Inflation Targeting: A Framework for Communication*

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Abstract

More than a monetary policy strategy, we interpret inflation targeting as a framework for communication. We model monetary policy as an information game between the Bank and private agents. Our analysis shows how the provision of an explicit numerical inflation objective overcomes potential information imperfections by providing a focal point for agents who form expectations. Furthermore, the combination of communicating the target and a tolerance band around it, provide a very clear framework with which to evaluate monetary policy outcomes. A *successful* Central Bank then builds up credibility and a *credible* Central Bank is in a better position to be successful in subsequent periods. We show how (and when) inflation targeting exploits this self-reinforcing loop to help the Central Bank endure large and long-lasting shocks. Last, we show that a trade-off emerges when choosing the band-width around the target: too narrow bands provide a focal point but reduce the likelihood of inflation being 'successful'. Too wide bands, on the other hand, lead easier to success but at the risk of failing to provide a clear focal point. We thus derive the *optimal* band-width for different scenarios.

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1 Introduction

It is often argued that the two distinct features of inflation targeting (IT) are the provision of first, an anchor for expectations and second, a transparent set of criteria with which to evaluate Central Banks (King 2002). In this paper, we concentrate not so much on what defines inflation targeting as a monetary policy strategy, but on how it operates as a communication framework that deals with information imperfections. With reference to the anchoring of expectations, we argue that when information available to agents is imperfect, the provision of clear signal, even if partial, can potentially provide a focal point at which agents coordinate. The deciding factor in the target's capacity as a focal point is credibility and how it is updated. With reference to the second feature, we examine how and why such a regime provides a clear framework for assessing monetary policy. In doing that we need to allow for two important mechanisms to enter explicitly in our methodology. The first is the inter-temporal self-reinforcing loop between credibility and success, which necessitates that credible Central Banks (CBs) are more successful, and successful Central Banks are easier credible. The second is modelling the choice of band-width around the announced target, in a way that captures the trade-off between providing a clear signal on the one hand (narrow bands), but wishing to be successful (wide bands), on the other. Allowing for these two mechanisms, we can then discuss the circumstances in which announcing an inflation target can be an effective communication framework.

They key variable that drives these mechanisms is expectations. Indeed, modern monetary policy has emphasized that maintaining a stable monetary environment depends crucially on the ability of the policy regime to control inflation expectations (Blinder et al, 2001, Woodford, 2003). Evidence of that is shown by Paloviita and Virén (2005) for inflation in the euro area and by Orphanides and Williams (2005) in their analysis of US monetary policy history. The latter argue that monetary policy failures are connected with changes in public sentiment about the future state of the economy. In other words, policy mistakes alone are not enough to produce long-term negative effects on monetary stability. Expectations will also have to deviate from long term objectives for these effects to materialize. As a means of preventing such expectations deviations, policy makers develop communication strategies that aim explicitly to align expectations with their own policy objectives. The provision of an explicit numerical inflation target is one such example of a communication strategy, the main advantage of which is arguably its ability to provide a focal point for private sector expectations. Empirical evidence appears to confirm that explicit quantitative targets for inflation succeed in that capacity, as shown by Mishkin and Schmidt-Hebbel (2001, 2007), Johnson (2002) and more recently by Levin

et al (2004), Fatás et al (2004) and Gürkaynak et al (2006)[1]. Central Bankers themselves emphasize the link between the two in their own evaluations of their respective monetary policies. Mervyn King claimed in 2002, (p.4) that for the UK case, inflation expectations had indeed been anchored to the pre-announced target. Similarly Issing et al (2005) emphasized the importance of announcing a clear inflation objective for helping coordinate expectations. Following this realization however, there are two questions that need to be addressed: first, why do expectations need to be coordinated? Second, how does communicating an inflation target actually help coordinate them? Demertzis and Viegi (2008) provide a model in which these questions are tackled explicitly. Monetary policy is portrayed as an information game in which, if private agents' objective is to correctly forecast inflation at the relevant horizon, then to do so they need to both assess the Central Bank's actions, as well as second-guess other agents' views. It is the latter aspiration that, in effect, generates the motive to coordinate with other players. Communicating an inflation target then provides the option of coordinating at this level. The necessary and sufficient condition for coordination at the desired level is that the target announced is 'sufficiently' credible, where the sufficiency condition is derived endogenously in the set-up. This critical condition is a function of economic circumstances and the quality of all information available to the agents. The inflation target satisfies its role as a coordinator of expectations the more stable economic conditions. Similarly, this role is better fulfilled the more noisy all other public information available, implying that the target acts as a substitute for all other public information. Once expectations are tied down to the target, the Central Bank can then identify that policy that will help it meet its objectives and therefore, be 'successful'[2].

This set-up allows for credibility to be the determinant of success in monetary policy. Equally important however is the fact that only demonstrably successful monetary policies can earn Central Banks credibility[3], which in turn would enhance their ability to be successful in the future. The opposite is also true; failing to achieve predefined objectives damages credibility and therefore, the Central Bank's ability to also do so in the future. The important point here being that credibility and 'success' feed into each other in a self-reinforcing loop. We argue that the dynamic nature of this loop is what provides an intertemporal link, crucial to the decisions Central Banks make (as they try to build up reputation), and is an essential component of modelling monetary policy in practice (see for example Blackburn and Christensen, 1989 and Bomfim and Rudebusch, 2000). The advantage of modelling monetary policy as an information game is that it provides an explicit measure for 'sufficient' credibility. At the same time, announcing an inflation target provides a very clear measure of

[1] See also Leiderman and Svensson (1995) and Bernanke et al (1999) for earlier accounts of experiences with inflation targeting.

[2] 'Success' is identified here with meeting one's objectives. Note that as a Central Bank's objectives are chosen based on some societal welfare criteria, a successful central bank is beneficial to society.

[3] In line with the 'competence implies credibility' argument presented by Blinder, 2000 and Moscarini, 2007.

success. Combining these two measures with a certain updating mechanism, we can exploit the way credibility and success feed into one another. We will show how communicating a target exploits favorable circumstances better in terms of building credibility, that will then increase a Central Bank's ability to withstand shocks when unfavorable conditions arise. This is the main contribution of our paper.

Last we are going to assume that credibility changes between periods are derived based on a Bayesian updating mechanism. The direction of change is determined by past inflation performance. The advantage of such a technique is that it can identify the exact band-width around the target that will enhance its efficiency. As success helps acquire credibility, there is a natural tendency to overestimate the size of the bands in order to increase one's success record. However, the incentive to coordinate implies that wide bands are discounted as unclear signals that show no confidence in achieving pre-defined objectives. Our methodology will capture this trade-off and thus identify the optimal band-width.

The paper is organized as follows. Section 2 summarizes the way that a number of countries have experienced inflation targeting. Section 3 describes monetary policy as an information game and shows how, and when, the provision of an inflation target amounts to providing a focal point for expectations. The decisive factor in this process will be credibility. Section 4 then introduces the dynamic aspect of the game and links inter-temporally credibility to success. We thus derive how credibility improves or worsens depending on previous period's inflation performance. Section 5 describes the results of Monte-Carlo simulations to generalize the circumstances in which communicating an inflation targets provides the greatest gains in credibility and inflation performance. Section 6 then explores which band-width is required for the inflation target to be part of an effective communication strategy and how it varies with different assumed parameterizations. Section 7 offers a brief discussion of our results and concludes.

2 Inflation Targeting Experience

We describe here briefly how a number of countries have experienced inflation targeting in relation to the points raised above[4]. Has the provision of an explicit inflation target acted as a focal point for expectations? Are there discernible benefits to credibility and how do they manifest themselves? How have countries chosen to communicate the bands around the target and to what effect?

It is fair to say that most of the countries had experienced periods of relative high and volatile inflation prior to the introduction of explicit targets but have also seen, on the whole, significant improvements in inflation around the time of introducing it (Bernanke et al, 1999). In Figures 1-4 we summarize the way

[4] See Mishkin and Schmidt-Hebel (2001) for a comprehensive discussion of the way a number of countries have experienced inflation targeting.

inflation, the target and the bands around it, and for some countries inflation expectations, have evolved over time[5].

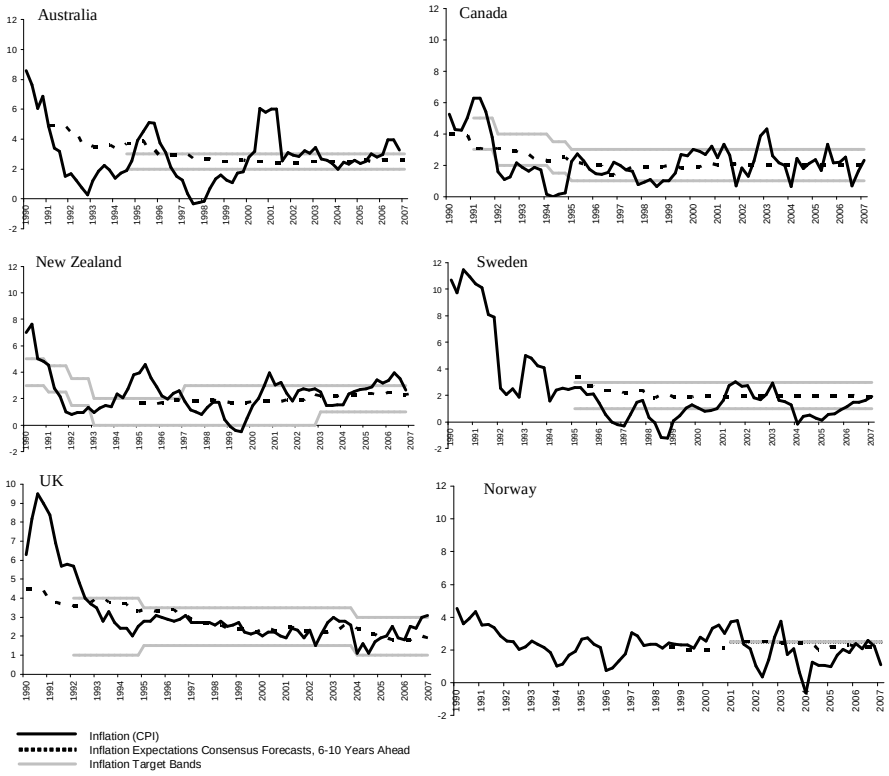

Figure 1: Inflation and Expectations

A number of countries have introduced the targets at the bottom, or at relative low levels, of the downward trend (e.g. Sweden, UK, CH). Others waited till inflation had stabilized at relatively low levels (Norway, Australia, South Africa). Finally, a separate group have changed the inflation target bands progressively to bring inflation down (New Zealand, Canada), an approach that proved particularly popular in countries that were at the time facing relatively high levels of inflation (most Latin American countries, but also the Czech Republic, Hungary, Republic of Korea and Israel). For a number of countries in Figure 1 we see that expectations are simply disconnected from the level of inflation and are focused on the mid-point (Canada and Sweden being the prime examples, followed by Australia and New Zealand). The UK is also very interesting, especially since agents were very quick to internalize the change of inflation measure

[5] See Appendix A for a detailed description of the data.

targeted in December 2003[6]. Figure 1 shows expectations moving to the new mid-point. But the Euro Area (Figure 4) and Norway, which only have an upper limit rather than a symmetric band around a target, also appear to fall into this category with that limit acting effectively as the focal point.

