INFLATION TARGETING AND THE INFLATION PROCESS: SOME LESSONS FROM AN OPEN ECONOMY

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Abstract

In an open economy inflation-targeting framework, whether policy-makers should target aggregate or non-traded inflation depends on the structural relationships in the economy. This paper shows that in a small empirical model of the Australian economy, it makes little difference which measure is targeted. This conclusion is reinforced by the significant changes to the inflation process that the paper suggests have occurred over the past two decades: the effect of exchange rate changes on inflation appears to have become more muted and the inflation process appears to have become better anchored.

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1. Introduction

Inflation targeting in an open economy has a number of additional complexities compared with inflation targeting in a closed economy. One of these is that central banks in open economies have to decide how to respond to changes in the exchange rate. Pitchford (1993), Svensson (1998) and Ball (1998) examined this issue theoretically, and, in broad terms, reached the conclusion that in the presence of exchange rate shocks, central banks should consider targeting a measure of non-traded, or 'domestic', inflation rather than the aggregate inflation rate. The implication of their analysis is that central banks should respond to developments in the exchange rate, but only to the extent that the shocks to the exchange rate stimulate output growth in the economy or affect aggregate inflation expectations.

In the broader discussion of optimal policy-making under an inflation target, several papers have used the Ball-Svensson framework to explore the impact of including non-traded rather than aggregate inflation in the central bank's objective or policy reaction function[1] and have investigated how the specifics of the exchange rate pass-through process affect the monetary policy decision.[2] In many cases, these issues are discussed in the context of policy reaction functions that are variants of the Taylor rule.

In this paper, we summarise the essential features of an economy that affect the choice between targeting aggregate and non-traded inflation, and examine the issue empirically. The empirical part of this paper has two components. First, in Section 3, we use an empirical model of the Australian economy to illustrate the choice between targeting aggregate inflation rather than a measure of non-traded inflation and some of the aspects of the economy that affect that choice.

1 Bharucha and Kent (1998) and Ryan and Thompson (2000).

2 Cunningham and Haldane (1999).

We examine the trade-off both in the context of optimal policy-making and assuming policy-makers use a Taylor-type rule to set interest rates.

These results, however, depend on our understanding of the inflation process. In Section 4 of the paper, we thus examine how the inflation process in Australia has changed over the last two decades, using reduced-form price equations that are often used for forecasting. We examine how the influence on the inflation rate of exchange rate shocks and deviations of output from potential have changed over time, as well as how the persistence of the inflation process has changed. The results for Australia are compared with those for the US, the UK, Canada and New Zealand.

2. Which Inflation Rate to Target in an Open Economy?

An important issue that confronts an inflation-targeting central bank in an open economy is that changes in the exchange rate can have a significant effect on inflation outcomes via the prices of traded goods. If the central bank is pursuing a strict inflation target, the policy responses required to offset the effects of exchange-rate-induced changes in inflation may be damaging to the non-traded sector of the economy, and generate a large degree of volatility in output.

Consequently, Ball (1998) and Svensson (1998) raised the possibility that it may be preferable that a central bank target a measure of inflation that abstracts from these direct exchange rate effects. This section reviews their argument and outlines the main considerations that might affect the choice of which rate of inflation to target.

These issues can be illustrated by the following simple model similar to that in Ball and Svensson.

$$y_t = \phi y_{t-1} - \beta r_{t-1} - \alpha e_{t-1} + \varepsilon_1 \tag{1}$$

$$\pi_t = \pi_t^e + \delta y_{t-1} - \gamma \Delta e_t + \varepsilon_2 \tag{2}$$

$$\Delta e_t = r_t - r^* + \varepsilon_3 \tag{3}$$

where y is the output gap, r the real policy interest rate, e the exchange rate and π inflation.

The first equation is an aggregate demand equation, where monetary policy is assumed to affect output with a one-period lag. A depreciation of the exchange rate also leads to an expansion in output with a one-period lag, through its effects on net exports. The second equation is an open-economy Phillips curve. Changes in the exchange rate are assumed to be passed through immediately into the prices of imported goods in the consumer price basket. For the moment, inflation expectations are assumed to be backward-looking, depending on past values of the aggregate inflation rate; this will be discussed further below. Note that exchange rate changes affect inflation more rapidly than they do output. The third equation implies that the exchange rate appreciates in response to a rise in domestic interest rates.

The central bank is assumed to have an objective function of the standard form:

$$\sum_{s=1}^{\infty} \theta^{s-1} \left[(1-\lambda)(\pi_{t+s} - \bar{\pi})^2 + \lambda y_{t+s}^2 \right] \qquad 0 \le \lambda < 1 \tag{4}$$

where it sets its policy instrument to minimise deviations of inflation from its target, and minimise the output gap. When λ is zero, the central bank can be characterised as a strict inflation targeter where output considerations are always secondary to minimising inflation variability.

Consider a temporary depreciation of the exchange rate that results from a portfolio realignment that lasts for only one period (that is, a decline in ε_3). The depreciation will generate an immediate increase in inflation as imported goods prices rise. If a rigid inflation target is in place, the increase in inflation can be counteracted by a rise in interest rates to offset the downward pressure on the exchange rate from the portfolio shift. This policy change is reversed in the following period when the downward pressure on the exchange rate dissipates. The policy-maker can thus successfully stabilise the inflation rate, but at the cost of inducing additional volatility in output, as output responds to the shifts in interest rates.

If instead the policy-maker were targeting non-traded inflation rather than aggregate inflation in Equation (4), the policy response would be considerably muted. A more muted response would also occur in a more flexible inflation-targeting regime. Output variability, in both these cases, would be correspondingly less but at the expense of greater volatility in the aggregate inflation rate. Some policy response would still be necessary to reduce the volatility resulting from the effect of the depreciation on output and to the extent that non-traded goods prices or inflation expectations are also affected by movements in the exchange rate.

Hence targeting aggregate inflation as against non-traded inflation presents a choice between inflation variability and output variability. Responding to exchange-rate-induced fluctuations in inflation increases output variability, ignoring them increases aggregate inflation variability.

Ball (1998, 2000) argues that responding to a measure of 'long-run' inflation 'purged of the transitory effects of exchange-rate fluctuations' is the optimal strategy for a central bank in an open economy. To further bolster his argument, he raises the possibility that, in practice, the increased output variability from responding to aggregate inflation may destabilise inflation in the medium term (although such a result is not possible in his simple framework).

However, to make such an assessment, one needs to be able to assess the relative costs of inflation and output variability. While trade-off curves can be drawn illustrating the various combinations of output and inflation variability that correspond to different objective functions or rules for the central bank, the paucity of knowledge about the relative costs to society of inflation and output variability prevents an easy comparison of these combinations. The coefficient λ in the objective function (Equation (4)) is a critical but unknown variable. The general assumption is that some degree of inflation variability should be permitted, the question is how much?

One also needs to know which measure of inflation enters the objective function. The aggregate consumer price index is designed to be representative of the average consumption basket, so would appear to be the most obvious measure of inflation to use. However, various sectors of the economy, most notably producers in the non-traded sector, may face considerably different price baskets and obviously would be relatively disadvantaged if an aggregate measure were targeted, rather than a non-traded measure.

Nevertheless, curves showing trade-offs between output variability and the variability of various measures of inflation can be generated, and presented as a menu of options to policy-makers. The rest of this section discusses some of the key features of the economy that affect the shape and position of these trade-off curves in an open economy, and hence the relative merits of targeting aggregate or non-traded inflation.

Firstly, the nature of the shocks hitting the economy will be important, both in terms of their source and their persistence. Bharucha and Kent (1998) examine this with a calibrated model similar to that above. They demonstrate that if the shocks occur primarily to the exchange rate (Equation (3)), then a non-traded inflation target may be preferable in the sense that output variability is substantially lower. If, on the other hand, the shocks primarily occur in the non-traded sector of the economy, then a non-traded inflation target will place much of the burden of adjustment on the traded goods sector.

The persistence of the shocks is also an important consideration. Temporary changes in the exchange rate that are likely to return to equilibrium within a short period do not necessarily warrant a policy response. The inflationary impulse from an exchange rate temporarily below equilibrium should be offset by the disinflationary effect of the subsequent appreciation back to equilibrium. On the other hand, if changes in the nominal exchange rate are expected to be permanent, monetary policy needs to ensure that the resultant inflationary pressures do not lead to a permanent increase in the inflation rate.

While it is easy to state this principle, its practical implementation is particularly problematic. As Ball (2000) notes, it would be useful to find an alternative measure of inflation that simplified this problem in practice. In the next section, we examine whether movements in unit labour costs may serve as a useful proxy.

A second element that affects the nature of the trade-off is the extent to which aggregate and non-traded inflation are affected by movements in the exchange rate.

The aggregate inflation rate will be affected directly according to the extent of import penetration of the consumer goods market. However, exchange rate changes may still have a significant direct impact on non-traded inflation to the extent that the non-traded sector is dependent on imported inputs in production.

The speed and extent of the pass-through of exchange rate changes to final goods prices is also important. A more protracted pass-through reduces the impact of a given exchange rate change on the inflation rate and thereby reduces the size of the necessary policy response to it. Some evidence of a change in the pass-through of exchange rate changes in the 1990s is discussed in Section 4.

Third, the inflation expectations process will play a critical role. An important aspect of inflation targeting is to maintain stability in inflation expectations, and thereby anchor ongoing inflation. Therefore, the appropriate inflation-targeting strategy will depend on how inflation expectations are formed, the degree to which they are forward-looking, and how well anchored they are.

