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Does Inflation Targeting Matter? A Reassessment

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Does Inflation Targeting Matter? A Reassessment

Abstract

A number of countries have adopted inflation targeting and a substantial literature exists on the virtues of inflation targeting in reducing inflation (e.g. Bernanke *et al.* (1999)). However, results in the existing empirical literature conflict. This paper uses a number of identification approaches (instrumental variables, assumptions about heteroscedasticity, panel fixed effects and a potential natural experiment) to estimate the effect of inflation targeting on inflation for a sample of OECD countries. Generally, it finds the effect is small and insignificant. It also finds little evidence that inflation variability, inflation uncertainty, inflation volatility or inflation expectations fall with targeting suggesting that inflation targeting does not affect a number of variables likely to be of interest to policy makers.

1. Introduction

A number of countries have adopted inflation targeting (where the central bank is responsible for achieving a publicly announced objective for an inflation rate) and a substantial literature exists on the virtues of inflation targeting in reducing inflation (e.g., Bernanke *et al.* (1999)). However the existing empirical literature on the effect of inflation targeting presents varied results. The seminal paper is by Ball and Sheridan (2003). They compare the inflation performance of inflation targeters to those of non-targeters amongst a sample of developed economies (using cross-sectional least squares analysis) and find that while inflation targeters reduced their inflation rates after inflation

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3 targeting, this effect goes away once controls for past inflation performance are
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5 introduced. They suggest that this is due to regression to the mean. However the
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7 subsequent literature has raised various concerns with these results.
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12 One line of the subsequent literature has sought to address the concern that using cross-
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14 sectional variation does not provide convincing evidence of the causal effect of inflation
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16 targeting and also is likely to provide imprecise estimates. Wu (2004a), using fixed time
17
18 and country effects, finds that OECD countries that were inflation targeters had lower
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20 inflation rates even after controlling for past inflation. In a revised version of his paper
21
22 (2004b), Wu recognizes the problems with using differences in differences estimators. He
23
24 argues that a valid approach to deal with this problem is to use Arellano-Bond panel
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26 estimation (1991) as long as the errors are not serially correlated. He finds no evidence of
27
28 serial correlation and hence argues that his estimates, which suggest inflation targeting
29
30 significantly reduces inflation, are reliable.
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39 A number of other papers, in addition to Wu's, have also concluded that inflation
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41 targeting has a significant effect on inflation. However these other papers that find a
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43 significant effect from being an inflation targeter typically include developing economies
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45 in the sample, which may mean they are less relevant for assessing the effects of inflation
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47 targeting for developed economies. For example, Levin *et al.* (2004), IMF (2005),
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49 Petursson (2004) and Truman (2003) look at the effect of inflation targeting on samples
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51 that include developing countries and also find that inflation targeting appears to matter.
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55 Vega and Winkelried (2005) present results for both developing and industrialized
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3 countries using matching methods (rather than least squares regression analysis which has
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5 often been used in the literature) which suggest that inflation targeting has a significant
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7 effect on inflation. Notably they present evidence that inflation targeting has an effect on
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9 inflation for a sample that just includes industrialized countries.¹ Mishkin and Schmidt-
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11 Hebbel (2006) also analyze a set of developing and developed economies using a variety
12
13 of techniques. I view their results as complementary as they use different techniques and
14
15 have a different focus. Their results are consistent with mine as they tend to find that the
16
17 effect of inflation targeting is insignificant or marginally significant for developed
18
19 economies. Some of their results could be viewed as potentially problematic due to what
20
21 they concede is an inadequate set of instruments. De Mendonca (2007) compares the
22
23 behavior of key variables before and after inflation targeting and the inter-relationship of
24
25 these variables before and after inflation targeting for a number of inflation targeters and
26
27 argues that it provides evidence that inflation targeting has improved economic outcomes.
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29 However as the results are not compared to how non-targeters performed it is difficult to
30
31 assess whether the results could be driven by other factors like the great moderation and
32
33 globalization which may have made it easier to have low interest rates and inflation rates
34
35 while maintaining good rates of growth. In addition the results of De Mendonca are based
36
37 on both advanced and emerging economies. While a number of papers suggesting that
38
39 inflation targeting is helpful in changing inflation outcomes, there is some analysis
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41 consistent with Ball and Sheredian's conclusions, with Grenec *et al.* (2007) finding that,
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51 ¹Differences between Vega and Winkelried's conclusions and those presented here could also be due to the
52 different identification approaches employed. For example, the preferred panel results in this paper rely on
53 more lags (e.g. a larger information set). In addition the nature of the identification assumptions is different
54 (they use matching methods and the methods used here include instrumental variable techniques). Heckman
55 and Navarro-Lozano (2004) provide some discussion about different identification approaches. Wilde and
56 Hollister (2007) provide some evidence that propensity score matching methods may perform poorly in at
57 least some circumstances. Using alternative identification strategies like the methods used here can be
58 useful in light of this.
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3 for four advanced economy inflation targeters, inflation after inflation targeting is
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5 statistically indistinguishable from the inflation process before, though inflation is
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7 somewhat lower.
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12 Another strand of the literature concerns whether it is valid to conclude from Ball and
13
14 Sheridan's results that inflation targeting has been irrelevant for inflation. Hyvonen
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16 (2004) confirms Ball and Sheridan's result that lagged inflation is important for
17
18 explaining the recent inflation performance of OECD countries. However Hyvonen finds
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20 that lagged inflation does not help predict inflation in the 1970s. Hyvonen also finds
21
22 reversion to the mean in inflation when developing countries are included in the sample
23
24 for the 1990s. Hyvonen interprets these results as being consistent with a global policy of
25
26 inflation targeting in the 1990s whether or not countries formally adopted inflation
27
28 targets.² This suggests that perhaps any regime which is focused on keeping inflation low
29
30 may be effective in achieving low inflation.³ Another concern, raised by Gertler (2005)
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32 and supported by the results in Mishkin and Schmidt-Hebbel (2001), is that the decision
33
34 to be an inflation targeter is potentially endogenous.
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43 My paper reassess whether inflation targeting reduces inflation, inflation variance,
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45 inflation variability, inflation uncertainty or inflation expectations, as these are likely to
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47 be of most interest to an inflation targeting body like a central bank. Given the conflicting
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49 evidence, one of the paper's purposes is to resolve the different results of Wu and Ball
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55 ² However changes in inflation behavior between the 1970s and 1990s could also be due to other factors
56 like greater globalization.

