Inflation targets as a stabilisation device

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Abstract

Over 80% of countries using explicit inflation targets in 2000 were doing so either as part of a disinflation strategy, or when inflation was neither low nor stable. Our illustrative theoretical model suggests annual revisions to short-run targets are endogenous to inflation outcomes during disinflation as long as the policymaker cares about misses from both the short-run target and a long-run target. Furthermore, target revisions will are larger when the target is undershot compared to when the target is overshot. We confirm the result using cross-country panel estimates from a unique data-set of inflation target misses in 60 countries in the 1990s. During disinflation it is therefore relatively difficult to separate decisions about target-setting from implementation. Short-term targets on a disinflation path may be more akin to conditional forecasts than policy rules, but their publication may nevertheless increase transparency and hence help policymakers to achieve lower inflation.

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1) Introduction

Over 50 countries were using an explicit inflation target in 2000. Over three-quarters of these countries were doing so as part of a disinflation process. Such paths to price stability are frequently bumpy. This paper is a theoretical and empirical interpretation of how policymakers have used inflation targets to enhance credibility when the short-run target is above the long-run target, and when inflation outcomes may differ markedly from each target. We focus on the implications for target-setting, policy reactions, framework design and credibility-building.[2] The issues are of interest to the large number of floating exchange rate countries implementing a disinflationary strategy, and to industrialised countries contemplating how their inflation-targeting framework might operate in less benign economic conditions than have usually been faced since the early 1990s.

The adoption of inflation targets in low-inflation economies has frequently been associated with more comfortable institutional arrangements. These arrangements have often provided a clear role for each of the central bank and government in setting inflation targets and in deciding upon policy interest rates. At the 1999 Central Bank Governors' Symposium held at the Bank of England,[3] Gordon Thiessen (Canada) reported that inflation targets had "changed enormously my relationship with the House of Commons standing committee." Reserve Bank of New Zealand Governor Donald Brash cited similar advantages of inflation targets and the Bank of England's Deputy Governor Mervyn King reported: "[t]he process works because [the MPC] do not question each other about the objective. We have a very clear objective, which is the inflation target. And when there is a discussion about what that target should be, it takes place outside the Committee."

Governors from disinflating economies have typically qualified their enthusiasm for inflation targeting. In completing his address at the same symposium Josef Tošovský (Czech), Governor of the first central bank in a transitional economy to undertake inflation targeting, completed his address by stating "I would welcome you in joining the club, but you should know that this nominal anchor is not a panacea for small open emerging economies."

In contrast to King's depiction of the UK process where the MPC do not question the objective, during disinflations monetary policymakers are typically involved in regular discussions about what the short-term policy target should be. In such circumstances it is difficult to completely separate such discussions about the target from decisions about changing interest rates. How else could it be so? One possibility would be for the target-setter to set in stone published year-by-year targets for the disinflation path at the start of the disinflation process. Yet this has rarely happened,[4] in part because there is a strong likelihood that in countries where high inflation may have undermined initial credibility, the announcement may not be perceived to be time-consistent. Walsh (1998, page 321) defines an action as time-consistent if "an action planned at time t for time t+i remains optimal to implement when time t+i actually arrives." In practice, the disinflation path is generally highly uncertain in terms of duration and smoothness, because policymakers expect inflation to be knocked from its targeted path by unforeseeable shocks[5] that may imply high output costs if policy aims to stick rigidly to a pre-specified path. A trade-off emerges: announcing a clear targeted disinflation path might potentially influence inflation expectations by more than the announcement of only a

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[2] Other papers have focused on the implications of particular aspects of the transmission mechanism during the transition to low inflation. For example Cufer, Mahadeva and Sterne (2000) assess the role of administered prices. Eichengreen (2001) assesses implications of various structural differences between emerging markets and industrialised economies.

[3] See Mahadeva and Sterne (eds) pages 182-205.

[4] By 2000, Mexico and Peru announced targets for each year to 2003. Few other countries have expressed the time path in such detail.

[5] Even Chile, the country whose inflation rate during its disinflation was amongst the smoothest ever achieved, refrained from specifying a multi-year disinflation path at any stage in the disinflation process. Landeretche, Morande and Schmidt-Hebbel (2000) argue that the benefits of short target horizons during disinflations may be balanced by costs, since they "may force central banks to overreact to price shocks in order to meet their targets at the cost of causing excessive output volatility, contributing also to more variability of interest and exchange rates."

short-term target. Conversely, if the detailed path is missed, credibility may be undermined even if the disinflation is broadly on track.

The other way in which the target-setting process could be distinguished clearly from instrument-setting would be for the government to assume complete responsibility for regularly revising the inflation target it sets the central bank. But government responsibility to set short-term inflation targets may undermine instrument independence. Responses to the survey of Fry, Julius, Mahadeva, Roger and Sterne (2000) (henceforth FJMRS)[6] indicated that central bankers in disinflating countries were relatively more likely to define independence according to the capacity to set their own targets or objectives.[7] In the words of one respondent 'What good is instrument independence if the Parliament or Cabinet sets politically motivated goals that are binding?'

So in practice it has been relatively difficult for monetary policymakers in disinflating economies to specify what should happen if the short-term target is missed. What should policymakers do if inflation falls below the short-run target but remains above the long-run objective for inflation?[8] Should they change interest rates to increase inflation to the short-term target, or should they operate a policy of opportunistic disinflation by revising the short-run target down? Such a blurring between objectives and implementation can translate directly to the challenge of designing unambiguous roles in monetary policy strategy for the principal (government) and its agent (the central bank).

We will conclude that during disinflation, inflation targets may be more akin to conditional forecasts than policy rules, since they are generally revised to reflect misses from the annual (short-run) target. As such, we will argue that one of the main benefits of introducing inflation targets during disinflation is that the target may in itself significantly increase the transparency of the regime, thereby making credibility more sensitive to the future actions of the central bank and prompting low-inflation policies. Our interpretation implies a marked departure from existing literature on inflation targets in emerging economies. The traditional literature on choice of policy targets has seen inflation and money targets as alternatives, but inflation and money forecasts as complementary. In our opinion there is relatively less reason to see inflation and money 'targets' as alternatives during disinflation. Furthermore, we will argue that there exist potential marginal benefits from increasing transparency through the introduction of inflation targets even if a central bank is not fully independent, has limited forecasting capacity and if the government is running a substantial fiscal deficit. This contrasts with previous literature that has argued that prerequisites need to be in place before the introduction of inflation targets.

Section 2 describes the data we use and provides evidence of a rapid increase in the use of inflation targets in the 1990s, particularly in disinflating countries. Section 3 describes the challenge faced by monetary policymakers when using inflation targets during episodes of disinflation. We argue that it is inherently more difficult during disinflations to provide distinct and comfortable roles for both government and the central bank that enable target setting and instrument setting to be clearly distinguished. The reason, we argue, is that the targeted path towards low inflation is endogenous to outcomes during the disinflationary episode. A short-run target undershoot is more likely to result in a downward-revision to the announced targeted path than an overshoot. We present a single theoretical model that explains why the target set may become endogenous to previous inflation

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[6] Their survey covers a broad range of institutional issues, central bank objectives, analysis conducted and structural factors. Here, we focus primarily on those issues that particularly relate to inflation targets.

[7] See FJMRS, page 111-112, where the authors contrast central bankers' definitions of independence. FJMRS report that "Inflation targeting central banks in low inflation countries did not generally regard the ability to set the target as important in assessing their own independence." These responses are in stark contrast to those from disinflating countries using inflation targets.

[8] Price or monetary stability is an important statutory objective of 96% of central banks covered in the FJMRS survey (see Mahadeva and Sterne page 9. And in 83% of all central banks no other conflicting statutory objective was specified

outcomes. Section 4 presents panel-estimates supporting our theoretical predictions, and section 5 draws implications for the design of monetary frameworks.

2) The spread of inflation targets in a decade of disinflation.

