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Establishing a Reputation for Dependability by Means of Inflation Targets

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Abstract

This paper develops a simple intertemporal model of inflation targets within a framework in which the public is uncertain about the dependability of policymakers, and in which policymakers do not perfectly control inflation. The framework is used to evaluate the effects of various parameters like the rate of time preference, initial reputation, and transparency (or precision of inflation control) on planned inflation, announced targets and the evolution of reputation and of inflationary expectations. The paper also shows that it is often the case that, when allowed to choose the precision of inflation control, more dependable policymakers choose relatively more precise control procedures. Implications for the type of inflation stabilization (cold turkey or gradual) chosen by dependable policymakers are also derived.

1   Introduction

The recent quest for price stability in conjunction with the breakdown of traditional nominal anchors induced several countries to introduce inflation targets.[1] Under this system of targeting policymakers preannounce a target or a target range for the rate of inflation. Although some details of the targeting method vary across countries a common motivation for this arrangement is to influence inflationary expectations early on.

Since deviations between announced and actual rates of inflation are possible and, as a practical matter, are not uncommon the mere announcement of an inflation target does not generate immediate credibility. On the other hand the announcement of targets usually has **some** effect on inflationary expectations. This imperfect credibility of inflation targets may be due to the fact that policymakers are not necessarily committed to achieve those targets. But in the presence of imperfect control of inflation by policymakers such deviations could also be due to bad luck. When individuals understand that actual inflation performance is due to a mixture of both elements they give some, but usually not full, credence to preannounced targets. How large is the effect of announced targets on expectations depends on the past record of policymakers to which I refer as "reputation". This reputation is valuable because it enables policymakers to influence inflationary expectations and through them real variables by merely making an announcement.

This paper develops a framework that makes it possible to evaluate some of the factors that affect the reputation of policymakers and of the speed with which this reputation is built up or depleted, as well as to identify the effect of reputational considerations on policy choices and on the formation of inflationary expectations. The analytical framework features two basic ingredients that appear to characterize most real life inflation targeting frameworks. First the public is uncertain about whether the target represents a commitment or is just

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[1]Those include, among others, Canada, the UK, New-Zealand, Australia, Spain, Sweden, Finland and Israel. Extensive descriptions of recent country experiences with inflation targeting and related issues appear in Leiderman and Svensson (1995), Haldane (1995) and in Bernanke et. al. (1999).

cheap talk. The second is that policymakers possess some but not perfect control over inflation.

The first element is modeled by assuming that there are two types of policymakers denoted "dependable" (D) and "weak" (W), or opportunistic, respectively. Both policymakers possess the **same** objective function. The only difference between them is that the dependable policymakers is truly commited to the target he announces whereas the weak one is not and chooses, therefore, his policy actions according to what is expedient expost, after expectations have been embedded into wage contracts. The public is unsure about the identity of the policymaker in office and the reputation of policymakers for dependability is, accordingly, the probability assigned by the public to the event that type D is in office. The second ingredient is modeled by assuming that there is a (white noise) random deviation between the inflation planned by policymakers and the actual rate of inflation. Differences in dependability between policymaker types are generally due to differences in the power or ability of policymakers and to the value they put on being dependable. One of the factors that determines the ability of monetary policymakers to live up to preannounced targets is the **actual** level of central bank independence. Although this level is affected by the central bank charter it is also affected by other less formal and visible factors.[2]

A main objective of the paper is to identify some of the factors that determine the speed and the direction of changes in reputation. This obviously requires a dynamic framework. For simplicity and pedagogical reasons I focus on a two periods' horizon. Although somewhat limited this framework captures, in a relatively simple manner, many of the factors that operate in longer time horizons and provides a simple and unified introduction to signalling games in monetary policy. The paper also provides theoretical underpinnings for

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[2]The formal model is closely related to that in Cukierman (1995) which is, in turn, a hybrid of of the framework in Cukierman and Liviatan (1991) (or chapter 16 of Cukierman (1992)) and Cukierman and Liviatan (1992). The two middle references contain a more detailed discussion of possible reasons for the difference in commitment ability between the two policymaker types. See also section 3 of chapter 8 in Walsh (1998).

the view that dependablity and the precision of inflation control are often positively related. The first six sections of the paper simply assume that this is the case. The seventh section shows that, when policymakers are allowed to choose the precision of control procedures, dependable policymakers often pick more precise control procedures than their opportunistic counterparts. This provides a more solid foundation for the assumption made in the first six sections.

During the mid eighties Backus and Driffill (1985) and Barro(1986) produced longer time horizon models that provide a dynamic analysis of the evolution of reputation. The model in this paper is aimed at a similar objective but it differs from those earlier frameworks in two basic respects. First, the public's doubts about the nature of the policymaker in office is due here to the fact that policymakers do not control inflation perfectly while in those earlier papers uncertainty is due to the fact that policymakers are using mixed strategies.[3] Secondly, unlike in those earlier papers, this paper explicitly features a preannouncement of inflation targets. Incorporation of such a preannouncement in the analysis seems essential for understanding the factors that govern the evolution of reputation under inflation targeting regimes.

Cukierman and Meltzer(1986a) provide an infinite horizon analysis of the evolution of inflationary expectations within a framework in which the public is uncertain about the relative importance attributed by policymakers to employment versus price stability considerations, and in which there is imperfect control of inflation. But, this framework still does not feature a preannouncement of targets. The earliest formal discussion of announced targets appears, as far as I know, in Cukierman and Meltzer (1986b).[4] But in that framework

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[3]Personally, I find the notion that the public is uncertain about the nature of policymakers because they do not exercise perfect control over inflation more realistic than the notion that this is due to strategic randomization by policymakers.

[4]From an analytical point of view this paper is an extension of Cukierman and Meltzer(1986a) to the case in which the policymaker makes a noisy, but unbiased, announcement of inflation in each period. An in depht treatement and comparison of those various alternative frameworks appears in chapters 8, 9, 10 and 14 of Cukierman (1992).

the announcement is not a fully free choice variable and the public's uncertainty is about the shifting preferences of policymakers rather than about their commitment ability, as is the case in the present paper.[5]

The paper's framework makes it possible to analyze the effects of various parameters like initial reputation, the rate of time preference of policymakers, the precision of inflation control, and the relative importance attributed to price stability versus employment considerations on the equilibrium policies of the two policymaker types and on the probability of a shock treatment.[6] A sample of results follows. First, better inflation control by dependable policymakers makes the policy plans of both policymaker types more conservative. Since, in a wider sense, better inflation control is positively related to the transparency of policy the broader implication of this result is that more transparency induces policymakers to make less inflationary policy plans. Second, the higher initial reputation, the less inflationary is the policy of opportunistic policymakers. The intuitive reason is that, when reputation is high, weak policymakers stand to loose more from being revealed as weak. Finally, the probability of a shock treatment rises or falls with policymakers' concern for the future depending on whether initial reputation is low or high.

The basic model, the equilibrium concept and the tradeoffs facing the two policymaker types are presented in section 2. Equilibrium strategies in the second and last period of the game and the evolution of reputation are characterized in section 3. Intertemporal considerations and equilibrium strategies in the first period are discussed in section 4. The impact of initial reputation and of other parameters on policy choices and on the evolution of reputation is discussed in section 5. The effect of alternative parameters on the probability of full separation between the two policymaker types is discussed in section 6. A basic

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[5]A discussion of the consequences of this distinction appears in Chapter 16 of Cukierman (1992). See also Vicker (1986).

