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The paper examines the role of credibility in the conduct of exchange rate policy in developing countries. The analysis is based on a model in which policymakers are concerned about inflation and external competitiveness. Price setters in the nontraded goods sector of the economy adjust prices in reaction to anticipated fluctuations in the domestic price of tradable goods. This type of model is shown to generate a "devaluation bias" which undermines the credibility of a fixed exchange rate. The effect of reputational factors, signaling considerations, and joining a currency union as possible solutions to this bias is examined.

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Figure 1. Determination of Alternative Equilibria 10a
I. Introduction

Policymakers in developing countries typically face a dilemma when using the exchange rate as a policy instrument. Although a nominal depreciation may improve the trade balance and the balance of payments, it is usually associated with a rise in the price level, which may turn into inflation and ultimately erode external competitiveness. Conversely, maintaining the exchange rate fixed to stabilize prices in the presence of a large current account deficit is often not a viable option, if the country faces a foreign exchange reserves or external borrowing constraint. In spite of these controversial issues, however, the exchange rate has been increasingly used as a policy instrument to promote external adjustment. Since the mid-1970s a number of developing countries have moved away from pegging to a single currency to more flexible exchange rate arrangements, such as composite pegs (see Aghevli, Khan and Montiel, 1991). To a large extent, this occurred because of the extreme fluctuations among the major currencies in the post-Bretton-Woods years. Some countries have also opted for more flexible arrangements in order to "disguise" the occasional depreciation of the domestic currency, enabling them to avoid the political costs of announced devaluations.

Despite this notable evolution towards increased use of the exchange rate as a policy tool, there has recently been a variety of arguments proposed in favor of adopting a fixed exchange rate regime. 1/ The debate has recently focused on the role of the exchange rate as an anchor for the domestic price level and on the "credibility effect" that a fixed rate may attach to a disinflation program when the commitment to defend the parity is clearly established. Without central bank credibility, private agents will continue to expect a high inflation rate, and this will increase the cost of any attempt to stabilize domestic prices. Establishing credibility means convincing the public that the central bank will not deviate from its exchange rate or money supply target in order to attain any short-term benefits associated with surprise inflation. This requires that the public be convinced that the authorities have some incentive to refrain from introducing monetary surprises. It has been argued that by acting as a constraint on macroeconomic policies, a fixed exchange rate may enhance the credibility of the central bank's commitment to maintaining a low and stable rate of money growth.

1/ These arguments relate to the role of exchange rate stability in the promotion of trade flows, foreign investment, etc. See Genberg (1988) and Joshi (1990) for a recent review of the literature on the choice of an exchange rate regime.
The purpose of this paper is to examine, in a developing-country context, recent arguments favoring a fixed exchange rate regime that are based on inflation problems caused by policymakers' lack of credibility. The analytical framework draws on recent developments in macroeconomics, which have emphasized the strategic aspects of disinflation policies resulting from the interdependence between the behavior of private, forward-looking agents and centralized policymakers. In this context—which lends itself to a game-theoretic interpretation—credibility issues have been shown to emerge because of an incentive for policymakers to pursue a strategic advantage and seek short-run gains by reneging on previously announced policies, leading to time-inconsistent policies (Kydland and Prescott, 1977). The dynamic inconsistency literature has shown that, if feasible, precommitment to certain rules by monetary authorities could improve the behavior of the economy by securing a low-inflation equilibrium, without sacrificing other macroeconomic objectives. The paper focuses particularly on the role of reputational factors, signaling considerations, and adherence to a monetary union as possible ways to mitigate, or even eliminate, the time-inconsistency problem in exchange rate management.

Our basic results can be summarized as follows. In a typical developing-country setting, in which the nominal exchange rate can be used as a policy instrument directed at either an external competitiveness target or a price level target, the authorities' intention to maintain a fixed exchange rate may not secure price stability. This is because private agents will be aware that the competitiveness target will create a temptation to devalue and will accordingly set prices higher in the expectation of devaluation, which the authorities will then find optimal to produce. This time-inconsistency problem arises because of the absence of a precommitment technology that can render the authorities' intentions credible. We show, however, that several factors may mitigate the problem. First, if the authorities' credibility depends on their past behavior, then "cheating" will incur a future penalty. Knowing this, the private sector will be more likely to expect adherence to announced intentions. Second, when the authorities' true intentions are uncertain, today's exchange-rate policy may help "signal" these intentions to the private sector, creating favorable future price expectations, and thus also supplying an incentive for adherence to an exchange-rate target. Third, credibility problems may be mitigated by "tying one's hands" by joining a monetary union (provided partner

1/ The dynamic inconsistency literature in macroeconomics has been almost exclusively concerned with the alleged inflationary bias of macroeconomic policy. For surveys of this literature, see Barro (1986b), Blackburn and Christensen (1989), Cukierman (1991), and Persson (1988). Papers that have specifically focused on exchange rate policy are discussed below.
countries maintain themselves a low-inflation policy stance) or by giving up some discretionary power over exchange-rate adjustment to some supra-national authority.

The rest of the paper is organized as follows. Section II establishes the basic time-inconsistency proposition in the context of exchange rate policy in developing countries. Section III determines the degree of credibility of a fixed exchange rate by examining how the policymaker is induced to behave under alternative policy rules. Section IV focuses on how the "devaluation bias" generated by the time-inconsistency problem faced by the policymaker can be solved by building up "reputation". Section V examines the costs and benefits of joining an international monetary arrangement in which the country surrenders the power to alter the exchange rate. The concluding section summarizes the main results of the paper, discusses possible extensions, and draws together the major implications of the analysis for exchange rate policy in developing countries pursuing a fixed exchange rate regime.

II. Time Inconsistency in Exchange Rate Policy

We examine in this section the time-inconsistency problem faced by a policymaker who must decide whether or not to maintain a fixed exchange rate, on the basis of potential gains and costs. The model we consider focuses on aspects of the economy that are relevant for developing countries.\(^1\) A key feature of the analysis is the assumption that policy announcements lack credibility, because the private sector is aware that the policymaker may have an incentive to renege on his commitment to an announced fixed exchange rate.

1. The framework

Consider a small open economy producing traded and nontraded goods. The economy’s exchange rate is determined by a policymaker who cares about external competitiveness and price stability. The foreign-currency price of traded goods is determined on world markets. Agents in the nontraded goods sector set their prices so as to protect their position relative to the traded goods sector, and to respond to domestic demand shocks. Prices are set at discrete intervals, while the exchange rate can be changed at very short notice. Agents in the nontraded goods sector are therefore assumed to set prices before the exchange rate is announced.

\(^1\) Although the paper attempts to highlight particular policy considerations deemed relevant for developing countries, the major implications of the analysis are also relevant for small, industrialized countries.
policymaker sets the exchange rate. 1/ Formally, the domestic rate of inflation, \( \pi \), is given by

\[
\pi = \delta \pi^*_N + (1 - \delta)(\epsilon + \pi^*_T), \quad 0 < \delta < 1
\]  

(1)

where \( \epsilon \) denotes the rate of devaluation of the nominal exchange rate, \( \pi^*_N \) the rate of increase in the price of nontradables, \( \pi^*_T \) the rate of increase in the price of tradables, and \( 1 - \delta \) the degree of openness.

The government's loss function, \( L^g \), depends on deviations of the rate of depreciation of the real exchange rate from a target rate \( \theta \), and the inflation rate:

\[
L^g = -\alpha(\epsilon + \pi^*_T - \pi^*_N - \theta) + \lambda \pi^2/2, \quad \alpha, \lambda \geq 0
\]  

(2)

The former objective reflects the assumption that the authorities are concerned with an improvement in competitiveness, which results from a depreciation of the real exchange rate. The rate of change of the real exchange rate enters the loss function linearly, because the authorities are assumed to attach a negative weight to a real appreciation relative to their target. 2/ The government's overall objective is to minimize its loss function given by (2). 3/

Agents in the nontraded goods sector change prices in reaction to fluctuations in the (expected) domestic price of tradables goods, and to an exogenous demand disturbance to their sector, \( z_N \), which occurs at the beginning of the period and becomes known immediately. Their loss function is therefore taken to be:

\[
L^d = [(\pi^*_N - (\epsilon^d + \pi^*_T) - \Phi z_N)^2]/2, \quad \Phi \geq 0
\]  

(3)

1/ This assumption, which reflects price stickiness, is important because without it there would be no incentive for the authorities to adjust the exchange rate. If policy is implemented before nontradable prices are set, the issue of time-inconsistency is irrelevant because the government policy is revealed when it is announced.

2/ Note that the real exchange rate target could be expressed in level form; the rate of change formulation used here is simply easier to work with analytically.

3/ More general loss functions are considered, for instance, in Fischer and Summers (1989). Stochastic preferences are examined in Cukierman and Meltzer (1986).
where $\varepsilon^a$ denotes the expected rate of depreciation of the exchange rate. The price setters' objective is to minimize $L^P$.