57 ³ Gertler (2005) also makes a related point about whether central banks may be inflation targeters even if
58 they are not officially categorized as such.
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3 and Sheridan. In addition to reconciling these two sets of results, instrumental variables
4
5 and other identification approaches are used to provide more evidence about the likely
6
7 effect of inflation targeting on inflation. To preview the results, using a number of
8
9 estimation approaches there is little evidence that inflation targeting has an economically
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11 or statistically significant effect on inflation. This conclusion is compelling as (a) a
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13 dataset is used which had previously been used to argue that inflation targeting was
14
15 significant and (b) a number of existing results in the literature are confirmed. It also
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17 finds little evidence that inflation targeting has a significant effect on inflation variance,
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19 inflation variability, inflation uncertainty or inflation expectations. (The notions of
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21 inflation variance, variability and uncertainty are clarified below.)
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29 **2. Method**

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34 First I seek to reconcile Wu's and Ball and Sheridan's results. Wu's (2004a) results use
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36 panel data with country and time fixed effects with a dummy variable, indicating whether
37
38 the country is currently an inflation targeter. Ball and Sheridan run cross-country
39
40 regressions examining what factors affected how inflation changed from roughly 1960-85
41
42 to the 1990s (when inflation targeting was practiced). The regressions Ball and Sheridan
43
44 ran are essentially of the form:
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46

$$47 \Delta\pi_i = \alpha + \beta T_i + \psi \pi^*_i + \varepsilon_i \quad (1)$$

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49 where change in π is the difference in inflation between the current and past (when no
50
51 countries practiced inflation targeting) periods, π^* is the pre-inflation target inflation rate
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3 and T is the indicator for being an inflation targeter. i is the country index. Wu's
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5 regressions are variants of

$$\Delta\pi_{it} = \alpha_i + \delta_t + \beta T_{it} + \psi\pi_{it-1} + \varepsilon_{it} \quad (2)$$

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10 where i is the country index and t indicates the time period where he uses quarterly data.

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Prima facie, the panel estimates use more observations than the cross-sectional estimates, so the estimates from the panel are likely to be more precise. However, Bertrand, Duflo and Mullianathan (2002) discuss how the panel approach, when there is serial dependence in both the dependent variable and in the treatment variable (i.e. the indicator that the country is an inflation targeter), will lead to misleading standard errors. As there is persistence through time in both inflation and the inflation targeting dummy, this seems like a potential concern here. So I use a number of approaches that are immune to this problem.

Using Wu's data, a specification similar to that of Ball and Sheridan, which compares average inflation before and after the inflation targeting period, was run. Though the ordinary least squares standard errors are correct, the estimates may be less precise as the number of data points are reduced by aggregating the data. In this paper, regressions similar to Wu's (2004b) have been rerun using the Arellano-Bond estimation technique. These results suggest that Ball and Sheridan's results and conclusions are supported by Wu's data.

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3 Because of potential endogeneity, Ball and Sheridan's ordinary least squares results do
4 not necessarily imply that inflation targeting was irrelevant for the lowering of inflation
5 in inflation targeting countries. For example countries with histories of high inflation or
6 expecting future high inflation are more likely to have felt compelled to adopt inflation
7 targets. There are a number of ways to account for endogeneity. The first and more
8 obvious approach is to use instruments for being an inflation targeter. I will use as
9 instruments (a) a dummy for being an English speaking country⁴ and (b) the interaction
10 between this and having high inflation. This identification approach assumes that sharing
11 a common language leads to the central bank and government being more likely to be
12 influenced by the same theories about how to effectively fight inflation. Cukierman *et*
13 *al.*'s (1992) measure of central bank independence in 1980-89 will also be used as an
14 instrument as central banks that had less historical independence may have had greater
15 need to become inflation targeters to indicate that they would be vigilant in fighting
16 inflation. Consistent with this, Boschen and Weise (2004) provides some evidence that
17 independence effects inflation performance. As a third instrument, benefit entitlements
18 during the 1980s will be used. Di Tella and MacCulloch (2001) argue and provide some
19 empirical evidence that higher unemployment benefits may mean the central bank is less
20 concerned about the costs of unemployment and hence focuses more on reducing
21 inflation. By this reasoning, economies which have had histories of low unemployment
22 benefits and/or high inflation are more likely to be perceived to lack a credible
23 commitment to low inflation and hence are more likely to adopt inflation targeting to try
24 to gain credibility.

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4 Australia, Canada, New Zealand, the UK and the US are treated as English speaking countries.

One potential concern is the validity of these instruments. It is not clear how language should directly affect the inflation process. So the language variable is plausibly a valid instrument. The Cukierman *et al.* independence measure is also a plausibly valid instrument if it is believed the direct effect of past central bank institutions and credibility on current inflation is adequately captured by the past inflation performance (which is included as a control).⁵

Another identification approach is employed which does not rely on an instrument. It assumes that the structural model can be represented as follows:

$$\begin{aligned}\Delta\pi_i &= \alpha + \beta T_i + \psi\pi_i^* + \varepsilon_i \\ T_i &= \delta + \rho\pi_i^* + u_i\end{aligned}\tag{3}$$

So the first equation describes inflation determination and the second equation is a selection equation for being an inflation targeter (where it is assumed the probability of treatment is δ plus ρ time past inflation). With these assumptions, the following two equations can be estimated by least squares consistently:

$$\begin{aligned}\pi_i &= (\alpha + \beta\delta) + (1 + \beta\rho + \psi)\pi_i^* + (\beta u_i + \varepsilon_i) \\ T_i &= \delta + \rho\pi_i^* + u_i\end{aligned}\tag{4}$$

The variance for the treatment equation is $(\delta + \rho\pi_i^*)(1 - \delta - \rho\pi_i^*)$. (This is because treatment is a binary variable.) Using this result, the covariance matrix for the reduced form errors are:

⁵ A potentially more plausible concern is that unemployment benefits in the 1980s may not be a valid instrument. Specifically, 1980s unemployment benefits may affect central bank behavior in the 1990s, through mechanisms other than their role in whether the central bank became an inflation targeter. For example, as unemployment benefits are relatively persistent, 1980s benefits could also be correlated with central bank behavior in the 1990s through their correlation with benefits in the 1990s. Again if the direct effect of past benefits on current inflation is adequately captured by past inflation performance, the instrument is valid.

$$\left(\begin{array}{cc} \sigma_{\varepsilon}^2 + \beta(\delta + \rho\pi_i^*)(1 - \delta - \rho\pi_i^*)(\beta + 2e_1 - 2e_0) & (\delta + \rho\pi_i^*)(1 - \delta - \rho\pi_i^*)(\beta + e_1 - e_0) \\ (\delta + \rho\pi_i^*)(1 - \delta - \rho\pi_i^*)(\beta + e_1 - e_0) & (\delta + \rho\pi_i^*)(1 - \delta - \rho\pi_i^*) \end{array} \right) (5)$$

where σ_{ε}^2 is the variance of inflation and e_1 and e_0 are the expected values of the structural error for inflation given treatment and non-treatment.

