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Inflation Targeting and Central Bank Behavior

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Does Talk Matter After All? Inflation Targeting and Central Bank Behavior*

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Abstract: Since 1990, a number of countries have adopted inflation targeting as their declared monetary strategy. Interpretations of inflation targeting differ, however. To some, inflation targeting implies the pursuit of an inflation goal without regard for other objectives, while to others, it represents a mechanism for communicating the central bank's objectives without sacrificing policy flexibility. Another view is that the policy is nothing more than verbal window dressing.

This paper identifies five distinct interpretations of inflation targeting, consistent with various strands of the current literature, and relates those interpretations to a the conventional model of monetary policy in which time consistency is a problem. The empirical implications of the model are compared to the experience of three counties that adopted inflation targets in the early 1990s: The United Kingdom, Canada, and New Zealand, focusing in particular on central bank behavior. For the U.K., the results are consistent with a successful policy of keeping inflation expectations in check without sacrificing flexibility. The results for Canada are less clear, but in neither case is the evidence consistent with a single-minded pursuit of the inflation target.

Keywords: Inflation targeting, credibility, monetary policy, central banking

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DOES TALK MATTER AFTER ALL?
INFLATION TARGETING AND CENTRAL BANK BEHAVIOR

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Since 1990, a number of economies — including Australia, Canada, Finland, Israel, New Zealand, Spain, Sweden, and the United Kingdom — have adopted inflation targeting as their declared monetary strategy. It had been explicitly discussed by the European Monetary Institute, as well, as one of the two candidate strategies for the European Central Bank's future monetary framework [EMI (1995), p. 4], although recent statements by the ECB President would seem to imply that it may not be chosen. Contemporaneous with this development, an academic literature on inflation targeting has arisen, led by the contributions of Svensson (1997a, 1997b, Svensson and Faust 1998)[1]. In this literature, inflation targeting is treated as the latest and perhaps best candidate strategy for resolving the time-inconsistency problem of monetary policy, following on the work of Rogoff (1985) and of Walsh (1995) and Persson and Tabellini (1993).

Yet, to many observers, it is not entirely clear how inflation targeting in practice serves the purpose asserted for it in theory. If inflation targeting simply consists of the central bank (or the controlling government) announcing its inflation goal — the π^* in the familiar rules-versus-discretion models following Kydland and Prescott (1977) and Barro and Gordon (1983) — it either is providing the private sector with information already presumed to be known in these models, or it is making a less than credible claim (in the

[1]Other works include Ball (1997, 1998), Bernanke and Mishkin (1996), Bernanke and Woodford (1997), Haldane, ed. (1995), and Leiderman and Svensson, eds. (1995).

sense of actions not talk defining weak versus strong types as in Cukierman and Meltzer [1986]). If inflation targeting is instead a commitment that the central bank will target only inflation without regard for other goals — the characterization given in Friedman and Kuttner (1996) and in various countries' political discussions — it is merely a limiting-case for the Rogoffian conservative central banker rather than a new type of monetary strategy, let alone a welfare-improving one.

The matching of model and operational practice is made more complicated by the institutional patterns which have emerged amongst inflation targeting central banks. As described in Mishkin and Posen (1997) and in Bernanke, et al (1999), a largely consistent operational form has been adopted by all inflation targeting central banks implying a convergence on best practice. This operational form does begin with the public declaration of a numerical goal for inflation over a specified time-frame, but it does not end there. It also always includes a number of other elements, notably regular publication of an *Inflation Report*-type document explaining the sources of inflationary pressures in the economy as well as careful design and detailed public description of the target inflation series and range. Moreover, every inflation targeting central bank exhibits flexibility in response to economic shocks (whether or not granted formal "escape clauses") and gradualism in the pursuit of their inflation goals (see the case studies in Bernanke, et al (1998) for details).

What, then, actually is inflation targeting? Does the central bank talk and institutional aspects associated with it serve a purpose, or is it solely verbal window dressing? If inflation targeting is instead merely a shift in preferences, can this be consistent with the apparently measured rather than crusading pursuit of low inflation by inflation targeting central banks? This paper identifies five different possible

interpretations of inflation targeting consistent with various strands present in the current literature. The existence of so many viable interpretations of inflation targeting may indicate that current academic discussions — and policy regimes — have taken the effects of this new monetary regime on central bank behavior for granted.[2]

The interpretation of King (1997) — that inflation targeting mimics the optimal state contingent rule precisely because the institutionalization of central bank talk enhances accountability — is one way of resolving the conundrum. The interpretations that inflation targeting represents a move towards greater counter-inflationary conservatism either by adopting central banks or as part of a worldwide preference shift, or that inflation targeting is actually inflation-only targeting, have very different implications for central bank behavior. Two further interpretations require distinguishing between the various inflation targeting adopting central banks — that increased central bank discussion of goals is a sign of weakness (as in Garfinkel and Oh [1995]), or that such talk only matters when tied to explicit contracts for central bankers complete with punishments (as in some interpretations of Walsh [1995] as applied to New Zealand). The implications of these for the behavior of monetary instruments and inflation expectations in the 1990s in a sample of three inflation targeting adopting (Canada, New Zealand, and United Kingdom) countries are used to examine the effects of inflation targeting on central bank behavior.[3]

Part I builds on the simple models of King (1997) and Svensson (1997a), to derive the implications for central bank behavior and inflation expectations of each interpretation

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[2] While there is a growing empirical literature on inflation targeting, most studies, such as Ammer and Freeman (1995), Laubach and Posen (1997), and Johnson (1997) have examined inflation outcomes. Almeida and Goodhart (1997) is one study that explicitly considers central bank behavior.

[3] Research in progress will add comparisons to non-inflation target adopting countries during the same period.

of inflation targeting. Part 2 discusses which countries' experiences may be realistically identified with each interpretation, drawing on the historical-institutional work in Mishkin and Posen (1997) and Bernanke, et al, (1999). Part 3 examines the hypothesized shifts in central bank behavior empirically, both in terms of the time-series behavior of inflation, and the impact of inflation surprises on long and short interest rates after adoption. Part 4 concludes that inflation targeting should be seen largely as a shift from more discretionary policy towards the optimal state contingent rule, although the inclusion of more strict contracting on the central bank can also make inflation targeting mimic an increase in anti-inflationary conservatism.

1. A Modelling Framework for Inflation Targeting

Models of monetary policy generally fall into one of two camps: those descended from Barro-Gordon (1983), which take expectations formation as the core problem; and those analyzing monetary policy's optimal control problem neglecting expectations formation.[4] The purpose of our investigation is not just to determine whether inflation targeting constitutes a regime shift, but whether the communication efforts that typically accompany an inflation targeting regime "matter", in the sense that they predictably affect the behavior of the central bank and expectations of that behavior. Consequently, our modelling approach falls into the first of these two camps. In particular, we draw on the Svensson (1997a), and King (1997) extensions of the basic Barro-Gordon framework.

The problem of monetary policy in both classes of models is to manage aggregate demand in a way to minimize the deviation of output and inflation from their targets.

[4] Examples of this latter group include Svensson (1995), Ball (1997), and Cecchetti (1998).

Formally, the central bank is assumed to have a quadratic loss function in each period of the form:

$$L_t = \frac{1}{2}\pi_t^2 + \frac{1}{2}\lambda (y_t - y^*)^2 \ ,$$

where π is the inflation rate and y can be interpreted as the output gap. We assume (without loss of generality) that the target rate of inflation is zero. For whatever reason, however, the CB may try to maintain output above potential; in this case, the target output gap, y^* would be greater than zero. The λ parameter represents the CB's weight on output stabilization vis à vis inflation; a value of zero indicates the CB cares *only* about inflation. The CB's preferences (i.e., the value of λ) are known to the public.[5]

Output obeys a Lucas-style aggregate supply relation,

$$y_t = \rho y_{t-1} + \alpha(\pi_t - \pi_t^e) + \epsilon_t \ ,$$

in which higher-than-expected inflation is associated with increases in output. This feature gives the CB an incentive to mislead the public with regard to its inflation objective in an attempt to create a "surprise" and increase output; consequently, absent a commitment mechanism, low inflation policies are typically not time consistent. The ε shock, as usual, is interpreted as a supply-side disturbance. Persistence is introduced through the inclusion of an autoregressive term, ρy_{t-1}.

We assume that private-sector inflation expectations are formed rationally before the ε disturbance is realized, so that $\pi_t^e = E_{t-1}\pi_t$. The CB *can* observe ε in real time, however, and sets policy contingent on its realization. This key assumption means the CB can play a constructive role in stabilization: when there is an adverse disturbance (a

[5] Interesting complications are introduced when the CB's preferences aren't known, but must be inferred by the public. Examples include Backus and Driffill (1985), Garfinkel and Oh (1995), Svensson and Faust (1998).

negative ε realization), the CB's optimal policy is to partially offset its effects on output by generating an inflation surprise. As shown by Rogoff (1985), appointing a conservative (lower λ than that of society's median voter) central banker, reduces the inflation bias, but results in more volatile output. King's (1997) "optimal state-contingent rule" (OSCR) is superior to that outcome, as discussed below, if only the central bank can be sufficiently trusted to pursue it.