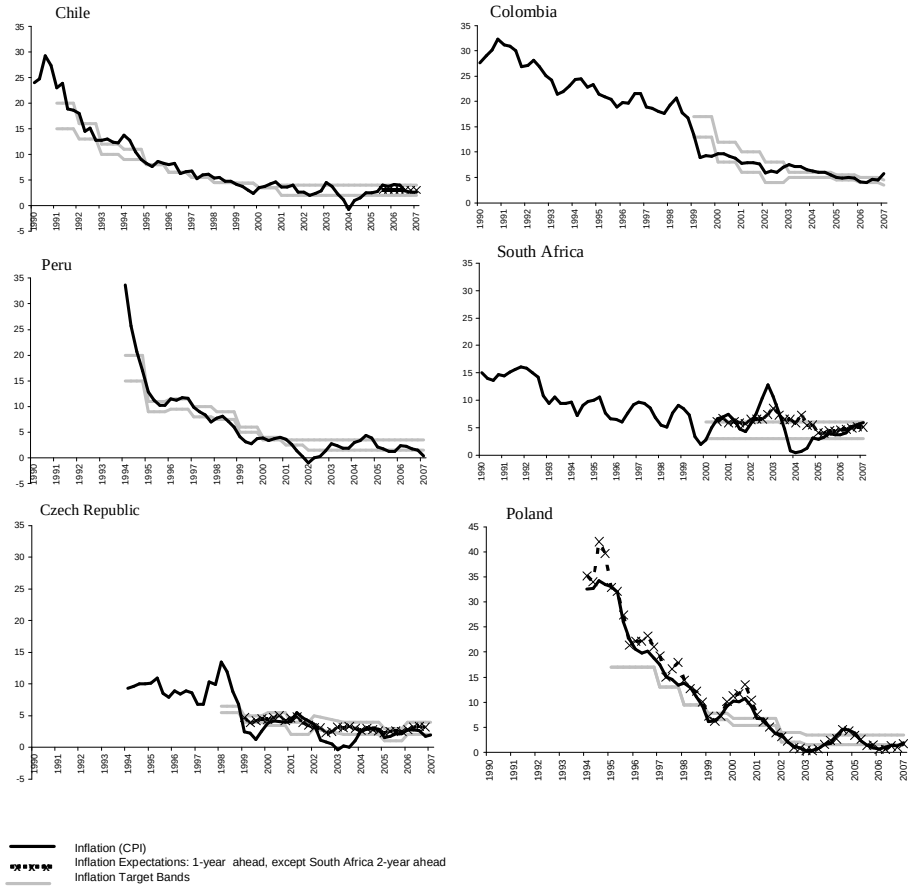

Figure 2: Inflation and Expectations

But there are also big differences in the way countries have implemented the inflation targeting regime. For some countries, the target and bands around it

[6]The Bank of England has been targeting the RPIX till December 2003 at a level of 2.5%. After that it switched to targeting CPI at the level of 2%. We thus present data for the first till December 2003 and the second after that. The remit given to the MPC by the Chancellor states a point target. We report bands however of ±1% to reflect that when this happens the Governor must write an open letter to the Chancellor explaining why inflation is away from the point target, what actions the MPC will take to return inflation to target and the horizon over which they intend to do so.

have been seen, right from the start, as the long term objective. Countries like Australia, Sweden or Norway announced just the one band-width (and target). For others, there has been a certain degree of refining at the beginning, (see Canada, New Zealand and to a lesser extent the UK), eventually settling to a unique target and band-width after few adjustments. On the other hand, for a big number of countries, inflation targets and the bands around them were introduced progressively and were subject to changes in small and gradual steps. This is typical for countries that were on a disinflationary path and were using the regime very much as a means of building up credibility. These countries - in particular in Latin America (Chile, Colombia, Mexico and Peru) - set progressively ambitious objectives, thus allowing the public to evaluate their performance from one year to the next.

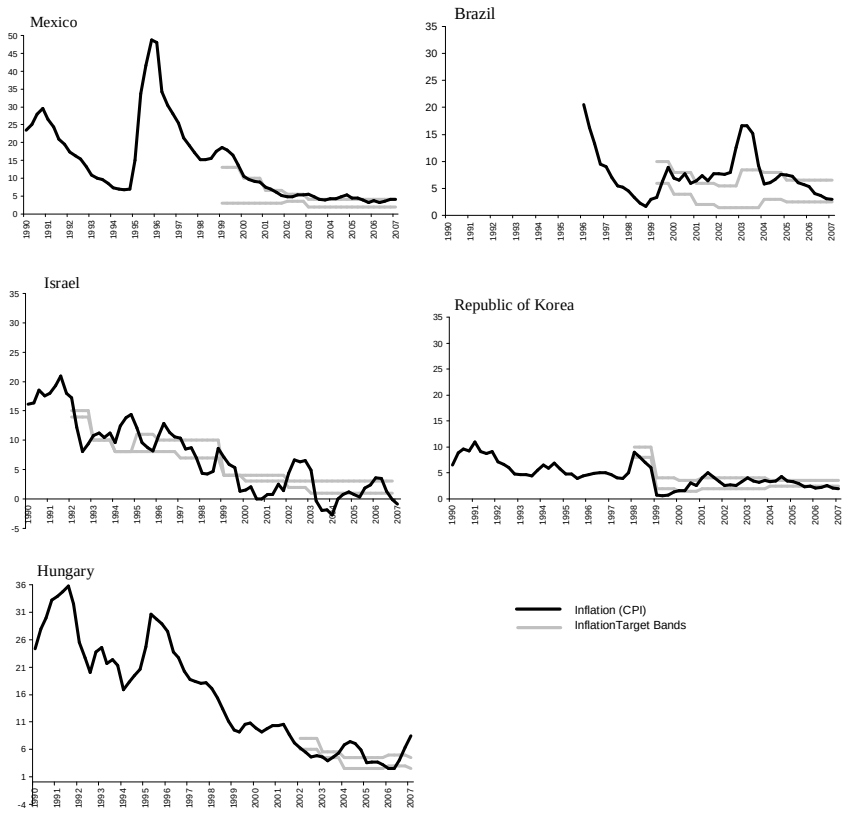

Figure 3: Inflation and Expectations

Once at a relatively low level of inflation, it will be very interesting to see whether the public in these countries makes the switch in terms of now interpreting the inflation bands as a medium to longer-term objective and thus not penalize

the Bank for short-term misses. Preliminary evidence for Chile and the Czech Republic shows that expectations are either tied to the mid-point (Chile) or are following the mid-point as the band-width changes (Czech Republic, both in Figure 2). In Poland and South Africa on the other hand, expectations (short run, 1-year and 2-year ahead respectively) appear to correlate highly with actual inflation, with little attention paid to the pre-specified bands. In both countries therefore, inflation targeting has not be successful in terms of disconnecting expectations from inflation, even though, and certainly in the case of Poland, inflation has been on a very successful downward trend[7].

Can we identify next instances where credibility, in the sense of anchored expectations, allowed countries to deal more effectively with adverse shocks? There are two instances that are interesting: Australia in the period between 2000 and 2002 and Canada in 2003. In these periods, actual inflation was pushed outside the predefined limits. However, as for both countries expectations were at the mid-point of the range and therefore arguably credible, this deviation in inflation was short-lived and did not present an obstacle to bringing it back to low levels[8]. Goodfriend (2007) argues that this was also the case for the US in 2001, "...The fact that inflation and inflation expectations were well-anchored enabled the Fed to cut the federal funds rate aggressively in 2001 from 6.5 to 1.75 percent to cushion the fall in aggregate demand and employment."
Last, the issue of the band-width is naturally pivotal to the implementation of the regime. The argument, as explained above, is that wide bands reflect lack of confidence on objectives set and therefore fail to provide a focal point. Too narrow bands, on the other hand, run the risk of being surpassed, which in itself penalizes Central Bank credibility. The issue of the band is a clear concern for Central Banks. Mishkin and Schmidt-Hebbel (2001) explain that "...when Chile adopted inflation targeting in 1991 with inflation exceeding 20 percent, the inflation target was treated more as an official inflation projection rather than as a formal 'hard' target....Over time, the central bank put greater emphasis on the price stability objective and with its *success in both disinflating and meeting its inflation objectives*, the public began to interpret those objectives as 'hard' targets for which the Central Bank could be made accountable" (italics added). In the beginning therefore, it is crucial to establish credibility. The bank then adopts relatively wide bands and puts an effort in achieving its announcement. As 'success' comes and credibility increases, the Central Bank can then afford to both move its objective along the long-term objective of price stability, as well as refine the band that will focus expectations more effectively. The experience of most countries is that bands at the point of introduction are wider, and only gradually become narrower as the mid-point is adjusted downwards. Countries that have instead experimented with the width along the way seem to

[7] Understanding the reasons behind this cannot be done without acknowledging the countries' degree of openness.

[8] Sweden has a number of instances in which inflation was outside the limits (which were also not penalized but they entail being below the lower limit which is often considered less problematic.

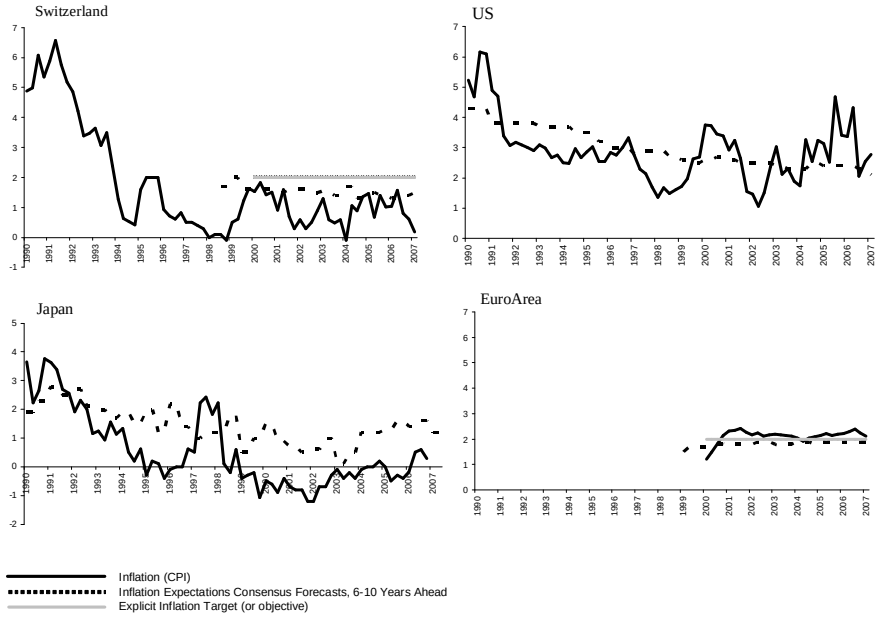

Figure 4: Inflation and Expectations

be less vested against inflation (Brazil, Israel) although for the case of the Czech republic expectations appear to just follow the mid-point irrespective of where it is or the width around it. The case of SA, on the other hand, is an example where a more gradual approach to the width may have been more beneficial to expectations. As it stands right now it appears that the communication of the target has not really helped disconnect expectations from the level of inflation.