Experiences of the 1990s afford an unprecedented opportunity to assess the context for the use of inflation targets during disinflations. First, the decade can be characterised as one of relatively orderly disinflation in each of low, medium and high-inflation groups of countries.[9] Second, the decade witnessed a rapid increase in the use of inflation targets and the adoption of other aspects of institutional reform, such as increased independence and transparency of central banks.[10]

Using data from one of the broadest ever survey of monetary frameworks contained in FJMRS, extended by the authors, Table 1 illustrates that 61 of the 95 economies surveyed have used explicit inflation targets between 1990 and 2001. Inflation targets have been used in a very broad range of circumstances and policy frameworks. The table illustrates in detail the exact years in which countries have used explicit (i.e. published) inflation targets, when they were adopted, and, where appropriate, when they were dropped. Early assessments of inflation targets were relatively cautious about their likely durability.[11] How would policymakers react, for example, in the face of severe supply shocks that might lead to a tension between achieving the target and accommodating the shock? Our data covers over 300 country-years of experience with inflation targets and their durability is very well established. In our data the only instances of inflation targets having been dropped are in the cases when countries have chosen to join European Monetary Union.

The literature on inflation targets has concentrated most on drawing lessons from the experience of a relatively narrow group of countries that are classified as 'inflation targeters'.[12] The distinction between an 'inflation targeter' and a country using inflation targets is inevitably arbitrary,[13] with definitions of 'inflation targeting' incorporating a broad array of framework characteristics. Our unique data-set provides us with the opportunity to minimise potential definitional problems by looking at the use of inflation targets first, in all countries in which they have been used, and second in the sub-group of countries loosely defined as 'inflation targeters'. For the latter, which account for under a third of the total number of countries using inflation targets, we follow Mishkin and Schmidt-Hebbel's (2001) classification.[14] We note, however, that even in 2000, the number of 'inflation targeters' is little over a third of those countries using explicit inflation targets (Table 2).

The distinction between an explicit inflation target or a published inflation assumption may also be fuzzy. Here, we rely on central bank's responses to the question "Do you have a specific, numerical, publicly announced target for prices or inflation?" We consider this to be an objective question and differences in flexibility of the use of targets across countries, and in other framework characteristics may be measured by other questions in the FJMRS survey.

It is even more striking that the number of central banks implementing low and stable inflation targets[15] is very small relative to those implementing them during disinflations. In 2000, over 80%

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[9] See FJMRS pages 18-28
[10] See Sterne (2000)
[11] See, for example, Haldane (1995) page v.
[12] See, for example, Haldane (1995), Leiderman and Svensson (1995), Bernanke, Laubach, Mishkin and Posen (1999)
[13] See Sterne (2000). Definitions include central bank independence, transparency, accountability, and the nature of analysis conducted.
[14] According to Mishkin and Schmidt-Hebbel, "full-fledged inflation targeting is based on five pillars: an institutional commitment to price stability, absence of fiscal dominance, absence of other nominal anchors, policy instrument independence, an d policy transparency and accountability."
[15] We define a country to be using an inflation target is low and stable when the inflation target is no more than 3%. This definition is appropriate in practice, since there are extremely few if any examples of countries that target inflation to remain steady and consistently above 3%, and there are also very few countries that have increased the inflation target

of countries using inflation targets were doing so when inflation was not low and stable. (Table 2). The literature on the applicability of inflation targets in such economies has also grown. A number of papers focus on country experiences.[16] Others draw lessons from cross-country comparisons[17] and some papers highlight particular issues in the transmission mechanism that affect the use of inflation-targeters outside the context of industrialised economies.[18] The papers by Mishkin and Schmidt-Hebbel (2001), and Sterne (2001) discuss specific policy issues involved in using inflation targets during disinflation, the focus of our theoretical model and empirical evidence.

The Israeli experience of disinflating using inflation targets provides a pertinent example of the issues tackled in our paper. At the start of its bumpy disinflation path in the 1990s, the Bank of Israel announced inflation targets[19]. Chart 1, taken from Bufman and Leiderman (2000), shows that there were several episodes in which the rate of inflation significantly deviated from its target at that time. But the Chart also reveals that these inflation targets were not abandoned altogether, but merely revised.

Targets were frequently missed, but on average they were hit: the average annual rate of inflation from 1992 to 1999 was 8.9% which was slightly lower than the average annual inflation target of 9%. There were four misses where the rate of inflation increased well above the target. In these cases, the credibility of the regime was challenged by an escalation of inflation expectations. Only in one case, 1994, did a target overshoot result in an upward revision of the target. There were also two significant target undershoots (1992 and 1998). In both these cases the target was adjusted downwards markedly. Later on we suggest that the greater number of downward revisions need not reflect an asymmetric bias in policy, but more simply that the long-run target is much lower than the initial condition of high inflation. Then short-run targets, used flexibly, are always more likely to be revised downwards towards the long-run goal. Bufman and Leiderman (op cit) provide a more detailed consideration of each of the shocks, and their arguments reinforce the view that the policy of revising or defending a target was shock-dependent.

3) Conditional inflation targets: in practice and theory

Many inflation targets have been implemented with the proviso that the probability of delivering low inflation in each year is conditional upon the absence of unusual circumstances that might lead to significant deviations from the long-run target. Formally, an inflation target set at time t may therefore be defined as being conditional when there is a significant probability that it will be revised at time t+N to reflect changes in economic conditions that occur between t and t+N.

We argue that revisions to the targeted path towards price stability are inevitable and that a central bank operating in such circumstances is likely to endure more volatility than its low inflation counterparts.[20] But can a central bank still gain credibility by announcing a target that may be missed and later revised? We argue here the answer is yes, so long as the conditions under which that target might be expected to be revised are compatible with the long-run goal of price stability.

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once it is reduced to 3% or less. The only four examples of target increases at such low inflation rates are (i) Korea in 2000 (2-4% to 1.5-6%); (ii) New Zealand in 1997(0-2% to 0-3%); Switzerland in 1995 (2.75% from 2%) (iv) Taiwan in 2000 (1.7% from 1.6%).

[16] For example, Landeretche, Morande and Schmidt-Hebbel ((2000) Chile), Bufman and Leiderman ((2000) Israel), Hrncir and Smidkova ((2000) Czech Republic), Blejer et al. (2000)

[17] Schaechter, Stone and Zelmer (2000), Mahadeva and Smidkova (2000), Cordo, Landeretche and Schmidt-Hebbel (2000), Sterne (2000)

[18] See for example, Mahadeva and Smidkova (2000), Eichengreen (2001)

[19] We note that similar issues arise in the history of the disinflations of other countries which announced inflation targets. See, for example, Hrncir and Smidkova (2000) for the Czech story.

[20] Noise may be present in the inflation rates of each of low and high inflation economies, yet evidence generally suggests that it is typically higher in high inflation economies. FJMRS (2000), for example, demonstrate that stable periods of inflation are much more common when inflation is less than 3.8%.

A conditional inflation target may be useful when a combination of three circumstances hold (see Figure 1):
a) *the current inflation rate is markedly different to the long-run target;*
b) *the output costs of moving to the long-run inflation target within a year or two years are expected to be large;*
c) *even if the long-run rate of inflation is tied to its fundamentals, its short-run behaviour is driven by many large and uncertain developments.*

Some or all of these characteristics are familiar to most countries using inflation targets. In some circumstances it may be possible to achieve rapid disinflations without incurring significant output costs, if for example, inflation expectations adjust very quickly to a policy announcement Sargent (1999). But for most countries the monetary authority may have to tread gingerly towards achieving its inflation target, since rapid deflations can be achieved only at the expense of significant output costs stemming from nominal rigidities. The real short-run output costs of changing interest rates are amplified when there are large real rigidities (Ball and Romer, 1991.).

If the inflationary process were predictable, then it would be possible to engineer a disinflation by pre-announcing and committing to a target *path*. In practice, however, prevailing conditions rarely allow costless disinflations. Very open economies, for example, may be sensitive to foreign price shocks and non-policy related exchange rate shocks (e.g. Czech Republic). Similarly, there are countries whose inflation profile is dominated by unforeseeable productivity shocks, such as weather conditions. Supply-side shocks are not only very difficult to measure, but incorrectly reacting to them can also lead to substantial output losses.[21]

One response to the circumstances outlined above could be to publish in advance and pre-commit to a target path that leads to the long–run goal. But the uncertainty that is frequently inherent in the disinflation process makes it is unlikely that a commitment to a target path will be fulfilled ex-post. The conditions under which a revision takes place and the central bank's commitment to explain these conditions then become crucial for credibility.

a)   Credibility during disinflation: definitions and interpretation

In this section, we motivate our panel estimation by setting up a theoretical model to derive the optimal rule for setting a short-run target. As we are not primarily interested in deriving a new theoretical insights but rather providing a fresh look at an old problem, the theory is kept as simple and as standard as possible.[22] A simple model, adapted from Bean (1998), Clarida et al. (1999) and Cecchetti (2001) cuts the transmission mechanism for a closed economy to just two equations: aggregate demand and aggregate supply. In the aggregate demand equation, (1), output (measured relative to its potential), y_t, is a function of the (policy-determined) real interest rate, r_t, and a demand-side shock, d_t:

$$y_t = -br_t + d_t;$$ *IS curve*   *(1)*

In the aggregate supply equation (2), inflation, π, is a function of the expectation of current inflation by the public based on their information sets, $E_t\left[\pi_t/I_{pub}\right]$, the output gap, y_t and a supply-side shock, s_t. $E_t\left[z/I_{pub}\right]$ denotes expectations of z conditional on the public's information set.