Central banks obviously don't set the inflation rate directly, however. Instead, they manage aggregate demand through the appropriate choice of interest rates. To model this, we assume aggregate demand is a simple function of the *ex ante* short-term real interest rate,

$$y_t = \delta(i_{1,t} - E_t\pi_{t+1} - r^*) \ ,$$

where $\delta < 0$, and r^* is the real rate consistent with a zero output gap. Conditional on period t expectations of period t+1 inflation, the CB chooses the nominal short-term interest rate $i_{1,t}$ consistent with the real rate that will yield the desired combination of output and inflation. This is tantamount to choosing π_t, of course, but this additional layer at least allows us to analyze the behavior of interest rates.

With output persistence, the problem becomes a dynamic one, and the policymaker must set i to minimize the discounted sum of the current and future one-period loss functions. In addition to the tradeoff between *current* inflation and output, the policymaker must also consider the effects of current actions on future realizations of those variables.

Discretion

Optimal policy under discretion can be described by a decision rule of the form

$$\pi_t = a - b\epsilon_t - cy_{t-1} \ .$$

The *a* coefficient, representing the time-invariant inflation bias, depends on the model's parameters just as it does in the static models of Barro-Gordon (1983) and King (1997), i.e., increasing in y^* and λ. The $-b\epsilon_t$ term represents the CB's optimal response to the supply shock; the CB will partially offset an adverse shock by increasing inflation. The degree of accommodation, naturally, will be greater for larger values of λ. Output persistence tends to increase these two terms whatever the relative weight on inflation goals. The inflation bias, *a*, will be larger because a given inflation surprise affects current *and future* output,; the degree of accommodation also will be larger with persistence (an effect Svensson terms "stabilization bias").[6]

More interesting from our standpoint is the "state-contingent" inflation bias persistence introduces, embodied by the $-cy_{t-1}$ term in the decision rule. All else equal, a lower level of output increases the expected loss from the output term in the objective function, which the CB will attempt to offset through increased inflation. The private sector understands this, of course, and will come to expect the higher inflation. In the end, inflation will be higher, but output will remain unaffected by policy.[7] It is this persistent effect of supply shocks on inflation that we intend to examine empirically in the work that follows.

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[6] Further details, and a derivation of the policy rule, appear in Svensson (1997a).

[7] An odd feature of Svensson's original model is that over some range, expectations of future inflation fall as the weight assigned to output fluctuations increases. In the limiting case as $\lambda \to \infty$, an adverse supply shock has *no* effect on expected inflation. In this case, the inflation increase is sufficient to perfectly stabilize output, and with output constant, there is no change in the state-contingent inflation bias. This curious result would obviously not hold in a model characterized by persistence in the inflation process.

The short-term (one-period) interest rate can be determined by equating aggregate demand with aggregate supply:

$$i_{1,t} = r^* + a + \delta^{-1}[(1 - c)\,\rho y_{t-1} + (1 - \alpha b + c\alpha b)\epsilon_t] \ .$$

In the presence of output persistence, the short-term rate will rise more than it would otherwise (provided the stabilization bias is not too large).

The pure expectations hypothesis can then be used to determine the long-term (two-period) interest rate as $\frac{1}{2}(i_{1,t} + E_t i_{1,t+1})$,

$$i_{2,t} = r^* + a + (\delta^{-1} - c)\,(1 + \rho)[\,\rho y_{t-1} + (1 - \alpha b)\epsilon_t] \ .$$

Again, the effect of the expected inflation term is to increase the response of the long-term rate.

Conservatism

The behavior of a weight-conservative "Rogoffian" central banker is similar, except λ in the social welfare function is replaced with some λ' describing the CB's preferences, where $\lambda' < \lambda$. As shown by Rogoff, (1985) such a policymaker will respond suboptimally to supply disturbances, while delivering a lower average rate of inflation. As in the case of discretion, the state-contingent inflation bias resulting from supply shocks generates persistence in the response of interest rates, although the magnitude is attenuated relative to the discretion case.

An interesting limiting case of conservatism is an "inflation-only targeter" for whom $\lambda' = 0$. As might be expected of a fanatic, this behavior generates highly suboptimal outcomes. In this case, $a = b = c = 0$, and inflation will equal its target (zero) in each period. The short-term interest rate will adjust to equate aggregate demand with supply

$$i_{1,t} = r^* + \delta^{-1}[\rho y_{t-1} + \epsilon_t] \ ,$$

rising sharply to prevent an adverse supply shock from affecting inflation. The response of the long-term rate rise along with the short-term rate,

$$i_{2,t} = r^* + \frac{1}{2}\delta^{-1}(1+\rho)(\rho y_{t-1} + \epsilon_t) \ ,$$

but the expected inflation effect will be absent.

OSCR

Let us say that the CB acquires some sort of a mechanism that allows it to commit to a zero inflation rate. (In King (1997), that mechanism is an inflation target; we return to this interpretation below.[8]) Since only inflation surprises affect output, the optimal policy, it turns out, is one in which the conditional expectation of inflation is always equal to its target, i.e., $E_{t-1}\ \pi_t = 0$. Consequently, supply shocks will have no persistent effects on inflation or monetary policy.

This result is derived formally in a dynamic model by Lockwood et al. (1995) and Svensson (1997a): if the CB can credibly commit to such a rule, the optimal decision rule takes the form

$$\pi_t = -b^* \epsilon_t \ ,$$

in which the time-variant inflation bias, *a*, disappears. More importantly, from our standpoint, is the disappearance of the state-contingent inflation bias, $-cy_{t-1}$, so that $E_t\pi_{t+1} = 0$. The reason for this is clear: since only "surprise" policy actions can affect

[8] King's interpretation of an inflation target is as a mechanism that allows the CB to commit to a given (presumably zero) average rate of inflation (i.e., unconditional on ε) while allowing the CB to respond to realizations of the ε disturbance. Svensson (1997) shows how state-contingent linear inflation contracts and state-contingent inflation targets with a weight-conservative central bank can be engineered to mimic the OSCR.

output, it doesn't pay to respond to predictable output movements. Hence, an optimal rule will ignore them, and revert to the inflation target after responding contemporaneously to the shock. Empirically, this means adverse supply shocks won't generate inflation premia in long-term interest rates. After responding optimally by letting inflation rise for one period, the CB is trusted to return inflation to its optimal level once the shock has passed.

The corresponding movements in short- and long-term interest rates would then be given by

$$i_{1,t} = r^* + \delta^{-1}[\rho y_{t-1} + (1 - \alpha b^*)\epsilon_t] \ ,$$

and

$$i_{2,t} = r^* + \frac{1}{2}\delta^{-1}(1 + \rho)[\rho y_{t-1} + (1 - \alpha b^*)\epsilon_t] \ .$$

Besides the dependence on lagged *y* and the mean inflation bias, the OSCR and discretionary regimes also differ in the size of the response to the ε realization. Because future values of the output gap are affected by current policy actions, there is a tendency to respond more vigorously to shocks, resulting in a *b* that is larger in size than the b^* obtained under the OSCR.[9]

Summary

If inflation targeting is more than "just talk," the response of central banks to macroeconomic shocks clearly *should* differ across these regimes. In understanding the way in which the responses differ, it is helpful to recognize the two mechanisms by which

[9] This result is driven by the endogenous nature of output persistence. With a serially uncorrelated but exogenous supply shock, the policy response under discretion and the OSCR would be identical. The result also depends on the lack of persistence in the inflation process.

Table 1
Response of Interest Rates to Supply Shocks Under Alternative Policy Regimes

Regime	short-term rate	long-term rate	spread
OSCR	$\delta^{-1}(1-\alpha b^*)$	$\frac{1}{2}\,\delta^{-1}(1+\rho)(1-\alpha b^*)$	$-\frac{1}{2}\,\delta^{-1}(1-\rho)(1-\alpha b^*)$
Discretion	$\delta^{-1}(1-\alpha b+\alpha bc)$	$\frac{1}{2}\,(\delta^{-1}-c)(1+\rho)(1-\alpha b)$	$-\frac{1}{2}\,(\delta^{-1}-c)(1-\rho)(1-\alpha b)$
Inflation-only	δ^{-1}	$\frac{1}{2}\,\delta^{-1}(1+\rho)$	$-\frac{1}{2}\,\delta^{-1}(1-\rho)$

supply shocks affect interest rates. The first is the effect on the real interest rate resulting from varying degrees of accommodation of the shock by the central bank; the second is the expected inflation introduced by the state-contingent inflation bias. Table 1 summarizes the relative responses derived in this section of the short- and long-term interest rates to an ε realization. Comparing the response of central bank's policy instrument (captured in the short-term interest rate) across the three regimes yields the following predictions about the behavior of short-term interest rates:

- The instrument rate response under "inflation-only" targeting is *greater than* that under the OSCR. Expected inflation is zero in either case, but under the OSCR, the CB will want to accommodate the shock to some extent, resulting in a smaller rise (in the case of a negative ε) in short-term rate.