If inflation expectations are primarily backward-looking and are dependent on movements in the aggregate inflation rate, exchange rate changes will tend to have a larger and more persistent impact on both aggregate and non-traded inflation, as they get built into expectations. If on the other hand, inflation expectations are forward-looking, temporary exchange rate changes (which are recognised as being so by wage and price-setters) will not lead to much movement in inflation expectations. This is a key part of the process that affects the extent to which exchange rate changes lead to a temporary boost to inflation rather than a permanent pick-up.

Similarly, if the inflation target is perceived as credible, inflation expectations will be better anchored on the target inflation rate and again will not respond as much to temporary deviations in the actual inflation rate. In such circumstances, the credibility of the inflation target is somewhat self-fulfilling. Shocks to the inflation rate, from changes in the exchange rate for example, would not be expected to lead to a prolonged deviation of inflation from target. Because this belief is held, expectations do not adjust, and the inflation rate is more stable.

3. Evidence from a Small Empirical Macro Model

The discussion in the previous section implies that the choice of the appropriate inflation target is, in large part, an empirical issue that depends on the structure of the economy and the specification of the welfare function. In this section, we use a small model of the Australian economy to illustrate the trade-off curves and their sensitivity to the structure of the economy. On the basis of these, some conclusions can be drawn on the relative merits of targeting aggregate and non-traded inflation.

This extends the work of Bharucha and Kent (1998) who examined the choice of inflation target in a simple calibrated version of the Ball and Svensson model, and focused in detail on the influence of different shocks on this choice. Ryan and Thompson (2000) also examined the issue using a model of the Australian economy, in terms of simple policy rules. The analysis here focuses primarily on optimal policy, although some policy rules are considered to provide a basis of comparison with Ryan and Thompson.

3.1 Methodology

The trade-off curves are generated using a simple empirical model of the Australian economy similar to that in Beechey *et al* (2000).[3] The model is a more complex version of the simple Ball-Svensson framework discussed in Section 3, but the central features are the same, namely an equation for output, aggregate inflation, and an objective function for the central bank.[4]

As in the Ball-Svensson model, there are two channels of transmission of monetary policy to output: directly through changes in the real interest rate (with a six-quarter lag) and indirectly through changes in the real exchange rate (with a four-quarter lag). The real exchange rate is explained by movements in the terms of trade and real interest rate differentials.

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[3] The model is described in detail in Appendix A. Beechey *et al* (2000) also provides a summary of macroeconomic developments in the Australian economy over the past two decades, and further details are provided in Gruen and Shrestha (2000).

[4] We assume the central bank doesn't discount outcomes in future periods, i.e. in Equation (4) θ is assumed to be unity throughout the simulations.

Aggregate inflation is measured by changes in the consumer price index. It depends on contemporaneous and lagged changes in import prices, lagged growth in unit labour costs and its own lags (proxying backward-looking expectations). There is no forward-looking component of inflation expectations.[5] The majority of the effect of exchange rate changes on import prices is assumed to occur contemporaneously, consistent with estimates of first-stage pass-through (Dwyer, Kent and Pease 1994). Hence exchange rate changes are transmitted immediately to aggregate inflation (although the initial impact is relatively small). Monetary policy affects aggregate inflation through its impact on the output gap in the unit labour cost equation and through its effect on import prices via the exchange rate.

As an appropriate specification of inflation in the central bank's reaction function in an open economy, Ball (2000) advocated a measure of long-run inflation that filtered out the transitory effects of exchange rate fluctuations. Initially, we tried a measure of inflation based on the prices of non-traded goods in the consumer price index. However, this proved to be dependent on exchange rate fluctuations, because of the importance of imported inputs in the production of non-traded goods, and also of government-determined prices.[6] Instead we use unit labour costs as a measure of inflation in the non-traded sector (hereafter unit labour costs and non-traded inflation are used interchangeably). Unit labour costs are modelled using a Phillips curve specification, with expectations modelled as a weighted average of aggregate and non-traded inflation. Hence, while there is no direct effect of the exchange rate on unit labour costs, there are indirect effects through the influence on inflation expectations and the output gap.

The policy-maker is assumed to have an objective function as described in Equation (4). Two forms of the objective function are considered: one with aggregate inflation, the other with growth in unit labour costs. To generate the trade-off curves, the relative weight on output variability (λ) is varied between 0 and 1. The instrument of monetary policy is the nominal cash rate.

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5 Backward-looking expectations have historically been an accurate characterisation of the inflation expectations process of households in Australia (Brischetto and de Brouwer 1999). Beechey *et al* (2000) find a role for a measure of inflation expectations obtained from the bond market.

6 Ryan and Thompson (2000) also found that non-traded inflation was sensitive to exchange rate movements, and examined a policy rule that targeted unit labour costs in the non-traded sector.

The model of the economy is then simulated by taking draws of the error terms in each equation for both exogenous and endogenous variables, using a distribution based on the estimated variance-covariance matrix. The policy-maker is assumed to know the full structure of the economy but assumes the value of all future shocks is zero. Each period the policy-maker chooses the optimal level and future path for interest rates to minimise the objective function. The model was simulated for 100 periods for each value of λ, and the variability of output, aggregate and non-traded inflation was calculated in each simulation.

3.2 Results

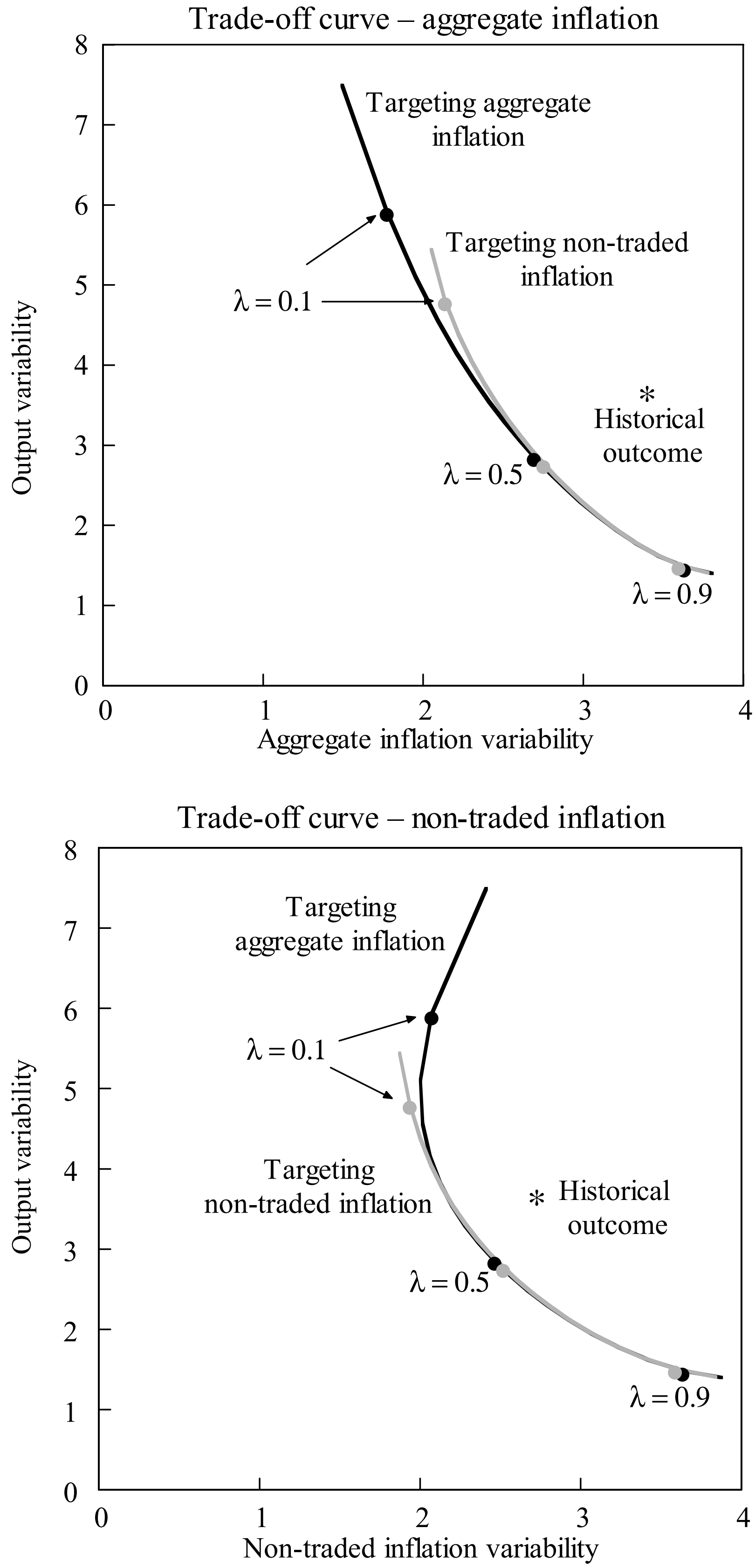
3.2.1 Optimal policy

The top panel of Figure 1 shows the trade-offs between output variability and aggregate inflation variability when aggregate inflation is the objective and when non-traded inflation is the objective. Similarly, the bottom panel shows the trade-off between output variability and non-traded inflation variability for the two different objective functions. As a point of comparison, the actual historical outcomes are also shown (for the period 1985:Q1–1999:Q4).

The figure illustrates the obvious conclusion that the best way to minimise the variability of a particular measure of inflation is to directly 'target' that measure, by placing it in the objective function. The upper panel shows that the variability of aggregate inflation is not significantly higher when non-traded inflation is targeted. A small difference only emerges as relatively more weight is placed on inflation variability (as λ declines). This result is not surprising because aggregate inflation is an important determinant of non-traded inflation. Therefore, in minimising the variability in non-traded inflation, the policy-maker will also seek to reduce the variability in aggregate inflation.

