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Transparency, reputation, and credibility under floating and pegged exchange rates

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Abstract

This paper shows that if the cost of importing foreign inflation and real exchange rate shocks are not too high, then the equilibrium nominal exchange rate regime for a country with a credibility problem is a peg, under which credibility is higher and inflation is lower than under a float. This holds true although devaluations of the pegged rate are assumed to be costless. The reason is that as realized inflation is not perfectly controllable, planned inflation under a float is private information. In contrast, since the exchange rate can be perfectly controlled, pegging resolves the private information problem, is more transparent, and makes reputation more effective.

Keywords: Credibility; Exchange rate regime choice; Private information; Reputation; Transparency

JEL classification: E52; E61; F33

1. Introduction

One explanation for excessively high inflation is that monetary policy suffers from a credibility problem (Barro and Gordon, 1983). According to this view, a government-dependent central bank does not have access to a precommitment technology, implying that the time inconsistent low inflation policy cannot be

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achieved. Therefore, an inflation bias results in equilibrium. Following the same logic, foreign inflation will be lower than domestic inflation if the foreign monetary authority can precommit. Since an irrevocably fixed nominal exchange rate imports foreign monetary policy into the domestic economy, it then reduces domestic inflation to foreign inflation. Giavazzi and Pagano (1988) therefore argued that fixing the exchange rate ties the hands of the domestic authority and amounts to the indirect appointment of the precommitted foreign central banker. It is frequently claimed that this is the reason why many countries with excessively high inflation records have at times fixed their exchange rates to a low inflation currency. Examples include the recent attempts at stabilizing from hyperinflation in Argentina, Bolivia, Israel, and Mexico; see Bruno (1993).[1]

Although Giavazzi and Pagano's argument has become widely accepted in the literature, there remains the critical problem that, in reality, exchange rate parities are never *fixed* irrevocably: while the nominal exchange rate can be *pegged* it remains adjustable. Thus, it is possible to create unexpected inflation through a devaluation. In light of this fact, a fundamental question arises: why should the equilibrium inflation rate be smaller and credibility be higher when the nominal exchange rate is pegged to a foreign low inflation currency than when the exchange rate floats and the domestic central bank tries to control the money supply so as to achieve a certain inflation rate? This question forms the basis of the present paper. In addressing it we assume for simplicity that the foreign central bank is precommitted to pursue a low inflation policy. Note that the analysis could also be extended to cases in which the foreign central bank has discretion, but does not suffer from a credibility problem as severe as the domestic one. Since achieving domestic precommitment through a reform of the central bank's institutional status is more difficult in practice than changing the exchange rate regime, we do not consider the former possibility here; see Herrendorf and Lockwood (1997) and Herrendorf (1998) for discussions of it.[2]

The present paper argues that the answer to the question raised above is related to the fact that a pegged exchange rate is more easily controlled than the inflation rate. A chosen parity that is consistent with the economic fundamentals can, in principle, be perfectly achieved, provided that the pegging authority gives up control over its money supply and has command over sufficient international reserves. The policy maker can then defend the exchange rate peg without limitations. In other words, problems related to speculative attacks are assumed

[1] The disinflation process within the European Monetary System has also been attributed to an import of credibility, in this case from the German Bundesbank; see e.g. Eichengreen (1993). However, the EMS crisis in 1992 gave rise to serious doubts whether the EMS indeed enhanced credibility.

[2] Note that, in many countries, the minister of finance is given the power to choose the exchange rate regime, whereas a reform of the central bank's institutional status requires the approval of parliament.

away.[3] In contrast, the inflation rate is endogenous when the authority tries to control the money supply under a float. Hence, a low inflation rate is inherently not perfectly achievable due to uncontrollable factors influencing the money supply, to the instability of money demand, and to the uncertain time lag with which changes in base money are transmitted to inflation.

It has sometimes been claimed that the higher credibility of a low inflation policy under a peg is due to this difference in controllability; see, for example, (Giavazzi and Giovannini, 1989, p. 103). However, the relationship between controllability and credibility has not been modelled formally. Existing contributions typically present some informal arguments and then proceed by assuming that there is a fixed cost of devaluing a pegged exchange rate [see Flood and Isard (1989), Rasmussen (1993), and Obstfeld (1997)], or that reputation does not work under a float [see de Kock and Grilli (1993) and also the critique in Herrendorf (1997a)]. This paper intends to close the existing gap. It points out that the imperfect controllability of realized inflation implies that monetary policy under a float is less transparent than under peg. In particular, planned inflation under a float will necessarily be the authority's private information. This means that, under a float, the private sector will, in general, be in doubt whether or not an inflation surprise was generated by a positive realization of a velocity shock or by an attempt of the policy maker to stimulate output. Consequently, the monitoring of monetary policy is imperfect. In contrast, exchange rate pegging is found to resolve the private information problem and to allow the private sector to monitor closely the actions of the monetary authority.

Canzoneri (1985) showed for a closed economy that the private information problem tends to weaken the functioning of reputational forces. Following his argument, one would expect reputation to be more effective when the exchange rate is pegged. That this is indeed true is proved analytically for a signalling game in the spirit of Backus and Driffill (1985), in which there is uncertainty about whether the policy maker is dependable [precommitted to zero inflation] or weak [not precommitted to zero inflation]. The results of the analysis are: (i) except in the last period, exchange rate pegging can enhance credibility [as measured by the inverse of inflation expectations] and reduce equilibrium inflation; (ii) in equilibrium, both types of policy makers may choose to peg the exchange rate when the cost of importing foreign inflation and real exchange rate shocks are not too high.

The paper is organized as follows. In Section 2 the model description is presented and Section 3 discusses the information structure under different exchange rate regimes. The effects of the exchange rate regime on equilibrium

[3] Note that to defend the peg it is sufficient that the central bank possesses enough international reserves to buy back the complete domestic money stock outstanding. In reality, the provisions of a mutual exchange rate agreement may assist.

inflation and credibility are analyzed in Sections 4 and 5. In Section 6 the choice of the optimal exchange rate regime is studied. A discussion of alternative policy regimes follows in Sections 6 and 7 concludes.