[6]A shock treatment is a situation in which a dependable policymaker deliberately plans to reduce inflation by a lot in order to establish his commitment ability with the public beyond any doubt. Such a strategy is sometimes also referred to as "cold turkey".

maintained assumption of the analysis in the first six sections is that dependable policymakers have better control of inflation than their opportunistic counterparts. Section 7 provides deeper underpinnings for this assumption by showing that, if allowed to pick the precision of inflation control, dependable policymakers often prefer to establish more precise control procedures than their weak counterparts. This is followed by concluding remarks.

2   The Model

The **common** objective function of policymakers is given by

$$A(\hat{\pi}_1 - \pi_1^e) - \frac{\hat{\pi}_1^2}{2} + \delta \left(A(\hat{\pi}_2 - \pi_2^e) - \frac{\hat{\pi}_2^2}{2} \right). \tag{1}$$

Here $\hat{\pi}_j$ and π_j^e, $j = 1, 2$ are actual and expected inflation in period j respectively, A is a parameter that is directly related to the relative importance of employment versus price stability considerations and δ is a discount factor, between zero and one, that measures the relative importance attributed by policymakers to the present in comparison to the future.[7] Let π_i be the rate of inflation planned by the policymaker in office for period j. This rate is implicitly determined by the policy instruments at his disposition. Throughout the paper I treat this planned rate as the policy instrument under his control without specifying explicitly the relation between underlying instruments (like the overnight interest rate) and the planned rate of inflation. The relation between actual and planned inflation is given by

$$\hat{\pi}_i = \pi_i + \varepsilon_i, \ i = D, W \tag{2}$$

where ε_i possesses a uniform distribution with support in the range $(-a_i, a_i)$, $i = $D,W, and $a_W > a_D > 0$. The first inequality reflects the presumption that, W is less dependable than D also in the sense that he institutes procedures that lead to a relatively poorer controls of

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[7]More precisely, A is the product of this relative preference with the slope of the short run Phillips tradeoff.

inflation.[8] Section 7 below provides deeper theoretical underpinnings for this assumption. At least in the case of the dependable policymaker equation (2) involves, as in Svensson (1997), targeting of the policymaker's inflation forecast rather than of actual inflation.

The timing of moves within each period is as follows: first the policymaker announces the inflation target for that period. Then inflationary expectations are formed and embedded into (at least partially) nominal wage contracts. Following that, the policymaker picks the rate of inflation he plans for the period. Finally, the control error ε_i realizes and determines, along with the policy plans, actual inflation $\hat{\pi}_i$. The timing of moves is illustrated in Figure 1. At the beginning of the game the policymaker in office is either D or W and he remains in office during **both** periods. Initial reputation, which is equal to the probability assigned by the public to the event that a dependable policymaker is in office is denoted by β_1 and is inherited from the past. Reputation at the beginning of the second period (β_2) is determined endogenously as a function of the policy choice and of the realization of random external circumstances.

Throughout most of the paper I deliberately refer to a policymaker (or policymakers) without specifying explicitly whether monetary policy decisions are made by the central bank or the political establishment.. In most countries both institutions have some input into those choices with the central bank having more influence the larger its independence.[9] The equilibrium choices of different policymakers derived below should be viewed as generally arising from the, at times conflicting, desires of the central bank and of the political establishement. One way to interpret the difference between the dependable and the weak policymaker is in terms of central bank independence. It is well known that, in addition to the letter of the law, this independence is affected by numerous informal relations between the central bank and its political masters that are usually not fully revealed to the public.

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[8]As we shall see later this presumption implies that the average level of inflation and its uncertainty are positively related. This implication is consistent with a lot of empirical evidence.

[9]A detailed analysis of the effect of independence on policy choices under imperfect information appears in chapter 18 of Cukierman(1992).

Since politicians normally feel less compelled to abide by preannounced targets than the central bank the "dependable policymaker" can be thought of as a central banker that has enough power to abide by the target, in spite of political pressures whereas the "weak policymaker" can be thought of as a central bank that cannot resist the pressures of politicians to behave in a discretionary manner.[10]

2.1 Full separation versus gradual learning and the equilibrium concept

By definition a dependable policymaker always plans to achieve the target rate of inflation. Hence under him any deviation between the target and actual inflation is due to events that were not expected by this policymaker when he chose his instrument. But the weak type plans to adhere to the target only if this is expedient expost. Hence, under a weak policymaker actual inflation may deviate from the target by deliberate design as well as because of events that were unexpected by him. Even when he does not plan to achieve the target the weak policymaker need not be revealed as such. This is due to imperfect control of inflation by both policymakers. But each policymaker type can influence, exante, the probability that his identity will be revealed at the beginning of the second period by planning a higher or a lower rate of inflation, taking as given what the public expects from him and from his counterpart.

Other things the same a dependable policymaker would like to maximize the probability of full separation and a weak one would like to minimize it. But neither of them necessarily finds it optimal to achieve such extreme outcomes. The reason is that, in order to separate himself with probability one from his weak counterpart at the beginning of the second period a dependable policymaker has to disinflate more aggressively in the first period and to produce therefore a larger recession. Similarly, in order to reduce the probability of

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[10]The current relationship (1998/99) between the Bank of Israel and the Israeli government can be reasonably characterized in these terms.

Figure 1: Timing of moves within each period

Target, π_j^t, is announced   Expectations, π_j^e, are formed   Planned inflation, π_j, is chosen   Inflation control error, ε_j, ($j = 1,2$) is realized
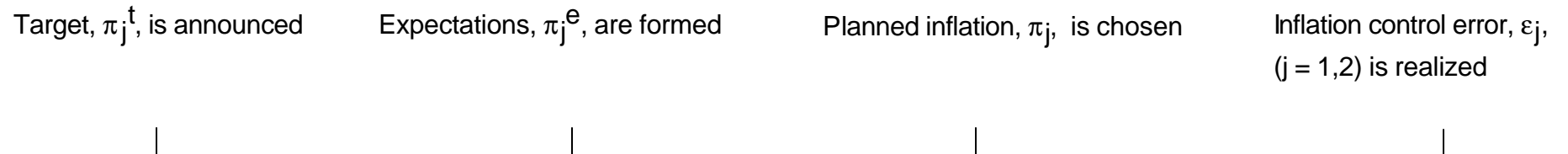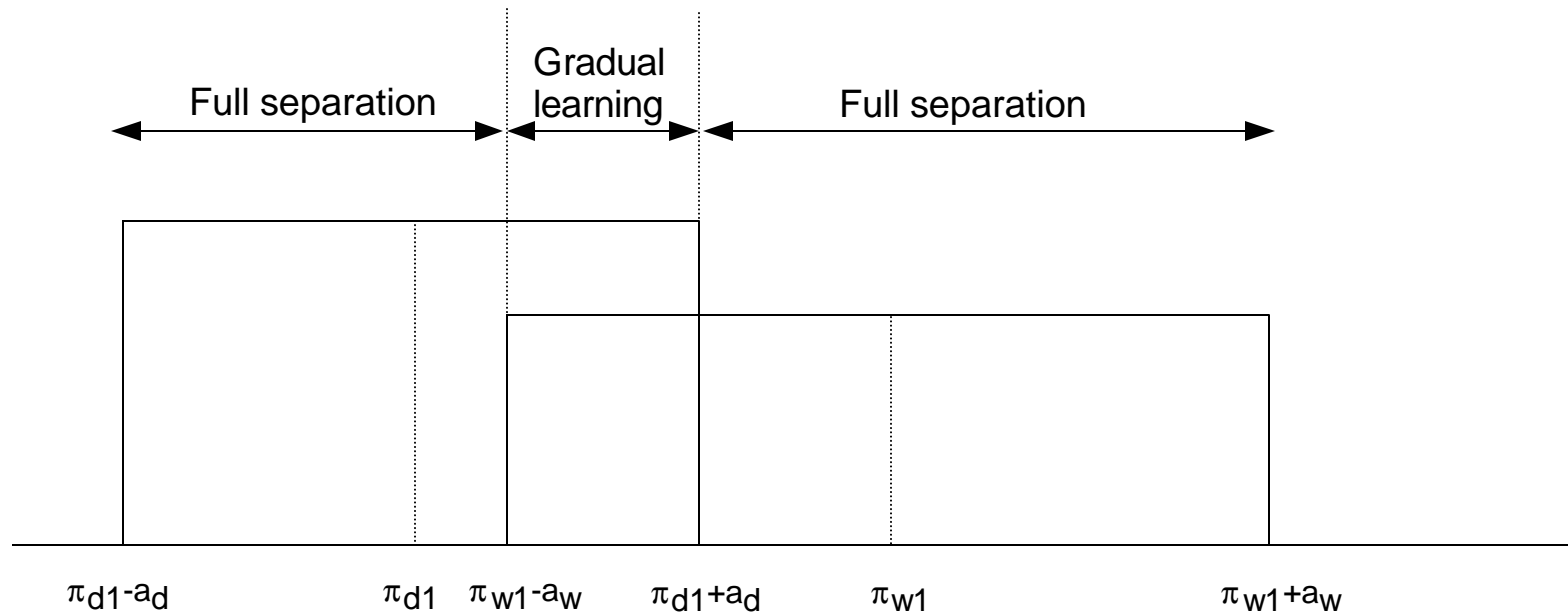
Figure 2: Strategies of dependable and of weak policymakers in the first period and the corresponding distributions of inflation

