early adopters and to date successful practitioners of inflation targeting, are natural choices for our purposes. The Federal Reserve in the United States (US), in contrast, is not a declared inflation targeting central bank. Nonetheless, it is of considerable interest to include it in our analysis as its behaviour has been described as being implicitly consistent with inflation targeting and our analysis provides an assessment of the accuracy of this description.[3] Moreover, the Federal Reserve, with its lack of an explicit inflation target, provides a useful point of comparison with the explicit inflation targeting behaviour of the Reserve Bank of Australia and the Bank of Canada.[4]

A number of issues motivate our analysis. In the first instance, we are interested in whether there is a close correspondence between inflation targeting as it is practiced, explicitly or implicitly, and as it is

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[1] For a summary of the international experience with inflation targeting, see Roger and Stone (2005) and the earlier work by Bernanke, Laubach, Mishkin, and Posen (1998).

[2] Woodford (2007). Svensson (1997) is the seminal theoretical treatment of inflation forecast targeting. Earlier work by King (1994) discusses the idea as a practical description of monetary policy in the UK.

[3] See the discussion in Kuttner (2004).

[4] Other candidates that could be usefully examined in the framework here are the United Kingdom, New Zealand, and Sweden, all having inflation targeting central banks.

prescribed by theory. If actual behaviour is consistent with theory, then models of inflation forecast targeting are arguably useful tools for analysis, in the same way that policy instrument rules, such as the Taylor rule, are used in policy analysis (see, Clarida, Gali, and Gertler, 1998 or the more general discussion in McCallum, 1999). Both Svensson (2003) and Woodford (2004, 2007) argue that central banks should move more explicitly to inflation forecast targeting; our results provide information as to how far past behaviour has been from these prescriptions for monetary policy.

An additional motivation is to examine directly the issue of flexible versus pure inflation targeting, or more simply the trade-off between inflation and output pursued by central banks. Svensson (1999) defines pure inflation targeting as a regime where the target criteria involve only the projected path of inflation. Such a target arises when the central bank places no weight on variation in any variable other than inflation in its loss function. Flexible inflation targeting, in contrast, includes other variables in the target criteria, most commonly the projected path of the output gap.[5] The general consensus is that most inflation targeting central banks practise flexible inflation targeting.[6] Despite this consensus, there is not much direct empirical evidence in support of flexible inflation targeting nor, consequently, is there much evidence of the trade-offs central banks pursue. One reason for this is that most empirical descriptions of inflation targeting central banks are based upon policy instrument rules, which do not provide a direct means of discriminating between flexible and pure inflation targeting.[7] In contrast, our approach provides evidence on the actual balance between inflation and cyclical variation in output that central banks have pursued over the short term horizon.

Related to this balance in the near term between inflation and output is a further forecast targeting criteria that is of interest to us here. As Woodford (2004, 2007) notes, inflation forecast targets should be consistent across different horizons. So, for example, a pure inflation targeting regime should restrict the conditional expectations of inflation from the near term horizon out through to the end of the policy horizon. Similarly, the balance or trade-off between inflation and output variation under a flexible inflation forecast targeting rule should be the same across all horizons. The only relevant restriction is that the horizons must be ones for which monetary policy has some effect on the target variable. Our empirical framework allows us to examine this criteria.

Finally, there is a substantive debate in the optimal monetary policy literature as to whether central banks should specify targeting rules — rules that specify paths for target variables — or policy instrument

5 Giannoni and Woodford (2005) consider in detail a variety of theoretical structures and their implications for target criteria, which in some instances include variables in addition to inflation and the output gap. While theoretically appealing, our focus here on inflation and the output gap is, we believe, more likely to be consistent with central bank practice.

6 See for example Svensson (1999) and Bernanke *et al.* (1999). Buiter (2007), however, is critical of the flexible inflation targeting approach, arguing that most central banks have mandates that are lexicographic in their targets. Price stability is ordered above other objectives. Thus output gap stability is not to be traded-off against price stability, but considered only once inflation is at its target value.

7 Policy instrument rules in most instances will include measures of output even if the loss function itself does not include output stabilization. See for example Svensson (2003).

rules — rules that specify paths for policy instrument rules, such as Taylor rules.[8] Our analysis, which focuses exclusively on targeting rules, does not address this debate directly but it does go some way to demonstrating the usefulness of interpreting and assessing the outcomes of central bank behaviour in terms of targeting rules. McCallum (2000), for instance, argues that the observed behaviour of inflation targeting central banks is best characterized as following policy instrument rules rather than the targeting rules of Svensson, not least of which because there is no evidence that they are optimizing in a manner consistent with targeting rules. Our analysis attempts to provide some such evidence.

Ours is not the first empirical study to consider the Euler conditions associated with optimal inflation forecast targeting. Favero and Rovelli (2003) estimate and test the Euler conditions associated with a particular structural model of central bank behaviour and the aggregate economy using US data. Their objective is to identify the preference parameters of the Federal Reserve, notably the targeted inflation rate, and determine whether there was a significant change in these preferences after the high inflation period of the 1970s. Similarly, Dennis (2004, 2006) and Giannoni and Woodford (2005) also provide estimates for the United States for very general models of an optimizing central bank pursuing flexible inflation targeting.

Our approach is much simpler than these general models; we focus exclusively on the Euler conditions alone. The benefit of doing so is twofold. First, these conditions are easily comparable across countries and we can admit alternative specifications for the behaviour of aggregate supply and demand. Second, ours is a limited information approach, imposing relatively little economic structure on the estimation. This can lead to less efficient estimation relative to full information methods applied to a complete structural model; however, we are much less danger of estimating a mis-specified model. This is particularly relevant in the current context because of well known difficulties with estimating different parts of the New Keynesian monetary model (see Henry and Pagan, 2004).

The other study that examines the forecast target conditions and which comes closest to ours in approach is Rowe and Yetman (2002). These authors examine whether the Bank of Canada has targeted either inflation or output in recent decades by asking whether there are predictable deviations from target values. The principles of our approach are identical to theirs. The difference is that we estimate and test flexible targets, weighted averages of inflation and output, as well as strict inflation targets, whereas Rowe and Yetman focus on single target variables: either inflation or output. Where our results overlap will be our estimates of strict inflation targets for Canada and these can be usefully compared to these authors' results.

Our study is also closely related to Kuttner (2004) though in this instance we share similar objectives rather than methods. His analysis is based upon a simple interpretation of the Euler conditions restricting

[8] See Svensson (2003, 2005) and McCallum and Nelson (2005) for different perspectives. See also Woodford (2007) and the

inflation and output in an optimal inflation forecasting framework. In most (but not all) cases, optimal policy should ensure that deviations of inflation from target should be unconditionally correlated with either the output gap or changes in the output gap. (The sign of the correlation depends upon the underlying structure of the economy, as we discuss below). Kuttner, using data for New Zealand, the United Kingdom, and the United States, considers the unconditional correlations between deviations of inflation from target and output gap measures at different horizons. There are two critical differences between this study and Kuttner's. First, we consider conditional rather than unconditional correlations and do so in a formal manner, allowing us to both estimate the inflation forecast parameters and to test the predictions of inflation forecast targeting. Second, Kuttner focuses on central bank forecasts in the target conditions. In contrast, we use the paths of actual data. The distinction is important. Kuttner is looking at the behaviour of central bank's projections and the trade-offs they imply. In contrast, we are asking whether central banks manage to achieve the outcomes predicted by inflation forecast targeting models. Ours is a more demanding question of central banks. While central bank projections may be consistent with inflation targeting we are asking whether and how they are able to manage the economy and if this is in line with inflation targeting models.

In the next section, we provide a simple set of conditions drawn from the theoretical literature. These conditions are used to guide the empirical analysis that follows and to provide a basis for interpreting the results. The empirical analysis considers the three countries, Australia, Canada and the United States, over samples starting in the early 1990s through to the end of 2007. The first stage of the analysis estimates the strict and flexible inflation targeting conditions. The second stage considers how well these estimated conditions satisfy the predictions of the model.

2. Monetary Targeting Conditions

2.1 Strict Inflation Targeting

We initially consider the simplest case of a central bank that uses its policy instrument to target only inflation — a strict inflation target (SIT). Given its model of the underlying economy and forecasts, the central bank will adjust the policy instrument to ensure that inflation does not deviate from target. Since in general the central bank's instrument only affects inflation with a lag, it will operate to ensure that expected inflation — at a horizon for which it can influence inflation — does not differ from target. If we suppose that relative to time t, the horizon under its control is $t+h, h \geq \bar{h}$, then optimal policy under strict inflation targeting requires;

$$E_t(\pi_{t+h} - \pi^*) = 0, \quad h \geq \bar{h} \tag{1}$$

comments in Taylor (2007). Kuttner (2004) provides a good discussion contrasting targeting and policy rules.

where π_{t+h} is inflation at time $t+h$ and π^* is the target rate of inflation. An optimality condition or Euler equation like (1) can be derived using the standard New Keynesian model of optimal monetary policy for a central bank that is concerned only about inflation, Gali (2008).

In most presentations of conditions such as (1), the focus is on the first horizon that is under the control of the central bank, that is for projections of $\pi_{t+\bar{h}}$. But properly, the condition should hold for all horizons beyond $\bar{h}$, a point emphasized by Woodford (2004, 2007). Note that the choice of $\bar{h}$ in general depends upon the underlying model for aggregate demand. For our purposes, we need not specify a particular model of aggregate demand just a reasonable choice for $\bar{h}$, which we discuss in the following section.

It is straight-forward to perform an empirical test of condition (1). Let $\eta_{t+h} = (\pi_{t+h} - \pi^*)$ then we have

$$E_t \eta_{t+h} = 0, \quad h \geq \bar{h}$$

which implies that for any horizon greater than or to equal to $\bar{h}$, deviations of inflation from target should be unpredictable using information available at time t. If the value of π^* is known, possibly because it has been publicly announced by a central bank, it can be imposed and there are no parameters that need to be estimated. This is one of the approaches of Rowe and Yetman (2002). Here, though, we treat π^* as unknown at each horizon and simultaneously estimate and test the restrictions implied by the forecast targeting model. That is, we estimate the following generalization of condition (1):

$$E_t(\pi_{t+h} - \pi_h^*) = 0, \quad h \geq \bar{h} \tag{2}$$

Given the estimates, we can then test the restriction that the parameters are consistent across horizons, $\pi_h^* = \pi^*, \forall h \geq \bar{h}$. We can also test whether the orthogonality conditions are satisfied. An advantage of this approach is the estimation of the inflation target π^*. This allows us to consider countries such as the United States, where there is no announced target, or countries that have an announced target band with no clear specification of a point target.[9] Most importantly, though, by estimating rather than imposing the inflation target, we are able to identify what central banks have achieved rather than what they announce as policy.

9 The Bank of Canada does stipulate that its goal is the mid-point of its target band of 1–3 percent. The Reserve Bank of Australia does not identify a point target.

2.2 Flexible Inflation Targeting

Few if any central banks claim to be strict inflation targeters and more general or *flexible* targets are likely to be a better characterization of central bank behaviour. The two flexible inflation targets commonly discussed in the literature on monetary policy are:

$$E_t(\pi_{t+h} + \phi\, x_{t+h} - \pi^*) = 0 \qquad h \geq \bar{h} \tag{3}$$

$$E_t(\pi_{t+h} + \phi\,(x_{t+h} - x_{t+h-1}) - \pi^*) = 0 \qquad h \geq \bar{h} \tag{4}$$

where x_t is the output gap, the difference between the logarithms of output and potential output. Both of these conditions are associated with models of monetary policy when the central bank's loss function depends upon variation in both inflation and output gaps but arise under different assumptions of central bank behaviour; see Svensson (2003).

Condition (3) arises in a model with a forward-looking New Keynesian aggregate supply curve and the assumption that the central bank pursues discretionary monetary policy — that is, it re-optimzes monetary policy every period.[10] The condition has been referred to as *a leaning against the wind* approach since for inflation to be above its target the bank must ensure output is below capacity to minimize social welfare loss. The condition, which is the Euler equation from the bank's optimization problem, simply captures how the central bank trades off variation in inflation and output. Svensson (2003) refers to conditions such as these as a *specific inflation forecast targeting rule*. Here we use the terminology flexible to distinguish from the strict inflation forecast rules of preceding section (which is also a specific inflation forecasting target rule, though one based on a different objective function).

An alternative means of viewing this condition is as a conditional or state contingent inflation target, as discussed in Woodford (2003). This comes about from re-organizing the condition to read as follows

$$E_t\pi_{t+h} = -\phi E_t x_{t+h} + \pi^* \qquad h \geq \bar{h}$$

This emphasizes that in the near term, when expectations of the output gap are possibly non-zero, the bank will be targeting a state-contingent inflation rate rather than the strict target of π^*. Of course, for

[10] Svensson (2003) provides an exact treatment of this condition when there are lags associated with monetary policy. The basic principle is outlined in Clardia, Gali, and Gertler (1999), among other places. See also Gali (2008) for a straightforward treatment.

horizons sufficiently far in the future when the output gap has expectation zero, this state contingent inflation forecast target is simply π^*.

