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The Dynamics of Optimal Gradual Stabilizations

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Inflation inertia may be quite tenacious because of the simultaneous interaction between policy actions and inflationary expectations under imperfect credibility. This result is particularly relevant for understanding some of the failed efforts to stabilize inflation in South America. This article deals with the issue of inertia in the framework of imperfect information about the type of the policymaker and extends the existing models to an infinite horizon. Because policymakers do not have perfect control of inflation, a "frivolous stabilizer" may deviate from the policies of a "serious stabilizer" without necessarily being unmasked immediately. When the difference in the ability of "strong" and "weak" policymakers to control inflation is large, unexpected inflation may be persistently negative for quite a while, thus causing reduced economic activity and giving the indication that credibility is low. If the policymaker persists with the stabilization, this pattern gradually disappears as his reputation rises. But before this final stage the serious policymaker has to compromise his inflation objective in view of adverse expectations about his type and pay the cost of imperfect credibility.

In some countries, particularly in Latin America, inflation has been quite tenacious in spite of recurring attempts at stabilization. Many of these attempts probably failed because the stabilization packages did not include a serious commitment to slow down the rate of growth of the money supply and to reduce the deficit. But even when such a commitment was in place, as in Chile and Argentina during the mid-1970s, inflation came down rather slowly and was accompanied by substantial and sustained reductions in the level of economic activity.

It is obviously possible to claim that if the monetary brakes had been applied more strongly, stabilization would have been faster. It is not clear, however, that such a course of action would have yielded better overall results. The policymaker may find it preferable to stabilize gradually because of credibility problems, thus providing a rigorous foundation for "inflation inertia" (Kiguel and Liviatan 1988).

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The behavior of the policymaker while in office depends on the public's expectations about inflation (Barro and Gordon 1983). The public's expectations reflect, in turn, the possibility that the policymaker is not serious about achieving stabilization (not a "serious stabilizer"). When the public has little faith that the policymaker has really become more concerned about price stability, even a serious stabilizer does not necessarily reduce inflation quickly in order to avoid very substantial decreases in economic activity. Hence, when a serious stabilizer is in office, inflationary expectations as reflected in nominal contracts turn out to be too high ex post, which causes them to be revised and reduced. This reduction in inflationary expectations raises the policymaker's reputation as a serious stabilizer. But this learning process, although optimal, is gradual because actual inflation is affected not only by the deliberate decisions of the policymaker but also by unpredictable events over which the policymaker has no control. Because subsequent policy actions also depend on expectations, and because expectations are reduced slowly, even a serious stabilizer may be led to stabilize gradually.

If in office for a sufficiently long period of time, the serious stabilizer will ultimately build up a good reputation and deliver a much lower rate of inflation. But the period of stabilization will be protracted, and during most of it unexpected inflation will be negative, thus creating a persistent lull in economic activity. This lull occurs in spite of the fact that the serious stabilizer partially accommodates inflationary expectations in order to minimize the combined costs of low employment and high inflation.

Much has been made of inflation inertia arising from long-term, overlapping wage contracts and backward-looking, formal or informal indexation arrangements. This article demonstrates that even without these sources of inertia, inflation may be quite tenacious because of the simultaneous interaction between policy actions and inflationary expectations when there is imperfect credibility. Policy actions respond to expectations, which in turn are updated optimally, but sluggishly, in light of actual inflation.

Practically all previous models in which the public is uncertain about what type of policymaker is in office postulate a finite horizon for the policymaker (Backus and Driffill 1985a, 1985b; Barro 1986; Vickers 1986; Persson and van Wijnbergen 1987; Andersen and Risager 1987, 1988; Cukierman and Liviatan 1991a). In this article we characterize the path of inflation and other variables when the policymaker has an infinite horizon. This extension makes it possible to determine whether a serious stabilizer is eventually able to deliver the best performance.

Because policymakers do not have perfect control over inflation, a "frivolous stabilizer" may deviate from the policies that would have been followed by a serious stabilizer without necessarily being revealed as a frivolous stabilizer immediately. Imperfect control of inflation makes it more costly for a serious stabilizer to build up credibility quickly.

The first dynamic implication of our framework is that inflation comes *down*

during a gradual stabilization process, in contrast to models with mixed strategies of the Backus and Driffill (1985a) or Barro (1986) type, in which inflation *goes up* during this process. The second is that as inflation comes down, so do inflationary expectations. In Barro and in Andersen and Risager, inflationary expectations are fixed over time. Moreover, because of their fixed horizon, these models imply that a serious stabilizer may not reap the benefits of better performance until the last few periods, or even the very last period, of the game. Hence, the fixed-horizon assumption of these models does not give a serious stabilizer who cares somewhat about economic activity much incentive to pursue stabilization. An infinite horizon thus seems necessary in order to understand situations in which it is optimal to embark on a stabilizing path even when the formation of reputation is lengthy and gradual.

The analytical framework we develop provides a natural vehicle for the discussion of the effect of foreign aid on the credibility of stabilization. Untied aid, by permitting a higher level of economic activity, reduces the incentive to inflate and increases the credibility of stabilization. Conditional foreign aid reinforces these tendencies and speeds up the process of stabilization even further.

Section I presents a simple, infinite-horizon, Barro-Gordon (1983) type of framework, with uncertainty about the type of policymaker and with imperfect control of inflation. Section II introduces the public's (Bayesian) process of learning. A full characterization of the model's solution for the case in which a serious stabilizer opts for a gradual stabilization is developed in section III. Section IV presents the dynamic features of the equilibrium solution and uses it to interpret the stabilization in the United Kingdom under Margaret Thatcher and the stabilization in Chile. Section V discusses the effect of conditional and unconditional foreign aid on the credibility of stabilization.