2. The model

We model the domestic economy by employing a version of Barro and Gordon's (1983) model of monetary policy. Domestic output is determined by an expectations augmented Phillips curve, the slope of which is normalized to one:

$$y_t = \pi_t - \pi_t^e. \tag{1}$$

There are two periods, implying that the time index t is in {1,2}. Furthermore, y_t denotes the logarithmic deviation of actual output from its equilibrium value [which is normalized to zero], and π_t and π_t^e stand for realized and expected inflation.

We assume that prices are flexible and that inflation is determined by the equilibrium in the money market. However, this is not modelled explicitly; instead, we take a short cut and postulate that the policy maker can directly set planned inflation, π_t^p. Realized inflation is then given by

$$\pi_t = \pi_t^p + \psi_t, \tag{2}$$

where ψ_t is a stochastic disturbance with zero mean and finite variance σ_ψ^2. Eq. (2) reflects that, in the real world, control over realized inflation is imperfect due to stochastic shocks to the money multiplier or velocity.

In order to model the domestic credibility problem, we follow Backus and Driffill (1985) and introduce uncertainty about the characteristics of the domestic policy maker: he may either be a dependable type, D, who is precommitted to plan zero inflation, or a weak type, W, who has discretion. The assumptions about the two types are as in Barro (1986) and Cukierman and Liviatan (1991).[4] When the game starts, individuals do not know which policy maker is in office, but hold a prior belief in the form of a probability $\mu_1 \in (0, 1]$ that it is the dependable type. This probability is referred to as the pre-game reputation for being dependable. Both types are assumed to have the same policy objective, the present discounted value of which is given by

$$U^i = \sum_{t=1}^{2} \delta^{t-1} u_t^i \equiv -\sum_{t=1}^{2} \delta^{t-1}[c(y_t - \bar{y})^2 + (\pi_t)^2], \tag{3}$$

[4]Note that they differ from those in Backus and Driffill. They distinguished between a dry type, who does not care at all about output (i.e. $c=0$ for the dry type), and a wet type, who cares about output (i.e. $c>0$ for the wet type). The results are the same in both settings.

where c, $\bar{y}>0$, $i\in\{D, W\}$, and $\delta\in(0, 1)$ is a discount factor. Underlying specification (3) are the standard notions that the policy maker's output target, $\bar{y}$, is overly ambitious [i.e. larger than equilibrium output] and that inflation involves social cost.

The nominal exchange rate is the price of the foreign currency in terms of the domestic currency. We assume that relative purchasing power parity holds on average. The rate of nominal exchange rate depreciation, e_t, can then be written as

$$e_t = q_t + \pi_t - \pi_t^*, \tag{4}$$

where q_t is an iid shock to the real exchange rate, which has zero mean, a finite variance σ_q^2, and is independent of all other shocks in the model. Since the domestic economy is small, the domestic policy maker can choose between a floating and a unilaterally pegged exchange rate without affecting the rest of the world. When the exchange rate floats, he attempts to control inflation, for example, through exercising control over the money supply. The rate of nominal exchange rate depreciation is in this case given by Eq. (4). Conversely, unilaterally pegging the nominal exchange rate implies $e_t=0$. Given the assumption that there are no capital controls, the domestic money supply then becomes endogenous and foreign inflation is imported:

$$\pi_t^p(peg) = E(\pi_t^* - q_t), \tag{5a}$$

$$\pi_t(peg) = \pi_t^* - q_t. \tag{5b}$$

For simplicity, foreign monetary policy making is not modelled explicitly, but foreign inflation, π_t^*, is specified as an iid disturbance with finite variance $\sigma_{\pi^*}^2$. Since the foreign authority is assumed to have access to a precommitment technology, the expected value of π_t^* is taken to be zero. Note that by Eq. (5a) planned domestic inflation under a peg is then zero too, $E(\pi_t^p(peg))=0$. The fluctuations in foreign inflation can either come from unanticipated foreign shocks to velocity, or from the foreign authority's attempts to stabilize anticipated shocks to foreign output. Since, in the present set-up, these shocks do not occur in the domestic country, the domestic authority does not appreciate the foreign stabilization attempts when the exchange is pegged, because they will lead to fluctuations of domestic inflation and output. This is a convenient way of capturing the notion that the optimal foreign monetary policy is not optimal from the domestic point of view.[5]

We complete the description of the model by specifying the sequence of events: (i) the domestic policy maker's type is determined; (ii) he chooses between a float and a peg; (iii) domestic individuals take as given this choice, the pre-game

[5] A similar assumption was made by Andersen (1994). A more complete set-up would model foreign stabilization policy explicitly and would also contain shocks to domestic output. However, this would not change the results in a crucial way.

reputation, and the reaction functions of both types; they form rational inflation expectations, π_1^e, and sign one period, nominal wage contracts so as to achieve equilibrium output; (iv) the domestic policy maker sets the money supply or the rate of exchange rate devaluation so as to achieve his preferred planned inflation rate; (v) the realizations of foreign inflation, π_1^*, the real exchange rate shock, q_1, and the domestic velocity shock, ψ_1, occur and domestic output and inflation result; (vi) individuals update the pre-game reputation according to Bayes rule and set the nominal wage for the second period; (vii) the steps (iv) and (v) are repeated.

For future reference, we note that the ex ante optimal domestic inflation plan of the one shot game is $\pi_t^p(opt)=0$. However, since $\pi_t^p(opt)$ is time inconsistent, it can only be achieved in the one shot game when it is known that the policy maker can precommit. In contrast, when the policy maker has discretion, then the time consistent Nash-equilibrium policy will result in the one shot game: $\pi_t^p(dis)=c\bar{y}$. As was pointed out by Barro and Gordon (1983), inflation is suboptimally high under discretion, $\pi_t^p(opt)<\pi_t^p(dis)$. The challenge of the credibility literature has been to find ways by which this inflation bias can be reduced. Here, we are interested in studying the disciplinary effects of reputational forces under different exchange rate regimes, given that the foreign country has solved the time consistency problem, for example, through a successful institutional reform.[6]

Before we start with the formal analysis, it is useful to discuss the effect of the exchange rate regime choice on the informational structure.