Last we present a graph for countries (Figure 4) that are slightly different altogether. The Euro area, although not an official inflation targeter, also has long-term expectations very close to the official quantitative objective for inflation of below but close to 2 percent. This is despite the fact that inflation appears to have stabilized just above the 2 percent mark. Japan and the US are two countries that have not communicated an explicit inflation target and have experienced monetary policy in very different ways. Expectations in Japan have been quite volatile and persistently above inflation. By contrast, in the US expectations are very monotonic and appear to follow the inflation trend, which up to 2000 was downward, whereas beyond 2000 stabilized at around 2.5 percent. If the inexistence of correlation between inflation and expectations is a sign of credibility, then the US appears to have acquired it.

3 Monetary Policy as an Information Game

The Central Bank has a standard loss function in which it chooses the rate of inflation x to minimize the distance from the inflation objective set x^T and close the output gap y,

$$L_{CB}|_{\xi} = \frac{1}{2}\mathbb{E}\left[\left(x - x^T\right)^2 + y^2\right] \tag{1}$$

subject to a standard Lucas supply function, $y = x - x^e + \xi$ where ξ is a supply shock with zero mean and constant variance, σ_{ξ}^2. Note that any Central Bank will have an objective x^T irrespective of whether it communicates it to the public clearly, or even at all. We assume for simplification that the CB's instrument is x. Optimization of (1) implies that

$$x|_{\xi} = \frac{x^T}{2} + \frac{x^e}{2} - \frac{\xi}{2} \tag{2}$$

where x is now the *ex post* inflation outcome conditional on the shock ξ, and x^e is private sector expectations about the relevant rate of inflation. Representation (2) is of a structural form[9] in the sense that expectations are not replaced (Leitemo, 2006). Svensson (2003) argues in favour of such a representation in order to indicate that factors like judgement that contribute to the way expectations are formed but cannot always be modelled, are an important contributor to monetary policy. In a typical commitment game, where the Central Bank communicates its target x^T and commits to it, expectations formed by all individuals collectively are equal to the CB's objectives, $x^e = x^T$ and the ex post outcome is

$$x|_{\xi} = x^T - \frac{\xi}{2} \tag{3}$$

$$\mathbb{E}(x) = x^T. \tag{4}$$

Modeling monetary policy as an information game implies a departure from the assumption that expectations are by default equal to the objective of the

[9] Note that (2) is specific to the underlying Lucas supply function assumed but demonstrates that the outcome will be a function of both the policy the Central Bank pursues as well as what the private sector anticipates. Analogously, had the model been of the standard Neo-Keynesian type based on Clarida Gali and Getler (1999),

$$x_t = \beta E_t x_{t+1} + k y_t + \varepsilon_t$$
$$y_t = E_t y_{t+1} - \gamma\left(i_t - E_t x_{t+1}\right) + \eta_t$$

then the structural representation of the *ex post* inflation outcome would be

$$x_t = \frac{k^2}{1+k^2}x^T + \frac{1}{1+k^2}E_t x_{t+1} + \frac{\varepsilon_t}{1+k^2}.$$

Our point is to show that the *ex post* outcome is a function of both the CB objective as well as the expectations of the private sector.

Central Bank and analyses instead how individuals go about interpreting the information that is available to them when forming expectations. Rather than impose that expectations equal the target, the information game looks for the process followed by agents that leads to that being true. Every individual i will be forming an expectation of inflation x_i, such that the collective outcome (for a continuum of agents) is $x^e = \int_0^1 x_j dj$, which is the expectation that is relevant to *ex post* inflation. The timing of the game assumed has the Central Bank deciding what its objectives are first, shocks occur next, then private agents form expectations based on information available about these shocks and policy objectives and finally the CB applies policy.

Typically every individual forms expectations based on two information sets: namely what is publicly available and therefore common to everyone, and what is available to them privately. Furthermore, every individual is aware of the fact that the *ex post* outcome of inflation x will be determined by (2), in other words will be affected equally (given the model we assume) by the policy the Central Bank pursues to attain its objectives, as well as the average of expectations formed by the public. However, as the individual is interested in predicting the *ex post* level of inflation correctly[10] (in order, for example, to base her wage negotiations on), she needs to interpret both components of (2) based on the information she has. Her objectives are captured by a standard expected dis-utility:

$$u_i\left(\mathbf{x}^e, x^T\right) \equiv \frac{1}{2}\mathbb{E}_i(x_i - x)^2. \tag{5}$$

Note that subscript i in the expectations operator indicates that the individual will be seeking to minimize her expected dis-utility, given her own perceptions. x_i is individual i's expectation of what inflation will be at the relevant horizon and x is again the *ex post* inflation outcome. We use $\mathbf{x}^e$ to refer to the expectations profile over all agents. The individual decides her action x_i based on the first-order condition of (5). This is:

$$\arg\min_{x_i} u_i\left(\mathbf{x}^e, x^T\right) = \mathbb{E}_i\left(x\right)$$

and from (2),

$$\begin{aligned} x_i &= \mathbb{E}_i\left(x\right) \\ x_i &= \mathbb{E}_i\left(\frac{x^T}{2} + \frac{x^e}{2} - \frac{\xi}{2}\right) \\ x_i &= \frac{1}{2}\mathbb{E}_i\left(x^T - \xi\right) + \frac{1}{2}\mathbb{E}_i\left(x^e\right). \end{aligned} \tag{6}$$

The optimal action for individual i in (6) is thus a function of three things: the objectives of the Central Bank and hence the policy it will pursue, the shock

[10] See Canzoneri (1985).

that will have occurred by the time she makes the decision, and finally the average expectation formed by all individuals. The individual i does not observe these three things directly but in forming expectations x_i she needs to evaluate them based on the information she has, indicated here by the expectations operator subscript i. It follows that if $x_i = x_j \ \forall j$, then $x_i = x^e$ and individuals' expectations are matched. However, although desirable, coordination between agents at simply any level of inflation is not sufficient; the optimal outcome occurs when agents coordinate at the objective pursued by the Central Bank, x^T. Coordination at any other expectation rate still leaves agents away from the level of inflation that the CB aims to achieve. We will argue further down that knowledge of the CB objective is necessary but not sufficient for coordination at it. Following Morris and Shin (2002), we argue that information used by the agents is available in the form of a public signal common to all and a private signal, which is specific to each agent in the economy. Individuals therefore, observe p and z_i where,

$$\text{Public signal:} \quad p = \left(x^T - \xi\right) + \eta \tag{7}$$

$$\text{Private signal:} \quad z_i = \left(x^T - \xi\right) + \varepsilon_i. \tag{8}$$

Terms η and ε_i represent the information noise and have a zero mean and variance σ_η^2 and σ_ε^2 respectively. Furthermore, the two error terms are independent of x and of each other, such that $\mathbb{E}(\varepsilon_i \varepsilon_j) = 0$ for $i \neq j$. The clarity of public information is not under the full control of the CB but is affected by a combination of the CB's information strategy, the general market information available and noise. Based on Morris and Shin (2002), these two signals imply that agent i's action (inflation expectation) then is

$$\begin{aligned} x_i &= \frac{2\alpha p + \beta z_i}{2\alpha + \beta} \\ &= x^T - \xi + \frac{2\alpha\eta + \beta\varepsilon_i}{2\alpha + \beta} \end{aligned} \tag{9}$$

where $\alpha = \frac{1}{\sigma_\eta^2}$ and $\beta = \frac{1}{\sigma_\varepsilon^2}$, the level of precision for the two information sets respectively.

Definition 1: *We call (9) the "MS action".*

We assume homogenous agents and calculate expectations across all agents as follows:

$$x^e = \int_0^1 x_j dj = x^T - \xi + \frac{2\alpha\eta}{2\alpha + \beta}. \tag{10}$$

Equation (10) shows that the average expectation across all agents will be distorted by the (lack of) precision of the two signals as well as the preference for the 'beauty term'(r in Morris and Shin terminology), here equal to $\frac{1}{2}$ (from 6).

3.1 Inflation Targets as Focal Points

Equations (9) and (10) show that expectations formed will be a function of the objectives of the Central Bank, the supply shock and the precision of information individuals have. However, if a Central Bank has communicated to the public what its inflation objective is, the individual effectively receives an extra signal in addition to (7) and (8), i.e.:

$$\text{Central Bank signal:} \quad h = x^T. \tag{11}$$

In turn the individual is faced with an option to either apply (9), or driven by her desire to coordinate with others, form expectations according to the target. In other words, the 'action' the individual takes could be either $a_i = x_i$ or $a_i = x^T$ and the 'average' action is respectively $\bar{a} = x^e$ or $\bar{a} = x^T$. The very provision of an inflation target therefore increases the number of options available to the individual and thus the number of potential outcomes[11]. Presenting the individual with this option is attractive because it overcomes the problem of having to guess what information everyone uses when forming expectations and is very much in line with the Morris and Shin (2002) observation that public information receives a greater weight in people's action than is justified by its quality. However, the gain of bypassing information imperfections comes at the cost of getting only partial information $\left(x^T\right)$ about the relevant set (state: $x^T - \xi$). The real trade-off therefore faced by the individual is less information for better precision. This is, in our view, how the announcement of an inflation target can affect expectations and therefore the monetary policy outcome as well. We examine then how the individual would go about evaluating this trade-off when forming a decision.

We re-write (5) to account for the multiplicity of actions and calculate the dis-utility attained when applying either of two actions, i.e.:

$$u_i\left(a_i, \bar{a}\right) \equiv \mathbb{E}_i(a_i - x)^2. \tag{12}$$

Note that while the announcement of a target increases the number of options that the individual has, it only really offers a *possibility* for coordination at the target. A number of conditions need to be satisfied for this to happen, credibility being the most important, as we show next. Table 1 summarizes the pure form strategies available to individual i under IT and the dis-utility outcomes associated with them, based on (12):

Table 1: Individual i's dis-utility in Normal Form

$a_i \quad \backslash\, \bar{a}$	x^e	x^T
x_i	$\frac{\alpha+\beta}{(2\alpha+\beta)^2}$	$\frac{1}{4}\sigma_\xi^2 + \frac{4\alpha+\beta}{(2\alpha+\beta)^2}$
x^T	$\sigma_\xi^2 + \frac{\alpha}{(2\alpha+\beta)^2}$	$\frac{1}{4}\sigma_\xi^2$

[11] Brazier *et al* (2006) allow also for this switch, only in their case it is between the target and past inflation, depending on which of the two had performed better in the past.

Table 1 shows that for any given level of precision for public and private information, adopting the inflation target x^T becomes a dominant strategy for individual i if the variance of the supply shock is below a given threshold, i.e.:

$$\sigma_\xi^2 < \frac{\beta}{(2\alpha+\beta)^2}. \tag{13}$$

As we assume homogenous agents (and by implication everyone adopts their dominant strategy) the game has then *one* Nash equilibrium, namely $E_1 \equiv (x^T, x^T)$. Individual i ends up facing dis-utility equal to $\frac{1}{4}\sigma_\xi^2$. However, if condition (13) is not satisfied, i.e. $\sigma_\xi^2 \geq \frac{\beta}{(2\alpha+\beta)^2}$, then individual i's optimal response in pure form strategies requires *'matching'* the average action. In other words, $a_i = x_i$ is the best response to $\bar{a} = x^e$, and $a_i = x^T$ is the best response to $\bar{a} = x^T$. The game has now *two* Nash equilibria in pure form, namely $E_2 = (x_i, x^e)$ and $E_3 = (x^T, x^T)$.

