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Exchange Rate Pegging, Transparency, and Imports of Credibility

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Exchange Rate Pegging, Transparency, and Imports of Credibility*

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Abstract

This paper studies the credibility of a low inflation policy in a two country Barro–Gordon framework. When the nominal exchange rate floats and inflation is targeted, the realized inflation rate is in part uncontrollable due to stochastic disturbances. In contrast, a pegged nominal exchange rate can in principle be perfectly controlled. Given the foreign authority is precommited to low inflation, exchange rate pegging is therefore also more transparent. It is shown that if real shocks to productivity are similar in both countries, then the higher transparency of exchange rate pegging can lead to lower domestic equilibrium inflation than when inflation itself is targeted. This is interpreted as an import of credibility.

KEYWORDS: Controllability; Credibility; Exchange Rate Pegging; Incomplete Information.

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1 Introduction

The European Monetary System (EMS) is probably the most frequently studied example of inflation convergence in a regime of pegged exchange rates.[1] When the system was founded in 1979, Germany was the EMS member with the lowest average inflation rate, which is usually attributed to the successive appointments of conservative and independent central bankers. As Rogoff (1985) showed, a conservative and independent central banker can credibly precommit to a low inflation policy and therefore avoid the inflationary bias arising from the time consistency problem of monetary policy. In contrast to the German Bundesbank, most other European central banks do not have access to such a precommitment technology because of their dependence upon the governments, which perceive surprise inflation as being beneficial. However, some of these countries have been able to disinflate successfully after entering the EMS. Giavazzi and Pagano (1988) explained this by suggesting that pegging to the German Mark can be interpreted as indirectly employing a conservative and independent central banker, namely the president of the Deutsche Bundesbank.

This argument has become widely accepted in the literature; see, for example, Melitz (1988), Giavazzi and Giovannini (1989), and Currie, Levine and Pearlman (1992). The main difficulty with it appears to be that the parities within the EMS were not irrevocably fixed but adjustable, which has been impressively demonstrated during the recent crises in the EMS. The question that needs to be addressed therefore is: Why could unprecommited European policy makers credibly peg their currencies to the Deutsche Mark and thereby import low German inflation, while at the same time they lacked the credibility to pursue a low inflation policy when the exchange rate floated?

This phenomenon has usually been explained by political and institutional rather than immediate economic reasons for the credibility of the

[1] The nominal exchange rate is said to be pegged if it is held constant while it remains adjustable at some less than infinite cost. In contrast, the realignment costs for a fixed exchange rate are infinite.

EMS. Before the uncertainty regarding the ratification of the Maastricht Treaty surfaced and the EMS experienced its dramatic crisis of September 1992, it had often been argued that its credibility stemmed from the credibility of the participants' commitment to the eventual economic and monetary integration implied by the process towards European Union. This commitment was considered to be credible because of "wider European political objectives", which led to substantial changes in the participating countries' policy stances.[2] Alternatively, it has been argued that the EMS was an agreement among equals, implying that reneging on an agreed exchange rate parity is more difficult than on an announced internal target. Additional costs may arise because of the possible loss of an *international* reputation, which could lead to a reduced incentive to cooperate with the devaluing authority in the future, perhaps in areas other than exchange rate policy.

Even though political and institutional reasons might indeed explain the EMS experience, they are limited to the specific institutional and political environment then in existence. Hence the question as to why exchange rate pegging has brought about low inflation rates in environments that were considerably different from the EMS remains. For example, Austria and some Scandinavian countries, although not being EMS members at the time, have recently achieved relatively low and stable inflation rates after pegging to certain EMS currencies. Furthermore, some countries in Central America have at times *unilaterally* pegged their currencies to the US dollar with essentially the same result. This, for example, holds true for Guatemala and Honduras; see Edwards and Losada (1994). Finally, exchange rate pegging to a low inflation currency has played a key role in almost all historical attempts at stabilization from hyperinflations or high inflation; compare Dornbusch and Fischer (1986), Bruno, Fischer, Helpman and Liviatan (1991), and Bruno (1993). Recent examples of successful, exchange rate based stabilizations include Argentina, Bolivia, Israel, and Mexico.

In light of these facts, the following fundamental problem arises:

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[2] Compare Goodhart (1990), Begg and Wyplosz (1992), Eichengreen (1993b), Eichengreen and Wyplosz (1993), or Svensson (1994).

