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**IMPORTING CREDIBILITY THROUGH EXCHANGE  
RATE PEGGING**

**Berthold Herrendorf**

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IMPORTING CREDIBILITY THROUGH EXCHANGE  
RATE PEGGING

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This paper is circulated for discussion purposes only and its contents should be considered preliminary.

# IMPORTING CREDIBILITY THROUGH EXCHANGE RATE PEGGING \*

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## Abstract

This paper employs an optimal taxation framework in order to study the credibility of monetary policy-making in an open economy. Since inflation is, in part, uncontrollable due to stochastic disturbances, the authority's actions cannot be monitored perfectly when the exchange rate floats, thus implying that reputational forces may become ineffective. In contrast, pegging the nominal exchange rate to a low-inflation currency allows perfect monitoring, because the exchange rate is, in principle, controllable. For this reason, exchange rate pegging may import credibility and result in the best reputational equilibrium, even though the authority retains the discretion to devalue unexpectedly.

KEYWORDS: Credibility; Exchange Rate Pegging; Incomplete Information; Inflation Tax; Reputation.

JEL CLASSIFICATION: E52; E61; F33.

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It has frequently been argued that one possibility of reducing the inflationary bias of monetary policy making lies in fixing *irrevocably* the nominal exchange rate to a stable foreign currency, whereby the low foreign inflation rate is imported into the domestic country.<sup>1</sup> Given that it is hardly possible to fix the exchange rate irrevocably, it is also important to understand the other benchmark case in which the exchange rate is *pegged*, that is, is fixed, but may be changed at the policy maker's discretion. Mutual exchange rate regimes such as the European monetary system have features of both cases, whereas unilateral pegs fall into the second category.

In an important, recent contribution, de Kock and Grilli (1993) [henceforth dK-G] showed, for a repeated policy game, that reputational effects may discipline the domestic policy maker not to devalue a *pegged* exchange rate unexpectedly.<sup>2</sup> However, since dK-G *assumed* that the suboptimal, time-consistent outcome of the one shot game emerges when the exchange rate floats, they left unanswered the critical question of why exchange rate pegging should lead to a reputational equilibrium preferable to that of a policy of money supply control under a floating exchange rate. This question appears widely in the literature and forms the basis of this paper.

In section I, dK-G's set-up is extended to allow control over inflation to be imperfect and their results are briefly summarised. Section II analyses the effectiveness of reputational effects when control over inflation is *perfect*, as was assumed by dK-G. We prove that, in this case, it is never optimal to peg the nominal exchange rate. In section III, we study reputation when control over inflation is *imperfect* and argue that, when the exchange rate floats, Canzoneri's (1985) private information problem weakens the effectiveness of reputation. In contrast, as was informally pointed out by Giavazzi and Giovannini (1989), exchange rate pegging is not subject to the private information

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<sup>1</sup> Giavazzi and Pagano (1988) viewed this as an *indirect* employment of a conservative central banker.

<sup>2</sup>Note that dK-G used this result to analyse an exchange rate escape clause, which, although interesting, is not our topic here.

problem, because the exchange rate can in principle be perfectly controlled. We show that, for these two reasons, a relatively imprecise degree of control over inflation may indeed lead to the scenario that dK-G assumed.

## I. AN OPTIMAL TAXATION MODEL

As per dK-G, we consider a small open domestic economy, in which real output is exogenously given and prices are flexible. Assuming the validity of relative purchasing power parity, the rate of nominal exchange rate depreciation is  $e_t = \pi_t - \pi_t^*$ , where  $\pi_t$  denotes domestic inflation and the superscript  $*$  indicates foreign inflation. Reflecting the fact that velocity shocks prevent perfect control over inflation, we express the realised inflation rate as the sum of the inflation rate planned by the policy maker,  $\pi_t^p$ , and an iid. disturbance,  $\psi_t$ , that is,  $\pi_t = \pi_t^p + \psi_t$ . For simplicity,  $\psi_t$  is supposed to be uniformly distributed on the compact support  $[-x, x]$ , its finite variance being denoted by  $\sigma^2$ .