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[21] There are of course some supply-side shocks such as changes in administered price that may be easier to predict.
[22] For a model with more micro foundations, see Clarida, Galí and Gertler (2001).

$$\pi_t = \alpha E_t\left[\pi_t / I_{pub}\right] + (1-\alpha)\pi_{t-1} + cy_t + s_t . \qquad\qquad \textit{Phillips curve} \qquad (2)$$

If $\alpha = 1$, then the Phillips curve is similar to that would which could be derived by a theory of *price* stickiness (Galí and Gertler, 1999; Galí, 2000). If $0 < \alpha < 1$ then the underlying model would be one in which there were *inflation* stickiness.[23] It is also important to emphasise that c is related the degree of nominal rigidity as well as the degree of real rigidity. If prices are more flexible, the higher will the value of c be, all other things being equal.

The central bank's incentives in each period are stipulated by a quadratic loss function, given as:

$$L_t = 0.5\left(y_t\right)^2 + 0.5\lambda\left(\pi_t - \pi_L\right)^2 . \qquad\qquad \textit{Central bank's one-period loss function} \qquad (3)$$

where π_L is the long-run inflation target and with the nominal rate of interest acting as an instrument;

$$i_t = r_t + E_t\left[\pi_{t+1} / I_{pub}\right] \qquad\qquad \textit{Central bank's instrument} \qquad (4)$$

The policymaker influences the real interest rate to minimise the weighted average of the output gap volatility and the volatility of inflation about its long-run rate (π_L). As in Blinder (1998, 2000), King (1986) and Clarida et. al. (op. cit.), no average bias exists in the central bank's preferences towards a positive output gap.

The central bank knows of the demand and supply shocks only with some error. This **control error** reflects the fact that the central bank does not know, with complete confidence, what the transmission mechanism is and how it is evolving, and the underlying shocks that are hitting it. The demand shock, as measured by the central bank, is d'_t. The control error in the demand shock is then $d_t - d'_t$. Analagously, $s_t - s'_t$ is the control error on the supply-side.

However what the central bank knows, and what the public knows may differ. This gives rise to another source of uncertainty –transparency errors- which explain how much less the public knows compared to the central bank, as in Faust and Svensson (1999). Hence the public's understanding of the underlying demand and supply shocks is cloaked by noise both from control errors and transparency errors. Although central banks world-wide have devoted substantial efforts to making the public aware of its decision-making, there may always be an extra fuzziness surrounding the public's perception of the transmission mechanism. The transparency errors denoted, by $s'_t - s''_t$ and $d'_t - d''_t$ for supply and demand shocks respectively, depend on how willing and able the central bank is to make the public privy to its understanding of the shocks.

We crucially assume that both parties form rational expectations based on the information sets available to them. This assumes that the learning process about these shocks has converged. The transparency errors and the control errors are white noise disturbance terms, with a known variance. The demand shock, its transparency error and its control error must be uncorrelated with each other, as must the supply shock, its transparency error and its control error. Another important assumption is that the long-run objectives of the central bank - it's target for the output gap and the long-run rate of inflation- and the weight that it places on them are fully known by the public.[24]

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[23] See Batini et al., (2000) for a model of inflation stickiness and Mankiw (2000), apgee 22, footnote7 for an explanation of how the weight on backward versus forward-looking inflation is related to the coefficient on the output gap.

[24] Eijffinger, Hoebrichts and Schaling (2000) discuss what would happen if there were uncertainty about the weight placed on inflation stabilisation compared to output stabilisation by the central bank, and show that the volatility of

Leaving these important assumptions aside for now, we note that as far as the central bank is concerned, its loss function over in infinite horizon is given as:

$$\sum_{s=0}^{\infty} L_{t+s} = 0.5 \sum_{s=0}^{\infty} E_t \left[(y_{t+s})^2 + \lambda (\pi_{t+s} - \pi_L)^2 \Big/ I_{cb} \right].$$ *Central bank's loss function #1*   (5)

where $E_t \left[z / I_{cb} \right]$ denotes expectations of z conditional on the central bank's information set. Society's loss function is identical to the central bank's loss function, as we assume that the inflation target is equal to the optimal rate of inflation, and the rate of potential output is that which the central bank targets:[25]

$$\sum_{s=0}^{\infty} L_{t+s} = 0.5 \sum_{s=0}^{\infty} E_t \left[(y_{t+s})^2 + \lambda (\pi_{t+s} - \pi_L)^2 \Big/ I_{pub} \right]$$ *Society's loss function*   (6)

where $E_t \left[z / I_{pub} \right]$ denotes expectations of z conditional on the public's information set.

Changing the loss function to allow for conditional targets

To motivate the equation that we estimate in this paper, we follow for example Walsh (1999) in adapting the standard model to allow the central bank to publish a short-term target that can be revised. We replace the standard central bank loss function (5) with a loss function (7) below:

$$\sum_{s=0}^{\infty} L_{t+s} = 0.5 \sum_{s=0}^{\infty} E_t \left[(y_{t+s})^2 + \lambda_1 \left(\pi_{t+s} - \pi_{St+s}^t \right)^2 + \lambda_2 \left(\pi_{t+s} - \pi_L \right)^2 \Big/ I_{cb} \right]$$

Central bank's loss function #2[26]   (7)

There are two key differences between this loss function and that above in Equation 5. First specification (7) stipulates that the central bank is penalised for deviating from a pre-set short-term target path ($\pi_{St}^t, \dots, \pi_{S\infty}^t$) (Walsh 1998, ch.8) as well as from the optimal rate of inflation. This is flexible targeting rule, in that the central bank can trade-off missing this target with other objectives-including the long-run inflation goal. That deviations of inflation from a preannounced target enters into the central bank loss function whereas it does not enter into the social welfare function reflects that legislation is responsible for determining the central bank's preferences.

A second adaptation is that this short-term target path is state-contingent and therefore may be revised in the future: π_{St+s}^t does not necessarily equal π_{St+s}^{t+q} for all $q = 1, \dots, s$, as in Walsh (1999). In most models where an inflation target is preannounced, the target rate (either a scalar value set forever or even a path) is fixed. In this set-up, the short-run target path cannot be pre-committed to

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inflation increases with this 'monetary policy uncertainty'. Uncertainty in the long-run objectives would also add to the volatility of output and inflation. One way this can be interpreted is that the central bank is not being fully transparent about its objectives- for example by not publishing a long-run inflation target. But if these long-run targets were subject to shocks about which neither the central bank nor the public have full information on, the shocks could reflect uncertainty in the underlying optimal rates of the inflation and potential output. For example, uncertainty in the optimal rate of inflation could arise from price measurement bias (Clarida et al, op cit; Boskin et al, 1998). In this case the volatility in inflation and output could be welfare-enhancing.

[25] There has been much recent discussion in the literature regarding whether the relative merits of having the long run-target expressed in terms of inflation or the price level (e.g. Sinclair (2000), Batini and Yates (2001)). In practice, however, none of our sample of countries used a price level target.

[26] Our results may be different if we used a loss function where the penalty for deviating from the short-run target is not linearly independent of the penalty from deviating form the short-run target.

by the central bank, instead it can be continually revised ex-post as the economy develops. As we have argued, allowing for a short-run target is especially important for economies where there are many unexpected shocks that are large and costly to offset. But its function is as a reference point, not a precommitment, and one that is useful even if it is revised.