- The response under "inflation-only" targeting is *greater than* that under discretion (for $c < 1$). The same reasoning holds: the CB's desired accommodation under discretion outweighs the change in expected inflation.

- The response under discretion is comparable to that under the OSCR. The state-contingent inflation bias implies higher expected inflation (in response to an adverse shock), which implies a larger short-term rate response; stabilization bias implies a smaller (more accommodative) short-term rate response. (In a static model without output persistence, the response is the same under discretion and the OSCR.)

The analogous predictions for the long-term rate are:

- The response under "inflation-only" targeting is *greater than* under the OSCR. There is no state-contingent inflation bias in either case, but the larger real rate response by the inflation-only targeter yields a larger increase in long-term rate.

- The response of the "inflation-only" targeter may be greater or less than the response under discretion, depending on whether the larger real rate effect for the "inflation-only" targeter is greater or less than the discretionary CB's state-contingent inflation bias.

- The discretionary CB's response is *greater than* the response under the OSCR (provided the stabilization bias isn't too large). The response of the short-term interest rate is similar under the two regimes (smaller for the discretionary CB due to the stabilization bias), but the lack of a state-contingent inflation bias under the OSCR removes the inflation premium in the long rate.

2. Identifying Inflation Targeting with Institutional Changes

As noted in the introduction, there are several different ways of characterizing inflation targeting which have been evoked. Each one of these characterizations can be grounded to a greater or lesser degree in a portion of the extant monetary economics literature. To enable rigorous comparison of these characterizations with each other, and with reality, we map these characterizations to moves by a central bank between one and another of the three types of central banker modelled above — the untrusted discretionary, the strictly-targeting conservative, or the trusted OSCR-following. Some distinctions can be identified by using variations in institutional frameworks between the inflation target adopting central banks (e.g., only those inflation target adopting central banks with formal punishments for failure to meet the targets can be said to switch from the untrusted discretionary regime). With this unified framework, each interpretation of inflation targeting should be associated with a shift in the behavior of (some of) the adopting central banks in response to disturbances, as well as in the response of private-sector inflation expectations to the central bank's activities. Testing of those empirical predictions is the subject of the following section.

Inflation Targeting as Trust Building

This is the interpretation of King (1997), that inflation targeting allows the central bank to (come close to) follow the optimal state contingent rule. By providing greater information about its forecasts (and therefore about the nature of the disturbances it faces) and accountability for meeting those forecasts, the central bank gains in the flexibility with which it can respond to shocks. This interpretation is consistent with Mishkin and Posen (1997) and Bernanke, et al (1999) on the practice of inflation targeting on two counts: first, it explains the pattern of inflation targeting central banks being able to convince the public that they can accommodate "one-time" inflationary shocks (e.g., the indirect tax rise in Canada in 1991; the United Kingdom exit from the ERM in 1992) without raising doubt about underlying counter-inflationary resolve; second, it justifies why all inflation targeting central banks invest so many resources in *Inflation Reports* and other forms of public information provision.

If this interpretation is correct, all three inflation targeters (New Zealand, Canada, and the United Kingdom) examined here should be characterized by smaller movements in inflation expectations (embodied in long-term interest-rates) when the central bank deviates from the target due to unforeseen shocks than seen prior to announcement of inflation targets. This should hold whether the central bank is moving from a more conservative but less publicly explicit regime, a more strictly rule based regime (such as membership in a fixed exchange rate system), or a soft-on-inflation discretionary regime. In either of the first two of these shifts to inflation targets, there should also be an increase in the accommodation of shocks by the central bank. Thus, if one believes the public distinguished between the mere appointment of conservative central bank governors prior to the adoption of inflation targets in Canada and New Zealand and the full-scale

implementation of transparent central bank talk, this increased accommodation of shocks should characterize either all three central banks, not just the ERM-exiting United Kingdom.

Inflation Targeting as Chatty Conservatism

This is an interpretation widespread among inflation targeting skeptics. Worldwide, there is evidence of central banks becoming more conservative with respect to inflation goals. This could be the result of intellectual commitment to the primacy of the price stability goal as the forward march of progress knowledge continues, of the pressures of internationally integrated capital markets, or of a general desire to be like the fashionable central bankers of the day. The institutional aspects of inflation targeting dedicated to transparency should then be seen as mere window dressing or as political concessions necessary for central bankers to maintain this desired shift — either way, the act of central banks talking about their inflation forecasts and publishing detailed reports is a side show.

This interpretation fits nicely with the fact that, in both Canada and New Zealand, the central banks expressed explicit commitment to a primary goal of price stability prior to the announcement of inflation targets (Bank of Canada Governor Crow's "Hansen Lecture" of 1988; the Reserve Bank Act of 1989 in New Zealand), while the United Kingdom had joined the ERM in 1990, and all three of these commitments followed years of frustration and disappointment with (what were perceived as) looser monetary strategies. Of course, this begs the question of why these central banks went on to explicitly announce inflation targets even after the declarations of the primacy of the price stability goal. In any event, were this the proper interpretation, the central banks would be

moving in the direction of greater conservatism, meaning less accommodative flexibility in response to disturbances. From this interpretation of inflation targeting, because it represents a move from away from weak discretion, the response of inflation expectations to whatever accommodation of shocks made, however, should decline.

Inflation Targeting as Inflation-Only Targeting

Some would hold that inflation targeting is actually "inflation-only targeting" (to use Ball's (1996) phrase), where inflation targeting literally means that the central bank only takes its inflation goal into account when setting policy. Given the tenor of some proposals in the United States Congress in the 1990s (before it apparently adopted the opinion that current Federal Reserve policy could not be improved upon), and Galbraith's (1999) characterization of inflation targeting as a sign of inflation obsession (without any regard for transparency), this view is shared by some inflation targeting advocates and opponents. Obviously, as the limiting case of anti-inflationary conservatism, inflation-only targeting predicts (when modelled) a shift to near-total inflexibility of monetary policy in response to shocks with far from optimal results.

Rhetoric aside, however, there is little institutional or historical evidence for such an interpretation of the behavior of most central banks publicly announcing inflation targets in the 1990s. As documented in Bernanke, et. al. (1999), the inflation targeting central banks of Australia, Canada, Israel, Spain, Sweden, and the United Kingdom (as well as their monetary targeting precursors in Germany and Switzerland) have, at a minimum, displayed gradualism in their responses to inflationary pressures out of concern for real-side or international goals, and have by institutional design actively pursued other short-run objectives besides price stability (e.g., the Bundesbank's resetting of their

"unavoidable rate of price increase" in 1980 following the 1979 oil-shock; the Bank of Canada's gradual disinflation from 1991, and its loosening response when inflation fell faster than expected; the Bank of England's decision to exclude the first-round effects of interest-rate increases from their target-series RPIX).

Nevertheless, it is more than a straw man or a test of the literalness of language to examine the case of what King (1997) calls an "inflation nutter." Even if the central bank in question were to have a typically mixed-goal perspective, a la Bernanke and Mishkin (1992), an inflation target designed to be very strict for reasons of accountability could still mimic the nutter with significant costs.[10] When almost all inflation-targets have central values only a small amount over the measurement bias in price indices, and those targets with ranges are much narrower than what simulations would indicate are confidence intervals for inflation control, it is plausible that these targets strictly interpreted would constitute something close to inflation-only targeting.

This divides inflation targeting regimes between those central banks which commit to a point-target (and the inherent flexibility of such) and those which announce strict ranges, as well as a division between those which take the exchange rate into account in a discretionary manner and those which adopt monetary conditions indices predetermining the response to exchange rate movements.[11] The trust-building OSCR interpretation which sees inflation targeting as an investment in transparency to increase flexibility is obviously

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[10] Friedman and Kuttner (1996) took on the dangerous implications of just such a rule-like policy regime as a warning against inflation targeting in the spirit of then-current congressional proposals for the Federal Reserve.

[11] Amongst inflation targeters, the United Kingdom and Australia have emphasized point targets and exchange rate flexibility, while Canada and New Zealand have adopted MCIs and strict target ranges. See the discussion of these operational issues in Laubach and Posen (1997) and Mishkin and Posen (1997).

at odds with the view that inflation-nutters get in through the back door of target design. What is key is that in practice it is easy to imagine the adoption of an inflation targeting regime which combines these motivations, perhaps through mistake or perhaps through political compromise. Empirically, as discussed in the next section, this would make inflation targeting look like an increase in conservatism as well as an increase in trust (and its welfare benefits would depend on how far towards the OSCR or the inflation nutter the regime was pushed).