I. The Model and Its Rationale

The model is designed to bring out the public's uncertainty concerning the likelihood that the policymaker is serious about stabilizing inflation and the effect of this uncertainty on policy. In order to capture the public's uncertainty, we assume that there are two types of policymakers: weak and strong. Both types of policymakers dislike inflation and desire to maintain employment above the natural level of employment. (The natural level of employment is the level at which expected and actual inflation rates are equal.) The desired level of employment of the "weak" policymaker is higher than that of the "strong" policymaker. More precisely, the combined cost of inflation and of being below the desired level of employment for each policymaker in period t is

$$z_t \equiv \frac{A}{2}(N_i^* - N_t)^2 + \frac{\pi_t^2}{2}, \qquad i = w,s \tag{1}$$

where z denotes cost; A is the relative preference for price stability versus employment objectives and is a parameter common to both types of policymaker;

N_i^* is the desired level of employment of policymaker i; w denotes the weak policymaker and s the strong policymaker; N_t is the actual level of employment; and π_t is the actual rate of inflation.

Neither policymaker has perfect control over the rate of inflation. In particular, when a policymaker plans to generate inflation at rate π_{pt}^i, the actual rate of inflation is

$$\pi_t^i = \pi_{pt}^i + \epsilon_t^i, \qquad i = w,s \tag{2}$$

where π_{pt}^i is the actual inflation under policymaker i, and ϵ_t^i is a stochastic noise term whose variance is inversely related to the degree of control of the policymaker over the rate of inflation. Imprecise control of inflation is the result of either imperfect control of the money supply (Cukierman 1992, chapter 9) or the policymaker's uncertainty about money demand. The public cannot determine with certainty to what extent a change in monetary expansion occurs because of the policymaker's deliberate plans and to what extent it occurs because of an error in the policymaker's forecast of money demand (Cukierman 1992, chapter 13; Canzoneri 1985). The change obviously may result from a combination of both possibilities. We assume that the stochastic noise term has zero expected value and is distributed uniformly. In particular,

$$p_r[\epsilon_t^w = x] = \begin{cases} 1/2a_w & -a_w \le x \le a_w \\ 0 & \text{otherwise} \end{cases} \tag{3a}$$

$$p_r[\epsilon_t^s = x] = \begin{cases} 1/2a_s & -a_s \le x \le a_s \\ 0 & \text{otherwise} \end{cases} \tag{3b}$$

where x is a particular realization of the noise term, and a_w and a_s denote measures of the imprecision of inflation control by the weak policymaker and strong policymaker, respectively. Assuming that the weak policymaker is less precise in controlling inflation than the strong policymaker is, $a_w > a_s$.

The policymaker can affect employment by creating inflation that was unanticipated at the time nominal contracts were concluded. This situation leads to a conventional expectations-augmented Phillips relation that is summarized in equation 4:

$$N_t - N_n = a(\pi_t - \pi_t^e), \qquad a > 0 \tag{4}$$

where N_n denotes the natural level of employment, and π_t^e represents the rate of inflation expected at contracting time for the period of the contract. Equation 4 states that the deviation of employment from its natural level is positively related to unanticipated inflation. Substituting equation 4 into equation 1 and setting $a = 1$ for simplicity,

$$z_t \equiv z(d_i, \pi_t, \pi_t^e) = \frac{A}{2}[d_i - (\pi_t - \pi_t^e)]^2 + \frac{\pi_t^2}{2} \tag{5}$$

where

$$d_i \equiv N_i^* - N_n, \qquad i = w,s. \tag{6}$$

Thus d_i is the (positive) divergence between the level of employment desired by a policymaker of type i and the natural level of employment.

From the Barro-Gordon (1983) analysis, when the public is fully informed about the type of policymaker holding office and there is perfect control of the money supply (ϵ_t^i being identically equal to zero), the equilibrium rate of inflation is

$$\pi^i = Ad_i, \qquad i = w,s. \tag{7}$$

This is the time-consistent or subgame-perfect equilibrium. It is obtained by letting the policymaker choose the level of inflation (π) so as to minimize the costs in equation 5. The policymaker would do this by taking the rate of inflation expected at contracting time (π_t^e) as given and then imposing rational expectation. Under perfect information, rational expectation amounts to the requirement $\pi_t^e = \pi_t$ (Cukierman 1992, chapter 3).

Because the difference between the desired rate of employment and the natural rate of employment is positive, the equilibrium rate of inflation is positive. Moreover, because there is no uncertainty of any kind, wage setters fully anticipate the subsequent action of the policymaker. As a consequence, employment is always at the natural level in spite of the fact that inflation is positive. Obviously, the same level of employment could have been obtained with zero inflation, provided wage setters had believed the policymaker would choose zero inflation. But the wage setters have no reason to hold such a view, because zero inflation is not optimal for the policymaker after the wage contract has been made. This dynamic inconsistency of monetary policy induces a suboptimally high rate of inflation (Kydland and Prescott 1977).

Because the difference between the desired level of employment and the natural level of employment is greater for the weak policymaker than for the strong one, the equilibrium in equation 7 implies that the weak policymaker produces a rate of inflation that is higher than the rate of inflation produced by the strong policymaker. The intuition is that the weak policymaker is known to have a larger employment objective and is rightly expected to inflate at a higher rate. Hence, wage setters demand higher wage increases than in the case in which the strong policymaker is known to be in office.