Full separation   Gradual learning   Full separation

$\pi_{d1}-a_d$ π_{d1} $\pi_{w1}-a_w$ $\pi_{d1}+a_d$ π_{w1} $\pi_{w1}+a_w$

separation in the second period as much as possible, the weak policymaker has to emulate D not only in pronoucements but also in actions in the first period. And this involves a current employment cost that he is not always willing to incur.

The tradeoffs facing the two policymaker types in the first period are illustrated in Figure 2. Given the choice of planned inflation, π_{i1}, by each type in the first period, the figure shows the **actual** rates of inflation that could arise under each of them. The left hand rectangle represents rates of inflation that could arise under a D type and the right hand rectangle represents rates of inflation that could arise under a W type. If D is in office and (actual) inflation falls to the left of the rectangle of the weak policymaker his dependability is revealed with probability one at the beginning of the second period. But if inflation falls in the range of overlap between the two rectangles there is no sharp separation. In this case individuals update their views about the probability β using Bayes rule. As will be shown below since D has better control of inflation than W the reputation of the policymaker in office increases in this case.

If W is in office and inflation in the first period falls to the right of the rectangle representing the distribution of inflation under a D type the identity of the weak policymaker is revealed with probability one. But if the realization of inflation under him is in the overlapping area there is no sharp separation and his reputation increases in the same manner as it would have increased had a D type been in office. Since the choice of planned rates of inflation determines the extent of overlap between the two distributions each policymaker can affect the probability of full separation by choice of planned inflation in the first period.

The equilibrium concept I use is a subgame perfect Bayesian Nash equilibrium. For non game theory specialists this simply means that at each stage of the game each policymaker type (when in office) chooses his strategy, taking the **structure** of the public's beliefs about his strategy and that of the other type as given, so as to maximize the expected value of his objectives **from that point and on**. In addition the public updates β by Bayes rule whenever possible and forms its inflationary expectation as the expected value of actual inflation conditional on the target announced at the beginning of the period. Subgame

perfection implies that we can start by finding equilibrium in the second period.

Figure 2 implicitly assumes that the equilibrium values of planned inflation are such that the probability of full separation is smaller than one and that the weak policymaker experiences a tradeoff between improving his first and his second period objectives. Whether this is the case or not depends on the values of the underlying parameters. Here I focus on the case in which the equilibrium probability of full separation is strictly between zero and one and there is some tradeoff between W's first and second period objectives. Conditions on the underlying parameters which assure that this is the case are discussed in part 1 of the appendix and before the end of section 4 below. Those conditions also imply that the policy plan of the opportunistic policymaker in the first period is more inflationary than that of his dependable counterpart. Further detail appears in part 1 of the appendix.

3   Equilibrium in the Second Period

In the second and last period the policymaker in office faces a one period problem that is similar to that of the one period problem with perfect control that appears in Cukierman and Liviatan (1991) and in chapter 16 of Cukierman (1992). Provided his identity has not yet been revealed a W type always announces the same inflation target as his dependable counterpart would have since otherwise he is unmasked already at the beginning of period 2.[11] Such a strategy is individually optimal since full revelation would have curtailed his ability to stimulate employment in the second period. Using the superscript "t" to denote an announced target this implies

$$\pi_{w2}^t = \pi_{d2}^t \tag{3}$$

But since he is not really committed to the target, and since this is the last period, the weak policymaker chooses his instrument, π_{w2}, so as to maximize the expected value (over the distribution of ε_{w2}) of the following expression:

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[11]See also footnote 11 below.

$$A(\pi_{w2} + \varepsilon_{w2} - \pi_2^e) - \frac{(\pi_{w2} + \varepsilon_{w2})^2}{2}. \tag{4}$$

The solution to this problem is:

$$\pi_{w2} = A \tag{5}$$

which is the well known discretionary solution when the public knows with certainty that the regime is indeed discretionary. The weak type chooses this rate also in the case in which he has been revealed as weak at the beginning of the second period. The only difference is that, in this case, it does not matter (for the public's inflationary expectation) what is the target he announces since the public knows with certainty that, no matter what he announces, the policymaker is going to set monetary instruments so as to achieve, on average, the discretionary rate A.

At the beginning of period 2 the public believes there is a probability β_2 that the policymaker in office is dependable. Consequently expected inflation is given by

$$\pi_2^e = \beta_2 \pi_{d2}^t + (1 - \beta_2)A. \tag{6}$$

I turn now to a characterization of the optimal strategy of a dependable policymaker. The main difference between him and his weak counterpart is that he chooses the target subject to the dependability constraint

$$\pi_{d2} = \pi_{d2}^t. \tag{7}$$

More precisely, D picks π_{d2} so as to maximize the expected value (over the distribution of ε_{d2}) of the following expression

$$A(\pi_{d2} + \varepsilon_{d2} - \pi_2^e) - \frac{(\pi_{d2} + \varepsilon_{d2})^2}{2} \tag{8}$$

subject to the process of expectation formation in (6) and the dependability constraint in (7). The solution to this problem is

$$\pi_{d2} = \pi_{d2}^t = (1 - \beta_2)A. \tag{9}$$

Note that the dependable policymaker partially accomodates the public's suspicions concerning his dependability and that the degree of accomodation is stronger the lower reputation. This is due to the fact that a D type always creates a recession and, given actual inflation, the recession is more severe the lower is reputation.[12]

The choice of equilibrium strategies in the first period depends, among other, on the difference between the expected, as of period one, equilibrium values of the second period objective functions in the presence and in the absence of full separation. The expectation of equilibrium values of second period objectives can be calculated by inserting the appropriate equilibrium strategies into equations (4) and (8). The resulting expressions are:

$$V_{w2}(NS) = A^2\beta_2^2 - \tfrac{1}{2}(A^2 + \sigma_w^2), \quad V_{w2}(S) = -\tfrac{1}{2}(A^2 + \sigma_w^2) \tag{10}$$

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[12]Note that this choice of strategy by D relies on the presumption, embedded in equation (6), that whenever he reduces the announced target by one percent inflationary expectations go down by β_2 percent. An off equilibrium assumption that supports this choice by D, is

$$\pi_j^e = \left\{ \begin{array}{ll} \beta_j\pi_j^t + (1-\beta_j)A, & if \ \pi_j^t \geq \pi_{dj} \\ \pi_{wj} & if \ \pi_j^t < \pi_{dj}. \end{array} \right\}$$

where π_{dj} is the equilibrium strategy of D in period j and $j = 1,2$. This assumption states that, as long as the announced target is above the (known by the public) equilibrium strategy of D, inflationary expectations are formed as an appropriate weighted average of the rates of inflation expected from D and from W respectively. But, if the target is over ambitious in the sense that it is even lower than the inflation expected from a dependable type, the public concludes that such an announcement could have come only from an opportunistic type who does not intend to live up to the target. The public expects, therefore, the higher inflation rate, π_{wj} in this case.