Inflation Targeting as Strict Contracting

According to some interpretations of the models of Walsh (1995) and Persson and Tabellini (1993) of optimal inflation contracts for central bankers, inflation targets can serve as such a contract, but require an explicit punishment mechanism for the central banker's failure to meet the target. This is, of course, embodied in the Reserve Bank Act of 1989 and the "Policy Targets Agreements" in New Zealand. Discussions in that country leading up to target make reference to these sorts of ideas as part of the justification for the design of their regime.[12] One could claim that some aspects of the United Kingdom inflation targeting framework also serve this purpose of making the central bank contractually accountable. On our view, however, this interpretation stretches the meaning of legal contracts beyond reasonable interpretation of the accountability of the U.K.'s framework, which is what such interpreters of the pre-independence Bank of England would have to argue given the absence of any more formal contracting and punishment mechanism in their inflation targeting framework (as they would with regard to the still legally far from independent Bank of Canada).

[12] See Bernanke, et al (1998), Chapter 5, for details.

If formal legal accountability for monetary policy actions with the possibility of punishment of the central banker is required to achieve credibility rather than or in addition to general talk to the public, then only the Reserve Bank of New Zealand should show behavior mimicking the OSCR upon adopting inflation targets. This interpretation is akin to the more realistic review of the inflation nutter as a central banker constrained by inflation targets, but like the OSCR emphasizes the relationship with authority rather the choice of goal. Alternatively, if a transparent record of targets, forecasts, and success in meeting them alone is sufficient to build central bankers' credibility, then we are back to the first interpretation of inflation targeting as trust building, and much of the extra apparatus in New Zealand is unnecessary. If, as seen in the RBNZ's response to minor broaches of the target ceiling during 1996, these extra obligations force the RBNZ to a more strict conservatism, that central bank will display *less* flexibility in response to shocks than the Bank of England and the Bank of Canada which mimic the OSCR without a formal contract.

Inflation Targeting as Cheap Talk of the Weak

An even more skeptical interpretation of inflation targeting than the preceding views is that those central banks which can credibly commit to low inflation do so, and those who cannot, talk about so doing. Central banks which adopt inflation targeting are those banks which have run out of alternatives because they cannot adhere to fixed exchange rate commitments, monetary targeting, or other rule-like behavior. To preserve some veneer of credibility, they talk. A theoretical grounding for this view is given in Cukierman and Meltzer (1986) and Garfinkel and Oh (1995). In Garfinkel and Oh (1995) and Faust and Svensson (1998), the central bank suffers from a two-fold credibility problem: the bias

from the possibility of discretionary surprise, and the existence of private information regarding disturbances known to the central bank. Here, the cheap talk of the central bank will have no meaning unless the central bank's hands are tied (talk alone cannot get the central bank to the OSCR).[13] In fact, talking about goals and forecasts is a sign of weakness.

While a seemingly robust theoretical result about cheap talk, identifying these models with actual developments in central banking is somewhat problematic. This interpretation of inflation targeting seems to make sense only for the United Kingdom, if one were to interpret the exit from the ERM as a sign of weakness. (Sweden, another inflation targeted not analyzed here, could be characterized in the same way.) It is more difficult to imagine what made either the Bank of Canada or the Reserve Bank of New Zealand "weaker", in terms of the credibility of their commitments to price stability, at the start of the 1990s than at their already less than credible starting point of the mid-1980s.

Yet, as a useful variant on the null hypothesis that inflation targeting made no difference to central bank behavior — and a reminder that not too long ago theoretical research seemed to conclude that the sort of efforts at public information and trust building by central banks advocated in Bernanke, et al (1999) were doomed to failure — this possibility must be considered. Inflation targeting under this interpretation is a move towards greater discretion due to lack of credibility, and so inflation target adopting central banks should greater flexibility with higher costs in the form of rises in inflation

[13] We are grateful to Michelle Garfinkel for an extended elucidation of these models, but we remain responsible for this interpretation and any errors herein.

expectations when shocks occur. This could apply to just the exchange-rate commitment dropping United Kingdom, or to all three central banks considered here.[14]

3. The effects of inflation targets in practice

Having set out a strategy of identification for the effects of inflation targets, we now turn to implementing that strategy econometrically. Our empirical approach emphasizes shifts in the *behavior* of central banks, and of interest rate expectations. An obvious but misleading alternative strategy for identifying the relationship between inflation targeting and central bank behavior is to compare the average rate of inflation pre- and post-target. Even if factors external to the monetary regime are controlled for, the discussion of the previous two sections indicates that this alone provides little useful information. A lower rate of inflation could result merely from a reduction in the target inflation rate, π^*, perhaps associated with a worldwide reduction in average inflation levels; observed lower inflation rates post-target could equally be associated with an increase in conservatism (i.e., a smaller weight on output in the central bank's objective function) *or* with a monetary policy that achieves the OSCR[15].

A second approach to see whether inflation expectations are consistent with the central bank's stated inflation target, as in Johnson (1997) and Svensson (1996). While this provides more direct evidence about credibility than inflation levels per se, it still does

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[14]In reality, it is possible to have both an increase in the degree of conservatism *and* transparency with the adoption of inflation targets. In fact, some political considerations might make these go together. We return to this point in the discussion of our empirical results below.

[15] Going outside of the model in section 1 above, central banks may choose to announce inflation targets following a favorable inflation shock. See Mishkin and Posen (1997) and Almeida and Goodhart (1998) for evidence of this pattern.

not distinguish between the varying interpretations of the regime. As discussed in section 2, despite their differences in response to shocks, on this measure the inflation-only targeting and the OSCR regimes are indistinguishable, since inflation expectations will converge to the central bank's inflation target in either case.[16]

Instead, we look for differences in this behavior in the time-series properties of inflation, and in the response of interest rates to inflation shocks before and after target adoption, matched up with the predictions of the previous section. Rather than just look at the inflation level, therefore, we disentangle the policy response to inflation, and the expectations about that policy response. Our goals are twofold. The first is to establish whether inflation targeting has, in fact, reduced the inflation bias problem in adopting countries or if it merely represents "cheap talk." The second is to see whether that outcome was achieved through the adoption of more conservative preferences by the central bank — becoming an "inflation-only targeter" in the limiting case — or through additional efforts at transparency allowing a policy that resembles the OSCR.

To test the null hypothesis that inflation targeting merely represents cheap talk, we draw on a key insight of the model discussed in section 1: namely, that inflation targeting, whether achieved through an increase in conservatism, or in transparency, if successful will lead to $E_t \pi_{t+1}$ = constant = π^*. That is, there will be no persistence in inflation;

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[16] A related approach is to assess whether inflation targeting reduces the "sacrifice ratio," so that a given reduction in inflation will exact a smaller cost in terms of employment and output. This approach requires additional assumptions about the responsiveness of labor markets to variations in monetary regimes which are largely unsupported for low inflation countries (see Posen[1998]), and which no inflation-target adopting central bank expected to occur over the short lifespans of those regimes to date (see Bernanke, et al [1999]). In the model discussed above, however, the structural parameter describing the output-inflation tradeoff doesn't change when a new policy regime is adopted. Hutchison and Walsh (1998) give an alternative view on the New Zealand experience.

higher-than-expected inflation at time *t* will have no implications for inflation in period *t*+1 and beyond. By contrast, if the central bank's behavior is governed by unchecked discretion, then an unfavorable shock at time *t* will increase inflation in subsequent periods by virtue of the state-contingent inflation bias. While these are limiting cases, a natural test of this null hypothesis, therefore, is to see whether inflation persistence falls after the adoption of an inflation target.[17]

While a decrease in the degree of inflation persistence post target adoption is consistent with reduction in the state-contingent inflation bias, and therefore the rejection of the cheap talk interpretation, such a reduction says nothing about which policy — conservatism or transparency — was used to achieve that outcome. To distinguish between these two cases, we rely on the model's implications regarding the policy response to inflation, and the response of expectations to that policy. A shift towards more conservative preferences ought to be associated with a larger weight on the inflation term, and a smaller weight on employment, and should alter expectations regardless of the extent of efforts at communication. By contrast, an increase in trust of the central bank (as in the OSCR) does not require a change in preferences, but will induce a change in the response to central bank policy moves to the extent that communication is effective.