2. Discretion and precommitment

When the authorities decide whether or not to devalue the exchange rate, they know prices set in the nontraded goods sector. Substituting (1) in (2) and setting $\pi_N^* = 0$ for simplicity, the resulting expression shows that the authorities can achieve their real exchange rate target by setting $\varepsilon - \pi_N = \theta$, while the zero-inflation target requires $\varepsilon = -\delta \pi_N/(1 - \delta)$. The optimal rate of adjustment of the nominal exchange rate is given by setting $dL^G/d\varepsilon = 0$, that is 1/

$$
\varepsilon = \frac{\delta}{1 - \delta} \left[ \frac{\alpha}{\lambda \delta (1 - \delta)} - \pi_N \right].
$$

Similarly, the optimal rate of inflation in the nontradable sector is determined by setting $dL^P/d\pi_N = 0$, which yields

$$
\pi_N = \Phi z_N + \varepsilon^a.
$$

In the non-cooperative Nash game implied by this behavior (in which each party optimizes, taking the other's behavior as given), the equilibrium values of the nontradable inflation rate and the rate of devaluation, denoted by $\tilde{\pi}_N$ and $\tilde{\varepsilon}$, are found by imposing rational expectations ($\varepsilon^a - \varepsilon$) and solving simultaneously equations (4) and (5). This yields:

$$
\tilde{\pi}_N = (\kappa + \Phi z_N)/\Omega \geq 0.
$$

1/ Note that equation (4) would not be independent of $\theta$ if the cost of deviations from the real exchange rate target in the loss function (2) were quadratic. This would occur if the policymaker were concerned not only with competitiveness of the tradable sector, but also with the beneficial effects of an appreciation of the real exchange rate. For instance, a real appreciation can benefit the economy by stimulating employment when wages are indexed to the price level, or by lowering the cost of imported intermediate goods. The major implications of the analysis would not, however, be qualitatively altered by this extension.
Equations (6a) and (6b) indicate that, in the absence of demand shocks, the optimal discretionary policy requires a positive rate of inflation in the nontradable sector. When demand shocks are present, that is, \( z_N \neq 0 \), whether the rate of devaluation \( \tilde{c} \) is positive or negative depends on the relative importance of the real exchange rate target and the inflation objective in the government's loss function. When the latter predominates, \(^1\) the optimal policy may even call for an appreciation of the nominal exchange rate.

Substituting (6a) and (6b) in (1)-(3) yields the solutions for the overall inflation rate and the loss functions under discretion:

\[
\bar{\pi} = \frac{\kappa}{\Omega}, \tag{7a}
\]

\[
\bar{L}^G = \alpha(\Phi z_N + \Theta) + \lambda(\kappa/\Omega)^2/2, \tag{7b}
\]

\[
\bar{L}^D = 0. \tag{7c}
\]

Equation (7a) indicates that the economy's inflation rate is independent of the demand shock and increasing with the relative weight attached to competitiveness in the policymaker's loss function, \( \alpha/\lambda \). Price setters achieve their target and bear no loss. Inflation is positive, because if it were zero, the policymaker would always have an incentive to devalue. Thus, the policymaker incurs a net loss unless \( z_N \) takes on large negative values— which improve competitiveness and reduce the rate of increase in nontradable prices.

Consider now the case where the policymaker is able to commit himself to a predetermined exchange rate. Formally, this means that in minimizing its loss function, the policymaker takes into account the effect of its actions on private sector behavior, knowing it will not renege. In this case it can readily be shown that the policymaker will announce and maintain a fixed exchange rate—or a rate of

\(^1\) That is, when \( \lambda \) is "high", when \( \alpha \) is "low", or more generally when \( \alpha/\lambda < \delta(1-\delta)\Phi z_N \). Note that the case \( \alpha = 0 \) (so that \( \tilde{c} = -\delta\Phi z_N \) and \( \pi = 0 \)) in the non-cooperative game corresponds also to the solution of the Stackelberg game in which the policymaker minimizes the loss function (2)—with \( \alpha > 0 \)—subject to (1) and the reaction function of the private sector, (5).
devaluation $\tilde{e} = 0$. If the private sector believes the announcement and acts on that basis, (5) yields $\pi_N = \Phi z_N$ which, in turn, implies
\[ \tilde{\pi} = \delta \Phi z_N \] and
\[ T^E = \alpha(\Phi z_N + \Theta) + \lambda\tilde{\pi}^2/2, \] (8)
or, if $z_N = 0$,
\[ T^E = \alpha \Theta. \] (8')

It is easy to verify from (7b) and (8) that $T^E \leq \tilde{T}^E$. Thus, the no-devaluation equilibrium—the precommitment solution—gives a value of the loss function which is less than that obtained under the non-cooperative solution when $z_N = 0$. This reflects the fact that the policymaker is not able to achieve the gain in competitiveness sought in the discretionary regime, because price setters simply increase nontradable prices accordingly. Thus, a binding commitment entails a gain in the form of a lower inflation rate with no loss in competitiveness. 2/

Consider now the case where the government announces at the beginning of the period its intention to maintain the exchange rate fixed (that is, $e = 0$), but decides to deviate from this policy and to implement a discretionary change once price decisions are taken. Let $\tilde{\pi}_N$ and $\tilde{e}$ denote solution values under this regime. If price setters believe the zero-devaluation announcement, they will once again choose $\tilde{\pi}_N = \Phi z_N$. Substituting this result in (4), the optimal rate of devaluation chosen by the policymaker becomes

1/ However, the government would still be subject to the same credibility problem as in the discretionary equilibrium if it merely announces a fixed exchange rate. To work, the commitment must be binding. We assume this can be achieved for the moment, and will return to this issue below.

2/ However, if the effect of the demand shock on nontradable prices is large enough, the loss under precommitment can exceed that obtained under discretion, that is, $\tilde{T}^E > \tilde{T}^E$. A large, positive demand shock is associated under both rules with an increase in domestic inflation but the rate of appreciation of the real exchange rate under discretion may be low enough to compensate for the loss incurred relative to the price target.
Once private agents in the nontraded goods sector have set their prices on the basis of the announced zero-devaluation policy, the policymaker has the incentive to renege on the declared strategy because a real exchange rate depreciation will improve external competitiveness, although this comes at the expense of an increase in inflation. The policymaker will devalue in a proportion such that the benefit of a higher rate of depreciation of the real exchange rate is just offset by the cost of a higher inflation rate. A fixed exchange rate policy is therefore time inconsistent; once it is announced and believed, the policymaker has an incentive to depart from it.

The minimized value of the policymaker's loss function under this "cheating" regime is

$$L^g = -a[\kappa - \Phi z_N/(1 - \delta) - \theta] + \frac{\lambda}{2},$$

where $\pi = (1 - \delta)\kappa$.

For $z_N = 0$, it can readily be verified that $L^g < L^g < L^g$. The discretionary solution produces the largest loss for the authorities, resulting in a positive rate of devaluation and inflation. Because the loss is lower when the policymaker succeeds in "fooling" the private sector than when it commits itself without reneging, there is an incentive to violate the fixed exchange rate target if price setters can be made to believe that the current parity will be adhered to, so that, for $z_N = 0$, $\ddot{\epsilon} = \kappa > \ddot{\epsilon} = \kappa/Q > \ddot{\epsilon} = 0$. However, although the rate of depreciation is higher under cheating than under discretion, the overall inflation rate is the same under both regimes ($\ddot{\pi} = \ddot{\pi}$), since, for $z_N = 0$, $\ddot{\pi}_N = 0$ and $\ddot{\pi}_N = \kappa/Q \geq 0$. The rate of inflation in the nontradable sector is lower when price setters are fooled than in the discretionary regime. Moreover, under discretion, the rate of depreciation of the real exchange rate is zero, since $\ddot{\epsilon} - \ddot{\pi}_N = 0$. The authorities are incapable of altering the real exchange rate by a nominal devaluation. By contrast, if the private sector can be successfully misled by the fixed exchange rate

1/ For positive demand shocks, the loss under cheating will always be less than that obtained under discretion ($L^g < L^g$), whatever the value of $z_N$. 

$$\dot{\epsilon} = \kappa - \nu \Phi z_N.$$
announcement, $\tilde{\epsilon} - \tilde{\pi}_N = \kappa$. 1/ Such a strategy, however, entails reputational costs, an issue which is examined below in a multi-period framework.

The three different solutions are represented in Figure 1. 2/ In the $\pi_N - \epsilon$ space, the locus $PP$, which reflects the objective of the private sector (given by equation 4), has a positive slope, while the policymaker’s reaction function under discretion (given by equation 5), depicted by $GG$, is negative. The non-cooperative equilibrium is located at the intersection of curves $GG$ and $PP$, that is, at point $A$. The precommitment solution obtains at point $B$, while the “cheating” solution obtains at point $C$. The discretionary solution is characterized by a “devaluation bias”. Private agents know that once they set prices of nontradables, the policymaker has the incentive to devalue so as to depreciate the real exchange rate and improve the balance of payments. They therefore set prices at a higher level, to the point where they believe the authorities are unwilling to trade off a higher inflation rate for a more depreciated real exchange rate. The precommitment solution, although not the best possible, provides a better outcome than the discretionary alternative. This provides an argument in favor of a fixed exchange rate—assuming the commitment can be made binding and perceived as such by price setters.

3. Seignorage and the incentive to devalue

It has often been observed that, to a greater extent than in industrial economies, in developing countries revenue from seignorage provides an incentive to produce inflation (see Spaventa, 1989). Bruno (1990), Cukierman (1991, Chapter 4) and Kiguel and Liviatan (1990a) for instance, have examined the time-inconsistency issue in a model in which seignorage yields a positive utility to the policymaker.

1/ Suppose the authorities are mainly concerned with the balance-of-payments objective. An alternative way to formulate the cheating solution is then to assume that a fixed exchange rate is announced, but that they actually devalue so as to maintain $\epsilon - \pi_N = 0$. If the private sector acts on the basis of the announcement, $\pi_N = \Phi z_N = \pi$. The loss function becomes $L^B = a \theta + \lambda (\Phi z_N)^2/2$, which is less than the precommitment outcome (see equation 8) if $\lambda$ is small.