The parameter ϕ plays an important role in conditions (3) and (4) in that it captures the relative weight the output gap variable receives in the flexible inflation target. If we can obtain stable empirical values for this parameter then we have a description of monetary policy which is of general practical interest since it will capture the manner in which central banks balance their objectives over the near term.

One could also attempt to use the underlying theoretical model to further interpret this parameter. Under certain assumptions about the structure of the underlying economy and preferences of the central bank, ϕ will be a simple function of the slope of the Phillips curve (α) and the weight on output in the central bank loss function (λ); specifically, $\phi = \lambda / \alpha$ (see Svensson, 2003). Consequently, if we have a value of α then we could infer a value for λ. For this paper, we leave such considerations aside, largely because there are many empirical studies of Phillips curves and it is not clear how to select an appropriate value of α. Moreover, the theoretical models that provide the simple decomposition of ϕ rely on Phillips curve representations very much simpler than those that are estimated, which further complicates choosing an appropriate value for α. We can provide some arguments though that suggest the value for ϕ is likely to be small, certainly less than one. First, empirical work for the US that has estimated λ finds it to be essentially zero (Favero and Rovelli, 2003; Dennis, 2004, 2006) while we certainly expect α to be positive.[11] Second, Giannoni and Woodford (2005) provide estimates of ϕ using US data that are around 0.1; their environment is much richer than that considered here so the comparison is not exact but this does provide a general guide. Finally, if λ arises from strict welfare theoretic considerations, then ϕ reduces further to be inversely related to the elasticity of substitution among alternative goods in the agent's welfare function, which using standard calibrations implies ϕ should be somewhere around 0.1.[12]

Condition (4) also arises in a model with a forward-looking New Keynesian aggregate supply curve but in this case under the assumption that the central bank is able to commit to a time invariant optimal path for current and future monetary policy) Without going into detail, the reason the conditions differ can be summarized quite easily. With discretionary optimization, the central bank need not concern itself with the dynamic structure of the aggregate supply relation; it need only focus on the contemporaneous trade-off between the current output gap and inflation. Under commitment, the central bank's optimization problem does need to take into account the dynamic structure of the aggregate supply relation, in particular the

[11] Other US studies also provide evidence that λ is very small; see the discussion in Dennis (2004).

[12] Woodford (2003, p.527).

dependence of current inflation on future inflation (with a forward-looking aggregate supply curve). Hence the trade-off between inflation and output will itself have a dynamic structure, as in condition (4).[13]

Condition (4) can also be motivated under different circumstances. It arises for a central bank committing to set monetary policy optimally while facing a backward looking aggregate supply curve. The difference in this case, though, is that the ϕ parameter will be negative, that is $\phi = -\lambda / \alpha$ so that inflation is positively related to changes in the output gap (Svensson, 2003). The reason we get this alternative relationship arises from the different dynamics of the backward looking relative to the forward looking aggregate supply curve. See Svensson (2003) for details.

Conditions (3) and (4), our flexible inflation targets, can be generalized for estimation in the same manner as we did for the strict inflation targets. In this case, we have

$$E_t(\pi_{t+h} + \phi_h x_{t+h} - \pi_h^*) = 0, \quad h \geq \overline{h}$$

or

$$E_t(\pi_{t+h} + \phi_h \Delta x_{t+h} - \pi_h^*) = 0, \quad h \geq \overline{h}$$

And as with the strict inflation targeting model, theory predicts that $\phi_h = \phi$ and $\pi_h^* = \pi^*$ for all h.

Setting aside the underlying theory, these conditions as written here are intuitively plausible. Both imply a leaning against the wind interpretation for describing central bank policy. We add a further similar condition that uses output growth to capture cyclical variation in output rather than the output gap:

$$E_t(\pi_{t+h} + \phi_h \Delta y_{t+h} - \pi_h^*) = 0, \quad h \geq \overline{h}$$

The advantage of this forecast target is its transparency and consistency with much central bank practice, which often focuses on output growth rather measures of output gaps.

[13] For the derivation of the condition and a full discussion of the trade-offs, see Svensson (2003).

3. Empirical Results

3.1 Data Sources and Methods

For the three countries, we use quarterly data with samples chosen specifically for each country based upon the period in which inflation targeting was adopted or, in the case of the US, a comparable period. Canada effectively adopted its current inflation target of 1–3 percent in December 1993, so the Canadian sample is 1994:1–2007:4.[14] Australia adopted an inflation target of 2–3 percent in 1993, so the Australian sample is 1993:1-2007:4.[15] The sample for the United States is 1990:1–2007:4. Since we are not restricted to a specific period in this case, we start somewhat earlier to include the recession of the early 1990s in our sample. Details on source and construction of the series used in estimation are provided in the Data Appendix.[16]

For all three countries, we use a headline measure of consumer price inflation, constructed as a year on year measure, consistent with the definitions of inflation targets at both the Bank of Canada and the Reserve Bank of Australia. These are presented in Figures 1–3. An alternative measure would be to use an inflation rate that has had volatile items such as food and energy, as well as tax changes, removed. Such measures are certainly used by the central banks as intermediate targets to guide policy. Our choice of headline is, however, consistent with what the banks are in fact targeting and ultimately responsible for controlling over the policy horizon.[17]

For the output gap, we use the Hodrick-Prescott filter to calculate potential GDP. This is a relatively crude means of identifying the output gap but does have the advantage of being easily applied across the three countries in a systematic manner. All inflation rates, growth rates, and deviations from trend are measured in annual percentage terms.

Two practical issues arise when estimating the theoretical moment conditions in equations (2)–(4). The first concerns the instruments used in estimation; the second concerns the output gap measures used in the objective function.

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14 Bank of Canada webpage: www.bank-banque-canada.ca/en/backgrounders/bg-i3.html.

15 Reserve Bank of Australia webpage: www.rba.gov.au/MonetaryPolicy/about_monetary_policy.html. The formal inflation target commenced in 1996; however, inflation targeting has in practice been in effect since 1993.

16 We have investigated monthly data, which is readily available for Canada and, to some extent, for the United States. The quality of estimation, however, is poor and we suspect this is due to weaker instruments. There are also difficulties constructing a meaningful measure of the output gap on a monthly basis. Nonetheless, a monthly frequency has the advantage of being more closely aligned with monetary policy decisions and probably merits further investigation. We leave this for future work.

17 We do make one adjustment here along these lines. Australian CPI is adjusted to remove the one off effects of the introduction of the goods and services tax in 2000. Details are in the Data Appendix.

The instruments used in estimation, z_t, must be observable at time t. For quarterly national accounts data, and any series derived from them, this means using measures for $t-1$ and earlier, since there is a two to three month delay in the production of these series. Similarly, consumer price inflation numbers are not available until after the end of the quarter, though in the case of Canada and the United States, which report monthly numbers, there is considerable information within the quarter about current inflation. Nonetheless, for consistency across countries, we only consider inflation and output measures at $t-1$ to be valid instruments at time t. Where we use other instruments, such as interest rates and commodity price inflation, that are consistently available on a monthly basis, we use time t values.

We will also use as instruments measures of the output gap, either in levels or quarterly differences. For these to be valid instruments, they need to be constructed using only current (time $t-1$) information. To achieve this, we construct a sequence of recursive output gap series using the HP filter. We begin with a series for GDP (in logarithms), y_t, for each country over the sample 1981:1–2007:4. Denote this full sample as $t=-p+1,...,0,1,...,T$. Let $HP(y_i, i=-p+1,...,t)$ be the HP filter over the first $t+p$ observations and the associated output gap series is $\{x_{i,t}\}_{i=-p+1}^{t} = HP(y_i, i=-p+1,...,t)$. Then for each observation $t=1...T$, we use the last element of each of these T series as our recursive output gap measure: $x_t^R = \{x_{t,t}\}_{t=1}^{T}$. For the change in the output gap, which we also use as an instrument, we have the series: $\Delta x_t^R = \{x_{t,t} - x_{t-1,t}\}_{t=1}^{T}$. Finally, because of the timing of the national accounts data, we use $\{x_{t-1}^R, \Delta x_{t-1}^R\}$ as instruments for time t. The full sample and recursive level output gaps for each country, along with the inflation measures, are presented in Figures 1–3. Inspection of these show that the difference between the two is largely one of levels. Once differenced, the full sample and recursive output gap measures are highly correlated for each country.

With these considerations in mind, we choose the following variables as instruments: the current and first two lags of commodity price inflation; the first two lags of CPI inflation; the (recursive) output gap and its first difference both lagged one period; lagged output growth and the change in a short term interest rate. These are denoted as,

$$z_t = \{1, \pi_t^{cx}, \pi_{t-1}^{cx}, \pi_{t-2}^{cx}, \pi_{t-1}, \pi_{t-2}, x_{t-1}^R, \Delta x_{t-1}^R, \Delta y_{t-1}, \Delta i_t\}$$

Details of the series are in the Data Appendix. We further discuss the choice and quality of these instruments below.

The second practical issue that arises is the measure used in the objective function for the output gap (or its difference). To facilitate discussion of this point, consider the restricted version of equation (3):

$$E_t(\pi_{t+h} + \phi x_{t+h} - \pi^*) = 0, \quad h \geq \bar{h}$$

One way to interpret these equations is that the bank is attempting to steer the economy as close as possible to its projections of inflation and the output gap for these horizons. With this interpretation in mind, one might then wish to use the bank's own time t projections in the above conditions to estimate ϕ and π, giving an indication of the balance between these objectives, and examine the consistency of this balance across horizons. This is not, however, a test of the optimizing framework since that requires that the bank achieve this balance with *actual* inflation and output gap, not the bank's projections for these variables. To put it somewhat differently, the bank's projections are its stated preferences; we are interested in whether we can use the forecast targeting framework to uncover its revealed preferences and its ability to control the economy.[18] This same argument applies to the suggestion that the recursive output gap measures be used in the objective function as these measures are likely to be much closer to what the bank believes will be the output gap in the near future. Again, however, the optimizing framework is not concerned with these artificial evolving measures but the actual path for inflation and output.

Following this logic, the variables required in the objective function are the correct or true values for these variables, which of course we do not have. But our best measure using the HP filter is arguably that constructed from the full sample of data, which in terms of the notation above, means using $x_{t,T}$ and $\Delta x_{t,T}$. This then is how we proceed. For simplicity, though, we use the notation x_t and Δx_t for these full sample measures.[19]

By proceeding this way, we are really adding another layer onto the optimizing framework: not only are we asking whether the bank is following — to some approximation — an optimal forecasting framework but we are asking whether it is any good at identifying the goals with which it is concerned (in this case, the output gap).

The final aspect we need to specify is the horizons that we focus on. The only issue here is that we need to consider horizons for which monetary policy has an effect on inflation and output. To this end, we

18 Kuttner (2004) evaluates these conditions, somewhat less formally than we do, but using central bank forecasts as discussed in the text. This is still an interesting exercise, particularly if one is interested primarily in the central bank's preferences concerning the balance between objectives. But for reasons noted, our view is that this is not a complete test of the optimizing framework. Moreover, as Kuttner notes, there are considerable difficulties with backing out output gap forecasts from central bank forecasts, which typically only involve output growth. Finally, and critically, the forecasts must be conditioned on the proposed path for the policy instrument that will deliver these forecasts. In many instances, central bank forecasts are not so constructed. These latter two concerns do not arise with the approach we follow.

19 The same arguments in favour of using the full sample output gap can be further used to support the use of current (full sample) vintage GDP data, as we do, versus real time GDP data. Technically, though, we should use real time data for output measures when we use these in the instrument sets — though we do not anticipate that the effects would be substantive. We leave this for future work.

consider horizons two quarters ahead or more (so $\bar{h}$ = 2). While empirically this would be generally regarded as too early for the main or maximum effects of monetary policy on inflation and output, that is not the issue here. As Woodford (2004) stresses, what matters is that there is some ability for the central bank to affect these variables and two quarters is certainly consistent with most empirical studies on the effects of monetary policy (see for example Christiano, Eichenbaum, and Evans, 2005). Moreover, it is the near term horizons that are potentially the most interesting since it is here where there will be meaningful trade offs between inflation and output. At longer horizons the there will be much less expected cyclical variation in output and in inflation around its target.