Why should the equilibrium inflation rate be smaller when the nominal exchange rate is *unilaterally* pegged to a foreign low inflation currency than when the inflation rate is targeted while the exchange rate floats? This question forms the basis of this paper. In addressing it we assume for simplicity that precommitment of the foreign central banker ensures the credibility of the low foreign inflation rate. Moreover, attention is deliberately restricted to a unilateral peg, because this rules out the possibility that the institutional design of a mutual exchange rate agreement like in the EMS is the reason for the credibility gain.

Although the above problem is widely recognized in the literature,[3] it is typically avoided in the formal treatments of policy credibility under a pegged nominal exchange rate. Some authors, including Flood and Isard (1989), Obstfeld (1991) and Rasmussen (1993), simply assumed the existence of a cost of reneging on the pegged exchange rate agreement, which presumably can be avoided through reneging on a domestic target. Others sought to explain the credibility of a pegged exchange rate through reputational forces in repeated games. However, they either did not address the credibility of a low inflation policy under a floating exchange rate [e.g. Horn and Persson (1988) or Andersen and Risager (1991)], or simply assumed that this policy is not credible [e.g. de Kock and Grilli (1993)]. This is unsatisfactory because within the frameworks employed with (relative) purchasing power parity (ppp) as a crucial building block, a low inflation policy under a float is equivalent to pegging the nominal exchange rate to a low inflation currency.[4]

On the other hand, the advantages of exchange rate pegging over inflation targeting have been articulated clearly albeit informally in the literature. To begin with, the nominal exchange rate is more visible than the inflation rate because the former is the price of the foreign currency

[3] See, among others, Canzoneri and Henderson (1988), Giavazzi and Giovannini (1989), Fratianni and von Hagen (1992), Blackburn and Sola (1993), and Eichengreen (1993a).

[4] Agénor (1994) provided an analysis of the credibility of a pegged exchange rate in a model that incorporates different sectors for tradables and nontradables and thus does not require ppp. However, he did not discuss the alternative policy of money supply control under a floating exchange rate either.

in terms of the domestic currency in the single foreign exchange market. This price is continuously quoted and not prone to measurement errors as is the reported inflation rate, which is calculated periodically by the use of price indices. The importance of the visibility (or observability) advantage of the nominal exchange rate was, for example, stressed by Melitz (1988) in the context of the EMS. It has also been noted frequently in the literature on the design of stabilization programs for high inflation countries; see, for example, Bruno (1993, p.135). An additional advantage of a pegged exchange rate is that it is more easily controlled. A chosen parity that is consistent with the economic fundamentals can in principle be perfectly achieved, provided the pegging authority completely gives up control over its money supply and has command over sufficient international reserves.[5] In contrast to a pegged exchange rate, the inflation rate is endogenous when the authority tries to control the money supply while the exchange rate floats. Thus a low inflation target 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.

In summary, the nominal exchange rate is both more clearly observed and more easily controlled and thus more transparent than the inflation rate. This has often been claimed to be the reason why a low inflation policy is more credible under exchange rate pegging than under inflation targeting; see, for example, Giavazzi and Giovannini (1989, p. 103). However, formally the relationship between the transparency of the exchange rate regime and the credibility of the ex ante optimal low inflation policy has not been modelled. The present paper attempts to close this gap. In sections 2 and 3, a two country open economy version of Canzoneri's (1985) closed economy model is presented. The effect of the

[5] Since the policy maker can then defend the exchange rate peg without limitations, problems related to speculative attacks are assumed away. Moreover, the consistency with the economic fundamentals excludes scenarios from the analysis in which the policy maker tries to peg the exchange rate *and* to control the domestic money supply at the same time. For example, the paper does not address the situations in most Southern European countries before the 1992 crisis of the EMS, where domestic inflation was too high to be consistent with the exchange rate parity.

different exchange rate regimes on the equilibrium inflation rate is analyzed within two standard policy games in the two subsequent sections. In particular, section 4 studies an infinitely repeated game. Independently of the policy regime, the policy maker is assumed to be able to precommit partially to plan the ex ante optimal low inflation rate. Partial precommitment is modeled as a finite cost that he incurs for *detected* surprises. In section 5, a finitely repeated signalling policy game in the spirit of Backus and Driffill (1985) is presented. An additional source of uncertainty arises in this game because it is unknown whether the policy maker can (fully) precommit or has discretion. For both policy games it is shown that there exist parameter configurations for which a low inflation outcome is a Nash–equilibrium only under a pegged exchange rate; an inflationary bias thus arises under inflation targeting. The implications and limitations of this result are discussed in the concluding section 6.