When stabilization programs are introduced, the public is usually uncertain about their outcome. We model this uncertainty by assuming that either the weak or the strong policymaker is in office forever but that the public is not sure which type is in office. As time passes, the public learns from the realizations of inflation which type is likely to be in office. But this process may be protracted: because both types of policymakers have imperfect control of inflation, realizations of past inflation do not necessarily convey precise information about the type to the public. The assumption that one type of policymaker is in office forever is obviously not made for its realism. Policymakers do change, and the relative emphasis on employment versus price stability may change even within the same administration. The assumption is made to illustrate the potential difficulties that low credibility brings to a strong policymaker even in the favor-

able case in which a particular type of policymaker is in office forever and public uncertainty concerns only his or her type.

The policymaker's plans about how to handle inflation are made by taking both the current and the future values of the costs $z(\cdot)$ into consideration. In particular, when in office, either type of policymaker makes plans for current and future inflation rates that will, given the information available at the time, minimize the expected present value of costs. This present value, as of the present period (denoted by 0), is given by

$$E_{p0}\sum_{t=0}^{\infty}\beta^t z(d_i,\pi_t,\pi_t^e), \qquad 0 < \beta \leq 1, i = w,s \tag{8}$$

where β is a discount factor that measures the policymaker's rate of time preference and E_{p0} is an expected value conditioned on the information available to the policymaker when the policymaker picks the average rate of inflation of the initial period. The weak policymaker is more sensitive to the costs of low employment in all periods because the difference between the desired and the natural level of employment is greater for the weak policymaker than for the strong one.

The length of a period is determined by the length of nominal wage contracts. Within each period, nominal wage contracts are made on the basis of the expected rate of inflation between the previous and the current period. Then the policymaker picks the planned rate of inflation for the period, taking those expectations (or nominal contracts) as given. This sequence shows that the government cannot precommit itself to a level of inflation. Actual inflation for the period is determined, through equation 2, by the policymaker's decision and by the realization of the uncontrollable inflationary shocks. The public observes the actual rate of inflation before it sets inflationary expectations and nominal contracts at the beginning of the next period. However, the public never observes the two components of the actual rate of inflation—one component planned by the policymaker and the other uncontrollable—separately.

II. Stabilization and the Evolution of Reputation

Inflation may be quite high for a while because a weak policymaker has been in office. If a strong policymaker then settles permanently in office and announces that a stabilization phase has commenced, the public will remain skeptical. This is because the earlier, weak policymaker would have had an incentive to make similar statements. We model the public's skepticism by assuming that its prior probability that the announced stabilization has been made by a strong policymaker is a number that is strictly bounded between zero and one. The smaller the prior probability, the lower the initial "reputation" of the policymaker (Backus and Driffill 1985a, 1985b; Vickers 1986).

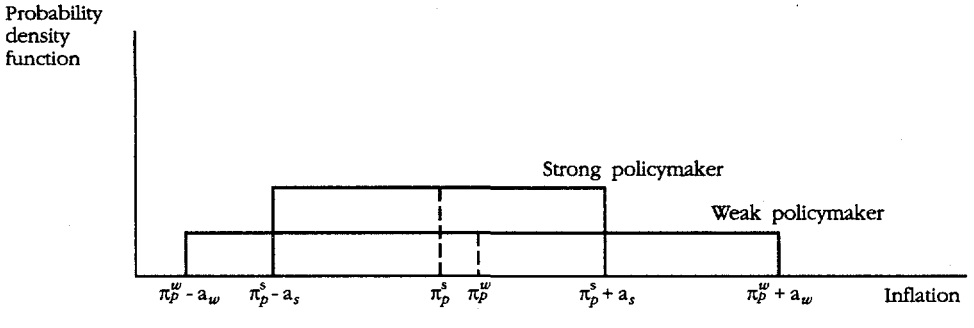
Inflation uncertainty normally rises with the level of inflation (Engle 1982;

chapter 18 of Cukierman 1992). We capture this feature in a simple manner by assuming that the weak policymaker, who always plans to inflate at a higher rate than does the strong policymaker, also does not control inflation as tightly ($a_w > a_s$).

In spite of this difference in the precision of inflation control, the public may not be able to ascertain with certainty, even many periods after the policymaker has taken office, that a strong type is in office. The reason is that imprecise control of inflation by both policymakers prevents the public from clearly separating one type from the other, even if, as is normally the case, they plan to produce different average rates of inflation. Figure 1 illustrates why this is so for arbitrary equilibrium strategies of the two types of policymakers. From equations 2 and 3a, actual inflation when a weak policymaker is in office is between $\pi_p^w - a_w$ and $\pi_p^w + a_w$. Similarly, actual inflation when a strong policymaker is in office is between $\pi_p^s - a_s$ and $\pi_p^s + a_s$. When actual inflation is in the common range, which is the range of the strong policymaker in figure 1, there is no way for the public to clearly identify that a strong policymaker is in office. But because the probability that a rate of inflation in the common range has been produced by a strong type is larger than the probability that it has been produced by the weak type (as can be seen from figure 1), realizations of inflation in the common range raise the reputation of the policymaker in office.

This intuitive argument is confirmed by Bayes' formula, which shows how reputation evolves when the realization of inflation is in the common range. Given the actual rate of inflation in the current period, Bayes' formula relates the public's subjective probability that the policymaker in office is strong to the probability that the policymaker was strong before the realization of current inflation. Equation 9 shows the updating formula when actual inflation falls in the common range.

