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Some Implications of Policy Games for High Inflation Economies

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Programs based on tight fiscal and monetary policies (the orthodox approach) are slow at reducing inflation in high-inflation countries. Why? The policy-game approach sheds light on the credibility problems that raise the public's inflationary expectations.

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This paper — a product of the Macroeconomic Adjustment and Growth Division, Country Economics Department — is part of a larger effort in PRE to examine stabilization policies. It was funded by the research project "Stopping High Inflation" (RPO 674-24). Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Raquel Luz, room N11-057, extension 39059 (32 pages).

Kiguel and Liviatan used the policy-game approach to gain insight into a problem that has puzzled analysts of high inflation economies.

Why are programs based on tight fiscal and monetary policies (the orthodox approach) slow at reducing inflation in high-inflation countries?

They conclude that lack of credibility generates disinflation costs.

One question relates to the apparent delinking of inflation from the long-term requirements of deficit finance. Distinguishing between regimes of rule and discretion, Kiguel and Liviatan explain that governments that cannot abide by policy rules and tend to use surprise inflation in a discretionary manner to achieve short-term goals — to erode the real wage, for example, or the real value of domestic debt — raise the rational public's inflationary expectations.

A given level of real seigniorage, in particular, can correspond to a much higher long-term rate of inflation — especially in high-inflation economies with a limited ability to abide by the rules. The results are different in countries with a credible rule about money supply.

If policymakers can convince the public that (even though they intend to rely on money finance) they will not resort to surprise inflation tactics, the long-term level of inflation may be reduced considerably. Then they are advised to limit the deviations from the preannounced target of their nominal anchor, whether a monetary or exchange rate.

Another problem is how should policymakers who are genuinely interested in disinflation react to adverse public expectations? The policymakers are faced with the dilemma of sticking to their announced policy and paying immediate costs in terms of unemployment and capital flight, or compromising their initial targets at the cost of renewed inflationary expectations.

If the source of a credibility problem is the inability of "weak" policymakers to honor their commitment, strong policymakers may need to compromise to some extent.

What if the source of a credibility problem lies in different attitudes of policymakers toward the relative importance of price stability versus distortion in the real sector (overvaluation, unemployment) — and in the incentives for high-inflation policymakers to mimic low-inflation policymakers? Then a case can be made for overadjusting in the initial stages of adjustment — for example, creating a fiscal surplus after a long history of deficits — to improve the government's credibility.

Produced at the PRE Dissemination Center

Some Implications of Policy Games for High Inflation Economies

by
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and
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INTRODUCTION

Recent developments in the application of game theory to macroeconomics can offer some new insights into the nature of the inflationary process in high inflation economies and shed new light on the difficulties encountered by stabilization policies in this environment. By "high inflation economies" we mean the so called chronic-inflation countries, where inflation seems to have a life of its own quite irrespective of the state of the fiscal deficit. In these economies, such as Brazil or Israel before 1985, it was usually felt that inflation was well above the minimum level required by considerations of seigniorage. (In fact both in Brazil and Israel the long term rise in inflation was unrelated to seigniorage.)

The purpose of the present paper is two-fold. First, we wish to present some of the main ideas of the policy-game approach in a simple manner for the benefit of readers who are less familiar with this line of thinking. Secondly, we intend to contribute to the existing literature on some specific topics which are of special relevance to high inflation economies.

One of the important insights provided by the recent works of Kydland and Prescott (1977) and Barro and Gordon (1983a) relates to the distinction between regimes of rules and discretion. A government which cannot abide by policy rules and which tends to use surprise-inflation in a discretionary manner in order to achieve short-term goals will raise inflationary expectations by the rational public. This can explain how inflation can rise above the "fundamentals" on a long-term basis. In particular, a given level of real seigniorage can correspond to a much higher long-term rate of inflation in a discretionary regime as compared with a rules regime. This issue is especially relevant for high inflation economies where the ability to abide by rules is often limited.

It is often puzzling how is it possible for inflation to go up on a longer-term basis with the fiscal deficit changing in the opposite direction, a phenomenon which has been observed recently in Brazil and Mexico [see Kiguel and Liviatan (1988)]. It is equally puzzling to find that inflation can rise, for many years, above the estimated revenue maximizing point, as was found for the case of Israel by Liviatan and Piterman (1986).

Conventional inflation-tax theory has no answers to this type of phenomena. Recently Bruno and Fischer (1986) provided an analysis of stable high-inflation equilibrium which can help in understanding the foregoing features of inflation. The policy game approach can provide an alternative, and in some ways less arbitrary, framework of dealing with these issues.

A basic idea in the latter approach is that a given need for seigniorage can generate a much higher long-term inflation level if the government uses surprise-inflation tactics as compared with the case where it can commit itself to a credible money supply rule. The inclination to use the former tactics may often be explained by political instability which is reflected in high time preference or short planning horizon by policy makers. In the present paper we make use of a somewhat modified version of Barro (1983) to elaborate on the issue of high inflation equilibrium.

The increase of inflation above the revenue maximizing point can also be driven by the existence of <u>non-fiscal</u> motivations for inflationary policies. For example, the policy makers may have a motivation to erode the real wage by surprise-inflation tactics in order to increase employment or to improve competitiveness. The policy game approach may explain how these short-term tactics can lead to a <u>long-term</u> increase of inflation, even above the revenue

maximizing point, because of the adverse effects on inflationary expectations. In the present paper we shall formalize this interaction between fiscal and non-fiscal motivations for inflation by combining different elements from the works of Barro and Gordon.

A basic feature of the policy game approach is that, in equilibrium, the policy maker cannot achieve any real gains from surprise inflation because of the public's correct anticipation. This creates a strong motivation for the policy maker to reach some sort of a "social pact" in order to break the inflationary spiral, a strategy which is often employed in income-policy supported stabilization.