Notice that this off equilibrium assumption also supports W's strategy to always announce the same target as his dependable counterpart. At first blush it would seem that since the announcement does not commit him W should announce a zero inflation. But the off equilibrium assumption above makes this choice undesirable since for any announced target below π_{dj} the public's expectation reverts to π_{wj}, raising rather than reducing inflationary expectations.

$$V_{d2}(NS) = -\tfrac{1}{2}(1-\beta_2^2)A^2 - \tfrac{\sigma_d^2}{2}, \quad V_{d2}(S) = -\tfrac{\sigma_d^2}{2} \ . \tag{11}$$

Here $V_{i2}(S)$ and $V_{i2}(NS)$ stand respectively for the equilibrium expected values of objectives of policymaker i when there is, and when there is no, (full) separation at the beginning of the second period. Note that $V_{w2}(NS) > V_{w2}(S)$ inducing W to try to reduce the probability of separation and $V_{d2}(NS) < V_{d2}(S)$ inducing D to try to raise the probability of sharp separation.[13]

3.1 The evolution of reputation and of inflationary expectations

When the realizations of external shocks are such that there is full separation $\beta_2 = 0$ if W is in office and $\beta_2 = 1$ if D is in office. When there is no separation reputation is adjusted according to Bayes' rule which states that[14]:

$$\Pr\left[D \mid \hat{\pi}_1\right] = \frac{\Pr\left[\hat{\pi}_1\mid D\right]\Pr\left[D\right]}{\Pr\left[\hat{\pi}_1\mid D\right]\Pr\left[D\right] + \Pr\left[\hat{\pi}_1\mid W\right]\Pr\left[W\right]} \tag{12}$$

where $\Pr\left[J \mid \hat{\pi}_1\right], J = D, W,$ is the probability that type J is in office conditional on the realization of first period inflation, $\hat{\pi}_1$, $\Pr\left[\hat{\pi}_1\mid J\right]$, is the probability that the rate of inflation $\hat{\pi}_1$ has been produced by a policymaker of type J, and $\Pr\left[J\right]$ is the initial probability that type J is in office.[15] Noting that $\Pr\left[D\right] = 1 - \Pr\left[W\right] = \beta_1$, $\Pr\left[\hat{\pi}_1\mid D\right] = \frac{1}{2a_d}, \Pr\left[\hat{\pi}_1\mid W\right] = \frac{1}{2a_w}$ and inserting those relations into equation (12) yields:

$$\beta_2 = \frac{\beta_1}{\beta_1 + \frac{a_d}{a_w}(1-\beta_1)}. \tag{13}$$

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[13]I am using the terms "separation" and "full separation" interchangeably.

[14]A statement of Bayes' theorem can be found in most texts on statistical theory. See for example pages 55-58 of DeGroot (1975).

[15]The more statistically inclined reader should replace the term "probability" everywhere in this sentence by the term: "probability density".

Since $a_d < a_w$, reputation in the second period is higher than in the first one. The speed with which reputation goes up, when there is no full separation, is inversely related to the ratio $\frac{a_d}{a_w}$.

Inserting the equilibrium value of π_{d2} into equation (6) inflationary expectations in period 2 can be expressed as

$$\pi_2^e = (1 - \beta_2^2)A. \tag{14}$$

4   Equilibrium in the First Period

Equilibrium choices in the first period take into consideration the effects of those choices both on the values of objectives in the first period as well as on the probability of full separation at the beginning of the second period and through this probability on the value of second period objectives. The weak policymaker mimics the dependable one in the announcement of targets in the first period as well and for the same reason. But he picks his first period instrument, π_{w1}, so as to maximize the expected value (over the distributions of ε_{w1} and of ε_{w2}) of the following expression:

$$V_w(.) \equiv A(\pi_{w1} + \varepsilon_{w1} - \pi_1^e) - \frac{(\pi_{w1} + \varepsilon_{w1})^2}{2} + \delta \left[-\frac{1}{2}(A^2 + \sigma_w^2) + \Pr(NS/W)\beta_2^2 A^2 \right] \tag{15}$$

where $\Pr(NS/W)$ is the probability of no separation under a weak policymaker. This probability is given by

$$\Pr(NS/W) = \frac{1}{2a_w} \left[\pi_{d1} - \pi_{w1} + a_d + a_w \right]. \tag{16}$$

The last term that is premultiplied by δ in equation (15) is a weighted average of the equilibrium values of W's objectives in the second period under full, and under no full, separation where the weights are the probabilities of those two events.

Maximizing equation (15) with respect to π_{w1} and rearranging, the optimal strategy of a weak policymaker in the first period is given by:

$$\pi_{w1} = A - \delta \frac{(\beta_2 A)^2}{2a_w}. \tag{17}$$

Thus, when the horizon is longer than one period, even the inflation planned by a weak, or opportunistic, policymaker is lower than the one period discretionary rate of inflation A. The reason is that, in the first period, due to the existence of intertemporal considerations the weak policymaker tries to balance out the current costs of restrictive monetary policy with the benefits of better chances to maintain his future reputation for dependability. How much lower is π_{w1} than π_{w2} depends on several factors all of which have clear intuitive interpretations. For example the difference between the two planned rates of inflation is larger, the larger are the discount factor, δ, and second period reputation, β_2. The reason is that when either of those two factors is larger the weak policymaker stands to loose more from sharp separation at the beginning of the second period.

Since initial reputation is β_1 inflationary expectations in the first period are a weighted average, with weights β_1 and $(1 - \beta_1)$, of the first period target and of the rate of inflation planned by a W type. More precisely

$$\pi_1^e = \beta_1 \pi_{d1}^t + (1 - \beta_1)\pi_{w1}. \tag{18}$$

I turn now to the decision problem of a dependable policymaker in the first period. Unlike his weak counterpart he is bound by the preannounced target. He therefore weights already at the announcement stage the relative impact of the announcement on expectations and on actual inflation. Inserting the dependability constraint, $\pi_{d1} = \pi_{d1}^t$ and equation (18) into equation (1) D's problem is to pick π_{d1} so as to maximize the expected value (over the distributions of ε_{d1} and of ε_{d2}) of the following expression

$$V_d(.) \equiv A\left[\pi_{d1} + \varepsilon_{d1} - (\beta_1\pi_{d1} + (1-\beta_1)\pi_{w1})\right] - \frac{(\pi_{d1} + \varepsilon_{d1})^2}{2} - \frac{\delta}{2}\left[\sigma_d^2 + \Pr(NS/D)(1-\beta_2^2)A^2\right].$$

(19)

where

$$\Pr(NS/D) = \frac{1}{2a_d}(\pi_{d1} - \pi_{w1} + a_d + a_w)$$

(20)

is the probability of no separation when a dependable policymaker is in office. The solution to this problem is:

$$\pi_{d1} = (1-\beta_1)A - \frac{\delta}{4a_d}(1-\beta_2^2)A^2.$$

(21)

As was the case with the weak policymaker the rate of inflation planned by the dependable policymaker in the presence of intertemporal considerations is lower than the rate of inflation he plans in the absence of intertemporal considerations $(\pi_{d1} < (1-\beta_1)A)$.[16] The difference between those two planned rates is larger the higher the discount factor and (in contrast to the W type) the lower β_2. The reason for the effect of the discount factor is the same as in the case of W. Since the future is relatively more valuable when the discount factor is higher it pays to invest more in reputation. The reason for the effect of β_2 is that when second period reputation in the absence of full separation is expected to be low a dependable policymaker (unlike a weak one) stands to gain a lot from full separation. Note that if δ and A are sufficiently large a dependable policymaker may even plan to create a deflation in the first period (in spite of the obvious first period cost of such a policy) in order to establish his dependability beyond doubt.