The variable that is going to be pivotal to the individual's decision, when faced with a matching game, is the extent to which the Central Bank is credible. A sufficiently credible, in the eyes of the individual, Central Bank will induce her to opt for x^T. Otherwise, the individual will resort to forming expectations based on all the information that she has, x_i. Our choice to use credibility as the decisive factor is based on the fact that modern monetary policy stresses it as the most important contributor to stable prices. This view is shared by professional economists and Central Banks alike, as shown in the surveys carried out by Waller and de Haan (2004) and Blinder (1999). Credibility is therefore what is going to allow Central Banks the flexibility to tackle shocks as they arise and what in itself will generate further monetary policy successes. Given the representative nature of the individual assumed, this allows us to predict which of the two Nash equilibria, E_2 or E_3, will prevail and under which conditions. We present next the outcome of this process.

Definition 2: *Let variable v denote the degree of the inflation target's credibility and $v \in [0, 1]$.*

Demertzis and Viegi (2008) use v in the context of an expected utility framework that will help the individual form a choice. This framework relies on Bacharach's *Variable Universe Games* (1993) contribution on focal points. Appendix B explains in detail how credibility enters the individual's choice-space and how she would go about deciding between the two actions. The necessary and sufficient condition for agents (individually and collectively) to form expectations according to the target is:

$$v \geq \frac{(2\alpha+\beta)^2 \sigma_\xi^2 - \beta}{4\alpha + (2\alpha+\beta)^2 \sigma_\xi^2}. \tag{14}$$

Or in other words, (14) shows that the sufficient condition for individual i to follow the target is when the target's credibility is sufficiently high. Based on this condition, individual i then forms expectations as follows:

$$a_i(\text{and } \bar{a}) = \begin{cases} x_i(\text{and } x^e) & \text{if } v < \frac{(2\alpha+\beta)^2\sigma_\xi^2-\beta}{4\alpha+(2\alpha+\beta)^2\sigma_\xi^2} \\ x^T & \text{if } v \geq \frac{(2\alpha+\beta)^2\sigma_\xi^2-\beta}{4\alpha+(2\alpha+\beta)^2\sigma_\xi^2}. \end{cases}$$

Note that the condition for credibility v depends on the variability of the shocks, and the precision of the two signals, public and private. It does not however depend on the draws of any of the three shocks, - supply, public and private information. This is the case because the agent evaluates the Central Bank in knowledge of the distribution properties of the three noise terms, but observes their realizations only imperfectly. Inflation, on the other hand, depends also on the actual supply shock, and when expectations are formed according to the MS action, also on the (public) information shock observed every period.

4 Evaluating Monetary Policy

Having announced a target, we examine next how this target helps the Central Bank gain credibility. The main assumption behind what follows is that credibility is solely determined by a Central Bank's previous performance, or in other words, by how well it has managed to achieve its objectives in the past (Blackburn and Christensen, 1989). However, 'success' itself is in turn affected by two things: the ability to tie down expectations to its target (credibility), but also the size of the supply shocks. Observing then the Central Bank's track record, agents update their beliefs about its abilities and accordingly affect the inflation outcome in the next period. There is therefore an inter-temporal loop between success and credibility, which is reinforcing in both directions and is essential to the monetary policy outcome.

This approach is very similar in spirit, to that of Bomfim and Rudebusch (2000) with two important differences. First, expectations in our case are discrete, in that the switch between the two 'expectations states' depends on how current credibility compares to the critical condition in (14). Bomfin and Rudebusch (2000) instead have expectations being formed in a continuous manner, depending partially on the target and its credibility (which is also updated given past success) and partially on past performance. The discrete switching applied here is the direct result of the individuals' incentive to coordinate, which induces them to look for opportunities to converge to focal points. Second, our updating mechanism is also slightly different to that of Bomfim and Rudebusch (2000), in that the individual rewards a successful Central Bank in terms of increasing the level of trust she puts in it, but she also penalizes an unsuccessful Central Bank by reducing credibility. The game is organized in such a way that at a given period, the Central Bank operates with a given 'stock' of credibility, very much in the Barro-Gordon (1983) sense. This implies that within that period, the Central Bank can no longer affect its credibility. This is a necessary feature in our view, in order to capture the fact that credibility is intrinsically the result of past performance only. At any given point in time when the Central Bank takes a decision, it reckons with the fact that it has to operate within the

confines of its own reputation. However, today's actions will affect next period's reputation, the Central Bank's credibility and ultimately also its ability to be successful thereafter. With the help of numerical simulations we will show, in the next section, how the Central Bank's success rate increases with a provision of a numerical target and under which conditions. We find the following: it is easier to build up credibility when the economic environment is stable, or put the other way around, it is a lot more difficult to improve reputation when economic circumstances are unfavorable. Within given economic circumstances however, when the CB is credible (i.e. expectations are tied down to the inflation objective), its ability to achieve that objective is enhanced. In all circumstances however, if reputation is linked to performance and performance is linked to exogenous shocks, reputation and credibility can be gained but can also be lost from one period to the next. This emphasizes the ephemeral nature of credibility and the importance of capitalizing on favorable circumstances in order to build up credibility that will help withstand unfavorable ones (Goodfriend, 2007). We explain how this updating occurs next.

4.1 Credibility Gained, Credibility Lost

We define first the terms 'success' and 'credibility' in monetary policy.

Let variable $S \in \{s, \bar{s}\}$ denote whether the Central Bank is successful or unsuccessful and $\Pr(S = s)$ the probability of a Central Bank being successful. We define ρ as the radius of tolerance around the target.

Definition 3: *A successful Central Bank ($S = s$) is one for which $\left|x_t - x^T\right| < \rho$* at a given t; by implication an unsuccessful Central Bank *($S = \bar{s}$)* is one for which $\left|x_t - x^T\right| \geq \rho$.

Definition 3 above implies that a Central Bank announces an inflation target x^T and a band around it (2ρ). It can easily by interpreted as the band-width around an inflation target, as used by most inflation targeting Central Banks in practice. Naturally, as appearing to be successful is of importance to the Central Bank, one could use the band-width strategically to maximize success. However, there is an important trade-off between providing a focal point (narrow band) and being successful (wide band) that leads to the existence of an optimal width. We will discuss this in section 6.

Let variable $C \in \{c, \bar{c}\}$ denote whether the Central Bank (and therefore its target) is credible or not. From definition 2 above, $v \equiv \Pr(C = c)$.

Definition 4: *A credible Central Bank ($C = c$) is one for which $\bar{a} = x^T$; a non-credible Central Bank ($C = \bar{c}$) is one for which $\bar{a} = x^e$.*

Agents form views about the Central Bank's credibility v based on past period's performance. For any period t, the timing of the game is as follows:

$$v_{t-1}|_{x_{t-1}} \rightarrow \xi_t \rightarrow \bar{a}_t = \begin{cases} x^e & \text{if } v_{t-1} < \frac{(2\alpha+\beta)^2\sigma_\xi^2-\beta}{4\alpha+(2\alpha+\beta)^2\sigma_\xi^2} \\ x^T & \text{if } v_{t-1} \geq \frac{(2\alpha+\beta)^2\sigma_\xi^2-\beta}{4\alpha+(2\alpha+\beta)^2\sigma_\xi^2} \end{cases} \rightarrow x|_{\xi_t,\bar{a}_t} \rightarrow x_t \rightarrow v_t$$

The Central Bank begins with a certain level of credibility v_0, that is common knowledge. Let $v_t' \equiv \frac{dv}{dt}$; the private sector observes inflation outcome x_t and updates its confidence at the Bank based on Bayes' rule:

$$\text{If } S_t = s \text{ then} \quad v_t' > 0 : \Pr(c|s) = \frac{\Pr(s|c)}{\Pr(s)} \Pr(c)$$
$$\text{If } S_t = \bar{s} \text{ then} \quad v_t' < 0 : \Pr(c|\bar{s}) = \frac{\Pr(\bar{s}|c)}{\Pr(\bar{s})} \Pr(c)$$

Corollary 1 *An implication of this updating is that as success increases credibility v, it will be easier to satisfy (14) in the next period and therefore tie down expectations. The opposite is also true; if monetary policy is unsuccessful, then it becomes increasingly more difficult to succeed in the period after that.*

Given the new level of credibility v_t, the sequence of events at period $t+1$ is identical to above, i.e.:

$$v_t|_{x_t} \rightarrow \xi_{t+1} \rightarrow \bar{a}_{t+1} = \{... \rightarrow x|_{\xi_{t+1},\bar{a}_{t+1}} \rightarrow x_{t+1} \rightarrow v_{t+1} \rightarrow ...,$$

the private sector evaluates the outcome and updates again.

4.2 The Inflation Distribution

Based on (2), we can now derive the first and second moments of inflation, given expectations.

First Moment: the expected inflation outcome is always x^T irrespective of how expectations are formed.

$$\mathbb{E}\left(x_t|_{\bar{a}}\right) = \begin{cases} \mathbb{E}\left(\frac{x^T}{2} + \frac{x^T}{2} - \frac{\xi}{2}\right) = x^T & \text{for} \quad \bar{a} : x^T \\ \mathbb{E}\left(\frac{x^T}{2} + \frac{x^e}{2} - \frac{\xi}{2}\right) = x^T & \text{for} \quad \bar{a} : x^e = x^T - \xi + \frac{2\alpha\eta}{2\alpha+\beta} \end{cases}$$

Second Moment: The variance however is different, depending on how expectations are formed[12].

$$\sigma^2\left(x_t|_{\bar{a}}\right) = \begin{cases} var\left(\frac{x^T}{2} + \frac{x^T}{2} - \frac{\xi}{2}\right) = \frac{\sigma_\xi^2}{2^2} & \text{for} \quad \bar{a} : x^T \\ var\left(\frac{x^T}{2} + \frac{x^e}{2} - \frac{\xi}{2}\right) = \frac{\sigma_\xi^2}{2} + \frac{\alpha}{(2\alpha+\beta)^2} & \text{for} \quad \bar{a} : x^e = x^T - \xi + \frac{2\alpha\eta}{2\alpha+\beta} \end{cases}$$

[12] Demertzis and Hughes Hallett (2007) observe a very similar result (theoretically as well as empirically), whereby greater degrees of transparency (and in this context inflation targeting is a more transparent regime) do not affect the level of inflation, but do affect its variability.