This brings us to the second major topic of the paper which is related to the credibility issues which arise in stabilization programs in high inflation countries. While quite often stabilization programs fail because of insufficient adjustment of the fundamentals, yet the empirical evidence suggests that this is not the whole story. For example, the disinflation policy by means of pegging the exchange rate in Chile in 1979-81 led to a balance of payments crisis in spite of the fact that the fiscal deficit was turned into a surplus [see Ramos (1986)]. In Israel's 1985 stabilization, a policy of using the exchange rate as nominal anchor jointly with a major fiscal adjustment were not sufficient to prevent excessive increases in real wages and overvaluation. It seems that these developments were in part due to credibility considerations regarding the determination of the policy makers to pursue the announced nominal policies.

The policy game approach may provide some insight into the way in which lack of credibility may generate disinflation costs. We shall pursue this subject by making use of Barro's (1986) seminal paper on monetary policy under incomplete information. However, this paper and the related literature do not

explain how a policy maker who is genuinely interested in disinflation should react to adverse expectations. This issue is of great practical importance in concrete stabilizations where the policy maker is faced with the dilemma of sticking to his announced policy and paying immediate costs in terms of unemployment and capital flight or compromising his initial targets at the cost of renewed inflationary expectations. In order to analyze this issue we shall modify Barro's model along the lines of a recent paper by Cukierman and Liviatan (1989).

We shall finally address another issue which arises often in planning stabilizations strategies. It is usually claimed that in order to enhance initial credibility, and underscore the change of regime, the policy maker should overadjust in the initial stage. For example, it may be advisable to create a fiscal surplus after a long history of deficits. We shall show that the considerations involved in this approach can be formulated in terms of signalling theory. Here we shall introduce some modifications in a recent model by Vickers (1986) who uses the basic Barro-Gordon framework, in order to discuss the pros and cons of overadjustment. We shall conclude with some comments on the interaction between two important principles mentioned above -- one is the need to compromise with adverse expectations and the other is the incentive to overadjust in order to enhance credibility.

This paper is divided into two parts. Part I deals with explanations of high inflation (in excess of seigniorage requirements) and Part II focuses on issues of stabilization and credibility.

PART I: EXPLANATIONS OF HIGH INFLATION

1. BASIC ASPECTS OF POLICY GAMES

The basic ideas of the policy games approach can be illustrated by means of a simple model used in the works of Barro and Gordon. Let the policy maker's utility function be given by

$$U = -(a/2)\pi^2 + b(\pi-\pi^e) \; ; \qquad a,b > 0 \qquad (1)$$

where π and π^e denote actual and expected inflation. This assumes that the policy maker is averse to π while he benefits from surprise inflation. If we interpret π^e as the rate of increase in nominal wages, then an excess of π over π^e reflects a reduction in real wages and an increase in employment. The latter may be desirable if unemployment is too low due to excessive unemployment insurance and the like (Barro 1983).

Suppose that the policy maker determines π through various policy instruments such as the money supply or the exchange rate. Suppose further that π^e (as reflected in the setting of nominal wages) is determined in the beginning of the period as the first step in the game. Then the policy maker will set π so as to maximize U, which yields

$$\pi^* = b/a \qquad (2)$$

as the government's policy function.

If we assume full information, so that U is known to the public, then

it will set π^e equal to expected π^* which yields, under certainty, $\pi^e = \pi^*$. This implies that in equilibrium surprise inflation is zero. Thus with a rational public the policy maker does not achieve its employment goal and in addition pays the cost of a high π.

It is evident that under these conditions the policy maker is interested in making a commitment not to inflate since he cannot obtain his employment objective anyway. However, while this is true ex-ante, the policy maker has an incentive to inflate ex-post. This is so since given π in (2) is optimal. It is because of this dynamic inconsistency that the policy maker's commitment may not be credible.

We may distinguish two types of regimes according to the ability of the policy maker to make credible commitments. At one extreme is the "discretionary regime" where the policy maker is not capable of making any credible commitment, which leads to the policy of (2). At the other extreme is the "ideal-rules's regime" where he is capable of fully credible commitments. In the latter case, the policy maker's inflation target is translated fully into the public's expectations so that the maximization of U is carried out subject to $\pi = \pi^e$, which yields an optimal policy of $\pi = 0$ (for further discussion, see Barro and Gordon 1983a).

What is it that determines the ability to make credible commitments? We may mention such factors as past experience in keeping commitments, the policy maker's political horizon, his rate of discounting the future and so on. In some models [Barro and Gordon(1983a)] these considerations induce the policy makers to adopt an inflation target between zero and the discretionary solution (b/a).

A most important aspect of the game relates to the kind of information that the public possesses about the nature of the policy maker. Quite often the

public has only incomplete information about the policy maker, as reflected in his ability to carry out his commitments. Under these conditions it is no longer true that surprise inflation is eliminated in equilibrium (in finite horizon models). In particular, the possibility of negative surprise inflation may explain various side-effects which accompany, ordinarily, stabilization programs - such as overvaluation, high real wages and high export real interest rates. We shall accordingly introduce considerations of incomplete information in the discussion of stabilization policies. However in Part I we shall assume full information.

2. THE HIGH INFLATION EQUILIBRIUM

The feeling that inflation may deviate from the fundamentals even in the long run has found its formal expression in recent research. Bruno (1986) and Fischer and Bruno (1987) analyze this issue in the conventional framework of the inflation tax model with two steady state equilibria at each level of the fiscal deficit - one above and one below the revenue maximizing point. It is shown that under myopic rational expectations, or under adaptive expectations with quick adjustment, the high inflation equilibrium can be stable.

A completely different approach to this issue (which does not rely on the foregoing assumptions) can be formulated in terms of policy games. For this purpose we shall use a somewhat modified version of Barro's (1983) paper on inflationary finance.