2/ The Figure assumes that $a/\lambda > \delta (1 - \delta) \Phi z_N$, which ensures that $\tilde{\epsilon} > 0$. 
because it reduces the need for distortionary taxation. In a similar perspective, it may be asked whether a fixed exchange rate regime, by lowering the equilibrium level of inflation, is optimal for a policymaker who needs to rely on the inflation tax. To examine this issue in the above setting, we modify the policymaker's loss function to

\[ L^G = - \sigma[\epsilon - \pi^a] - \theta] + \lambda \pi^2 / 2 - \omega \pi m(\pi^a) \quad \omega > 0 \quad (2') \]

where \( m(.) \geq 0 \) denotes the demand for real cash balances, and \( \pi^a \) the expected inflation rate. \( \pi_m \) measures the flow of seignorage, under the assumption of money market equilibrium. As for nontradable prices, real money holdings are chosen at the beginning of the period, on the basis of the expected inflation rate, which depends on the anticipated exchange rate policy. Therefore, \( \pi^a = \delta \pi_N + (1 - \delta) \epsilon^a \), so that, using (5), \( \pi^a = \epsilon^a \). The real demand for money is therefore predetermined. Using (2'), the optimal rate of devaluation in the discretionary regime is now determined by (5) and, from (2'),

\[ \epsilon = \kappa - \nu \pi_N + \omega m(\pi_N) / \lambda (1 - \delta). \quad (4') \]

A comparison of equations (4) and (4') shows that, at each point in time, the rate of devaluation is higher by an amount proportional to the value that the policymaker attaches to seignorage. Once agents have determined their holdings of cash balances, there is an incentive for the policymaker to depreciate the exchange rate--or raise the inflation rate--in order to increase seignorage revenues. In Figure 1, equation (4') is represented as \( G'G' \), with the corresponding Nash equilibrium given by point \( A' \) where the two reaction functions intersect. The equilibrium rates of devaluation and nontradable inflation under discretion are both higher than in the previous case. It is easy to verify, however, that none of the above conclusions--in

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1/ The analysis in Bruno, Cukierman and Miguel-Liviatan is based on an earlier paper by Barro (1983). Calvo (1978) provides a general analysis of the time-inconsistency problem based on seignorage considerations. In his model, however, the policymaker attaches no cost to inflation, so that there is no well-defined solution under discretion. See also Grossman and Van Huyck (1986), who examine the role of reputational factors in Calvo's model.

2/ Inflation itself has distortionary effects, which is one way to explain the negative utility associated with deviations from price stability in the model above.

3/ In equilibrium, expectations are rational. An explicit solution can be derived by taking a linear approximation of \( m(\pi^a) \).
Figure 1

Determination of Alternative Equilibria

\[ \epsilon = \kappa - \omega \pi_N + \omega M(\pi_N) / \lambda (1 - \delta) \]
particular the ranking of policies when $z_N = 0$ are affected by this extension. 1/ We will, therefore, retain specification (2) in what follows.

Several papers have recently focused on strategic aspects of exchange rate policy. Andersen and Risager (1991), Cukierman (1991), and Horn and Persson (1988) examine the existence of a devaluation bias in a model where nominal wages are set by a trade union at the beginning of each period based on its price expectations and a real wage target. 2/ In Cukierman's model, dynamic inconsistency explains why nominal devaluations fail to improve the current account and only cause inflation. Under discretion, the public knows in advance that the policymaker is willing to tolerate devaluations and inflation in order to improve the balance of payments. Since the policymaker is not bound by any commitment, private agents know that once nominal wage contracts have been concluded, the authorities have an incentive to devalue. They, therefore, ask and obtain higher nominal wage rates to start with. Once contracts are set, the government indeed devalues at the expected rate. However, relative to a situation without a devaluation and no expectation of a parity change, such action has no impact on the current account, since the prior actions of the public have neutralized such an effect. By precommitting exchange rate policy, the authorities can avoid this inefficient outcome. In the presence of a credible peg, unions would rationally expect no inflation and would have no reason to ask for nominal wage increases — provided the current nominal wage is, to start with, at the level that produces the desired real wage.

In the model developed here, the time-inconsistency problem is qualitatively similar to the one described in the above papers: a fixed exchange rate policy is time-inconsistent because the policymaker has an incentive to deviate from it when agents expect it to be followed. The mechanism stressed here, however, does not rely on a specific Lucas-type supply function in which only unanticipated inflation matters. Moreover, it does not rely on the assumption of a monolithic union, which has been criticized as being at variance with the institutional features of labor markets in highly developed economies.

1/ The qualitative features of the solutions noted above remain also unaffected when $z_N \neq 0$.

2/ In Andersen and Risager (1991) and Horn and Persson (1988) the policymaker's loss function is assumed to depend on inflation and the level of employment. Cukierman (1991), however, explicitly considers the current account deficit as a policy target in addition to the rate of increase of prices.
countries (Blackburn and Christensen, 1989). 1/ The key distinctive feature of the model, however, is that the inflation rate is an endogenous variable, resulting from the behavior of both private agents (who set the price of nontradables) and the policymaker (who sets the exchange rate). As a consequence of this formulation, the optimal policy in the discretionary regime may call for a revaluation of the nominal exchange rate—a feature which is absent in existing strategic models of exchange rate policy. Overall, the model developed here may provide a more realistic setup for analyzing the time-inconsistency problem in exchange rate management, particularly for small open developing economies.

III. Credibility of a Fixed Exchange Rate

In the framework described above, a fixed exchange rate policy is time-inconsistent because the authorities may gain by devaluing the nominal exchange rate so as to depreciate the real exchange rate and improve competitiveness. The policymaker's attempt to alter the real exchange rate, however, will not be successful if the public is aware of the authorities' temptation to deviate from a preannounced exchange rate commitment. In the resulting discretionary (or consistent) equilibrium, the rate of depreciation of the real exchange rate is zero but the rate of devaluation is inefficiently high, in the sense that it generates a costly positive rate of inflation without an offsetting gain in competitiveness.

In order to avoid this discretionary equilibrium, it has been argued above that the authorities may decide to commit themselves to a preannounced zero-devaluation rule. However, precommitment can be successful only if the authorities would incur some penalty if they deviate from their rule. One form that this penalty can take is that if the policymaker were to deviate from the preannounced rule, the public would not believe its announcements in the following period(s), so that the economy reverts to the discretionary equilibrium. In this context, a zero-devaluation rule—which is, of course, a fixed exchange rate target—is credible if the temptation to deviate from the rule is less than the discounted value of the "punishment" associated with reversion to the discretionary equilibrium. In such circumstances, it is rational for the public to believe that the rule will not be broken. Following Barro and Gordon (1983b), we use in what follows the difference between the present value of the punishment and the temptation as an indication of the degree of credibility of a fixed exchange rate regime.

1/ The assumption of synchronized price setting in the nontradable sector may, however, be subject to the same type of criticism, although it may appear more defensible.
Assume that, unlike in the previous Section, private agents and the government expect that their interaction will be of infinite duration. Both groups will then minimize the discounted sum of their loss functions (2) and (3), or \( \sum_{t=0}^{T} \gamma^{t} L^{G}(t) \) and \( \sum_{t=0}^{T} \eta^{t} L^{P}(t) \)--where \( \gamma \) and \( \eta \) are discount factors--with \( T = \infty \). To evaluate the viability of a rule specifying a zero rate of devaluation of the nominal exchange rate, explicit strategies for price setters and the policymaker must now be formulated. Formally, assume that private agents increase prices at the rate \( \pi_{N, t} = \Phi_{N, t} \)--which, as shown above, is optimal provided the authorities adhere to the fixed exchange rate--if they correctly anticipated the rule followed in the previous period. Otherwise, nontradable prices are increased at the discretionary rate \( \pi_{N, t} \). Similarly, the authorities select a zero rate of devaluation if they did so in the previous period and private agents did increase the price of nontradables at the rate \( \pi_{N, t} \); otherwise, they devalue the exchange rate at the discretionary rate \( \varepsilon_{t} \). 1/ Thus, if the policymaker cheats once, credibility is lost forever and the loss associated with discretionary behavior is incurred in all future periods. 2/

As shown in the previous Section, the period-by-period loss for the policymaker when the zero-devaluation rule is expected and is actually followed, \( L^{G} \), is given by equation (8). The loss incurred when the policymaker "cheats" and selects the discretionary devaluation rate after prices have been set on the assumption that the fixed exchange rate will be maintained, \( L^{G} \), is given by equation (10). The announcement of the zero-devaluation rule \( \varepsilon = 0 \) will be credible when the total loss incurred by maintaining a fixed-exchange rate, given by

\[
L^{G}(t) + \sum_{k=1}^{\infty} \gamma^{k} L^{G}(t+k) = L^{G}(1 - \gamma),
\]

1/ This type of behavior represents a "trigger strategy" discussed for instance by Friedman (1990), and used by Barro and Gordon (1983b), and Horn and Persson (1988), among others. However, such a process is not the only rational process possible leading to "perfect" equilibria. The problem of multiple solutions to intertemporal games is well known; Rogoff (1987, pp. 151-53) gives an example of another consistent set of strategies.