3.2 Strict Inflation Forecast Targets

Table 1 presents single equation estimates for h = 2, 4, 6, 8 and system equation estimates for h = 2, 4 for each of the three countries. All models are estimated using generalized method of moments (GMM). We follow the usual procedure of iterating the estimation using as the weighting matrix the inverse of successive estimates of the covariance matrix. The covariance matrix is estimated following Newey and West (1987) with truncation parameters indicated in the table.[20]

For the single equation estimates for each of the three countries, the estimates of the inflation target are all statistically significant and reasonably uniform over the different horizons. Canada's are the lowest, ranging from 1.7 to 2.1 percent while Australia and the US are fairly similar, ranging from 2.6 to 2.7 percent and 2.7 to 2.9 percent respectively. For all horizons and for each country, we cannot reject the over-identifying restrictions, based on Hansen's (1982) *J*-statistic, at usual significance levels. These results do not provide any direct evidence against the strict inflation forecast targeting model, including the requirement that the inflation target be stable across different horizons. It is also worth noting that in the case of Canada, there is a tendency to target (based on these estimates) inflation slightly below the mid-point of the published target of 1–3 percent. In contrast, for Australia, there is a tendency to target inflation at the high end of the published target of 2–3 percent. As for the United States, these estimates suggest that its actual behaviour over this period is comparable to explicit inflation targeting countries.

Table 1 also presents system based estimates for the strict inflation targeting model. Because of difficulties with estimation, we limit the system to the first two horizons.[21] From a policy perspective, this is not unreasonable since the two and four quarter horizon are clearly focal when setting monetary policy. The systems are estimated both as an unrestricted form, where the inflation targets are allowed to vary

[20] The choice of truncation parameter reflects the fact that for a forecast horizon of h, there is likely to be a moving average structure of h-1; Hansen and Hodrick (1980). For the single equation estimates, this is our choice of h. For the system estimates, we choose h to be one less than the maximum horizon. All estimation programmes, in GAUSS, are available upon request.

[21] We limit the horizon to four for the system estimates because of difficulty in getting the estimation to converge, which we conjecture may be due to weak instruments. Instrument quality is discussed further below.

across horizons, and in a form where they targets are restricted to be equal. The advantage of the system estimates is that we can now test formally whether the inflation targets are stable across horizons.

For each of the three countries, the estimates of π^* are comparable to the single equation estimates. And as before, we cannot reject the over-identifying restrictions. As far as parameter constancy is concerned, for Canada the two estimates are virtually identical at 1.8 percent and we cannot reject the hypothesis that the two targets are equal. When the model is estimated subject to these restrictions, we again obtain an inflation target of 1.8 percent.

These results are similar to those reported in Rowe and Yetman (2002) for the inflation targeting sample they focus on, 1992-2001. Their estimate for the inflation target for this period is 1.6 percent. This number can be compared to our single equation estimate for h = 8, π_8^* = 2.1, as this is the horizon they use for their estimation. Our estimate is somewhat higher, which may be because we use headline inflation rather than core inflation as they do, or the different sample, or both. Of more relevance though is that they also fail to reject the over-identifying restrictions as we do here, finding evidence in favour of a simple inflation targeting model. This is in fact the principal conclusion of their study.

For Australia and the United States, we reject the restriction the coefficients are equal across the two and four quarter horizon. In the case of Australia, the rejection is very strong with a *p*-value of 0.00. For the United States, the *p*-value is 0.07 (throughout, we focus on a ten percent significance level). For Australia, the difference is perhaps economically meaningful as well; the two coefficients are 2.8 and 3.1 percent. For the United States, however, the difference is smaller, 2.7 versus 2.8 percent, and perhaps not economically meaningful.

These results provide some support for the strict inflation forecast targeting model for all three countries, though with some qualifications about parameter constancy over different horizons for Australia and possibly for the United States. We find these results quite surprising, largely because our priors are that central banks do care about cyclical variations in aggregate demand in the short run and as such, we would anticipate that the test of over-identifying restrictions would provide evidence against the model. It is possible, though, that the Hansen's J -test is not sufficiently powerful to identify mis-specification of the model and so we now turn to richer targeting models.

3.3 Flexible Inflation Forecast Targets

Table 2 reports the estimates of the first of the flexible target conditions, equation (3), which uses the output gap x_t in the objective function. Recall that this condition can be motivated as arising from discretionary optimization by a central bank facing a forward-looking Phillips curve and in this instance we expect ϕ to be positive and less than one.

For Australia, the single equation estimates of ϕ are positive at all four horizons though only h = 2 and h = 6 are statistically significant (using a two-sided t-test with a ten percent significance level). The point estimates range from roughly 0.1 to 0.2, magnitudes that are consistent with expectation and without too much variation across the horizons. For the inflation target, π^*, the estimates are again statistically significant, consistent with prior expectations, and relatively stable across the horizons. When we estimate the model as a system over h = 2, 4, a similar pattern emerges: all but ϕ_4 are statistically significant. When we test for stability of the coefficients across the two horizons, we cannot reject a common value for the inflation target coefficient but we do strongly reject a common weight on the output gap. In summary, for Australia, this is a plausible model of flexible inflation forecast targeting with two qualifications: the insignificant coefficient estimate on the h = 4 horizon and, relatedly, the lack of parameter constancy across horizons. If we have strong prior beliefs in the restrictions of the model then we could simply use the restricted estimates reported in Table 2, which provide a ϕ coefficient of 0.11 and an inflation target of 2.9 percent, which is also a plausible model of flexible inflation forecast targeting.[22]

In contrast to Australia, the estimates for Canada and the US in Table 2 provide little support for this type of flexible inflation target. For Canada, the ϕ coefficients are negative and in all but one instance (single equation, h = 4) statistically significant. Taken at face value, these estimates suggest that monetary policy in Canada is *leaning with the wind* rather than *leaning against the wind*. For the United States, the single equation estimates of the ϕ parameter are in all but one instance statistically insignificant — suggesting that the output gap could be dropped from these equations implying a strict inflation forecast target (which would be consistent with the studies mentioned previously that found a zero value for λ). The system estimates, in contrast, give rise to statistically significant coefficients for ϕ at both the two and four quarter horizon; however, one coefficient is negative the other positive, which seems an implausible description of monetary policy. On balance, a flexible inflation target using the output gap does not appear to be a useful description of monetary policy in either Canada or the US.

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22 A comparison of the single equation and system estimates in these tables reveals that the unrestricted system estimates can differ significantly from the single equation estimates for the same horizons — as they do for Australia in Table 1. This may at first seem puzzling since the single equation models are present in the system estimates. The source of the difference is the weighting matrix used in the GMM estimation, which is proportional to inverse of the covariance matrix. With the system estimates, the weighting matrix depends upon the entire system rather than the single equation and so the parameter estimates may differ.

Table 3 reports the estimates for a flexible inflation forecast target using the change in the output gap. As previously discussed, this can be motivated either as the outcome of a central bank facing a purely backward looking Phillips curve, in which case ϕ will be negative, or as the outcome of a central bank, faced with a forward looking Phillips curve, able to commit to optimal monetary policy. In this latter case, ϕ will be positive.

An immediate conclusion from Table 3 is that across all three countries, all of the ϕ coefficients are positive or not statistically different from zero (at the ten percent level) with one exception, the coefficient for Canada in the single equation estimates for h = 6. These positive coefficients are consistent with forward looking rather than backward looking Phillips curves.[23]

The single equation estimates are somewhat mixed; while the inflation target coefficients are consistent with earlier results and prior expectations, the ϕ parameters do vary considerably. If we focus on only the first two horizons, where instrument quality is better, then the estimates for ϕ tend to be positive or statistically insignificant. Matters look considerably better, however, if we consider the system estimates. In this case, the ϕ parameters for each of the three countries are statistically significant, positive, and again take on small values as expected. The estimates of π^* are also consistent with expectations and line up roughly with what we observed in Table 1 under strict inflation targeting. And as before, we cannot reject the over-identifying restrictions for any of the models.

Looking at each country individually, the unrestricted estimates for Australia have ϕ coefficients of 0.10 and 0.16 for h = 2, 4 and inflation targets of 2.7 and 2.8. When we test whether these coefficients are equal across the two horizons, we fail to reject these hypotheses at usual significance levels. The associated restricted estimates are 0.13 and 2.7, providing a very plausible model of flexible inflation forecast targeting for Australia. Recall that for Australia we were also able to obtain a plausible model using the level of the output gap, though with inconsistency in coefficient estimates across horizons. As the results in Table 3 more closely accord with the theoretical model, we view this as our preferred model for Australia. Either way, of course, we have evidence of a flexible inflation target, one where the Australian authorities are leaning against the wind.

For Canada, we have estimates for ϕ of 0.20 and 0.16 for h = 2, 4 and estimates for the inflation targets of 1.9 and 1.6 percent. In this case, we reject the hypothesis that the two inflation targets are common across horizons; we do not reject the hypothesis, though, that the two ϕ coefficients are common. For

[23] Whether or not Phillips curves are backward or forward looking, or some combination of both, has been the focus of a considerable literature, see Rudd and Whelan (2005). Our results provide only very limited indirect evidence in this respect. To explore this issue in a substantive manner requires a structural model of the economy in contrast to our limited focus on inflation targets.

comparison purposes, we also report the fully restricted estimates, giving a ϕ coefficient of 0.14 and an inflation target of 1.8 percent. For the United States, we have estimates for ϕ of 0.16 and 0.07 for h = 2, 4 and estimates for the inflation targets of 2.7 and 2.7 percent. In contrast to Canada, though, we cannot reject the hypothesis of a common inflation target across horizons but do reject the hypothesis of a common ϕ parameter. Again, for comparison purposes, we report the restricted estimates, which in this case are 0.09 and 2.7.

There are two points of comparison with the related empirical literature. First, our results suggest that all three countries have inflation and output paths consistent with flexible inflation targets, implying that each puts positive weight on output variation in their objective functions (recall that ϕ can be decomposed to be proportional to λ, the weight on output variation in the central bank's objective function). We are unable to provide an estimate of the weight but our results do suggest that it is non-zero. This contrasts with Dennis's (2004, 2006) results for the United States. Second, we can loosely compare our ϕ estimates with those of Giannoni and Woodford (2005), which are very close in magnitude to those reported here.

Table 4 reports estimates of the model where output growth is used rather than the output gap or the change in the output gap. In part, this provides a check on our previous results but may also be interpreted as an alternative model in its own right, where the central bank focuses on the readily available and interpretable output growth measure to guide policy. It also has the practical advantage of not relying on calculations of the output gap. Because output growth and changes in the output gap are highly correlated for all countries, the results in Table 4 closely accord with those in Table 3. Focusing on the system estimates for brevity, we see that across the three countries the ϕ estimates are essentially the same as are the conclusions from the restriction tests. The same conclusion holds for the estimates of the inflation target once one realizes that it now combines the target for inflation as well as the `target' for output growth.

To clarify this last point, it is helpful to change the notation somewhat from that in the tables. The condition we are estimating is,

$$E_t(\pi_{t+h} + \phi\Delta y_{t+h} - \tau) = 0$$

where τ is the combined target. This can be reinterpreted as follows:

$$E_t(\pi_{t+h} + \phi(\Delta y_{t+h} - \Delta y) - \pi^*) = 0$$

where Δy is the output growth target and $\tau = \phi\Delta y + \pi^*$. If, by way of example, we use the Australian restricted estimates from Table 3 for π^* and the restricted estimates from Table 4 for τ (reported as π^* in the table), we can back out an estimate of the output growth target. In this case, it is 3.4 percent. This is very close, as we would hope, to average quarterly growth rates over this sample, which is 3.7 percent (annual terms). Similar conclusions hold for Canada and the United States. Using the methods outlined above and the restricted estimates in Tables 3 and 4, we obtain Δy = 3.6 for Canada and Δy = 2.2 for the United States. These compare to quarterly average growth rates of 3.3 and 2.9 percent (annual terms).

In summary, we have plausible general descriptions of flexible inflation forecast targets for all three countries though for two of these countries, Canada and the United States, we observe significant variation in coefficients across horizons. And in both of these cases, the difference in estimates is also, arguably, significant in economic terms. It is possible to plausibly interpret the pattern of variation. For Canada, we observe that its near term (two quarter) inflation target is higher, or less strict if you will, than its longer horizon (four quarter) target. This might be explained by greater concerns or uncertainty about output costs of a tighter near term target relative to the four quarter horizon. The United States can also be interpreted as being less stringent in the short run with its inflation target though in this case it shows up as a greater weight on the near term change in the output gap. Whatever the explanation, these variations are still departures from the model, suggesting either the forecast targeting model may be too simple or, if we accept the model's prescriptions, that these central banks could improve their targeting behaviour.

There is a further point worth making based on these estimates of flexible inflation targets — they are entirely dominated by the behaviour of inflation, even allowing for a statistically significant coefficient on the change in the output gap term. Figure 4 presents the residuals or deviations from target for the unrestricted system estimates reported in Table 3 for each of the three countries for the two quarter horizon. Also included in the Figure are the inflation rate and the scaled change in the output gap, $\hat{\phi}_2\Delta x_t$. Together these two series make up the flexible inflation target. The dominant role of inflation in the residual series is immediately apparent, arising because the scaled change in the output gap is, relative to the variation in output, much smaller. A very similar picture emerges if one uses the output growth and the coefficient estimates from Table 4.