The seigniorage in the inflation tax model is given by

$$S = \frac{M_t - M_{t-1}}{} = \frac{M_t}{} - \frac{M_{t-1}}{} \quad \frac{P_{t-1}}{} \qquad (3)$$

t P_t P_t P_{t-1} P_t

where M_t and P_t denote the nominal money stock and the price level in period t. Inflation and expected inflation in period t are defined as

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}} \quad ; \quad \pi^e_{t+1} = \frac{P^e_{t+1} - P_t}{P_t}$$

where π^e_{t+1} is based on the information set of t. The demand function for real balances in period t is given by $L(\pi^e_{t+1})$. Assuming that the money market is always in equilibrium and using the approximation $(1+\pi)^{-1}=1-\pi$ we may rewrite (3) as

$$S_t = L(\pi^e_{t+1}) - L(\pi^e_t)(1-\pi_t) \qquad (4)$$

Let us consider first the discretionary regime. Here π^e_{t+1} is assumed to be unaffected by a change in monetary growth which affects π_t. For a fixed real interest rate, π^e_{t+1} can be regarded as representing the nominal interest rate. In view of this interpretation, the policy maker in the discretionary regime assumes that when he increases M_t, the money market will be equilibrated by a proportional increase in P_t, rather than by a reduction in the interest rate, as can be seen from $M_t = L(\pi^e_{t+1})P_t$.[1]

We may treat this situation as one where the nominal interest rate (π^e_{t+1}) is determined <u>first</u> with M_t being set immediately after that.

Alternatively, we may regard prior announcements of M_t as not being credible and therefore incapable of affecting expectations. The latter will be determined on the basis of the public's assessment of the government intentions, as in Section 2.

Following Barro (1983), we express the government's utility function for period t as

$$U_t = \theta_t S_t - \phi(\pi_t) - \tau(\pi^e_{t+1}) \quad ; \quad \phi', \tau' > 0 \tag{5}$$

where θ represents the utility from seigniorage while ϕ and τ are functions which represent the loss from actual and expected[2] inflation. Here S_t increases utility because it is assumed to reduce the need for distortionary taxation. The distortionary effects of inflation itself are expressed through the functions ϕ and τ. Although the policy maker is assumed to maximize a sum of discounted utilities, the problem can be reduced (in the discretionary regime) to the maximization of each U_t separately. The maximization is carried out with respect to π_t for given values of π^e_{t+1} and π^e_t (the latter is predetermined).

The first order conditions yield

$$\theta_t L(\pi^e_t) - \phi'(\pi_t) = 0 \tag{6}$$

Solving for π_t we obtain the policy function

$$\pi^*_t = \pi^*(\pi^e_t, \theta_t) \tag{7}$$

Let us assume that θ_t is a constant equal to θ. Assuming full

information about the government's objective function and about L(.), rational expectations require that

$$\pi^{e}_{t} = \pi^{*}_{t}; \quad \text{all } t \tag{8}$$

Noting that $\pi_t = \pi^*_t$, we see that (7) and (8) can determine a steady state equilibrium for π. It is plausible that when θ is large, we may obtain a long term solution for π above the revenue maximizing point (this possibility is also suggested briefly in Barro's op.cit. p. 12).

To see this, note that in steady states (6) implies

$$\theta = \frac{\phi'(\pi)}{L(\pi)} = F(\pi)$$

where F will be increasing in π if $\phi'' \geq 0$ (the latter is implied in Barro op.cit). So, in general, it is possible to raise π in steady states by raising θ. There is, in fact, no restriction which prevents π from rising above the revenue maximizing point (where the elasticity of L is greater than unity).

We may illustrate this case, in a different manner, by drawing the seigniorage curve in the (S,π) plane for steady state conditions where $\pi_t{}^{e}=\pi^{e}_{t+1}=\pi_t=\pi$ in which case $S_t=S=\pi L(\pi)$. The normal shape of this curve is represented by SS in Figure 1. However, in the discretionary regime we have to consider the relation between S_t and π_t given π^{e}_{t} and π^{e}_{t+1}, which yields $S/\pi=L(\pi)$. The latter is positive even in the downward sloping portion of SS, as is illustrated by the BB lines.

The slope of the indifference curve between S_t and π_t for a fixed π^e_{t+1}, is given by ϕ'/θ. A steady state equilibrium under the discretionary regime may be obtained beyond the revenue maximizing point as is illustrated by the tangency point V. The reason for this is that under the discretionary regime the policy maker aims only at the erosion of the public's real balance $L(\pi^e_t)$ without being constrained by the possible effect of π_t on $L(\pi^e_{t+1})$. This may explain why we may find that empirical demand functions for money in high inflation countries imply an elasticity greater than unity (see Liviatan and Piterman op.cit.).

Since the point V moves to the right along SS when θ increases, we obtain the paradoxical result that an increase in the need for seigniorage may result in an actual reduction in seigniorage collection, a phenomenon to which we referred in the introduction.

The fact that the policy maker determines π_t for a given π^e_t implies that he retains the option of creating surprise inflation. Under the rules regime the policy maker relinquishes this option and sets a rule in the form of (say) a constant inflation target π_r. We assume that under the rules regime the policy maker's commitments are credible and incorporated immediately in the public's expectations.

Suppose tentatively that the economy is in a long run equilibrium in the rules regime, beyond the revenue maximizing point. If the policy maker announced a permanent reduction of π_r as of next period, then he will raise his permanent flow of seigniorage and in addition benefit from an initial stock adjustment in real balance which will raise his revenues in the initial period. Therefore we cannot expect to find a high-inflation equilibrium (i.e. one on the inefficient segment of the Laffer curve) under the rules regime.

3. THE EMPLOYMENT WEDGE AND MONETARY ACCOMMODATION

The fiscal needs are not the only motivation for creating surprise inflation. We have seen in Section 1 that the policy maker is motivated to create surprise inflation in order to increase employment (or to improve the balance of payments by increasing competitiveness). Let us now introduce the employment target explicitly (as in Barro and Gordon 1983b) and combine it with the analysis of the preceding section.