2/ This assumption of an "infinite" punishment interval follows Horn and Persson (1988) and is justified below.
is lower than the loss from any alternative strategy. Similarly, the total loss incurred when the policymaker "cheats" in period \( t \) and adheres to the discretionary policy thereafter is given by

\[
\bar{L}_g(t) + \sum_{k=1}^{\infty} \gamma^k \bar{L}_g(t+k) = \bar{L}_g + \gamma \bar{L}_g/(1 - \gamma). \tag{12}
\]

Since \( \bar{L}_g \), \( \bar{L}_g \) and \( \bar{L}_g \) are time-invariant, a sufficient condition for the fixed-exchange rate announcement to be credible is

\[
\bar{L}_g/(1 - \gamma) \leq \bar{L}_g + \gamma \bar{L}_g/(1 - \gamma),
\]

that is,

\[
\bar{L}_g - \bar{L}_g \geq \gamma(\bar{L}_g - \bar{L}_g)/(1 - \gamma). \tag{13}
\]

Equation (13) has first been derived, in a similar context, by Horn and Persson (1988). The quantity \( (\bar{L}_g - \bar{L}_g) \) can be viewed as the "temptation" to cheat, that is, the incentive to deviate from the initial fixed exchange rate, while \( (\bar{L}_g - \bar{L}_g) \) can be viewed as the "punishment" resulting from a discretionary exchange rate adjustment. The gain from acting opportunistically is therefore equal to the temptation minus the present discounted value of the loss that starts a period later. The degree of credibility of a fixed exchange rate, \( C \), is inversely related to the gain from opportunism, and may be defined as

\[
C = (\bar{L}_g - \bar{L}_g) - \gamma(\bar{L}_g - \bar{L}_g)/(1 - \gamma), \tag{14}
\]

or, substituting equations (7b), (8), and (10) in (14),

\[
C = \alpha\kappa + \frac{\lambda}{2(1 - \gamma)}(\bar{\pi}^2 - \bar{\pi}^2) - \alpha\bar{\pi}/(1 - \delta). \tag{14'}
\]

1/ Note that in this certainty setting a reputational equilibrium is possible only if the horizon of the policymaker is infinite. Otherwise the policymaker would be sure in the last period to produce the discretionary outcome whatever the behavior of the private sector is, and working backwards would be expected to do the same in the first period. This is so because the policymaker will always find it optimal to choose the discretionary outcome in period \( t \) if he is expected to do so in period \( t+1 \), since in this case there would be no reputation gain from eschewing such behavior in period \( t \).
For $z_N = 0$, it is easily shown that a necessary condition for the degree of credibility of a fixed exchange rate to be positive is

$$\bar{\pi} \geq 2\alpha(1 - \gamma) / \lambda(1 - \delta) > \bar{\pi} = 0. \tag{15}$$

Equation (15) indicates that a fixed exchange rate can be credible only if the inflation rate that would obtain in a discretionary regime is high enough to "discourage" any attempt to devalue. Using (7a), it can be shown that (15) requires, in turn, $\gamma \geq 0.5$. The initial level of credibility can therefore be equal to zero (in which case the temptation equals the punishment) or may even be negative if future losses are heavily discounted. 1/ In such circumstances, the policymaker will pursue an active exchange rate policy, and will be expected to. 2/

When the discount factor is greater than one-half, the authorities should maintain the exchange rate fixed. For $z_N = 0$, this is consistent with a zero inflation rate and a constant real exchange rate. A fixed exchange rate, under perfect information about the policymaker's preferences, is the optimal strategy provided that the future costs of higher inflation are not sufficiently discounted so as to fall short of the current gain from a depreciation of the real exchange rate resulting from a devaluation. The potential loss of credibility, or reputation, motivates the policymaker to abide by the zero-devaluation rule; the short-term benefits from a nominal devaluation are foregone in order to secure the gain from low inflation over the long term.

Finally, it can be noted that using (15), the effect of changes in the structural parameters on the degree of credibility can be readily analyzed. For instance, since both the temptation and the punishment are increasing in $\alpha$, the net effect of a change in $\alpha$ on credibility is a priori indeterminate, and depends on the curvature of the loss function. An increase in the degree of "openness" (as measured by a fall in $\delta$) reduces the temptation to devalue, since it increases the effect of exchange rate changes on overall inflation, and thus increases the punishment. The net effect on exchange rate

1/ A similar result is derived by Horn and Persson (1988). A possible reason for a high discount rate might be an exogenous institutional constraint, such as the need for the government to seek re-election periodically.

2/ If the credibility loss lasted only one period, the policymaker would devalue further in every succeeding period because he is faced with the same decision each time. This would occur despite the fact that in this model the choice of a current rate of devaluation implies no direct constraints on future choices.
credibility of an increase in openness is therefore unambiguously positive.

IV. Incomplete Information and Exchange Rate Commitment

In this Section, we examine how reputational factors and signaling considerations may help mitigate the time inconsistency problem faced by the policymaker when choosing an exchange rate policy. The analysis is based on an extension of the model developed in the previous sections, but we now assume that agents are uncertain about the "type" of policymaker (that is, the structure of his preferences) in office.

1. Reputation and uncertain preferences

Let us assume that there is a continuum of types of policymakers which differ with respect to the cost incurred from reneging on a fixed-exchange rate commitment. 1/ The policymaker's horizon is fixed at T periods. 2/ Formally, the government loss function can be written as

\[ L^g = -\alpha[(\epsilon - \pi_N) - \theta] + \lambda \pi^2/2 + c, \tag{2''} \]

where

\[ c = \begin{cases} -c_T & \text{if } \epsilon_t \neq 0 \text{ and } \epsilon_{t-k} = 0 \text{ for } k > 0, \\ 0 & \text{otherwise}, \end{cases} \tag{16} \]

where \( c \) denotes the reneging cost incurred by the policymaker. Private agents do not observe directly \( c \), and, therefore, do not know the "type" of the policymaker in office. They, however, form a prior

1/ The issue of uncertain preferences was first examined in the context of models of monetary policy in a closed economy developed by Backus and Driffill (1985a, 1985b) and Barro (1986a), whose work has been extended to consider exchange rate policy by Horn and Persson (1988), and Andersen and Risager (1991). The methodology used in these papers rely on the theory of incomplete information games developed by Kreps and Wilson (1982). The analysis that follows here relies, in part, on Rogoff (1987, 1989).

2/ The value of \( T \) is common knowledge and may be related to the term of office of the government. More generally, it may be assumed that the government believes that its actions will not affect the credibility of future governments beyond period \( T \).
distribution on \( \overline{c} \) over a given interval. Over time, initial priors are updated through a learning process discussed below.

If the policymaker chooses to devalue in period \( t \), he will do so at the optimal, discretionary rate \( \epsilon = \kappa/Q \) (see equation 6b). In subsequent periods, however, he loses credibility and incurs a fixed cost \( c \) and no "real" gains (although he continues to devalue at the discretionary rate) since price setters will anticipate future devaluations and increase nontradable prices accordingly. As long as the fixed exchange rate is adhered to, expectations will be formed according to observed policies, so that

\[
\epsilon^a = (\epsilon^a_0, \epsilon^a_{t-1}, \epsilon^a_{t-2}, \ldots). \tag{17}
\]

Assume for the moment that expectations are exogenous and are fixed at the beginning of period 0. The discounted loss incurred by the policymaker when adhering to the fixed exchange rate from periods 0 to \( t-1 \) and selecting the discretionary policy from periods \( t \) to \( T \) is given by, setting \( \theta = 0 \),

\[
L^0(\epsilon, \overline{c}) = \alpha \sum_{k=0}^{t-1} \gamma^k \epsilon^a_0 - \alpha \gamma^t (\kappa/Q - \epsilon^a_0) \tag{18}
\]

\[
+ \left( \frac{\lambda}{2} \right) \sum_{k=t}^{T} \gamma^k (\kappa/Q)^{2} + \overline{c} (\gamma^t + \gamma^{t+1} + \ldots + \gamma^{T}),
\]

or

\[
L^0(\epsilon, \overline{c}) = \alpha \sum_{k=0}^{T} \gamma^k \epsilon^a_0 - \alpha \epsilon^a_0 (1 - \gamma^{T+1})/(1 - \gamma), \tag{18'}
\]

Equation (18') shows that sticking to a zero-devaluation rule during \((0, T)\) yields a present-value loss equal to

\[
\alpha \sum_{k=0}^{T} \gamma^k \epsilon^a_0 - \alpha \epsilon^a_0 (1 - \gamma^{T+1})/(1 - \gamma),
\]

while adhering to a fixed exchange rate until period \( T-1 \) and devaluing at \( T \) yields

\[
L^0(T, \overline{c}) = \alpha \sum_{k=0}^{T} \gamma^k \epsilon^a_0 + \gamma^T \left[ \overline{c} + \frac{\lambda \kappa}{2Q} - \alpha \kappa \right]. \tag{19}
\]
Equation (19) shows that if the reneging cost $c$ is large enough, the policymaker will stick to a fixed exchange rate even in the last period. 1/

Consider now the behavior of expectations. As shown by equation (17), private beliefs are updated as time proceeds on the basis of observed exchange rate policy: the longer the policymaker sticks to a fixed exchange rate, the lower will be the expected rate of devaluation. But if the policymaker abandons the fixed exchange rate, private agents will raise devaluation expectations (to the discretionary level) and will adhere to such beliefs until period $T$. Formally, such a process of gradual learning can be formalized by assuming that private beliefs evolve according to a Bayesian rule. As shown by Rogoff (1987, 1989), a sequential process of this type leads agents to revise continually upwards the threshold level of cost below which they assume the government has an incentive to renege --provided, of course, that no devaluation occurs. As a result, devaluation expectations tend to fall over time. Although agents may never discover the "true" value of the cost attached to reneging by the policymaker, the behavior of expectations creates an incentive to commit to a fixed exchange rate rule. "Reputation", in this context, is viewed as a mechanism which translates into a progressively lower expected rate of depreciation. 2/ Rogoff's (1987, 1989) analysis suggests that a government which faces a relatively low cost of reneging may be tempted to devalue very early in its term in office. But if the time horizon $T$ is long enough, (or if the discount rate is high enough) the temptation to devalue is lowered because of the costs resulting from high devaluation expectations.