Based on the assumptions made so far, the parameter of interest, β , can not be identified.

However, beta can be identified by making any one of a number of assumptions. One is to assume that the structural error on the first equation in the system described by (3)

varies depending on whether the country was a high or low inflation country in the past.⁶

One potential motivation for this is that inflation volatility increases with the level of inflation, which has been argued elsewhere.⁷ A natural way of capturing this is to assume that countries that had higher than average inflation in the past have a structural error for inflation which is A times the size of the structural error of low inflation countries (so the variance is A squared times bigger and the covariance with the other structural error is A times bigger). This will result in the covariance of the reduced form errors differing between the high and the low inflation countries. An alternative view might be that central banks with histories of past high inflation may be more vigilant at mitigating the effect of extreme inflation shocks in the future and hence that A may be less than one.

Either way, as long as A does not equal one, we can estimate beta and the other parameters using GMM.⁸

⁶ This is an application of Rigobon's (2003) approach of using heteroscedasticity to identify the parameter of interest, though here the treatment variable is binary. For estimation, the additional moment condition that $P(T=1)e_1 + P(T=0)e_0 = 0$ (as $E(\varepsilon) = 0$) is used.

⁷ Andersen and Gruen (1995) observe that average inflation is correlated with inflation variability.

⁸ The assumption that parameters like β and ψ are the same for the high and low inflation countries could be concerning. However as this assumption is standard in the literature, it seems like a natural assumption to make in any attempt to reconcile apparently conflicting results in that literature.

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6 Analysis is also reported which examines inflation performance of particular country
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8 pairs during the recent increase in oil prices using difference in differences. In addition
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10 some analysis is reported on how inflation targeting influences inflation volatility,
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12 variability, persistence, uncertainty and inflation expectations.
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17 **3. Results**

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22 To reconcile the Wu and Ball and Sheridan results, first I use Wu's data to estimate
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24 models very similar to Ball and Sheridan's. Specifically I estimate cross-sectional models
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26 where inflation is average quarterly inflation from 1995 and past inflation is average
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28 quarterly inflation from 1985 to 1989.⁹ This essentially captures the periods before
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30 treatment (no country was an inflation targeter before 1990) and after treatment.¹⁰ Past
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32 inflation is included as a control as this could effect both current inflation and the
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34 decision to become a targeter.
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41 As a simple check for whether the results appear sensitive to potential endogeneity bias,
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43 instrumental variables regressions are estimated. There is some evidence that the
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45 instrumental variable estimation is reasonable. The F tests of the first stage regression
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47 suggest that the instruments are good predictors of being an inflation targeter. At least
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49 some of the coefficients are consistent with reasonable priors. For example, English
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54 ⁹ For more details about the data, refer to the Appendix.

55 ¹⁰ Except for the following cases, all inflation targeters in the sample were consistently targeting after
56 1995. Switzerland became an inflation targeter in 2000 and for the purposes of the cross-sectional analysis
57 is considered a non-targeter. Spain and Finland were targeters until 1999 when they adopted the euro.
58 They are treated as inflation targeters for the cross-sectional analysis.
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3 speaking countries with high past inflation are more likely to be targeters and countries
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5 with histories of high unemployment benefits are less likely to be targeters.¹¹ As a
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7 robustness check, I also examine whether the results are sensitive to stopping the sample
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9 at 1999 when arguably the institutional arrangements of many countries become less
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11 clear because of the beginning of the European Monetary Union.
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18 Both the IV and OLS results (Table 1) suggest that targeting in almost all specifications
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20 have an insignificant effect of inflation. Moreover the coefficient on the targeting variable
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22 is of roughly the same order of magnitude as Ball and Sheridan's estimates and is about
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24 one-third the size of Wu's.¹² It is known that these cross-sectional results do have reliable
25
26 standard errors so *prima facie* these results confirm Ball and Sheridan's findings that
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28 inflation targeting has a small and insignificant effect and at best Wu's results are
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30 different because of the increased number of observations available from using quarterly
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32 data. To the extent that the goal of inflation targeting is primarily about reducing the
33
34 *medium term* inflation rate then Ball and Sheridan's finding disturbingly suggests that the
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36 effect is small (even if Wu's estimation procedure is robust). The estimates generally
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38 imply the long run affect on inflation targeting is to reduce quarterly inflation by roughly
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40 0.1 to 0.3 percentage points per quarter (depending on the estimates chosen in Table 1).¹³
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49 11 Both the English speaking and the Cukierman variables are included as variables in column (4) of Table
50 1 as the Cukierman variable is a weak instrument when used by itself. In column (5) of Table 1, the
51 summary measure of benefit entitlements over 1979-1985 given in Table 8.2 of OECD (1994) is used as an
52 instrument. It is basically the benefits entitlement before tax as a percentage of previous earnings before
53 tax averaged over various earning levels and years of the unemployment benefit (see OECD (1994) for
54 more details).

55 12 The only regression to result in a significant and somewhat more substantial estimate for the targeting
56 coefficient is in the 11th column of Table 1. One could be skeptical about the weight to put on this result
57 because the result is not robust.