Let unemployment be given by

$$v = v_N - \alpha(\pi-\pi^e) \tag{9}$$

where v_N is the natural rate of unemployment. The latter is considered to be too high by a policy maker who has an unemployment target of $v_G<v_N$. Let us now extend the policy maker's utility function (5) to include the employment motive -

$$U = Q-(b/2)(v-v_G)^2 = Q-(b/2)[-\alpha(\pi-\pi^e)+D]^2 \tag{10}$$

where Q is the utility function in (5) and $D=v_N-v_G>0$.

The first order conditions in the discretionary regime imply

$$(\partial U)/(\partial \pi)/\pi^e,\pi^e_{+1} = (\partial Q)/(\partial \pi)+b\alpha[\alpha(\pi-\pi^e)+D] = 0 \tag{11}$$

($\pi^e_{+1} = \pi^e_{t+1}$). In equilibrium $\pi=\pi^e$ so that $(\partial Q)/(\partial \pi) = -b\alpha D<0$. The policy maker will thus try to push π further than before[3] (where we had $\partial Q/\partial \pi=0$). This makes it more likely for π to exceed the revenue maximizing point, leading to a high inflation equilibrium.[4] By contrast, in the rules regime, the policy

maker gives up the option of pursuing the employment target so that this additional incentive for inflation is not operative.

Suppose now that D represents the difference between the government's and the union's targets of employment in the tradables sector. Suppose further that as a result of a deterioration of the external position the government's employment target increases more than that of the unions', so that D rises. This will raise the government's incentive to inflate, as can be seen from (11), which will reduce real wages on impact, before the change in D is incorporated in π^e. However after that, employment will be determined by the union's target while inflation will remain higher. The level of seigniorage may rise or fall depending on the initial position on the demand curve for money. This may explain how a permanent negative external shock may raise inflation on a long-term basis in a discretionary regime.

PART II: STABILIZATION POLICIES

1. COMMITMENTS AND CREDIBILITY

The foregoing discussion showed that the ability to make a credible commitment can by itself reduce inflation dramatically. A new policy maker who feels that he is capable of committing himself to a low inflation rule will then be induced to impress the public with the seriousness of his commitment.

One way of signalling the policy maker's commitment is by announcing a fixed exchange rate regime backed by a commitment for supporting fiscal policies. However, since there is usually no effective way to enforce this commitment, it may not be credible.

Another phenomenon which we observe in stabilization programs is the attempt to reach a social pact involving the government, labor unions and

employers, whereby each party is bound to refrain from using its nominal policy instruments unilaterally (for example, the government may freeze the exchange rate, labor may refrain from nominal wage demands and employers may freeze prices). We may view this as a way of performing a transition from the inflationary trap inherent in the discretionary regime to a rules regime which is backed by credible commitments. However, experience shows that the basic conflicts of interest between the parties to the pact render this solution to be of a temporary nature.

If the government pursues stabilization policies which are not fully credible, then inflationary expectations will rise above the actual inflation level. This will cause excessively high real wages and a correspondingly low real exchange rate. It will also cause high real interest rates which lead to financial crises in the private sector. A policy maker who faces these undesirable side-effects of stabilization may compromise his inflation targets to reduce social costs (as we shall show below).

2. COMMITMENTS UNDER IMPERFECT INFORMATION

A stabilization program may not be credible because it appears to be internally inconsistent (such as one involving a fixed exchange rate and a large fiscal deficit). This is conceptually a trivial case which we shall not pursue. A more difficult issue of credibility arises in relation to stabilization programs which seem to be consistent with low inflation in the present but which raise some question marks about the future course. Lack of credibility will arise if the public suspects that the policy maker has a motivation to renege in the future on his commitment. This issue cannot arise under full information since then the public knows exactly how the policy maker will behave in the

future. It follows that this type of problem should be analyzed in the framework of incomplete information, which is the course we shall pursue.

The formal analysis of the forgoing problem involves the following issues. What is the possible motivation of a policy maker to cheat? How is it possible for him to conceal his intentions? How does the degree of credibility affect the policies of the cheating policy maker? What does lack of credibility imply for the honest policy maker? Can the latter pursue policies which may remove the uncertainty about his intentions?

3. IMPLICATIONS OF BARRO'S MODEL OF INCOMPLETE INFORMATION

We may use the important paper by Barro (1986) on incomplete information as a starting point for dealing with the foregoing questions. Here the credibility issue is modelled through uncertainty about the type of the policy maker. There are two types - one who is always true to his commitment (denoted S for "strong") and one who is incapable of honoring his commitments but may have an incentive to mimic S temporarily if this is justified ex-post (we denote the second type by W for "weak"). The public is uncertain about the identity of the type in office and assigns an initial probability (α_1) that the policy maker is S. The duration of the game is fixed at T periods.[5] The utility function of both policy makers for each period is of the form given by (1) in Part I.

In this model S, who can overcome the problem of dynamic inconsistency, announces a rule $\pi=0$ to which he adheres ex-post. If the policy maker happens to be S and is believed to be such, then the rule will give him a better outcome than the discretionary strategy of setting $\pi=b/a$ for all periods (t).

The policy maker W will certainly adopt the discretionary strategy for the last period (T) since he is not bound by any commitment. However, in the

multiperiods case, W may have an incentive to mimic S for a number of periods (instead of being revealed immediately) because then he may benefit from a span of low inflation levels (i.e. $\pi=0$). If the policy maker deviates from the rule just once, he is revealed to be W for the rest of the game.