The major implication of the above analysis is that even policymakers that are concerned about a balance-of-payments target may tend, at the start of their term in office, to act as if they do not in order to maintain the impression, among private agents, that inflation is the primary target and reduce expectations. Such policymakers, nevertheless, may devalue near the end of their term in office.

1/ In models of exchange-rate policy such as those of Andersen and Risager (1991) or Horn and Persson (1988), in which there are no (contemporaneous) cost of reneging on an exchange-rate commitment, a policymaker who is more concerned with a "real" target is certain to devalue in period $T$ because there is no incentive to invest in "reputation" beyond $T$.

2/ In Barro's (1986) analysis, as well as in Horn and Persson (1988), reputation is explicitly defined in probabilistic terms. However, Barro's approach has the unattractive feature of involving a phase of randomizing strategy. Mino and Tsutsui (1990) consider, as is done here, a model with a continuum of policymakers, which differ by the relative weight attached to the "real" target in the government loss function.
office in an attempt to increase competitiveness. A nominal
devaluation will "work", in this context, as long as the policymaker
has a reputation of being a "pegger", or as long the cost of reneging
on the exchange-rate commitment is not "large". The critical element
on which this result rests is the public's lack of information about
the policymaker: even if the authorities are committed to maintaining
a fixed exchange rate, private agents cannot know this with certainty.
Complete credibility in this context is impossible to achieve. 1/
This analysis also shows, however, how reputational factors can help
overcome the time-inconsistency problem. A policymaker who is more
concerned about a balance-of-payments target has nevertheless an
incentive to avoid the discretionary outcome early in his term in
office because doing so secures more favorable price behavior on the
part of private agents.

2. Signaling and discretionary policy

We now consider a situation where there are only two types of
policymakers which differ in the relative weights they attach to the
"internal" target (inflation) and the "external" target (the real
exchange rate). Using a variant of the terminology developed by
Vickers (1986) and used as well by Horn and Persson (1988), we call
the first type D-policymakers ("devaluers") who attach a value to both
low inflation and to a more depreciated real exchange rate. The
second type, called P-policymakers ("peggers"), attaches a lower
weight to the real exchange rate in its loss function. Price setters
do not know the type of policymaker in office, but they have a prior
probability that the policymaker is of type P. As time proceeds,
private agents observe the exchange rate policy and revise their
assessment of the policymaker's type.

In the presence of imperfect information about policymakers'
preferences, even a government that cares relatively more about
inflation (i.e. a P-type policymaker) may have an incentive to devalue
less that it would otherwise find optimal, in order to signal its
preferences to the public. As shown by Vickers (1986), a policymaker
who cares relatively more about inflation can signal his preferences
to the private sector by inducing a temporary recession. 2/
Policy-makers with relatively greater concern about output and employment are
unwilling to bear this cost, so the signal successfully conveys the
policymaker's intention to disinflate. In the context of the above
analysis, Vicker's analysis suggests that one way for the P-type
policymaker to reveal his identity might be to select an exchange rate

1/ Driffill (1987) considers the case where private agents are
unable to monitor perfectly the policymaker's actions due to exogenous
disturbances.

2/ See also Cukierman (1991) for a useful exposition of Vickers'
model.
policy which is such that the $D$-type policymaker would not find optimal to replicate. Such a policy would not, of course, be without cost for the $P$-type policymaker, but could be a credible signalling device under some circumstances. In what follows, we show that, under imperfect information about its preferences, an anti-inflation government may devalue by less than it would find otherwise optimal, in order to signal unambiguously its policy goals to price setters and its commitment to price stability.

For simplicity, we consider a two-period game. In period 1, only the policymaker acts, and sets $\epsilon_1 > 0$. In period 2, price setters move first. Before setting prices, they receive $\epsilon_1$ as a message which they use to assess the policymaker's type, and to form expectations about the rate of depreciation for period 2, $\epsilon_2$. After nontradable prices are set, the policymaker fixes the rate of depreciation of the nominal exchange rate, $\epsilon_2$.

From equation (3), with $z_N = 0$,

$$\pi_N(2) = \frac{\epsilon_2}{2},$$

while from (2), with $\pi_N(1) = 0$,

$$L^G = -\alpha(\epsilon_1 - \theta) - \alpha\gamma[(\epsilon_2 - \pi_N(2)) - \theta] + \lambda[(1 - \delta)^2\epsilon_1^2 + \gamma\pi_2^2]/2.$$

so that

$$\epsilon_1 = \kappa > 0, \quad \epsilon_2 = \kappa - \nu\pi_N(2) > 0.$$  \hspace{1cm} (22)

As indicated above, agents do not know the type of the policymaker in office. They only have a probability $\rho$ of having a $P$-policymaker in office. They also know, however, that the $P$-policymaker puts a lower weight on the real exchange rate target,

1/ Since prices are fixed at the beginning of every period, they cannot respond to the signal sent by the current, effective devaluation rate. As a result, the assumption of $\pi_N(1) = 0$ does not have much bearing on the analysis that follows.

2/ $\rho$ can be taken as determined by factors such as the fraction of governments which historically have turned out to maintain a fixed exchange rate during their terms, the appearance and personality of the elected politicians, etc.
and sets $0 < \alpha_p < \alpha_D$. In period 1, the $D$-policymaker pledges to refrain from a large depreciation (it mimics the $P$-type) because he hopes to deter agents from raising nontradable prices too rapidly in period 2. If, however, agents do increase prices, the $D$-policymaker will renege on his commitment to a low depreciation rate in the second period—assuming that reneging does not entail prohibitive costs—and will devalue so as to offset the loss in competitiveness, as shown in equation (22).

From (20) and (22), the non-cooperative solution obtained when agents can identify unambiguously the type of policymaker in office is given by

\[ \varepsilon_1^i - \kappa_i > 0, \quad \varepsilon_2^i - \pi_N(2) = (1 - \delta)\kappa_i > 0, \quad i = P, D \quad (23) \]

where $\kappa_i = \alpha_i u/\lambda \delta (1 - \delta)$, and $\kappa_p < \kappa_D$. Equations (23) basically replicate the time-inconsistency result derived in Section II. 1/ For both types of policymakers, a fixed exchange rate is the optimal policy ($\varepsilon_1^i = \varepsilon_2^i = 0$) only if competitiveness does not matter ($\alpha_p = \alpha_D = 0$, so that $\kappa_p = \kappa_D = 0$).

Equations (23) also show that both types of policymakers have a well-defined strategy in the second period—under rational expectations ($\varepsilon_1^p = \varepsilon_2^i$). 2/ Things are, however, different in the first period if uncertainty over policy preferences prevails. The $D$-policymaker, who tries to mimic the $P$-policymaker in period 1, sets either $\varepsilon_1^D = \kappa_p$ or $\varepsilon_1^D = \kappa_D$, and chooses $\varepsilon_2^D = (1 - \delta)\kappa_D$ if nontradable prices increase at the beginning of period 2. The $P$-policymaker understands the incentive for the $D$-policymaker to conceal his identity and select $\varepsilon_1^D = \kappa_p$ so as to secure a lower rate of increase in nontradable prices in period 2. The question now is under what conditions does the $P$-policymaker, in order to signal unambiguously his type to the public, have an incentive to depart from the optimal, perfect-information response ($\varepsilon_1^P = \kappa_p$) and instead set $\varepsilon_1^P < \kappa_p$.

1/ Note that, as a result of the rise in nontradable prices in period 2, $\tilde{\varepsilon}_2^i < \tilde{\varepsilon}_1^i$.

2/ This is important because it implies that the "cost" of signaling the anti-inflation stance of the $P$-policymaker will not persist beyond period 1.
The solution to this problem is as follows. When price setters observe the exchange rate signal in period 1, they do not know precisely the type of policymaker in office. They recognize, however, that there is a possibility that both types may be sending the same signal (that is, $\tilde{\varepsilon}_1^P = \tilde{\varepsilon}_1^D = \kappa_P$), since they are aware of the incentive for the D-type to mimic the P-type. This situation characterizes a pooling equilibrium, in which private agents are unable to extract any information regarding the policymaker's type by observing $\varepsilon_1$. In this last case, the initial probability of having a P-policymaker in office cannot be updated on the basis of information received in the first period, and the expected rate of depreciation of the exchange rate in period 2 is given by

$$\varepsilon_2^a = \rho \varepsilon_2^P + (1 - \rho) \varepsilon_2^D = \varepsilon_2^D + \rho (\varepsilon_2^P - \varepsilon_2^D).$$

(24)

If the two types send separate signals, however, private agents will be able to distinguish between the P-policymaker (and will accordingly set $\varepsilon_2^a = (1 - \delta)\kappa_P$, or $\rho = 1$ in equation 24) and the D-policymaker (so that $\varepsilon_2^a = (1 - \delta)\kappa_D$, or $\rho = 0$ in 24). Using the above definitions, the assumption of rational expectations, and writing $\rho = \rho(\varepsilon_1^I)$, equation (20) becomes 1/

$$\pi_N(2) - (1 - \delta) [\kappa_D + \rho(\varepsilon_1^I)(\kappa_P - \kappa_D)],$$

(25)

which shows that, since $\kappa_P < \kappa_D$, the higher the probability of having a P-policymaker in office (the higher $\rho$), the lower the rate of increase in nontradable prices and, from (23), the lower the rate of depreciation of the exchange rate.