2 A Two Country Open Economy Model

The framework used is a synthesis of Canzoneri's (1985) and Obstfeld's (1991) extensions of the model proposed by Barro and Gordon (1983).

2.1 The Domestic Economy

The domestic economy is populated by a large number of identical and rational individuals. A representative individual supplies labor in a competitively organized labor market. As is standard in the literature, the representative individual is assumed to aim for equilibrium output when negotiating the nominal wage for the next period. This leads to the determination of *real output* by an expectation augmented Phillips curve,

$$y_t - x_t = \theta(\pi_t - \pi_t^e - \xi_t). \tag{1}$$

The following notation is used in (1): y_t and x_t denote the logarithms of realized and equilibrium real output. Furthermore, π_t and π_t^e stand for the realized inflation rate and for the rational inflation expectation for period t. The *realized inflation rate* is defined as the difference between the logs of the current and the previous price level, $\pi_t = p_t - p_{t-1}$ and the inflation expectation is formed at the end of period t–1 conditional on the available information, I_{t-1}, i.e. $\pi_t^e = E(\pi_t|I_{t-1})$. Finally, as in Obstfeld (1991), ξ_t represents an independently and identically distributed *productivity shock*, which has a zero unconditional mean, a finite variance, and is not predictable at the end of period t–1,

$$\xi_t \text{ i.i.d. } (0, \sigma_\xi^2) \quad \text{and} \quad E(\xi_t|I_{t-1}) = 0. \tag{2}$$

We assume that *prices* in the economy are perfectly flexible and result from equilibrium in the money market, which is described by the simple quantity equation[6]

$$m_t + v_t = x_t + p_t, \tag{3}$$

where m_t and v_t denote the logs of the nominal money supply and of the velocity. The money supply is assumed to be the policy instrument under the control of the authority. Following Canzoneri (1985), we model the well recognized instability of money demand by the assumption that the logarithm of the *velocity* follows a random walk,

$$v_t = v_{t-1} + \varphi_t, \quad \text{where} \quad \varphi_t \text{ i.i.d. } (0, \sigma_\varphi^2) \quad \text{and} \quad E(\varphi_t|I_{t-1}) = 0. \tag{4}$$

This leads to the familiar dependence of the realized inflation rate on the realized growth rate of the money supply, $\hat{m}_t$, the growth rate of the equilibrium output, $\hat{x}_t$, and the realization of the velocity (or demand) shock φ_t,

$$\pi_t = \hat{m}_t - \hat{x}_t + \varphi_t. \tag{5}$$

(5) realistically implies that control over inflation is imperfect due to the

[6]Note that as in Canzoneri (1985), equilibrium output, x_t, instead of realized output, y_t, enters (3) for simplicity. Using y_t would lead to the "unpleasant" dependence of the price level on the rate of inflation, and thus to the dependence of the inflation rate on the rate of change of the inflation rate.

occurrence of velocity shocks.[7]

Finally, the *preferences of the policy maker* need to be specified. The present discounted value in period t of his current and future period–by–period utility is represented by a standard quadratic specification

$$V_t = -\frac{1}{2}\sum_{i=t}^{T}\beta^{i-t}v_i = -\frac{1}{2}\sum_{i=t}^{T}\beta^{i-t}\Big[\tilde{c}(y_i - x_i - \tilde{\kappa})^2 + \pi_i^2\Big], \qquad (6)$$

where $\beta \in (0,1)$ is a discount factor and T the number of periods the policy game is played. Whether T is smaller or equal to ∞ will vary throughout the paper depending on the version of the policy game considered.

Underlying equation (6) is the assumption that the policy maker gains from positive deviations of real output from its equilibrium value, which is reflected by the constant $\tilde{\kappa}$. That x_i is too low from the policy maker's point of view may for instance be due to distortions in the labor market.[8] Moreover (6) reflects the notion that the policy maker suffers loss from nonzero realized inflation because of the standard costs of inflation; for detailed discussion, see, for example, Driffill, Mizon and Ulph (1990). The parameter $\tilde{c}$ is the weight of the gain from positive deviations of output from equilibrium relative to the loss from realized inflation. The higher $\tilde{c}$, the more the policy maker trades off higher inflation for higher output.[9]

[7] Notice that in reality the policy maker's control over the money supply is also likely to be imperfect, but this distinction between planned and realized money growth is not modeled here because it would not add any additional insight.