Unlike Walsh (1999), there are two targets announced. It is important to stress there is no conflict between these targets. A hierarchy is clearly established because as we shall show, the short-run target is set conditional on the long-run target (as well as the central bank's preferences; and its and the public's, admittedly imperfect, knowledge of the transmission mechanism).

A different motivation for the publication of a short-run target is to think of the short-run target path as a *conditional* forecast that the central bank preannounces at each time t (Svensson 2001). The state-contingent forecasted path for inflation will deviate from the long-run target in the short run because of the threat of output losses. But it will eventually converge to the long-run target within a long enough horizon.[27]

The closer the central bank *chooses* to keep the short-run target to the long-run target, then the more our model resembles a standard model with a time invariant long-run target. Substituting $\pi_{St} = \pi_L$ in the loss function, and setting $\lambda_1 + \lambda_2 = \lambda$ would imply that 5 and 7 are equivalent.

In the appendix, we derive the rule by which the central bank would set the short-run target, given values for λ_1 and λ_2, for the special case that there is only price stickiness; where $\alpha = 1$. We assume that the central bank cannot commit to any rule, and the solution is under discretion.

$$\pi_{St}^t = \pi_L + \frac{\left(s_t'' - s_t'\right)}{c^2 \lambda_2 \left(1 + c^2 \lambda_2\right)} + \frac{\left(s_t' - s_t\right)}{c^2 \lambda_2} + \frac{s_t}{c^2 \lambda_2} \qquad \qquad 8$$

The short-run target depends on fully on the long-run target. But it also depends on the shocks that are hitting the economy and the control and transparency errors associated with these shocks[28].

The short-run target deviates from the public's expectations of inflation only because of transparency errors (see the appendix). If information sets are symmetric, and the public was able to process information as well as the central bank, then the short-run target would be equal to public's inflation expectations. This does not imply indeterminacy, as discussed by Bernanke and Woodford (1997), because both are conditional on, and therefore anchored by, the long-run target.

In this set up, the central bank wants to improve its understanding of the transmission mechanism. Imperfect measurement of the demand and supply shocks by the central bank and public-control errors- create further volatility in the output gap as well as inflation. Control errors about supply shocks affect inflation through excess output volatility and unstable inflation expectations. Fuzziness surrounding demand shocks feeds through to inflation via output only.

Here, transparency errors in supply, but not those in demand, also add to volatility. Transparency errors in demand are not important for either inflation or output, because the central bank is able to

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[27] In the solution to this simple model, the announced target path is always going to be equal to the central bank's rational expectation of inflation, given its information set: $\pi_{St+s}^t = E_t\left[\pi_{t+s} / I_{cb}\right]$, as there is no gain to not being fully transparent.

[28] In a more realistic model, the central bank would have to identify the supply and demand shocks, and their associated transparency errors, from an imperfect data set on macro economic variables such as output and inflation, and measures of agent's expectations (see for example, Svensson (2001) page 80, and Aoki (2002)).

offset the impact of these shocks on both output and inflation simultaneously with a flexible inflation process. It does not matter whether or not the public is made aware of this.[29] Transparency errors in supply do matter, however. Because supply shocks drive inflation and the output gap in opposite directions, the central bank is unable to achieve its goals for both inflation and output by either raising or cutting interest rates. The less the public know about supply shocks, the more unstable inflation expectations become and the more active real interest rates must be.

In practice, there may be limited scope for a central bank to reduce control and transparency errors. Given the assumptions underlying our simple framework, it follows that the central bank would always choose to reduce such errors where possible. The elasticity of a given transparency error on inflation and output depends on how sticky prices are and the real costs of this price stickiness- it diminishes with the parameter c (see appendix). It is also true that the effect of a given transparency error on inflation and output also falls with the weight placed on the long-run target- it depends inversely on the parameter λ_2.

In terms of our conditional short-run target set-up, what does it mean that the central bank would want to be transparent? In the case when the economy is hit by shocks whose cause and effects are more easily explained and costly to offset—imported price changes, weather conditions, government price changes, indirect tax movements- the model points to the potential benefits from using caveats and escape clauses to limit transparency errors rather than revising the short-term target.

However this framework, intended mainly to motivate the estimates, has some important limitations. In particular, although the information sets of the public and the central bank differ, there is no feature of the model that makes it interesting to explore why or why not there is a gain to the central bank, or society, from the publishing of short-term targets. More complicated models in which the central banks targets a positive gap (on average),[30] or where agents are in the process of learning about the central bank's uncertain preferences, are needed to discuss the gains from not being transparent since there an incentive exists for the central bank to cheat the public. See Barro and Gordon, 1983; Cukierman and Meltzer, 1986; Cukierman, 2000; Eijffinger, Hoebrichts and Schaling, 2000; Faust and Svensson (1998, 1999); Jensen, 1999 and Geraats (2001). Better developed dynamics in inflation, with more forward and backward-looking elements (for example, Bean, 1998; Clarida et. al.,op.cit. and Jensen, 1999), learning (for example, King, 1996; Faust and Svensson, 1998 and 1999 and Sargent, 1999) and uncertainty about parameters (for example, Sack, 1998 , Hall et al. 1999 and Srour, 1999) could also change the trade-offs of the model.

Indeed a more realistic model which would be needed to describe our data would have to feature sticky inflation and not just sticky prices, and hence require that $0 < \alpha < 1$. But this more complicated model cannot easily be solved analytically (Clarida et. al., op.cit.). To derive the functional form that we estimate, therefore, we have to guess the form that the rule for the short-term inflation target would take if $0 < \alpha < 1$. As the model is still homogenous in its nominal variables, the rational expectation of inflation formed by the public would most likely be a weighted average of past inflation and the long-run target, and also a function of the current shocks as well as the expectations of future shocks.[31] The short-term inflation target would only differ from this expectation because of transparency errors. This would suggest that a rule of the following form would be appropriate:

$$\pi_{St}^t = \phi\pi_L + (1-\phi)\pi_{t-1} + \text{shocks} ; \qquad\qquad 9$$

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[29] When inflation is sticky, transparency errors in demand will be important for both output and inflation.

[30] Whether or not this assumption is realistic is controversial (Blinder, 1998).

[31] With inflation sticky, demand shocks and their associated errors are now also important in affecting the short-run target.

where $0 < \phi < 1$.

According to Equation 9, the short-run target at time t, π_{St}^{t}, is now endogenous to past inflation as well as the long-run target. Therefore the short-run target will deviate from the long-run target, not only depending on a) where past inflation is but also on b) what shocks are hitting the economy.

Rewriting Equation 9 in error correction mechanism form gives us the model that we estimate:

$$\pi_{St} = \pi_{St-1} - \left(\pi_{St-1} - \pi_{t-1}\right) + \phi\left(\pi_L - \pi_{t-1}\right) + \text{shocks} . \qquad 10$$

4) An empirical examination of inflation target-setting and target-misses

The empirical tests we conduct focus upon how the targeted path of inflation may be endogenous to macroeconomic outcomes, and in particular to the misses from short- and long-run inflation targets. The data set we use is unique in its comprehensive coverage of the global use of inflation targets in the 1990s. It includes 318 annual observations of inflation targets and outcomes, starting in 1980. The data represent an unbalanced panel; within the 56 countries, the number of annual observations ranges between 1 and 11. Our analysis covers three aspects of target use. First, we shall examine the extent of target misses to draw conclusions about the accuracy and flexibility with which targets are implemented. Second, we assess the way in which annual targets have been revised using panel regressions to provide information on the other side of the coin. To what extent do target misses influence the future path of inflation targets?

a) Target misses

To the extent that unexpected shocks even out over the sample period, the results suggest that policymakers have, on average, shown little bias in meeting their short-run inflation targets. The first column of Table 3 illustrates that in the overall sample, there is no significant evidence that inflation outcomes overshoot or undershoot the short-run target on average. The median miss is an undershoot of just under 0.1 percentage points.[32] There is, however, evidence that misses are strongly skewed such that upside misses have been relatively larger; the mean miss is 3.7, compared to the median miss of −0.1. Columns 2 to 6 of Table 3a divide the sample into five groups, according to the size of the target. The results illustrate that countries with higher short-run inflation targets are relatively more likely to overshoot their target. For countries with targets less than 2.5 percentage points, the median absolute miss is just 0.5 percentage points (column (2)). In contrast, the median absolute miss for countries setting inflation targets of over 15 percentage points is 6.4 percentage points.