Domestic monetary policy-making is discretionary, as described by dK-G's stylised optimal taxation model, which ignores the possibility of issuing government bonds.<sup>3</sup> We depart from dK-G in one respect, namely, that government expenditures are not stochastic here, but, for simplicity, held constant. Denoting government expenditure relative to GNP by  $g_t$ , the average output tax rate by  $\tau_t$  and seigniorage relative to GNP by  $\varsigma_t$ , the end-of-period version of the government budget constraint can be written as

$$g = \tau_t + \varsigma_t, \quad \text{where} \quad \varsigma_t \equiv s(\pi_t - \pi_t^e) + \alpha s \pi_t^e, \quad s > 0, \quad 0 < \alpha < 1, \quad (1)$$

and  $\pi_t^e \equiv E_{-1}(\pi_t)$  represents the rational inflation expectation for period  $t$ . (1) shows that an increase of either expected or unexpected inflation generates additional seignior-

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<sup>3</sup> Obeying the space constraint we keep the exposition parsimonious. For a justification of the model the reader is referred to dK-G. Moreover, a detailed discussion of the public finance approach to seigniorage collection can be found in Herrendorf (1995a).

age and that the marginal seigniorage from unexpected inflation [i.e.  $s$ ] exceeds the one from expected inflation [i.e.  $\alpha s$ ]. Collecting revenues is assumed to cause social loss, the present value of which is given by

$$L \equiv \sum_{t=0}^{\infty} \beta^t l_t, \quad \text{where} \quad l_t \equiv \tau_t^2 + c\pi_t^2, \quad c > 0, \quad (2)$$

and the discount factor  $\beta$  is in  $(0, 1)$ .

The domestic authority's optimal taxation problem is to find a sequence of *planned* rates of average taxes and inflation,  $\{\tau_t^p, \pi_t^p\}$ , that minimises expected social loss (2) subject to the budget constraints (1). Since inflation cannot be perfectly controlled, (1) implies that the actual average tax rate must be adjusted at the end of period  $t$ :  $\tau_t = \tau_t^p - s\psi_t$ . Using this identity and  $\pi_t = \pi_t^p + \psi_t$ , one can express social loss and the budget constraints as functions of the choice variables  $\{\tau_t^p, \pi_t^p\}$ .

We first consider the solutions to the optimal taxation problem when the *nominal exchange rate floats*. The *ex ante optimal policy* solves the optimal taxation problem while respecting the additional constraints  $\pi_t^p = \pi_t^e$ . This leads to the Ramsey principle of optimal taxation:<sup>4</sup>

$$\tau^p(opt) = \frac{c}{c + (\alpha s)^2} g \quad \text{and} \quad \pi^p(opt) = \frac{\alpha s}{c + (\alpha s)^2} g. \quad (3)$$

Given that unexpected inflation yields higher marginal seigniorage than expected inflation, the ex ante optimal policy is time inconsistent. The *time consistent policy* results when the authority makes its decisions after inflation expectations have been formed,

$$\tau^p(con) = \frac{c}{c + \alpha s^2} g \quad \text{and} \quad \pi^p(con) = \frac{s}{c + \alpha s^2} g. \quad (4)$$

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<sup>4</sup>Since the policy game is repeated, the optimisation problems in every period are identical; thus, we may drop the time indices. Moreover, note that certainty equivalence holds, implying that the solutions to the optimal taxation problem are not affected by the imperfection of inflation control.

$\pi^p(con)$  is suboptimal, since it exhibits an inflationary bias  $[\pi^p(con) > \pi^p(opt)]$ ,

$$E_{-1}[l(opt)] = \frac{c}{c + (\alpha s)^2} g^2 + (c + s^2) \sigma^2 < \frac{c(c + s^2)}{(c + \alpha s^2)^2} g^2 + (c + s^2) \sigma^2 = E_{-1}[l(con)]. \quad (5)$$

When the *nominal exchange rate is pegged*, the rate of exchange rate depreciation is zero and relative purchasing power parity determines realised domestic inflation as  $\pi = \pi^*$ . We assume that the foreign country has no credibility problem, due to the fact that the foreign policy maker is precommitted to planning zero inflation. Realised foreign inflation is thus given by  $\pi_t^* = \psi_t^*$ , where  $\psi_t^*$  too is assumed to be independently, identically and uniformly distributed. To focus the discussion, domestic and foreign shocks to inflation are supposed to have the same variance. Given that  $E_{-1}(\psi^*) = 0$ , we have  $\pi^p(peg) = 0$ , implying that  $\tau^p(peg) = g$  and

$$E_{-1}[l(peg)] = g^2 + (c + s^2) \sigma^2. \quad (6)$$

Comparing (5) with (6) reveals that pegging the exchange rate improves upon the time consistent outcome of the one shot game iff  $c(1 - 2\alpha) > (\alpha s)^2$ , which is identical to dK-G's inequality (15).