One way to go after the question of conservatism versus transparency is to see whether the adoption of inflation targets is accompanied by a change in the relative

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[17] This is similar to the approach taken by Ireland (1998) in testing whether the time consistency problem can account for the behavior of U.S. inflation. In the context of the Barro-Gordon (1983) model, he shows that a unit root in the natural rate of unemployment makes inflation I(1) and cointegrated with the unemployment rate. The mechanism is exactly the same as that described here: a persistent supply shock has similarly persistent effects on the inflation bias. Though it must be noted that this is a joint hypothesis, the fact is if the time-inconsistency problem is irrelevant for inflation, then either the driving force for inflation targeting is gone or expectations do not matter.

weights on employment and inflation in a Taylor-style reaction function. Leaving aside for the moment the possibility of a movement towards both greater conservatism and greater trust at once, the reduction in inflation persistence resulting from inflation targeting creates a potential problem with this approach. If the policy were *perfectly* successful, then inflation would be perfectly unforecastable; the policy instrument would be manipulated in such a way as to keep expected future inflation constant. This is essentially the empirical counterpart to the degeneracy problem identified by Bernanke and Woodford (1998).[18] Lagged inflation would provide no information about the future, nor would any other variable dated *t* or earlier.

In terms of estimation, this property undercuts the use of lagged inflation as a proxy for future inflation, and also subverts the more sophisticated instrumental variable approach of Clarida, Galí, and Gertler (1998). In this situation, tests based on an estimated reaction function would reveal little to distinguish inflation-only targeting from the OSCR. Given the reality that any monetary regime short of a currency board, not even the Bundesbank in the 1970s or the Reserve Bank of New Zealand in the 1990s, can be characterized as truly inflation-only targeting, and that trust even after an educational transparency effort is likely to be incomplete, estimated reaction functions will still be informative in real-world cases of inflation targeting.

In any event, our third test, examining the response of monetary policy to inflation surprises, addresses this problem as well as bringing in the behavior of inflation expectations. Inflation's unforecastability is not an issue: even though expected inflation

[18] Obviously, no inflation targeting policy could be expected to completely eliminate predictable inflation fluctuations. Nonetheless, a reduction in inflation predictability will exacerbate the finite-sample problems associated with instrumental variables estimators. See Staiger and Stock (1997).

is constant under an inflation target, the central bank will respond to *unexpected* changes in the inflation rate in such a way as to maintain expectations at or returning to target levels. Furthermore, as discussed earlier in section 1, the *size* of the policy response provides some information on whether the central bank's behavior is better described by an inflation-only or an OSCR regime.

To be more explicit, as our first step towards characterizing the central banks' behavior, we examine estimates of a simple Taylor-style monetary policy reaction function. The operating instrument is assumed to be the short-term (overnight, in the case of the U.K.) interest rate, whose target level is a simple function of the inflation and unemployment "gaps":

$$r_t^* = \alpha + \beta(E_t\pi^k_{t+k} - \pi^*) + \gamma(u_t - u^*)$$

where π^* is the central bank's inflation target, $E_t\pi^k_{t+k}$ is expected future inflation over some horizon k, u_t is the unemployment rate, and u^* is its target. As in Clarida et al. (1998), a partial-adjustment specification is used to capture central banks' tendency to smooth interest rates,

$$r_t = (1-\rho)r_t^* + \rho r_{t-1} + e_t \quad .$$

Average inflation rate over the preceding six months, π^6_t, is used as a proxy for expected future inflation. Although lagged inflation is a poor proxy for inflation expectations under a policy of inflation targets, this approach sidesteps the statistical problems associated with instrumental-variables estimation when the fit of the first-stage regression is poor.

The two equations can then be combined to yield the following regression equation which can be estimated using OLS:

$$r_t = b_0 + b_1 \pi_t^6 + b_2 u_t + e_t \quad .$$

The target inflation and unemployment rates are subsumed into the constant term, while the b_1 and b_2 coefficients can be interpreted as $(1-\rho)\beta$ and $(1-\rho)\gamma$, respectively.

Our third test concerns the interest rate response to inflation surprises. The regressions used for this analysis are of the form:

$$r_{t+3} - r_t = b_0 + b_1 (\pi_{t+3} - E_t \pi^3_{t+3}) + \epsilon_{t+3}$$

where r now represents either the short-term or the bond rate, π^3_{t+3} is the average inflation rate over the next three months, and $E_t \pi^k_{t+3}$ is its expectation as of time t. In other words, the change in the interest rate over three months is regressed on the unexpected change in inflation over the same horizon. A three-month horizon was chosen on the grounds that month-to-month changes in inflation are dominated by "noise" that doesn't elicit reactions from either the central bank or the bond market. To account for possible changes in the response of interest rates, an augmented version of this equation is estimated in which the coefficients are interacted with a dummy variable equal to one after the adoption of the inflation target.

Expected inflation is not observable, of course, so forecasts from simple statistical models are used instead.[19] One set of results (denoted "AR" in the Tables) uses forecasts from a regression of inflation on lagged inflation and unemployment, consistent with the simple inflation models in the first tests. An alternative set of results (denoted "YC" in the tables) uses a yield curve approach, regressing inflation on lagged inflation, the

[19] Consensus forecasts of inflation are available for many countries, but they are reported as monthly forecasts of current-year and coming-year average inflation. This structure renders the extraction of *k*-period-ahead inflation forecasts impossible without additional assumptions. Other measures, such as the nominal to index-linked gilt spread for the U.K., are not available for all the countries under consideration.

overnight rate, and the 10-year government bond rate. The overlapping nature of the data introduces an MA(2) error structure, however, so a Newey-West correction is used in the computation of the standard errors.

Naturally, implicit in all these — or any — comparisons of central bank behavior and economic outcomes across regimes is the assumption that all other structural parameters remain constant across the two periods. While so baldly stated, this is not an especially attractive assumption, its implications are of questionable relevance for the sample of inflation targeters in question. There is good reason to argue that the three countries discussed here went through much of their reforms in non-monetary areas *prior* to their adoption of inflation targeting in the 1990s[20]. Furthermore, there is no clear econometric evidence that the changes in monetary policy generated any significant structural change in fundamental macroeconomic relationships in these countries [Laubach and Posen (1997b)].

United Kingdom

We turn first to the results for the United Kingdom, which adopted an inflation targeting policy after exiting the ERM in September 1992. In terms of explicit intent and design, the Bank of England's framework comes closest to the model of using transparency to achieve the OSCR [see King (1997) and Bernanke, et al (1999), ch. 7]. On the face of it, the U.K.'s adoption of an inflation target would appear to be clearly untinged by a

[20] In New Zealand, the onslaught of liberalization began in 1984, and the Reserve Bank of New Zealand Act was passed in 1989, almost two years prior to the adoption of inflation targeting. In Canada, the ongoing discussion of economic policy has focussed on the apparent absence of structural change, especially in labor markets. In the United Kingdom, Thatcherite policies were pursued for over a decade prior to the announcement of inflation targets in October 1992.

movement towards increased anti-inflationary conservatism; if anything, the unwillingness to remain in ERM and sacrifice domestic real-side goals for the sake of a strong pound and price stability would seem to be a sharp break towards OSCR-like discretion. Also, unlike in Canada and New Zealand, changes in the Bank's mandate, independence, and governor all took place *after* inflation target adoption. Thus, the United Kingdom experience should be the clearest candidate inflation targeting regime to look like the "trust-building" interpretation, if one will. On the other hand, as discussed in Section 2 above, if any of the three targeters could be interpreted to be replacing an anti-inflationary commitment with cheap talk, it would also be the forcibly devaluing United Kingdom.

The experience under an inflation target is compared with the period from 1984 through 1989. The two years in which Britain participated in the ERM, and the eight months leading up to it, are excluded from the analysis on the grounds that the period represents a third policy regime.[21] As with all three inflation targeters examined here, the average rate of inflation is indeed lower during the targeting period: 2.7 percent, compared with 5.2 percent for the 1984–9 period.

Table 2 reports measures of inflation persistence, and changes in its behavior between the two subsamples. These, and subsequent, results are based on monthly data, and inflation is calculated from seasonally-adjusted RPIX. One simple measure of persistence is the sample autocorrelations, reported in panel A of Table 2. In the 1984–89 period, British inflation exhibited a high degree of serial correlation, with a first-order

[21] Unusual inflation volatility which characterized this period — including one month in which the annualized rate exceeded 20 percent — is another reason to exclude the months leading up to the ERM. The results are qualitatively similar if this period is included, however.

autocorrelation coefficient of 0.45. This changes markedly with the adoption of an inflation target: over the 1992–97 subsample, the autocorrelations are all close to zero.

This finding is confirmed in the time-series regressions of inflation on lagged inflation and unemployment reported in panels B and C.[22] In panel B, the regressions are run separately on pre- and post-target subsamples separately. Over the earlier period, the coefficients on the first two lags of inflation are positive and significantly different from zero at the 0.10 and 0.05 levels; the coefficient on lagged unemployment is also highly significant, and negative. In addition, with an R^2 of 0.32, inflation fluctuations are relatively predictable. Lagrange Multiplier (LM) test statistics for first- and fourth-order serial correlation, and for the inclusion of a third lagged inflation term, are all insignificant.