Inflation targets have been characterised as being operated with "constrained discretion"[33] and have been described as "a framework not a rule." We are unable to determine from these data the exact extent to which misses are attributable to less than 100% rigidity in attempts to hit targets, or because the lengthy transmission lags imply that even if policymakers are unable to restore inflation back to target within an annual horizon. The data are nevertheless consistent with a flexible approach to the use of inflation targets, particularly at higher targeted rates of inflation. The median absolute target miss is 1.4 percentage points. Finally, the table shows that the magnitude of misses remain roughly in proportion to the level of the target.

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[32] Some of these targets are ceilings, so a marginal undershoot may not be indicative of systematic target undershooting. Another data problem is that some targets are expressed as year-end, while others are annual average.

[33] Bernanke, Laubach, Mishkin and Posen (*op cit*)

b) Target Revisions

Our annual data on target revisions illustrate the widespread use of inflation targets as part of strategies that have succeeded in reducing inflation and keeping it low (Table 4). During the 1990s, annual inflation targets have been much more frequently revised down than up; in the sample as a whole only 14% of the 274 observations represented upward revisions. When targets were 4.5% or less, upward revisions were very rare, representing just 5% of observations. The median absolute revision in our sample is 0.7 percentage points, with the size of the revision increasing roughly in proportion to the magnitude of the previous period's target.

c) Relating target revisions to target misses

Our data suggest that inflation targets are frequently missed and frequently revised yet have been dropped extremely rarely. These stylised facts are consistent with the view that one of the reasons that inflation targets have proven so durable to many types of economic shocks is that they can be used relatively flexibly without necessarily undermining credibility of the framework. The corollary of inflation targets not usually being used as a strict rule is that missing them does not generally break any rules. Competent economic policy may improve credibility even if the target is missed, as long as the miss is consistent with striking an appropriate balance between reacting to shocks and maintaining price stability in the long run.

An important objective of our empirical analysis is to relate target revisions to the size of target misses so that we may then draw out implications for institutional design of monetary frameworks. In particular we seek to show how the change in inflation targets on a disinflationary path may itself be endogenous to inflation outcomes. Our theoretical analysis drew out two main implications that we test empirically in this section:

- The change in the inflation target depends upon last period's miss;
- The short-run target will be revised down disproportionately when inflation *undershoots* the short-run target relative to when the target is overshot: in particular the change in the target will be some linear combination of current inflation, the short-run target and the long-run target.[34]

Table 5 provides simple correlation coefficients between the annual target revision and last year's miss. There is a strong correlation between the lagged miss and the change in the target. Column 1 shows that for the entire sample of 274 observations, the correlation coefficient is 0.73. The table therefore suggests that target-setting and inflation outcomes are endogenous. Columns (2) and (3) illustrate that target revisions are much more strongly correlated with last period's miss when inflation was below target, than when it was above it. The contrast between the two scenarios is stark. When inflation is below target, the target is very highly correlated with the miss. In contrast, when inflation is above target, the target revision is significantly *negatively* correlated with the target miss. The results are similar, though less strong, for 'inflation targeters' (lower row of the table). We reserve our detailed policy interpretation for section 5 below; here we merely note that we find the results consistent with sensible, pragmatic policymaking.

The results from our panel estimates shed light on the simple correlations. Based on our theoretical results we run four regressions that explain revisions to short-term targets by the degree to which short and long-term targets were missed in the previous period. Below are two general equations that differ only insofar as the second one allows for asymmetric responses to misses that are above and below the short-term target. The four equations we estimates are variants of these two equations:

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[34] Only a minority of those disinflating countries specifying annual inflation targets also express explicit numerical long-run targets. However, over 95% of countries in our sample have specific reference to monetary or price stability in their statutory objectives, so we believe our analysis is appropriate whether or not such an explicit long-run target exists.

$$\text{TS}_{it} - \text{TS}_{it-1} = \alpha_1(\pi_{it-1} - \text{TS}_{it-1}) \qquad\qquad\qquad + \alpha_2(\pi_{it-1} - \text{TL}_i) + \varepsilon_{it}$$

or:

$$\text{TS}_{it} - \text{TS}_{it-1} = \qquad\qquad \alpha_3(\text{D1}* (\pi_{it-1} - \text{TS}_{it-1})) + \alpha_4(\text{D2}* (\pi_{it-1} - \text{TS}_{it-1}) + \alpha_2(\pi_{it-1} - \text{TL}_i) + \varepsilon_{it}$$

where:

TS_{it} is the short-run inflation target (the annual target in country i, set at time t, set at t-1)

TL_i is the long-run inflation target (the annual target in country i). For convenience TL_i is assumed to be zero, though an alternative assumption would make no difference other than to the constant term in the regression.

π_{it} is the inflation rate in country i at time t, a proxy for the deviation from the long-run target

ε_{it} is the error term

D1 is a dummy which is 1 if the target miss was negative in the last period

D2 is a dummy which is 1 if the target miss was positive in the last period

Equation 10 above predicts that the estimated equations would satisfy the coefficient restrictions that $\alpha_1 = 1$ and $-1 \le \alpha_2 \le 0$. Also, as we have assumed that there is no inherent asymmetry in the central banks preferences over revising the target over and above their desire to hit the long-run target, we would expect $\alpha_3 = \alpha_4$ when we include the miss from the long-run target in the equation as a regressor. When it is left out of the regression, and the short-run target is above the long-run target, we would expect that $\alpha_3 > \alpha_4$. We assess our results against the these tests.

Discussion of econometric results

Table 6 shows results from panel regressions using all 274 usable annual observations in the sample. The diagnostic results are satisfactory (see Table 6 and footnote 33). R^2 is generally much higher than is frequently the case in panel regressions, owing in part to the narrowness of the hypothesis we test; R^2 ranges between 0.50 and 0.95 for the whole sample, and between 0.10 and 0.61 for the smaller sample of 'inflation targeters.' In each of Tables 6 (results for all countries) and 7 (results for 'inflation targeters') our preferred regression is the final one (regressions 4 and 8). We describe the other results as they are building blocks to our preferred ones.

The first two regressions confirm the target revision depends strongly upon last period's target miss. Regression 1 suggests that targets are revised in accordance with last period's miss, with a strongly significant coefficient of 1.36. In regression 2, we allow for an asymmetric response of target revisions to misses depending upon whether the short-run target was undershot or overshot in the last period. We do so by including two target-miss variables, the first of which multiplies the lagged miss by a dummy that is set to one when the target was undershot, and zero otherwise. The second equals one when the target is overshot, and zero otherwise. The results markedly increase R^2 and suggest a very marked asymmetry. The results suggest the effect of the miss on the target revision is relatively much stronger for countries undershooting their short-run targets.

Regression 3 illustrates that such asymmetries disappear when we include the lagged inflation rate as a proxy for deviations from the long run target. Coefficient restriction tests on the target miss terms (tests of $\alpha_3 = \alpha_4$) cannot reject the null hypothesis that they are the same. Thus the apparent asymmetric reaction is merely indicative of a significant weight being attached to an explicit or implicit long-run target.

Regression 4 (our preferred regression) imposes symmetry in the reaction to missing above and below the short-term target ($\alpha_3 = \alpha_4$). The expected results holds: the extent to which the target is revised down depends upon the target misses from both the short- and long-run target. The

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coefficients are broadly consistent with our predictions: the coefficient on the miss from the short-run target is positive and close to unity; missing the short-term target leads to a revision in the direction of the miss. Our theory suggests $\alpha_1 = 1$. This is close to our estimate of 0.95, but the difference is significant at the 95% level. We suggest that the significant difference stems from the fact that included in our sample are a number of countries that never change their short-run target, thus reducing the overall sensitivity of the sample to target misses. The coefficient on the miss from the long-run target is negative, consistent with the theoretical prediction that $-1 \leq \alpha_2 \leq 0$: as long as inflation remains above the long-run target then this leads policymakers to revise down next period's short-run inflation target.

Table 7 presents the results for the sub-group of 80 observations for 'inflation targeting' countries. The results are similar to those for the entire sample of observations, though the coefficients and t-statistics tend to be lower. The smaller impact of target misses on next year's target revision are unsurprising given that a large proportion of the group never revise the targets: in the sample of 80 observations, 35 represent those in which the target was reduced, 4 when it was increased and 41 when the target was not revised. There is some evidence of asymmetric reactions to target misses in regression 2, though it is not significant. And in our preferred regression 8, the coefficients are correctly signed though the affect of the target miss is weaker than theory predicts.