3. Transparency under a float and a peg

When the nominal exchange rate floats, individuals can only observe the realization of domestic inflation, that is, the sum of planned inflation, π_t^p, and the stochastic disturbance ψ_t. As was first pointed out by Canzoneri (1985), π_t^p must then be the domestic policy maker's private information, because it is not incentive compatible to reveal it truthfully when the effect of surprise inflation is perceived as being beneficial. This is due to the fact that an unprecommitted policy maker optimally plans surprise inflation and blames a large realization of the disturbance ψ_t for the possibly resulting increase in realized inflation. Consequently, individuals cannot completely verify whether unexpected inflation was caused by a shock or by the authority attempting to stimulate output. The monitoring of the authority's actions will thus be imperfect when the exchange rate floats. In contrast, when the exchange rate is pegged, an unexpected domestic velocity shock will lead to offsetting changes in the central bank's stock of

[6] Note that in a finitely repeated game such as ours, reputation cannot have an effect in the last period. Thus, there will always be an inflation bias in the last period if the weak type is in power.

international reserves [and the domestic money supply], while the exchange rate and the domestic inflation rate remain unchanged. Moreover, given that Eq. (4) holds and that expected foreign inflation is zero, pegging the nominal exchange rate unambiguously implies that planned domestic inflation is zero too. Consequently, it eliminates the ambiguity about the actions of the domestic policy maker and monitoring is perfect.

Two implicit assumptions underlying the preceeding discussion are that there are no capital controls and that the nominal exchange rate can be perfectly controlled when control over domestic inflation is relinquished. This implies that we exclude situations from the analysis in which the domestic policy maker does not have command over a stock of international reserves sufficiently large to buy the excess supply of the domestic currency in the foreign exchange market. Furthermore, speculative attacks are assumed away through the requirement that the peg be consistent with the economic fundamentals determining the nominal exchange rate.

It should be stressed that a peg is transparent despite the fact that shocks to foreign inflation or the real exchange rate will give rise to domestic inflation surprises. These surprises do not affect transparency because under perfect capital mobility attempts to expand the domestic money supply will be frustrated by a loss of foreign reserves. Thus, the domestic authority cannot generate domestic inflation surprises when the exchange rate remains pegged, implying that planned inflation must be zero. This would be different in a Mundell–Fleming model with sticky prices and capital controls, in which domestic monetary policy is effective in the short run. In this case, a peg would no longer be transparent, because changes in domestic output could be due to shocks or to deliberate manipulations of the domestic money supply. This point underlies the conventional wisdom put forth by Friedman and Johnson in the 1960s and 1970s, who argued that a pegged exchange rate leaves room for misbehavior.[7] Their idea was that under a peg with capital controls the authority's monetary policy actions are only reflected in the evolution of the stock of international reserves that most individuals do not observe closely. Hence, it may be possible to create unexpected inflation even though the exchange rate is pegged. Notice that even if there are no capital controls, an unsustainable *fiscal* policy stance may remain unnoticed for some time when the exchange rate is pegged, again because the resulting loss of international reserves is not immediately spotted by most individuals. Friedman and Johnson also argued that a float cures these problems, as any change in the money supply results in an immediate change in the nominal exchange rate that is observed by everybody. While it is true that misbehavior translates into exchange rate fluctuation under a float, the public may not be able to distinguish these exchange rate movements from those arising from LM-shocks. The reason is the same

[7] I owe this point to a referee.

private information problem as prevails in the present set-up. A float is therefore never fully transparent.

A final interesting point to notice is that while in the present model, the incompleteness of information about the policy maker's actions stems from a difference in controllability, it could as well have been derived from a difference in observability. In particular, the nominal exchange rate is more visible than the inflation rate, because the former is the price of the foreign currency in terms of the domestic currency in the single foreign exchange market. This price is continuously quoted. In contrast, inflation is, in reality, measured periodically and by the use of various price indices. These measurements are often thought to be substantially inaccurate, for example, because of the uncertain time lag with which actual price changes are measured or because of the well known imprecision of price indices. Therefore, a similar incomplete information problem to that described above would be present, if one accounted for the fact that the public can only observe the measured inflation rate, i.e. the sum of the true inflation rate and a measurement error.[8]

To summarize, individuals know the policy maker's planned inflation rate only when the exchange rate is pegged. Hence, exchange rate pegging is a more transparent regime than money supply control under a floating exchange rate. In the following two sections, we will show formally that, for this reason, reputational forces can have a stronger disciplinary effect on a weak policy maker when the exchange rate is pegged.

4. Reputation and inflation under a float

In order to keep the formal analysis tractable, we assume from now on that the disturbance ψ_t is uniformly distributed with a compact support $[-s_\psi, s_\psi]$, where $0<s_\psi<\infty$. This implies that $\sigma_\psi{}^2=s_\psi{}^2/3$. Since we are interested in the consequences of a relatively imprecise degree of control over inflation, attention is restricted to cases in which the support of ψ_t is relatively large, by which we mean that

$$c\bar{y} \leq 2s_\psi. \tag{6}$$

Assuming Eq. (6) ensures that planned inflation does not exceed $2s_\psi$, because it is

[8]In independent work, Canavan and Tommasi (1996, 1997), have analyzed the consequences of this difference in observability. They have shown that policy makers who are more committed to disinflate prefer to peg the exchange rate. One important difference between their and our game is that pure strategy equilibria exist in our model, but not in their model. Thus, they cannot study the interaction between the exchange rate regime choice and the effectiveness of reputational forces in a pooling equilibrium. The analysis of this interaction is the main focus of the present paper.

never optimal to plan more than the time consistent inflation rate of the one shot game, $\pi_t^{\,p}(dis)=c\bar{y}$.