The converse is also generally true *except* when there is a relatively large weight on inflation variability (when λ is less than about 0.25). In those circumstances, strict inflation targeting generates considerably more variability in non-traded inflation. Consequently, those parts of the economy for which non-traded inflation is more important will be worse off under a strict aggregate-inflation targeting regime.

Figure 1: Optimal Policy



When a strict aggregate inflation target is pursued, output variability is also considerably higher than under a strict non-traded inflation target. These results are similar to those in Svensson (1998), who also finds that strict inflation-targeting regimes generate a large amount of volatility in 'domestic' inflation and output.

In these simulations, the policy-maker is able to exactly distinguish between temporary and permanent shocks to the exchange rate and respond appropriately. In practice, this is considerably more difficult. These results suggest that there may not be much cost in focusing on a non-traded measure of inflation. That is, the policy-maker need only respond to the exchange rate changes to the extent that s/he expects them to be reflected in movements in non-traded inflation.

The variability of interest rates associated with these trade-off curves is considerably larger than that observed in practice. The standard deviation of the quarterly interest rate changes ranges between 2½ and 5½ per cent per annum. Consequently, the objective function was amended in the normal way to include an interest-rate smoothing term penalising interest rate variability. A weight on the smoothing term that was sufficient to reduce the volatility in interest rates to that observed historically did not have a significant impact on the trade-off curves: the variability in output and aggregate inflation only increased marginally. This result is similar to that in Lowe and Ellis (1997), who also found that reducing the volatility of policy interest rates does not greatly affect the variability of the other target variables. However, when a smoothing objective is included, the increase in the variability of non-traded inflation when a strict aggregate inflation target is pursued is even greater.

To test the sensitivity of these results to the structure of the economy, the model was altered in a number of ways. First, the variability of the exchange rate shocks was doubled.[7] This naturally shifted the variability frontiers up and to the right but did not materially alter the conclusion that the choice of inflation target does not have much impact except in the case of strict inflation targeting.

Second, the process for the real exchange rate was changed. In the model, long-run movements in the real exchange rate are driven by the terms of trade, which are assumed to be stationary. The terms of trade was changed to a non-stationary

7 It was assumed that this change in the variability did not alter any other aspect of the model.

process, allowing for permanent shifts in the real, and hence nominal, exchange rate.[8] The effect of this was to steepen the trade-off curves. That is, increasing the weight on output in the objective function led to a larger reduction in output variability and a smaller increase in inflation variability than the baseline case. However, again, there was very little difference in outcomes for the two different inflation objectives.

Third, the expectations process in the non-traded sector (unit labour costs) was altered to allow for some credibility in the inflation target. A positive weight was placed on a constant term set equal to the inflation target, thereby anchoring unit labour costs in the long run. However, inflation expectations retained some backward-looking element. This change to the expectations process naturally shifted the trade-off curves towards the origin, as the expectations process was less volatile. That is, establishing credibility in the inflation target allows the policy-maker to choose from a superior set of economic outcomes. The choice of inflation target did not result in any significant differences in the variability of either measure of inflation. However, a strict aggregate inflation target generated even more variability in output compared to a strict non-traded inflation target, than in the baseline case.

3.2.2 Policy rules

To date, the analysis has been conducted in terms of optimal policy. Ball (1998), Svensson (1998) and Ryan and Thompson (2000) all examined the choice of the appropriate inflation target in the context of Taylor-type policy rules. In the simple Ball-Svensson framework, a Taylor rule that includes the exchange rate is the optimal policy reaction function. However, in more complicated models like that used in this section, such rules may only be rough approximations to optimal policy. Optimal policy in these models takes account of changes in all the variables in the economy, rather than only the variables in the policy rule. The simple rules, however, may be useful to the extent that aggregate output and inflation are summary statistics for developments in the economy, or that tractable and transparent rules are desirable.

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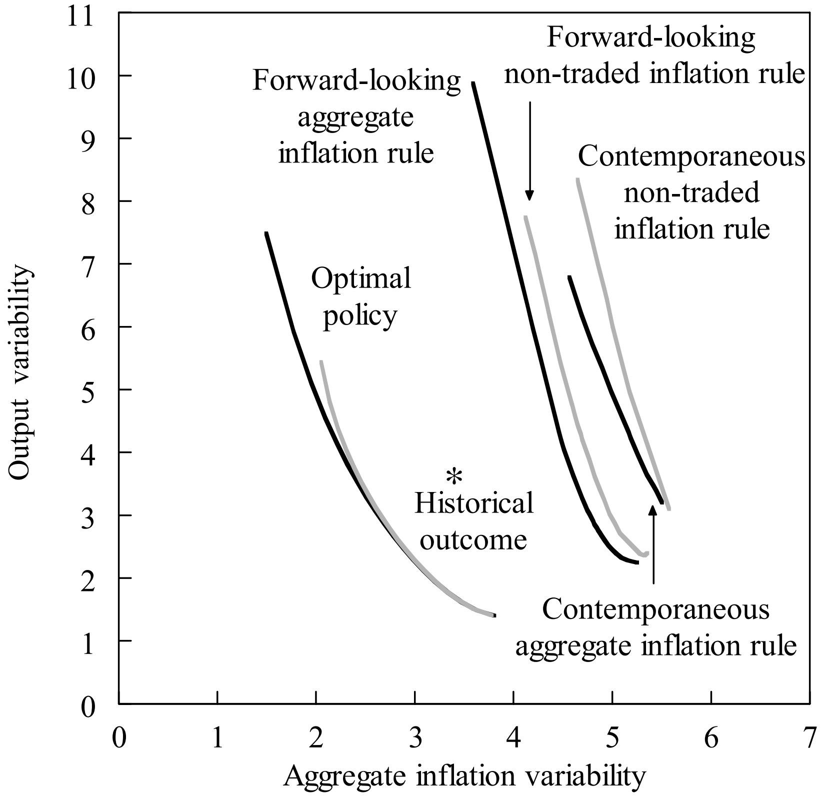
[8] This also implies a permanent shift in the neutral real interest rate.

To investigate the trade-off when the central bank follows a policy rule, the model was simulated in the same way as in the previous section except that the central bank follows a rule rather than optimising an objective function every period. Two policy rules were examined: one with weights on output and aggregate inflation, the other with weights on output and non-traded inflation. In the first set of simulations, these policy rules were contemporaneous, including only current-dated measures of inflation and output. Simulations were then conducted using forward-looking rules, where the forecast of output and inflation three quarters ahead entered the policy rule.[9] In each case, a number of simulations were conducted for different sets of weights on output and inflation in the policy rule. An efficient frontier for each rule traces out the lowest combinations of inflation and output variability as these weights are varied.

Figure 2 shows the efficient frontiers from rules that respond to contemporaneous movements in output and aggregate inflation and rules that respond to forecasts for these variables. By way of comparison, it also shows the optimal policy frontiers derived earlier. The frontiers for the policy rules result in significantly more variability in inflation and output than optimal policy, and indeed than that which was actually observed in practice. These simulations also confirm two results in Ryan and Thompson (2000). Firstly, an aggregate inflation rule generates a more preferable trade-off than a non-traded inflation rule, although the differences between the two rules are not stark. Secondly, a forward-looking rule leads to lower output and inflation volatility than a contemporaneous rule.

[9] Ryan and Thompson (2000) present results which suggest that three quarters is the most efficient horizon for a Taylor rule in a model similar to that used here.

Figure 2: Taylor Rule Trade-off Curves



3.2.3 Summary

The results of these simulations suggest that in a representative model of the Australian economy, targeting aggregate inflation and targeting non-traded inflation deliver similar economic outcomes. This occurs because exchange rate changes have a muted effect on aggregate inflation. The only exception to this conclusion is that a strict aggregate inflation target significantly increases the variability of non-traded inflation and output, as greater reliance is placed on the faster-acting exchange rate channel of monetary transmission.

As mentioned earlier, an important caveat to this conclusion is that the simulations assume the policy-maker is able to distinguish between temporary and permanent movements in the exchange rate. These results are also very sensitive to the nature of the inflation process. The next section examines how this has changed over the past two decades.

4. Evidence of Changes in the Inflation Process

In order to operate an inflation-targeting regime, and to assess the range of options facing policy-makers, it is crucial to have a reasonable understanding of the inflation process. The policy-maker's desired response to a given shock depends on its most likely effect on inflation, particularly in the medium term, which, in turn, ultimately depends on the behaviour of inflation expectations. An important factor which small open economies have to contend with is that shocks to the exchange rate, which occur frequently and are often large, can have a significant direct effect on the inflation rate. Understanding the link between changes in the exchange rate and inflation is thus particularly important.