If T is sufficiently long, there will be in equilibrium two qualitatively different intervals - in the first interval, (1,Z-1), W will mimic S and set $\pi=0$, and in the second interval, (Z,T-1), W will randomize his policy setting $\pi=(b/a)$ with probability P_t and $\pi=0$ with $1-P_t$. In the first interval, the "reputation" parameter α_t remains constant while in the second interval α_t is updated according to Bayes' formula $\alpha_{t+1}=\alpha_t[\alpha_t+(1-\alpha_t)P_t]^{-1}$ provided $\pi=0$ up to period t. In the second interval, α_{t+1} is increasing and P_t is decreasing as long as $\pi_t=0$, while in the first one $\alpha_t=\alpha_1$ and $P_t=1$ in each period.

The intuition behind these results is that when the planning horizon of the policy maker is long W has a strong incentive to mimic S because this may give him many periods of low inflationary expectations while still retaining the option of cheating in the end. During this interval the public knows that both policy makers choose $\pi = 0$, hence no new information is gained about the type of the policy maker by observing this policy. Therefore, α_t remains constant.

When the game draws nearer to its end W finds that the gain from having low inflation just balances the advantage from cheating today, so he becomes indifferent whether to set $\pi = 0$ or $\pi = b/a$ in which case W is revealed. Since W is indifferent between the policies he is also willing to randomize between them as stated above. In the type of equilibrium defined for this game (a "sequential" equilibrium) there is a definite path for P_t which is common knowledge. Suppose that in a given period t (with $P_t < 1$) the outcome is a decision not to inflate. Since the public knows that $\pi = b/a$ was a possible

outcome, and yet in practice he observed $\pi = 0$, he will find it reasonable to raise his subjective probability that the policy maker is S. This is the intuition of the updating formula.

The model has some important implications for stabilization policies. Note first that inflationary expectations are given by

$$\pi^e_t = (1-\alpha_t)(1-P_t)(b/a) \qquad (21)$$

which is derived from the fact that π^e is a weighted average between $\pi_t = 0$ (with probability α_t) and $(1-P_t)(b/a)$ with probability $1 - \alpha_t$. The expression $(1 - P_t)(b/a)$ is the expected value of π_t conditional on the policy maker being W.

It follows from (21) that in the first interval $\pi_t=\pi^e_t=0$. In this interval, the policy maker, of any type, does not encounter any costs resulting from negative surprise inflation. The length of this interval depends positively on T, α_1 and on the policy maker's discount rate δ (all these parameters are common knowledge). Thus, in the beginning, the policy will enjoy a "period of grace". For example, if the rule $\pi=0$ takes the form of a fixed exchange rate policy, then in the beginning the policy will be fully credible if the foregoing parameters are favorable. Since high values of T and δcan be interpreted as indicating political stability, the model implies that under the latter conditions the costs of disinflation will be relatively low.

As the program approaches the end of the policy maker's horizon, the system enters the second phase where P_t starts to decline (note that $P_T=0$) and α_t starts to rise. In view of (21), π^e becomes positive[6] and S has to incur

the cost of negative surprise inflation ($\pi-\pi^e$) till the end of the program.[7] Of course, if the duration of the game is short, and/or α_1 and δ are small, there may not be a mimicking phase at all so that the hardships for S will begin with the first period. This will not change the policy chosen by S, but it will involve the phenomena of excessively high real wages, unemployment and so on, right from the start.

4. CREDIBILITY, ACCOMMODATION AND COMPROMISE

One of the shortcomings of Barro's analysis for the study of stabilization programs is that S, while being honest, is not realistic. By this we mean that he does not modify his policies in the face of adverse expectations. More specifically, Barro's model provides an optimal policy for W but not for S, who sticks arbitrarily to the rule $\pi=0$. [This issue is investigated fully in Cukierman and Liviatan (1989).]

This assertion can be easily verified by the fact that for the last period (T), it is not optimal for S to announce $\pi=0$. Suppose that S is free to announce any policy rule for T, say π^*_T, which he is bound to carry out. If the public were in fact certain that the policy maker is S, then it would be optimal for him to set $\pi^*_T=0$. We know, however, that there is a probability of $1-\alpha_T$ that the policy maker is W, who will set $\pi_T=b/a$. Moreover, it is optimal for W to mimic the announcement of S since it is costless and it enables him to reduce π^e_T.

Suppose that π^*_T is the optimal announcement by S. Then the public's expectations will be determined by

$$\pi^e_T = \alpha_T \pi^*_T + (1-\alpha_T)\,\beta \qquad ; \beta = b/a.$$

Assuming that $\pi_T^* < \beta$ (as we shall show later) it is easily verified that if W is in office he will prefer to announce π_T^* and then actually to set

$\pi_t = \beta$, rather than both announce and set $\pi_T = \beta$ (in the latter case $\pi^e_T = \beta$).

Now how will S determine π^*_T? Since W will always mimic the optimal announcement of S we may take it, as an off-equilibrium assumption, that S considers any announcement that he makes as entering π^e with a weight of α_T. The residual weight, $1 - \alpha_T$, will be attached to the possibility that the same announcement is made by W who will in practice play $\pi_T = \beta$. Hence S acts on the assumption that

$$\pi^e_T = \alpha_T \pi'_T + (1 - \alpha_T) \beta \tag{22}$$

where π'_T is the off equilibrium commitment by S. Since S is bound by his commitment we also have

$$\pi'_T = \pi_T \tag{23}$$

where π_T is the actual π set by S. Substituting (22) and (23) in the utility function (1) and maximizing with respect to π_T we obtain [8]

$$\pi^*_T = (1 - \alpha_T) \beta \tag{24}$$

It is only when S is fully credible ($\alpha_T = 1$) that he will follow Barro's rule and announce $\pi^*_T = 0$. The lower his credibility, or reputation, as measured by α_T, the more will he tend to compromise with W's optimal policy.