As mentioned before, it is assumed that the dependable policy maker is precommitted to plan zero inflation. For this reason, we only need to find the sequential equilibrium strategy of the weak policy maker,

$$S^W(\mathit{float}, \omega_1) = (\pi_1^p(\mathit{float}, \omega_1), \pi_2^p(\mathit{float}, \omega_1)), \text{ where} \tag{7a}$$

$$\pi_1^p(\mathit{float}, \omega_1) \equiv \omega_1 c\bar{y}, \; \omega_1 \in [0, 1/(1+\mu_1 c)]. \tag{7b}$$

In Appendix A, it is shown that following $S^W(\mathit{float}, \omega_1)$ gives the weak policy maker an expected present discounted payoff of

$$\begin{aligned} E(U^W(\mathit{float}, \omega_1)) = & -[c(1-\mu_1\omega_1 c)^2 + (\omega_1 c)^2]\bar{y}^2 - (1+\delta)(1+c)\sigma_\psi^2 \\ & - \delta\left\{\left[1 - \frac{\omega_1 c\bar{y}}{2s_\psi}\right]\frac{c(1+c)}{(1+\mu_1 c)^2}\bar{y}^2 + \frac{\omega_1 c\bar{y}}{2s_\psi}c(1+c)\bar{y}^2\right\}. \end{aligned} \tag{8}$$

To characterize when $S^W(\mathit{float}, \omega_1)$ is a sequential equilibrium strategy for the weak policy maker, we consider possible deviations from it:[9]

$$S^W(\mathit{float}, \omega_1, \varepsilon_1) = (\pi_1^p(\mathit{float}, \omega_1, \varepsilon_1), \pi_2^p(\mathit{float}, \omega_1, \varepsilon_1)), \text{ where}$$

$$\pi_1^p(\mathit{float}, \omega_1, \varepsilon_1) \equiv \omega_1 c\bar{y} + \varepsilon_1 \text{ and } \varepsilon_1 \in (-\omega_1 c\bar{y}, (1-\omega_1)c\bar{y}]. \tag{9}$$

The Appendix B proves that the expected present discounted payoff after such a deviation is

$$\begin{aligned} E(U^W(\mathit{float}, \omega_1, \varepsilon_1)) = & \; E(U^W(\mathit{float}, \omega_1)) - (1+c)\varepsilon_1^2 \\ & - \left\{\delta\left[1 - \frac{1}{(1+\mu_1 c)^2}\right]\frac{c(1+c)\bar{y}^2}{2s_\psi} \right. \\ & \left. - [1 - \omega_1(1 + c\mu_1)]2c\bar{y}\right\}\varepsilon_1. \end{aligned} \tag{10}$$

$S^W(\mathit{float}, \omega_1)$ is a sequential equilibrium strategy of the policy game, if and only if [iff for short] no deviation increases the present value of the weak policy maker's expected payoffs, $E(U^W(\mathit{float}, \omega_1, \varepsilon_1)) \leq E(U^W(\mathit{float}, \omega_1))$ for all $\varepsilon_1 \in (-\omega_1 c\bar{y}, (1-\omega_1)c\bar{y}]$. In light of Eq. (10), this is equivalent to

[9] Note that $(1-\omega_1)c\bar{y}$ is an upper bound for ϵ_1 because for larger deviations the resulting planned inflation rate would be larger than the time consistent rate. This cannot be optimal.

$$0 \leq \frac{1+c}{2}\,\varepsilon_1^2 + \left\{\delta\left[1 - \frac{1}{(1+\mu_1 c)^2}\right]\frac{c(1+c)\bar{y}^2}{4s_\psi} - [1-\omega_1(1+c\mu_1)]c\bar{y}\right\}\varepsilon_1$$
$$\forall \varepsilon_1 \in (-\omega_1 c\bar{y}, (1-\omega_1)c\bar{y}]. \tag{11}$$

In order to analyze Eq. (11) further, we need to distinguish between $\omega_1 = 0$ and $\omega_1 \in (0, 1]$.

If $\omega_1 = 0$, Eq. (11) has to hold $\forall \varepsilon_1 \in (0, c\bar{y}]$. After dividing by ε_1 and letting ε_1 converge to zero, one finds a necessary condition for Eq. (11) to be satisfied,

$$c\bar{y} \leq \delta\left[1 - \frac{1}{(1+\mu_1 c)^2}\right]\frac{c(1+c)\bar{y}^2}{4s_\psi}. \tag{12}$$

The left-hand side represents the expected gain from a marginal deviation from pooling [i.e. the expected output gain in period one], whereas the right-hand side comprises the marginal expected cost [i.e. the expected increase in inflation expectations for period two]. Note that the marginal expected cost decreases when the support of the disturbance ψ increases. This is due to the private information problem under a float: a larger variability of realized inflation reduces the probability with which a surprise is detected.

Since Eq. (12) guarantees that the coefficient of ε_1 in Eq. (11) is positive, Eq. (12) is also sufficient for Eq. (11) to be satisfied. Rearranging Eq. (12) and using that for a uniform distribution $\sigma_\psi = s_\psi \sqrt{3}$, we therefore have

Lemma 1. *Under a floating exchange rate regime, a pooling equilibrium exists iff*

$$4\sqrt{3}\sigma_\psi \leq \delta\left[1 - \frac{1}{(1+\mu_1 c)^2}\right](1+c)\bar{y}. \tag{13}$$

Eq. (13) shows that the weak policy maker plans zero inflation in period one iff: (i) control over inflation is precise; (ii) the future is not discounted heavily; (iii) the pre-game reputation for being dependable is high; (iv) the inflationary bias $c\bar{y}$ under discretion is large. In contrast, if these conditions are not met then the disciplining effect from a possible loss of reputation is too weak and a pooling equilibrium does not exist under a floating exchange rate regime. For example, during attempts at stabilization from high inflation, control over inflation is typically rather imprecise and a pooling equilibrium is not likely to exist under a float. We now characterize the sequential equilibrium in this case.