The equilibrium characterized above for the first period planned rates of inflation implicitly assumes that the probability of full separation is smaller than one and that the weak policymaker faces a tradeoff between his first period objectives and the desire to hide

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[16] In the absence of intertemporal considerations $\delta = 0$ so that $\pi_{d1} = (1-\beta_1)A$.

his identity. I refer to the first requirement as "uncertain or probabilistic separation". Part 1 of the appendix presents conditions on the underlying parameters of the economy and of policymakers objectives under which this is indeed the case.[17]

To sum up we have established that, given the condition in part 1 of the appendix, the first period equilibrium strategies of the two policymaker types, inflationary expectations in the first period and the dynamic evolution of reputation when there is no full separation are given respectively by

$$
\begin{aligned}
\pi_{w1} &= A - \delta \frac{(\beta_2 A)^2}{2a_w} \\
\pi_{d1} &= (1 - \beta_1)A - \frac{\delta}{4a_d}(1 - \beta_2^2)A^2 \\
\pi_1^e &= \beta_1 \pi_{d1}^t + (1 - \beta_1)\pi_{w1} \\
\beta_2 &= \frac{\beta_1}{\beta_1 + \frac{a_d}{a_w}(1 - \beta_1)}.
\end{aligned}
\tag{22}
$$

Those results are reproduced here for compact reference in the following sections that deal with comparative statics.

5　The Effects of Initial Reputation and of Other Parameters on Equilibrium Strategies and on the Evolution of Reputation

The main results are summarized in the following series of propositions. The propositions are usually followed by an intuitive discussion of their results.

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[17] For other ranges of values of the underlying parameters equilibrium may be of the conventional separating variety in which the probability of separation is one. Depending on parameter values the weak policymaker may or may not face a tradeoff between his first period objectives and the desire to minimize the probability of being revealed **even when the probability of separation is smaller than one**. I focus here on the first type of equilibrium since it seems to be the most relevant for understanding reality.

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Proposition 1 : *In the case of no full separation second period reputation, β_2, is higher the higher initial reputation, β_1, and the lower the ratio $\frac{a_d}{a_w}$.*
Proof. : *By differentiating the expression for β_2 in (22)* ∎

The proposition states that there is some degree of persistence in the evolution of reputation. Other things the same second period reputation is higher the higher initial reputation.

Proposition 2 : *The higher the precision of inflation control under a dependable policy-maker (the lower is a_d) the more conservative are the policy plans of **both** policymaker types in the first period (both π_{d1} and π_{w1} are lower).*

Proof. : In part 2 of the appendix.

The response of the weak type is due to the fact that, given initial reputation, a lower value of a_d means that second period reputation is higher implying that he stands to loose more from full separation. As a consequence the weak type plans a more restrictive policy when the quality of inflation control by dependable policymakers is better. Essentially, by raising transparency, better inflation control on the part of dependable policymakers makes it more costly, at the margin, for weak policymakers to indulge in achieving their first period objectives.

The response of a dependable policymaker to an increase in the precision of his inflation control is a combination of two opposing factors. On one hand the increase in second period reputation induces him to be more expansionary since he stands to gain less from full separation. On the other hand the increase in precision also raises the effect of a marginal reduction in his planned inflation on the probability that he will succeed to establish his dependability beyond doubt. This induces him to be more conservative. The proposition states that the second effect dominates. Hence the overall effect of an increase in the precision of inflation control by a dependable policymaker is to reduce the inflation he plans. The broader implication of this result is that more transparency by dependable types induces all policymakers to be less inflationary.

How does the precision of inflation control by an opportunistic type affect policy plans? The effect on his own policy is generally ambiguous. An increase in a_w triggers two opposing effects on W's policy plans. On one hand he can indulge in more short run output stimulation by planning higher inflation since the marginal risk he takes of being revealed is lower when his control precision is lower. On the other hand, since second period reputation is higher when a_w is higher, W stands to lose more from full revelation. This moderates his expansionary tendencies. By contrast, as can readily be seen from an examination of equation (21), the effect of an increase in a_w on D's policy plans is unambiguously positive. This is summarized in the following proposition.

Proposition 3 : *A higher precision of inflation control by the opportunistic type induces the dependable type to be more conservative in the first period (π_{d1} is lower).*

Intuitively, for a given policy plan by D, a higher precision of inflation control by W reduces reputation and induces the dependable policymaker to make a stronger effort to reveal his dependability to the public. Thus, an increase in the transparency of policy plans of weak types induces dependable types to be less inflationary.

The following two propositions report the effects of initial reputation on the policy plans of the two types.

Proposition 4 : *The higher initial reputation, β_1, the more conservative is the policy plan of the weak policymaker in the first period (π_{w1} is lower).*

Proof. : By using proposition 1 in the expression for π_{w1} in equation (22). ∎

The intuition is the same as that of proposition 2. Since second period reputation is directly related to first period reputation, the weak policymaker stands to loose more from sharp separation. He, therefore, plans a more moderate rate of inflation when initial reputation is higher in order to reduce the probability that he will be fully revealed as weak.

A similar logic would seem to imply that when initial reputation is higher the dependable policymaker will inflate at a higher rate since he stands to gain less from sharp

separation. But this abstracts from the effects of initial reputation on first period's objectives. As can be seen from the appropriate expression in equation (22) the direct effect (as opposed to its effects through β_2) of initial reputation is to **reduce** the rate of inflation planned by a dependable policymaker. The reason is that, the higher initial reputation, the less costly it is for him, in terms of **first period objectives** to reduce inflation. This is due to the fact that the higher initial reputation, the higher is the impact of the first period inflation target on expectations and the smaller, therefore, the first period recession caused by the fact that a D type takes the target seriously. The upshot is that the direction of the effect of a higher initial reputation on the planned policy of a dependable policymaker is generally ambiguous and depends on whether the present or the future dominate his objectives. The following proposition provides conditions under which the impact is positive or negative.

Proposition 5 *: The rate of inflation planned by a dependable policymaker is an increasing function of initial reputation if and only if*

$$\delta > \frac{2a_w \left(\beta_1 + \frac{a_d}{a_w}(1 - \beta_1) \right)^3}{A\beta_1} \equiv \delta_c \tag{23}$$

Proof. *: In part 3 of the appendix.*

The proposition states that when the future is sufficiently important an increase in initial reputation induces the dependable policymaker to be, on balance, more inflationary. The converse holds when the future is not so important (the discount factor δ is below the threshold δ_c). Intuitively, when δ is sufficiently large an increase in β_1 raises the future marginal benefit of an increase in planned inflation by more than it reduces the current marginal benefit of such an action. And when δ is smaller than the threshold the opposite is true.