The need of S to compromise can be further clarified by considering the surprise-inflation element for S, which is given by

$$\pi_T - \pi_T^e = \pi_T^* - \pi_T^e = (1 - \alpha_T)(\pi_T^* - \beta) \qquad (25)$$

If S sets $\pi_T^* = 0$ then surprise inflation is $-(1 - \alpha_T)\beta$ which diminishes his utility (implying, say, a rise in real wages and an increase in unemployment). If, in this situation, he raises π_T^* by 1%, then his utility loss will be cut by $b(1 - \alpha_T)$ while his loss from the increase in inflation will be negligible [the derivative of $-(a/2)\pi^2$ at $\pi = 0$ is zero]. As π_T increases the latter loss becomes more substantial till S reaches his optimum at $a\pi_T^* = b(1-\alpha_T)$, which is just (24).

It is shown in Cukierman and Liviatan (1989) that the need of S to compromise carries over to the multiperiod case for a certain range of parameters δ and α_1 (the latter denotes initial reputation). In general, there are three types of behavior of W in periods prior to T - setting $\pi_t=\pi^*_t$ with probability 1 (i.e. mimicking), setting $\pi_t=\pi^*_t$ with probability $0<P_t<1$ and (β) with probability $1-P_t$ (i.e. randomizing), and setting $\pi_t=\beta$ with probability one (with W revealing himself). The general expression for π^*_t set by S is $\pi^*_t=(1-P_t)(1-\alpha_t)(\beta)$, where α_t is the value of reputation in period t. In the randomization range, P_t and α_t are fractions so that $\pi^*_t>0$.

Let us apply these ideas to a two period model. The third case mentioned above is called a "separating equilibrium" since the public can identify the types in the first period. In this case there is no surprise inflation in the second period so that S will set $\pi_2 = 0$, while in the first period π_1 will be set by S, at $(1 - \alpha_1)\beta$. The case of mimicking is called a

"pooling equilibrium" in which there is no surprise inflation in the first period (since the public expects both types to act identically). In this case S will adopt a strategy $\pi_1 = 0$ and $\pi_2 = (1 - \alpha_1)\ \beta$. The randomizing case occurs when W is indifferent between revealing himself in the first period or in the second one.

Which regime will actually apply depends on the relation of initial reputation (α_1) and the time preference discount factor δ (δ multiplies the second periods utility). It is shown in Cukierman and Liviatan (1989) that we shall have a separating equilibrium when $\delta < (\alpha_1^2/2)$. This is explained by the consideration that when the future is heavily discounted, W will have a strong incentive to reap the gains from surprise inflation in the present, and thus be revealed. In this case the strategy of S will be to set $\pi_1 = (1 - \alpha_1)\ \beta$ and $\pi_2 = 0$. When $\delta > (1/2\ \alpha_1^2)$ we shall have a pooling equilibrium with $\pi_1 = 0$ and $\pi_2 = (1 - \alpha_1)\ \beta$ (for S).

The mixed strategies equilibrium will take place in the intermediate range $(\alpha_1^2/2) \leq \delta \leq (1/2\ \alpha_1^2)$ in which case S will set $\pi_1 = (1 - P_1)\ (1 - \alpha_1)\beta$ and $\pi_2 = (1 - \alpha_2)\ \beta$, where $(1 - P_1)$ is the probability of W setting $\pi = \beta$ and α_2 is the updated reputation. Note that in the mixed strategies regime S will compromise in <u>both</u> periods and this is more likely to occur when α_1 is small. This consideration carries over with some modifications to the multiperiod case. Hence when initial credibility is low the policy maker will have to compromise the zero inflation target for a large proportion of his planning horizon. Throughout this range S will have to incur the cost of a negative surprise inflation [since $\pi_t^e = \alpha_t\ \pi_t^* + (1 - \alpha_t)\ \beta$ while $\pi_t = \pi_t^*$], but this is still the preferable course.

The foregoing theory can explain two phenomena associated with stabilization programs. First, it explains why the policy maker is driven to announce his inflation target, since it is only in this way that S can materialize his comparative advantage. Secondly, it shows that it is usually not optimal for the strong policy maker to follow policies which ignore the credibility issue. For example, it is not optimal for S to stick for a long period to a policy of a fixed exchange rate, even when the fundamentals are consistent with it. With lack of credibility, an adjustable peg, or a crawling peg, will do better.

5. SIGNALLING AND OVERADJUSTMENT

In the literature on stabilization programs, we often encounter the claim that in order to reduce inflationary expectations, the authorities should make in the early stages more extreme adjustments than those required under full credibility. This intuitive notion can be given a more precise content in the framework of signalling theory, using the standard Barro-Gordon model of the previous section. In this analysis, we shall follow the basic formulation of Vickers (1986) with some extensions needed for the issue at hand.

Following Vickers (1986) and Torsten and Van Wijnbergen (1989), let us consider a different formulation for inflationary and non-inflationary policy makers. We assume that while both policy makers are not capable of making precommitments, they differ in their tastes regarding inflation and unemployment. The "strong" policy maker is now considered to be the one who is relatively more averse to inflation. Formally we assume $\beta_s < \beta_w$.

Under conditions of full information, there is no incentive for any policy maker to deviate from his discretionary optimum which yields $\pi_i=\beta_i$ (i=S,W)

for each period. This is not necessarily true, however, under incomplete information.

Consider a two-period model where the objective function of the policy maker is

$$U_i = -(a/2)\pi_{1i}^2+b_i(\pi_{1i}-\pi^e_1)+\delta[-(a/2)\pi_{2i}+b_i(\pi_{2i}-\pi^e_2)] \qquad (25)$$

where π_{ti} is π in period t when the policy maker is i. At this stage, the only modification from Vickers is by allowing the time preference parameter (δ) to be less than unity. The public knows everything about the policy makers' objectives but does not know which one of them is in office. The identity of the policy makers may not be directly inferred from their behavior because W may gain by mimicking S. We denote by α_1 the initial probability that S is in power.