## II. REPUTATION UNDER PERFECT INFLATION CONTROL

It is important to realise that exchange rate pegging cannot be an equilibrium in the one shot game, because it corresponds to planning zero inflation and thus leaves an incentive to create surprise inflation through an unexpected devaluation. In the repeated game, however, pegging may be an equilibrium when reputational effects are taken into account. In order to model reputation, dK-G use the following convention for the individual expectation-formation process: if the authority has not devalued in the past, agents expect that it will not devalue in the next period either; in contrast, if it has devalued, agents expect the time-consistent inflation rate for all future periods. A pegged exchange rate is then sustainable as an equilibrium of the policy game, iff the expected



current gain from a devaluation does not exceed the expected future cost, i.e.

$$E_{-1}[l(peg) - l(dev)] \leq E_{-1}[L_{+1}(con) - L_{+1}(peg)], \quad (7)$$

where  $L_{+1}$  represents the present discounted value of social loss from the next period onwards, that is,  $L_{+1} \equiv l\beta/(1 - \beta)$ . As dK-G showed, (7) is satisfied when the policy maker does not discount the future too heavily; compare their condition (29). They concluded that exchange rate pegging is an equilibrium policy, if, in addition, it is preferred to the time consistent outcome of the one shot game, which they *assume* to materialise when the exchange rate floats. The critical problem with this assumption is that reputational forces may also be effective under a float.

**PROPOSITION 1.** *If control over inflation is perfect, then the ex ante optimal policy is sustainable as a reputational equilibrium if exchange rate pegging is sustainable.*

*Proof.* We need to prove that

$$\begin{aligned} E_{-1}[l(peg) - l(dev)] &\leq E_{-1}[L_{+1}(con) - L_{+1}(peg)] \\ \implies E_{-1}[l(opt) - l(surp)] &\leq E_{-1}[L_{+1}(con) - L_{+1}(opt)], \end{aligned} \quad (8)$$

where  $l(surp)$  denotes the social loss in the period of an inflation surprise created under a float. We first observe that, since  $E_{-1}[L_{+1}(opt)] < E_{-1}[L_{+1}(peg)]$ , the right hand sides of the two inequalities in (8) satisfy the inequality

$$E_{-1}[L_{+1}(con) - L_{+1}(peg)] \leq E_{-1}[L_{+1}(con) - L_{+1}(opt)]. \quad (9)$$

In order to compare the left hand sides, we note that if the exchange rate floats and the policy maker decides to deviate while individuals expect  $\pi^p(opt)$ , the optimal rate of surprise inflation is  $\pi^p(surp) = gs(c + \alpha s^2)/[(c + s^2)(c + (\alpha s)^2)]$ . Hence, the expected

reduction of social loss in the period of this surprise is

$$E_{-1}[l(opt) - l(surp)] = \left[ \frac{c}{c + (\alpha s)^2} - \frac{c(c + \alpha s^2)^2}{(c + s^2)[c + (\alpha s)^2]^2} \right] g^2 < \left[ \frac{c}{c + (\alpha s)^2} - \frac{c}{c + s^2} \right] g^2. \quad (10)$$

Conversely, if individuals expect the exchange to be pegged, the optimal rate of surprise inflation is  $\pi^p(dev) = gs/(c + s^2)$ , reducing expected social loss during the period of devaluation by

$$E_{-1}[l(peg) - l(dev)] = \frac{s^2}{c + s^2} g^2. \quad (11)$$

(10) and (11) show that

$$E_{-1}[l(opt) - l(surp)] \leq E_{-1}[l(peg) - l(dev)]. \quad (12)$$

The proof is completed by observing that (9) and (12) imply (8). QED

Since exchange rate pegging involves a cost, due to the import of foreign inflation, which is suboptimally low from the domestic point of view [compare (3)], proposition 1 implies that a rational policy maker would never peg the nominal exchange rate if control over inflation were *perfect*. Instead he would control inflation so as to obtain the ex ante optimal domestic outcome. This result shows that, when inflation can be perfectly controlled, as in dK-G, then one cannot assume consistently that reputational effects are at work under pegging but not under a floating.