If $\omega_1 \in (0, 1]$, Eq. (11) has to hold $\forall \varepsilon_1 \in (-\omega_1 c\bar{y}, (1-\omega_1)c\bar{y}]$. Since the right-hand side of Eq. (11) is a quadratic function in ε_1 that becomes zero for $\varepsilon_1 = 0$, Eq. (11) can only be true if this quadratic function has a minimum in zero. This is equivalent to

$$0=\delta\left[1-\frac{1}{(1+\mu_1 c)^2}\right]\frac{(1+c)\bar{y}}{4s_\psi}-[1-\omega_1(1+c\mu_1)]. \tag{14}$$

Solving Eq. (14) for ω_1 gives

Lemma 2. *If condition (13) is violated under a floating exchange rate, then the first period equilibrium strategy of the weak type is*

$$\pi_1^p(\mathit{float},\omega_1)=\omega_1 c\bar{y},\ \text{where}$$
$$\omega_1\equiv\frac{1}{1+\mu_1 c}\left\{1-\delta\left[1-\frac{1}{(1+\mu_1 c)^2}\right]\frac{(1+c)\bar{y}}{4\sqrt{3}\sigma_\psi}\right\}. \tag{15}$$

Note that $\omega_1\in[0, 1/(1+\mu_1 c)]$ when condition (13) does not hold, that is, Eq. (15) is consistent with Eq. (7b). Moreover, we can observe that the inflationary bias is the larger, the less precisely inflation can be controlled. This reflects the fact that more noise reduces the probability of revelation after the creation of surprise inflation. In the limit, σ_ψ is infinite, reputational forces 'lose their bite completely' and $\pi_1^p(\mathit{float}, 1)=c\bar{y}/(1+\mu_1 c)$ becomes the sequential equilibrium strategy of the weak policy maker for the first period of the policy game.[10]

It is worth mentioning that our sequential equilibrium exhibits some non-standard features: although Eq. (15) is a pure strategy equilibrium, it is neither a pooling nor a separating equilibrium.[11] Instead, revelation occurs with the positive probability $(\omega_1 c\bar{y})/(2s_\psi)$. The intuition behind this result is that by choosing a planned inflation rate for the first period that is larger than under pooling, but smaller than under separation, the weak policy maker optimally trades off the probability of revelation against the first period gains from unexpected inflation. If there were no noise, this tradeoff would be absent since any deviation in the first period would reveal his type. Second, providing there is enough noise [i.e. condition (6) holds true], the sequential equilibrium will always be the pure strategy equilibrium Eq. (15). Hence, mixed strategy equilibria with randomization between pooling and separation may be absent when one accounts for the fact that control over inflation is imperfect.

5. Reputation and inflation under a peg

The dependable policy maker is again assumed to be precommitted to plan zero inflation, which, however, is now accomplished through pegging the exchange rate. As discussed in Section 3, the key feature of a pegged nominal exchange rate

[10]Notice that $\pi_1^p(\mathit{float}, 1)$ equals the ex post optimal strategy for period two when revelation has not occurred in period one.

[11]In a separating equilibrium revelation occurs in the first period.

is that it is transparent and indicates unambiguously which inflation rate the domestic policy maker plans. Thus, monitoring of the policy maker's actions becomes perfect. The proposition to be proved is that this strengthens the disciplinary effect of reputation compared to the situation under a float. Therefore, we seek to derive a condition for the existence of a pooling equilibrium, in which the weak policy maker pegs the nominal exchange rate in the first period. His strategy in a pooling equilibrium is represented by

$$S^W(peg,\ pool) = (0,\ \pi_2^p(peg,\ pool)), \tag{16}$$

where $\pi_2^p(peg,\ pool)$ is to be determined.

In a pooling equilibrium, inflation expectations for the first period are zero and the expected first period utility is

$$E(u_1^W(peg,\ pool)) = c\bar{y}^2 - (1+c)(\sigma_{\pi*}^2 + \sigma_q^2). \tag{17}$$

Since under pooling there is no updating of beliefs, inflation expectations for the second period are $\pi_2^e(peg,\ pool) = (1-\mu_1)\pi_2^p(peg,\ pool)$, implying that

$$\pi_2^p(peg,\ pool) = \frac{c}{1+\mu_1 c}\,\bar{y}, \tag{18a}$$

$$E(u_2^W(peg,\ pool)) = -\frac{c(1+c)}{(1+\mu_1 c)^2}\,\bar{y}^2 - (1+c)\sigma_\psi^2. \tag{18b}$$

Note that we have implicitly assumed that the weak policy maker abandons the exchange rate peg and increases the money supply when he decides to create surprise inflation. Thus, the variance of domestic inflation, σ_ψ^2, enters Eq. (18b). Alternatively, surprise inflation could be achieved through a devaluation of the exchange rate. Domestic inflation would then be determined endogenously and its variance would equal the variance of foreign inflation plus the variance of the real exchange rate shock, $\sigma_{\pi*}^2 + \sigma_q^2$ In order to justify the assumption that surprise inflation is not engineered through a devaluation, we assume that control over the domestic money supply results in less variance of domestic inflation than pegging the exchange rate,

$$\sigma_\psi^2 < \sigma_{\pi*}^2 + \sigma_q^2. \tag{19}$$

This excludes cases from the analysis in which exchange rate pegging is not costly, despite its import of foreign inflation and real exchange rate shocks. Since we intend to derive a condition under which exchange rate pegging is preferred regardless of its cost, it is appropriate to assume that Eq. (19) holds.