The strategy vector of S is $X_S=(\pi_{1S},\pi_{2S})$ and that of W is $X_W=(\pi_{1W},\pi_{2W})$. Expectations π^e_1 are formed prior to period 1 while π^e_2 is formed by the public on the basis of the observed π_1 by means of a function $\pi^e_2(\pi_1)$. We denote the pair $(\pi^e_1,\pi^e_2(.))$ by π^e. Equilibrium is defined as a state where X_i maximizes U_i given π^e, and where the latter is correct given X_i (i=S,W).

There are two types of equilibrium - a "separating equilibrium" where the types are revealed in the first period and a "pooling equilibrium" where W mimics S in the first period so that the public cannot tell one from the other. In the second period, the types are revealed since there is no point in mimicking.

Let us consider first the separating equilibrium and its relation to overadjustment. Since the types are revealed in the first period, we have in

equilibrium $\pi_{2i}=\beta_i$ (i=S,W) and $\pi^e{}_2=\beta_i$ if the type revealed in the first period is i. Since the policy makers cannot affect the public's prior the former can consider $\pi^e{}_1$ as a parameter. Given that π_{2i} has been determined in the foregoing manner, the only free variables in U_i are π_{1i} and $\pi^e{}_2$. Following Vickers, we may draw indifference curves (I_S and I_W) relating these two variables as in Figure 2. It may be noted that utility increases in the downward direction since a low π^e_2 is always preferred. To the left of β_i, I_i is rising since an increase in π_{1i} raises utility and therefore π^e_2 has to rise to keep utility constant (the opposite holds for $\pi_{1i} > \beta_i$). Note also that the shape of the indifference curves is independent of $\pi^e{}_1$.

Under full information, the strategy of the players is $\pi_{ti}=\beta_i$ and $\pi^e{}_t$ equals β_i, depending on the type in office. These strategies are represented by the points R and Q. The strategies are less clear under Imperfect information, since in this case it is possible that W will mimic S. This can happen if, for example, S chooses $\pi_1 = \beta_S$ (with $\pi^e{}_2 = \beta$) and W can be mistaken for S. If S sets $\pi_1 = k$ [and this point ($\pi_1 = k$, $\pi^e{}_2 = \beta_S$) lies somewhat to the left of I_W that passes through Q], then the public may infer that the policy maker is S since in this case W will prefer setting $\pi_1=\beta_W$ and being revealed.

Suppose that the public expects S to behave in the foregoing manner. We may then describe the public's expectation function $\pi^e{}_2(\pi_1)$ as the segmented line AEGH. This leads to a possible separating equilibrium at E where S maximizes U_S at the point E with $X_S=(k,\beta_S)$ and W maximizes U_W by $X_W=(\beta_W,\beta_W)$. Expectations will be correct in the sense that $\pi^e{}_1=\alpha_1 k+(1-\alpha_1)\beta_W$ and $\pi^e{}_2=\beta_i$ where i is the type revealed in the first period.

Note that in equilibrium S sets π_1 below its full information optimum (β_S) so as to make it too hard for W to follow. Thus S overadjusts in order to reduce[9] π^e_2. By doing this, S eliminates the negative surprise inflation in the second period, but it still faces a negative surprise inflation in the first period (equal to $-(1-\alpha_1)(\beta_W-k)$). In fact, the larger the overadjustment, as measured by (β_S-k), the larger the negative surprise inflation in the first period will be.

In this setting, S is motivated to overadjust because W has an incentive to mimic him in an attempt to reduce π^e_2. However, if W's discount factor (δ) is low, the incentive to mimic will diminish and so will the need to overadjust. In terms of Figure 2, a reduction in δ will cause the indifference curves (of both players) to shrink inward so that the point E will move to the right, reducing the amount of overadjustment. If δ is sufficiently small, as in the case of the dotted indifference curve, then separation will be achieved without any overadjustment by S. Thus, paradoxically, when new governments have more concern for the future, the need of S to overadjust, or to "signal", will increase because its "shadow" (W) has a greater incentive to mimic.

It may be the case that S will give up signalling altogether because the benefit from reducing inflationary expectations is not worth the sacrifice of overadjustment. In this case, there may result a pooling equilibrium, which is a more elusive concept than the separating equilibrium. Vickers suggests that the former is an unlikely outcome when some refinements in the concept of equilibrium are introduced.[10] We claim, however, that a pooling equilibrium (even in its refined form) is quite likely when the reputation of S is high.

The foregoing analysis presupposes that S prefers being revealed in the first period rather than accepting the possibility of continued uncertainty about

his identity. However this presumption may not be warranted, in which case a pooling equilibrium may arise.

Let us suppose that when the public remains uncertain about the type, it will set $\pi_2^e = \alpha_1 \beta_s + (1 - \alpha_1) \beta_w = \bar{\pi}_2$, which corresponds to a pooling equilibrium (in which case α_1 is not updated). For simplicity let us confine the analysis to three possible values of π_1: k_1 β_S and β_W in Figure 2. We shall have a pooling equilibrium when (a) W has an incentive to mimic S and (b) S has no incentive to deviate from the proposed value of π_1.

Let us examine whether $\pi_1 = \beta_S$ can be a possible candidate for a pooling equilibrium (in which case we also have $\pi_1^e = \beta_S$). Note first that if $\bar{\pi}_2$ is below Z in Figure 2, in which case the proposed equilibrium is represented by points such as M or N, then W will have an incentive to mimic S, so that condition (a) is satisfied. It remains to be seen whether S can benefit from a shift to k (a shift by S to β_W can be ignored).

Note that if S shifts from β_S to k then the public knows that this move could not have been made by W since any point with $\pi_2^e \geq \beta_S$ is inferior to M or N, from W's point of view. S may therefore count on the public changing its expectations from $\bar{\pi}_2$ to $\pi_2^e = \beta_S$ (here we apply the "intuitive criterion" for off equilibrium beliefs, as in Cho and Kreps (1987)).