We focus in what follows on separating equilibria, in which the first-period action reveals the policymaker's type. 2/ In this case, the P-type government separates itself from the D-type by setting $\varepsilon_1^P < \kappa_P$, that is, by actually depreciating the currency by less than

1/ The assumption of rational expectations rules out any "cheating" strategy by the policymaker, and ensures a time-consistent outcome.

2/ Vickers (1986) shows that practically all pooling equilibria can be eliminated in this type of problem, by appealing to several refinements to solution concepts, in particular the Cho-Kreps (1987) intuitive criterion. See also Cukierman (1991).
it would have found optimal under perfect information. It also chooses $\tilde{\epsilon}_2^P = (1 - \delta)\kappa_p$. The D-policymaker sets $\tilde{\epsilon}_1^D = \kappa_D$ and $\tilde{\epsilon}_2^D = (1 - \delta)\kappa_D$. If price setters observe $\tilde{\epsilon}_1^D = \kappa_D$, they will also expect $\epsilon_2 = (1 - \delta)\kappa_p$ (since they set $\rho = 1$ in 24) and therefore also choose $\pi_N(2) = (1 - \delta)\kappa_p$. If, on the contrary, price setters observe $\tilde{\epsilon}_1^D = \kappa_D$, they will expect $\epsilon_2 = (1 - \delta)\kappa_D$ (since they set $\rho = 0$ in 24) and therefore, from (25), also choose $\pi_N(2) = (1 - \delta)\kappa_D$. The upshot is that, although the P-type government would have preferred $\tilde{\epsilon}_1^P = \kappa_p$ if its commitment to a more stable exchange rate was fully understood by the public, it chooses $\tilde{\epsilon}_1^P < \kappa_p$ because this unambiguously reveals its type and consequently lowers the incentive for the private sector to raise nontradable prices in the future.

For a separating equilibrium to exist, there must clearly be no incentive for the D-policymaker to choose $\tilde{\epsilon}_1^D < \kappa_D$, even if that would allow him to "fool" private agents about his type, and would induce them to set $\rho = 1$ when forming their second-period exchange rate expectations, while there must be no incentive for the P-policymaker to select $\tilde{\epsilon}_1^P > \kappa_p$--in which case private agents would wrongly identify him as a D-policymaker and would accordingly set $\rho = 0$. This yields two restrictions on the value of $\tilde{\epsilon}_1^P$:

\[
\begin{cases}
L^S(\tilde{\epsilon}_1^P < \kappa_p, \epsilon_2^P, \epsilon_2^a|\rho=1) - L^S(\epsilon_1^P = \kappa_p, \epsilon_2^P, \epsilon_2^a|\rho=0) \leq 0, & \text{(P-type)} \\
L^S(\tilde{\epsilon}_1^D < \kappa_D, \epsilon_2^D, \epsilon_2^a|\rho=1) - L^S(\epsilon_1^D = \kappa_D, \epsilon_2^D, \epsilon_2^a|\rho=0) \geq 0, & \text{(D-type)}
\end{cases}
\]

Intuitively, the conditions for the existence of a separating equilibrium mean that the P-policymaker's gain resulting from lower nontradable prices in the future must outweigh the immediate loss incurred by depreciating the exchange rate by less than the optimal perfect-information amount, whereas for the D-policymaker, the loss associated with an initially lower rate of depreciation must exceed the immediate benefit of getting a lower price reaction in the next period. The first inequality in (26) sets an upper bound on $\tilde{\epsilon}_1^P$, while the second leads to a lower bound on $\tilde{\epsilon}_1^P$. Using equations (20)-(26),
The following ranges are obtained: 1/

\[
P_{\text{min}} = \kappa_P(1 - \sqrt{\Psi}) \leq \epsilon_1 \leq P_{\text{max}} = \kappa_P(1 + \sqrt{\Psi}), \tag{27a}
\]

\[
\epsilon_1 \leq D_{\text{min}} = \kappa_D[1 - \sqrt{\Psi/(1 + \Psi)}], \quad \epsilon_1 \geq D_{\text{max}} = \kappa_D[1 + \sqrt{\Psi/(1 + \Psi)}] \tag{27b}
\]

where \(\Psi = (q - 1)(1 + q)\), and \(q = \kappa_D/\kappa_P > 1\). Equation (27a) defines the range of values of \(\alpha_P\) and \(\alpha_D\) for which it is optimal for the \(P\)-policymaker to depreciate by less than would have been chosen under perfect information, and thus successfully signal his type. Similarly, equation (27b) defines the range of values for which it is optimal for the \(D\)-policymaker to choose an optimal, perfect-information strategy in the first period and abstain from trying to mimic the \(P\)-policymaker. 2/ The intersection of these two ranges, if non empty, defines therefore the range of values for which a separating equilibrium will indeed obtain. 3/ This equilibrium is such that \(\epsilon_1^P \in (P_{\text{min}}, D_{\text{min}})\). By a refinement of the solution concept, it can be shown that the multiplicity of separating equilibria can be reduced to

1/ The inequalities (26) yield the polynomials

\[
P(\epsilon_1) = \epsilon_1^2/2 - c_1^P \epsilon_1 + c_2^P \leq 0, \quad D(\epsilon_1) = \epsilon_1^2/2 - c_1^D \epsilon_1 + c_2^D \geq 0,
\]

where, for \(i = P, D\),

\[
c_1^i = \kappa_i = \alpha_i/\lambda(1 - \delta)^2 > 0, \quad c_2^i = [\gamma(\kappa_P^2 - \kappa_D^2) - \kappa_1^2] / 2 + \kappa_i^2 > 0.
\]

Solving for the roots of \(P(\epsilon_1)\) and \(D(\epsilon_1)\) yields equations (27).

2/ It can be seen from (27a) that an increase in \(\alpha_P\) increases the optimal range for signaling behavior for the \(P\)-policymaker. From (27b), an increase in \(\alpha_D\) reduces the range for the \(D\)-type.

3/ A sufficient condition for the intersection of the sets defined by (27a) and (27b) to be non empty is \(D_{\text{min}} > P_{\text{min}}\) or, using (27a,b),

\[
q > \left[1 - \sqrt{\Psi/(1 + \Psi)}\right] / (1 - \sqrt{\Psi}),
\]

a condition which is always satisfied, since \(\Psi > 0\) and \(q > 1\).
a unique solution where the P-policymaker chooses $\epsilon_1^P = D_{\text{min}} < \kappa_D$. 1/

The above result provides an interesting argument in support of an exchange rate freeze in stabilization programs, of the type that has been observed recently in many Latin American countries and Israel (see, for instance, Kiguel and Liviatan 1990b). Fixing the exchange rate (or more generally lowering the rate of depreciation of the exchange rate) may prove successful in signaling the anti-inflationary commitment of the policymaker, and will therefore enhance the credibility of a stabilization program. 2/ Indeed, an extension of the argument suggests that it may ultimately be beneficial for a government to revalue its currency to convey unambiguous information about its policy preferences. Chile, for instance, revalued its currency twice in 1977, in an attempt to demonstrate the government's resolve to fight inflation. An argument along these lines has also been presented by Winckler (1991) to explain the decision of the United Kingdom to enter the Exchange Rate Mechanism of the EMS at an appreciated exchange rate on October 8, 1990.

There are, however, situations in which signaling considerations are incapable of mitigating the time-inconsistency problem. For instance, both types of government may have a high rate of time preference, in which case the optimal solutions under perfect information and uncertain preferences may not be very different from each other. Intuitively, this is because $D$-type policymakers have a reduced incentive to masquerade as a $P$-type. Since price setters are aware of this, the signal that must be sent by the $P$-policymaker to separate himself from the $D$-type need not be as "strong". 3/ Another

1/ This requires recourse to a restriction which eliminates "weakly dominated strategies." Essentially, the closer is $\epsilon_1^P$ to $D_{\text{min}}$, the smaller the loss in terms of his first-period targets that the $P$-policymaker incurs in order to separate himself from the $D$-policymaker. For further elaboration, see Cukierman (1991).

2/ An alternative view on this issue relates to Kamin's (1991) discussion of "front-loading" in exchange rate management—a deliberate over-depreciation of the nominal exchange rate in the initial phase of a stabilization program, so as to "undervalue" the real exchange rate and provide room for possible future policy slippages. The above discussion suggests, however, that over-depreciation may send the "wrong" signal in the context of a disinflation program.