There are two implications from this conclusion. The first concerns whether the flexible inflation targeting model fits the data better than the strict inflation targeting model. The results tend to favour the flexible target model in so far as when we include the change in the output gap it is statistically significant. But this is, so far, the only substantive support. When we estimate the strict inflation targeting model we do not find any direct evidence against the model. This latter conclusion may seem surprising; given that the change in the output gap is significant we might expect the strict inflation target model to be rejected based on Hansen's J -statistic. But when we consider that the contribution to the residual from the change in the output gap is very small, the failure to reject is perhaps understandable. The consequence of this is that it is going to be difficult empirically to discriminate between these two models. Below, we further test the predictions of the model by considering whether the deviations from the targets, strict or flexible, are predictable over the sample; as we shall again see, it is still difficult to discriminate between the two models.

The second implication of these results concerns how we might evaluate central bank behaviour or, more particularly, how we might evaluate a flexible inflation targeting central bank. One way to think about this is to re-organize the flexible inflation target condition, as Woodford (2003) does, into a state-contingent target for inflation (at the two quarter horizon):

$$\pi_{t+2} = \pi^* - \phi \Delta x_{t+2}$$

With ϕ estimates around 0.1 to 0.2, only fairly large changes in the output gap are going to substantially affect the conditional inflation target. Of course, in theoretical presentations, π^* is usually taken to be zero and in this case output gap changes would play a larger role. But for empirically relevant inflation targets of close to two percent, their role is significantly diminished.

Before we consider further specification tests of the models, we briefly discuss our choice of instruments and instrument quality. We selected a consistent set of instruments across all three countries. As a guide to instrument choice, we refined the instrument set to ensure that the *system equation* estimates, which are demanding to estimate because of the number of moments, are consistent with the *single equation* estimates. Further, because we have strong prior information on the magnitude of the π^* parameter, we focused on sets that provided estimates consistent with these priors. Within these limits, our parameter estimates are reasonably robust.[24] A further robustness concern is the choice of horizon for the system estimates. Looking at sets of moment conditions at different horizons than we do here can give rise to significantly different results, which we suspect is due to instrument quality.

The quality of instrumental variables estimation depends greatly upon the quality of the instruments. In Table 5, we report instrument quality measures for each of the endogenous variables. In the weak instruments literature, an F -statistic of 10 or higher is considered an indication of a good instrument

[24] An example of the sensitivity to instrument choice is the estimate of π^* for Australia for h = 8 reported in Table 4. As noted in the table, we introduce an additional instrument, i_t, for this model. With the instrument set in use for the other models, we obtain an estimate of π^* = 10.15, which is not consistent with our priors or indeed any of the other estimates. If we use this expanded instrument set for the other horizons the results are essentially unchanged.

(Stock, Wright, and Yogo, 2002). Unfortunately, none of our measures are this high though in some instances at the two quarter horizon the statistics are close, values around 8 or 9. The relative weakness of instruments here is obviously an important qualification to our results. The difficulty arises in part from the nature of the estimation problem — it is always going to be difficult to find instruments for these variables because of the lags involved. And this of course makes it particularly difficult for the longer horizons and explains our focus on the two and four quarter horizon.

3.4 Further Tests of the Models

While all of the models presented so far are not rejected based on Hansen's J-test of over-identifying restrictions, it is possible that this is not a very powerful test of the model. As noted, we have already seen that it fails to discriminate between the strict and flexible inflation target despite the statistically significant coefficients on various output measures. To pursue this further, we ask whether residuals from either the strict or flexible inflation targets are predictable; theoretically, any variable known at time t should not predict deviations from the targets.

For the strict inflation target models, we use the single equation estimates for h = 2, 4. We chose the single equation estimates because they are relatively stable across horizons. For the flexible inflation target models, we use the unrestricted system estimates based on the change in the output gap (Table 3). For each model, we regress the two and four quarter horizon residual on the following sets of variables: (1) lagged inflation; (2) lagged output gaps (recursive); (3) lagged changes in output gaps (recursive); (4) lagged changes in output; (5) current and lagged changes in the policy nominal interest rate; and (6) current and lagged changes in the nominal exchange rate (except for the United States). Details of the series are provided in the Data Appendix.

The results for Australia are presented in Table 6. Significant coefficients (ten percent two-sided t-test) are indicated in bold. A first immediate conclusion is that the predictability of deviations from the strict inflation target is the same as that for the flexible target, which reinforces our previous point that the output gap contributes relatively little to the deviations. At the two quarter horizon, we find lagged inflation predicts deviations from the either target and, summing the coefficients, the effect is positive. One interpretation of this, and this will be true for any instance where we observe predictability, is that the target is mis-specified: we are missing some objective of the central bank or we are treating the objectives too simply.[25] Another interpretation is the Reserve Bank has not been aggressive enough in its control of inflation over the entire course of the inflation targeting experience.[26]

[25] As these models are enriched, either by refinements to the economic environment or to the objective functions of the central bank, the targeting conditions become more complicated. See Woodford (2003). This is a real and important possibility and an obvious direction for further work. Our objective, however, is to ask whether the simple targets used here, and that could be easily used in practice by central banks, have any empirical relevance.

At the two and four quarter horizon, again for both models, we also find changes in policy interest rates predict deviations from targets. On balance, the relationship is positive. Again, this may point to mis-specification of the target. Alternatively, it may mean that policy interest rate rises, associated with excess inflation, have not been sufficiently aggressive.

The results for Canada, presented in Table 7, look quite good. One or two variables are statistically significant but the information in them is relatively small. In no instances do the $\bar{R}^2 s$ exceed 0.1 and in most instances they are much lower than that. So there is relatively little predictability in the Canadian inflation target, strict or flexible. As far as comparing the two models, if anything the strict inflation targeting regime fairs slightly better (based on goodness of fit), though there is really very little increase in predictability. On balance, we would argue that Bank of Canada's behaviour over the inflation targeting period has been quite consistent with either a strict or flexible inflation targeting model.

For the United States, presented in Table 8, we see the same key result that we saw for Australia: considerable persistence in inflation. Again, the total effect is positive leading to similar conclusions that we put forward for Australia. There is also some evidence of policy interest rates predicting deviations from the strict inflation target, notably at the four quarter horizon. This goes away for the flexible inflation target providing some limited support for this model.

4. Conclusions

We examine strict and flexible inflation targets for two inflation targeting countries — Australia and Canada — as well as the United States. These targets can be motivated from standard theoretical models of monetary policy in New Keynesian environments though they also have a fairly simple intuitive interpretation, representing the near term balance between inflation and cyclical variations in output that a central bank wishes to achieve. For all three countries, we obtain plausible estimates of the weight on output variations in the flexible inflation forecast target that captures this balance. Remarkably, the parameter estimates for this weight are very similar across the three countries.

Although the parameter estimates are plausible, we do identify a number of qualifications to the results. First, for our preferred models there is evidence that the weights in the forecast targets for Canada and the United States are not constant across different horizons as we would expect. Of greater importance, however, is that for Australia and the United States deviations from the forecast targets are predictable, suggesting possible problems with the specification of the simple forecast targeting model for these countries. For Canada, in contrast, these specification issues do not arise and, on balance, we think the simple forecast targeting model works quite well in this instance.

[26] This role for lagged inflation is strongly influenced by the early part of the sample, where there are significant swings in inflation. If we restrict the forecast regressions to the latter part of the sample, deviations from target are no longer predictable

There are a number of lessons from the exercise that are worth emphasizing. First, despite a number of qualifications including some concerns about instrument quality, we see the results as generally quite supportive of the forecast targeting approach. One way to interpret what we have done is that it is analogous to the empirical literature on fitting Taylor rules as a description of monetary policy and a possible rule to which central banks might commit. Svensson (2003) and Woodford (2007) strongly advocate commitment by central banks to the sorts of forecast targets considered here. Our results demonstrate that the actual behaviour of these central banks, particularly Canada, is broadly consistent with such targets and that a formal commitment would be a practical possibility.

The second lesson from our analysis is that the difference between strict and flexible inflation forecast targeting is, empirically, quite subtle. Discriminating between the two types of targeting, for the outside observer, is going to be difficult. The reason for this is that the targets — weighted average of inflation and output variation — are dominated by the behaviour of inflation. To our minds, this strengthens the arguments for central banks to be more transparent about the near term objectives since reading the entrails of their policy may not be sufficient to assess and judge policy objectives.

The third lesson is simply a practical one. As far as specifying forecast targets are concerned, we find essentially no difference in our results between using changes in the output gap — as prescribed by theory — and output growth. This points to the possibility of using output growth — which is readily measured and easily explained — in forecast targets rather than measures of the output gap that rely on measures of potential output.

As a final broad point, we attempt to fit very simple models of strict and flexible inflation targeting. Obviously, there are many possible policy considerations that are absent from these models; central banks may have significantly richer set of objectives than we have considered here. Interest rate and exchange smoothing are two such possible directions that could be considered for future research.

by lagged inflation.

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Table 1. Strict Inflation Targeting

Instruments: $z_t = (1, \pi_t^{cx}, \pi_{t-1}^{cx}, \pi_{t-2}^{cx}, \pi_{t-1}, \pi_{t-2}, x_{t-1}^R, \Delta x_{t-1}^R, \Delta y_{t-1}, \Delta i_t)$

Single Equation Models: $E_t(\pi_{t+h} - \pi_h^*),\ h = 2, 4, 6, 8$

	Australia		Canada		United States	
	π_h^*	J	π_h^*	J	π_h^*	J
$h = 2$	2.7389	9.7808	1.9146	14.1026	2.7417	11.7743
	(0.0993)	(0.3685)	(0.0856)	(0.1187)	(0.0975)	(0.2263)
$h = 4$	2.6261	6.2076	1.8663	5.1004	2.7430	7.5565
	(0.1075)	(0.7190)	(0.0894)	(0.8255)	(0.1097)	(0.5794)
$h = 6$	2.6387	4.5439	1.7367	6.4197	2.8433	4.4721
	(0.0882)	(0.8721)	(0.0726)	(0.6973)	(0.0956)	(0.8777)
$h = 8$	2.5916	4.2503	2.0888	4.6129	2.8522	4.6264
	(0.0798)	(0.8942)	(0.0451)	(0.8667)	(0.0616)	(0.8656)

System Models: $E_t(\pi_{t+h} - \pi_h^*),\ h = 2, 4$

	Australia			Canada			United States		
	π_2^*	π_4^*	J	π_2^*	π_4^*	J	π_2^*	π_4^*	J
Unrestricted									
	2.8377	3.0877	10.5687	1.7793	1.7932	9.8252	2.7761	2.6804	11.3176
	(0.0641)	(0.0760)	(0.9118)	(0.0497)	(0.0552)	(0.9375)	(0.0974)	(0.0974)	(0.8804)
Restricted									
	2.6600		11.4072	1.7843		9.8063	2.7809		12.1522
	(0.0818)		(0.9094)	(0.0425)		(0.9576)	(0.0827)		(0.8790)
Tests									
$\pi_2^* = \pi_4^*$									
		18.0343			0.0543			3.3275	
		(0.0000)			(0.8157)			(0.0681)	

Notes: J is Hansen's (1982) J-statistic, distributed $\chi^2(9)$ for the single equation models and distributed $\chi^2(18)$ or $\chi^2(19)$ for the unrestricted and restricted system models respectively. Numbers in parentheses are standard errors except for the reported statistics, which are marginal significance levels. Covariance matrices are Newey and West (1987) using a lag truncation parameter of $h-1$ for the single equation models and 3 for the system models. The numbers reported in the row denoted $\pi_2 = \pi_4$ are the appropriate Wald test and marginal significance levels.