Figure 1. *Strategies of Different Policymaker Types and the Corresponding Distributions of Inflation*



Note: The relative positions of the two distributions in the figure are meant to be illustrative. Other relative configurations, some of which are discussed in the text and illustrated in figure 2, are possible.

$$(9)\qquad \alpha_{t+1} \equiv Pr\,[i = s \mid \pi_t]$$

$$= \frac{Pr\,[\pi_t \mid i = s]\; Pr[i = s]}{Pr[\pi_t \mid i = s]\; Pr[i = s] + Pr[\pi_t \mid i = w]\; Pr[i = w]}$$

$$= \frac{\frac{1}{2a_s}\alpha_t}{\frac{1}{2a_s}\alpha_t + \frac{1}{2a_w}(1 - \alpha_t)} = \frac{\alpha_t}{\alpha_t + \frac{a_s}{a_w}(1 - \alpha_t)}$$

where *Pr* is an abbreviation for probability. Because the ratio of the imprecision of inflation control of the strong policymaker to that of the weak one is smaller than one, the probability that the policymaker is strong is greater in the current period (after the realization of π_t) than in the previous period for all t as long as inflation falls in the common range of figure 1. In other words, given that the public is still uncertain about the type in office, an additional realization of inflation in the common range always raises the reputation of the policymaker in office. (If the ratio of imprecision of inflation control is one, then realizations of inflation in the common range are not informative.)

When the weak policymaker is in office, there is a positive probability that inflation will fall in the noncommon range. When inflation actually falls in this range, the policymaker is revealed as being weak with certainty, and the public's prior probability that the policymaker is strong jumps to zero. The public knows that such a realization of inflation could not have occurred had a strong policymaker been in office. Thus, given the strategies postulated in figure 1 for the weak and strong policymaker types, the weak type will ultimately be revealed as weak, although that may take a long time. However, it will never be demonstrated to the public with full certainty that the strong type is in office when this is the case. But the reputation of the strong type will increase monotonically, reaching one asymptotically as time goes to infinity.

III. Equilibrium Strategies, Policy Convergence, and Expectations under Gradualism

The policymakers' equilibrium choice of strategy determines the probability that the public will be able to identify the policymaker as weak or strong. When the divergence between the equilibrium strategies of the two types of policymakers is small compared with the divergence in the precisions of their control over inflation, the probability that the public will be able to separate a strong policymaker from a weak policymaker may be zero. Conversely, the probability of the public's being able to make a distinction is usually positive, and may even be one, if the divergence between the equilibrium strategies is sufficiently large in relation to the difference in the precisions of inflation control.

The case of a small divergence in equilibrium strategies leads to equilibria in

which it is optimal for a strong policymaker to stabilize gradually. The case of a large divergence corresponds to situations in which it is optimal for a strong policymaker to take a chance with a "shock treatment." Which of the two methods of stabilization is optimal generally depends on the policymakers' reputations at stabilization, their rate of time preference, the precision of their control over inflation, and other parameters. The main focus of this article is on equilibrium when the optimal method of stabilization is gradual.

Characterization of Gradual Stabilizations

This section fully characterizes the equilibrium strategies of the two types of policymakers, but under a (provisional) assumption. The assumption is that the range of possible inflation rates produced by the weak policymaker's strategy fully covers the range of inflation rates that could be produced by the strong policymaker's strategy. In this case, the dynamic optimization problem decomposes into a series of one-period maximization problems. A convenient feature of the uniform distributions postulated for the noise terms (ϵ_t^i) is that all observations on inflation are equally informative and are independent of the magnitude of inflation as long as they all fall within the common range. Hence, as long as the strategies (planned inflation rates) of the weak and strong policymakers are such that the range of possible rates produced by the strong policymaker is fully covered by the range of rates that could be produced by the weak policymaker, the probability that the type will be revealed is independent of the precise location of the planned inflation rates within this range. As a consequence, within this range, either policymaker can select a current strategy to maximize the value of current objectives without paying attention to future values of the objectives.

Because equilibrium strategies depend on the process of forming expectations and this process depends in turn on what the public knows about these strategies, expectations and equilibrium strategies are determined simultaneously. The appendix shows that the equilibrium strategies are given by equation 10 or, alternatively, by equations 11 and 12, where B is a positive combination of parameters (whose precise form appears in the appendix). Expectations are given by equation 13, which is also derived in the appendix.

$$\pi_{pt}^i = \frac{A}{1+A}(d_i + \pi_t^e), \qquad i = w,s \tag{10}$$

$$\pi_{pt}^s = Ad_s + (1-\alpha_t)B(d_w - d_s) \tag{11}$$

$$\pi_{pt}^w = Ad_w - \alpha_t B(d_w - d_s) \tag{12}$$

$$\pi_t^e = \alpha_t(Ad_s) + (1-\alpha_t)(Ad_w). \tag{13}$$

Equation 13 implies that inflationary expectations in period t are a weighted average of the discretionary rates of inflation that would have been chosen by each policymaker under perfect information. Because the difference between the

desired and natural level of employment is greater for the weak policymaker than for the strong policymaker ($d_w - d_s > 0$), equations 11 and 12 imply that imperfect information causes both policymakers to have equilibrium strategies that converge toward each other compared with the equilibrium strategies they would have under perfect information. When the value of the reputation indicator is one-half ($\alpha_t = 1/2$), the planned rate of inflation of the weak policymaker decreases and that of the strong policymaker increases by the same amount compared with their full-information counterparts. As the value of the reputation indicator increases above one-half, the tendency of the weak policymaker to move toward the strong one increases, and the tendency of the latter to move toward its weak counterpart diminishes. The converse happens when the value of the reputation indicator decreases below one-half.