### III. REPUTATION UNDER IMPERFECT INFLATION CONTROL

In order to resolve the above inconsistency, we now study the case of *imperfect* control over inflation. Unexpected inflation may then come either from a positive realisation of the shock  $\psi$  or from a deliberate attempt of the policy maker to create surprise inflation. In order to verify whether the surprise was caused by the policy maker, individuals must know the planned inflation rate,  $\pi^p$ . However, as Canzoneri (1985) pointed out,  $\pi^p$  by necessity is the policy maker's private information, because it is not incentive-compatible

to reveal the correct rate when surprise inflation is perceived as being beneficial. An optimising policy maker would simply create surprise inflation and attempt to cover this up by blaming a large positive realisation of the shock  $\psi$  for the resulting inflation. Consequently, individuals cannot perfectly monitor the policy maker's actions when the exchange rate floats.

It is important to understand that the private information problem does not arise when the exchange rate is pegged. This is due to fact that, provided that the foreign central banker is precommitted to plan zero inflation and that relative purchasing power parity holds, pegging the nominal exchange rate unambiguously implies that the domestic policy maker plans zero inflation too.<sup>5</sup> Hence, there is no ambiguity and individuals can monitor the actions of the domestic policy maker perfectly under a peg. Notice that, as is standard, it is implicitly assumed that the nominal exchange rate can be perfectly controlled. This means that situations, in which the domestic policy maker does not command a stock of international reserves sufficiently large to intervene in the foreign exchange market, are excluded from the analysis. Furthermore, the domestic policy maker must relinquish control over the money supply in order to ensure that the peg is consistent with the economic fundamentals and that there is thus no basis for a speculative attack.

In order to study the consequences of the private information problem under a float, we first consider an arbitrary, planned inflation rate  $\pi^p \in [\pi^p(opt), \pi^p(con)]$ , assume that individuals expect  $\pi^p$  and derive an explicit expression for the following *necessary* condition that  $\pi^p$  is a reputational equilibrium:

$$\lim_{\varepsilon \rightarrow 0} E_{-1}[l(\pi^p) - l(\pi^p + \varepsilon)] \leq \lim_{\varepsilon \rightarrow 0} E_{-1}[L_{+1}(\pi^p + \varepsilon) - L_{+1}(\pi^p)]. \quad (13)$$

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<sup>5</sup> Note that it is irrelevant in the present context that a pegged exchange rate translates foreign velocity shocks into domestic inflation surprises, because the source of these surprises is unambiguously foreign.

We then show that this expression is violated whenever control over inflation is relatively imprecise.

We start by noticing that the expected decrease in current social loss after the creation of an inflation surprise  $\varepsilon \in (0, 2x]$  is unaffected by the private information problem,<sup>6</sup>

$$E_{-1}[l(\pi^p) - l(\pi^p + \varepsilon)] = 2[sg - (c + \alpha s^2)\pi^p]\varepsilon - (c + s^2)\varepsilon^2. \quad (14)$$

In contrast, the private information problem does affect by how much a deviation increases the expected present discounted value of future social loss. On one hand, since  $\psi$  is assumed to be uniformly distributed here, individuals can only detect the surprise if the realised inflation rate  $[\pi = \pi^p + \varepsilon + \psi]$  exceeds the maximum inflation rate that would be possible if the authority adhered to the target  $[\pi^p + x]$ , that is, if  $\psi > x - \varepsilon$ . Hence, with probability  $\varepsilon/(2x)$  the deviation is noticed and the economy reverts to the time consistent equilibrium.<sup>7</sup> On the other hand, if  $\psi \leq x - \varepsilon$ , then the surprise remains unnoticed and individuals continue to expect  $\pi^p$ . Consequently, planning the surprise  $\varepsilon$  leads to the following increase of the expected present value of future social loss:

$$\begin{aligned} E_{-1}[L_{+1}(\pi^p + \varepsilon) - L_{+1}(\pi^p)] &= \frac{\varepsilon}{2x} \frac{\beta}{1 - \beta} E_{-1}[l(con) - l(\pi^p)] \\ &= \frac{\varepsilon}{2x} \frac{\beta}{2(1 - \beta)} \left\{ [c + (\alpha s)^2] [\pi^p(con)]^2 - [\pi^p]^2 \right\} - 2\alpha s g [\pi^p(con) - \pi^p]. \end{aligned} \quad (15)$$

In order to check whether (15) is indeed positive for all  $\pi^p$  in  $[\pi^p(opt), \pi^p(con)]$  we proceed as follows: (i) define a function  $f(\pi^p) \equiv [c + (\alpha s)^2][\pi^p]^2 - 2\alpha s g \pi^p$ ; (ii) notice that  $\partial f(\pi^p(opt))/\partial \pi^p = 0$  and that  $\partial^2 f(\pi^p)/\partial \pi^{p2} > 0$ ; (iii) conclude that  $\partial f(\pi^p)/\partial \pi^p > 0$

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<sup>6</sup> Restricting  $\varepsilon$  to no more than  $2x$  does not lead to a loss of generality, since we are only interested in a necessary condition.