Table 2. Flexible Inflation Targeting with the Output Gap

Instruments: $z_t = (1, \pi_t^{cx}, \pi_{t-1}^{cx}, \pi_{t-2}^{cx}, \pi_{t-1}, \pi_{t-2}, x_{t-1}^R, \Delta x_{t-1}^R, \Delta y_{t-1}, \Delta i_t)$

Single Equation Models: $E_t(\pi_{t+h} + \phi_h x_{t+h} - \pi_h^*),\ h = 2, 4, 6, 8$

	Australia			Canada			United States		
	ϕ_h	π_h^*	J	ϕ_h	π_h^*	J	ϕ_h	π_h^*	J
$h=2$	0.1815	2.7004	7.8536	-0.0552	1.9639	14.000	-0.0547	2.8352	10.5104
	(0.0778)	(0.0987)	(0.4479)	(0.0244)	(0.0898)	(0.0818)	(0.0338)	(0.0951)	(0.2310)
$h=4$	0.1576	2.7169	4.7614	-0.0404	1.9313	5.0855	0.0878	2.6576	4.3857
	(0.1042)	(0.1124)	(0.7827)	(0.0424)	(0.1008)	(0.7484)	(0.0447)	(0.1194)	(0.8208)
$h=6$	0.1737	2.6685	3.1672	-0.0805	1.8988	5.9857	-0.0325	2.8847	4.0447
	(0.0962)	(0.0797)	(0.9234)	(0.0227)	(0.0501)	(0.6488)	(0.0299)	(0.1018)	(0.8531)
$h=8$	0.0935	2.6276	4.4243	-0.1172	2.2038	4.5251	-0.0132	2.8699	4.4524
	(0.0639)	(0.0623)	(0.8170)	(0.0404)	(0.0562)	(0.8069)	(0.0350)	(0.0648)	(0.8142)

System Models: $E_t(\pi_{t+h} + \phi_h x_{t+h} - \pi_h^*),\ h = 2, 4$

	Australia					Canada					United States				
	ϕ_2	ϕ_4	π_2^*	π_4^*	J	ϕ_2	ϕ_4	π_2^*	π_4^*	J	ϕ_2	ϕ_4	π_2^*	π_4^*	J
Unrestricted															
	0.1503	-0.0641	2.6355	2.6377	8.6445	-0.0359	-0.0488	1.8755	1.9042	9.4706	-0.0678	0.1128	2.9300	2.6869	8.4032
	(0.0271)	(0.0511)	(0.0766)	(0.0833)	(0.9273)	(0.0144)	(0.0260)	(0.0546)	(0.0481)	(0.8928)	(0.0222)	(0.0215)	(0.0786)	(0.0830)	(0.9359)
Restricted															
	0.1124		2.8909		10.6699	-0.0332		1.8735		9.5200	-0.0421		2.9751		11.2359
	(0.0291)		(0.0545)		(0.9078)	(0.0133)		(0.0429)		(0.9465)	(0.0159)		(0.0690)		(0.8841)
Tests															
$\phi_2 = \phi_4$			19.5145	(0.0000)				0.5296	(0.4668)				28.5170	(0.0000)	
$\pi_2^* = \pi_4^*$			0.0007	(0.9796)				0.2123	(0.6450)				6.1142	(0.0134)	
$\pi_2^* = \pi_4^*\ \phi_2 = \phi_4$			20.0076	(0.0000)				0.6184	(0.7340)				29.4302	(0.0000)	

Notes: J is Hansen's (1982) J-statistic, distributed $\chi^2(9)$ for the single equation models and distributed $\chi^2(16)$ or $\chi^2(18)$ for the unrestricted and restricted system models respectively. Numbers in parentheses are standard errors except for the reported statistics, which are marginal significance levels. Covariance matrices are Newey and West (1987) using a lag truncation parameter of $h-1$ for the single equation models and 3 for the system models. The numbers reported in the rows denoted *Tests* are the appropriate Wald test and marginal significance levels.

Table 3. Flexible Inflation Targeting with Output Gap Changes

Instruments: $z_t = (1, \pi_t^{cx}, \pi_{t-1}^{cx}, \pi_{t-2}^{cx}, \pi_{t-1}, \pi_{t-2}, x_{t-1}^R, \Delta x_{t-1}^R, \Delta y_{t-1}, \Delta i_t)$

Single Equation Models: $E_t(\pi_{t+h} + \phi_h \Delta x_{t+h} - \pi_h^*),\ h = 2, 4, 6, 8$

	Australia			Canada			United States		
	ϕ_h	π_h^*	J	ϕ_h	π_h^*	J	ϕ_h	π_h^*	J
$h = 2$	0.1364	2.7141	7.9893	0.1981	1.9988	12.0305	0.0567	2.7500	11.6872
	(0.0919)	(0.1081)	(0.4345)	(0.0640)	(0.0928)	(0.1498)	(0.0927)	(0.0951)	(0.1657)
$h = 4$	0.0899	2.6608	5.3000	0.1356	1.9003	4.1614	0.1512	2.8073	4.2270
	(0.1260)	(0.1152)	(0.7251)	(0.0663)	(0.1063)	(0.8423)	(0.0748)	(0.0977)	(0.8361)
$h = 6$	0.0516	2.6429	4.6064	-0.1492	1.6920	4.8825	-0.0208	2.8428	4.4190
	(0.1646)	(0.0946)	(0.7987)	(0.0791)	(0.0736)	(0.7701)	(0.0840)	(0.0931)	(0.8175)
$h = 8$	-0.0208	2.5957	4.1797	0.4735	1.8101	4.4523	0.1413	2.8456	3.9060
	(0.1065)	(0.0835)	(0.8406)	(0.1087)	(0.0604)	(0.8142)	(0.0661)	(0.0601)	(0.8655)

System Models: $E_t(\pi_{t+h} + \phi_h \Delta x_{t+h} - \pi_h^*),\ h = 2, 4$

	Australia					Canada					United States				
	ϕ_2	ϕ_4	π_2^*	π_4^*	J	ϕ_2	ϕ_4	π_2^*	π_4^*	J	ϕ_2	ϕ_4	π_2^*	π_4^*	J
Unrestricted															
	0.1021	0.1642	2.7557	2.8010	6.8504	0.1999	0.1589	1.8827	1.5985	8.9696	0.1569	0.0670	2.7142	2.6603	9.1183
	(0.0445)	(0.0484)	(0.0891)	(0.0933)	(0.9760)	(0.0250)	(0.0498)	(0.0484)	(0.0604)	(0.9147)	(0.0397)	(0.0393)	(0.0715)	(0.0611)	(0.9085)
Restricted															
	0.1275		2.7617		7.4509	0.1410		1.8038		10.2404	0.0887		2.6993		10.9035
	(0.0145)		(0.0781)		(0.9857)	(0.0233)		(0.0374)		(0.9238)	(0.0351)		(0.0665)		(0.8984)
Tests															
$\phi_2 = \phi_4$			0.4896	(0.4841)				0.7231	(0.3951)				5.3570	(0.0206)	
$\pi_2^* = \pi_4^*$			0.3070	(0.5795)				15.6699	(0.0001)				1.1793	(0.2775)	
$\pi_2^* = \pi_4^*\ \phi_2 = \phi_4$			0.6910	(0.7079)				22.1686	(0.0000)				8.0775	(0.0176)	

Notes: J is Hansen's (1982) J-statistic, distributed $\chi^2(9)$ for the single equation models and distributed $\chi^2(16)$ or $\chi^2(18)$ for the unrestricted and restricted system models respectively. Numbers in parentheses are standard errors except for the reported statistics, which are marginal significance levels. Covariance matrices are Newey and West (1987) using a lag truncation parameter of $h-1$ for the single equation models and 3 for the system models. The numbers reported in the rows denoted *Tests* are the appropriate Wald test and marginal significance levels.

Table 4. Flexible Inflation Targeting with Output Growth

Instruments: $z_t = (1, \pi_t^{cx}, \pi_{t-1}^{cx}, \pi_{t-2}^{cx}, \pi_{t-1}, \pi_{t-2}, x_{t-1}^R, \Delta x_{t-1}^R, \Delta y_{t-1}, \Delta i_t)$

Single Equation Models: $E_t(\pi_{t+h} + \phi_h \Delta y_{t+h} - \pi_h^*),\ h = 2, 4, 6, 8$

	Australia			Canada			United States		
	ϕ_h	π_h^*	J	ϕ_h	π_h^*	J	ϕ_h	π_h^*	J
$h=2$	0.1646	3.2557	7.8030	0.1647	2.5040	11.8667	0.1069	3.0882	11.5811
	(0.0906)	(0.3456)	(0.4529)	(0.0536)	(0.1613)	(0.1573)	(0.0861)	(0.2917)	(0.1709)
$h=4$	0.1332	3.1330	4.8031	0.1486	2.3565	3.7643	0.1414	3.2428	4.1055
	(0.1164)	(0.4242)	(0.7784)	(0.0606)	(0.2114)	(0.8777)	(0.0672)	(0.2234)	(0.8475)
$h=6$	0.1260	3.0811	4.5472	-0.0828	1.3898	5.5353	-0.0367	2.7323	4.3116
	(0.1631)	(0.6003)	(0.8047)	(0.0788)	(0.2913)	(0.6991)	(0.0840)	(0.2639)	(0.8280)
$h=8$	0.0270	2.6871	4.3975	0.3498	2.9793	4.2420	0.1076	3.1801	4.3633
	(0.1129)	(0.3968)	(0.8834)	(0.0532)	(0.1848)	(0.8347)	(0.0522)	(0.1510)	(0.8229)

System Models: $E_t(\pi_{t+h} + \phi_h \Delta y_{t+h} - \pi_h^*),\ h = 2, 4$

	Australia					Canada					United States				
	ϕ_2	ϕ_4	π_2^*	π_4^*	J	ϕ_2	ϕ_4	π_2^*	π_4^*	J	ϕ_2	ϕ_4	π_2^*	π_4^*	J
Unrestricted															
	0.1156	0.1605	3.1363	3.3303	7.0622	0.1630	0.1463	2.4233	2.1109	8.9252	0.1550	0.0676	3.2122	2.8789	8.7215
	(0.0464)	(0.0447)	(0.1976)	(0.1610)	(0.9720)	(0.0223)	(0.0436)	(0.0765)	(0.1351)	(0.9165)	(0.0366)	(0.0388)	(0.1262)	(0.1325)	(0.9244)
Restricted															
	0.1332		3.2026		7.4322	0.1369		2.2722		9.8882	0.0900		2.9840		10.7207
	(0.0159)		(0.0926)		(0.9859)	(0.0199)		(0.0688)		(0.9355)	(0.0328)		(0.1108)		(0.9058)
Tests															
$\phi_2 = \phi_4$			0.2712	(0.6025)				0.1626	(0.6868)				6.5089	(0.0107)	
$\pi_2^* = \pi_4^*$			0.3751	(0.5402)				5.5635	(0.0183)				10.7951	(0.0010)	
$\pi_2^* = \pi_4^*\ \phi_2 = \phi_4$			0.4525	(0.7975)				13.6977	(0.0011)				11.3560	(0.0034)	

Notes: J is Hansen's (1982) J-statistic, distributed $\chi^2(9)$ for the single equation models and distributed $\chi^2(16)$ or $\chi^2(18)$ for the unrestricted and restricted system models respectively. Numbers in parentheses are standard errors except for the reported statistics, which are marginal significance levels. Covariance matrices are Newey and West (1987) using a lag truncation parameter of $h-1$ for the single equation models and 3 for the system models. The numbers reported in the rows denoted *Tests* are the appropriate Wald test and marginal significance levels. Single equation estimates for Australia for $h=8$ include an additional instrument, i_t. See text for details.

Table 5. Instrument Quality

Instruments: $z_t = (1, \pi_t^{cx}, \pi_{t-1}^{cx}, \pi_{t-2}^{cx}, \pi_{t-1}, \pi_{t-2}, x_{t-1}^R, \Delta x_{t-1}^R, \Delta y_{t-1}, \Delta i_t)$

	Australia				**Canada**				**United States**			
	π_{t+h}	x_{t+h}	Δx_{t+h}	Δy_{t+h}	π_{t+h}	x_{t+h}	Δx_{t+h}	Δy_{t+h}	π_{t+h}	x_{t+h}	Δx_{t+h}	Δy_{t+h}
$h=2$	8.200	3.159	1.605	1.795	5.673	7.144	3.246	4.674	8.839	9.446	2.291	2.949
$h=4$	4.530	2.846	0.919	1.232	1.532	2.767	1.858	2.447	1.820	8.254	1.259	1.651
$h=6$	5.957	1.181	0.217	0.258	1.538	2.593	1.036	1.293	0.979	7.159	0.653	0.857
$h=8$	5.583	0.851	0.202	0.324	1.520	2.343	0.515	1.210	1.020	3.848	1.041	1.270

Notes: Numbers are *F*-tests for the joint hypothesis that all instruments (except the constant term) have coefficients zero when regressed against each of the instruments.