[8] Note that this could also result when a trade union negotiates nominal wage contracts that are in the interest of only part of the labor force.

[9] The objective function (6) has often been interpreted as a social welfare function as was originally proposed by Kydland and Prescott (1977) and Barro and Gordon (1983). However, it may also be motivated by a political approach that leads to a positive theory of monetary policy. This was advocated by Cukierman and Meltzer (1986). Both interpretations are possible here.

2.2 The Foreign Economy and the Exchange Rate

The domestic and the foreign economy are identical in all but two aspects. On the one hand, productivity shocks possibly affect foreign output differently to domestic output. For simplicity, this asymmetry is modeled by the assumption that there are no foreign productivity shocks. Denoting foreign variables by a superscript $*$, *foreign output* is thus given by

$$y_t^* - x_t^* = \theta^*(\pi_t^* - \pi_t^{*e}). \tag{7}$$

On the other hand, it is assumed that the foreign policy maker is precommited to the ex ante optimal policy to be derived below, and that this is common knowledge.[10] In contrast, the domestic policy maker is not necessarily precommited.

The *nominal exchange rate*, e_t, between the domestic and the foreign country is defined as the price of the foreign currency in terms of the domestic currency. Postulating the validity of relative purchasing power parity (ppp), the nominal exchange rate is determined by

$$e_t = \alpha \frac{p_t}{p_t^*}, \tag{8}$$

where α is some constant.[11] The rate of nominal exchange rate depreciation, $\hat{e}_t$, must then equal the difference between the domestic and the foreign inflation rates,

$$\hat{e}_t = \pi_t - \pi_t^*. \tag{9}$$

Provided that the foreign policy maker sets the money supply and does not manage the exchange rate, the domestic policy maker can choose between floating and a unilaterally pegged nominal exchange rate.[12] On the one hand, when he targets domestic inflation by using the nominal

[10] A policy maker that is precommited to a certain policy rule follows that rule by definition, independently of whether this is ex post optimal.

[11] See Horn and Persson (1988), Obstfeld (1991), or Rasmussen (1993) for a similar assumption in open economy policy games.

[12] For a policy game model of a bilateral exchange rate peg on which both policy makers may renege, compare von Hagen (1992).

money supply as his instrument, the nominal exchange rate floats. The rate of nominal exchange rate depreciation is then given by (9). On the other hand, he may unilaterally peg the nominal exchange rate, implying $\hat{e}_t = 0$. The policy maker then has to buy the resulting excess supply of the domestic currency in the foreign exchange market, and consequently to give up control over the domestic money supply.[13] From (9), the realized domestic inflation rate under an exchange rate peg is endogenously determined by the realized foreign inflation rate, $\pi_t = \pi_t^*$.

3 The Policy Game

In this section, the policy game is described. In subsection 3.1, the one shot version is defined with particular emphasis on the timing of events and the informational structure. In the following subsection, the outcome of the one shot version is derived for alternative policies and exchange rate regimes. Finally, subsection 3.3 provides a discussion of the differences between the informational structure in the one shot game and in the repeated game.

3.1 The Informational Structure in the One Shot Game

Assuming that both the policy maker and a representative individual follow noncooperative Nash–strategies, the policy game in any period t proceeds as follows: At the end of the previous period, the *representative individual* forms inflation expectations, π_t^e, conditional on its information set I_{t-1}. On the basis of π_t^e, it then negotiates a nominal wage for period t so as to achieve equilibrium real output. Its information set I_{t-1} contains the model structure, all parameter values, and the distributions of φ_t, ψ_t,

[13] Note that in practice an exchange rate peg is likely to be implemented by pegging the domestic nominal interest rate. This feature could be captured by adding an uncovered interest parity relation to the present model. In addition, the velocity in (3) should then depend on the nominal interest rate.

and ξ_t. In forming expectations the policy maker's reaction function is taken as given.