This pattern changes after the adoption of inflation targets. The lagged inflation term is not statistically significant, and the coefficient on the unemployment rate, while still negative, is significant at only the 0.10 level. (The specification again passes the diagnostic tests for serially correlated residuals and an omitted second lag on inflation.) The drop in the R^2 is from 0.32 to 0.06 shows that inflation is now much less predictable — consistent with successful inflation targeting. There is, therefore, no evidence that in the U.K. in the 1990s "cheap talk" replaced the discipline imposed by the ERM.

Panel C of Table 2 reports formal statistical tests for parameter constancy from a regression in which the independent variables are interacted with a dummy variable that takes on the value of one beginning in October 1992. The results confirm the reduction in

[22] Strictly interpreted, the model in section 3 implies a positive relationship between inflation and the unemployment rate, since adverse supply shocks would reduce output and increase the inflation bias. The observed negative correlation between unemployment and inflation could be captured by adding demand shocks to the model.

inflation persistence identified above: the coefficient on the second lag of inflation falls by a statistically significant 0.38 with the adoption of the inflation target.

Table 3 reports an estimate of the reaction function allowing the b_1 and b_2 coefficients to change with the adoption of the inflation target. (The equation also includes a time-varying constant, which is not reported.) Although there is some weak evidence for shifts in the coefficients, for the reasons discussed above, the interpretation of these changes requires some discussion. The most noticeable change between the subsamples is in the coefficient on inflation, which falls to essentially zero from a highly significant 0.16 (which is consistent with β=0.62, a positive but less than one-for-one response of the target overnight rate to inflation). This would be consistent with a move towards the OSCR, and certainly opposite from a move towards greater conservatism.

The post-target coefficient is estimated very imprecisely, however, so the difference in the two coefficients is not statistically significant. The zero coefficient may indicate a reduced weight on inflation, but it also may simply reflect the fact that lagged inflation has become less informative about future inflation, as demonstrated earlier. At the same time, there was a slight increase in the weight on unemployment. Neither unemployment coefficient is statistically significant, however; nor is its change between subsamples.

Results of our third test for the U.K., concerning the interest rate response to inflation surprises, are somewhat sharper, and appear consistent with a shift from a discretionary policy regime to one approximating the OSCR. The results show that prior to the adoption of the inflation target, both short-term and long-term interest rates rose sharply in response to inflation surprises: a one percentage point surprise increase in inflation is associated with an increase in the short-term rate of over 25 basis points, and an increase in the long rate of 8–12 basis points (depending on the inflation model).

Considered in isolation, the size of the interest rate response prior to inflation target adoption is difficult to interpret. Inflation shocks elicit a contractionary policy response regardless of policy regime (including discretion). Similarly, the rise in bond rates may reflect an increase in inflation expectations (consistent with a "weak" central bank), or it may embody higher expected real short-term rates (consistent with a "conservative" central bank).

It is the comparison between the pre- and post-target adoption interest rate responses that is most revealing. The adoption of an inflation target appears to have attenuated the response of both short- and long-term rates: only 7–8 basis points on the short end, and a *negative* 3–5 basis points at the long end. Although none of these estimates is statistically significant at the 0.05 level, the difference in the short-rate response pre- versus post- is statistically significant at the 0.10 level, and at the 0.05 level for the bond rate. This pattern is consistent with the successful implementation of the OSCR policy in place of untrusted or untransparent discretion: the policy response to inflation shocks is mild, yet there is no "inflation scare" à la Goodfriend (1993) to send long-term rates climbing. The decline in aggressiveness of interest rate moves by the Bank of England cannot be reconciled with an increase in conservatism.

Canada

Like the United Kingdom, inflation fell by about 2.5 percent (from 3.8 to 1.3 percent) with the adoption of inflation targets in February 1991.[23] Unlike what was seen in the United Kingdom, however, there is little evidence of a change in the time-series properties

[23] These figures, and the results which follow, are based on an inflation measure obtained from the Bank of Canada that removes the effects of changes in the Goods and Services Tax (GST).

of inflation post-adoption. As shown in Table 5, the inflation rate is, essentially, serially uncorrelated both before and after this date. The autocorrelations reported in panel A are all small, and those that are nonzero tend to be negative. This result is underscored in the inflation regression reported in panel B, where the coefficients on lagged output and inflation are small and statistically insignificant in both subsamples. Diagnostic LM tests show no evidence of higher serial correlation, and the R^2s from the two regressions are 0.01 and 0.04, respectively. Apparently, nothing forecasts Canadian inflation — a finding consistent with successful inflation targeting and inconsistent with inflation targeting as cheap talk.[24] This could be dated to the appointment of Governor John Crow at the Bank of Canada, or to his Hansen Lecture of 1988 declaring price stability to be the sole long-run goal of Canadian monetary policy [see Mishkin and Posen (1997)].

The question remains, however, as to whether the Bank of Canada achieved this outcome through a policy of increased conservatism, possibly approaching "inflation-only" targeting as seen in Canada's dips into deflation, or through a policy that approximated the OSCR by building transparency and trust. As expected, the estimated reaction function reported in Table 6 sheds little light on this question. The coefficients on the six-month average inflation rate are small and statistically insignificant — as are the coefficients on the unemployment rate. Unfortunately, the response of interest rates to inflation surprises, reported in Table 7, are also uninformative. No statistically significant relationship between inflation surprises and interest rates are apparent in the data.

One plausible interpretation of this result is that in spite of the inflation target, Canadian monetary policy has been focused on the exchange rate. Indeed, even after

[24] Obviously, there are other factors — the exchange rate, commodity prices — that might be related to Canadian inflation. But none of these omitted variables generate serially correlated movements in inflation.

February 1991, the Canadian overnight rate has been punctuated by sharp increases without any apparent link to domestic inflation developments.[25] This of course implies some contrast between following of a monetary conditions index in practice, and the its declared intent to maintain a steady tightness of monetary policy with respect to domestic inflation as the exchange rate varies. Another factor is that swings in fiscal policy, recently towards consolidation, have been the dominant determinant of macroeconomic performance in Canada in recent years, as the Bank of Canada has itself argued to explain the movements in long-term interest rates distinct from expected response to the adoption of targets [see, e.g., Clinton (1998)].

New Zealand

The last case considered is that of New Zealand, which adopted inflation an inflation target in January 1990. Monthly data on inflation and other variables are not available, and the small number of quarterly observations in the pre- and post-target subsamples, severely limits our ability to make precise inferences from the data.

As with the U.K. and Canada, average inflation has been lower post-target: 1.9 percent, versus 8.1 percent over the 1982 through 1990 period. And like the U.K., the inflation rate exhibits much less persistence after the adoption of the inflation target, as shown in Table 8. Prior to 1991, the autocorrelations, reported in panel A, show a great deal of positive serial correlation; after 1991, they become small and generally negative. In the inflation regression reported in panel B, the AR(1) coefficient drops from 0.64 pre-target to essentially zero post-target, with no evidence residual correlation or an omitted

[25] Examples include a 300 basis point increase in early 1986, a 270 basis point spanning late 1992 and early 1993 — both rapidly reversed — and, most recently, the 100 basis point increase in September 1998.

lag on inflation. While this difference is striking and large enough to be economically meaningful, it is statistically insignificant. The effects of the unemployment rate on inflation are small and statistically insignificant in both subsamples.

The estimated reaction function coefficients reported in Table 9 are consistent with a strong policy response to expected inflation both pre- and post-target. Before target adoption, the coefficient on the inflation rate is a highly significant 0.50. (The two-quarter average, π^2_t, takes the place of the six-month average used in the monthly regressions reported in the UK and Canadian cases). With a coefficient of 0.59 on the lagged short-term rate, this implies a greater than one-for-one response of the interest rate to inflation. While the size of the coefficient increases slightly post-target, the difference is not statistically significant. Taken together with the results on persistence, this is consistent with inflation targeting in New Zealand being a move away from discretion, but without a noticeable increase in conservatism.

Pinning down the response of New Zealand interest rates to inflation surprises is difficult, however, and the results emerging from this analysis, shown in Table 10, are unclear. With inflation forecasts from the yield curve model (YC), the response of short-term rates is much sharper post-target — but the estimated response is not statistically significant, nor is it consistent with the results using the autoregressive (AR) forecasts. Regardless of the inflation model used, bond rates tend to rise more steeply in the post-target subsample, but again the estimates are not statistically significant. Because of this imprecision, it is hard to characterize the policy response associated with New Zealand's adoption of an inflation target. One thing is clear, however, that the narrowness and legalistic rigidity of the RBNZ's inflation targeting framework does not seem to produce

noticeably better results than the arguably more discretionary though still transparent regimes in Canada and the United Kingdom.