It is straightforward to see that the variance of inflation is smaller if expectations are tied to the target x^T. We can now calculate the probabilities of success given a certain distribution for the shocks and assuming that inflation is normally distributed, i.e. $x_t \to N\left[x^T, \sigma^2(x_{t|\bar{\alpha}})\right]$. The probability of success when $\bar{\alpha} = x^T$ - i.e. $\Pr(s|c)$ - is as follows:

$$\begin{aligned}\Pr\left(x^T - \rho \leq x_{t|x^T} \leq x^T + \rho\right) &= \left(\frac{x^T - \rho - x^T}{\sigma(x_{t|x^T})} \leq z_t \leq \frac{x^T + \rho - x^T}{\sigma(x_{t|x^T})}\right) \\ &= \Pr\left(\frac{-\rho}{\frac{\sigma_\xi}{2}} \leq z_t \leq \frac{\rho}{\frac{\sigma_\xi}{2}}\right). \end{aligned} \tag{15}$$

Naturally the probability of success when $\bar{\alpha} = x^e$ (i.e. $\Pr(s|\bar{c})$) is smaller (as the variance is larger):

$$\begin{aligned}\Pr\left(x^T - \rho \leq x_{t|x^e} < x^T + \rho\right) &= \Pr\left(\frac{x^T - \rho - x^T}{\sigma(x_{t|x^e})} \leq z_t \leq \frac{x^T + \rho - x^T}{\sigma(x_{t|x^e})}\right) \\ &= \Pr\left(\frac{-\rho}{\sqrt{\frac{\sigma_\xi^2}{2} + \frac{\alpha}{(2\alpha+\beta)^2}}} \leq z_t \leq \frac{\rho}{\sqrt{\frac{\sigma_\xi^2}{2} + \frac{\alpha}{(2\alpha+\beta)^2}}}\right). \end{aligned} \tag{16}$$

4.3 A Numerical Example

Assume the following values for relevant parameters including a level for initial credibility (v_0):

$$x^T = 2 \quad \rho = 0.5 \quad \sigma_\xi^2 = 0.25 \quad v_0 = 0.5 \quad \alpha = 4\ (\sigma_\eta^2 = 0.25) \quad \beta = 4\ (\sigma_\varepsilon^2 = 0.25)$$

The variance of private and public information is equal to that of the shocks, and the Central Bank is successful if $1.5 \leq x \leq 2.5$ in each period with the mid-point being the target announced. Moreover, we assume that the distribution of inflation is $x_t \to N\left[2, \sigma^2(x_{t|\bar{\alpha}})\right]$, so that we can apply the standard normal tables for updating v. The Central Bank is assumed to start with credibility equal to 50 percent. The joint probability density function for the two variables C and S is shown in table 2:

Table 2: Credibility and Success

IT			
	s	$\bar{s}$	$C:$
c	$\Pr(c \cap s)$	$\Pr(c \cap \bar{s})$	$\Pr(c) = v$
$\bar{c}$	$\Pr(\bar{c} \cap s)$	$\Pr(\bar{c} \cap \bar{s})$	$\Pr(\bar{c}) = 1 - v$
$S:$	$\Pr(s)$	$\Pr(\bar{s})$	1

We these probabilities we can then calculate the probability of Central Bank monetary policy being successful. From (15), (16) and the standard normal tables we calculate the following:

$$\Pr(s|c) = \Pr(-0.71 \leq z \leq 0.71) = 0.5205$$
$$\Pr(s|\bar{c}) = \Pr(-0.49 \leq z \leq 0.49) = 0.3781$$

Accordingly, we can fill in the rest of the table:

Table 3: Credibility and Success

IT			$\rho = 1$
	s	$\bar{s}$	$C:$
c	0.26	0.24	0.5
$\bar{c}$	0.19	0.31	0.5
$S:$	0.45	0.55	1

Based now on Bayesian updating, we calculate the level of credibility for the next period, for a successful Central Bank:

$$v_1 = \Pr(c|s) = \frac{\Pr(s|c)}{\Pr(s)}\Pr(c)$$
$$= \frac{0.5205}{0.45}0.5 = 0.58.$$

We observe therefore, that the private sector will increase the level of confidence that it has about the Bank, from 0.5 to 0.57. If however, the Central Bank is unsuccessful, then it will be penalized in the sense that v will reduce:

$$v_1 = \Pr(c|\bar{s}) = \frac{\Pr(\bar{s}|c)}{\Pr(\bar{s})}\Pr(c)$$
$$= \frac{0.3781}{0.55}0.5 = 0.44.$$

Credibility reduces from 0.5 to 0.44.

5 Credibility and Success

We can now show how the announcement of an inflation target can help the Central Bank stay within the range of values that constitute a successful monetary policy. We will show this first through illustrative numerical simulations for 20 periods and second through Monte Carlo simulations to generalize our results. We assume the same parameterization in the simulations as above:

$$x^T = 2, \quad \rho = 0.5, \quad \beta = 4 \text{ (or } \sigma_\varepsilon^2 = 0.25)$$

Two parameters are now subject to uncertainty and these are supply shocks ξ and public information noise η, which are drawn from their distributions in every period. Both parameters have a zero mean and respective variances $\left(\sigma_{\xi}^{2},\ \sigma_{\eta}^{2}\right)$ equal to 0.25. Private information precision is fixed in this exercise. In the absence of shocks, if expectations are equal to the target, then the CB achieves its inflation objective and welfare is maximized. If on the other hand, expectations are equal to the MS action, then inflation will not be equal to the target. Irrespective of how expectations are formed however, the presence of supply shocks can seriously hamper the CB's ability to be successful. This inevitably affects the way private agents update credibility. We demonstrate this next.

Following the parameterization assumed, the condition for inflation expectations to be equal to the target is 0.62 (from 14). We assume a starting value for $v = 0.6(< 0.62)$, implying that in the first period, $t = 1$, expectations will follow the MS rule. Random numbers are drawn for each period for both the supply shock ξ as well as the shock to public information η, for 20 consecutive periods. Figure 5 demonstrates how successful the CB is under IT (x_t and x^e) and non-IT (x_t^{MS} and $x^{e,MS}$), and how credibility evolves based on the success of IT.

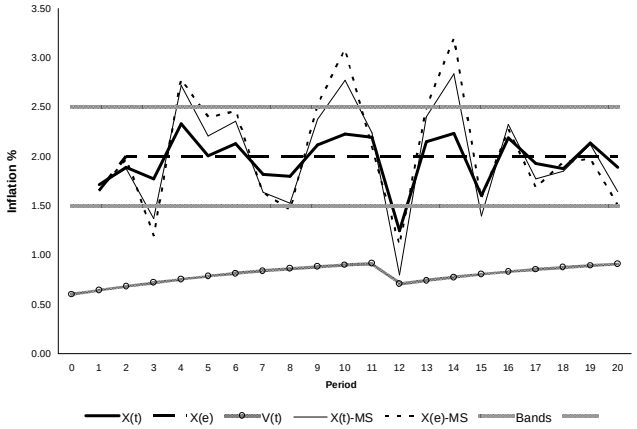

Figure 5: Credibility and Performance

It shows that despite the lack of credibility in the first period, the shocks drawn do not prevent the CB from being successful in maintaining inflation within the specified bands. This success helps reward the CB in the next period by increasing v, helping it go over the 0.62 mark. For the IT regime this implies that expectations are now tied down to the target. In turn, this helps control inflation in the period after that and given the size of the new shocks that occur,

still hold inflation within the bands. The same is true for the MS regime in the first two periods even though expectations do not equal the target. However, after the third period, the shocks occurring are large enough to throw inflation under the MS regime outside the bands. By contrast, the fact that credibility was sufficiently high for expectations to be equal to target implied that the same shock was easier to handle with IT preventing inflation from coming out of the bands. This process reinforces itself in all the periods and while inflation under the MS regime exits the bands on a number of occasions, the fact that expectations are tied to the target under IT allows inflation to remain within the bands. There is only one occasion, at the 12th period, that inflation will fail to remain within the bands and credibility drops as a result. However, this drop does not harm expectations, which remain fixed at the mid-point helping inflation recover after that. Allowing for credibility to affect expectations and the monetary policy outcomes has accounted for the fact that the success rate for IT is 95 percent, whereas that for MS is 70 percent.

However, it is also possible that for the same parameterization, the shocks drawn are unfavorable enough for the coordinating feature of IT to never come into operation. This is shown in Figure 6 where the two regimes overlap with each other.

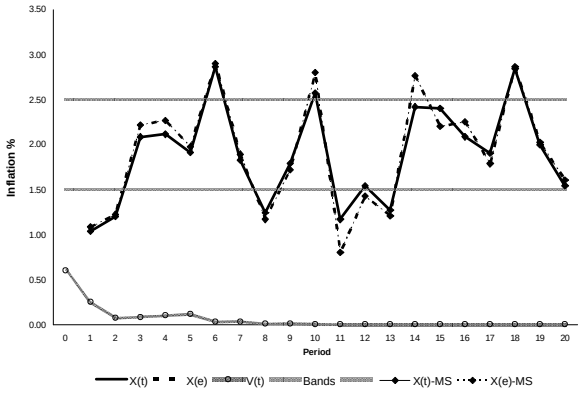

Figure 6: Credibility and Performance

A third possibility (again under the same parameterization) is that illustrated in Figure 7. In this example, acquiring credibility trough inflation targeting is not a permanent characteristic of the regime: if a series of negative shocks hit the economy, the credibility gained can also be lost. What inflation targeting does however achieve is that it makes the system more robust to unfavorable circumstances. In our example, although credibility starts decaying after the seventh period, the focal point characteristic lasts for an extra period before

expectations revert to the MS formation. At period 16 however, the combination of unfavorable shocks and reducing credibility imply that the two regimes become identical.

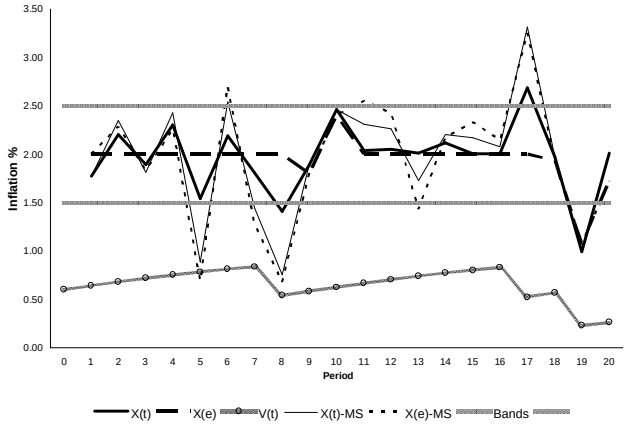

Figure 7: Credibility and Performance

The question is then how often can IT improve the success rate, and under which conditions are these improvements the greatest? Simulations will demonstrate the general results implied for a variety of shocks, based on 1000 repetitions.

5.1 Simulations

We generalize some of these results by performing Monte-Carlo simulations. Figures 5-7 show a block of 20 consecutive simulations. Given the formula applied for updating credibility, twenty periods are sufficient for credibility to converge to either one or zero. In evaluating the results from these Monte Carlo simulations, it is important therefore to rely on multiples of 20-period blocks. We will run 1000 (larger numbers of draws do not change the results) of 20-period blocks rather than the alternative of 20000 consecutive simulations. Parameterization will be identical to what is shown above, unless otherwise stated. We investigate two issues: first, how often the announcement of an IT causes a level of credibility at the end of the 20th period that is higher than that at the first period, i.e. an overall improvement in credibility; and second, what this in turn implies for the success of monetary policy.