Collecting the terms in Eqs. (17) and (18b), the expected present discounted value of the weak policy maker's payoff under pooling is obtained,

$$E(U^W(peg, pool)) = -c\bar{y}^2\left[1 + \delta\frac{1+c}{(1+\mu_1 c)^2}\right] - (1+c)[(\sigma^2_{\pi*} + \sigma^2_q) + \delta\sigma^2_\psi]. \tag{20}$$

We now turn to deviations from pooling in the first period of the game. Since any deviation from planning zero inflation must cause a devaluation of the nominal exchange rate, it will inevitably lead to revelation. Thus, individuals expect the discretionary outcome for the second period and we get

$$E(u^W_2(peg, pool, dev)) = -(1+c)c\bar{y}^2 - (1+c)\sigma^2_\psi. \tag{21}$$

If the weak policy maker intends to deviate in the first period, he will plan the rate of surprise inflation that maximizes his expected first period utility. Recalling that individual inflation expectations for the first period are zero in a pooling equilibrium, the optimal deviation can be shown to equal $\pi^p_1(peg, pool, dev) = \bar{y}c/(1+c)$. This gives the following expected utility for the first period:

$$E(u^W_1(peg, pool, dev)) = -\frac{c}{1+c}\bar{y}^2 - (1+c)\sigma^2_\psi. \tag{22}$$

The expected present discounted value of the weak policy maker's payoffs after creating surprise inflation is immediate from Eqs. (21) and (22),

$$E(U^W(peg, pool, dev)) = -c\bar{y}^2\left[\frac{1}{1+c} + \delta(1+c)\right] - (1+\delta)(1+c)\sigma^2_\psi. \tag{23}$$

As before, $S^W(peg, pool)$ is a sequential equilibrium strategy iff $E(U^W(peg, pool, dev)) \le E(U^W(peg, pool))$. Using Eqs. (20) and (23), we obtain:

Lemma 3. *Under exchange rate pegging a pooling equilibrium exists iff*

$$(1+c)[(\sigma^2_{\pi*} + \sigma^2_q) - \sigma^2_\psi] + \frac{c^2}{1+c}\bar{y}^2 \le \delta\left[1 - \frac{1}{(1+\mu_1 c)^2}\right]c(1+c)\bar{y}^2. \tag{24}$$

The intuition for condition (24) is similar to that for condition (13): the left-hand side shows the expected marginal gain from deviating in period one, whereas the right-hand side shows the expected marginal cost. However, there are two differences between the two conditions. First, since exchange rate pegging guarantees perfect monitoring, only condition (13) depends on σ_ψ. Second, only condition (24) depends on the sum of the variances of foreign inflation and the real exchange rate minus the variance of domestic inflation, that is, the cost of exchange rate pegging.

6. Credibility and the exchange rate regime choice

We now combine the results of the preceeding two sections and discuss the optimal regime choice. To this end, we first notice that comparison of conditions (13) and (24) yields

Proposition 1. *Pooling is a sequential equilibrium under a peg, but not under a float iff*

$$\frac{1+c}{c\bar{y}}\left[(\sigma^2_{\pi*}+\sigma^2_q)-\sigma^2_\psi\right]+\frac{c}{1+c}\,\bar{y}\le\delta\left[1-\frac{1}{(1+\mu_1 c)^2}\right](1+c)\bar{y} < 4\sqrt{3}\sigma_\psi. \tag{25}$$

There certainly exist parameter combinations for which both inequalities in condition (25) hold true. For example, if $\sigma^2_{\pi*}+\sigma^2_q=\sigma^2_\psi$, and $\mu_1=1$, then the first inequality will clearly be satisfied when $\delta\ge 1/(2+c)$. Moreover, the second inequality will be met whenever σ_ψ is sufficiently large. Hence, if (i) the cost of exchange rate pegging is small, (ii) the future is not discounted too heavily, (iii) the pregame reputation for being dependable is large, (iv) the precision of domestic inflation control is poor, then the weak policy maker pegs the nominal exchange rate in the first period, although he would plan positive inflation under a float.[12]

Next, we turn to the optimal policy regime choice at the beginning of the game. Attention is restricted to situations in which planning zero inflation is a pooling equilibrium only when the exchange rate is pegged, that is, the validity of condition (25) is assumed to hold from now on. We start with the dependable policy maker's decision problem. In spite of being precommitted to plan zero inflation under both exchange rate regimes, his expected payoff depends on the exchange rate regime. The reason is that inflation expectations differ between both regimes. In particular, under a peg, $\pi^e_1(peg,\ pool)=0$ and $\pi^e_2(peg,\ pool)=(1-\mu_1)c\bar{y}/(1+\mu_1 c)$. The expected present discounted value of the dependable policy maker's payoff under a pegged exchange rate is

$$E(U^S(peg,\ pool)) = -c\bar{y}^2\left\{1+\delta\left[\frac{1+c}{1+\mu_1 c}\right]^2\right\} - (1+\delta)(1+c)(\sigma^2_{\pi*}+\sigma^2_q). \tag{26}$$

[12] Note that our results for the first period when the policy maker is weak are similar to those often *assumed* in the literature: an inflationary bias emerges only under a floating exchange rate; see, for instance, de Kock and Grilli (1993). In contrast to this literature, which typically employs infinitely repeated games, the weak policy maker in a finitely repeated game, like ours, produces an inflation bias in the second period irrespective of the exchange rate regime.