The policy maker is assumed to make his decisions at the beginning of period t *after* individuals have decided about their labor supply. In order to model a role for stabilization policy, the *informational structure* is as follows: *Before* he decides, some information about the realizations of the two disturbances φ_t and ξ_t becomes available, which individuals did not know when forming their inflation expectations. As in Canzoneri (1985), the policy maker is supposed to learn about part of the realization of the velocity shock φ_t. Denoting this part by $\tilde{\varphi}_t$, φ_t may be decomposed into $\tilde{\varphi}_t$ and a shock ψ_t, which he cannot predict because it materializes after the money supply is determined,

$$\varphi_t = \tilde{\varphi}_t + \psi_t, \quad \text{where} \quad \psi_t \text{ i.i.d. } (0, \sigma_\psi^2) \quad \text{and} \quad E(\psi_t | I_t \cup \tilde{\varphi}_t) = 0. \quad (10)$$

After substitution of (10) into (5), the realized inflation rate results as the sum of the inflation rate planned by the policy maker and the unpredictable shock ψ_t,

$$\pi_t = \pi_t^p + \psi_t, \quad (11)$$

where

$$\pi_t^p \equiv \hat{m}_t - \hat{x}_t + \tilde{\varphi}_t. \quad (12)$$

Concerning the productivity shock, it is assumed that ξ_t is fully revealed *after* wage contracts have been negotiated but *before* the money supply is chosen. Moreover, this realization is supposed to be common knowledge.[14] The information set, $\tilde{I}_t$, on which the policy maker bases his decisions in period t may then be written as

$$\tilde{I}_t \equiv I_{t-1} \cup \tilde{\varphi}_t \cup \xi_t, \quad (13)$$

[14] As an example, one might think of a shock to the international prices of some imported materials, which certainly is observable by both individuals and the policy maker. Note that one could also parallel the assumption made about the shock ϕ_t, i.e. that the policy maker learns about only part of the productivity shock ξ_t. However, while complicating the analysis, this would not change the results in any important respect.

implying $I_{t-1} \subset \tilde{I}_t$.

After having explained the informational structure, we now turn to the description of the *policy maker's behavior*. We fist observe, that the substitution of (1) and (11) into (6) leads to a version of the policy objective in terms of planned and expected inflation,

$$V_t = -\frac{1}{2}\sum_{i=t}^{T}\beta^{i-t}\Big[c(\pi_i^p + \psi_i - \pi_i^e - \xi_i - \kappa)^2 + (\pi_i^p + \psi_i)^2\Big], \qquad (14)$$

where $c \equiv \tilde{c}\theta^2$ and $\kappa \equiv \tilde{\kappa}/\theta$. Hence, independently of the exchange rate regime, we may describe the policy maker's strategy in terms of choosing a planned inflation rate: At the beginning of period t, he determines π_t^p so as to maximizes the expectation of his utility v_t conditional on $\tilde{I}_t$. In doing so the policy maker takes inflation expectations as given.

In the two *exchange rate regimes* under consideration, the planned rate of inflation is achieved in different ways. On the one hand, when the exchange rate floats, (12) implies that the money supply is to be set as

$$\hat{m}_t = \pi_t^p + \hat{x}_t - \tilde{\varphi}_t. \qquad (15)$$

On the other hand, given the exchange rate regime is a peg, it can be seen from (9) that a planned inflation rate of π_t^p results from a devaluation of

$$\hat{e}_t = \pi_t^p - \pi_t^{*p}. \qquad (16)$$

Notice that in order to calculate this rate of devaluation the domestic policy maker needs to know to which inflation rate the foreign policy maker is precommited. Inter alia, this is discussed in the following subsection.

3.2 The Outcomes of the One Shot Game

3.2.1 Precommitment

First, the equilibrium is derived when the domestic policy maker has access to a precommitment technology. Since the present set–up is linear quadratic, the equilibrium policy rule must be an element from the following set of contingent rules:

$$\mathcal{R} = \{\pi_t^p \mid \pi_t^p = a\xi_t + b,\ a, b \text{ constant}\}. \tag{17}$$

Part A of an appendix shows that it is *ex ante optimal to precommit to the domestic policy rule*

$$\pi_t^p(opt) = \frac{c}{1+c}\xi_t, \tag{18}$$

which calls for partly offsetting the productivity shock ξ_t. The more the policy maker values the loss from a deviation of realized from equilibrium output (i.e. the larger is c), the more actively he stabilizes. However, ξ_t is never fully offset because realized inflation is costly. Given the policy maker precommits to (18), a representative individual expects zero inflation because $E(\xi_t|I_{t-1}) = 0$.