5.1.1 Does Announcing a Target Always Improve Credibility?

We first ask whether the announcement of a target always leads to an increase in credibility. In what follows we show the percentage of times for which credibility at the 20th period was higher than the level assumed at the start. This does not

account for oscillations in credibility during the 20-period block but provides an indication of what level credibility converges to. We do this for two different levels of initial credibility and for a variety of different assumptions for the two shocks drawn. Table 4 presents the results.

Table 4: Credibility Improvement

$v(0) = 0.5$		%
$\sigma_\xi^2 = 0.25,$	$\sigma_\eta^2 = 0.25$	20
$\sigma_\xi^2 = 0.25,$	$\sigma_\eta^2 = 0.5$	49
$\sigma_\xi^2 = 0.5,$	$\sigma_\eta^2 = 0.25$	0.02
$\sigma_\xi^2 = 0.5,$	$\sigma_\eta^2 = 0.5$	0.05
$v(0) = 0.7$		
$\sigma_\xi^2 = 0.25,$	$\sigma_\eta^2 = 0.25$	74
$\sigma_\xi^2 = 0.25,$	$\sigma_\eta^2 = 0.5$	83
$\sigma_\xi^2 = 0.5,$	$\sigma_\eta^2 = 0.25$	0.15
$\sigma_\xi^2 = 0.5,$	$\sigma_\eta^2 = 0.5$	0.29

Starting with low initial credibility and values for the shocks $\sigma_\xi^2 = 0.25, \sigma_\eta^2 = 0.25$, IT will lead 20 percent of the times to an increase in final credibility levels. This improvement occurs 49 percent of the times when public information precision declines. However, the presence of unstable economic conditions (i.e. relatively high supply shocks, $\sigma_\xi^2 = 0.5$), irrespective of the quality of public information, prevents IT from improving credibility. A barely 0.02 percent of the times will credibility have increased (and 0.05 percent when public information is more unclear) by the end of the 20 period block.

Alternatively, relatively high levels of credibility can make a difference to the extent of improvement brought by the application of IT. Under 'standard' shocks, inflation targeting will cause an improvement to the initial 0.7 level of credibility, 74 percent of the times. When public information is imprecise, the 'focal point' argument is almost always (83 percent of the time) helping the Central Bank improve its credibility. But starting from high credibility does not guarantee improvements to credibility if the economy is subjected to significant supply shocks. Again, it is the size of the shocks that will determine accumulation versus decumulation of credibility. Inflation targets work as good coordinating mechanisms only when supply shocks are relatively low.

5.1.2 Monetary Policy Regime and Monetary Policy Success

We now evaluate the effectiveness of the two regimes in terms of the rates of success for a variety of model parameterizations. Table 5 presents the success rates for the two regimes, IT and MS, or in other words the number of times that, following the two shocks and the CB's reaction, inflation ends up being between 1.5 and 2.5 percent. We show this under different parameterizations for the shocks and the initial level of credibility assumed.

Table 5: IT and Successful Monetary Policy

		Success IT %	Success MS %
Standard:	$\sigma_\xi^2 = 0.25, \sigma_\eta^2 = 0.25$		
	$v_0 = 0.7$	88	66
	$v_0 = 0.5$	71	66
Large Supply Shock:	$\sigma_\xi^2 = 0.5, \sigma_\eta^2 = 0.25$		
	$v_0 = 0.7$	57	50
	$v_0 = 0.5$	51	50
Small Supply Shock:	$\sigma_\xi^2 = 0.1, \sigma_\eta^2 = 0.25$		
	$v_0 = 0.7$	99	84
	$v_0 = 0.5$	99	84
Large Information Shock:	$\sigma_\xi^2 = 0.25, \sigma_\eta^2 = 0.5$		
	$v_0 = 0.7$	91	65
	$v_0 = 0.5$	80	65
Small Information Shock:	$\sigma_\xi^2 = 0.25, \sigma_\eta^2 = 0.1$		
	$v_0 = 0.7$	75	66
	$v_0 = 0.5$	67	66

Our first observation from Table 5 is that initial levels of credibility matter both in terms of the success of IT itself, but also in terms of bringing big improvements by comparison to MS. With reference to (relatively) large supply shocks, the two regimes are almost identical and IT will not be able to help coordinate expectations (except in very extreme cases). When shocks are small on the other hand, although IT helps in that respect, MS is also capable of providing successful results (difference of 15 percent independently of initial credibility assumed[13]). It is when shock are mediocre ('Standard') that IT can be beneficial, especially when credibility is relatively high to start with (difference of 22 percent for $v_0 = 0.7$). When it comes to the precision of public information, IT is not generally advantageous if information is generally good (small information shocks). However, when all other public information is relatively poor, then the provision of a clear monetary objective can improve the success rate by up to 26 percent. Here the level of initial credibility matters such that the greater the credibility to begin with, the bigger the increase in IT monetary policy success by comparison to MS. This contributes to our original suggestion that the benefits of communicating and inflation target come in the form of tackling information inefficiencies.

[13] This is because with this parametrization the credibility threshold for the target to become focal point is very low (0.34), i.e. even if the target is not credible there is no implied cost in focusing on it, as the shocks are very low on average.

6 Optimal Inflation Targeting Bands

We discuss next how the choice of band-width affects the trade-off between precision and success[14]. One the one hand, while a relative wide band increases naturally the probability of success, at the same time the mid-point target is less effective in terms of acting as a focal point. So the inflation target looses its meaning as the bands widen. On the other hand, while a target and its known range help solve the coordination motive in the agents' objective function, it is also true that the shear provision of a clear criterion also exposes failure. Calculating the relevant conditional probabilities illustrates this. For the parameterization assumed in section 4.3, where $\rho = 0.5$, the following hold:

$$\Pr(c/s) = 0.58 \qquad \Pr(c/\bar{s}) = 0.44$$
$$\Pr(\bar{c}/s) = 0.42 \qquad \Pr(\bar{c}/\bar{s}) = 0.56$$

In other words, if success is observed, it is 58 percent likely that this was due to credible policies. If failure is observed on the other hand then the probability that this is due to lack of credibility is 56 percent. Now lets see how these probabilities change as the band-width increases. We assume now that $\rho = 2$. The joint probability distribution is shown in Table 6:

Table 6: Credibility and Success

IT			$\rho = 2$
	s	$\bar{s}$	$C:$
c	0.49	0.01	0.50
$\bar{c}$	0.48	0.02	0.50
$S:$	0.97	0.03	1

The first observation is that the probability of success is 97 percent, which is natural as the bands are now relatively wide. However, while it is very difficult to assign the cause of success when it is observed, (51 percent vs 49 percent), once failure is observed (and it will be observed very rarely, 3 percent of the times), then it is almost certain (91 percent) that this failure is the result of lack of credibility. This is intuitive, as failing to keep inflation within a relatively wide band is more likely to be the fault of the Central Bank rather than the outcome of bad luck. So, in this respect, the announcement of the target has worked against the Central Bank, as it provided a very obvious criteria by which to identify its failure.

[14] See Mishkin and Westelius (2008) for an attempt to examine how the band-width deals with time-inconsistency problems. In their attempt the authors introduce an explicit cost in the CB's utility function for landing outside the bands. In our case this is already incorporated in the mechanism for updating credibility, as we show next. However, their approach has the attractive feature that costs from deviating from the target are a function of the distance from the bands, although graphs in section 2 illustrate that in terms of pinning down expectations that does not seem to matter very much.

$$\Pr(c/s) = 0.51 \qquad \Pr(c/\bar{s}) = 0.09$$
$$\Pr(\bar{c}/s) = 0.49 \qquad \Pr(\bar{c}/\bar{s}) = 0.91$$

The width of the bands works also in the opposite direction. We assume next very narrow bands, i.e.: $\rho = 0.1$.

Table 7: Credibility and Success

IT			$\rho = 0.1$
	s	$\bar{s}$	$C:$
c	0.06	0.44	0.5
$\bar{c}$	0.04	0.46	0.5
$S:$	0.10	0.90	1

Success is now rather unlikely (10 percent of the times in Table 7), but once you observe it, it is more likely to be the result of CB credibility (59 percent). By contrast, failure is a lot more likely (90 percent), but the source of this failure is a lot more difficult to discern (49 percent versus 51 percent).

$$\Pr(c/s) = 0.59 \qquad \Pr(c/\bar{s}) = 0.49$$
$$\Pr(\bar{c}/s) = 0.41 \qquad \Pr(\bar{c}/\bar{s}) = 0.51$$

But this then points to the fact that there is an optimal band-width for the Central Bank which encapsulates the trade-off between enhancing the probability of being successful on the one hand, and the provision of a clear and precise signal, on the other. We apply numerical methods to identify next what the optimal band-width is for a number of different parameterizations in the shocks.

6.1 Grid-Search for the Optimal Band-Width

We plot the radar graphs for the social loss contours based on different values for credibility, supply shocks and information shocks. For every radius ρ around the target - depicted along the circumference of the radar graphs - we report the average losses (based on 1) of 1000 (20-period block) simulations. Losses are minimized at the centre of the circle and are therefore increasing as the ray of each contour lengthens. We start by addressing how the optimal band-width is affected by the initial level of credibility.

Figure 8 displays losses for four different values of initial credibility. We see that as the level of initial credibility increases, losses become smaller. However, for any given level of credibility, losses are minimized at a certain band-width shown by the shortest ray from the centre to the respective contour. These are also depicted in the graph. For example, for $v_0 = 0.5$ the optimal band width is equal to 0.45. As the level of initial credibility increases the optimal

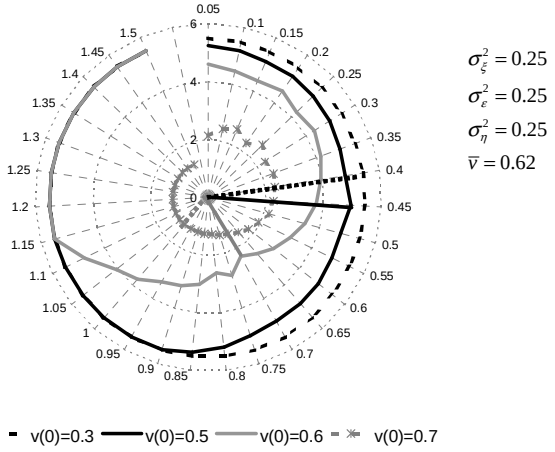

Figure 8: The Relevance of Band-Width: Different levels of Initial Credibility

band-width also increases (0.7 and 1 for $v_0 = 0.6$ and $v_0 = 0.7$ respectively). This points to the fact that Central Banks that are not credible need to be tighter in formulating their ambitions. At the same time we see that when credibility is either very high or very low, losses are fairly constant (although not exactly) across the different band-widths. However, as credibility becomes more *average* (0.7 and especially 0.6), identifying the correct band-width can make a substantial difference and therefore become an effective way of increasing welfare.