Table 6. Prediction Regressions for Australia

	Strict				Flexible			
Dep.	$\pi_{t+2}-\hat{\pi}_2^*$		$\pi_{t+4}-\hat{\pi}_4^*$		$\pi_{t+2}+\hat{\phi}_2\Delta x_{t+2}-\hat{\pi}_2^*$		$\pi_{t+4}+\hat{\phi}_4\Delta x_{t+4}-\hat{\pi}_4^*$	
Cons.	**-1.2335**	(0.4308)	-0.1169	(0.6617)	**-1.2046**	(0.4198)	-0.2967	(0.6561)
π_{t-1}	**1.2270**	(0.3624)	0.6546	(0.4394)	**1.1827**	(0.3639)	0.4956	(0.4119)
π_{t-2}	**-0.8623**	(0.3774)	-0.6934	(0.4965)	**-0.8334**	(0.3823)	-0.5296	(0.4762)
$\bar{R}^2$	0.338		0.064		0.312		0.018	
Cons.	-0.3189	(0.2450)	-0.1548	(0.2249)	-0.3220	(0.2374)	-0.3357	(0.2218)
x^R_{t-1}	-0.0228	(0.0393)	0.0544	(0.0878)	-0.0304	(0.0379)	0.0728	(0.0864)
x^R_{t-2}	0.0261	(0.0960)	-0.0850	(0.0806)	0.0271	(0.1008)	-0.1011	(0.0909)
$\bar{R}^2$	-0.037		-0.017		-0.035		-0.008	
Cons.	-0.3176	(0.2883)	-0.1888	(0.2807)	-0.3216	(0.2832)	-0.3702	(0.2776)
Δx^R_{t-1}	-0.0023	(0.0365)	0.0559	(0.0780)	-0.0297	(0.0374)	0.0737	(0.0786)
Δx^R_{t-2}	0.0095	(0.0572)	0.0485	(0.0803)	-0.0212	(0.0557)	0.0642	(0.0894)
$\bar{R}^2$	-0.036		-0.013		-0.033		0.004	
Cons.	0.0232	(0.3647)	-0.2404	(0.3939)	0.1962	(0.3466)	-0.5603	(0.4476)
Δy_{t-1}	-0.0637	(0.0502)	0.0132	(0.0700)	-0.0768	(0.0495)	0.0341	(0.0698)
Δy_{t-2}	-0.0308	(0.0550)	0.0050	(0.0710)	-0.0679	(0.0528)	0.0236	(0.0793)
$\bar{R}^2$	-0.019		-0.038		0.004		-0.032	
Cons.	**-0.3435**	(0.2025)	-0.2009	(0.2451)	**-0.3512**	(0.2061)	-0.3761	(0.2437)
Δi^p_t	**1.2759**	(0.4839)	**1.5372**	(0.6251)	**1.1786**	(0.5352)	**1.4625**	(0.6657)
Δi^p_{t-1}	**0.5596**	(0.3266)	-0.0374	(0.3741)	0.4999	(0.3518)	-0.0879	(0.3679)
Δi^p_{t-2}	**0.9478**	(0.4127)	0.1630	(0.3514)	**0.9601**	(0.4310)	0.3253	(0.3717)
$\bar{R}^2$	0.438		0.188		0.387		0.165	
Cons.	-0.3227	(0.2910)	-0.1899	(0.2838)	-0.3439	(0.2849)	-0.3622	(0.2800)
Δs_t	-0.0042	(0.0093)	-0.0078	(0.0079)	-0.0085	(0.0092)	-0.0041	(0.0077)
Δs_{t-1}	-0.0082	(0.0065)	-0.0028	(0.0073)	-0.0062	(0.0066)	-0.0050	(0.0076)
Δs_{t-2}	-0.0065	(0.0082)	-0.0091	(0.0086)	-0.0046	(0.0082)	-0.0056	(0.0094)
$\bar{R}^2$	-0.021		-0.018		-0.020		-0.038	

Notes: Standard errors are Newey-West with lag truncation parameter 3. The covariance matrix is constructed using the small sample adjustment suggested in Davidson and Mackinnon (1994). Standard errors are in brackets to the right of point estimates. Coefficients in boldface indicates significance at 10% using a two-sided *t*-statistic. Estimated values for constructed residuals are as follows:

Strict $\hat{\pi}_2^*$= 2.7389; $\hat{\pi}_4^*$= 2.6261

Flexible $\hat{\phi}_2$= 0.1021; $\hat{\pi}_2^*$= 2.7557; $\hat{\phi}_4$= 0.1642; $\hat{\pi}_4^*$= 2.8010

Table 7. Prediction Regressions for Canada

Dep.	Strict				Flexible			
	$\pi_{t+2}-\hat{\pi}_2^*$		$\pi_{t+4}-\hat{\pi}_4^*$		$\pi_{t+2}+\hat{\phi}_2\Delta x_{t+2}-\hat{\pi}_2^*$		$\pi_{t+4}+\hat{\phi}_4\Delta x_{t+4}-\hat{\pi}_4^*$	
Cons.	0.2889	(0.3605)	0.0687	(0.2559)	0.3390	(0.3493)	0.2206	(0.3067)
π_{t-1}	0.1984	(0.1530)	-0.2361	(0.2095)	0.0606	(0.1389)	-0.1917	(0.1940)
π_{t-2}	**-0.2896**	(0.0951)	0.2946	(0.2241)	-0.1712	(0.1275)	0.3024	(0.2295)
$\bar{R}^2$	0.018		0.022		-0.014		0.029	
Cons.	0.1553	(0.1669)	0.2235	(0.1710)	0.1940	(0.1447)	**0.4835**	(0.1555)
x_{t-1}^R	0.0677	(0.0485)	-0.0188	(0.0539)	0.0842	(0.0513)	-0.0503	(0.0523)
x_{t-2}^R	-0.1033	(0.0674)	-0.0194	(0.0508)	**-0.1448**	(0.0606)	0.0091	(0.0519)
$\bar{R}^2$	0.010		0.010		0.082		0.049	
Cons.	0.1114	(0.1641)	0.1942	(0.1629)	0.1286	(0.1514)	**0.4500**	(0.1500)
Δx_{t-1}^R	0.0376	(0.0579)	0.0311	(0.0525)	0.0758	(0.0582)	-0.0049	(0.0528)
Δx_{t-2}^R	0.0178	(0.0520)	-0.1099	(0.0851)	-0.0366	(0.0517)	-0.1054	(0.0782)
$\bar{R}^2$	-0.023		0.026		-0.014		0.054	
Cons.	**-0.3300**	(0.1376)	0.2464	(0.3455)	-0.2545	(0.1781)	**0.6152**	(0.3185)
Δy_{t-1}	0.0797	(0.0509)	0.0604	(0.0601)	**0.1165**	(0.0570)	0.0271	(0.0616)
Δy_{t-2}	0.0574	(0.0585)	-0.0803	(0.0927)	0.0020	(0.0556)	-0.0776	(0.0877)
$\bar{R}^2$	0.054		-0.012		0.050		-0.011	
Cons.	0.1319	(0.1720)	0.1702	(0.1669)	0.1369	(0.1605)	**0.4211**	(0.1554)
Δi_t^p	0.3165	(0.1950)	-0.1124	(0.1951)	0.1837	(0.2207)	-0.1505	(0.1806)
Δi_{t-1}^p	-0.0704	(0.1191)	-0.1398	(0.1989)	-0.0660	(0.1113)	-0.2282	(0.1756)
Δi_{t-2}^p	-0.0828	(0.2117)	-0.1446	(0.1769)	-0.1855	(0.1929)	-0.0594	(0.1720)
$\bar{R}^2$	-0.003		-0.012		-0.017		0.013	
Cons.	0.1061	(0.1852)	0.1612	(0.1872)	0.1041	(0.1651)	**0.4123**	(0.1791)
Δs_t	-0.0052	(0.0127)	-0.0027	(0.0090)	-0.0096	(0.0110)	-0.0028	(0.0094)
Δs_{t-1}	-0.0038	(0.0115)	0.0032	(0.0074)	-0.0051	(0.0114)	-0.0009	(0.0085)
Δs_{t-2}	0.0000	(0.0094)	-0.0104	(0.0072)	-0.0026	(0.0104)	-0.0068	(0.0070)
$\bar{R}^2$	-0.056		-0.047		-0.039		-0.055	

Notes: Standard errors are Newey-West with lag truncation parameter 3. The covariance matrix is constructed using the small sample adjustment suggested in Davidson and Mackinnon (1994). Standard errors are in brackets to the right of point estimates. Coefficients in boldface indicates significance at 10% using a two-sided *t*-statistic. Estimated values for constructed residuals are as follows:

Strict $\hat{\pi}_2^*$= 1.9146; $\hat{\pi}_4^*$= 1.8663

Flexible $\hat{\phi}_2$= 0.1999; $\hat{\pi}_2^*$= 1.8827; $\hat{\phi}_4$= 0.1589; $\hat{\pi}_4^*$= 1.5985

Table 8. Prediction Regressions for the United States

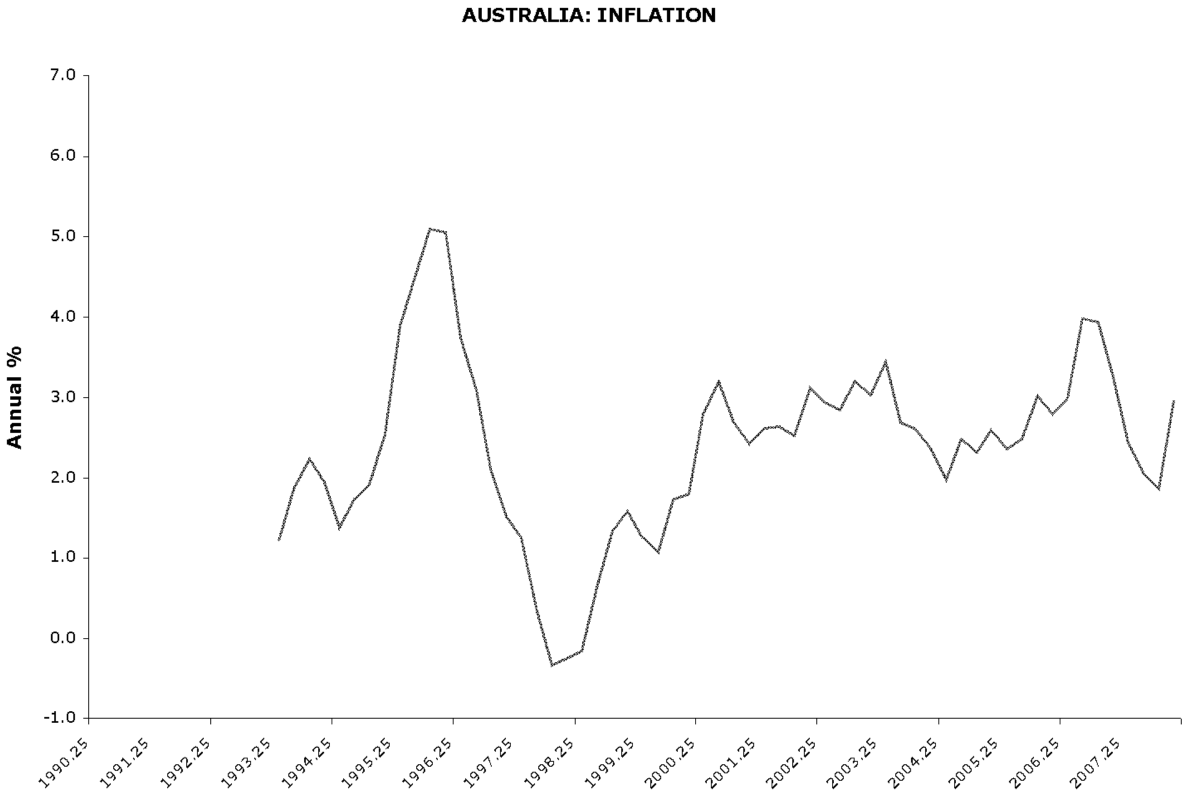
	Strict				Flexible			
Dep.	$\pi_{t+2}-\hat{\pi}_2^*$		$\pi_{t+4}-\hat{\pi}_4^*$		$\pi_{t+2}+\hat{\phi}_2\Delta x_{t+2}-\hat{\pi}_2^*$		$\pi_{t+4}+\hat{\phi}_4\Delta x_{t+4}-\hat{\pi}_4^*$	
Cons.	**-1.0924**	(0.3024)	-0.3200	(0.3243)	**-0.9134**	(0.2777)	-0.2206	(0.3148)
π_{t-1}	**0.7889**	(0.1554)	0.0362	(0.1878)	**0.7465**	(0.1683)	0.0535	(0.1885)
π_{t-2}	**-0.4506**	(0.1780)	0.0549	(0.2054)	**-0.4148**	(0.1746)	0.0337	(0.2087)
$\bar{R}^2$	0.297		-0.014		0.248		-0.016	
Cons.	0.0054	(0.1597)	-0.0558	(0.1433)	0.0334	(0.1539)	0.0304	(0.1411)
x_{t-1}^R	-0.0245	(0.0705)	0.0398	(0.0497)	-0.0191	(0.0683)	0.0372	(0.0513)
x_{t-2}^R	0.0359	(0.0638)	-0.0475	(0.0490)	0.0253	(0.0626)	-0.0476	(0.0495)
$\bar{R}^2$	-0.025		-0.015		-0.028		-0.016	
Cons.	0.0007	(0.1575)	-0.0528	(0.1389)	0.0307	(0.1534)	0.0344	(0.1372)
Δx_{t-1}^R	-0.0390	(0.0696)	0.0342	(0.0455)	-0.0371	(0.0649)	0.0298	(0.0466)
Δx_{t-2}^R	0.0568	(0.0479)	0.0105	(0.0401)	0.0626	(0.0521)	0.0134	(0.0423)
$\bar{R}^2$	-0.006		-0.016		-0.002		-0.017	
Cons.	-0.0016	(0.3648)	-0.0878	(0.2501)	0.0467	(0.3755)	0.0185	(0.2621)
Δy_{t-1}	-0.0471	(0.0717)	0.0190	(0.0469)	-0.0521	(0.0647)	0.0119	(0.0465)
Δy_{t-2}	0.0477	(0.0493)	-0.0074	(0.0405)	0.0461	(0.0524)	-0.0070	(0.0415)
$\bar{R}^2$	-0.008		-0.029		-0.005		-0.030	
Cons.	0.0260	(0.1524)	-0.0420	(0.1331)	0.0511	(0.1483)	0.0427	(0.1323)
Δi_t^p	0.0422	(0.3202)	**0.5595**	(0.2983)	0.1282	(0.3574)	0.4913	(0.3114)
Δi_{t-1}^p	0.4145	(0.2549)	-0.1142	(0.1887)	0.2603	(0.2680)	-0.0441	(0.1803)
Δi_{t-2}^p	0.0487	(0.1792)	-0.1199	(0.2456)	0.0220	(0.2295)	-0.1716	(0.2467)
$\bar{R}^2$	0.041		0.050		0.001		0.037	