58 13 The last column however implies that inflation would fall by about 0.6 percentage points in the long run.
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3 Two additional points concerning the IV estimation are of note. First, the similarity of the
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5 IV and OLS results indicates that while there may be some endogeneity bias, it is not
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7 large. Second the F tests reported in the second last row of Table 1 give evidence on the
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9 strength of the instruments used for identification. Based on the rule of thumb in the weak
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11 instruments literature that the first stage F test be around 10 or higher, they seem to be at
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13 least arguably satisfactory (see for example Stock and Watson (2003) however there is
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15 discussion in Stock and Yogo (2002) about how this may be considered too conservative
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17 a rule under some criteria and too generous under others).
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24 INSERT TABLE 1
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29 Using the cross-sectional data the treatment coefficient can be identified by examining
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31 the estimated covariance matrix of the reduced form equations (see the discussion above).
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33 Using inflation after 1995 as the measure of inflation during the treatment period, beta is
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35 roughly -0.1 which is fairly small and insignificant and implies that in the long run
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37 inflation targeting reduces inflation by about 0.1 percentage points (see Table 2). This
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39 seems consistent with the results in Table 1 – that the coefficient is close to zero and
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41 insignificant. Moreover some of the other parameter point estimates are consistent with
42
43 reasonable priors. Higher inflation is associated with higher inflation in the future and
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45 higher past inflation is associated with being a targeter. The scale factor, A , is different in
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47 absolute value from one though it is imprecisely estimated.¹⁴
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54 INSERT TABLE 2
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58 ¹⁴ Broadly similar results are obtained using alternative cut-off points for high and low inflation in the past.
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4 As already discussed, Wu's original paper (2004a) used difference in difference
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6 estimation to estimate the effect of targeting which can lead to misleading standard
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8 errors. In a revised version of Wu's paper (2004b), he recognizes the problems of using
9
10 differences in differences estimators and uses Arellano-Bond panel estimation. His
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12 specifications include a time trend and one lag. He tests and finds no serial correlation at
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14 the 5 percent significance level arguing that this suggests his estimates are reliable. While
15
16 a treatment effect of similar magnitude is found here when using one lag for inflation (see
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18 Table 3), I find that higher order lags are significant. The preferred specification has 12
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20 lags of inflation, as for the three possible models (without time effects, with a time trend
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22 and with time fixed effects) the 12th lag is significant and the 4 and 8 lag models show
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24 signs of serial correlation. This suggests Wu's results are likely to be affected by omitted
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26 variable bias. When additional lags are included the targeting variable becomes
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28 insignificant (or marginally significant) in the specification with time fixed effects (which
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30 is arguably the preferred specification) suggesting there is no statistically significant long
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32 run effect on inflation from inflation targeting.
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47 Two potential concerns with the above results are that (a) the instruments used in the
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49 Arellano-Bond estimation may be weak and (b) the inclusion of 12 lags may be
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51 excessive, leading to inefficient estimates. Regarding the first concern, simple regressions
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53 of the first difference of inflation on its lag are highly significant (with t statistics of
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55 around 11 or more, in absolute value, whether the model is specified without time effects,
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3 with a trend or with time fixed effects) suggesting that the instruments are not weak. A t
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5 statistic of around 11 (which is equivalent to a F statistic of about 121) is well above the
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7 rule of thumb for a F statistic of around 10 suggested in the weak instrumental variable
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9 literature.
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15 Regarding the second concern, the target variable is insignificant and of a similar order of
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17 magnitude once four lags are included in either the specification with time fixed effects
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19 or with a time trend, suggesting that the results are not being driven by overspecification
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21 of the model.¹⁵
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27 Based on the evidence so far, there is at best only weak evidence that inflation targeting
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29 contributed to the reduction in inflation experienced in developed countries in the 1990s.
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31 While this suggests that inflation targeting may not have been critical in reducing
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33 inflation, there are a number of reasons to think the data may not be informative about
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35 whether inflation targeting can help moderate inflationary pressures. First, global
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37 inflationary pressures have been relatively benign since the early 1990s so it is difficult to
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39 assess from the data whether inflation targeting is able to maintain low inflation when
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41 there are serious inflationary pressures. Second, many inflation targeters did not adopt
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43 formal targets until inflation had moderated in the 1990s (Canada and New Zealand are
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45 important exceptions to this) so there are not many examples on which to assess whether
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51 15 It appears that the exact number of lags does not significantly affect the results. The estimated long run
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53 impact with 4 lags is -0.58*, -0.24 and -0.13 (for the specifications with no time effects, trend and fixed
54
55 time effects respectively) while with 16 lags it is -0.58*, -0.31 and -0.01, where * indicates significance at
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57 the 5 per cent level. There is some evidence that at least 17 lags should be included in the specification.
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59 However in order to maintain a reasonable number of observations from the 1980s the preferred
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specification includes 12 lags. Also note that throughout the paper, generally results are reported with
robust standard errors. This reduces concerns of incorrect inference due to heteroscedasticity (which might
be a concern given Table 5).

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3 inflation targeting helped in reducing inflation initially. This seems most relevant for the
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5 panel data analysis. Third to the extent that the existence of inflation targeting caused an
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7 increase in the focus on the costs of inflation during the 1990s and the need to reduce
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9 these costs throughout the developed world, inflation targeting may have played a role in
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11 the global decrease in inflation during the past decade. Finally the apparent insignificance
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13 could be because the analysis has assumed that the effect of inflation targeting on
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15 countries that introduced inflation targeting early (e.g. New Zealand and Canada) is the
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17 same as the effect on late adopters. This may not be true as the early adopters had explicit
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19 targets to achieve reductions in inflation while the late adopters did not. There is some
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21 evidence that the experience of inflation targeters is heterogeneous. Assuming inflation is
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23 an AR(4) process, simple F statistics for structural breaks suggest that the most likely
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25 date for a structural break only occurred near the introduction of inflation targeting for
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27 early adopters (New Zealand, Canada and the UK).¹⁶
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35 One possible approach to address these concerns is to focus more specifically on similar
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37 country pairs (where one country is a targeter and the other is not) and to focus on an
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39 episode near the end of the sample when there was a natural experiment that led to higher
40
41 inflationary pressures. Arguably the recent increases in energy prices provide such a
42
43 natural experiment. Plausibly Canada and the US are reasonably similar as are Sweden
44
45 and Finland, as each pair has generally reasonably similar institutions and Figure 1
46
47 indicates that in the early 1990s the countries in each pair had similar inflation
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56 16 The evidence is somewhat mixed as by the Andrews' statistic (1993) the NZ and UK breaks are not
57 statistically significant. Note that for this F statistic and Figures 1 and 2 inflation data to 2005 is used. This
58 captures the effect of the oil price rise from the beginning of this decade.
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3 outcomes.¹⁷ As energy prices inflation increased significantly after 2002 (US consumer
4 energy prices rose by over 50 percent from Q4 2002 to Q 4 2005), I define the treatment
5 period as beginning in 2003 and find there is little evidence of inflation targeting having a
6 significant effect on inflation (see the interaction term in Table 4). In case there are
7 concerns that including all four countries in the same regression may be problematic
8 because of cross-country pair heterogeneity, results for each country pair are also
9 reported. Figure 1 which compares the inflation performance of Canada (with the United
10 States, a non-targeter) and Sweden (with Finland, a non-targeter over this decade) suggest
11 that alternative specifications of the treatment period would yield similar results.¹⁸
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27 INSERT Figure 1: Energy Prices and Inflation
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32 As with the other identification strategies, this approach has its potential limitations. For
33 example, it cannot shed any light on whether inflation targeting assisted in the transition
34 from high inflation outcomes. It can only shed light on the effect of inflation targeting
35 when an economy with low inflation experiences inflationary pressures. One might argue
36 that the energy price increase had minimal effect on prices and so there was no significant
37 natural experiment. However even under extreme inflationary pressures, inflation may
38 not rise noticeably if policy is effective at keeping inflation low (whether or not an
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49 17 Also for all four economies energy has a similar weight in the CPI of around 8 per cent, though of
50 course energy prices are an important input for many goods so the effect of energy prices on the CPI is
51 potentially much higher.