3/ Formally, one needs to consider the effect of a change in $\gamma$ on $D_{\text{min}}$, which yields $\partial D_{\text{min}}/\partial \gamma < 0$. In the limiting case where $\gamma = 0$, the $P$-policymaker mimics the $D$-type by choosing $\epsilon_1^P = \kappa_D$. It should be noted, however, that $\gamma$ has no effect on the range of values of $\epsilon_1$ for which a separating equilibrium exists ($\partial [P_{\text{min}} - D_{\text{min}}]/\partial \gamma = 0$).
situation (which may prove particularly relevant for developing countries) may be that, when implementing a disinflation strategy, countries are faced with a large current account deficit and a financing constraint—which render a "high" rate of depreciation inevitable. Formally, this is reflected in the weight $\alpha_p$ which, if sufficiently large, eliminates the region in which separating equilibria may be obtained. Finally, there are other ways for a $P$-type policymaker to send signals that would enable the public to clearly identify his preferences: signals may be sent via the removal of capital controls, a drastic cut in the budget deficit, the appointment of a "conservative" central banker, etc. An interesting extension to the present analysis would be, therefore, to examine in a more detailed model the benefits and costs of alternative signaling strategies.

V. Credibility Effects of Monetary Unions

An alternative way to attach credibility to a fixed exchange rate regime (and signal the policymaker’s commitment to a stable parity) would be for the authorities to surrender the power to alter the exchange rate. This could be achieved, for instance, by forming a monetary union under which a group of countries adopt a common currency and fix their parity against a major currency—for developing countries, the CFA Franc Zone or the East Caribbean Currency Area provide examples of such an arrangement. A less rigid arrangement would probably be more similar to the European Monetary System, under which the exchange rate can be adjusted periodically, although such adjustments are subject to international scrutiny. The credibility argument has indeed been presented as an important consideration favoring EMS membership, especially among small high-inflation European countries. One way for a government to establish credibility for an anti-inflationary policy is to appoint a conservative central banker, who is highly averse to inflation (Rogoff, 1985). It has been argued that EMS membership plays an equivalent role: it allows member countries, in effect, to appoint a German central banker, establishing credibility by linking the country’s monetary policy to the strong anti-inflationary preferences of the Bundesbank. 1/ By "tying their hands" when joining a fixed-exchange rate arrangement,

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1/ See Giavazzi and Giovannini (1989), and Giavazzi and Pagano (1988). Lane and Rojas-Suarez (1989) have questioned the "credibility effect" attached to EMS membership by arguing that such a view is inconsistent with the existence of exchange rate bands within the system. However, such fluctuation bands may be viewed as a response to the trade-off between exchange rate flexibility, required for stabilization and competitiveness, and fixity, required to enhance credibility.
therefore, policymakers can combat inflationary expectations more effectively. 1/ In these circumstances, it may be desirable for the authorities to adopt an institutional arrangement that imposes large-political or otherwise-costs to reneging on such precommitment. The important and general point emphasized in this line of reasoning is that, to be credible, such monetary arrangements have to be based on institutional features that make it costly to alter the exchange rate.

There are, however, costs associated with foregoing the use of the exchange rate as a policy instrument, particularly in the presence of large external shocks. The credibility of a country's commitment to the "rules of the game" of a monetary union-and thus the extent to which membership in a union can overcome time-inconsistency problems-must depend on the nature of such costs. This section examines these issues by extending the model developed previously so as to capture the institutional and macroeconomic constraints imposed by an international monetary arrangement.

1. Credibility and political costs

Consider a country which has to decide whether or not to join an international monetary union. By joining, it incurs a fixed domestic political cost of \( c_J \) per period as long as it adheres to the fixed-exchange rate agreement, but enjoys full credibility for its declared parity. If it decides to join and then reneges on its commitment, it incurs a fixed (international) political cost of \( c_L \). 2/,3/ If the

1/ Italy, for instance, is thought to have been able to solve its precommitment problem by tying the lira to the mark (Canzoneri and Henderson, 1988). The annual inflation differential vis-à-vis Germany has been brought down from an average of 12 percentage points in 1979-83 to nearly 3 percentage points in 1988-90, while the lira's average annual rate of depreciation vis-à-vis the mark declined from over 6 percent to 1 percent over the same period. However, this "solution" to the credibility issue has been criticized by Canzoneri and Henderson (op. cit.). An announcement about an exchange rate target is not necessarily more binding than an announcement about a money supply target. This issue is further discussed below.

2/ \( c_J \) itself could be made a function of the length of the period during which the country maintains its exchange rate fixed in the arrangement, while \( c_L \) could depend on the size of the exchange rate change-should the country decide to devalue. These extensions would not, however, alter the basic implication of the analysis.

3/ The international exchange-rate arrangement could be such that it also reduces the member countries' discretionary power by
country commits itself at period \( t = 0 \), the present discounted value of the costs incurred by joining the union forever is given by

\[
    c_J(\infty) = \sum_{k=0}^{\infty} \gamma^k c_J = c_J / (1 - \gamma).
\]  

(28)

Similarly, the present discounted value of the costs of leaving the currency arrangement forever—assuming, for simplicity, that at \( t = 0 \) the country is already a member of the union—is given by 1/

\[
    c_L(\infty) = c_L / (1 - \gamma).
\]  

(29)

The degree of credibility of a fixed exchange rate, as previously defined, must accordingly be modified to reflect the existence of political costs. Adding (28) to (11) and (29) to (12) and solving as before yields, for credibility to be positive, 2/

\[
    \gamma \geq 1/2 - (c_L - c_J) / \alpha \kappa.
\]  

(30)

Equation (30) indicates that the higher the political cost of leaving a currency union relative to the cost of joining the arrangement, the less stringent the condition that must be satisfied by the discount factor to ensure credibility. By choosing to precommit its exchange rate policy to a zero-devaluation path as a member of a currency union, the government incurs an additional domestic political cost in each period. This requires that future losses be subjected to a smaller discount rate (or a higher \( \gamma \)) if credibility of the fixed exchange rate is to be ensured. By contrast, an increase in the cost incurred by the policymaker when he reneges on his fixed-rate commitment within the currency union lowers the requisite discount rate. This is because the short-term benefit resulting from a discretionary exchange rate change is reduced by an

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1/ Note that since \( c_L \) is constant, it does not matter for the expression in (29) whether the government chooses the cheating solution or the discretionary outcome when it decides to alter the exchange rate.

2/ (cont'd from p. 27) imposing a commitment to a higher weight on inflation in the domestic policymaker's loss function. This would work just as if the country were agreeing to appoint a "conservative" central bank (as suggested by Rogoff, 1985), since it would induce less inflationary price setting behavior (note from (6b) that \( \tilde{e} \to 0 \) for \( z_N = 0 \) if \( \lambda \to \infty \), or if \( \alpha \to 0 \)).

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3/ We assume that the political cost differential is such that the condition \( \gamma \leq 1 \) holds, or that \( (c_J - c_L) < \alpha \kappa / 2 \).
additional cost which is incurred over a longer term. Political costs may therefore have an enforcement effect which can alleviate the institutional deficiency behind the devaluation bias.

2. The optimality of "tying one's hands"

Consider now a country which has to decide whether or not to maintain its exchange rate fixed within the framework of a monetary union with its major trading partner. Suppose, moreover, that inflation in the partner country is positive, or that there is a positive shock to the price of tradables, that is, $T^*_T > 0$. Assume that both the policymaker and private agents learn about the realization of the shock immediately after its occurrence, and take their decisions afterwards. For simplicity, let $z_N = 0$. The discretionary solution is now given by

\begin{align}
\bar{\pi}_N &= \frac{\kappa}{\Omega} \geq 0, \\
\bar{\varepsilon} &= (\kappa/\Omega) - \pi_T^* < 0,
\end{align}

which yields an overall inflation rate equal to

\begin{align}
\bar{\pi} &= \bar{\pi}_N = \kappa/\Omega, \\
\bar{\pi} &= \bar{\pi}_N = \kappa/\Omega,
\end{align}

and a rate of change of the real exchange rate $\bar{\varepsilon} + \pi_T^* - \bar{\pi}_N = 0$. Abstracting from political costs, the associated loss for the policymaker becomes therefore

\begin{equation}
\bar{L}^E = \lambda (\kappa/\Omega)^2 / 2.
\end{equation}

If the authorities decide to maintain the nominal exchange rate fixed, and if such a policy is believed by price setters,

\begin{align}
\bar{\varepsilon} = 0, \\
\bar{\pi}_N = \bar{\pi} = \pi_T^*, \\
\bar{\pi} + \pi_T^* - \bar{\pi}_N = 0,
\end{align}

the loss function is equal to

\begin{equation}
\bar{L}^E = \lambda (\pi_T^*)^2 / 2.
\end{equation}

A comparison of equations (33) and (35) shows that the loss under a (credible) commitment to maintain the exchange rate fixed is higher than under discretion when $\pi_T^* > \kappa/\Omega$—in which case the policymaker
may decide to renege on his commitment to a fixed parity. When the foreign price shock is small, its direct inflationary impact is limited, and the rate of appreciation of the nominal exchange rate required to offset its impact in the discretionary regime is also small. If the commitment to the fixed exchange rate is credible and enforced, the rate of appreciation of the real exchange rate is the same under both regimes. But the overall effect on inflation under precommitment is $\pi^*_T$ (since prices of nontradables are adjusted upwards) while under discretion it is $\kappa/\Omega$.

The analysis suggests therefore that, for a government possessing a loss function which trades off inflation and competitiveness, the desirability of "tying one's hands" as a solution to the time-inconsistency problem depends on whom one's hands are tied to. If joining a monetary union subjects a country to large nominal shocks, the credibility gain may be outweighed by the cost of lost autonomy. When the economy is not subjected to large adverse nominal shocks (that is, when union members have stable, low inflation rates), a case can be made for the authorities to precommit to a fixed exchange rate as a means of demonstrating their resolve to maintain financial discipline. But when the economy is subject to large nominal shocks, it may be optimal to alter the exchange rate. Thus, while it may be desirable for policymakers to attach a greater weight to price stability than that perceived by society as a whole (Rogoff, 1985), this weight should not be so large that the exchange rate is never moved.