Because the marginal costs of being away from the desired level of employment are higher the further away actual employment is from its desired level (equation 1), both types of policymakers partially accommodate inflationary expectations. This is reflected by the positive, but smaller-than-one, coefficient $[A/(A + 1)]$ of the rate of inflation expected at contracting time (π_t^e) in equation 10. Because the expected rate of inflation is affected by what the public knows about the equilibrium strategies of both policymakers, the expected rate is somewhere between the rates of inflation that the strong and the weak policymakers plan to generate. Because the latter rate is larger, it follows that the weak policymaker's planned rate of inflation will be lower than it would have been under perfect information. The strong policymaker's planned rate of inflation is higher than it would have been under perfect information. The public's uncertainty pulls the policies of the two types toward each other. As reputation increases, expectations approach the equilibrium strategy of the strong policymaker. Hence, the tendency of the strong policymaker's planned rate of inflation to converge toward that of the weak policymaker diminishes, and the tendency of the weak policymaker's planned rate of inflation to converge toward that of the strong policymaker increases. Alternatively, as reputation diminishes, the tendency of the strong policymaker to compromise on the full-information strategy increases. As the reputation indicator approaches zero, the strong policymaker's planned rate of inflation approaches $Ad_s + B(d_w - d_s)$ (equation 11). The difference between this strategy and the strong policymaker's strategy under perfect information tends toward $B(d_w - d_s)$. Thus, with poor credibility, the actual policy of a strong policymaker may very well resemble that of a weak policymaker.

To assure that the strategies given in equations 10, 11, and 12 are indeed equilibrium strategies, it is necessary to assure that neither the strong nor the weak policymaker wants to deviate from the range in which the rates of inflation that could have been produced by the weak policymaker fully cover the range of rates that could have been produced by the strong policymaker. A sufficient condition for the weak policymaker not to want to deviate from this range is

$$a_s > \pi_{pt}^w - \pi_{pt}^s \text{ for all } t, \tag{14}$$

which, using equations 6 and 10, is equivalent to

$$a_s > \frac{A}{1+A}(N_w^* - N_s^*). \tag{15}$$

Condition 14 requires that the imprecision of inflation control by the strong policymaker (measured by a_s) is larger than the difference in the equilibrium strategies of the two types in equation 10. When this is the case, the weak policymaker has no incentive to change the planned inflation rate in a way that would eliminate the full coverage of the strong policymaker's distribution by the weak policymaker's distribution.

The inflation rate the weak policymaker plans to generate is greater than the rate the strong policymaker plans to generate for all periods. The weak policymaker obviously does not have an incentive to reduce the planned inflation rate, because doing so would not reduce the probability of revelation but would increase the weak policymaker's expected costs in period t. The weak policymaker also does not have an incentive to increase the inflation rate it plans to generate above its value from equation 10, because doing so would raise current expected costs and may increase the probability of revelation.[1] Equation 15 restates this condition in terms of the fundamental parameters of the model and clarifies that the condition is independent of the time index, t. The condition basically requires that the imprecision of inflation control by the strong policymaker be large compared with the difference between the desired employment objectives of the two policymakers.

Partial- versus Full-Revelation Equilibria

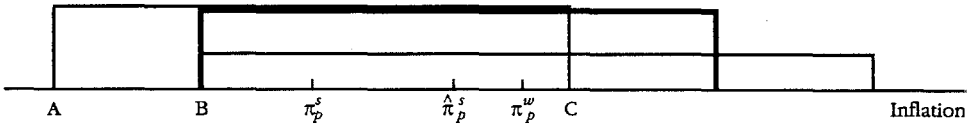
Unlike the weak policymaker, who has an incentive, other things being equal, to reduce the probability of revelation, the strong policymaker has an incentive to increase it. If revealed as such, the strong policymaker will reap the benefits of a good reputation during the entire future. But to increase the probability of the public's being able to separate the strong policymaker from the weak one, the strong policymaker's planned rate of inflation must be lowered. Thus the range of inflation rates that could be produced only by the strong policymaker would be widened.

If, given the weak policymaker's planned rate of inflation, the strong policymaker chooses a planned rate of inflation denoted by $\hat{\pi}_p^s$ in figure 2, the distribution of both policymakers' planned inflation rates would fully overlap, thus making the probability of sharp separation zero. But, by reducing the planned rate of inflation to π_p^s, the strong policymaker can create a positive probability

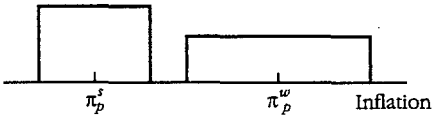
1. The implicit assumption underlying this statement is that both policymakers believe that off-equilibrium observations of inflation do not induce updating in the reputation parameter, α, and in expectations. The game theory literature refers to assumptions regarding the beliefs of players about off-equilibrium situations as "conjectures" and to the type of conjecture used here as a "passive conjecture" (Rubinstein 1985).

Figure 2. *Partial- and Full-Revelation Equilibria*

a. A Partial-Revelation Equilibrium



b. Revelation with Probability of One



of sharp separation. In the figure this probability is measured by the ratio of linear segments AB/BC. In the extreme case, the strong policymaker can reduce the planned rate of inflation enough to create a complete separation (with a probability of one) between the two types. Figure 2b illustrates such a situation. This corresponds to the notion of a separating equilibrium in signalling theory as illustrated, for example, by the work of Vickers (1986).

When Is Gradualism the Optimal Strategy for a Strong Policymaker?

Returning to the case of strictly gradual stabilization, as in figure 1, in order for the strategy of the strong policymaker in equation 10 to be optimal, it must dominate all strategies that yield positive probabilities of sharp separation. This occurs when the current cost of deviating from the strategy in equation 10 to a strategy that opens a "window of separation" is larger than the expected present discounted value of the benefits of separation. The present cost arises because, by lowering current inflation, the strong policymaker deviates from the optimal strategy of balancing the costs of low employment and high inflation in the current period. Sharp separation yields future benefits, however, because once he or she is recognized as strong, the policymaker enjoys the benefits of higher employment and lower inflation levels associated with a perfect reputation ($\alpha = 1$). The present costs of partial or full separation are more likely to be higher than its future benefits, the larger the difference between the policymakers' imprecision of inflation control ($a_w - a_s$) is compared with the difference in their desired levels of employment ($N_w^* - N_s^*$) and the lower the discount factor (β) is. In addition, it is likely that no separation will be attempted when the initial reputation is relatively high. The precise condition underlying this statement is presented in part 1 of the appendix in Cukierman and Liviatan (1991b).