Figure 9 shows next how the band-width changes for a variety of supply shocks. For small supply shocks, losses are very small as well. As the size of the shocks increases from 0.2 to 0.3, then the Central Bank can afford to increase the band-with a little from 0.5 to 0.6. However, as Figure 9 shows the losses are fairly constant across the width of the band.
This is not the case when considering different shocks to public information (information of different quality), for which losses could benefit greatly from the identification of the optimal band-width. Figure 10 plots losses for three different information shocks. When looking at just the optimal band-width we see that in the presence of relative imprecise public information ($\sigma^2_\eta = 0.7$), the optimal band-width is relatively large (0.65). This points to the fact that when information is very poor, any signal is better than no signal. By contrast, when information is by itself very precise ($\sigma^2_\eta = 0.3$), then for a signal to be helpful it has to be very precise (narrow band, 0.4) before it induces agents to switch forming expectations from MS to IT. It is interesting that in Figure 10 losses are always smaller when information quality is relatively poor by comparison to when it is relatively good. This is in line with results presented at Table 5, where we saw that providing an inflation target is very beneficial to the level

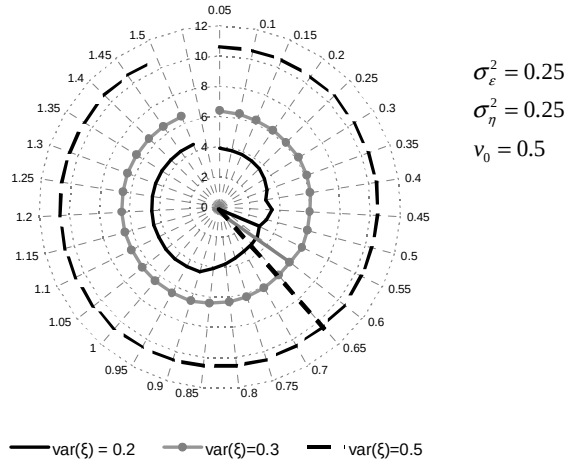

Figure 9: The Relevance of Band-Width: Diffent Supply Shock Variances

of success when information is very poor. By contrast when public information is very precise, then both regimes achieve fairly similar results. Again this points to the substitutability between public information, which is complete but imprecise and the inflation target, which is incomplete but very precise.

Between the three cases (Figures 8-10), we see that identifying the right band-width is particularly important for different levels of credibility. The same holds for differences in the quality of public information available, although to a lesser extent. Differences in the shocks on the other hand, are not particularly affected by the width of the bands.

7 Conclusions

Critics often argue that inflation targeting as a monetary policy regime puts far too high a weight on inflation to the detriment of output and growth. Friedman, (2003) argues that "...the language in which that debate takes place exerts a powerful influence on the substance of what the participants say, and eventually even over what they think". He then goes on to say that "...a powerful motivation for adopting this framework, at least in some quarters, is the hope that if the explicit discussion of the central bank's policy is carried out entirely in terms of an optimal inflation trajectory, concerns for real outcomes may somehow atrophy or even disappear from consideration altogether". Mervyn King (1997) has objected to this argument by arguing that inflation targeters are not synonymous to 'inflation nutters'. To this, our analysis adds that the strength of the 'use and meaning of words' argument notwithstanding, the potential benefits of inflation targeting arise from its ability to tackle information imperfections

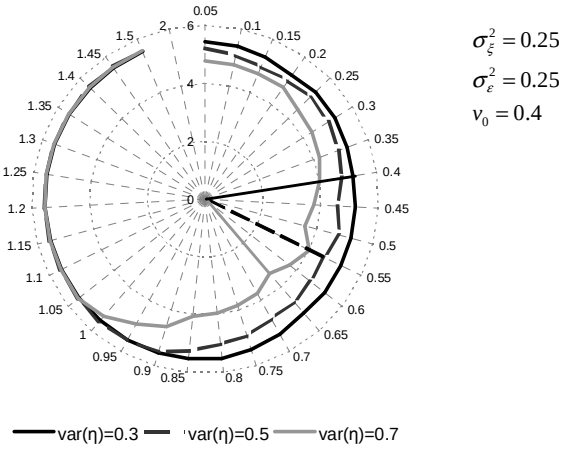

Figure 10: The Relevance of Band-Width: Different Public Information Variances

and not necessarily from the monetary policy choices it implies. We argue that the emphasis is on the communication of certain choices, not the choices themselves. The underlying monetary policy strategy (preferences and objectives) is then not necessarily uniquely identified. Indeed, countries have implemented and also experienced inflation targeting in very different ways[15].

Our analysis also shows under which conditions inflation targeting can make a difference, but by consequence also when it cannot. It is important therefore to note that no regime seals the Central Bank from external shocks totally. There will be occasions when economic circumstances will just prevent good outcomes from occurring. What good and effective communication can achieve however, is help build up the Central Bank's ability to withstand unfavorable shocks when they arise. And the provision of a clear signal will be of the greatest value-added when all other information available is unclear, because it then provides a focal point for expectations. Countries for which information is abundant and clear, and for which Central Banks are either credible already or are faced with small shocks, will see no discernible benefits from dedicating resources to improving their communication.

In fact one needs to examine whether providing a clear signal may even be harmful. One of the implications of very precise communication is that both

[15] Goodfriend (2007) mentions that ITers may differ in four respects: "...1) the announcement of an explicit numerical inflation target by the central bank, 2) patience in reversing an inflationary shock to minimize adverse effects on employment, 3) transparency of central bank concerns and intentions about the economy and interest rate policy, and 4) formal governance mechanisms designed to hold a central bank accountable for inflation outcomes".

success as well as failure are clearly defined for the public to see. The private sector observes where current inflation is vis-à-vis the objective announced and therefore rewards or penalizes the Central Bank in terms of credibility. In our analysis, the default monetary policy regime (MS) does not allow for credibility and success to feature in the game. In every period, the Central Bank and private agents decide on their action to the best of their abilities, without reviewing performance and credibility. The expectations formation process is therefore independent of past performance and by comparison, inflation targeting can only improve success. However, one could conceivably compare inflation targeting to other regimes that do allow for this credibility-success loop, but then defined less tightly. We could then compare how these alternative regimes affect a Central Bank's credibility in periods of adverse shocks. Our discussion on how the width of the band affects success is a clear indication that other less clear definitions might prove less harmful (although also less effective in providing a focal point).

We examine the merits of inflation targeting in communicating monetary policy choices. The clear criteria for evaluating outcomes that it entails, as well as the ability to provide focal points, maximize the way the credibility-performance loop is exploited. Coupled with sound policies, our analysis shows that a clear communication strategy can improve monetary policy performance.

APPENDICES

A DATA

Data on inflation target bands compiled in section 2 is based primarily on Mishkin and Schmidt-Hebbel (2001), Levin, Natalucci and Piger (2004) and national Central Bank websites. Series for inflation (quarterly, y-o-y, 1990q1-2007q2) are taken from DATASTREAM and for long-term expectations (6-10 years ahead) from Consensus Forecasts.

COMMENTS

Chile:	Inflation Expectations - one-year ahead www.bcentral.cl
Euro Area:	From 1999-mid2003 - EU two-year ahead inflation forecasts www.ecb.int/stats/prices/indic/forecast/html/table_hist_hicp.en.html
South Africa:	Bureau for Economic Research - CPI Expectations 2-years ahead
Poland:	Official Inflation Targeting from 1998 only Prior to 1998, eclectic monetary policy Inflation Expectations: IPSOS SURVEY DATA Mean of the expected rate of inflation over next 12 months www.nbp.pl
Czech Republic:	Inflation Expectations -12 months ahead Inflation Bands updated from the web-site As from January 2010, the point target will become 2 percent www.cnb.cz

B Variable Universe Games

When expectations formation becomes a matching game, individual i is unable to differentiate between the two Nash equilibria in pure form, $E_2 \equiv (x^T, x^T)$ and $E_3 \equiv (x_i, x^e)$. To decide on an action therefore, she needs to compare the *expected* (rather than *actual*) dis-utility that each of them delivers; in other words $\mathbb{E}\left[u_i(a_i, \bar{a})\right]$, where $a_i \in \left\{x_i, x^T\right\}$ and $\bar{a} \in \left\{x^e, x^T\right\}$. This in turn depends on the probability with which the average action takes one of its own two respective values.

Definition A1: *Define:* $q \equiv \Pr(\bar{a} = x^T)$ *and* $(1-q) \equiv \Pr(\bar{a} = x^e)$, $\quad q \in [0,1]$.

Expected dis-utility for individual i for each of her two actions is then:

$$\mathbb{E}\left\{u_i\left[x_i, \left(x^e \text{ or } x^T\right)\right]\right\} = (1-q)u_i\left(x_i, x^e\right) + q\, u_i\left(x_i, x^T\right) \tag{17}$$

$$\mathbb{E}\left\{u_i\left[x^T, \left(x^e \text{ or } x^T\right)\right]\right\} = (1-q)u_i\left(x^T, x^e\right) + q\, u_i\left(x^T, x^T\right). \tag{18}$$

The difficulty with this however, is that probability q is unknown to individual i and she is thus unable to evaluate which action to take based on (17) and (18). She needs therefore, to identify an alternative framework that provides

her with sufficient information that she can then base her choice on. We will argue that rather than evaluate q, it will suffice for individual i to simply know how the target is perceived (and not necessarily applied) on average. Otherwise put, it will suffice for the individual to know the proportion of people that consider the target credible. We believe that in the context of monetary policy this information is publicly available and easier for the individual to deduce. Based on that, we will show that she can then identify under which conditions following the target provided by the Central Bank is to her advantage.

As q is not known to the individual, we need to identify an other prior that captures information that is more readily available to the individual. The regime of inflation targeting implies the following[16]:

1. First, the option of following the target is available to everyone. We believe this to be an adequate representation of the fact that inflation targets are widely announced and are therefore, seen and understood by everyone. In that respect, it is reasonable to assume that any random individual would understand that the options shown in Table 1 under IT are now available to them.

2. Second, not necessarily everyone believes that the target is credible. In other words, not everyone believes that the CB can actually achieve the target, or even that the notion of "price stability" and the value x^T announced are necessarily equivalent. This is in our view an important reflection of the fact that revealing a quantitative objective is not automatically sufficient for attaining it.

3. Finally, while credibility is by no means certain, there is nevertheless a common perception as to how credible such a target might be. In other words, everyone knows and understands how the target is perceived by others. More specifically, one could interpret this likelihood as the proportion of people, say v, who consider the target credible. We assume that v is common knowledge and sufficient for the individual to base her choice on.

Based on Bacharach's (1993) paper, we can rely on this likelihood v to evaluate individual i's expected dis-utility $\mathbb{E}\left[u_i(a_i, \bar{a})\right]$ of following action a_i for a given collective action $\bar{a}$. This has the advantage that the priors used are now known to her. However, as v is not the actual probability with which the collective action is equal to the target ($v \neq q$), we need to proceed in three steps in order to provide a comprehensive framework that accounts for all possible outcomes.

[16] Note that our description of what the provision of an explicit quantitative target implies draws heavily from the common notion that IT constitutes "...a simple yardstick by which to judge policy. Given lexicographic preferences over inflation and other goals, an inflation target range, and a fixed horizon, inflation targeting becomes very easy to monitor", Faust and Henderson (2004), p127.