Notes: Standard errors are Newey-West with lag truncation parameter 3. The covariance matrix is constructed using the small sample adjustment suggested in Davidson and Mackinnon (1994). Standard errors are in brackets to the right of point estimates. Coefficients in boldface indicates significance at 10% using a two-sided *t*-statistic. Estimated values for constructed residuals are as follows:

Strict $\hat{\pi}_2^*$ = 2.7417; $\hat{\pi}_4^*$ = 2.7430

Flexible $\hat{\phi}_2$ = 0.1569; $\hat{\pi}_2^*$ = 2.7142; $\hat{\phi}_4$ = 0.0670; $\hat{\pi}_4^*$ = 2.6603

Figure 1. Australian Inflation and HP Output Gaps



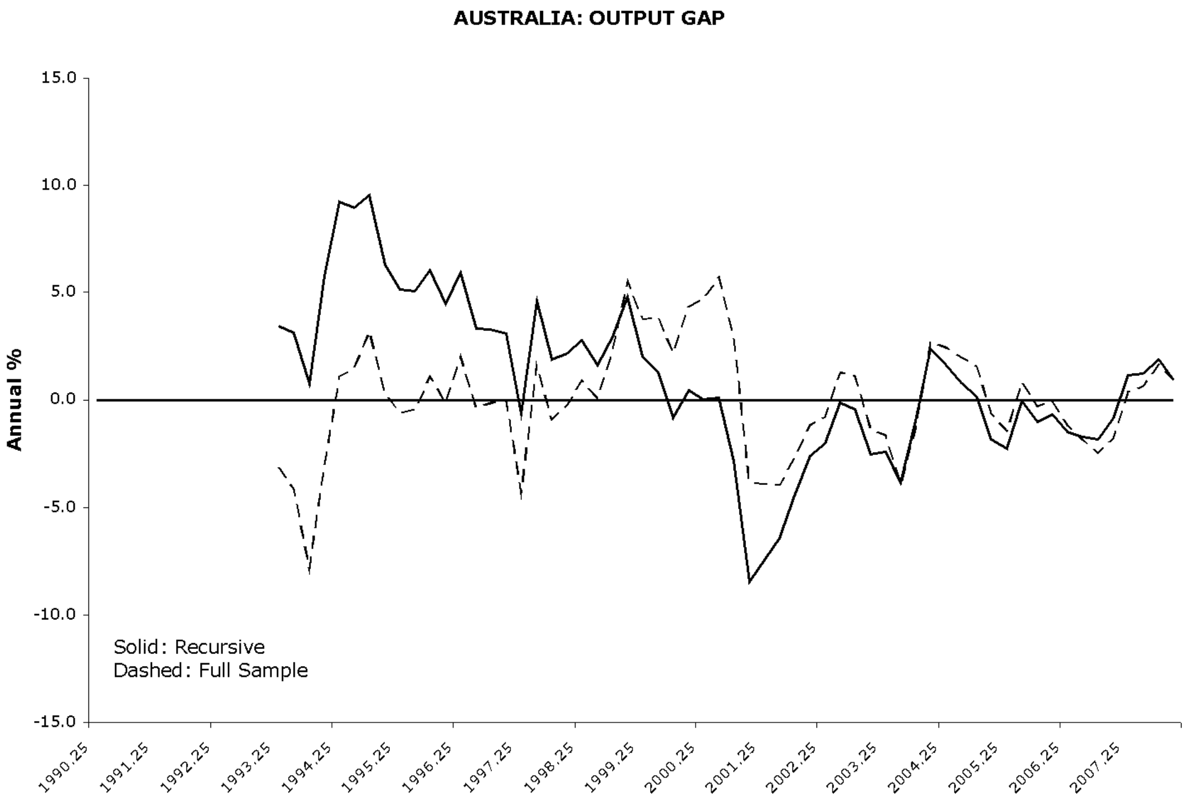
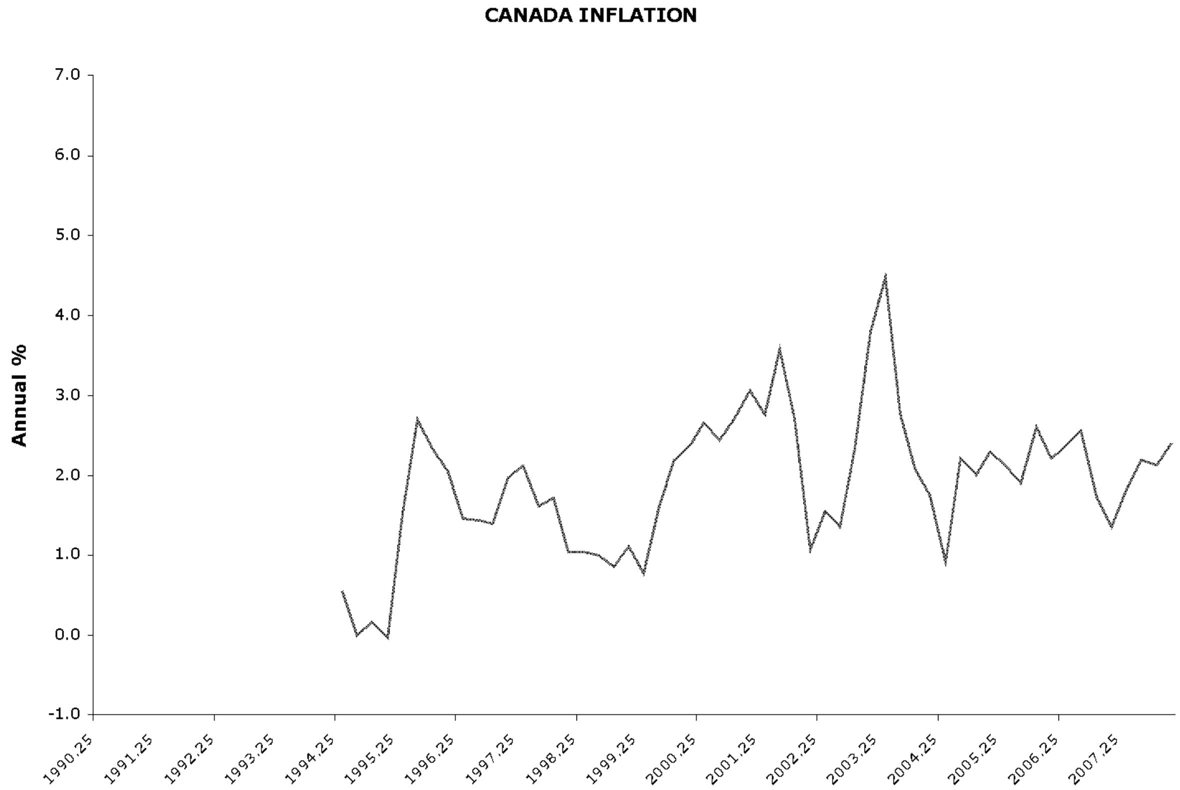


Figure 2. Canadian Inflation and HP Output Gaps



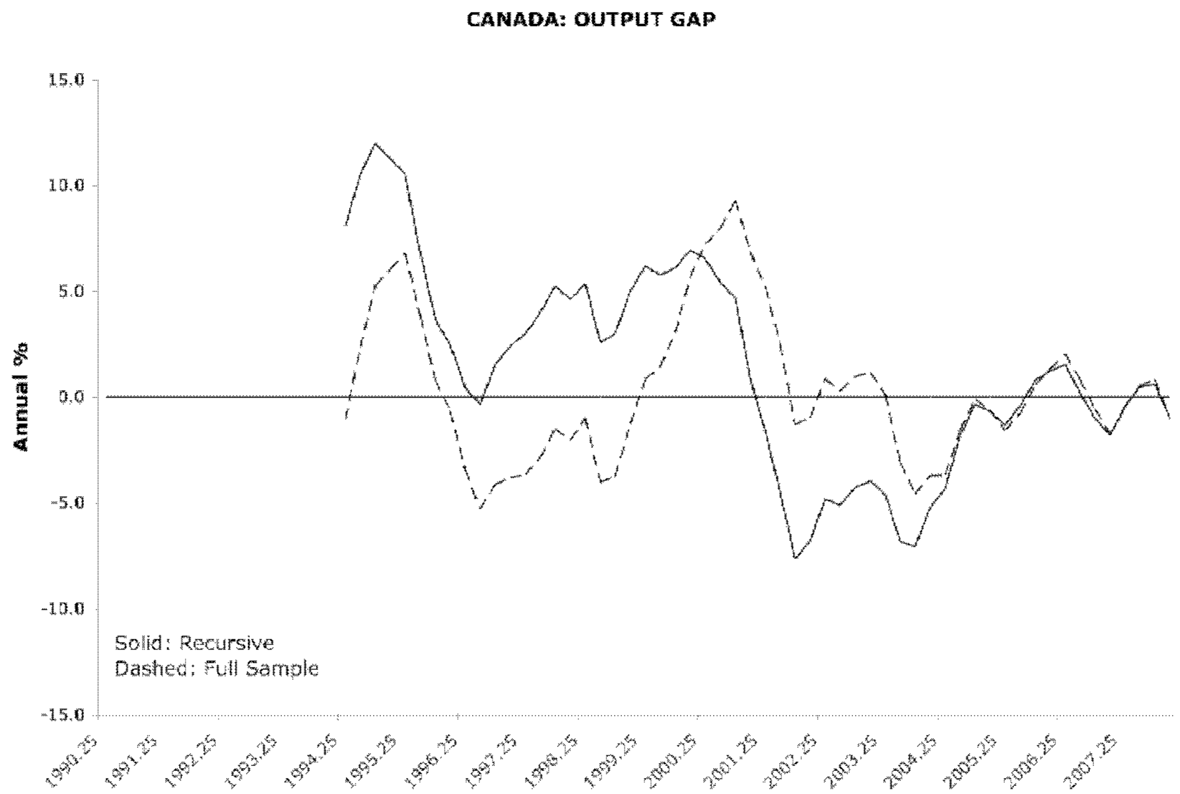
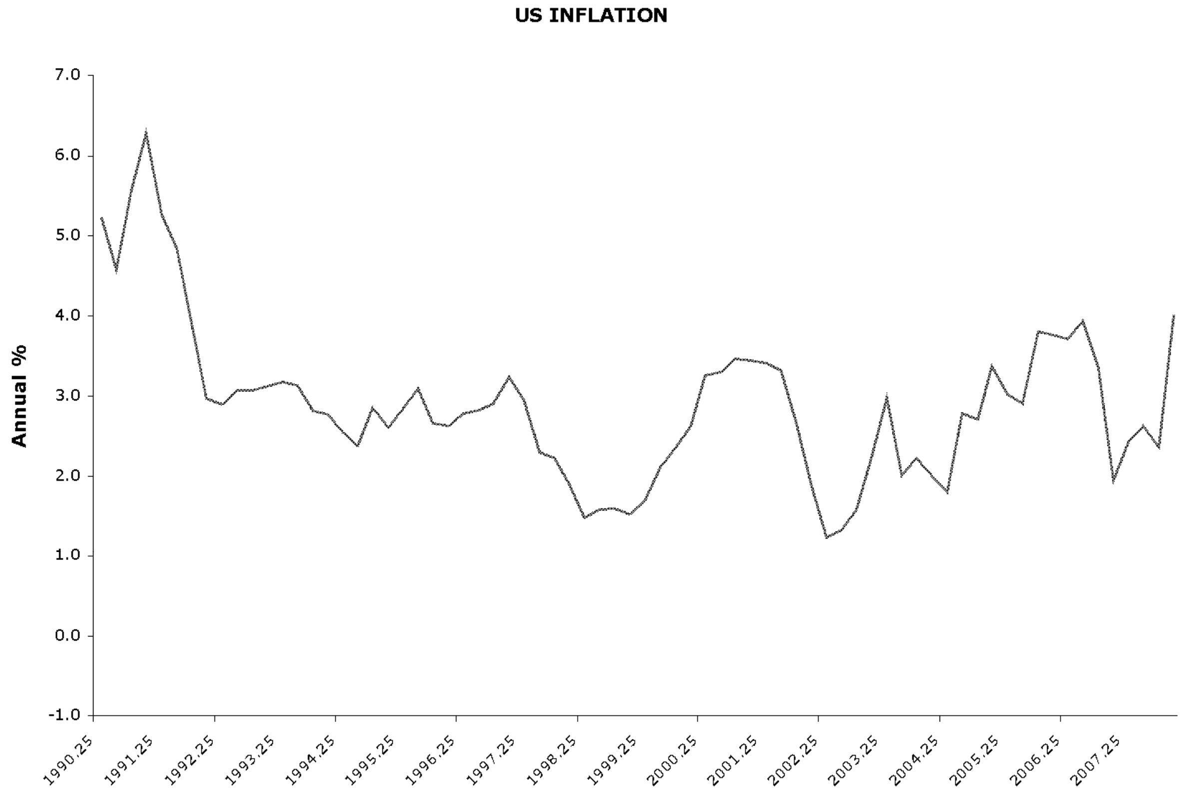