52 18 This section uses more recent data than that used in the previous cross-sectional and panel data analysis
53 (and used by Wu) so it includes the recent oil price increase. Regressions similar to the one in the first
54 column of Table 4 have been estimated with four lags of inflation (using the Arellano Bond estimation
55 technique). They suggest that the interaction term is small and insignificant with estimates (and standard
56 errors) of 0.01 (0.04), 0.02 (0.16) and 0.03 (0.15) for the model with no time effects, a time trend and time
57 fixed effects. The implied long run effects on inflation are the same as the point estimates in each case.
58 This suggests that the results in Table 4 are robust to the inclusion of lags of inflation.
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3 inflation targeting strategy is employed). It seems reasonable to interpret this result (and
4
5 the others above) as suggesting that inflation targeting has little effect on inflation
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7 outcomes or, at least, that it is difficult to find evidence inflation targeting mattered
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9 during the sample period.
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15 INSERT TABLE 4
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20 A general concern with the above analysis is that it focuses on whether inflation targeting
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22 affected average inflation performance. Inflation targeting may be adopted not only to
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24 reduce average inflation but also to reduce inflation volatility (or deviations from an
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26 inflation target). A simple way to assess this is to estimate equation (1) replacing change
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28 in inflation with change in the standard deviation of inflation and replacing lag inflation
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30 with the lag of the standard deviation of inflation.¹⁹ Indeed Ball and Sheridan estimate
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32 least square regressions very similar to this to assess whether the volatility of inflation
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34 changes.
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41 Table 5 reports the results of estimating this equation by ordinary least squares and
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43 instrumental variables. The results are broadly consistent with Ball and Sheridan's least
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45 squares results. The targeting variable is insignificant. Moreover some of the regressions
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47 suggest that targeting if anything increased inflation volatility. The strongest evidence for
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53 19 Any comparison of deviations from target is difficult because non-targeters often do not have a simple
54 inflation target. However if each central bank has a constant inflation target, the difference between
55 average squared deviations from average inflation and average squared deviations from target is the
56 squared difference between the target and average inflation. This suggests that if it is difficult to find
57 evidence that inflation targeters have significantly reduced either average inflation or the standard deviation
58 of inflation (compared to non-targeters) then it is unlikely that targeting contributed to a reduction in the
59 deviations from target.
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3 targeting reducing inflation volatility appears in the final column which suggests that
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5 targeting reduces the long run standard deviation of quarterly inflation by less than 0.2 of
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7 a percentage point.²⁰
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12 INSERT TABLE 5
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18 Inflation targeting could also reduce the variability of inflation (how much components of
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20 inflation deviate from average inflation). It is difficult to get data to evaluate this but,
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22 using a similar approach to the one used above to assess the role of energy prices, Figure
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24 2 reports the variability of inflation for Canada, Finland, Sweden and the US based on the
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26 weighted (by component weight) squared deviation of components of inflation from
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28 headline quarter on quarter inflation.²¹ The data is volatile and there seem to be outlier
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30 observations. Nevertheless it appears difficult to clearly see that inflation variability in
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32 Sweden and Canada (the prolonged inflation targeters) have lower variability than the US
33
34 and Finland (the comparison group – neither was an inflation targeter for any of this
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36 decade and the US has never been). Indeed, it looks if anything that Sweden has greater
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38 variability than Finland, but as the data does not cover the period before Sweden became
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40 an inflation targeter (due to data availability) it is difficult to know what the role of
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42 inflation targeting is.
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53 20 The results are generally similar when, in the first stage, targeting is modeled as depending on the lag of
54 Std(Inflation) and interactions between it and other instruments (disregard the results using benefits as
55 instruments as the first stage is weak). Of the regressions estimated, targeting led, at most, to a reduction in
56 the standard deviation of 0.3 with the targeting variable being insignificant.

57 21 Over ten CPI or harmonized CPI components were used for each of the variance calculations. The
58 calculations used fixed weights and used data from Datastream and information on weights from national
59 authorities or Eurostat. More details are available on request.
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3 INSERT Figure 2: Inflation variability.
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8 Inflation targeting may also influence other aspects of the statistical properties of
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10 inflation. For example, persistence may be reduced. There has been some discussion
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12 about the most appropriate way to measure persistence (see for example Pivetta and Reis
13
14 (2007)). At least one plausible simple metric is the coefficient on lagged inflation, which
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16 regardless of how one exactly interprets the coefficient does describe in one statistical
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18 sense the relationship between current and past inflation. By this metric there is some
19
20 evidence for inflation targeting effecting the inflation process with a simple panel model
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22 of inflation as being a function of last quarter's inflation, whether one is an inflation
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24 targeter and the interaction of these two terms, indicating that interaction term is negative
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26 and significant (the coefficient is -0.7 and has a robust t value of -2.4). However this
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28 result is fragile - the coefficient becomes smaller and insignificant at the 5% level once
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30 time dummies are included. Moreover the interaction coefficient is close to twice as large
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32 in absolute terms than the lagged inflation coefficient, suggesting that past inflation has
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34 an important influence on inflation outcomes under inflation targeting.
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43 Another feature that may be influenced by inflation targeting is the level of inflation
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45 uncertainty (Here this is taken to be the variance of residuals for a given model. This
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47 seems to be consistent with how these words have been used in other contexts, e.g. Grier
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49 and Perry (1996) and Aarstol (1999), where the focus is on some notion of variance of the
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51 residuals, though often it is used in the context of a more complicated model than
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53 considered here.). Again there are many possible metrics for this (which depend on the
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3 inflation model). One simple measure is to look at the root mean square error of the
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5 residuals of a simple inflation model where inflation depends on the first lag of inflation.
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7 Comparing the root mean square error before 1990 with the root mean square error after
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9 1994, for the five inflation targeters after 1994 the root mean square error fell for two,
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11 while amongst the non-targeters only eleven of the fifteen experienced a fall in the root
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13 mean square error. (A few countries were left out of the analysis because they were
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15 inflation targeters for only some of the period.) This suggests that a fall in uncertainty by
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17 this metric was more common amongst the non-targeters. However the experience was by
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19 no means homogenous – for example both New Zealand experienced a large decline in
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21 the root mean square error.
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29 Inflation targeting may also be adopted to reduce inflation expectations. It is difficult to
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31 examine this in a totally satisfactory way, in part due to limited data on inflation
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33 expectations, especially consumer inflation expectations and especially during the pre-
34
35 targeting period. The approach I adopt here is to be pragmatic given the data constraints
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37 and estimate regressions similar to those in Table 5. Specifically I use Consensus
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39 Forecasts for inflation in 1991 based on the survey in April 1990 as my measure of pre-
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41 targeting inflation expectations and I use Consensus Forecasts for inflation in 2001 based
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43 on the survey in April 2000 as a measure of post-targeting inflation expectations. The
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45 results in Table 6 are similar to those found for inflation. Without controlling for past
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47 expectations, targeting is correlated with a decline in inflation expectations but once I
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49 control for past expectations the correlation becomes smaller and insignificant either
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3 using OLS or IV.²² These results are again consistent with inflation expectations being
4
5 mean-reverting, like inflation, though Ball and Sheridan did not examine this in their
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7 original study. Also these results seem consistent with the observation by Grenville
8
9 (1995) that New Zealand's inflation expectations came down only after actual inflation
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11 had come down (despite having an inflation target).
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18 INSERT TABLE 6
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22 Much of the above results summarize using regressions in some sense the average
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24 experience of inflation targeting on inflation related outcomes. This is valuable in
25
26 shedding light on the typical experience of an advanced economy who became an
27
28 inflation targeter. However it also in some sense does not recognize the heterogeneity of
29
30 different countries experiences. Regression analysis may not be well suited to this (in part
31
32 because looking at a smaller set of countries makes the asymptotic assumptions, which
33
34 regression analysis typically relies on, seem less satisfactory. However individual country
35
36 experiences (e.g. Canada around the early 1990s – see Figure 1) provide at least some
37
38 evidence that the introduction of inflation targeting was associated with a reduction of
39
40 inflation, though looking at such a small number of cases makes it difficult to be sure
41
42 whether the relationship is causal, as well as raising question about generalizability.
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48 Focusing on the heterogeneity of country experiences also raises other questions about
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50 what are the most appropriate features of the data to focus on. For example for euro area
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56 22 I have conducted some robustness tests which lead to similar results, looking at forecasts at different
57 horizons *etc.* Indeed many of the unreported results suggest that targeting increases inflation expectations,
58 though the effect is statistically insignificant. There are few observations to assess the variability of
59 inflation expectations before treatment so I have not estimated this.
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3 countries plausibly reducing individual country inflation rates was not the goal, but the
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5 average inflation rate of the region. Addressing these issues in greater depth is likely to
6
7 be a fruitful area for future research.²³
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10 11 12 13 **4. Conclusions**