The policymaker's rate of time preference affects the likelihood that the current costs of separation are larger than its future benefits. The less the strong

policymaker cares about the future, the larger the importance attributed to the current costs of separation. The role played by the relative sizes of the difference between the imprecision of inflation control by the weak and the strong policymakers ($a_w - a_s$) and the difference between the weak and strong policymakers' desired levels of employment ($N_w^* - N_s^*$) can be understood intuitively as follows. The larger the difference in imprecision of inflation control compared with the difference in the desired level of employment, the larger the divergence between the strong policymaker's optimal strategy for the current period and the strategy necessary to produce a positive probability of separation. Hence, when the difference in imprecision of inflation control is large in relation to the difference in the desired level of employment, the current costs of separation are more likely to be prohibitively high. Finally, when reputation is high to start with, the marginal future benefits of full revelation are small and therefore not worth the current costs of revelation.

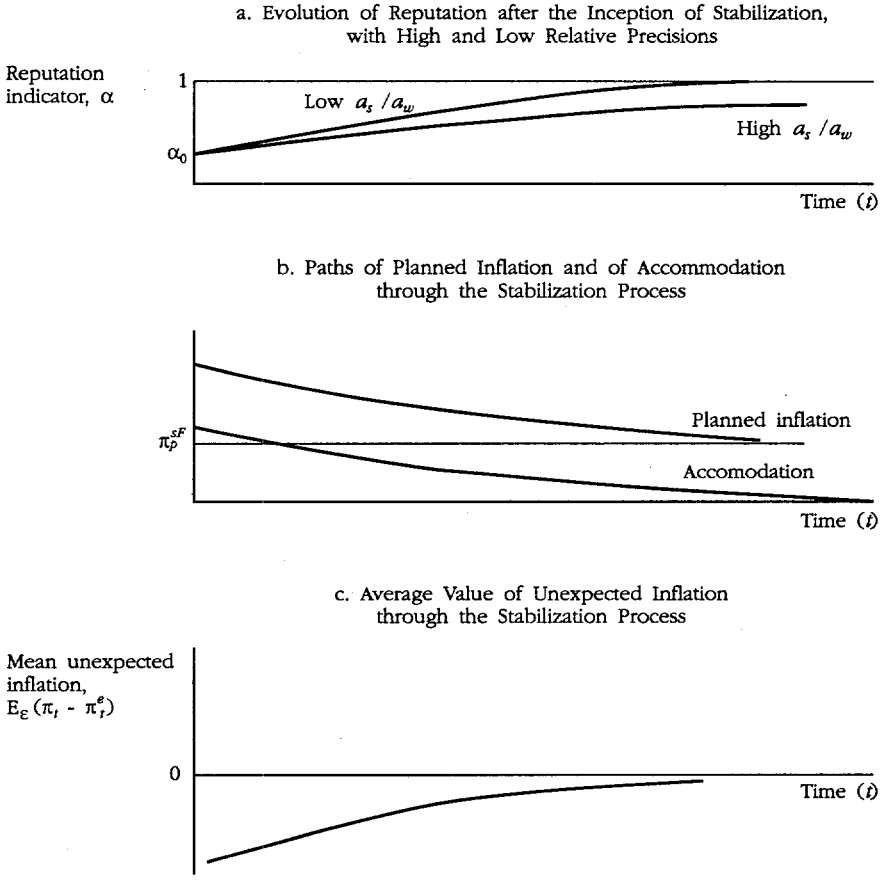
IV. Features of Optimal Gradual Stabilizations and Applications

Even under the relatively favorable conditions in which a strong policymaker gets into office at the beginning of the stabilization process and remains there forever, it may be optimal to stabilize gradually. Speaking somewhat loosely, gradual stabilizations are optimal when there is a lot of noise in the control of inflation and when the policymaker, even if strong, has a high rate of time preference.

Under these circumstances the reputation of the strong policymaker as a stabilizer rises gradually (see equation 9). The speed at which it rises depends on the precision of inflation control of the strong policymaker (a_s) in relation to that of the weak policymaker (a_w). This relative precision is conveniently measured by the ratio a_s/a_w. The lower this ratio, the higher the relative precision of the stabilizing policymaker (that is, the strong one) and the faster the rate of growth of reputation. In the limit, when the ratio approaches 1, the process of reputation building may take forever. At the other extreme, when the ratio approaches 0, reputation rises extremely rapidly. Figure 3a illustrates two paths of reputation building starting from a common initial reputation α_0. In both paths, the process of reputation building is gradual, but it is faster when the ratio is lower.

From equations 11 and 12, when a firm reputation is finally established, the average rate of inflation stabilizes at the level $\pi_p^{sF} \equiv Ad_s$, which may be a reasonably low level, provided the difference between the strong policymaker's desired level of employment and the natural level of employment is sufficiently small. But during the period of reputation buildup even a serious stabilizer (that is, the strong policymaker) partially compromises on its perfect information inflation by accommodating some of the public's suspicions. The extent of accommodation can be measured as the difference between the decisions of a serious stabilizer with and without perfect information. This measure of accom-

Figure 3. *Reputation, Accomodation, and Unexpected Inflation during Stabilization*



modation is $\pi_{pt}^s - \pi_p^{sF} = [A^2/(1 + A)]\,(d_w - d_s)(1 - \alpha_t)$, where π_p^{sF} is the strong policymaker's planned inflation rate under full information.