Figure 3. United States Inflation and HP Output Gaps



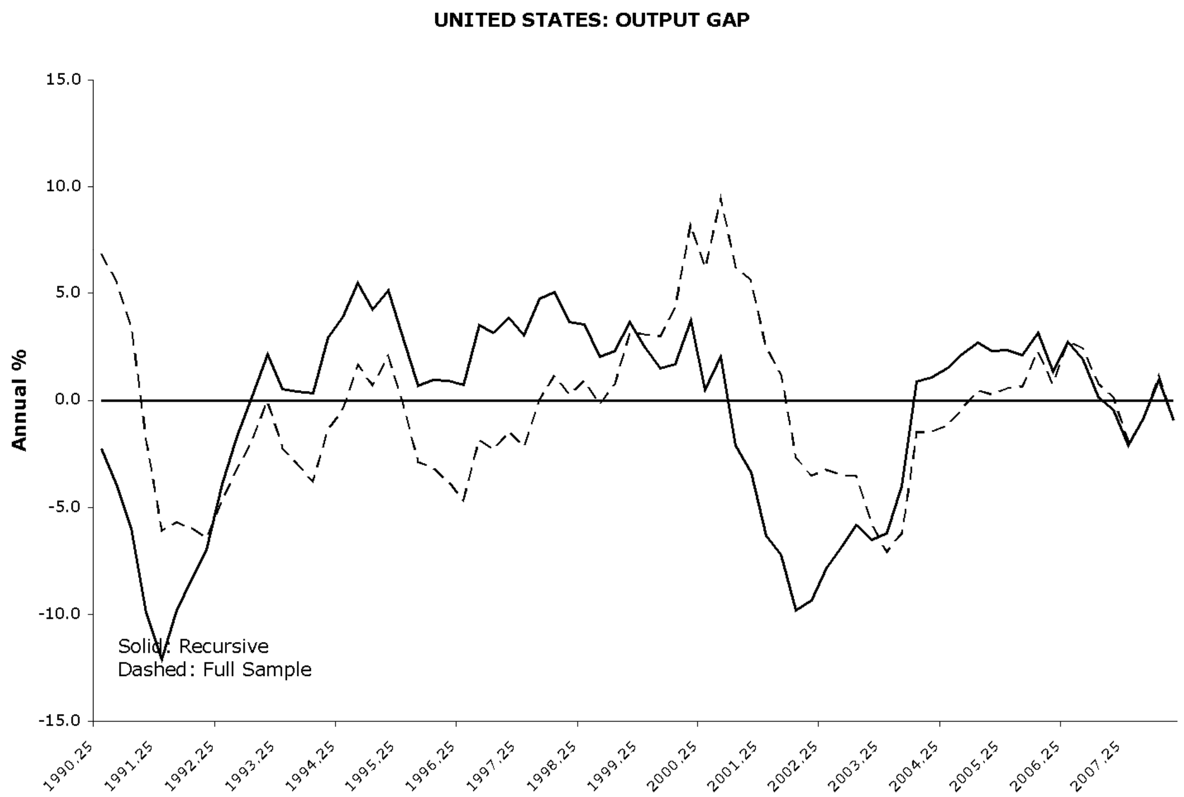
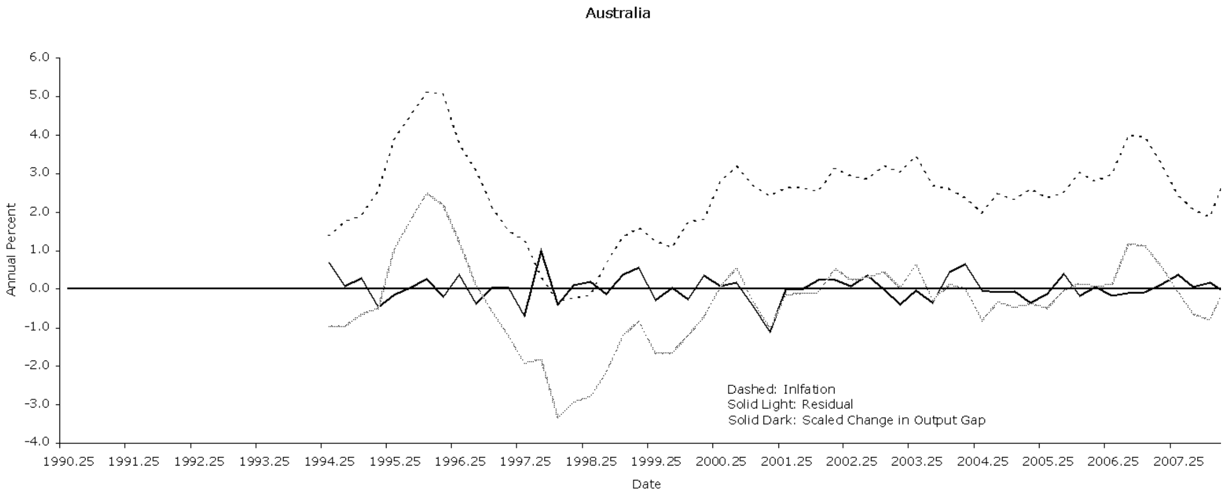
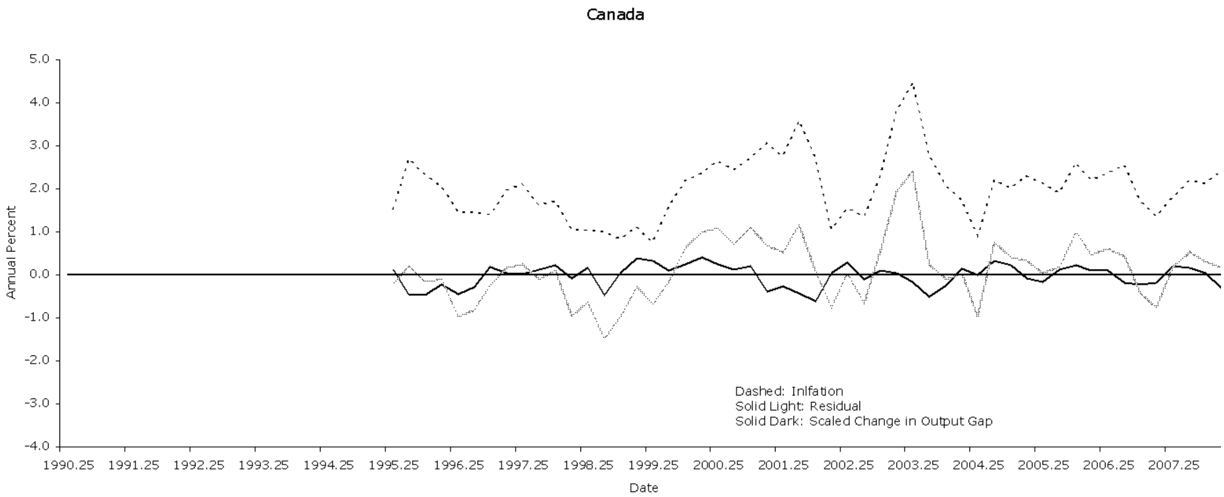
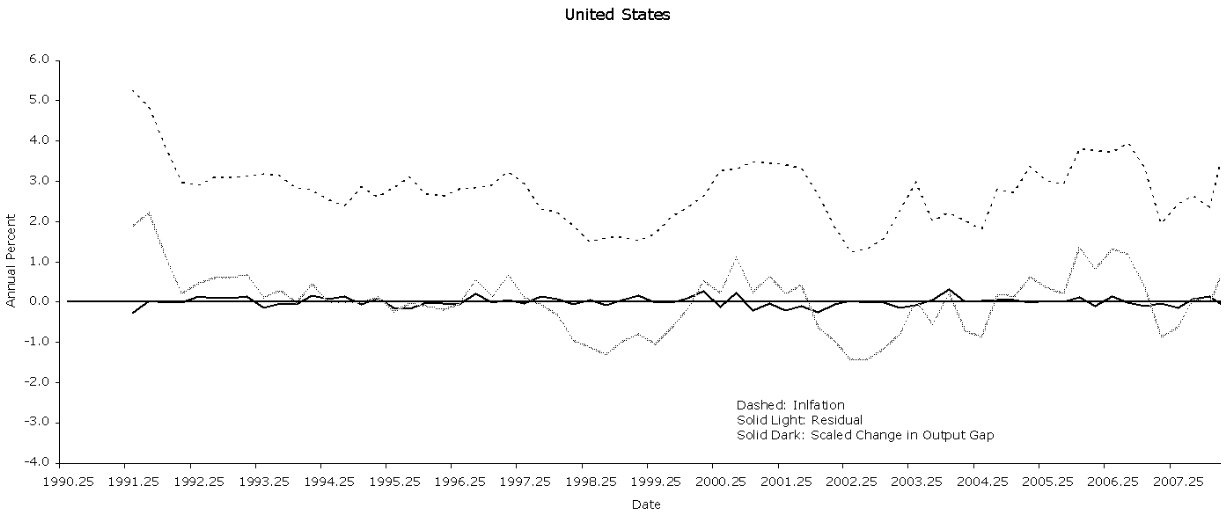


Figure 4. Estimated Deviations from Flexible Inflation Targets and Scaled Change in Output Gap







Data Appendix

Details of data sources are provided below.

Variable	Description	Source
Australia		
Y	GDP SA at AR; chained 2005-06 dollars.	Tab. G10, ABS 5206, RBA Bulletin
P	CPI All Groups*	Tab. G02, ABS 6401, RBA Bulletin
i^p	Money Market Rate	19360B..ZF..., IFS Series
i	90 day BAB Rate	RBA Bulletin
s	AUD/USD	RBA Bulletin
Canada		
Y	GDP SA at AR; chained 2000 dollars	Tab. 3800002, v1992067, CANSIM
P	CPI All, 2005 Basket	Tab. 3260020, v42690973, CANSIM
i^p	Bank rate	Tab. 1760043, v122530, CANSIM
i	3 Month TB Rate	Tab. 1760043, v122531, CANSIM
s	CAD/USD	Tab. 1760064, v37426, CANSIM
United States		
Y	GDP SA at AR; chained 2000 dollars	BEA GDPC96
P	CPI All Urban, All Items	BLS CPIAUCSL
i^p	Effective Federal Funds Rate	Board of Governors, H.15
i	3 Month TB Rate	Board of Governors, H.15
Commodity Prices		
P^{cx}	Non-Fuel Index	00176NFDZF..., IFS Series

Variable	Description/Details	Construction
π_t	Year on year quarterly CPI inflation, %	$100 \cdot (P_t - P_{t-4}) / P_{t-4}$
π_t^{cx}	Year on year quarterly commodity price inflation, %	$100 \cdot (P_t^{cx} - P_{t-4}^{cx}) / P_{t-4}^{cx}$
$\bar{y}_t^Q$	H-P Filter, λ = 1600; sample 1980:Q1–2007:Q4.	$HP(\ln Y_t, 1600)$
x_t	Output Gap	$400 \cdot (\ln Y_t - \bar{y}_t^Q)$
Δx_t	Quarterly first-difference output gap	$x_t - x_{t-1}$
x_t^R	Recursive output gap; see text	
Δx_t^R	Recursive output gap, differenced; see text.	
Δy_t	Quarterly growth rate	$400 \cdot (\ln Y_t - \ln Y_{t-1})$

*Australian CPI is adjusted for the effect of the introduction of the GST in 2000:Q3. The average quarterly change from the previous twenty quarters is used to estimate the change from quarter two to quarter three of 2000. Subsequent actual changes are used to calculate the remaining adjusted changes.