The threshold, δ_c, is a decreasing function of A implying that when the relative importance attributed by policymakers to employment versus price stability considerations is higher, the range of discount factors for which future objectives dominate is wider. This

is due to the fact that the future marginal benefit of an increase in planned inflation is proportional to A^2 wheras the current marginal benefit of such an action is only linear in A. Hence, the larger A, the wider the range of discount factors for which future objectives dominate the impact of an increas in initial reputation on the rate of inflation planned by dependable policymakers.

6   Determinant of the Probability of Full Separation

Due to imperfect control of inflation full separation, or a shock treatment as this is sometime called in the literature on inflation stabilization, is a random event that may or may not materialize. But policymakers can influence the probability of full separation via the choice of their planned inflation rates in the first period. The further apart the planned rates of inflation of the two types the larger the probability of full separation. From equation (22) the difference between the stategies of the two types is

$$\pi_{w1} - \pi_{d1} = A\beta_1 + \frac{\delta A^2}{2} \left[\frac{1}{2a_d} - \left(\frac{1}{a_w} + \frac{1}{2a_d} \right) \frac{\beta_1^2}{\left(\beta_1 + \frac{a_d}{a_w}(1 - \beta_1) \right)^2} \right]. \qquad (24)$$

Since the probability of full separation is an increasing function of the difference between the policies planned by the two policymakers in equation (24) it is possible to find the effect of various parameters on this probability by differentiating this equation with respect to each of those parameters. The following propositions report the effect of the discount factor and of the degree of "liberalism" of policymakers on the equilibrium probability of a shock treatment.

Proposition 6 : *(i) The probability of a shock treatment increases or decreases with the discount factor, δ, depending on whether initial reputation is lower or higher than a threshold, β_{1c}, that is given by*

$$\beta_{1c} \equiv \frac{\frac{a_d}{a_w} \sqrt{\frac{1}{1 + 2\frac{a_d}{a_w}}}}{1 - \left(1 - \frac{a_d}{a_w} \right) \sqrt{\frac{1}{1 + 2\frac{a_d}{a_w}}}}. \qquad (25)$$

(ii) When initial reputation is equal to β_{1c} the probability of a shock treatment does not depend on the discount factor.

Proof. : In part 4 of the appendix.

The proposition implies that when the future becomes more important dependable policymakers are more likely to induce a shock treatment when reputation is low than when it is high. The intuition underlying the proposition follows. An increase in the discount factor makes the future more important and induces **both** policymakers to inflate at a lower rate. When reputation is low the reduction in planned inflation by D is larger than the reduction in planned inflation by W because, at a low reputation, D stands to gain relatively more from full separation than W stands to loose from it at the margin. As a consequence the probability of separation goes up. When reputation is high W stands to loose relatively more than what D stands to gain from full separation. Hence when the future becomes more important, W makes a relatively stronger effort to prevent full separation and the probability of such an event goes down.

Proposition 7 *: An increase in A raises the probability of a shock treatment if $\beta_1 \leq \beta_{1c}$.*

Proof. : In part 5 of the appendix.

The proposition implies that a shock treatment is more likely to be observed when initial reputation is low and policymakers are liberal in the sense that the relative emphasis they put on employment is high. The proposition reveals the existence of an interesting interaction between the magnitude of A and the size of initial reputation. A larger A implies that the inflation bias is larger so that the incentive of the dependable policymaker to induce a sharp separation is stronger, and the incentive of the weak policymaker to prevent it is stronger as well. The total effect is therefore ambiguous in general. When initial reputation is small the first effect dominates since the dependable policymaker stands to gain a lot from sharp separation and the weak one does not loose much from it. When reputation is high the second effect dominates since the weak policymaker now stands to loose more from sharp separation than what his dependable counterpart might gain from it.

Note, however, that the condition in proposition 7 is not necessary. In other words, an increase in A may raise the probability of a shock treatment even when $\beta_1 > \beta_{1c}$. A condition that is both necessary and sufficient is given in part 4 of the appendix.

7 A Deeper Motivation for the Positive Association Between Dependability and the Precision of Inflation Control

To this point a basic maintained assumption of the paper has been that the precision of inflation control by dependable policymakers is better than that of their opportunistic counterparts. This section explores the extent to which the association between dependability and the precision of inflation control is due to deliberate choices by those two different policymaker types and provides, in the process, deeper foundations for this assumption. The intuition underlying such a presumption is that, since they gain from establishing their identity, dependable policymakers would like to pick control procedures that raise the probability of separation while their opportunistic, or weak counterparts, would like to reduce this probability since they loose from having their identity revealed. To the extent that an increase in the precision of inflation control raises the probability of separation, D types have an incentive to raise this precision while W types have an incentive to reduce it.

I endogenize the choice of precision by adding, prior to the beginning of the game described in Figure 1, a preliminary stage in which the policymaker in office chooses the precision of inflation control for the duration of his term in office. In doing that he takes as given the public's beliefs about the equilibrium choices of both policymaker types. Note that prior to separation the public does not know what the actual precision is, but it does know what are the equilibrium individually optimal levels of precision for each policymaker type. In the preliminary stage the policymaker in office chooses the precision, a_j, $j = D, W$, taking into consideration this structure of beliefs and subgame perfection. That is he takes into

consideration that, once the choice of a_j has been made, his subsequent choices of first and of second period planned inflation proceed optimally taking a_j as given. To characterize the individually optimal choices of precision we first calculate the impact of a change in a_j on the probability of no separation in the first period. From equations (16) and (20) the marginal impacts of an increase in a_j on the probability of no full separation when policymaker j, $j = D, W$, is in office are given respectively by:[18]

$$\frac{\partial \Pr(NS/W)}{\partial a_w} = \frac{1}{2a_w^2} \left[A\beta_1 + \frac{\delta A^2}{4a_d}(1 - \beta_2^2) - \frac{\delta A^2}{a_w}\beta_2^2 - a_d \right] \tag{26}$$

and

$$\frac{\partial \Pr(NS/D)}{\partial a_d} = \frac{1}{2a_d^2} \left[A\beta_1 + \frac{\delta A^2}{2a_d}(1 - \beta_2^2) - \frac{\delta A^2}{2a_w}\beta_2^2 - a_w \right]. \tag{27}$$

Differentiating equation (15) with respect to a_w and equation (19) with respect to a_d, and using equations (26) and (27) we obtain respectively:

$$\frac{\partial V_w(a_w)}{\partial a_w} = -\frac{1 + \delta}{3}a_w + \frac{\delta A^2 \beta_2^2}{2a_w^2} \left[A\beta_1 + \frac{\delta A^2}{4a_d}(1 - \beta_2^2) - \frac{\delta A^2}{a_w}\beta_2^2 - a_d \right] \tag{28}$$

and

$$\frac{\partial V_d(a_d)}{\partial a_d} = -\frac{1 + \delta}{3}a_d - \frac{\delta A^2(1 - \beta_2^2)}{4a_d^2} \left[A\beta_1 + \frac{\delta A^2}{2a_d}(1 - \beta_2^2) - \frac{\delta A^2}{a_w}\beta_2^2 - a_w \right]. \tag{29}$$

Equations (28) and (29) represent respectively the marginal impacts of a change in the own precision of inflation control on the expected value of objectives of each of the two policymaker types. In principle there could be four types of solutions. One in which the equilibrium values of both a_d and a_w are internal and another in which both of them are