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17 This paper has used a number of relatively simple, transparent approaches to assess the
18
19 effects of inflation targeting. While the different identification approaches employed
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21 suggest somewhat different estimates of the impact of inflation targeting on inflation for
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23 developed economies, they are generally insignificant and suggest that inflation targeting
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25 reduces quarterly inflation by something like 0.2 percentage points in the long-run.²⁴ This
26
27 suggests that inflation targeting reduces four-quarter ended inflation by on average about
28
29 0.8 percentage points which by a number of possible metrics is small. First, inflation
30
31 targeters typically have a band of one percentage point or more (e.g. Australia and New
32
33 Zealand). Also, central banks have a fairly imprecise control over inflation. Finally, 0.8
34
35 percentage points is small compared to the large drops in inflation seen in many of these
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37 countries over the sample period (e.g. inflation in New Zealand fell from around 9 per
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39 cent in 1989 to around 2 percent in 1992). Even using estimates based on specifications
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41 similar to those of Wu, this only explains a small fraction of the observed decrease in
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43 inflation.
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53 23 Future research could also look at some of the other effects of inflation targeting. Frappa and Mesonnier
54 (2009) have started work on this research agenda and found some evidence that inflation targeting may
55 have played a role in the recent increases in house prices.

56 24 For some specifications, such as the ones without time effects (which are problematic), the estimated
57 long run effect is substantially higher at roughly 0.7 percentage points, but for some specifications the
58 effect is around 0.1 percentage points or even smaller.
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6 Whatever estimation approach is adopted, the estimated effect of inflation targeting on
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8 inflation is generally small and insignificant. Long-run inflation is the ultimate target of
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10 inflation targeting central banks and so the cross-section approach of Ball and Sheridan is
11
12 most relevant. Using this approach, similar results are obtained whether or not potential
13
14 endogeneity is accounted for. While Wu's results are confirmed, there are reasons to
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16 question their reliability (as he excludes statistically significant lags of inflation). Using
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18 more lags of inflation lead to a much smaller estimated effect. Other identification
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20 approaches also generally confirm these conclusions. Also the analysis here provides
21
22 little evidence that inflation targeting reduces inflation variability, inflation uncertainty,
23
24 inflation volatility or inflation expectations. As inflation targeting does not appear to have
25
26 a significant effect on probably the three most important variables to an inflation targeter
27
28 – inflation, inflation variance and inflation expectations – it is difficult to make a
29
30 compelling argument that inflation targeting influences inflation outcomes, at least for
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32 developed economies.²⁵ This may be because the data is relatively uninformative about
33
34 the effects of inflation targeting. This could be, for example, because inflation targeting
35
36 was often introduced after inflation had already declined. However by using a number of
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38 identification approaches this paper is relatively immune from this criticism. Also the
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48 25 Some of the other existing literature (e.g. Truman (2003)) also argues that inflation targeting led to
49 better inflation related outcomes in developed countries. Truman's results however seem likely to be due to
50 the exclusion of lagged inflation from their specification which the analysis here suggests is significant.
51 Levin *et al.* (2004) argue that inflation is less persistent and the standard deviation in the change inflation
52 expectations and inflation are lower in inflation targeting countries. However, as the analysis is based on
53 comparing across countries without attempting to adjust for possible country fixed effects, the approach is
54 very different from the one adopted for most of this paper and may be more problematic. Papers including
55 developing economies (e.g. IMF (2005) and Petursson (2004)) provide more convincing evidence that
56 inflation targeting matters (though they do not use IV techniques to control for potential endogeneity). This
57 suggests that inflation targeting may be a useful monetary policy strategy for some countries, specifically
58 for developing ones.
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3 results of the paper are striking because others have argued that empirically inflation
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5 targeting does have a significant effect.
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10 The results presented above summarize in some sense the typical experience of inflation
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12 targeting for a sample of developed economies. This can hide the heterogeneity of
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14 individual country experiences. Indeed the results above about the root mean square error
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16 are an example of this. There is other evidence of this. However a cross-section least
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18 squares regressions of the change in inflation on past inflation and whether one is a
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20 targeter (as in Table 1) leads to insignificant targeter coefficients whether or not one
21
22 includes euro area economies in the analysis (though the point estimate of the effect is
23
24 negative for both regressions but closer to zero when euro area economies are excluded).
25
26 While looking at country heterogeneity can be useful in appreciating the variety of
27
28 individual country experiences (and perhaps for future research gaining insights into what
29
30 factors might be important for driving this heterogeneity), it becomes more difficult to
31
32 discern whether results are statistically significant and possibly how the results influence
33
34 one's views about the effects of inflation targeting. (For example excluding euro area
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36 countries from the analysis would reduce the sample size by around a half making it
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38 pretty small and in some ways unusual sample.)
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48 The main policy implications of this paper are to potentially clarify some aspects of
49
50 arguments for inflation targeting. These results could be interpreted as suggesting that
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52 inflation has no or at least difficult to detect effects on key policy variables like inflation
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54 (at least for developed economies). However the results are also consistent with (a) all the
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3 countries in the sample having acted in ways very similar to inflation targeters during the
4 sample period (by for example setting and communicating a policy that seeks to achieve a
5 stable rate of inflation) and/or (b) these countries not experiencing shocks to inflation that
6 were sufficiently large to demonstrate clearly the superiority of inflation targeting. If
7 either of these are true, which seem to the author reasonable, then there could still be real
8 benefits from inflation targeting. Also the increased transparency and accountability of
9 having an explicit inflation target is desirable in its own right.
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20 21 22 **Appendix A. Data Appendix** 23