Thus the question becomes whether E is preferred by S to the proposed pooling equilibrium (given $\pi_1^e = \beta_S$). The answer is positive for point N and negative for M. The latter case will require α_1 to be sufficiently large. It follows that when initial credibility is sufficiently high there will be no incentive to overadjust ("a respectable person is not required to go out his way to prove his honesty"). This lends support to the intuitive notion that a policy

maker who faces severe credibility problems should make an effort to overadjust, and this is expected from him by the public.

6. COMPROMISE AND OVERADJUSTMENT

In the last two sections we indicated two opposing influences on the level of π_1 set by the strong policy maker under incomplete information. If the latter policy maker is characterized by living up to his commitments (announcements) then the fact that they are only partially believed induces him to raise π_1 above his full information optimum (which is zero inflation). In this way he may avoid excessive costs in terms of negative surprise inflation. On the other hand, if the policy maker is less inflationary in the sense that he is relatively more averse to inflation, then he may be induced to reduce π_1 below his full information optimum (which is β_S).

What happens if the policy maker is less inflationary according to both criteria? Consider for example a separating equilibrium, so that the types are revealed in the first period. If W does not have an incentive to mimic S then overadjustment is not relevant and S will set $\pi_{1S} = (1 - \alpha_1)\, \beta_S$, which means that S will compromise by setting π_{1S} between zero and β_S (but not between β_S and β_W!).

Since S is revealed in the first period we shall have $\pi_{2S} = \pi_2^e = 0$.

If however W has an incentive to mimic the foregoing solution, then, in a separating equilibrium, S will have to reduce π_{1S} below $(1 - \alpha_1)\, \beta_S$, i.e. S will have to behave strategically. In this case S will still compromise with

respect to the target $\pi_1 = 0$ but will overadjust relative to $(1 - \alpha_1)\ \beta_S$.

7. CONCLUDING COMMENTS

One of the implications of part I is that the same degree of fiscal needs may result in widely different long-term levels of inflation under rules or discretion. This suggests that if the policy maker can convince the public that (even though he intends to rely on money finance) he will not resort to tactics of surprise inflation, the long term level of inflation may be reduced considerably. The policy maker would then be advised to limit the deviations of his nominal anchor from the preannounced target. This applies equally well to monetary and exchange rate rules. If a change in the target is required, it should be carried out with minimal surprise effects.

An example of the latter kind of policy was observed in the recent Israeli stabilization where the government avoided the implementation of maxi-devaluation without reaching prior agreement, or understanding, with the trade unions. This kind of behavior was aimed at reducing the suspicion that the government intends to use surprise inflation tactics which call for preemptive steps by labor.

An important implication of part II is that in the beginning of a stabilization program, even a policy maker who is not able to persist with stabilization will enjoy credibility because there may not be a clear way to identify his true nature. This may explain why we often observe that heterodox stabilization programs (based on initial wage-price freezes and pegging of the exchange rate) are very effective in the initial stage in reducing inflation drastically without appreciable social cost in terms of unemployment. However, the credibility theory described earlier explains why the difficulties in the

form of overvaluation and so on, will arise in the flexibilization stages even for the policy maker who pursues the stabilization effort relentlessly.

What should a "strong" policy maker do when he is confronted with credibility problems along the way? If the source of the problem lies in the inability of the "weak" policy maker to honor his commitment then the strong policy maker will find it optimal to compromise to some extent (depending on his initial credibility) with adverse expectations. In this way he may mitigate the excessive recessionary effect which were encountered, for example, in the Chilean tablita policy (which was supported by a fiscal surplus).

On the other hand, when the main source of credibility problems stems from different attitudes of policy makers toward the relative importance of price stability versus distortion in the real sector (overvaluation, unemployment), and in the incentives of the high inflation policy maker to mimic the low inlation policy maker then a case can be made for an initial overadjustment by the less inflationary policy maker. This is especially true when the credibility of the latter policy maker is low.

In our earlier analysis, the overadjustment took the form of setting an excessively low inflation target by the less-inflationary policy maker in order to make it more difficult for his imitator to follow. However, more generally, the overadjustment may take the form of running fiscal surpluses, drastic cuts in governmental expenditures and tough wage policies. Quite often overadjustment is essential to signal that a change of regime has taken place. Without the recognition of this change the future costs of stabilization may become too hard to bear.

FOOTNOTES

1 Assuming we begin at a steady state, with $\pi^e_{t+1} = \pi^e_t$ we have $\pi_t = (M_t - M_{t-1})/M_{t-1}$.

2 This is reflected, for example, by a reduction in real balances.

3 Here we make use of the assumption $(\partial^2 Q/\partial \pi^2)<0$. The claim in the text can be established rigorously by making use of the specific form of Q in (5).

4 The slope of the indifference curve in Figure 1 will now be $\partial S/\partial \pi=(\phi'-baD)\theta^{-1}$, which is flatter than before.

5 The treatment of credibility in an infinite horizon framework in the Barro-Gordon models ran into the problem that equilibrium is not unique, which results from different possibilities of the public's reaction to the government's deviation from the rule.

6 In Barro's model, π^e is constant in the second interval.

7 If the policy maker happens to be W, then he will be indifferent, in the second interval, between revealing himself (playing $\pi=b/a$) and mimicking.

8 One could argue alternatively as follows. Since in equilibrium $\pi^e_T = \alpha_T \pi^*_T + (1 - \alpha_T)\, ß$ where π^*_T is the optimal announcement by S, as the public perceives it, we may ask ourselves the following question: what is the value of π^*_T that S would prefer most to be the public's perception of his optimal announcement? This must clearly lead to (24). Consequently the public expects S to make this announcement. W who realizes these considerations will also prefer to announce (24). Hence (24) is the unique equilibrium announcement.

9 More precisely, in order to make sure that π^e_2 will not exceed β_S.

10 The refinement is essentially that S should not prefer a separating option to the pooling equilibrium.

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