In contrast, if the exchange rate regime is a float, then $\pi_1^e(\mathit{float}, \omega_1) = (1-\mu_1)\omega_1 c\bar{y}$, $\omega_1 \in [0, 1/(1+\mu_1 c)]$. Furthermore, since realized inflation will not exceed s_ψ when the dependable policy maker is in charge, there is no updating of beliefs after the first period and expected inflation for the second period is $(1-\mu_1)c\bar{y}/(1+\mu_1 c)$, the same as under exchange rate pegging. Consequently, the dependable type's expected payoff under a float is

$$E(U^S(\mathit{float}, \omega_1)) = -c\bar{y}^2\left\{[1+(1-\mu_1)\omega_1 c]^2 + \delta\left[\frac{1+c}{1+\mu_1 c}\right]^2\right\} - (1+\delta)(1+c)\sigma_\psi^2. \quad (27)$$

The dependable policy maker favors pegging iff this yields a higher expected payoff than floating, $E(U^S(\mathit{float}, \omega_1)) \le E(U^S(\mathit{peg}, \mathit{pool}))$. Using Eqs. (26) and (27), this is found to be equivalent to

$$(1+\delta)(1+c)[(\sigma_{\pi*}^2 + \sigma_q^2) - \sigma_\psi^2] \le c\bar{y}^2\{[1+(1-\mu_1)\omega_1 c]^2 - 1\}. \quad (28)$$

Inequality (28) certainly holds if $\sigma_{\pi*}^2 + \sigma_q^2 = \sigma_\psi^2$. Hence, by continuity arguments, there must exist parameter combinations for which both inequality (25) and (28) are met. The inequality (28) reflects a trade-off between flexibility and credibility akin to that in Rogoff (1985). On one hand, pegging the exchange rate imports foreign inflation and shocks to the real exchange. This leads to suboptimal fluctuations of domestic output [left-hand side of inequality (28)].[13] On the other hand, exchange rate pegging improves credibility as measured by a reduction in the present discounted value of inflation expectations [right-hand side of inequality (28)].

We complete the discussion of the optimal exchange rate regime choice by noting that the weak policy maker chooses an exchange rate peg if the dependable one would do so. The reason is simply that a different choice would reveal his type before individuals form expectations for the first period. The weak type could clearly improve upon this outcome by choosing a peg and dropping it in the first period. Thus, we have:

Proposition 2. *Given that condition (25) is satisfied, an exchange rate peg is the equilibrium policy regime iff condition (28) holds in addition.*

7. Alternative policy regimes

In this section, we discuss whether our results can also be generalized to the following alternative policy regimes: base money targeting; nominal interest rate pegging; a managed float; a crawling peg. First, while the monetary base can be

[13] Note that this effect would be amplified if the domestic economy were also subject to output shocks, which would, presumably, be different from the foreign ones. A peg would then also imply that these domestic shocks cannot be stabilized.

controlled more precisely than the inflation rate, it is not as visible. Therefore, base money targeting is not transparent.[14] In addition, base money targeting has the disadvantage that velocity or output shocks are not stabilized. Second, interest rate pegging may be as transparent as exchange rate pegging. However, given our set-up, covered interest parity holds and interest rate pegging is equivalent to exchange rate pegging. Third, we have assumed that the domestic policy maker does not possess any information about the realizations of foreign inflation and the shock to the real exchange rate. If this assumption were relaxed, then part of the cost of exchange rate pegging could be avoided when the import of anticipated disturbances were prevented through devaluations. However, such a managed float is not a transparent exchange rate regime, because the policy maker's information about π_t^* and q_t is not verifiable by the domestic public due to the same private information problem as discussed above.

Fourth, in our setting, there is no role for a crawling exchange rate peg, under which the nominal exchange rate is periodically devalued by a preannounced rate and domestic inflation differs from foreign inflation by the rate of devaluation. However, crawling pegs were chosen by various countries in their attempts to stabilize from high inflation, a recent example being Poland. The model could be generalized in two ways to explain this fact. On one hand, optimal taxation considerations could be added: if the domestic authority optimally collects a larger share of government revenues from seigniorage than the foreign authority, then the ex ante optimal domestic inflation rate is larger than the foreign one.[15] This could be captured by changing the domestic policy objective to $u^i = -c(y_t - \bar{y})^2 - (\pi_t - \bar{\pi})^2$, where $\bar{\pi} > 0$. A crawling peg would then result as the preferred exchange rate regime whenever a peg is preferred in the present model.

Alternatively, one could relax the assumption that the dependable policy maker is precommitted to plan zero inflation and allow him to announce the inflation rate to which he prefers to precommit. As shown by Cukierman and Liviatan (1991), he would then choose a positive rate of planned inflation in all periods in which a credibility problem prevails and private inflation expectations are positive. The intuition is that by partly accommodating positive inflation expectations, the dependable policy maker can mitigate the recession that results when realized inflation falls short of expected inflation. Thus, if the sequential equilibrium is pooling in our model, a crawling peg would result as the equilibrium outcome in periods in which inflation expectations are positive.

8. Conclusion

In this paper, the credibility of monetary policy making has been analyzed under

[14] In related work, Cukierman (1995) compared base money targeting and inflation targeting under the assumption that the dependable policy maker wants to separate himself from the weak one.

[15] For a detailed discussion of optimal seigniorage collection see Herrendorf (1997b).

two different nominal exchange rate regimes. It has been argued that exchange rate pegging to a low inflation currency is transparent and resolves the private information problem, which necessarily prevails when the domestic policy maker attempts to control inflation while the nominal exchange rate floats. We have shown that, for this reason, exchange rate pegging may strengthen the disciplinary effects of reputational forces, import credibility, and reduce the inflationary bias of discretionary policy making, compared to a floating exchange rate regime. Moreover, it has been proved that a peg can be the equilibrium policy regime, provided that the implied cost [import of foreign inflation etc.] are not too large.

The novelty of the results is that exchange rate pegging may improve domestic credibility in our model even if the domestic policy maker is endowed with complete discretion to devalue. This makes the results widely applicable. In particular, the model can explain why unilateral exchange rate pegs have been an integral part of the vast majority of historical stabilization programs from high inflation or hyperinflation, during which control over inflation has been relatively loose and the private information problem relatively severe.

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Appendix A

Derivation of Eq. (8)

If $\pi_1^p(\mathit{float},\ \omega_1)$ is a sequential equilibrium strategy, individual inflation expectations for the first period are $\pi_1^e(\mathit{float},\ \omega_1) = (1-\mu_1)\omega_1 c\bar{y}$ and the expected first period utility is

$$E(u_1^W(float, \omega_1)) = -[c(1-\mu_1\omega_1 c)^2 + (\omega_1 c)^2]\bar{y}^2 - (1+c)\sigma_\psi^2. \tag{A.1}$$

Individual inflation expectations for the second period depend on the realization of the disturbance ψ_1.