5) Implications for the choice of institutional framework

Our results have striking implications for the design of monetary frameworks that use inflation targets during disinflation, or when shocks cause relatively large departures from (declared or implicit) long-run inflation targets. Our two main empirical results were that policymakers are unbiased insofar as they do not systematically undershoot or overshoot short-term inflation targets, yet target-setters do indeed treat the process of setting short-run target as endogenous to inflation outcomes. If inflation is lower than the previous target, next years target will be revised down. These were consistent with our theoretical result that optimising policymakers revise the targeted path for disinflation in accordance with deviations from both the explicit short-run target and the (explicit or implicit) long-run target for inflation.

The results imply limitations in the capacity of policy makers to pre-commit to a disinflation path. The results are complementary to that implied by Lohmann (1992) who argues that it is impossible to commit to state-contingent policy rules since it is "impossible or prohibitively costly to specify all possible contingencies in advance." The implications of our results differ from Lohmann's insofar as she stresses the importance of allowing the policymaker to over-rule the delegated monetary authority in the case of extreme shocks, whereas we focus upon the implications for revising short-term targets caused by small or large deviations from the target. Lohmann's interpretation is relatively more appropriate for countries where shocks that cause significant potential deviations from target are relatively infrequent; ours is more applicable to the large number of countries that experience frequent shocks.[35]

For the 80% of countries using inflation targets as part of a disinflation process, frequent shocks and inherent uncertainties associated with disinflation are likely to imply a relatively high noise-signal ratio that can potentially undermine the clarity of the distinction between target and instrument independence in a framework that uses inflation targets. As shocks (and in some cases target revisions) become more frequent, the capacity for government to over-rule the central bank may increasingly undermine central bank instrument independence. Similarly, approaches to inflation

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[35] It has sometimes been argued that escape clauses should be circumstance-specific and specified ex-ante, so that it is clear that the policymaker is not 'breaking the rules'. Revisions to the target tend to be general and ex-post. But in principle, revisions could be accompanied by a transparent explanation and could happen ex-ante.

targeting based upon providing clear and distinct roles for government and the central bank in setting and implementing inflation targets (e.g. Walsh (1995)) are less practicable when using inflation targets on a disinflating path.

Inflation targets may nevertheless provide a strong marginal contribution towards delivering price stability in disinflating economies. Our interpretation is that short-term targets on a disinflation path may be more akin to conditional inflation forecasts than policy rules. Conditional here refers to the assumptions made about the nature of the shocks, and fiscal policy. Our results have shown that, in common with a good forecast, short-term targets are met on average, but if they are missed then the target for next year is likely to be revised.

Explicit inflation targets can therefore contribute strongly to credibility building since they represent an act of transparency. During disinflation, inflation targets, particularly when accompanied by clear explanations of misses and target revisions, may still have a very important role to play in communication between the central bank, government and the private sector. There may be some credibility gains if allowable misses are announced ex-ante, but in practice the scale of the uncertainty may lead central banks to specify such wide target ranges and exemptions that the credibility gains of the exercise are diluted. This could be done by providing the central bank with a high degree of target and instrument independence (e.g. Chile), or by having some role for government (such as in Israel).

The literature on transparency has recently grown quickly (see Chortareas et al (2001) for a review). Transparency can result in lower inflation (e.g. Faust and Svensson (2000)), since it makes a central bank's reputation more sensitive to its actions and reduces any inflation bias.[36] Transparency may also reduce uncertainty and improve the efficiency with which agents make decisions. Cross-country estimates suggest that greater transparency is strongly associated with lower inflation (see Chortareas et al (2001)). These authors also find that the effect is higher for countries with higher rates of inflation, since introducing transparency when credibility is low or inflation is high offers greater scope for credibility gains.

When targets are viewed as being more akin to forecasts than rules, the case for viewing inflation and money targets as alternatives is undermined. Publishing forecasts for more than one variable may *increase* transparency since publishing a forecast for more than one variable may better inform the public about the source of the shock. Such an interpretation is opposed to a common interpretation of targets for different variables as being potentially colliding rules. During disinflation we argue that there is a much stronger case for publishing both money and inflation forecasts, providing they are mutually consistent. Our interpretation is consistent with the practice of central banks, contained in the striking results of FJMRS (2000), who show that in a sample on 93 economies each country on average uses explicit targets for 1.5 variables (where the variables include only the exchange rate, money and inflation).

6) Conclusions

The rapid spread of inflation targets to disinflating countries has been one of the most striking developments in monetary policy framework design in the 1990s. It has led us to reconsider our interpretation of inflation targets and inflation targeting in a disinflating context. Our theoretical model has shown that short-term target revisions are inherently endogenous to the outcome for inflation in a way that is predictable: optimising policymakers who place some weight on long-term inflation objectives are more likely to revise the short-run target down if they undershoot the short-

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[36] But increased transparency in not inevitably good for output stabilisation (Cukierman) since it reduces the capacity to conduct surprise inflation.

run target than if they overshoot it.[37] Our empirical results, using unique and comprehensive data on the use of inflation targets in the 1990s show the theoretical results to be true in practice.

The practical implications for interpreting the use of inflation targets on disinflating paths are striking. Such targets may be more akin to forecasts than policy rules. Hence a contracting approach such as that used by the Bank of England, whereby the government sets the target and provides the central bank with instrument independence to meet the target, would be much more difficult to implement during disinflation. Yet even during disinflations targets can still make an important contribution to improving the quality of monetary policy and enhancing credibility, since they increase transparency. Finally, during disinflation there is relatively less reason to view the publication of inflation targets as an alternative to other targets (e.g. for money). Both can be akin to forecasts, and can help to improve the central banks capacity to communicate preferences and its knowledge of current and expected shocks to the economy.

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[37] Revisions to the target may also reflect other aspects of policymakers' knowledge of the transmission mechanism, and their preferences with regard to the optimal trade-off between inflation and output stability, though this is beyond the scope of our paper.

Inflation targets as a stabilisation device – charts and tables

Table 1   Central banks using explicit inflation targets since 1990
(with dates they were adopted and dropped)

	Central banks reporting use of explicit inflation targets: (61 economies from a total of 95 in the survey)			Of which, defined as: 'inflation targeters'[1]	Inflation targeting with low and stable inflation targets[2]
	30			**7**	**1**
Developing	Malaysia (70s–)	Nigeria (93–)	Sierra Leone (96-)	Chile (91–)	Thailand (00-)
	Tanzania (80's–)	Vietnam (93–)	W. Afr. States (97–)	Colombia (91-)	
	Mozambique(87–)	Bangladesh (94-)	China (98–)	Peru (94–)	
	Chile (91–)	Ecuador (94–)	Kenya (98?)	Brazil (98-)	
	Colombia (91-)	Mexico (94–)	Lebanon (98–)	Mexico (99–)	
	Egypt (91–)	Peru (94–)	Turkey (98–)	South Africa (00-)	
	India (91–)	Uruguay (95–)	Brazil (98-)	Indonesia (00-)	
	Uganda (92–)	Zambia (95–)	South Africa (00-)		
	Indonesia (92–)	Jamaica (96–)	Indonesia (00-)		
	Guyana (93–)	Mauritius (96–)	Thailand (00-)		
	16			**2**	
Transitional	Poland (92–)	Armenia (95–)	Romania (97–)	Czech Rep. (98–)	
	Albania (93–)	Moldova (96–)	Slovenia (97–)	Poland (98–)	
	Macedonia (93–)	Georgia (96–)	Turkmenistan (97–)		
	Russia (93–)	Kazakhstan(97–)	Czech Rep. (98–)		
	Slovakia (93–)	Kyrgyz (96–)			
	Croatia (94–)	Mongolia (97–)			
	15			**11**	**11**
Industrialised	New Zealand (88–)	UK (92–)	Italy (95–98)	New Zealand (88–)	New Zealand (88–)
	Greece (90? –)	Australia (93–)	Spain (94–98)	Israel (91-)	Canada (91–)
	Taiwan (90?–)	Finland (93–98)	Korea (98–)	UK (93–)	UK (92–)
	Canada (91–)	Sweden (93–)	Switzerland (00-)	Canada (93–)	Australia (93–)
	Israel (91-)	France (94–98)	Iceland (01-)	Australia (93–)	Finland (95–98)
				Finland (93–98)	Sweden (95–)
				Sweden (93–)	Spain (94–98)
				Spain (94–98)	Taiwan (97-)
				Korea (98–)	Korea (98–)
				Switzerland (00-)	Switzerland (00-)
				Iceland (01-)	Iceland (01-)

1   'inflation targeters' are categorised in accordance with Mishkin and Schmidt-Hebbel (2000), updated by authors
2   We define low and stable inflation targets as those whose targets are less than or equal to 3 per cent.
3   Germany and Switzerland (up to 1999) had explicit long-term objectives for inflation but are not included in the table since the central banks did not regard these as inflation targets. A "?" is included for Greece, Kenya and Taiwan because we are not sure if inflation targets were used before 1990.
Sources: FJMRS (2000), updated by the authors. The updated sample includes a total of 94 economies, with Brazil and Colombia being the countries added since the original survey.