Case 1: First, we consider the case when the collective choice is always the default MS action. The target is therefore never applied, irrespective of whether it is deemed credible. This may happen either because the average perception is that the CB's target is not credible, or because the average individual does not believe that about others. The default MS action is then applied on average and inflation expectations equal x^e. Are there then circumstances in which individual i is still better-off following the target? Her expected dis-utility of following either of her two options is then:

$$\begin{aligned}\mathbb{E}\left[u_i(x_i, x^e)\right] &= (1-v)u_i\left(x_i, x^e\right) + vu_i\left(x_i, x^e\right) \\ &= u_i\left(x_i, x^e\right) \\ \mathbb{E}\left[u_i(x^T, x^e)\right] &= (1-v)u_i\left(x^T, x^e\right) + vu_i\left(x^T, x^e\right) \\ &= u_i\left(x^T, x^e\right).\end{aligned}$$

From Table 1, these equal respectively

$$\begin{aligned}\mathbb{E}\left[u_i(x_i, x^e)\right] &= \frac{\alpha+\beta}{(2\alpha+\beta)^2} \\ \mathbb{E}\left[u_i(x^T, x^e)\right] &= \sigma_\xi^2 + \frac{\alpha}{(2\alpha+\beta)^2}.\end{aligned}$$

It follows that

$$\begin{aligned}\mathbb{E}\left[u_i(x^T, x^e)\right] < \mathbb{E}\left[u_i(x_i, x^e)\right] \quad iff \\ \sigma_\xi^2 < \frac{\beta}{(2\alpha+\beta)^2}.\end{aligned} \tag{19}$$

Expression (19) illustrates the condition for which individual i would effectively ignore the fact that everyone else applies the MS default action, and still follow the target, even though she is aware she would be the only one. But this is only rational if following the target constitutes her dominant strategy. It is therefore, no surprise that (19) is identical to the condition shown earlier on under dominance, i.e. (13).

Case 2: Second, we then relax the stringency of the first assumption and assume now that the proportion of people who believe that the target is credible, actually apply it. When should then individual i choose the target? This is a somewhat less restrictive case than the one above and expected dis-utility for player i of pursuing either of her two options is now,

$$\begin{aligned}\mathbb{E}\left\{u_i\left[x_i, \left(x^e \text{ or } x^T\right)\right]\right\} &= (1-v)u_i\left(x_i, x^e\right) + vu_i\left(x_i, x^T\right), \\ \mathbb{E}\left\{u_i\left[x^T, \left(x^e \text{ or } x^T\right)\right]\right\} &= (1-v)u_i\left(x^T, x^e\right) + vu_i\left(x^T, x^T\right)\end{aligned}$$

and from Table 1,

$$\mathbb{E}\left\{u_i\left[x_i,\left(x^e \text{ or } x^T\right)\right]\right\} = (1-v)\frac{\alpha+\beta}{(2\alpha+\beta)^2} + v\left[\frac{1}{4}\sigma_\xi^2 + \frac{4\alpha+\beta}{(2\alpha+\beta)^2}\right],$$
$$\mathbb{E}\left\{u_i\left[x^T,\left(x^e \text{ or } x^T\right)\right]\right\} = (1-v)\left[\sigma_\xi^2 + \frac{\alpha}{(2\alpha+\beta)^2}\right] + v * \frac{1}{4}\sigma_\xi^2.$$

It follows that,

$$\mathbb{E}\left\{u_i\left[x^T,\left(x^e \text{ or } x^T\right)\right]\right\} < \mathbb{E}\left\{u_i\left[x_i,\left(x^e \text{ or } x^T\right)\right]\right\},\ iff$$
$$\sigma_\xi^2 \leq \frac{\beta + v4\alpha}{(1-v)(2\alpha+\beta)^2}. \tag{20}$$

Again, the size of the shock needs to be below a given ratio before the individual applies the target. However, as the condition is less restrictive than before, (since $\frac{\beta}{(2\alpha+\beta)^2} < \frac{\beta+v4\alpha}{(1-v)(2\alpha+\beta)^2}$), it is also the sufficient condition for individual i to follow that target. Interestingly, we can re-write this condition in terms of v

$$v \geq \frac{(2\alpha+\beta)^2\sigma_\xi^2 - \beta}{4\alpha + (2\alpha+\beta)^2\sigma_\xi^2}. \tag{21}$$

This now shows that the sufficient condition for individual i to follow the target is when a suitably large proportion of the public believe the target to be credible.

Case 3: The average action is now assumed to always be the target. One could envisage a situation (admittedly unlikely) in which everyone thinks for themselves that the target is not credible but choose nevertheless to follow it, because they believe they are alone in thinking that. It is trivial then to show that following the target is individual i's preferred strategy.

$$E\left\{u_i\left[x_i,\ x^T\right]\right\} = \frac{1}{4}\sigma_\xi^2 + \frac{4\alpha+\beta}{(2\alpha+\beta)^2}$$
$$E\left\{u_i\left[x^T,\ x^T\right]\right\} = \frac{1}{4}\sigma_\xi^2$$
$$E\left\{u_i\left[x^T,\ x^T\right]\right\} < E\left\{u_i\left[x_i,\ x^T\right]\right\}.$$

References

[1] Bacharach, M., 1993. Variable Universe Games, in *Frontiers of Game Theory*, by Ken Binmore, Alan Kirman and Piero Tani, MIT Press, 255-275.

[2] Barro, R. and D.B. Gordon, 1983. Rules, Discretion and Reputation in a Model of Monetary Policy, Journal of Monetary Economics, July.

[3] Bernanke, B.S., T. Laubach, F.S. Mishkin and A. Posen, 1999. *Inflation Targeting: Lessons from International Experience*, Princeton: Princeton University Press.

[4] Blackburn, K. and M. Christensen, 1989. Monetary Policy and Policy Credibility: Theory and Evidence, Journal of Economic Literature, Vol. 27, March, 1-45.

[5] Blinder, A., 1999. *Central Banking in Theory and Practice*,Cambridge, MA, MIT Press.

[6] Blinder, A., 2000. Central-Bank Credibility: Why Do We Care? How Do We Build It?, American Economic Review, Vol. 90, No. 5. 1421-1431.

[7] Blinder, A., C. Goodhart, P. Hildebrand, D. Lipton and C. Wyplosz, 2001. *How do Central Banks Talk?*, Geneva Report on the World Economy, No. 3, London, Centre for Economic Policy, Research/International Centre for Monetary and Banking Studies.

[8] Bomfin, A and G. Rudebusch, 2000. Opportunistic and Deliberate Disinflation Under Imperfect Credibility, Journal of Money Credit and Banking, 32, November, 707-721.

[9] Brazier, A., R. Harrison, M. King and T. Yates, 2006. The Dangers of Inflating Expectations of Macroeconomic Stability: Heuristic Switching in an Overlapping Generations Monetary Model, Bank of England, Working Paper, no. 303, August.

[10] Canzoneri, M., 1985. Monetary Policy Games and the Role of Private Information, American Economic Review, vol. 75, 5, 1056-70.

[11] Clarida, R., J. Gali and M. Gertler, 1999. The Science of Monetary Policy: A New Keynesian Perspective, Journal of Economic Literature, vol. 37, 4, 1661-1707.

[12] Demertzis, M. and A. Hughes Hallett, 2007. Central Bank Transparency in Theory and Practice, Journal of Macroeconomics, Vol 29, No 4, 760–789.

[13] Demertzis, M. and N. Viegi, 2008. Inflation Targets as Focal Points, International Journal of Central Banking, Vol. 4, No. 1, March, 55-87.

[14] Fatás, A., I. Mihov and A. Rose, 2004. Quantitative Goals for Monetary Policy, Centre for Economic Policy Research, London, Discussion Paper, No. 4445, June.

[15] Faust, J. and D.W. Henderson, 2004. Is Inflation Targeting Best-Practice Monetary Policy?, Federal Reserve Bank of St. Louis, vol. 86, 4, July/August, 117-143.

[16] Friedman, B.M., 2003. The Use and Meaning of Words in Central Banking: Inflation Targeting, Credibility and Transparency, in Central Banking, *Monetary Theory and Practice: Essays in Honour of Charles Goodhart*, Vol. one, (ed) Paul Mizen, Edwar Elgar.

[17] Goodfriend, M. 2007. How the World Achieved Consensus on Monetary Policy, The Journal of Economic Perspectives, Vol. 21, No. 4, 47-68.

[18] Gürkaynak, R., A.T. Levin and E.T. Swanson, 2006. Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the US, UK and Sweden, Federal Reserve Bank of San Francisco, Working Paper 09.

[19] Issing, O, V. Gaspar, O. Tristani and D. Vestin, 2005. Imperfect Knowledge and Monetary Policy, Cambridge University Press.

[20] Johnson, D.R., 2002. The Effect of Inflation Targeting on the Behavior of Expected Inflation: Evidence from an 11 Country Panel, Journal of Monetary Economics, 49, 1521-1538.

[21] King, M., 1997, Changes in UK Monetary Policy: Rules and Discretion in Practice, Journal of Monetary Economics, 39, (June), 81-97.

[22] King, M., 2002. The Inflation Target 10 Years On, Speech delivered to the London School of Economics, 19 November.

[23] Leiderman, L. and L.E.O. Svensson, 1995. *Inflation Targets*, (eds), London: Centre for Economic Policy Research, 1995.

[24] Leitemo, K., 2006. Inflation Targeting Rules: History Dependent or Forward-Looking?, Norwegian School of Management, Oslo.

[25] Levin, A., F.M. Natalucci and J.M. Piger, 2004. The Macroeconomic Effects of Inflation Targeting, Federal Reserve Bank of St. Louis Review, Vol. 86, 4, 51-80.

[26] Mishkin, F S. and K. Schmidt-Hebbel, 2001. One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know? in Norman Loayza and Raimundo Soto, (eds), *Inflation Targeting: Design, Performance, Challenges*, Central Bank of Chile, Santiago, 117-219.

[27] Mishkin F.S. and N.J. Westelius, 2008. Inflation Band Targeting and Optimal Inflation Contracts, Journal of Monecy Credity and Banking, forthcoming.

[28] Mishkin, F S. and K. Schmidt-Hebbel, 2007. Does Inflation Targeting Make a Difference?, NBER Working Paper, No. 12876, January.

[29] Morris, S. and H.S. Shin, 2002. Social Value of Public Information, American Economic Review, Vol. 92, No. 5, December, 1521-1534.

[30] Moscarini, G., 2007. Competence Implies Credibility, American Economic Review, Vol. 97, No. 1, March, 37-63.

[31] Orphanides, A. and J.C. Williams, 2005. The Decline of Activist Stabilisation Policy: Natural Rate Misperceptions, Learning and Expectations, Journal of Economic Dynamics and Control 29(11), 1927-1950.

[32] Paloviita, M. and M. Virén, 2005. The Role of Expectations in the Inflation Process in the Euro Area, Bank of Finland Research Discussion Papers, No. 5.

[33] Svensson, L.E.O., 2003. What is Wrong with Taylor Rules? Using Judgement in Monetary Policy through Targeting Rules, Journal of Economic Literature, Vol. XLI, June, 426-477.

[34] Waller, S. and J. de Haan, 2004. Credibility and Transparency of Central Banks: New Results Based on IFO's World Economic Survey, CESifo WP 1199.

[35] Woodford, M., 2003, *Interest and Prices*, Princeton University Press.