<sup>7</sup> Note that the less precise the control over inflation, the smaller is this probability and the weaker will be the disciplinary effect of reputation on the policy maker.

for all  $\pi^p \in (\pi^p(opt), \pi^p(con))$ . Thus, the positivity of (15) follows.

Using (14) and (15), dividing by  $\varepsilon$ , and taking the limit for  $\varepsilon \rightarrow 0$ , we find that

$$2[sg - (c + \alpha s^2)\pi^p] \leq \frac{\beta}{2x(1-\beta)} \left\{ [c + (\alpha s)^2] [\pi^p(con)]^2 - [\pi^p]^2 - 2\alpha s g [\pi^p(con) - \pi^p] \right\} \quad (16)$$

is equivalent to (13), that is, is necessary for  $\pi^p$  to be a reputational equilibrium.

**PROPOSITION 2.** *If control over inflation is relatively imperfect, that is,*

$$x \geq \frac{\beta}{(1-\beta)} \frac{cs(1-\alpha)}{2(c + \alpha s^2)} g, \quad (17)$$

*then no planned inflation rate  $\pi^p \in [\pi^p(opt), \pi^p(con))$  can be sustained as a reputational equilibrium when the nominal exchange rate floats.*

*Proof.* To prove the proposition, it is sufficient to show that, if (17) holds, then (16) is violated for all  $\pi^p < \pi^p(con)$ . To demonstrate this, notice first that the left hand side of (16) is linear in  $\pi^p$  and negatively sloped, whereas the right hand side is quadratic and goes to minus infinity when  $\pi^p$  goes to infinity. Moreover,

$$\frac{\partial rhs[\pi^p(con)]}{\partial \pi^p} = -\frac{\beta}{x(1-\beta)} \frac{cs(1-\alpha)}{c + \alpha s^2} g < 0. \quad (18)$$

(17) and (18) imply that  $\partial lhs(\pi^p(con))/\partial \pi^p \leq \partial rhs(\pi^p(con))/\partial \pi^p < 0$ . Since the left and the right hand side are both equal to zero for  $\pi^p = \pi^p(con)$ , the former must be larger than the latter whenever  $\pi^p < \pi^p(con)$ . QED

In summary, accounting for the fact that control over inflation is imperfect can lead to the scenario assumed by dK-G: when the exchange rate floats, the time consistent outcome of the one shot game emerges also in the repeated game, whereas pegging the nominal exchange rate to the foreign currency can be sustained as a reputational equilibrium. Since exchange rate pegging reduces the domestic inflationary bias, it may then be viewed as importing credibility from the precommitted foreign policy maker.

The costs of this import come from the fact that planned foreign inflation is suboptimal from the domestic point of view.

It should be stressed that we have derived the previous results under the simplifying assumption that both countries can control inflation equally precisely. Hence, exchange rate pegging would be even more preferable if foreign inflation control were more precise than domestic inflation control, because it would then not only reduce the level but also the *variability* of domestic inflation; see Herrendorf (1995b) for further discussion. This scenario is likely to prevail during stabilisations of high inflation or hyper-inflation economies, when the velocity of money is typically very unstable and control over inflation is very poor. Since our formal analysis could easily be extended to incorporate this case, the paper also provides a rigorous reason for the credibility gain that exchange rate pegging may bring about during attempts at stabilisation.

#### IV. CONCLUSION

This paper has addressed the question of why exchange rate pegging may give the best reputational equilibrium, though reputational effects may, in principle, also discipline domestic monetary policy making under a float. We have argued that the reason lies in the imperfect controllability of inflation under a float, which leads to a private information problem that is absent under exchange rate pegging. The analysis suggests that low precision in domestic inflation control is one important motivation to peg the exchange rate, even if foreign inflation control is equally bad.

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