Table 2: The number of countries using inflation targets since 1990

	Countries with Inflation targets	Of which: 'Inflation targeters'	Low and stable targets* (targets ≤ 3%)	Disinflating* (targets > 3%)
1990	7	1	0	7
1991	11	4	2	9
1992	14	4	2	12
1993	23	9	3	20
1994	30	11	5	25
1995	37	11	7	30
1996	43	11	7	36
1997	49	11	8	41
1998	56	15	9	47
1999	52	14	7	45
2000	56	17	9	47
2001	57	18	10	47

* Our definition of "disinflating" countries is empirically appropriate since virtually all countries with inflation targets of more than 3% have attempted further disinflation.
Source: FJMRS (2000) extended by the authors

Chart 1: Inflation, inflation expectations and inflation targets in Israel
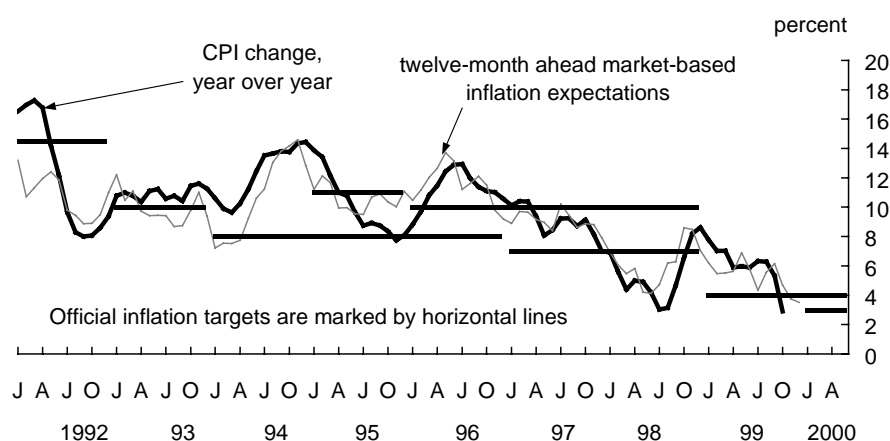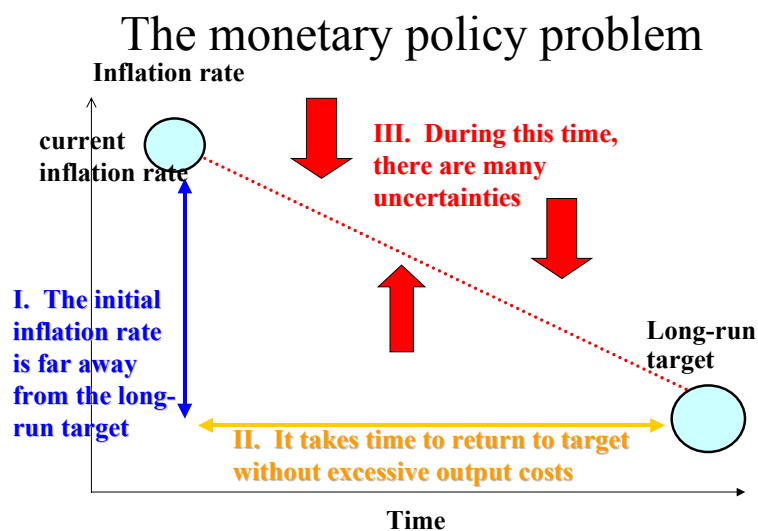

Source: Bufman and Leiderman (op cit.)

Figure 1:

The monetary policy problem

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Table 3: Inflation target misses at different magnitudes of inflation targets

Average Target (T)	(1) All*	(2) T <=2.5 (very low)	(3) 2.5 <T<= 4.5 (low)	(4) 4.5<T<=8 (medium)	(5) 8<T<=15 (high)	(6) Above 15 (very high)
Observations	318	71	59	65	60	63
25th percentile miss	-1.2	-0.7	-1.2	-1.5	-1.25	-3.2
Median miss	-0.08	-0.3	-0.1	0.3	.25	1.5
75th percentile miss	1.7	0.4	0.62	2.1	3.56	8.1
Median absolute miss	1.4	0.50	0.94	1.8	1.8	6.4
Mean	3.7	-0.16	-.32	.77	1.6	4.7
Standard deviation	6.4	2.0	2.0	4.9	9.3	13.7

The median target for all countries with inflation targets is 6%. For 'inflation targeters' it is 2.75

Table 4: Inflation target revision at different magnitudes of inflation targets

Average Target (T)	(a) All*	(b) T <=2.5 (very low)	(c) 2.5 <T <= 4.5 (low)	(d) 4.5<T<=8 (medium)	(e) 8<T<=12 (high)	(f) Above 12 (very high)
Observations	270	63	45	62	47	53
10th percentile revision	-6	-0.5	-2	-4.5	-7.7	-10.7
25th percentile revision	-2	0	-0.8	-2.0	-5.0	-6.0
Median revision	0	0	0	-1.0	-.75	-1.0
75th percentile revision	0	0	0	0	0	0
90th percentile revision	0.8	0	0.25	0.8	1	6.5
Median absolute revision	0.7	0	0.2	1.3	1.2	4.0
Mean	-1.4	-0.11	-1.17	-1.5	-3.1	-1.5
Standard deviation	5.3	0.32	4.0	2.6	6.7	8.9

The median target for all countries with inflation targets is 6%. For 'inflation targeters' it is 2.75

Table 5. Correlation between change in the target and last period's miss?

Correlation coefficients	(1) All countries	(2) when inflation below target	(3) when inflation above target
For all inflation targets	0.73	0.98	-0.36
(number of observations)	(274)	(137)	(135)
For 'inflation targeters'	0.32	0.52	0.19
(number of observations)	(80)	(45)	(34)

Table 6: Panel estimates: how targets are revised following target misses[38]

All countries: fixed effects regression, t-statistics in brackets

Dependent Variable: change in the inflation target from previous year

	Regression 1	Regression 2	Regression 3	**Regression 4**
α_1: Miss from short-term target last period	1.36 (21.5)			**0.95 (44.2)**
α_3: Miss from short-term target last period x below target dummy D1		1.74 (41.1)	0.911 (22.8)	
α_4: Miss from short-term target last period x above target dummy D2		-0.311 (-3.4)	1.02 (14.2)	
α_2: Miss from long-run target			-0.79 (-24.1)	**-0.76 (-45.9)**
Constant	-4.7 (-6.1)	0.77 (1.43)	5.7 (16.7)	**5.6 (17.1)**
R^2 (overall)	0.54	0.88	0.95	**0.95**
F-stat	463.3	845	2356	**3533**
F-test for poolability	4.0	1.88	4.0	**4.1**
Chi^2 for coefficient restriction $\alpha_3 = \alpha_4$		845 (p=0.00)	1.1 (p=0.30)	
Chi^2 Hausman test for fixed effects versus random effects model*	73.1	4.07	12.3	**8.2**
Number of observations	274	274	274	**274**

* The results were similar when we used random effects regressions, though in all cases the Hausman test rejected

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[38] In all cases the Hausman tests favours using fixed effects over random effects regressions. Most panel studies do not report tests of serial correlation because the tests may adopt the implausible alternative that the serial correlation is homogenous across data groupings. Our preferred regression nevertheless marginally fails the LM and LM(5) tests reported by Baltagi (1995, page 91) for first-order serial correlation in a fixed effects model. When we estimated the fixed-effects model to allow for first order serially correlation in the errors, the coefficients on the misses from the short- and long-term target each changed by less than 0.03. The serial correlation could arise from a missing lagged dependent variable that in our model could arise from persistence in target setting. To test for this we estimated a dynamic panel, including last year's target revision as a regressor. Our estimates using the Arrellano and Bond (1991) GMM method adjusted for robust standard errors report that the lagged dependent variable is insignificant at the 95% level. And the estimates of the other coefficients do not change much. As dynamic panel estimation methods are arguably more subject to bias than their static equivalents (Smith (1999)), we use this as grounds to stick with the static estimates. As the serial correlation could arise from autocorrelated residuals- supply-shocks that are correlated and repeatedly ignored by the target setters- we also carried GLS estimations with a first-order autocorrelation process that differs across countries: the estimates of the other coefficients were virtually unchanged. Finally, the coefficients were also virtually unchanged when we used hetereoskedastic consistent errors.