4. Conclusions

It only exaggerates slightly to suggest that the widespread adoption of inflation targeting has acted as something of a Rorschach test for observers of monetary regimes. Those inclined to be skeptical of all but hard and fast monetary rules have viewed inflation targeting as a form of political window-dressing for the capital market pressures towards price stability, at best, and as merely cheap talk in lieu of credible policy at worst. Alternatively, those who fear crusades for price stability and disregard of output stabilization by central banks have seen in inflation targeting an open declaration of obsession, that nothing but inflation matters. The central bankers adopting inflation targeting regimes have themselves, however, given pride of place to the role of transparency in the inflation targeting framework, both as an end unto itself and as a means to greater accountability and flexibility. Even amongst the adopting central banks, however, there has been some variation in the degree of explicit contracting (with punishment) binding the central bank to strict pursuit of the inflation target.

In essence, the adoption of inflation targeting constitutes a test of whether central bank communication can substitute for strict and simple rules. From the monetary policymaker's point-of-view, this is the practical aspect of the long-standing academic "rules-versus-discretion" debate. In a world where both central bank information about the economy, and control of it, is imperfect, what matters is the response to shocks — debates over the appropriate target level of inflation or the relative weight of inflation versus output goals may best be seen as long-term decisions that may be ideological, but

tend to get settled for extended periods on the basis of relative intellectual consensus[26]. The pedal truly comes to the metal when a central banker must deviate from her long-term goal of price stability in the face of uncertain predictions or negative events[27]. That is why our identification scheme for the effects of inflation targeting focusses precisely on — and is able to differentiate the extant interpretations of inflation targeting on the basis of — predictions for how talk by central bankers is or is not consistent with their behavior in response to shocks.

The evidence presented in this paper would seem to indicate that talk by central banks matters after all. Mapping the shifts between three types of monetary strategy frameworks (untrusted discretionary, strictly conservative, trusted OSCR-following) to the institutional practices of the Bank of England, the Bank of Canada, and the Reserve Bank of New Zealand after target adoption, allowed us to create predictions about central bank behavior consistent with five different interpretations of inflation targeting. The interpretation that inflation targeting simply represents cheap talk, and would be consistent with a move towards greater discretion (and distrust) in the commitment to price stability, is rejected for all three economies examined, including for the ERM-exiting United Kingdom (the economy for which the strongest prima facie case for such an interpretation could be made). The interpretation of inflation targeting as strict contracting, meaning requiring an explicit legal arrangement of central bank reporting and accountability to elected officials to make the transparent talk have real effect, also is rejected; the RBNZ,

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[26] This is consonant with the distinction between goal and instrument independence in Debelle and Fischer (1994), as well as the distinction between constitutional and policy phases of political economy in Dixit (1996).

[27] See Laubach and Posen (1997) for statements by central bankers in Germany and Switzerland characterizing their success as the management of such short-run flexibility.

which exemplifies this approach, did not display noticeably more credibility or even conservatism than the Bank of Canada and the Bank of England, which were lacking some of these aspects in their framework. Even talk which matters, however, need not be interpreted too simplistically or as literally binding — there is no evidence that the sort of "inflation *only* targeting" hoped for or feared by some who hear the words "inflation targeting" was practiced by any of the three central banks considered here.

Whether talk alone is sufficient to earn the central bank enough trust to follow the optimal state contingent rule, or whether the talk of inflation targeting represents a shift towards greater conservatism short of inflation obsession, is less clear. There is some evidence that the adoption of inflation targeting in the New Zealand case combined a shift towards both greater conservatism and the OSCR; this is consistent with (though by no means proof of) the case study interpretation of the New Zealand inflation targeting framework in Bernanke, et al, (1999), Chapter 5, that the narrow target band and formal reporting to government aspects in that framework made the RBNZ follow a more rules based approach than strictly necessary. The Bank of England's framework, which, as described in King (1997) and documented in Bernanke, et al (1999), Chapter 7, goes to great institutional lengths to rely on transparency instead of formal rules, thereby providing OSCR-like short-run flexibility with long-run credibility, seems to produce exactly the results we would have predicted for that interpretation. The lesson of the Bank of Canada's experience with inflation targeting, which is mixed on our results, clearly not a move towards greater discretion but not clearly anything else seems to be a reminder that whatever central banks do (talk or otherwise) cannot overcome large movements in a country's fiscal and international environments.

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Table 2

Time Series Properties of the Inflation Rate
United Kingdom

A. Autocorrelations of inflation rate, pre- and post-target

Sample	1	2	3	4	5	6
Pre-target	0.45	0.43	0.19	0.07	0.10	0.09
Post-target	0.10	–0.03	–0.06	0.01	–0.04	0.06

B. Inflation regression, estimated over pre- and post-target samples

							LM tests		
	Coefficient on:						serial correlation		add'l
Sample	const	π_{t-1}	π_{t-2}	u_{t-1}	R^2	SE	1st ord	4th ord	π term
Pre-target	6.80	0.23	0.25	–0.43	0.32	2.55	1.47	4.80	0.31
	(2.98)	(1.95)	(2.16)	(2.21)			0.22	0.31	0.31
Post-target	5.36	0.04		–0.33	0.06	2.34	2.43	3.32	0.91
	(3.07)	(0.28)		(1.74)			0.12	0.50	0.51

C. Tests for structural change in the inflation regression

Coefficient on:						Difference:		
Pre-target			Post-target			Post – pre		
π_{t-1}	π_{t-2}	u_{t-1}	π_{t-1}	π_{t-2}	u_{t-1}	π_{t-1}	π_{t-2}	u_{t-1}
0.23	0.25	–0.43	0.04	–0.13	–0.38	–0.18	–0.38	0.04
(2.03)	(2.25)	(2.30)	(0.29)	(0.93)	(1.85)	(0.29)	(2.15)	(0.87)

Notes: Data are monthly. The pre-target sample runs from January 1984 through December 1989, and the post-target sample runs from October 1992 through December 1997. (The period from January 1990 through September 1992 is excluded.) Numbers in parenthesis are *t*-statistics. In panel B, the Lagrange Multiplier (LM) test statistics for 1st order serial correlation and for the omission of an additional lagged inflation term are distributed χ^2_1, and the statistics for 4th-order serial correlation are χ^2_4; p-values appear below the test statistics. The results in panel C are based in a regression of inflation on a constant, two lags of inflation, and one lag of the unemployment rate; the independent variables are interacted with a dummy variable equal to one after the adoption of an inflation target in October 1992.

Table 3

Monetary Policy Reaction Function
United Kingdom

Coefficient on:					Difference:				LM test
	Pre-target		Post-target		Post – pre				for 1st order
r_{t-1}	π^6_t	u_t	π^6_t	u_t	π^6_t	u_t	R^2	SE	serial corr.
0.74	0.16	–0.06	0.00	–0.09	–0.16	–0.03	0.92	3.01	0.06
(13.04)	(2.11)	(0.83)	(0.03)	(1.10)	(0.32)	(0.75)			0.80

Notes: Data are monthly. The pre-target sample runs from January 1984 through December 1989, and the post-target sample runs from October 1992 through December 1997. (The period from January 1990 through September 1992 is excluded.) Numbers in parenthesis are *t*-statistics. The dependent variable in the regression is the overnight rate. The regression also includes an intercept, which is not reported; all variables are interacted with a dummy variable equal to one after the adoption of the inflation target in October 1992. The Lagrange Multiplier (LM) test statistics for 1st order serial correlation is distributed χ^2_1; the p-values appears below the test statistic.

Table 4

Response of Interest Rates to Unanticipated Inflation
United Kingdom

Rate	Model	Coefficient on inflation surprise			R^2
		Pre-	Post-	Difference	
Overnight	AR	28.29	7.27	–21.02	0.150
		(2.98)	(1.29)	(1.89)	
	YC	26.72	8.13	–18.59	0.141
		(3.21)	(1.46)	(1.89)	
Bond	AR	8.50	–3.24	–11.75	0.054
		(1.93)	(1.37)	(2.36)	
	YC	12.62	–5.80	–18.42	0.121
		(2.81)	(1.89)	(3.35)	

Notes: Data are monthly. The pre-target sample runs from January 1984 through December 1989, and the post-target sample runs from October 1992 through December 1997. (The period from January 1990 through September 1992 is excluded.) Numbers in parenthesis are *t*-statistics. The dependent variable in the regression is the three-month change in the interest rate. The independent variables are a constant and a measure of the unanticipated three-month change in inflation; both are interacted with a dummy variable equal to one after the adoption of the inflation target in October 1992. For the results labeled AR, the unanticipated change is the residual from a regression of the three-month-ahead rate of inflation on a constant, two lags of inflation and one lag of unemployment. A similar procedure is used for the results labeled YC, but the regressors are two lags each of inflation, the overnight rate, and the 10-year bond rate. Both regressions are estimated separately over pre-target and post-target subsamples.