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27 For most of the analysis and unless otherwise stated, Wu's data is used, which is from Q1
28 1985 to Q3 2002 for the traditional OECD country members: Australia, Austria, Belgium,
29 Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg,
30 Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United
31 Kingdom and the United States. Inflation as discussed by Wu is measures using CPI as
32 reported in the IMF International Financial Statistics.
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41 Quarterly inflation rates are used and the following are considered inflation targeters:
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43 Australia (from September 1994), Canada (from February 1991), Finland (from February
44 1993 to December 1998), New Zealand (from March 1990), Spain (from September 1994
45 to December 1998), Sweden (from January 1993), Switzerland (from January 2000) and
46 the United Kingdom (from October 1992). For some countries (like Australia) the dating
47 of inflation targeting is not straight forward. (Bernanke *et al.* (1999) notes the informality
48 with which the Australian inflation target was announced.) Here the dating of Wu has
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3 been adopted. Benefits data on Luxembourg is unavailable, so it is omitted from the
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5 relevant regressions. When lags are included the number of observations in the sample
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7 are reduced accordingly.
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Figure 1: Energy Prices and Inflation

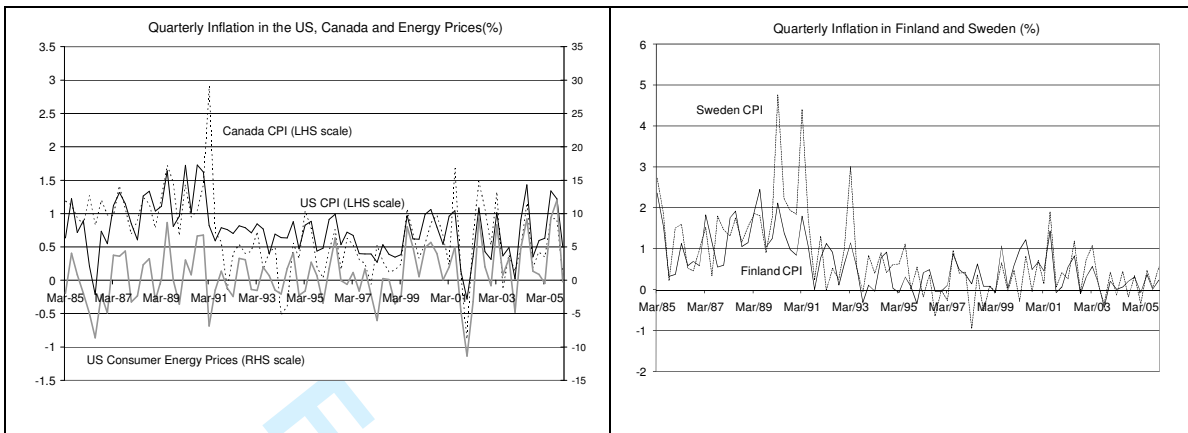


Figure 2: Inflation Variability

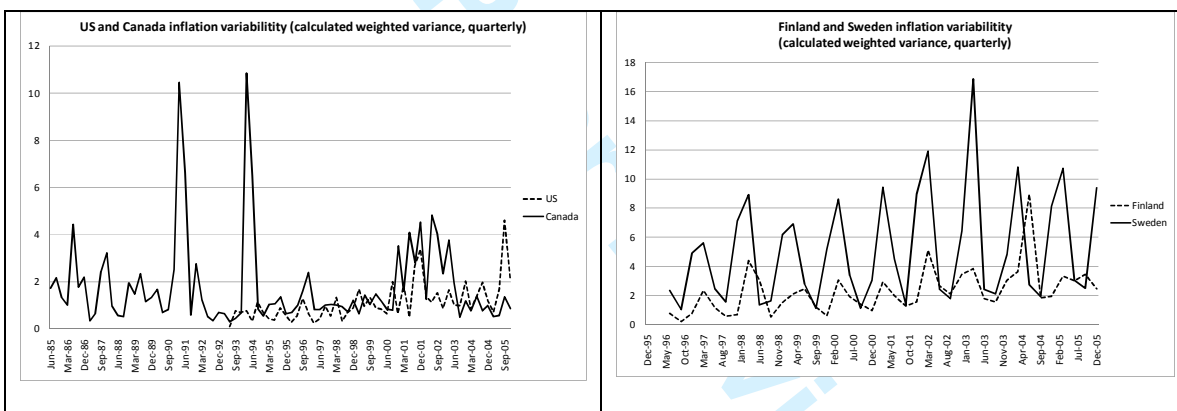


Table 1: Cross-sectional Results

Model	OLS (1)	OLS (2)	IV - 1 st stage (3)	IV - 1 st stage (4)	IV - 1 st stage (5)	IV -2 nd stage (6)	IV -2 nd stage (7)	IV -2 nd stage (8)	IV -2 nd stage (9)	IV -2 nd stage (10)	IV -2 nd stage (11)
Dependent Variable	Change in Inflation	Change in Inflation (up to 1999)	Targeter	Targeter	Targeter	Change in Inflation	Change in Inflation (up to 1999)	Change in Inflation	Change in Inflation (up to 1999)	Change in Inflation	Change in Inflation (up to 1999)
Targeter	-0.10 (0.07)	-0.19 (0.11)				-0.10 (0.14)	-0.21 (0.20)	-0.07 (0.10)	-0.18 (0.18)	-0.23 (0.12)	-0.41* (0.15)
Inflation lagged	-0.82* (0.03)	-0.74* (0.06)				-0.82* (0.03)	-0.74* (0.06)	-0.83* (0.04)	-0.75* (0.06)	-0.81* (0.03)	-0.72* (0.05)
English speaking			0.14 (0.55)#	3.02* (0.89)#							
English speaking× Past inflation			0.29 (0.26)#	-1.64* (0.68)#							
Cukierman				0.32 (0.44)#							
Cukierman× Past Inflation				-1.10 (0.81)#							
Cukierman× English speaking				-7.29* (3.21)#							
Cukierman× English speaking× Past inflation				5.10* (2.20)#							
Benefits					-0.02 (0.01)#						
Benefits× Past Inflation					0.03* (0.01)#						
Past Inflation			0.04 (0.08)	0.58 (0.43)	-0.21* (0.07)						
F test for # variables			9.15* [0.00]	30.88* [0.00]	9.88* [0.00]						
Instrument from Model						(3)	(3)	(4)	(4)	(5)	(5)

Robust standard errors in parenthesis and p values in brackets. * Significant at the 5 percent level. # indicates the variables which are jointly tested for significance in the second last row of the table.

The dependent variable is (a) whether or not the central bank became a targeter, (b) change in inflation from pre-1990 to post-1994 or (c) change in inflation from pre-1990 to 1995-1998.

Table 2: Model Estimates Based on Heteroscedasticity Assumption

δ	ρ	α	β	$1+\psi$	σ_ε	e_0	e_1	A
Constant term for targeting	Effect of past inflation on target	Constant term for inflation	Effect of targeting on inflation	Effect of past inflation on inflation	Standard Deviation for Inflation	Expected value of Inflation Error Given No Treatment	Expected value of Inflation Error Given Treatment	Scale factor for high inflation
0.19 (2.7)	0.10 (1.9)	0.37 (2.8)	-0.11 (-1.4)	0.16 (2.1)	0.19	-0.02	0.05	-0.68 (1.0)*