In practice, exchange rate arrangements involving a peg typically incorporate an "escape clause" or a contingency mechanism which allows members to deviate from the declared parity under exceptional circumstances. To examine this issue in the above setting, suppose that $\pi^*_T$ is now a random variable which follows a uniform distribution over the interval $(0, c)$, and occurs after price setters take their decisions. Suppose also that the domestic country is allowed to devalue if the foreign price shock is "large". The probability that the contingency mechanism will be invoked is therefore

$$q = \text{Prob}(\pi^*_T \geq \mu)$$

where $0 \leq q \leq 1$, and $\mu < c$ denotes a given threshold. Under the assumption regarding the distribution of $\pi^*_T$, this probability is given by

$L/ A case in point is the Bretton Woods system. The optimality properties of monetary policy rules which combine discretionary elements and state-contingent mechanisms have been discussed by Flood and Isard (1989). See also Obstfeld (1991b) and Persson and Tabellini (1989).
The expected rate of depreciation of the exchange rate will therefore be given by

\[ \epsilon^d = qE(\epsilon|\pi_T^* \geq \mu) + (1 - q).0, \]

or, using (2),

\[ \epsilon^d = \bar{\pi}_N = q(\kappa - \pi_T^*)/(1 + uq), \]  \hspace{1cm} (37)

where \( \bar{\pi}_N = E(\pi_T^*|\pi_T^* \geq \mu) = (c + \mu)/2. \) Equations (36) and (37) indicate that as long as there is a less-than-one probability that the contingency mechanism will be invoked, the expected rate of depreciation is lower than in the purely discretionary regime examined above, in which \( \epsilon^d - \kappa/\Omega. \) The discretionary exchange-rate policy is now given by

\[ \tilde{\epsilon} = (\kappa - uq\bar{\pi}_N)/(1 + uq) - \pi_T^* \geq 0, \]  \hspace{1cm} (38)

which is lower than (31b), since devaluation expectations are lower. An implication of equation (38) is that the higher \( q \) is--or, equivalently, the lower \( \mu \) is--the more effective is a contingency mechanism in mitigating the devaluation bias of a discretionary regime \( (\delta \tilde{\epsilon}/\delta q < 0). \) A high value of \( q \) does, however, generate real costs in circumstances in which foreign price shocks turn out to be "small". As shown above, in the purely discretionary regime, the change in the real exchange rate is zero in equilibrium. In a regime in which the possibility to invoke an escape mechanism exists, however, equations (36) and (37) yield

\[ \tilde{\epsilon} + \pi_T^* - \bar{\pi}_N = [\kappa(1 - q) + q(1 - u)\bar{\pi}_N]/(1 + uq) \geq 0. \]  \hspace{1cm} (39)

The actual (ex post) rate of depreciation of the real exchange rate is determined by the size of the foreign price shock. If the realized value of \( \pi_T^* \) is "large", and the contingency mechanism is triggered, equation (39) shows that the real exchange rate will depreciate, regardless of whether the nominal exchange rate is devalued or revalued (see equation 38). If \( \pi_T^* \) is "small", the authorities will maintain the nominal exchange rate fixed. The change in the real exchange rate will in this case be given by
which is in general indeterminate. The point, however, is that in "normal circumstances", a high probability of using the contingency mechanism has a negative effect on competitiveness. This suggests, therefore, that if this type of mechanism is to be considered as part of an exchange-rate arrangement, \( q \) should not be "too high", that is, the threshold above which a discretionary adjustment of the exchange rate is allowed should not be too "low".

Finally, having shown the pros and cons for a small country of avoiding time-inconsistency problems by joining a monetary union in which the exchange rate is kept unalterably fixed, we can show that time-consistency problems could also be mitigated—and countries be made better off—by considering a more "flexible" type of monetary arrangement in which countries commonly manage the exchange rate, through a supra-national entity with discretionary powers. Essentially, this is because the supra-national entity always chooses a rate of devaluation that is less than would have been chosen by the domestic country if it acted alone, because it takes into account the induced adverse effect of an exchange rate depreciation on the competitiveness of the foreign country. Again, a fixed exchange-rate arrangement can be viewed as a "solution" to the time-inconsistency problem—in the sense of representing a compromise between the benefits of complete flexibility and the need for precommitment—only when the economy is not subjected to large, external shocks. When, on the contrary, foreign price disturbances are large, the cooperative solution in which a supra-national entity determines the "optimal" rate of depreciation of the exchange rate may yield a more favorable outcome.

VI. Concluding Remarks

The purpose of this paper has been to examine the time-inconsistency problem in the conduct of exchange rate policy which creates incentives for policymakers to "cheat" on fixed-exchange rate announcements, and the role that reputational factors, signaling considerations, and adherence to a currency union may play to alleviate it. The analysis has been based on a model in which the interactions between price-setting behavior in the nontraded goods

\[
\pi^*_T - \tilde{\pi}_N = \pi^*_T - q(\kappa - \tilde{\pi}_T)/(1 + uq) \geq 0,
\]
sector and concerns over the behavior of the real exchange rate create a temptation for the policymaker to pursue an active exchange rate policy. In this setting, inflation arises because price setters rationally fear that the authorities will try to devalue in order to depreciate the real exchange rate. The analysis also shows that a binding commitment to a fixed exchange rate, if feasible, would result in lower inflation with no loss in competitiveness. If commitment is not feasible—or not credible—the outcome is biased towards an inflationary process resulting from exchange rate devaluations, even in the absence of demand shocks. The incentive structure under a pegged arrangement thus may not be conducive to the adoption of an immutably fixed exchange rate (with attendant financial discipline) but rather to periodic devaluations.

The degree of credibility of a fixed exchange rate has been analyzed under the general assumption that a no-devaluation rule is credible only if it is rational for the public to believe that the authorities have the incentive to adhere to it. Credibility can be achieved if the policymaker worries enough about his reputation and balances future losses of credibility against immediate prospective balance-of-payments gains. Alternatively, when the preferences of the policymaker are uncertain, eschewing devaluation may provide a valuable signal to the private sector, thus increasing the incentives for the authorities to adhere to an announced exchange rate target. The analysis has also focused on the rationale for joining an international monetary arrangement which is intended to lead to permanently fixed exchange rates. Following Giavazzi and Pagano (1988), it has been argued that one could view an exchange rate union as a mechanism that enhances the pegging government’s credibility by raising the cost of inflationary policies. Governments can make binding commitments to the rules in the zone while they cannot precommit to macroeconomic rules outside the system because there are significant costs to the option of dropping out: these costs are related to the gains from macroeconomic cooperation that member countries would forego by going it alone. Finally, we have examined how international surveillance over exchange rate movements—in the limit by surrendering the discretionary power to alter the exchange rate to a supra-national authority—can enhance the credibility of an exchange-rate target by weakening the incentives for competitive devaluations.

There are several extensions of the present analysis that would be worth investigating. 1/ First, the paper has not examined the role

1/ The design of empirical methods to evaluate the degree of credibility of a fixed exchange rate regime is only just beginning and constitutes an important part of the research agenda in this area; see Bordo and Redish (1990) for a recent attempt which focuses on Canada’s interwar experience.
of budgetary and monetary policies in supporting a credible exchange rate policy. The relationship between fiscal policies and the credibility of the commitment of a country to price stability is, however, crucial. More generally, the analysis of credibility developed here is partial in the sense that it focuses only on exchange rate management. In practice, credibility should be assessed in the context of a model where several other policy instruments are available, and where their overall consistency with policy goals is deemed important. In that regard, an important issue would be to examine under what conditions an announced fixing of the nominal exchange rate might be preferable to a money supply target as a nominal anchor for tight financial policies.  

Second, the analysis does not deal with the intertemporal aspects of the government budget constraint in a fixed exchange rate regime, and its implications for the credibility and viability of a fixed parity.  

Third, the analysis could be extended to consider the effect of credibility on balance-of-payments crises. When agents perceive that the authorities' commitment--and ability--to maintain a fixed exchange rate is weak, speculative attacks may occur. If successful, a speculative attack will be self-fulfilling in the sense that it will lead to a devaluation--or a realignment of the currency within an exchange rate union. Such an attack may occur when the competitiveness of a high-inflation country has been eroded by holding the nominal exchange rate parity. This will, therefore, generate speculation that the currency will be devalued which may lead to an eventual exhaustion of the authorities' foreign exchange reserves and their external borrowing capacity, forcing them to devalue. Such a situation may be exacerbated if price setters incorporate the possibility of a devaluation in their pricing behavior, thereby adding further inflationary pressure.

Nevertheless, independently of how useful these extensions might prove to be, the central implication of the analysis developed here is likely to remain unaltered. In countries where policymakers can use the nominal exchange rate so as to alter the degree of competitiveness or to affect prices, simply fixing the exchange rate will not in general be sufficient to ensure financial and price stability. Additional institutional mechanisms must be enforced to convince a skeptical public of the authorities' commitment to adhere to its stated policy.

1/ For a discussion of alternative nominal anchors for an open economy, see Fischer (1986) and Bruno (1990).

2/ See Obstfeld (1991a) for a recent attempt to examine this issue.
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