Over the latest decade, however, there have been indications that the inflation process in many industrialised countries may have changed. The monetary policy, or inflation, reports of inflation-targeting central banks, for example, allude to a fall in the extent of pass-through of exchange rate shocks to domestic retail prices in several different countries over several different episodes:

> Exchange rate passthrough continues to be more muted and diffuse than historical experience would suggest… (Reserve Bank of New Zealand Monetary Policy Statement, March 1999, p 13)

> …staff analysis suggested that import prices had fallen by less than was expected given the rise in the exchange rate…In other words, the pass-through from exchange rate appreciation had been unexpectedly weak. [Members concluded that] since the pass-through from the earlier much larger appreciation seemed to be incomplete, there was a good chance that the recent depreciation would have little effect. (Bank of England, 'Minutes of Monetary Policy Committee Meeting', 8 and 9 October 1997, p 4)

> …the exchange rate normally affects inflation through import prices…In practice, however, the weak krona has not affected either import or consumer prices as much as the Riksbank had anticipated. (Speech by First Deputy Governor Lars Heikensten, Monetary Policy and the Exchange Rate, Riksbank, 19 April 1999)

> Import prices have for some time exerted a restraining influence on consumer price inflation. The extent of this effect was unexpected. Historical experience suggested that, given the exchange rate depreciation between mid 1997 and late 1998…some eventual impact in the form of higher import prices at the retail

> level could be expected. (Reserve Bank of Australia *Bulletin*, 'The Economy and Financial Markets', August 1999, p 32)

This is a possibility that has been raised and explored in a number of papers in recent years.[10]

There have also been suggestions that the inflation process more generally may have changed in recent periods. Taylor (2000) examines data for the US, and finds a reduction in the 'persistence' of inflation shocks. That is, he finds that the inflation process in the US is less highly autocorrelated in the 1980s and 1990s than it was in the previous two decades. Taylor argues that the low inflation outcomes of the latest two decades may have caused this reduction in persistence. Kuttner and Posen (1999) also present evidence of a reduction in the persistence of inflation in Canada, the UK and New Zealand in the period since they have been inflation targeting. They argue that this reduction in persistence may reflect the success of the inflation-targeting regime in 'enhancing public trust of the central bank's long-run target commitment'.

In a recent paper, Andersen and Wascher (2001) take a different perspective. They show that there has been a systematic positive bias to OECD inflation forecasts during the 1990s, and examine whether particular shocks, which have been common across countries, can explain these outcomes. They also explore whether structural changes in the inflation process can be identified. They conclude that there is no systematic explanation across countries for the lower-than-expected inflation outcomes, and the structural changes they find are neither common across countries, nor are they statistically significant.[11]

The Australian experience has been similar to that of many other OECD countries. During the 1990s, inflation was both lower and considerably less variable than would have been predicted at the beginning of the decade, and the response of

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[10] See, for example, Cunningham and Haldane (1999), Dwyer and Leong (2001), and McCarthy (1999). McCarthy (1999) finds that for the nine OECD countries he examines, pass-through is considerably lower over 1983–1998 than it was over the full sample period (1976–1998), although he claims that these differences are probably statistically insignificant.

[11] Their paper examines forecasts and developments in eight OECD countries: US, Japan, UK, Canada, Australia, Spain, Sweden and Switzerland. It compares the behaviour of inflation during the 1990s with that of the previous three decades.

inflation to exchange rate shocks, in particular, has been considerably more muted. Dwyer and Leong (2001) examine the Australian experience and look for evidence of a structural change in both the inflation process and the process that drives each of the major determinants of inflation. Using recursive estimation techniques, they provide tentative evidence that the speed with which exchange rate changes are passed through to consumer prices has fallen. Although they do not find that this change is statistically significant, they emphasise that the magnitude of the change would be economically significant. They also discuss changes to the wage-setting process in Australia over the last two decades, and argue that these are likely to have dampened the transmission of price shocks to wages and hence reduced the potential for wage/price spirals to develop.

In this part of the paper, we further explore these issues. First, we estimate a simpler, reduced-form price equation for Australia in an attempt to summarise the dynamics of the combined price and wage setting processes.[12] Similar equations are estimated for New Zealand, Canada, the UK and the US by way of comparison. Unlike earlier studies, however, we then use rolling regressions with a 10-year window to gauge the changes in these processes that are taking place. Although rolling regressions provide less efficient coefficient estimates than recursive regressions, they can also provide a clearer indication of structural changes as they are occurring. Our focus is as much on whether these changes would be of economic significance as whether we can reject the statistical hypothesis of no structural change at conventional levels of significance.

We derive the equation we estimate from the following two reduced-form relationships:

$$\pi_t = \pi_t^e + \alpha_1(\pi_{t-i}^m - \pi_{t-1}) + \alpha_2(y_{t-i}) + \alpha_3(\Delta y_{t-i}) + u_t \tag{5}$$

$$\pi_t^e = (1 - \Sigma\beta_k)\pi^* + \Sigma\beta_k\pi_{t-k} \tag{6}$$

where π is the log difference of the aggregate price level, π^e is expected inflation, π^m is the log difference of import prices and y is the log of output relative to potential. π^* is discussed below.

[12] These equations are similar to those estimated in Andersen and Wascher (2001).

The first equation is a Phillips curve, where inflation outcomes depend on expected inflation, growth in real import prices (a measure of the real exchange rate), the output gap and the change in the output gap. The last term reflects the fact that in the Australian data, the speed at which the output gap is being closed, as well as its level, is typically important.

The second equation describes the process by which inflation expectations are formed. Some proportion ($\Sigma\beta_k$) of inflation expectations is formed in a backward-looking manner, and the rest $(1-\Sigma\beta_k)$ is anchored at some constant rate of inflation, π^*, which we will call the perceived inflation target. Over time, it is therefore possible that both the perceived inflation target π^* and the extent to which inflation expectations are linked to the target rate $(1-\Sigma\beta_k)$ may change, and movements in these two can be distinguished from each other. So if $\Sigma\beta_k = 1$, inflation expectations are entirely backward-looking, while if $\Sigma\beta_k = 0$, they are completely anchored to the target, π^*.[13]

Substituting (6) into (5), and assuming $k=2$, we have the equation that we estimate:

$$\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 y_{t-i} + \delta_5\Delta y_{t-i} + u_t \tag{7}$$

from which individual parameter estimates of the short-run elasticities of inflation with respect to import prices and the output gap, as well as the extent to which expectations are backward-looking ($\Sigma\beta_k = \delta_1+\delta_2+\delta_3$) and the perceived inflation target ($\pi^* = \delta_0/(1-\delta_1-\delta_2-\delta_3)$) can be calculated.

Before we proceed to examine the results, a couple of caveats. The model we are using to capture inflation expectations includes a backward-looking part and an anchored part. This is incomplete, since it does not explicitly include an alternative forward-looking indicator of inflation expectations. One justification for using such a simple model is that in Australia's case, at least, indicators of

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[13] These two equations imply that in the short run there is a trade-off between output and inflation, but in the long run, provided inflation expectations eventually adjust one-for-one with actual inflation there will be no trade-off. If $\Sigma\beta_k = 1$ this will always be the case; if $\Sigma\beta_k<1$, it thus requires that π^* eventually converges on the actual inflation rate.

forward-looking inflation expectations are quite poor, and seem to be quite well explained by an anchor and the recent inflation experience.[14]

Second, the constant term (δ_0) in the above equation, and the way in which it changes over time, could reflect several factors in addition to those outlined above. Mismeasurement of the true output gap, for example, would affect the estimate of the constant: if the true level of potential output of the economy were underestimated, the constant (and the implied estimates of the perceived inflation target) would be biased downwards. If the degree of mismeasurement of the output gap changed over time, this could thus explain variations over time in the estimates of the constant. The existence of other sources of structural change that are not captured in this very simple model would also affect the constant term, as would mis-specification more generally. We are thus inclined to interpret any of the results pertaining to the constant term, and hence the estimates of the perceived target rate of inflation, as indicative of the changes that may be taking place, rather than being definitive evidence for them.

4.1 Estimation Results

Equation (3) is estimated for each country over the period from 1983:Q1 to 2000:Q2 using quarterly data. The dependent variable is underlying inflation in Australia's case, and either a measure of core inflation or the first difference of the private consumption deflator for each of the other countries.[15] The lag length of the output gap and import price terms were chosen for each country to best fit the data over the full sample period. The full sample estimates of these regressions are presented in Table 1.

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[14] See Footnote 5.

[15] See Appendix B for further details.

Table 1: Estimated Price Equations

Dependent variable: quarterly log difference of the price level

Estimation period: 1983:Q1–2000:Q2

Coefficient estimates on:	Constant	π_{t-1}	π_{t-2}	π^m_{t-i}	y_{t-j}	Δy_{t-k}	Adj R^2	SE	LM test(1st to 4th)	Chow test[(a)]
Australia	0.001 (1.6)	0.408 (3.8)	0.459 (4.6)	0.025 (2.4)	0.048 (2.6)	0.144 (3.2)	0.842	0.003	0.268	0.031
New Zealand	0.001 (1.1)	0.418 (3.4)	0.396 (3.3)	0.063 (2.2)	0.079 (1.4)	0.303 (3.3)	0.641	0.007	0.210	0.001
Canada	0.003 (2.9)	0.327 (2.9)	0.297 (2.8)	0.010 (0.3)	0.055 (1.7)	0.211 (2.6)	0.332	0.004	0.513	0.020
UK	0.004 (3.2)	0.333 (2.9)	0.282 (2.6)	0.040 (2.2)	0.096 (2.9)	0.143 (1.9)	0.517	0.003	0.045	0.003
US	0.002 (2.4)	0.456 (3.1)	0.246 (2.0)	–0.013 (–0.6)	0.030 (1.1)	0.068 (1.0)	0.353	0.003	0.013	0.069

Notes: The equations were estimated using the following specifications:

Australia: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 y_{t-2} + \delta_5\Delta y_t + \mu_t$

New Zealand: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 y_{t-3} + \delta_5\Delta y_{t-1} + \mu_t$

Canada: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 y_{t-4} + \delta_5\Delta y_{t-1} + \mu_t$

UK: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-3} + \delta_4 y_{t-4} + \delta_5\Delta y_{t-2} + \mu_t$

US: $\pi_t = \delta_0 + \delta_1\pi_{t-1} + \delta_2\pi_{t-2} + \delta_3\pi^m_{t-1} + \delta_4 y_{t-4} + \delta_5\Delta y_{t-1} + \mu_t$

Figures in brackets are *t*-statistics. Chow and LM test results reported as *p*-values.