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[18]Note that those marginal impacts include only the non expectational effects of a_j on the probability of no separation since each policymaker type takes the publics' beliefs regarding a_d and a_w, and therefore also about the choicesof π_{d1} and π_{w1}, as given. In other words, those marginal impacts include, besides the direct effect of a change in a_j on the probability of separation, only the effect via the subsequent adjustment in the first period planned rates of inflation π_{j1}, by each type.

equal to the minimal technologically feasible value of a denoted $\underline{a}$ [19]. Two other conceivable solutions are that $a_d = \underline{a}$ and the solution for a_w is internal, or the reverse configuration. A full characterization of the mapping from parameter values to types of equilibrium solutions is beyond the scope of this paper. But even without doing that it is possible to establish that there is a reasonably strong presumption that the opportunistic policymaker chooses less precise control procedures than his dependable counterpart. More precisely I show below that this is always the case when the equilibrium solutions for the levels of inflation control are internal and that it is also the case for a whole range of parameter values when the dependable policymaker picks the highest possible level of precision that is technologically feasible.[20]

Assuming that the exogenous parameters are such that there are positive internal equilibrium solutions for both a_d and a_w equations (28) and (29) can be equated to zero and rearranged to yield the (implicit) reaction functions of the two policymakers' types in the (a_d, a_w) space.[21]

$$a_w^3 = \frac{3}{2}\frac{\delta}{1+\delta}(A\beta_2)^2\left[A\beta_1 + \frac{\delta A^2}{4a_d}(1-\beta_2^2) - \frac{\delta A^2}{a_w}\beta_2^2 - a_d\right] \equiv \frac{3}{2}\frac{\delta}{1+\delta}(A\beta_2)^2 N_w \qquad (30)$$

and

$$a_d^3 = \frac{3}{2}\frac{\delta}{1+\delta}A^2(1-\beta_2^2)\left[\frac{\delta A^2}{2a_w}\beta_2^2 + a_w - A\beta_1 - \frac{\delta A^2}{2a_d}(1-\beta_2^2)\right] \equiv \frac{3}{2}\frac{\delta}{1+\delta}A^2(1-\beta_2^2)N_d. \quad (31)$$

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[19] Although in practice $\underline{a}$ is probably strictly positive nothing in the analysis precludes it from being 0.

[20] One may wonder why it does not always pay D to choose $\underline{a}$. The reason is that, for uniform distributions of ε_i, the choice of a lower value of a given the strategy and the precision of inflation control by the weak type does not always increase the probability of full separation for the dependable type. It does increase it when, as is the case in figure 2, the equilibrium policies of the two types are sufficiently distant from each other. More precisely when $\pi_{d1} < \pi_{w1} - a_w$. But when the reverse inequality holds a decrease in a_d is counterproductive from D's point of view since it reduces his chances to fully separate himself from his opportunistic counterpart.

[21] This assumption implies that N_d and N_w are both positive.

Although those two equations do not provide explicit solutions for each precision level in terms of the precision level of the other policymaker they determine implicitly (along with equation (13) for β_2) the equilibrium levels of inflation control by the two policymaker types.

Proposition 8 : *When the equilibrium solutions for a_d and for a_w are internal the equilibrium level of a_w is larger than that of a_d.*

Proof. : Since the solutions for a_d and for a_w are internal N_d and N_w are both positive which implies:

$$\frac{\delta A^2}{2a_w}\beta_2^2 + a_w > A\beta_1 + \frac{\delta A^2}{2a_d}(1 - \beta_2^2)$$

and

$$A\beta_1 + \frac{\delta A^2}{4a_d}(1 - \beta_2^2) > \frac{\delta A^2}{a_w}\beta_2^2 + a_d$$

The last two equations imply that

$$\frac{\delta A^2}{2a_w}\beta_2^2 + a_w > \frac{\delta A^2}{a_w}\beta_2^2 + a_d. \tag{32}$$

Equation (32) is satisfied only if $a_w > a_d$. ∎

When the exogenous parameters are such that the dependable policymaker chooses the corner solution at $\underline{a}$ it can be shown that, provided initial reputation and $\underline{a}$ are both sufficiently small, the equilibrium level of a_w is larger than $\underline{a}$. Those conditions are jointly sufficient but not necessary. Together with proposition 8, this result supports the presumption that, in a non negligible number of cases, dependable policymakers have an incentive to choose more precise inflation control procedures than their weak or opportunistic counterparts. In summary, the underlying basic intuition is that, by choosing less precise control procedures, weak policymakers reduce the (undesirable to them) probability of being revealed as weak. Conversely, by choosing more precise control procedures, dependable policymakers raise the (desirable to them) probability of being revealed as dependable.

8   Concluding Remarks

An important general lesson of the paper is that, in the presence of intertemporal considerations, the policies of **both** types of policymakers depend on the level of reputation and on the relative precision of inflation control by different types of policymakers.[22] In particular the higher the transparency of policy plans under a dependable policymaker (i.e; the tighter his control of inflation), the more conservative are the policy plans of the two policymaker types. The broader implication of this result is that better precision of inflation control induces less inflationary policies. The paper also establishes a theoretical presumption for the view that dependability and the precision of inflation control are often positively related. This is basically due to the fact that, dependable policymakers like to raise the probability of being revealed as such whereas opportunistic policymakers like to reduce the probability of being revealed as opportunistic or weak since this ruins their reputation and destroys the effectiveness of inflation targets as a device for influencing expectations.

The paper also contains results concerning the speed with which dependability is built up or depleted. There are two cases. When there is no sharp separation and learning is gradual the speed of learning is higher the higher is the **relative** precision of inflation control by dependable policymakers. The speed of learning is also higher on average the larger the probability of sharp separation, which depends in turn on the policy plans of the different policymaker types. When reputation is sufficiently low an increase in concern for the future (an increase in the discount factor), raises, or reduce, the probability of sharp separation and with it the average speed of learning depending on whether initial reputation is low or high. The intuition underlying this dependence of results on the level of initial reputation follows. By making the future more important, an increase in the discount factor motivates **both** policymaker types to be less inflationary. When reputation is low the incentive of the dependable policymaker to moderate inflation is larger than that of his weak counterpart

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[22]This contrasts with a single period model in which only the policy of dependable policymakers depends on reputation (see section 3).

since he stands to gain a lot from a sharp separation while the weak type does not risk much in terms of lost reputation. The exact opposite is true when initial reputation is sufficiently high since, in this case, the dependable type has little to gain, and the weak one has a lot to loose, from sharp separation.

More broadly those results imply that, when policymakers become more concerned with the future, shock treatments are more likely to be observed if initial reputation is low and that gradual stabilizations are more likely to be observed when initial reputation is already non negligible. Stabilization of many high inflations in Latin America during the eighties appear to fit the first pattern and many episodes of inflation stabilization in developed economies seem to fit the second one.[23]

Another result is that a higher initial level of reputation moderates the inflationary tendencies of weak policymakers The broader implication is that, once reputation has been established, even an opportunistic policymaker may find it expedient to deliver a reasonably low level of inflation. Furthermore, to the extent that, government involvment in the public setting of inflation targets increases initial reputation, the above mentionned result implies that such an involvment moderates inflation when monetary policymakers are not dependable

Melnick and Liviatan (1998) have recently documented the fact that the inflationary process in Israel tends to behave as a step function. The type of model proposed here may be used to "explain" such steps in terms of full separation of the policymaker type due to lucky or unlucky random economic events. More precisely as long as shocks are small there is no full separation - reputation changes in relatively small increments and so does policy. As a consequence inflation remains within the "same step". But when there is a sufficiently extreme shock full separation occurs triggering a jump in both planned and actual inflation.