Table 5

Time Series Properties of the Inflation Rate
Canada

A. Autocorrelations of inflation rate, pre- and post-target

Sample	1	2	3	4	5	6
Pre-target	0.004	–0.117	–0.053	0.102	0.074	–0.249
Post-target	–0.104	–0.019	–0.062	0.069	–0.007	–0.089

B. Inflation regression, estimated over pre- and post-target samples

						LM tests		
	Coefficient on:					serial correlation		add'l
Sample	const	π_{t-1}	u_{t-1}	R^2	SE	1st ord	4th ord	π term
Pre-target	5.48	–0.01	–0.19	0.01	2.62	0.95	2.99	1.65
	(2.70)	(0.04)	(0.87)			0.38	0.56	0.20
Post-target	2.28	–0.16	–0.05	0.04	1.92	0.02	5.35	0.14
	(0.77)	(1.78)	(0.19)			0.90	0.25	0.71

C. Tests for structural change in the inflation regression

Coefficient on:				Difference:	
Pre-target		Post-target		Post – pre	
π_{t-1}	u_{t-1}	π_{t-1}	u_{t-1}	π_{t-1}	u_{t-1}
–0.01	–0.19	–0.17	–0.05	–0.16	0.13
0.04	(0.99)	(1.48)	(0.16)	(1.05)	(0.34)

Notes: Data are monthly. The pre-target sample runs from January 1984 through January 1991, and the post-target sample runs from February 1991 through December 1997. Numbers in parenthesis are *t*-statistics. In panel B, the Lagrange Multiplier (LM) test statistics for 1st order serial correlation and for the omission of an additional lagged inflation term are distributed χ^2_1, and the statistics for 4th-order serial correlation are χ^2_4; p-values appear below the test statistics. The results in panel C are based in a regression of inflation on a constant, one lag of inflation, and one lag of the unemployment rate; the independent variables are interacted with a dummy variable equal to one after the adoption of an inflation target in February 1991.

Table 6

Monetary Policy Reaction Function
Canada

Coefficient on:					Difference:				LM test
	Pre-target		Post-target		Post – pre				for 1st order
r_{t-1}	π^6_t	u_t	π^6_t	u_t	π^6_t	u_t	R^2	SE	serial corr.
0.92	0.10	–0.06	–0.10	–0.01	–0.20	0.05	0.95	0.66	3.28
(32.07)	(1.15)	(1.00)	(1.10)	(0.14)	(1.62)	(0.40)			0.07

Notes: Data are monthly. The pre-target sample runs from January 1984 through January 1991, and the post-target sample runs from February 1991 through December 1997. Numbers in parenthesis are *t*-statistics. The dependent variable in the regression is the overnight rate. The regression also includes an intercept, which is not reported; all variables are interacted with a dummy variable equal to one after the adoption of the inflation target in February 1991. The Lagrange Multiplier (LM) test statistics for 1st order serial correlation is distributed χ^2_1; the p-values appears below the test statistic.

Table 7

Response of Interest Rates to Unanticipated Inflation
Canada

Rate	Model	Coefficient on inflation surprise			R^2
		Pre-	Post-	Difference	
Overnight	AR	–0.75	–4.54	–3.79	0.003
		(0.15)	(0.86)	(0.51)	
	YC	0.29	–5.20	–5.49	0.003
		(0.06)	(0.99)	(0.75)	
Bond	AR	2.95	0.70	–2.25	0.007
		(0.87)	(0.19)	(0.45)	
	YC	3.03	1.45	–1.57	0.008
		(0.89)	(0.40)	(0.32)	

Notes: Data are monthly. The pre-target sample runs from January 1984 through January 1991, and the post-target sample runs from February 1991 through December 1997. Numbers in parenthesis are *t*-statistics. The dependent variable in the regression is the three-month change in the interest rate. The independent variables are a constant and a measure of the unanticipated three-month change in inflation; both are interacted with a dummy variable equal to one after the adoption of the inflation target in February 1991. For the results labeled AR, the unanticipated change is the residual from a regression of the three-month-ahead rate of inflation on a constant, two lags of inflation and one lag of unemployment. A similar procedure is used for the results labeled YC, but the regressors are two lags each of inflation, the overnight rate, and the 10-year bond rate. Both regressions are estimated separately over pre-target and post-target subsamples.

Table 8

Time Series Properties of the Inflation Rate
New Zealand

A. Autocorrelations of inflation rate, pre- and post-target

Sample	1	2	3	4
Pre-target	0.65	0.32	0.13	–0.06
Post-target	–0.19	–0.05	–0.26	0.09

B. Inflation regression, estimated over pre- and post-target samples

						LM tests		
	Coefficient on:					serial correlation		add'l
Sample	const	π_{t-1}	u_{t-1}	R^2	SE	1st ord	4th ord	π term
Pre-target	4.27	0.64	–0.29	0.49	3.51	0.31	6.48	0.30
	(1.04)	(3.62)	(0.48)			0.58	0.17	0.58
Post-target	2.24	–0.06	–0.02	0.01	0.85	0.76	5.61	0.04
	(3.07)	(0.35)	(0.24)			0.38	0.23	0.85

C. Tests for structural change in the inflation regression

Coefficient on:				Difference:	
Pre-target		Post-target		Post – pre	
π_{t-1}	u_{t-1}	π_{t-1}	u_{t-1}	π_{t-1}	u_{t-1}
0.64	–0.29	–0.06	–0.02	–0.70	0.27
(4.90)	(0.66)	(0.12)	(0.08)	(1.29)	(0.52)

Notes: Data are quarterly. The pre-target sample runs from 1982Q1 through 1990Q4, and the post-target sample runs from 1991Q1 through 1998Q2. Numbers in parenthesis are *t*-statistics. In panel B, the Lagrange Multiplier (LM) test statistics for 1st order serial correlation and for the omission of an additional lagged inflation term are distributed χ^2_1, and the statistics for 4th-order serial correlation are χ^2_4; p-values appear below the test statistics. The results in panel C are based in a regression of inflation on a constant, one lag of inflation, and one lag of the unemployment rate; the independent variables are interacted with a dummy variable equal to one after the adoption of an inflation target in 1991Q1.

Table 9

Monetary Policy Reaction Function
New Zealand

Coefficient on:					Difference:				LM test
	Pre-target		Post-target		Post – pre				for 1st order
r_{t-1}	π^2_t	u_t	π^2_t	u_t	π^2_t	u_t	R^2	SE	serial corr.
0.59	0.50	0.58	0.65	–0.18	0.15	–0.75	0.86	2.05	2.75
(7.87)	(5.86)	1.90	(0.93)	(0.81)	(0.22)	(2.02)			0.10

Notes: Data are quarterly. The pre-target sample runs from 1982Q1 through 1990Q4, and the post-target sample runs from 1991Q1 through 1997Q4. Numbers in parenthesis are *t*-statistics. The dependent variable in the regression is the RBNZ discount rate. The regression also includes an intercept, which is not reported; all variables are interacted with a dummy variable equal to one after the adoption of the inflation target in 1991Q1. The Lagrange Multiplier (LM) test statistics for 1st order serial correlation is distributed χ^2_1; the p-values appears below the test statistic.

Table 10

Response of Interest Rates to Unanticipated Inflation
New Zealand

Rate	Model	Coefficient on inflation surprise			R^2	DW
		Pre-	Post-	Difference		
Discount	AR	6.16	–7.51	–13.66	0.004	2.42
		(0.47)	(0.13)	(0.24)		
	YC	–2.40	28.29	30.70	0.004	2.24
		(0.18)	(0.44)	0.46		
Bond	AR	3.17	16.46	13.28	0.010	2.11
		(0.46)	(0.55)	(0.43)		
	YC	6.20	38.91	32.71	0.044	2.19
		(0.94)	(1.27)	(1.04)		

Notes: Data are quarterly. The pre-target sample runs from 1982Q1 through 1990Q4, and the post-target sample runs from 1991Q1 through 1997Q4. Numbers in parenthesis are *t*-statistics. The dependent variable in the regression is the quarterly change in the interest rate. The independent variables are a constant and a measure of the unanticipated one-quarter change in inflation; both are interacted with a dummy variable equal to one after the adoption of the inflation target in 1991Q1. For the results labeled AR, the unanticipated change is the residual from a regression of the three-month-ahead rate of inflation on a constant, one lag of inflation and one lag of unemployment. A similar procedure is used for the results labeled YC, but the regressors are one lag each of inflation, the discount rate, and the 10-year bond rate. Both regressions are estimated separately over pre-target and post-target subsamples.

Data appendix

United Kingdom
The Bank for International Settlements (BIS) is the source for all data series. Core inflation is derived from the RPIX, and is seasonally adjusted using the X11 procedure.

Canada
All data, except the inflation rate, are from the BIS. The short-term interest rate is the overnight interbank rate. The bond rate is the 10-year Government bond yield. Inflation is derived from the CPI excluding indirect taxes, seasonally adjusted, obtained from the Bank of Canada.

New Zealand
Interest rate data are from the BIS. The short rate is the Reserve Bank of New Zealand (RBNZ) discount rate, and the bond rate is the yield on 10-year Government bonds. Inflation and unemployment data were obtained from the RBNZ. Inflation is derived from the CPI excluding credit services.