(a) Chow breakpoint test for structural change at 1992:Q1.

Over the full sample, this very parsimonious model does quite a good job of capturing the inflation process. In Australia's case the equation explains 85 per cent of the variation in quarterly inflation, which is very close to the explanatory power of more fully elaborated models of inflation estimated on the Australian data.[16] In Australia's case, the coefficients on the explanatory variables have the expected sign and are significant. They imply that a 10 per cent shock to import prices would lead to a 0.6 per cent increase in the price level over the following year, and a 1 per cent increase after two years. A 1 percentage point fall in the output gap for one year would lead to a 0.5 per cent fall in inflation over the first year and 0.3 per cent over the second year.

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[16] In Beechey *et al* (2000), an error correction model for quarterly changes in the acquisitions CPI is estimated; it explains around 90 per cent of the variation in quarterly inflation. This model has a richer dynamic structure, and incorporates unit labour costs and oil prices as well as the explanators included above.

For the other countries, these equations also perform quite well, explaining between 35 and 65 per cent of the variation in quarterly inflation over the full sample. For the NZ, UK and Canadian data, the coefficient estimates are generally of the expected sign and significant. In the case of the US, both the import price term and the output gap terms are insignificant. Across all equations, the coefficient estimates are of similar orders of magnitude.

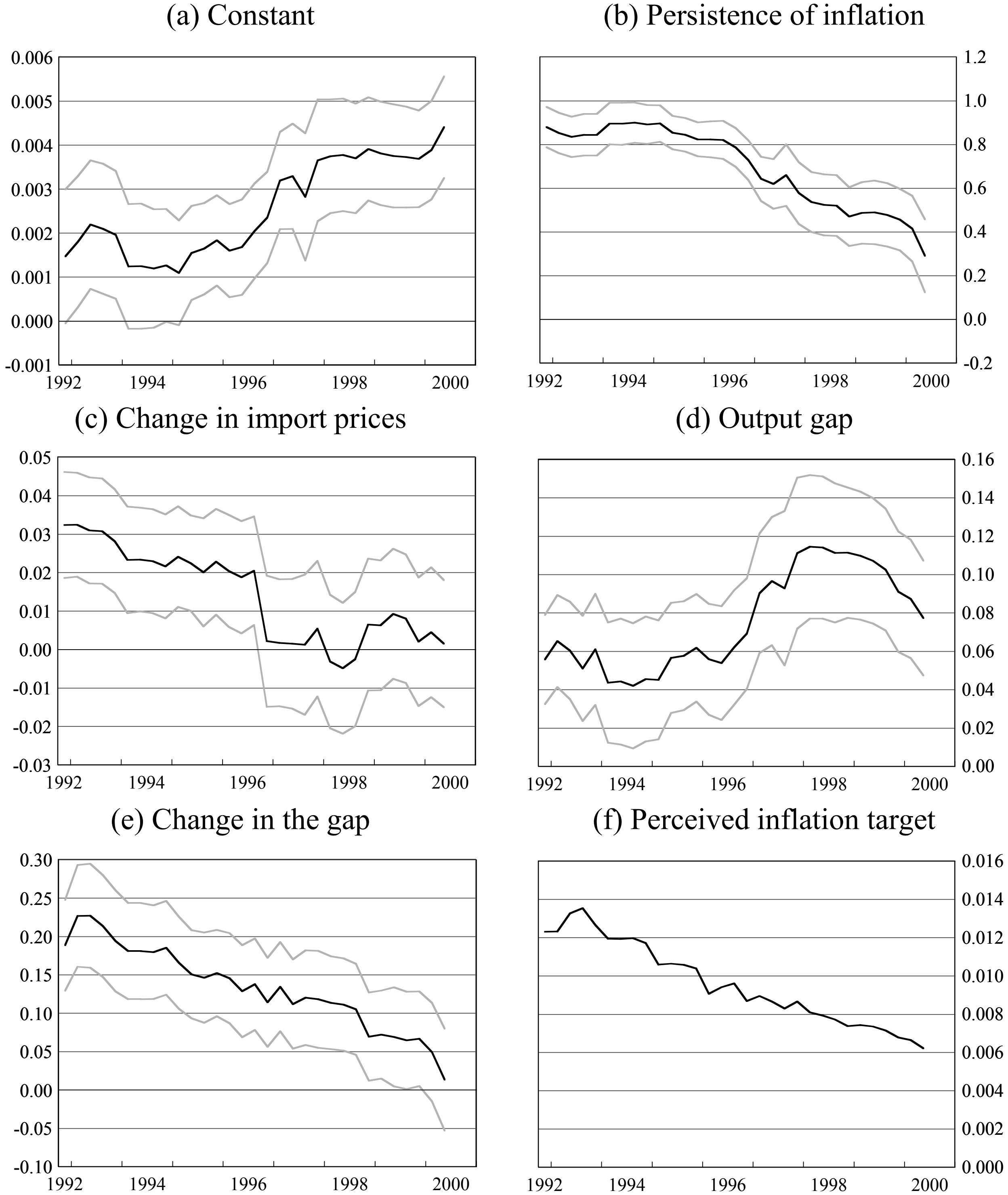
Figures 3 to 7 show rolling regression estimates using the above specifications for each country. In each case, the window is 10-years wide. So, for example, the first point on each of these figures illustrates the coefficient estimates from the equations that were estimated using data from March 1983 to December 1992, and the last point illustrates estimates from regressions taken from September 1990 to June 2000. One-standard error bands around each estimate are also presented.

For Australia (Figure 3), the results point to quite a substantial change in the inflation process over the last two decades. We will discuss each of the coefficient estimates in turn.

First, we focus on the response of inflation to shocks to import prices. Figure 3(c) shows rolling regression estimates of the coefficient on import prices in these inflation equations. It shows that import prices had a significant effect on inflation in the early part of the sample, but they have had no systematic effect on inflation outcomes since around 1987. In other words, once the large depreciation of the exchange rate in the mid 1980s is excluded from the estimation period, inflation has been much less sensitive to exchange rate developments. This could reflect a change in the price-setting process of either importers or retailers, or it could reflect a non-linearity in the effect of exchange rate developments on inflation outcomes. It could also reflect the fact that the depreciation of the mid 1980s, as well as being large, was widely perceived as being permanent, because it coincided with a period in which commodity prices had fallen particularly sharply and the current account deficit had increased markedly. The depreciation was thus widely interpreted as being necessary to assist the Australian economy adjust to these developments. In most other episodes, in contrast, it was much less clear whether exchange rate changes were likely to be permanent or temporary.

Figure 3: Coefficient Estimates from Rolling Regressions for Australia

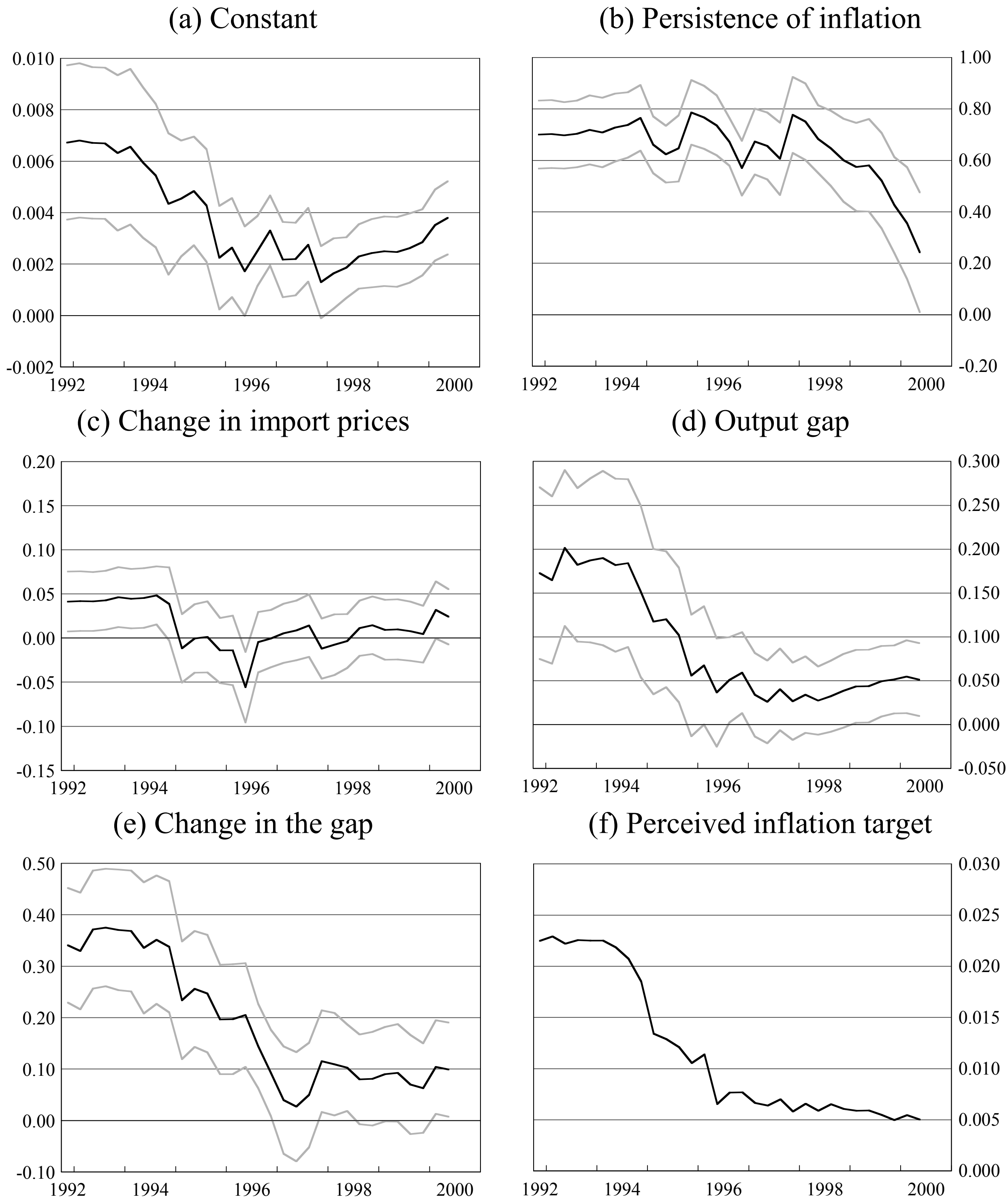
10-year rolling regression, 1983:Q1–2000:Q2



Notes: Specification as in Table 1. Grey lines are 1-standard error bands. Persistence of inflation is $(\delta_1 + \delta_2 + \delta_3)$. Perceived inflation target is $\dfrac{\delta_0}{1-(\delta_1+\delta_2+\delta_3)}$.