Thus, the larger the divergence in the employment targets of a weak and a strong policymaker and the lower the current level of reputation, the larger the extent of accommodation. As the reputation of the serious policymaker rises, the extent of accommodation diminishes monotonically and tends to disappear altogether after a sufficiently large number of periods. Concurrently, average planned inflation decreases monotonically and finally converges toward the full-information low inflation rate (π_p^{sF} in figure 3b). Figure 3b shows the paths of planned inflation and accommodation during the stabilization process. The speed at which inflation and accommodation diminish is determined by the rate of increase in reputation, which is, in turn, faster the larger the relative precision of inflation control by the strong policymaker.

Equation 13 and the fact that the difference between the desired and the natural level of employment is greater for the weak than for the strong policymaker imply that inflationary expectations also decrease monotonically during

the stabilization process and finally converge toward the low inflation rate that obtains in full information. The speed at which inflationary expectations decrease is again directly related to the relative precision of inflation control by the serious stabilizer. In spite of the fact that stabilization is gradual, the serious policymaker has to accept a prolonged period of employment below normal because the average rate of inflation is consistently lower than expected. From equations 2, 11, 12, and 13, $\pi_t - \pi_t^e = -[A/(1 + A)](d_w - d_s)(1 - \alpha_t) + \epsilon_t^s$.

Because the expected value of ϵ_t^s is zero, the average discrepancy between actual and expected inflation is negative on average. It is large initially and decreases monotonically toward zero as the reputation of the policymaker improves. Figure 3c depicts the path of the average discrepancy between actual and expected inflation. The tighter the relative control of the strong policymaker over inflation, the faster the rate at which unexpected inflation converges to zero. Hence, a serious stabilizer who has a tighter relative control of inflation stabilizes with a shorter and less severe reduction in economic activity. Conversely, when the policymaker's relative control is known to be loose, the recession induced by stabilization is longer and deeper.

An additional implication of the analysis concerns the dependence of the policies of both policymaker types on the evolution of reputation. From equations 11 and 12, it can be seen that, as reputation rises (as α_t goes up), the equilibrium strategies of both types gradually shift to lower rates of inflation. The intuition is that, as the reputation indicator goes up, expectations get nearer to the equilibrium strategy of the strong policymaker and further away from that of the weak policymaker. Other things being equal, this situation reduces inflationary expectations. The fact that the policies of both policymakers are positively related to expectations tends to reduce the planned rates of inflation of both types. Essentially, the increase in reputation and the associated reduction in inflationary expectations pulls both types toward lower rates of inflation.

The possibility that gradualism may be the optimal strategy sheds new light on several recent stabilization efforts in various countries. At the end of the 1970s and through the first half of the 1980s the British government under Margaret Thatcher implemented a gradual stabilization program. During this time Britain went through a prolonged period of unemployment accompanied by increasing real wages. Sargent (1986b, p. 150) criticized this gradualist approach on the grounds that it "invites speculation about future reversals, or U-turns, in policy." Sargent is right in the sense that our strong policymaker could produce a probability of one of separating himself from the weak policymaker by deflating at a sufficiently low rate. As demonstrated in the previous section, however, this course of action is not necessarily optimal. For appropriate configurations of parameters like highly imprecise control of inflation and a reasonably high initial reputation, the best stabilization strategy is gradualism.

A somewhat similar argument can be made about the disinflation process in Chile in 1974–77, where the rate of monetary growth fell rather gradually (in 1977 annual monetary growth was still above 100 percent). Contrary to a claim by Harberger (1981, 1982), a gradual reduction in monetary growth may be

consistent with a monetary crunch. Applying the principles of our model, one could argue that, under imperfect credibility, even the gradual reduction in the rate of monetary growth set by the policymaker may systematically exceed the public's expectations of this reduction. This will result in a situation of tight money. Indeed Edwards and Edwards (1987) and Corbo and Solimano (1989) conclude that monetary policy in Chile in the early stage of stabilization was contractionary.

Ireland during the 1980s also partially fits the pattern of gradualism. After 1982, both fiscal and monetary policies in Ireland became substantially more restrictive. There ensued a gradual reduction in inflation and a prolonged increase in the rate of unemployment (Dornbusch 1989). However, it is likely that part of the increase in unemployment, particularly during the second part of the 1980s, can be attributed to factors other than those modeled in this article (Blanchard and Summers 1986).

Our model provides a framework for analyzing stabilization policies in settings of moderate or high inflation, in which the main motive for inflation is high economic activity. But it does not seem to be appropriate for stabilization of hyperinflation, as experienced by Germany or Austria after World War I. Hyperinflation is a result of an unsustainable fiscal situation in which the policymaker inflates mostly or only to finance the government's budget; historically, in all major hyperinflations the revenue motive was paramount. In such cases the structure of nominal contracts becomes so condensed that the short-run tradeoff all but disappears (a in equation 4 tends to zero), and any differences in emphasis on economic activity between policymakers become inconsequential.

The credibility of stabilization relates, in this case, to the ability of the policymaker to finance expenditures in a sustainable manner (including the use of an inflation tax). This means that the issue is the credibility of the government's *solvency*. In such cases, credibility can be established (as in Sargent 1986a) more swiftly for two reasons. First, any potential differences between policymakers with regard to employment are relatively unimportant because of a shrunken Phillips tradeoff. Second, balancing of the budget (usually with foreign assistance) sends a clear signal that the major motive for inflation has been eliminated. This differs from the setting of our model, which deals with high, but not hyperinflationary, conditions, in which the credibility issue is not related to solvency, but rather to the inflation-unemployment tradeoff. In the latter setting, the gradualist solution becomes more relevant; budget balance alone does not establish quick credibility, because financing governmental expenditures is not the main motive for inflation.