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[23]"Cold turkey" Latin American stabilizations during the eighties and the 1985 "shock" Israeli stabilization are discussed in Bruno et. al. (1988) and in Cukierman, Kiguel and Liviatan (1992). The work of Ball (1994), (1997) suggests that the stabilization of inflation in many developed economies has been substantially more gradual. A related discussion regarding the factors that affect the choice of stabilization type appear in Cukierman and Liviatan (1992).

Recall from equation (22) that the policies of both policymakers depend on reputation. When there is a dependable policymaker in office and he happens to experience a "lucky" downward shock to inflation his identity is fully revealed inducing him to also adjust planned inflation downward in a stepwise fashion. Similarly, when there is a weak policymaker in office, and he happens to experience an "unlucky" upward shock to inflation his identity, and therefore the discretionary nature of policy, is fully revealed inducing him to fully indulge in discretionary policies. This creates an upward step in the rate of inflation. Thus, under a weak policymaker, an unlucky inflationary draw can push inflation to a self fulfilling higher step and, under a dependable policymaker, a lucky inflation draw can pull inflation to a self fulfilling lower step.

I have assumed, that policymakers announce a point target. In practice a target range rather than a point target is often announced. Note, however, that individuals in the model understand that the point target that is announced really means that actual inflation falls within some range. Thus the point target is interpreted, in any case, by individuals in the model as a range.[24]

To preserve analytical simplicity I have restricted the supports of the control errors to finite ranges by assuming that they possess uniform distributions. Had those supports been unbounded, as is the case with normal distributions for example, full separation would not have been possible and the area of gradual learning in Figure 2 would stretch over the entire range between minus and plus infinity. Although the uniform distribution assumption may therefore be construed as a limitation of the model I believe it should not be taken too seriously for two reasons. First, the uniform distribution can always be sufficiently stretched out to approximate a wide support. Perhaps more importantly, it is likely that, as a rule of thumb, individuals treat , respectively, very low and very high levels of reputation as full reputation and no reputation at all even if Bayes formula implies that reputation has not quite reached the extreme values of one and zero. Thus, uniform distributions may better

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[24]Additional discussion of the relative merits of a point target versus a target range appears in chapter 12 of Bernanke et. al. (1999).

describe the actual evolution of individual beliefs than distributions with full supports.

To preserve analytical simplicity I also have taken the level of inflation planned by each policymaker to be the "policy instrument". Since currently many central banks use some short term interest as the main policy instrument it would be interesting to map the level of planned inflation from this paper into an interest rate instrument. Such a formulation would hopefully make it possible to derive propositions on some of the basic factors that influence the difference in the interest rate policy of different policymaker types. Since it would have to recognize the potential role of the interest rate as a signal of dependability such a reformulation is not likely to be an immediate extension of this paper and is left for future work.

9 Appendix

9.1 Statement and derivation of a condition for probabilistic separation and for the existence of a tradeoff between W's first and second period objectives

Claim: (i) A sufficient condition for probabilistic separation and for the existence of an equilibrium tradeoff between W's first and second period objectives is:

$$a_d + a_w + \frac{\delta A^2}{2a_w}\beta_2^2 > \beta_1 A + \frac{\delta A^2}{4a_d}(1 - \beta_2^2) > a_w - a_d + \frac{\delta A^2}{2a_w}\beta_2^2 \tag{33}$$

where

$$\beta_2^2 = \frac{\beta_1^2}{\left(\beta_1 + \frac{a_d}{a_w}(1 - \beta_1)\right)^2}.$$

(ii) The condition in equation (33) implies $\pi_{w1} - \pi_{d1} > a_w - a_d > 0$.

Proof. : (i) After some rearrangement the left hand inequality implies (using the equilibrium expressions for π_{w1} and for π_{d1} in equation (22))

$$\pi_{w1} - a_w < \pi_{d1} + a_d.$$

This inequality in conjunction with Figure 2 imply that the probability of separation is smaller than one. In other words, there is probabilistic separation.

Rearrangement of the right hand inequality in equation (33) and use of the equilibrium expression for π_{d1} yield

$$\pi_{w1} - a_w > \pi_{d1} - a_d. \tag{34}$$

Equation (34) in conjunction with Figure 2 imply that W faces an equilibrium tradeoff between his first period and his second period objectives. For if he did not he would have reduced π_{w1} at least down to the level of $\pi_{d1} - a_d$ in order to reduce the probability of being revealed as weak.

(ii) The result follows by rearrangement of the right hand inequality in equation (33) and by use of the expressions for π_{d1} and for π_{w1} in equation (22). ∎

9.2 Proof of proposition 2

The effect of a_d on π_{w1} follows from direct examination of the expression for π_{w1} in equation (22). Differentiating the expression for π_{d1} in equation (22) with respect to a_d and rearranging

$$\frac{\partial \pi_{d1}}{\partial a_d} = \frac{\delta A^2 (1 - \beta_1)}{4 a_d a_w \left(\beta_1 + (1 - \beta_1) \frac{a_d}{a_w} \right)^2} \left[(1 - \beta_2)\beta_1 + \frac{a_d}{a_w}(1 - \beta_1) \right].$$

Since this expression is unambiguously positive a decrease in a_d reduces π_{d1}. ∎

9.3 Proof of proposition 5

Differentiating the equilibrium expression for π_{d1} from equation (22) with respect to β_1

$$\frac{\partial \pi_{d1}}{\partial \beta_1} = A \left(\frac{\delta A \beta_1}{2 a_w \left(\beta_1 + (1 - \beta_1) \frac{a_d}{a_w} \right)^3} \cdot - 1 \right)$$

Rearrangement shows that this expression is negative, zero or positive as δ is smaller than, equal to, or larger than δ_c in equation (23). ∎

9.4 Proof of proposition 6

Differentiating equation (24) with respect to δ

$$\frac{\partial (\pi_{w1} - \pi_{d1})}{\partial \delta} = \frac{A^2}{2} \left[\frac{1}{2 a_d} - \left(\frac{1}{a_w} + \frac{1}{2 a_d} \right) \frac{\beta_1^2}{\left(\beta_1 + \frac{a_d}{a_w}(1 - \beta_1) \right)^2} \right]$$

Rearrangement of this expression reveals that the difference $\pi_{w1} - \pi_{d1}$ is an increasing, or decreasing function of δ depending on whether β_1 is smaller than, or larger than β_{1c}. When $\beta_1 = \beta_{1c}$ this difference is independent of δ. ∎

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9.5   Proof of proposition 7 and an extension

(i) Differentiating equation (24) with respect to A

$$\frac{\partial(\pi_{w1} - \pi_{d1})}{\partial A} = \beta_1 + \delta A \left[\frac{1}{2a_d} - \left(\frac{1}{a_w} + \frac{1}{2a_d} \right) \frac{\beta_1^2}{\left(\beta_1 + \frac{a_d}{a_w}(1 - \beta_1) \right)^2} \right] \tag{35}$$

The proof of proposition 5 implies that if $\beta_1 \leq \beta_{1c}$ the term in brackets on the right hand side of (35) is non-negative. It follows that, for $\beta_1 \leq \beta_{1c}$, an increase in A raises the probability of separation. ∎

A necessary and sufficient condition for the probability of a shock treatment to increase in A is (rearranging equation (35)):

$$\frac{1}{2a_d} - \left(\frac{1}{a_w} + \frac{1}{2a_d} \right) \frac{\beta_1^2}{\left(\beta_1 + \frac{a_d}{a_w}(1 - \beta_1) \right)^2} + \frac{\beta_1}{\delta A} > 0.$$

10 References

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