Figure 4: Coefficient Estimates from Rolling Regressions for New Zealand

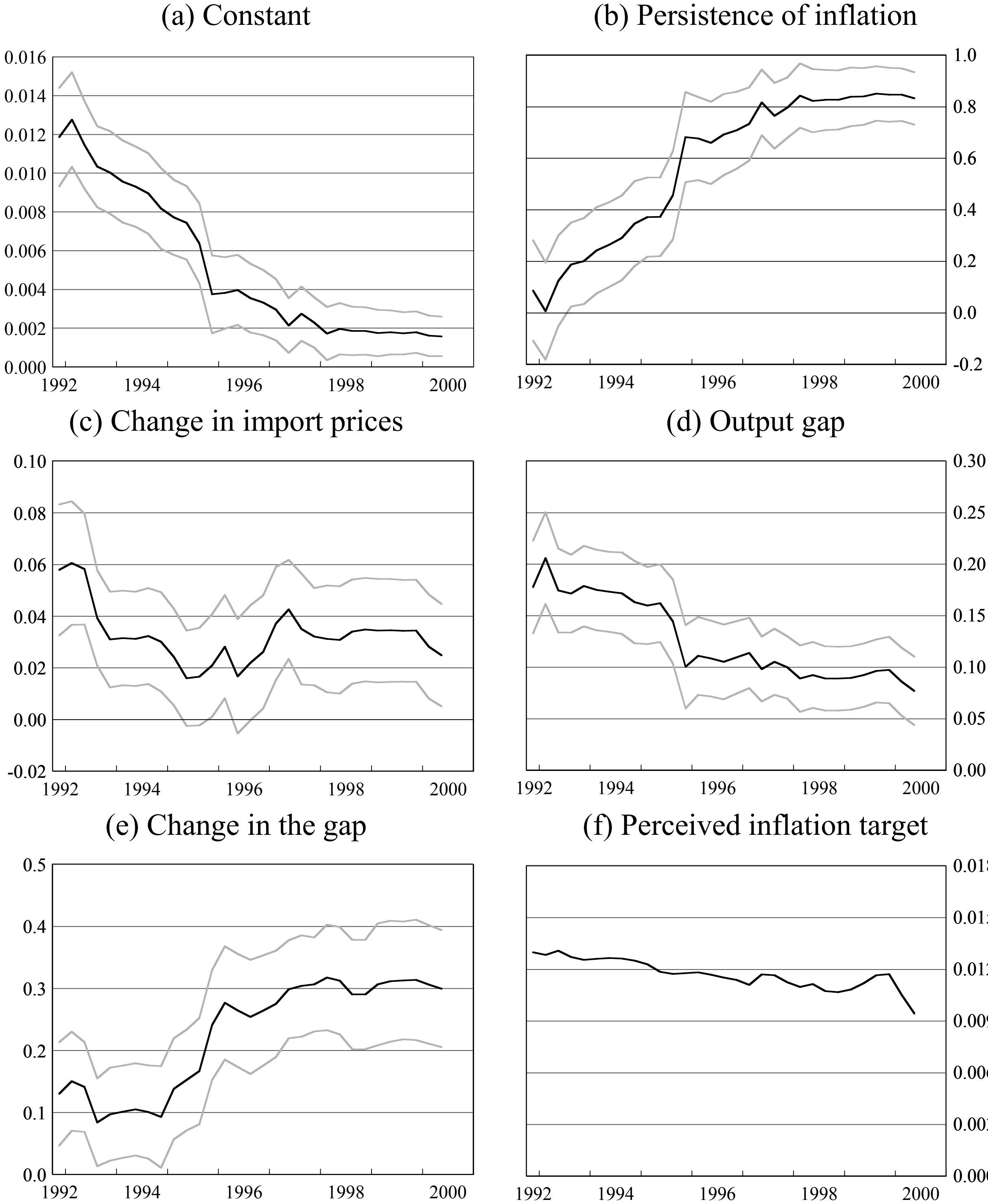
10-year rolling regression, 1983:Q1–2000:Q2



Note: See Figure 3

Figure 5: Coefficient Estimates from Rolling Regressions for the UK

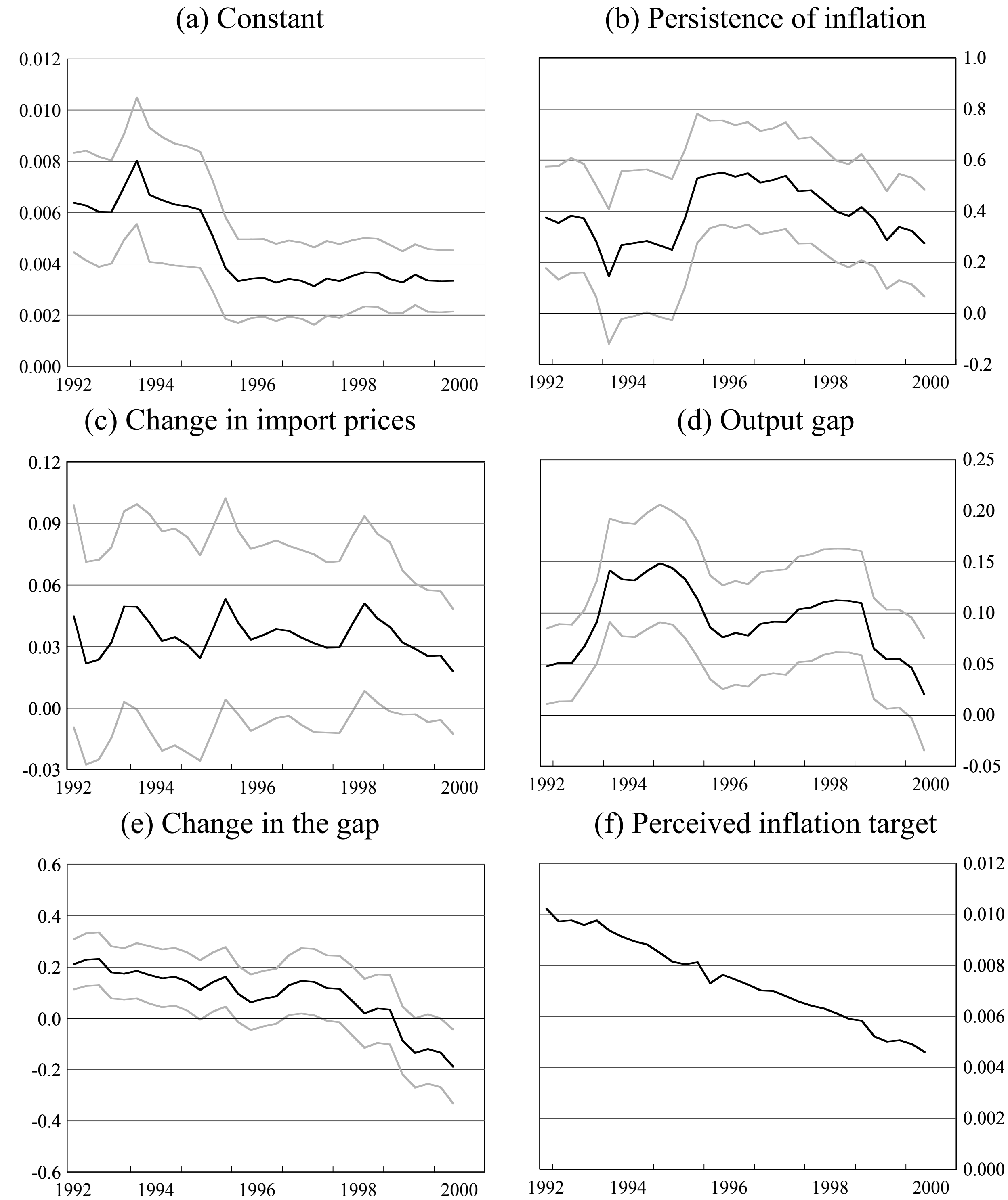
10-year rolling regression, 1983:Q1–2000:Q2