Point estimates and t-statistics are reported in parentheses. Estimated by efficient GMM. * This is a t statistic for A being different from -1.

Table 3: Panel Regressions of Quarterly Inflation

Target	-0.74* (0.15)	-0.36* (0.13)	-0.35* (0.16)	-0.14* (0.07)	-0.10 (0.08)	-0.005 (0.08)
Inflation lags	1	1	1	12	12	12
Country effects	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	No	No	Yes	No	No	Yes
Time trend	No	Yes	No	No	Yes	No
Autocorrelation	0.15	0.15	0.12	0.16	0.16	0.11
Test p value						
Implied Long Run Effect of IT	-0.89* (0.16)	-0.39* (0.15)	-0.39* (0.19)	-0.66* (0.20)	-0.34 (0.20)	-0.02 (0.29)

Arellano-Bond estimation of first differences regression assuming the targeting variable is exogenous. The Sargan p value for all regressions is 1. The autocorrelation test is a test of whether the average autocovariance of residuals of order 2 is zero. Robust standard errors in parenthesis and p values in brackets. * Significant at the 5 percent level.

Table 4: Effect of Energy Price Increase

Sample	Canada/Finland/Sweden/US	Canada/US	Finland/Sweden
Treatment period dummy (from 2003)	-0.05 (0.09)	0.14 (0.14)	-0.24* (0.10)
Interaction between treatment period dummy and inflation targeter dummy	0.01 (0.14)	-0.13 (0.21)	0.16 (0.19)

Each column reports the regression results for a different sample. * indicates significance at the 5 percent level. Robust standard errors are reported. All regressions include country fixed effects. The sample is Q1 1995- Q4 2005, which is well after inflation targeting was introduced so is plausibly not affected by issues to do with the transition to inflation targeting. Also plausibly during this period past inflation is less relevant for the analysis so it has been dropped from the specification.

Table 5: Cross-sectional Results for Standard Deviation - OLS and 2nd Stage IV

Model	Dependent Variable	Targeter	Std(Inflation) lagged	Instruments from 1 st stage Model
OLS	Change in Std(Inflation)	0.03 (0.10)	-0.67* (0.23)	
OLS	Change in Std(Inflation) (up to 1999)	-0.02 (0.10)	-0.60* (0.20)	
IV -2 nd stage	Change in Std(Inflation)	-0.10 (0.27)	-0.66* (0.21)	Marked # in (3) in Table 1
IV -2 nd stage	Change in Std(Inflation) (up to 1999)	-0.16 (0.25)	-0.59* (0.19)	Marked # in (3) in Table 1
IV -2 nd stage	Change in Std(Inflation)	0.04 (0.20)	-0.67* (0.23)	Marked # in (4) in Table 1
IV -2 nd stage	Change in Std(Inflation) (up to 1999)	-0.01 (0.18)	-0.60* (0.21)	Marked # in (4) in Table 1
IV -2 nd stage	Change in Std(Inflation)	-0.02 (0.19)	-0.66* (0.22)	Marked # in (5) in Table 1
IV -2 nd stage	Change in Std(Inflation) (up to 1999)	-0.12 (0.18)	-0.60* (0.20)	Marked # in (5) in Table 1

Robust standard errors in parentheses. * Significant at the 5 percent level. The dependent variable is (a) change in the standard deviation of inflation from pre-1990 to post-1994 or (b) change in the standard deviation of inflation from pre-1990 to 1995-1998. All IV results include the standard deviation of past inflation (but exclude lagged inflation) as an instrument.

Table 6: Cross-sectional Results for Inflation Expectations - OLS and 2nd Stage IV

Model	Dependent Variable	Targeter	Inflation Expectations lagged	Instruments from 1 st stage Model
OLS	Change in Inflation Expectations	-1.70* (0.52)		
OLS	Change in Inflation Expectations	-0.27 (0.24)	-0.83* (0.10)	
IV -2 nd stage	Change in Inflation Expectations	-0.63 (0.43)	-0.78* (0.12)	Marked # in (3) in Table 1
IV -2 nd stage	Change in Inflation Expectations	-0.39 (0.36)	-0.81* (0.11)	Marked # in (4) in Table 1
IV -2 nd stage	Change in Inflation Expectations	-0.32 (0.58)	-0.82* (0.10)	Marked # in (5) in Table 1

Robust standard errors in parentheses. * Significant at the 5 percent level. The dependent variable is (a) change between 1990 and 2000 inflation expectations. All IV results also include lagged inflation expectations as a non-excluded instrument. Greece and Luxembourg are not included in this sample due to data availability.