The foreign policy maker is precommited to the foreign analogue of (18). Since there are no foreign productivity shocks in the model economy, the *ex ante optimal foreign inflation rate* is

$$\pi_t^{*p}(opt) = 0, \tag{19}$$

implying $\pi_t^{*e}(opt) = 0$ and $\pi_t^*(opt) = \psi_t^*$.

If the domestic and the foreign policy maker are precommited to (18) and (19), respectively, relative purchasing power parity (9) leads to

$$\hat{e}_t(opt) = \frac{c}{1+c}\xi_t + \psi_t - \psi_t^* \quad \text{and} \quad \hat{e}_t^p(opt) = \frac{c}{1+c}\xi_t, \tag{20}$$

implying that the exchange rate necessarily floats. On the other hand, an *exchange rate peg corresponds to a degenerate contingent rule*, i.e.

$$\pi_t^p(peg) = \pi_t^{*p}(opt) = 0, \quad \pi_t^e(peg) = \pi_t^{*e}(opt) = 0, \quad \pi_t(peg) = \pi_t^*(opt) = \psi_t^*, \tag{21}$$

which prevents accommodation of domestic productivity shocks. Pegging the exchange rate is therefore equivalent to planning zero domestic inflation. Notice that by (5) and (21), the domestic money growth under a peg is endogenously determined by the relation

$$\hat{m}_t(peg) = \psi_t^* + \hat{x}_t - \varphi_t. \tag{22}$$

For future reference, we calculate the expected utilities of the policy maker's in period t under both rules. Since expected inflation depends on the policy regime in operation, it is appropriate to take the expectation conditional on the information set I_{t-1}. Substituting (18) into (14), one finds

$$E\Big(v_t(opt)\Big|I_{t-1}\Big) = -\frac{1}{2}\Big[\frac{c}{1+c}\sigma_\xi^2 + c\kappa^2 + (1+c)\sigma_\psi^2\Big]. \tag{23}$$

Similarly, one gets for a peg

$$E\Big(v_t(peg)\Big|I_{t-1}\Big) = -\frac{1}{2}\Big[c\sigma_\xi^2 + c\kappa^2 + (1+c)\sigma_{\psi^*}^2\Big]. \tag{24}$$

Comparing (23) and (24) immediately leads to

Lemma 1 *In the one shot game, the difference between the policy maker's expected utilities under precommitment to the ex ante optimal policy rule and to a pegged exchange rate amounts to*

$$E\Big(v_t(opt) - v_t(peg)\Big|I_{t-1}\Big) = \frac{1}{2}\Big[\frac{c^2}{1+c}\sigma_\xi^2 + (1+c)(\sigma_{\psi^*}^2 - \sigma_\psi^2)\Big]. \tag{25}$$

If $c > 0$ and $\sigma_{\psi^*}^2 \geq \sigma_\psi^2$, then the ex ante optimal policy rule yields a larger expected value of the policy objective than a pegged exchange rate. Intuitively the reason is that under a regime of inflation targeting the policy maker finds it optimal to accommodate productivity shocks even though he could clearly chose not to as is implied by a pegged exchange rate. However, this intuition is no longer appropriate if the foreign policy maker can control inflation much more accurately than the domestic policy maker, i.e.

$$\frac{c^2}{(1+c)^2}\sigma_\xi^2 \leq \sigma_\psi^2 - \sigma_{\psi^*}^2. \tag{26}$$

If this condition is met in the one shot game, then the domestic policy maker prefers precommitment to a pegged exchange rate.

3.2.2 Discretion

If precommitment is not feasible in the one shot game, then the domestic policy maker has discretion and chooses the *ex post* optimal policy. As is widely recognized in the literature originated by the seminal paper of Kydland and Prescott (1977), the *ex ante* optimal policy rule cannot be an equilibrium under discretion, because it is time inconsistent. Put differently, it leaves an ex post incentive to stimulate output through the creation of surprise inflation in excess of that is called for by (18). In equilibrium a representative individual therefore expects an inflation rate for which there is no ex post incentive to deviate. In part B of the appendix the discretionary equilibrium outcome of the one shot game is proved to be

$$\pi_t^p(dis) = \frac{c}{1+c}\xi_t + c\kappa \quad \text{and} \quad \pi_t^e(dis) = c\kappa. \tag{27}$$

By construction the Nash–equilibrium (27) is time consistent. As is standard, it exhibits an inflationary bias of $c\kappa$. Moreover, notice that under discretion, pegging the exchange rate is not a Nash–equilibrium, implying that the exchange rate necessarily floats.