Note: See Figure 3

Figure 6: Coefficient Estimates from Rolling Regressions for Canada

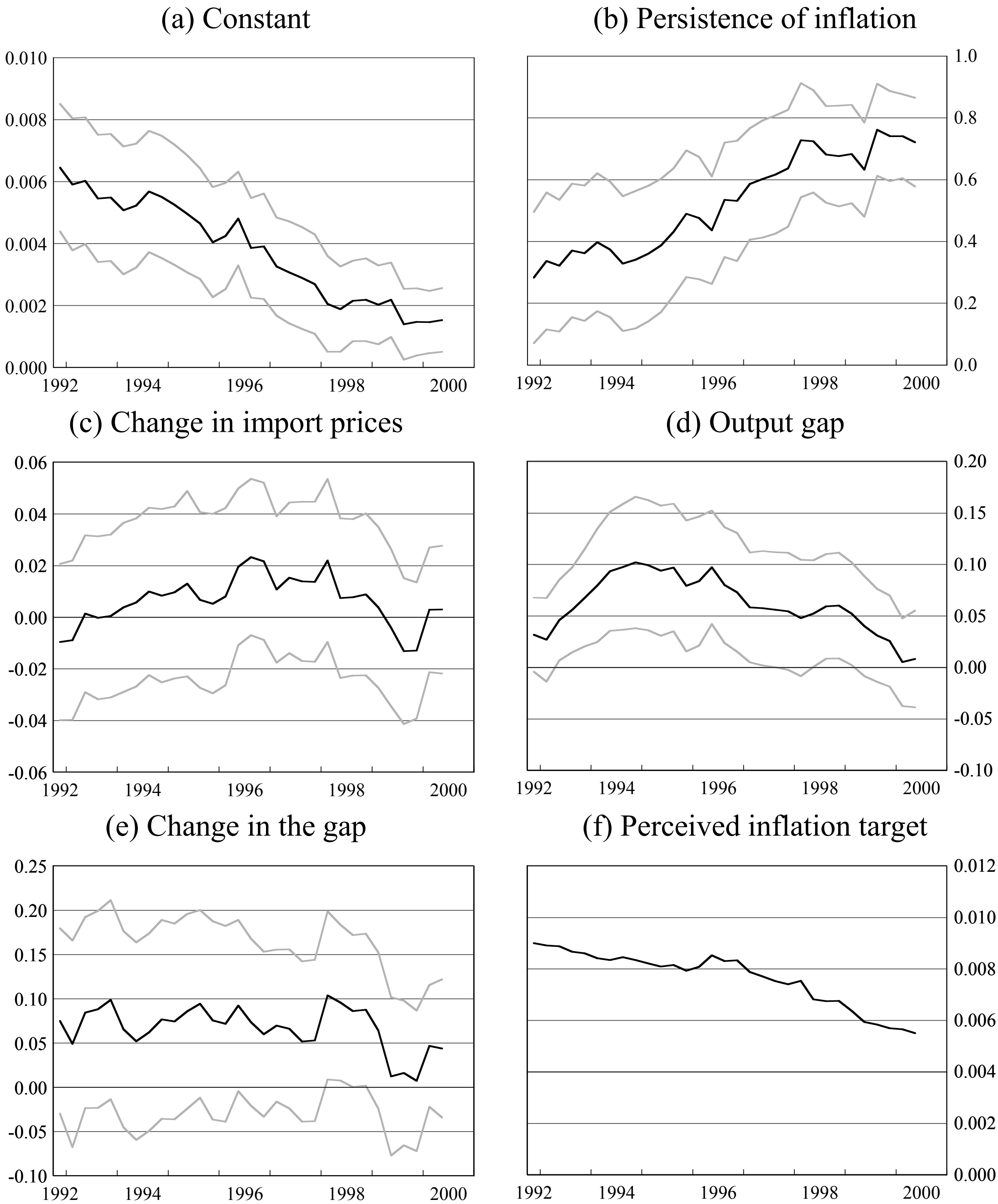
10-year rolling regression, 1983:Q1–2000:Q2



Note: See Figure 3

Figure 7: Coefficient Estimates from Rolling Regressions for the US

10-year rolling regression, 1983:Q1–2000:Q2.



Note: See Figure 3

Note that the models we are estimating are designed primarily to capture the short-run dynamics of the inflation process. It would thus be unwise to use them to draw conclusions about changes in the extent of exchange rate pass-through over a long horizon. It is possible, for example, that the long-run relationship between imported prices and consumer prices has changed little, but pass-through has become more protracted.[17] In an inflation-targeting framework, however, this change still implies that a given shock to the exchange rate would require less of a policy adjustment.

Interestingly, the lack of response of inflation to exchange rate developments is also evident in the New Zealand data (Figure 4(c), again especially after the first few years of the sample are excluded) while for Canada (Figure 6(c)) and the UK (Figure 5(c)), these coefficient estimates have stayed roughly stable over the sample period. So while the recent experience in Australia and New Zealand would suggest that inflation has become less sensitive to exchange rate movements, this has not been a common experience for these other open, inflation-targeting countries, all of which have recorded low inflation outcomes in recent periods.

The coefficient on the output gap in the Australian equation has varied somewhat over the sample period (Figure 3(d)), and has been both higher and statistically more significant in the second half of the sample. On the other hand, the coefficient on the change in the output gap (Figure 3(e)) (i.e., the indication that there are 'speed limits' to growth) has drifted down over the period and has been insignificant in regressions starting from around 1987. The latter trend would be consistent with the increasing flexibility of both product and labour markets in Australia.

For the other countries, estimates of the coefficient on the change in the output gap have also varied quite a lot over time, and in the case of New Zealand, for example, as in Australia, the change in the output gap appears to have been a much more significant explanator of inflation developments earlier in the sample than it has been more recently. The estimated coefficients on the level of the output gap have been roughly stable in the case of the UK and Canada, while for the US, the coefficient has drifted down towards zero as the sample increasingly includes the 1990s.

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[17] Gruen and Leong (2001) present evidence which supports this conclusion.

We now turn to estimates of the degree of autocorrelation, or persistence, in the inflation process. In the model outlined above, these estimates correspond to estimates of the degree to which inflation expectations can be characterised as being backward-looking. For Australia, Figure 3(b) suggests that over the last two decades, the inflation process has become markedly less autocorrelated. These estimates could be interpreted as implying that during the 1980s, inflation expectations were based almost exclusively on past inflation developments, while during the 1990s, close to 70 per cent of inflation expectations can be characterised as being tied to a target rate of inflation. This result support the Kuttner and Posen (1999) hypothesis that the adoption of inflation targeting has increased the capacity of the central bank to manage inflation, by reducing the propagation of inflation shocks. The results could also, however, be interpreted as providing support for Taylor's (2000) hypothesis that the persistence of inflation shocks decreases in a low-inflation environment.

Turning to the results for the other countries, however, qualifies these conclusions (Figures 4(b), 5(b), 6(b), 7(b)). Only in the case of Australia and New Zealand has there been a clear decline in the persistence of inflation over the period, although in both of these cases it has been quite sharp. In the UK and the US, by contrast, the degree of persistence appears to have increased quite markedly and monotonically from the 1980s to the 1990s, while in Canada it has remained roughly unchanged. The results for the US are counter to those presented in Taylor (2000); these rolling regression estimates suggest that conclusions about persistence are quite sensitive to the time period chosen.

There is no obvious explanation for the diversity of these outcomes across countries. All of the countries we are considering (other than the US) became inflation targeters in the early 1990s, and all have achieved very low inflation outcomes during the latest decade. In the case of Australia and New Zealand, it is plausible that other structural changes in the economy, in particular the deregulation of the labour market, could be responsible for a large part of the reduction in the degree of persistence in the inflation process. As pointed out in Dwyer and Leong (2001), in 1985 around 80 per cent of wages in Australia were indexed and by 1990 this proportion had fallen to less than 10 per cent. Similar (and even more far-reaching) changes to the industrial relations system occurred in New Zealand. But this can't explain why, over the 1990s, the persistence of inflation was so much lower in Australia and New Zealand than in the US and the UK, given the flexibility of the latter countries' product and labour markets. More generally, the wide variation in these estimates over time and across countries suggests that any conclusions drawn from these sorts of reduced-form price equations may not be particularly robust.

Overall, the results in this section of the paper suggest that there may well have been structural changes in the inflation process in each of these countries between the 1980s and the 1990s. Chow tests of structural change, presented in Table 1, support this conclusion at a 10 per cent level for the US and at a 5 per cent level for each of the other countries.[18]

Like Andersen and Wascher (2001), however, we find that the structural changes that have occurred in the inflation processes have differed quite a lot across the countries considered and it is hard to attribute these changes to any specific global phenomenon. In particular, it seems unlikely that increased credibility can convincingly be argued to have driven the reduction in inflation persistence found for Australia and New Zealand given the other countries' results. As a result, it will be important to remain on the lookout for further changes to the inflation process.

5. Conclusion

Whether an open economy should target aggregate or non-traded inflation depends on the objective function of the policy-maker, the nature of the shocks that the economy is exposed to, and the structural relationships in the economy. In the end,

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[18] Table 1 reports tests for a structural break at March 1992, but the results were not particularly sensitive to the break point. For simplicity, a common break point was chosen across countries at a time that coincided roughly with the beginning of the low-inflation episode for most of these countries. These results are in contrast to those presented in Andersen and Wascher (2001), although in that paper, the authors were testing whether the inflation process in the whole of the 1990s (including the disinflationary period at the beginning of the decade) was significantly different from the behaviour of inflation during the previous three decades. Beechey *et al* (2000) also do not find statistically significant evidence of a structural break in the Australian inflation process in the error correction model they estimate. That equation, however, includes unit labour costs as an explanator, where the equation estimated above is a reduced-form price equation. Our tests for structural change are thus implicitly tests for structural change in either the price or wage-setting process.

the answer to this question is an empirical issue. The results in this paper suggest that, for the Australian economy, the choice of inflation target does not generally make much difference to the extent of inflation or output variability. In part, this appears to be because the estimated pass-through of exchange rate changes to aggregate inflation is protracted.