V. The Effect of Foreign Aid on the Credibility of Stabilization

The path of inflation can be affected by external intervention in the form of foreign aid. An increase in the country's resources as a result of foreign aid may reduce the incentive of any type of policymaker to use surprise inflation to

increase employment and output. For example, foreign aid, by increasing the availability of raw materials and physical capital, may increase the natural levels of employment and thereby reduce the difference between the desired and the natural level of employment. Such a reduction reduces the equilibrium rate of inflation under both types of policymakers.

Foreign aid may, however, be tied more directly to the performance of the stabilization program. For example the foreign aid for any given year may be made conditional on inflation being below some target level, say π^*. If π^* is below $\pi_p^s + a_s$ in figure 1, it is clear that each policymaker will have an incentive to reduce the planned inflation rate, thus leading to a lower inflation path. The presumption is that both policymakers are better off accepting the aid and the associated conditions than rejecting this package. However, even if π^* is above $\pi_p^s + a_s$ (but below $\pi_p^w + a_w$), the strong policymaker still has an incentive to reduce the planned inflation rate, provided the following condition holds: without the constraint on the inflation rate, the weak policymaker would have inflated at a higher rate, and the public understands this fact. As a result, the public's expectation of inflation goes down compared with its expectation in the case of no conditionality. From equation 10, this decline in the expectation of inflation induces the strong policymaker to lower the planned inflation rate even further. The reason is that the public understands that tying the aid to performance would constrain the behavior of a weak policymaker.

Foreign aid conditionality will, when it is binding, motivate the weak policymaker *more* than the strong policymaker to reduce the planned rate of inflation. Consequently, the rate of inflation the weak policymaker plans to generate will move closer to the rate the strong policymaker plans to generate, and the motivation of the strong policymaker to separate will therefore diminish. Thus foreign aid conditionality will tend to make the gradualist solution more likely. However, the level of inflation with foreign aid conditionality will be lower on average.

In practice, the foregoing form of conditionality is problematic because the policymaker may be induced to produce an artificially low inflation rate by means of price controls or by similar methods (such as setting an unrealistically low exchange rate or artificially reducing public sector prices). It will therefore be advisable to formulate a more robust kind of conditionality, one that makes explicit reference not only to inflation but also to fundamentals such as the size and composition of public sector expenditures and revenues, and the stock of money or domestic credit.

VI. Conclusions

Imperfect control of inflation fundamentally alters the dynamics of inflation, reputation, expectations, and economic activity during stabilization (see also, Cripps 1991). When the difference in the ability to control inflation of strong and weak policymakers is large, unexpected inflation may be persistently nega-

tive for a while, causing reduced economic activity and giving the indication that credibility is low. But if the policymaker persists with stabilization, this pattern gradually disappears. Imperfect control also leads to a generalization of the concept of separation because it creates situations in which the equilibrium policies of different types of policymakers diverge without necessarily inducing clear-cut separation. Imperfect control of inflation is the result of factors that are related to the structure of the economy and of policymaking institutions. In particular, it is likely that the lower the degree of independence of the central bank, the lower the precision of inflation control (Cukierman 1992, chapter 18).

When the fundamental cause of inflation inertia is imperfect information about the objectives of policymakers, there is no gradualism without pain. This contrasts with the role of gradualism when the basic reason for inertia is backward-looking nominal contracts. It is possible to devise, in such cases, patterns of gradual disinflation that eliminate the employment costs of stabilization.

Appendix. Derivation of Equilibrium Strategies and Expectations under Gradualism (Equations 10 to 13)

To simultaneously solve for the equilibrium strategies and for expectations, we use the method of undetermined coefficients. In particular, we postulate that the equilibrium strategies of the two types of policymakers can be represented as the following two functions of d_i, $i = w,s$, and of expectations

$$\pi^s_{pt} = k_d d_s + k_e \pi^e_t;\ \pi^w_{pt} = r_d d_w + r_e \pi^e_t \tag{A-1}$$

where k_d, k_e, r_d, and r_e are unknown coefficients to be determined. It can be shown that only the current expectation belongs in the solution and that, given linearity and decomposability, the solution is therefore unique. There also are history-dependent trigger strategies, but we rule them out because of their limitations and lack of descriptive realism. Discussions of the coordination problem and other problems of trigger strategies appear in Rogoff (1987, 1989) and Cukierman (1992, chapter 11).

The public knows the decision rules in equation A-1 but is uncertain about the identity of the policymaker in office. Hence, inflationary expectations are given by

$$\pi^e_t = \alpha_t \pi^s_{pt} + (1 - \alpha_t)\pi^w_{pt} = \alpha_t[k_d d_s + k_e \pi^e_t] + (1 - \alpha_t)[r_d d_w + r_e \pi^e_t]. \tag{A-2}$$

Because the dynamic optimization problem in equation 8 reduces to a series of one-period problems, the equilibrium strategy of policymaker i at time t can be characterized by solving

$$\min E^i_{pt} z(d_i,\ \pi^i_{pt} + \epsilon^i_t,\ \pi^e_t), \qquad i = w,s \tag{A-3}$$

where E^i_{pt} denotes the information available to policymaker i when the policy-

maker picks the planned rate of inflation for the period. The superscript i attached to the expected value denotes the fact that the information sets of the two policymakers differ. Equation 10 is obtained from the first-order condition for the problem in A-3 and by using equation 5 and the fact that, when the policymaker picks π^i_{pt}, the policymaker takes π^e_t as given. Equating the coefficients of d_i and π^e_t across equations A-1 and 10 yields

$$k_d = r_d = k_e = r_e = [A/(1 + A)]. \tag{A-4}$$

Equation 13 follows by using A-4 in A-2. Equations 11 and 12 follow by letting $B = [A^2/(1 + A)]$.

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