The conditional expected utility under discretion is found to equal

$$E\Big(v_t(dis)\Big|I_{t-1}\Big) = -\frac{1}{2}\Big[\frac{c}{1+c}\sigma_\xi^2 + c(1+c)\kappa^2 + (1+c)\sigma_\psi^2\Big]. \tag{28}$$

It clearly is smaller than the analogue (23) under precommitment, witness of the unwanted inflationary bias. However, it is not a priori clear whether discretion or precommitment to a pegged exchange rate results in a higher expected utility. The comparison of (28) with (24) proves the following Lemma:

Lemma 2 *In the one shot game, the difference between the expected* *values of the policy maker's utility under discretion and under precommitment to a pegged exchange rate is*

$$E\Big(v_t(dis) - v_t(peg)\Big|I_{t-1}\Big) = \frac{1}{2}\Big[\frac{c^2}{1+c}\sigma_\xi^2 - c^2\kappa^2 + (1+c)(\sigma_{\psi^*}^2 - \sigma_\psi^2)\Big]. \quad (29)$$

Hence, precommitment to a pegged exchange rate is preferable if

$$\frac{c^2}{(1+c)^2}\sigma_\xi^2 - \frac{c^2}{1+c}\kappa^2 \leq \sigma_{\psi^*}^2 - \sigma_\psi^2. \quad (30)$$

Similarly to the discussion after Lemma 1, this clearly is the case when the domestic policy maker can control inflation relatively imprecisely. In contrast, even if $\sigma_{\psi^*}^2 = \sigma_\psi^2$, precommitment to a peg may or may not be preferable compared to discretion. The reason is that, on the one hand, precommitment to an exchange rate peg eliminates the discretionary inflation bias. On the other hand, it prevents the accommodation of domestic productivity shocks that the precommited foreign policy maker does not account for when setting the money supply. While the first effect increases expected utility, the second one decreases it, which results in an ambiguous net effect.

3.3 The Transparency Issue in the Repeated Policy Game

The previous subsection has shown that in the one shot game the informational structure does not depend on the exchange rate regime. This no longer holds true when the game is repeated for a finite or infinite number of times. In the repeated game the individual information sets, I_{t-1}, also contain all observable realizations of past variables, in particular, the observed realizations of past inflation. Reflecting the transparency difference that results from the controllability difference between the inflation rate and the exchange rate, the sets I_{t-1} differ between a floating and a pegged nominal exchange rate regime.

When the exchange rate is pegged (and the domestic policy maker does not exercise control over the domestic money supply), an unexpected domestic velocity shock leads to offsetting changes in the international reserves and the domestic money supply while the exchange rate and the domestic inflation rate remain unchanged. Moreover, given that the foreign central banker is precommited to a low inflation rate and that relative purchasing power parity holds, pegging the nominal exchange rate unambiguously implies that the domestic policy maker planned the low foreign inflation rate.[15] Hence a velocity shock does not give rise to any doubt about the actions of the domestic policy maker.

In contrast, when the domestic policy maker controls the money supply while the nominal exchange rate floats freely, a domestic velocity shock that he could not forecast may lead to an unexpected increase of the domestic rate of inflation in excess of what is called for to offset optimally the productivity shock ξ_t. In order to verify whether the surprise was caused by the authority in an attempt to stimulate output excessively, $\tilde{\varphi}_t$ must be known to a representative individual; compare (13). However, as Canzoneri (1985) pointed out, $\tilde{\varphi}_t$ is necessarily the policy maker's private information, because it is not incentive compatible to reveal it correctly when surprise inflation is perceived as being beneficial. A rational policy maker would simply understate $\tilde{\varphi}_t$ and claim that the excess inflation surprise deliberately created by him is in fact due to an unforecastable shock. As a consequence of not knowing $\tilde{\varphi}_t$, individuals cannot decompose π_t into π_t^p and ψ_t; compare (11). For this reason, the inflation rate planned by the policy maker is his private information.[16]

There is an implicit but crucial assumption underlying the previous discussion, notably that the nominal exchange rate can be perfectly controlled when control over the domestic money supply is relinquished. This implies that situations are excluded from the analysis in which the domestic policy maker does not have command over a stock of interna-

[15] It should be pointed out that although foreign velocity shocks will give rise to domestic inflation surprises under a pegged exchange rate, this is irrelevant in the present context since the source of these surprises is unambiguously foreign.