Changes in the structure of the economy, and particularly the inflation process, however, will affect this conclusion. The paper has also shown that there have been quite significant changes in the inflation process over the past two decades. Most notably, the effect of exchange rate changes on inflation has become more muted. The inflation process overall also appears to have become considerably better anchored. Both of these developments would tend to provide further support for the above conclusion and imply that the Australian economy has become more resilient to temporary price level shocks.

Evidence from other countries, however, suggests a need for caution. There is considerable variation in the inflation process both across countries and over time, in ways that seem difficult to explain. It is possible, in particular, that the response of the economy to specific shocks may vary from the average responses implied by reduced-form regression analysis, because of changing perceptions about the nature and likely permanence of shocks. Because such changes can have significant effects on inflation and growth outcomes, policy-makers will always need to be mindful of this fact, and exercise judgement and flexibility in assessing the economic outlook.

Appendix A: A Small Macroeconomic Model of Australia

This model is similar in structure to that in Beechey *et al* (2000). The primary difference is that aggregate inflation is not modelled in an error-correction framework. The model is estimated over the period 1985:Q1–1999:Q4. All the inflation processes in the model are calibrated to deliver 2.5 per cent inflation in steady-state, which is the assumed value of the inflation target in the central bank's objective function.

Output gap

$$y_t = \underset{(0.052)}{0.852}\, y_{t-1} + \underset{(0.061)}{0.159}\, y^f_{t-1} - \underset{(0.027)}{0.137}\left(r_{t-6} - 3.5\right) - \underset{(0.008)}{0.025}\left(rer_{t-3} - \underset{(1.83)}{464.701} \right) \quad \text{(A1)}$$

where y is the domestic output gap, measured as deviations from a linear trend of real non-farm output; y^f is the foreign output gap, measured as deviations of US GDP from a linear trend; r is the real cash rate (the instrument of monetary policy less aggregate inflation); and rer is the real exchange rate.

Aggregate prices

$$\begin{aligned} \Delta p_t = {} & \underset{(0.112)}{0.246}\Delta p_{t-1} + \underset{(0.102)}{0.399}\Delta p_{t-2} + \underset{(0.108)}{0.223}\Delta p_{t-3} \\ & + \underset{(0.049)}{0.084}\Delta ulc_{t-5} + \underset{(0.015)}{0.040}\Delta pm_t + \underset{(0.016)}{0.008}\Delta pm_{t-1} \end{aligned} \quad \text{(A2)}$$

where p is the level of the CPI, ulc is a measure of unit labour costs, and pm is import prices. The restriction that the coefficients on prices, unit labour costs and import prices sum to 1 was imposed.

Unit labour costs

$$\Delta_4 ulc_t = \underset{(0.088)}{0.513}\Delta_4 p_{t-1} + \underset{(0.088)}{0.487}\Delta_4 ulc_{t-1} + \underset{(0.065)}{0.187}\, y_{t-1} \quad \text{(A3)}$$

The unit labour cost equation is a linear Phillips Curve incorporating adaptive expectations. The assumption of adaptive expectations has historically provided the best fit for Australian data. The equation was estimated with the restriction that the coefficients on lagged inflation sum to 1.

Import prices

$$\begin{aligned}\Delta pm_t = &-\underset{(0.023)}{0.748}\,\Delta e_t - \underset{(0.022)}{0.197}\,\Delta e_{t-1} + \underset{(0.022)}{0.005}\,\Delta e_{t-2} \\ &-\underset{(0.023)}{0.060}\,\Delta e_{t-3} + \underset{(0.117)}{0.430}\,\Delta wp_t + \underset{(0.117)}{0.570}\,\Delta wp_{t-1}\end{aligned} \tag{A4}$$

where e is the nominal exchange rate and wp represents world export prices. We assume unitary pass-through of movements in the exchange rate and world prices.

Real exchange rate

$$\begin{aligned}\Delta rer_t = &-\underset{(0.108)}{0.331}\left(rer_{t-1} - \underset{(1.83)}{464.701}\right) + \underset{(0.102)}{0.423}\left(tot_{t-1} - \underset{(1.05)}{463.516}\right) \\ &+\underset{(0.233)}{0.589}\left(r_{t-1} - r^f_{t-1} \ -1.5\right) + \underset{(0.162)}{1.382}\,\Delta tot_t - \underset{(0.082)}{0.228}\,\Delta rer_{t-1} \\ &-\underset{(0.082)}{0.088}\,\Delta rer_{t-2} - \underset{(0.081)}{0.228}\,\Delta rer_{t-3}\end{aligned} \tag{A5}$$

where rer is the real exchange rate, measured using the real trade weighted index, tot is the terms of trade and r^f is the G3 real interest rate.

Nominal exchange rate

$$\Delta e = \Delta rer + \Delta p^f_{t-1} - \Delta p_{t-1} \tag{A6}$$

where p^f is the foreign price level, measured using G7 core inflation.

Foreign output gap

$$y^f_t = \underset{(0.047)}{1.104}\,y^f_{t-1} - \underset{(0.120)}{0.0405}(r^f_{t-1} - 2.0) \tag{A7}$$

Terms of trade

$$\Delta tot_t = -\underset{(0.047)}{0.193}\left(tot_{t-1} - \underset{(1.05)}{463.516} \right) + \underset{(0.100)}{0.217}\Delta tot_{t-1} + \underset{(0.103)}{0.215}\Delta tot_{t-2} + \underset{(0.106)}{0.173}\Delta tot_{t-3} + \underset{(0.109)}{0.091}\Delta tot_{t-4} + \underset{(0.111)}{0.249}\Delta tot_{t-5} \quad \text{(A8)}$$

World export prices

$$\Delta wp_t = 0.625 + \underset{(0.092)}{0.462}\left(\Delta wp_{t-1} - 0.625\right) - \underset{(0.098)}{0.118}\left(\Delta wp_{t-2} - 0.625\right) + \underset{(0.091)}{0.320}\left(\Delta wp_{t-3} - 0.625\right) \quad \text{(A9)}$$

G7 core inflation

$$\Delta p_t^f = 0.625 + \underset{(0.107)}{0.344}(\Delta p_{t-1}^f - 0.625) + \underset{(0.106)}{0.332}(\Delta p_{t-2}^f - 0.625) + \underset{(0.113)}{0.327}(\Delta p_{t-3}^f - 0.625) - \underset{(0.110)}{0.103}(\Delta p_{t-4}^f - 0.625) + \underset{(0.113)}{0.327}\Delta y_{t-4}^f \quad \text{(A10)}$$

G3 real interest rate

The following reaction function was assumed:

$$r_t^f = 2 + 0.3\, y_{t-2}^f + 0.1(\Delta p_{t-2}^f - 0.625) \quad \text{(A11)}$$

where the equilibrium G3 real interest rate is 2 per cent and the equilibrium world inflation rate is 2.5 per cent.

Appendix B: Data

The data sources for the simulations in Section 3 are described in Beechey *et al* (2000). The data sources for Section 4 are described below.

Australia

Inflation

Definition: Median inflation index excluding mortgage interest charges and consumer credit charges.

Source: Calculated by the Reserve Bank of Australia from data in *Consumer Price Index*, ABS Cat No 6401.0

Output gap

Definition: See Beechey *et al* (2000).

Source: Beechey *et al* (2000)

Import prices

Definition: Implicit price deflator for imports, excluding fuels and lubricants, civil aircraft and Reserve Bank of Australia imports of gold. Tariff adjusted.

Sources: *National Income, Expenditure and Product*, ABS Cat No 5206.0, Australian Customs Service

New Zealand

Inflation

Definition: Implicit price deflator for private final consumption, adjusted for indirect tax changes in 1986:Q4 and 1989:Q3.

Source: New Zealand Department of Statistics, Datastream codes NZCONEXPA and NZCONEXPC

Output gap

Definition: Deviation of GDP from HP filtered series (λ=1 600), mean-adjusted assuming a sacrifice ratio of 3 per cent.

Source: New Zealand Department of Statistics, Datastream code NZGD….D

Import prices

Definition: Import price index.

Source: New Zealand Department of Statistics, Datastream code NZIMPPRCF

United Kingdom

Inflation

Definition: Retail price index excluding mortgage interest (RPI-X), seasonally adjusted, adjusted for the change in the VAT in 1991:Q2.

Source: United Kingdom Office for National Statistics, Datastream code UKRPAXMIF

Output gap

Definition: Deviation of GDP from HP filtered series (λ=1 600), mean-adjusted assuming a sacrifice ratio of 3 per cent.

Source: United Kingdom Office for National Statistics, Datastream code UKABMI..

Import prices

Definition: Import price index.

Source: United Kingdom Office for National Statistics, Datastream code UKBQKS..

Canada

Inflation

Definition: Chain linked price index of personal consumption expenditures, seasonally adjusted, adjusted for the introduction of the GST in 1991:Q1.

Source: Statistics Canada, Datastream code CN15614.

Output gap

Definition: Deviation of GDP from HP filtered series (λ=1 600), mean-adjusted assuming a sacrifice ratio of 3 per cent.

Source: Statistics Canada, Datastream code CNGDP…D

Import prices

Definition: Import price index, seasonally adjusted.

Source: Statistics Canada, Datastream code CNB1226.

United States

Inflation

Definition: Index of personal consumption expenditures, seasonally adjusted.

Source: United States Bureau of Economic Analysis, Datastream code USCE..CE

Output gap

Definition: Deviation of GDP from HP filtered series (λ=1 600), mean-adjusted assuming a sacrifice ratio of 3 per cent.

Source: United States Bureau of Economic Analysis, Datastream code USGDP…D

Import prices

Definition: Chain type price index for imports, seasonally adjusted.

Source: United States Bureau of Economic Analysis, Datastream code USIMN..CE

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