Table 7: Panel estimates: how targets are revised following target misses: 'inflation targeters' only

Dependent Variable: change in the inflation target from previous year, fixed effects regression, t-statistics in brackets

	Regression 5	Regr. 6*	Regr. 7**	**Regr. 8****
α_1: Miss from short-term target last period	0.39 (3.7)			**0.52 (8.4)**
α_3: Miss from short-term target last period x below target dummy D1		0.48 (3.13)	0.65 (5.8)	
α_4: Miss from short-term target last period x above target dummy D2		0.11 (0.78)	0.41 (4.0)	
α_2: Miss from long-run target			-2.6 (-9.6)	**-0.25 (-10.1)**
Constant	-0.7 (-5.2)	-0.60 (-1.86)	0.21 (2.8)	**0.57 (3.3)**
R^2 (overall)	0.10	0.16	0.62	**0.61**
F-stat	14.0		41.7	**60.8**
F-test for poolability on fixed effects regr.	2.86	1.88	1.12	**1.26**
Chi^2 for coefficient restriction $\alpha_3 = \alpha_4$		2.42 (p=0.12)	2.00 (p=0.16)	
Chi^2 Hausman test for fixed effects versus random effects model*	3.02	2.18	n/a	**5.4**
Number of observations	80	80	80	**80**

* The Hausman test for regression 6 indicated a systematic difference using the random effects regression, and these are the results we report, with z, rather than t-statistics in brackets. The results were similar whichever technique was used.

** Regressions 7and 8 are pooled estimates, as the F-tests on fixed-effects regression indicating pooling to be acceptable. The results were similar whichever technique was used.   In regression 8 we also tested for the significance of the lagged dependent variable. It was insignificant at the 95% level.

Appendix

The model

The closed economy is summarised by an aggregate demand curve (A1) and an aggregate supply curve (A2):

$$y_t = -br_t + d_t \; ; \tag{A1}$$

$$\pi_t = E_t\left[\pi_t / I_{pub}\right] + cy_t + s_t . \tag{A2}$$

π is the inflation, $E_t\left[\pi_t / I_{pub}\right]$ is expected inflation rate at time t based on the publics information set at time t, y is the output gap, r the real rate of interest and d and s are demand and supply shocks, respectively.

Substituting (A1) into (A2) gives

$$\pi_t = E_t\left[\pi_t / I_{pub}\right] - cbr_t + cd_t + s_t . \tag{A3}$$

Information

At time t, both the public and the central bank are aware of the model's parameters. However the central banks ability to measure the demand and supply shocks at time t is imperfect. Hence $E_t\left[s_t / I_{cb}\right] = s_t'$ and $E_t\left[d_t / I_{cb}\right] = d_t'$. The random *control* errors in demand and supply are written as $d_t - d_t'$ and $s_t - s_t'$ respectively. These errors are white noise with a known variance.

The public's knowledge of the demand and supply shocks at the time it sets its prices is subject not only to these control errors but also on white noise *transparency* errors, $E_t\left[s_t / I_{pub}\right] = s_t''$ and $E_t\left[d_t / I_{pub}\right] = d_t''$. The transparency errors in demand and supply are written as $d_t' - d_t''$ and $s_t' - s_t''$ respectively and are white noise with a known variance.

Both the public and the central bank are forming rational expectations; hence the control error for demand is uncorrelated both with the demand shock and the transparency error for demand. Similar assumptions hold for the supply shock. We assume that the only the discretionary solution is time consistent.

The central bank's loss function is

$$\sum_{s=0}^{\infty} L_{t+s} = 0.5 \sum_{s=0}^{\infty} E_t\left[\left(y_{t+s}\right)^2 + \lambda_1\left(\pi_{t+s} - \pi_{St+s}^t\right)^2 + \lambda_2\left(\pi_{t+s} - \pi_L\right)^2 / I_{cb}\right]$$

With a linear model whose parameters are known, additive uncertainty and a quadratic loss function, we can solve this problem under certainty equivalence. Substituting for inflation and output, and conditioning on the central bank's information set gives the current period losses as:

$$L_t = 0.5\left(-br_t + d_t'\right)^2$$
$$+0.5\lambda_1\left(E_t\left[\pi_t / I_{pub}\right] - cbr_t + cd_t' + s_t' - \pi_{St}^t\right)^2 \tag{A4}$$
$$+0.5\lambda_2\left(E_t\left[\pi_t / I_{pub}\right] - cbr_t + cd_t' + s_t' - \pi_L\right)^2 .$$

Minimising $\sum_{s=0}^{\infty} L_{t+s}$ with respect to the rate of interest gives us a first-order condition with respect to the real interest rate, taking inflation expectations as given. Substituting the expression for the rate of interest into Equation A3 and conditioning for the public's information set gives us a solution for inflation expectations.

$$E_t\left[\pi_t / I_{pub}\right] = \pi_L + \frac{\left(s_t'' - s_t'\right)}{c^2 \lambda_2} + \frac{\left(s_t' - s_t\right)}{c^2 \lambda_2} + \frac{s_t}{c^2 \lambda_2} \tag{A5}$$

This can be used to yield solutions for the real interest rate, inflation, the output gap and the short-run inflation target as follows:

$$r_t = \frac{\left(s'' - s'\right)}{bc\left(1 + c^2 \lambda_2\right)} + \frac{\left(s' - s\right)}{bc} + \frac{s}{bc} + \frac{\left(d' - d\right)}{b} + \frac{d}{b} \tag{A6}$$

$$\pi_t = \pi_L + \frac{\left(s_t'' - s_t'\right)}{c^2 \lambda_2 \left(1 + c^2 \lambda_2\right)} + \frac{\left(1 - c^2 \lambda_2\right)}{c^2 \lambda_2}\left(s_t' - s_t\right) + \frac{s_t}{c^2 \lambda_2} - c\left(d_t' - d_t\right) \tag{A7}$$

$$y = -\frac{\left(s_t'' - s_t'\right)}{c\left(1 + c^2 \lambda_2\right)} - \frac{s_t' - s_t}{c} - \frac{s_t}{c} - \left(d_t' - d_t\right) \tag{A8}$$

$$\pi_{St}^t = \pi_L + \frac{\left(s_t'' - s_t'\right)}{c^2 \lambda_2 \left(1 + c^2 \lambda_2\right)} + \frac{\left(s_t' - s_t\right)}{c^2 \lambda_2} + \frac{s_t}{c^2 \lambda_2} \tag{A9}$$

$$\pi_{St+s}^t = \pi_L \quad \text{for } s = 1,...,\infty. \tag{A10}$$

Important results are as follows:

1. Minimising $\sum_{s=0}^{\infty} L_{t+s}$ with respect to the short-run target with inflation expectations as given implies:

$$\pi_{St}^t = \pi_t^e - cbr_t + cd_t' + s_t' \tag{A11}$$

(A 11) also follows from combining (A5), (A6), (A7) and (A9). Hence the short-run target is optimal for the central bank, given the parameters λ_1 and λ_2 in the central bank's loss function.

2. Contrasting (A5) and (A9), the short-run target only differs from the public's inflation expectations in a term in the transparency error associated with the supply-side shock.

3. Looking at the solution for inflation, (A7), the elasticity of the transparency error on supply-side shocks on inflation is decreasing in c and decreasing in λ_2.

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