Given that ψ_1 is uniformly distributed and that (6) is satisfied, two possibilities are to be distinguished. First, if

$$\pi_1(float, \omega_1) = \omega_1 c\bar{y} + \psi_1 \leq s_\psi, \tag{A.2}$$

then the deviation cannot be detected, because the resulting inflation rate could also occur if the policy maker planned zero inflation. Using Bayes rule shows formally that beliefs are not updated,

$$\mu_2 = prob(S|\psi_1 \leq s_\psi - \omega_1 c\bar{y}) = \mu_1. \tag{A.3}$$

For a given $\omega_1 \in [0, 1]$, this outcome occurs with probability $1-(\omega_1 c\bar{y})/(2s_\psi)$.[16] The ex post optimal second period policy for this case can be derived as follows. First, taking individual inflation expectations as given, the reaction function of the policy maker is obtained by maximizing the expectation of his second period objective. Then, using the fact that there is no updating, individual inflation expectations can be calculated from this reaction function by taking the expectation operator through. Substituting the result back into the reaction function eventually yields

$$\pi_2^e(float, \omega_1|\psi_1 \leq s_\psi - \omega_1 c\bar{y}) = \frac{(1-\mu_1)c}{1+\mu_1 c}\bar{y}, \tag{A.4a}$$

$$\pi_2^p(float, \omega_1|\psi_1 \leq s_\psi - \omega_1 c\bar{y}) = \frac{c}{1+\mu_1 c}y, \tag{A.4b}$$

which implies

$$E(u_2^W(float, \omega_1)|\psi_1 \leq s_\psi - \omega_1 c\bar{y}) = -\frac{c(1+c)}{(1+\mu_1 c)^2}\bar{y}^2 - (1+c)\sigma_\psi^2. \tag{A.5}$$

Second, with probability $(\omega_1 c\bar{y})/(2s_\psi)$,

$$\pi_1(float, \omega_1) = \omega_1 c\bar{y} + \psi_1 > s_\psi. \tag{A.6}$$

Such a realization of inflation cannot result if planned inflation is zero. Applying Bayes rule shows that revelation of the weak policy maker's type will occur,

$$\mu_2 = prob(S|\psi_1 > s_\psi - \omega_1 c\bar{y}) = 0. \tag{A.7}$$

The time consistent outcome of the one shot game then materializes in the second period and the expected second period utility of the weak policy maker amounts to

[16] Note that from inequality (6) it follows that $(\omega_1 c\bar{y})/(2s_\psi)$ does not exceed one; the probability is therefore well defined.

$$E(u_2^W(\mathit{float}, \omega_1)|\psi_1 > s_\psi - \omega_1 c\bar{y}) = -(1+c)c\bar{y}^2 - (1+c)\sigma_\psi^2. \tag{A.8}$$

Eq. (8) now follows from Eqs. (A.1), (A.5), (A.8) and the fact that

$$\begin{aligned} E(U^W(\mathit{float}, \omega_1)) = {} & E(u_1^W(\mathit{float}, \omega_1)) \\ & + \delta\left[1 - \frac{\omega_1 c\bar{y}}{2s_\psi}\right] E(u_2^W(\mathit{float}, \omega_1)|\psi_1 \le s_\psi - \omega_1 c\bar{y}) \\ & + \delta \frac{\omega_1 c\bar{y}}{2s_\psi} E(u_2^W(\mathit{float}, \omega_1)|\psi_1 > s_\psi - \omega_1 c\bar{y}). \end{aligned} \tag{A.9}$$

Appendix B

Derivation of Eq. (10)

Given that individuals expect the weak policy maker to plan $S^W(\mathit{float}, \omega_1)$, the first period inflation expectation is $(1-\mu_1)\omega_1 c\bar{y}$ and the expected first period utility of the weak policy maker will be

$$\begin{aligned} E(u_1^W(\mathit{float}, \omega_1, \varepsilon_1)) = {} & E(u_1^W(\mathit{float}, \omega_1)) - (1+c)\varepsilon_1^2 \\ & + [1 - \omega_1(1 + c\mu_1)]2c\bar{y}\varepsilon_1. \end{aligned} \tag{B.1}$$

As before, individual inflation expectations for the second period depend on the realization of the disturbance ψ_1 and we have to distinguish two possibilities.

First, with probability $1-(\omega_1 c\bar{y}+\varepsilon_1)/(2s_\psi)$, the realization of ψ_1 will be such that

$$\pi_1(\mathit{float}, \omega_1, \varepsilon_1) = \omega_1 c\bar{y} + \varepsilon_1 + \psi_1 \le s_\psi, \tag{B.2}$$

and the deviation remains unnoticed. Recalling Eq. (A.5), we then have

$$E(u_2^W(\mathit{float}, \omega_1, \varepsilon_1)|\psi_1 \le s_\psi - \omega_1 c\bar{y} - \varepsilon_1) = -\frac{c(1+c)}{(1+\mu_1 c)^2}\bar{y}^2 - (1+c)\sigma_\psi^2. \tag{B.3}$$

Second, with probability $(\omega_1 c\bar{y}+\varepsilon_1)/(2s_\psi)$,

$$\pi_1(\mathit{float}, \omega_1, \varepsilon_1) = \omega_1 c\bar{y} + \varepsilon_1 + \psi_1 > s_\psi, \tag{B.4}$$

implying that revelation occurs and the time consistent outcome materializes in the second period. Consequently,

$$E(u_2^W(\mathit{float}, \omega_1, \varepsilon_1)|\psi_1 > s_\psi - \omega_1 c\bar{y} - \varepsilon_1) = -(1+c)c\bar{y}^2 - (1+c)\sigma_\psi^2. \tag{B.5}$$

Eq. (10) now follows from Eqs. (8), (B.1), (B.3), (B.5).

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