[16] Note that from (5), individuals can compute the realizations of φ_t from the observations of π_t, $\hat{m}_t$, and $\hat{x}_t$. However this does not reveal which share of φ_t was known to the policy maker when setting the money supply.

tional 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 pointed out that while in the present set–up the incomplete information about the policy maker's actions stems from the less than perfect control over the inflation rate, it could also have been derived from the incomplete observability of inflation. As mentioned in the introduction, inflation is in reality measured periodically and by the use of 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 composition of the price index employed. Hence a similar incomplete information problem as above would be present if one accounted for the fact that a representative individual can only observe the measured inflation rate, i.e. the sum of the true inflation rate plus a measurement error.

To sum up, in the repeated policy game individuals know the policy maker's planned inflation rates for previous periods only when the exchange rate is pegged. Hence exchange rate pegging is a more transparent policy than inflation targeting under a floating exchange rate. In fact the information available under exchange rate pegging and *incomplete* information about $\tilde{\varphi}_t$ is equivalent to the information that would be available under inflation targeting if there were *complete* information about $\tilde{\varphi}_t$, that is, if $\tilde{\varphi}_t$ were common knowledge.

4 Partial Precommitment in an Infinitely Repeated Policy Game

As in the one shot game there are two benchmark cases to be distinguished: On the one hand, if the policy maker has (full) discretion, then the Nash–equilibrium (27) of the one shot game will also be the unique subgame perfect Nash–equilibrium of the repeated game in any period independently of the exchange rate regime. This holds true, because there are no dynamics in the standard version of the Barro and Gordon model.[17] On the other hand, if the policy maker can (fully) precommit to any policy rule, he will clearly find it optimal to precommit to the ex ante optimal policy rule (18) in all periods; the exchange rate then floats.

The choice of the exchange rate regime possibly affects the equilibrium outcome in "intermediate cases" only. The policy maker then neither has (full) discretion nor access to (full) precommitment, but instead can precommit only *partially* to a policy rule from the set $\mathcal{R}$. More precisely, partial precommitment to a rule is defined by the existence of a *finite* cost that is incurred after a *detected* deviation from the rule. The requirement that a deviation must be detected to be costly is important in the present context of incomplete information about the policy maker's actions. It implies realistically that the creation of excess surprise inflation, that is, of surprise inflation that is not justified by the chosen policy rule, is *not* costly for the policy maker as long as the public erroneously attributes this excess inflation to the occurrence of a positive realization of the disturbance ψ_t.

As will become clear in a moment, this feature of the present model allows one to derive the possible credibility advantages of exchange rate pegging without making the usual ad hoc assumption that the costs of reneging on the policy rule implied by an exchange rate peg are larger than the ones of reneging on the ex ante optimal policy under a float. Instead, we assume that a detected deviation from any rule in $\mathcal{R}$ *ex post* causes the same costs and proceed to show that *ex ante* the expected costs are higher for a deviation from a pegged exchange rate. In doing so, the present value of the costs from a detected deviation is denoted by K and is for analytical convenience taken to be constant. This has become common in the literature; see, for instance, Flood and Isard (1989), Obstfeld (1991), Cukierman (1992,p.99), or Rasmussen (1993).[18]

[17] In more elaborate specifications, current decisions would affect future decisions. Drazen and Masson (1994), for example, establish an intertemporal link by introducing unemployment persistence.

[18] Reputational effects are one frequently used motivation for the existence of such costs K. In infinitely repeated games, these effects are usually modeled by "trigger

The remainder of this section is organized as follows: In the next subsection, the equilibrium of the policy game is studied given that the policy regime is a float. In subsection 4.2, the game is analyzed under exchange rate pegging. Finally, a condition is derived in subsection 4.3 under which exchange rate pegging leads to an equilibrium outcome with a lower (average) inflation rate. Moreover, given this is true, we discuss when the policy maker actually finds it in his interest to peg the exchange rate.

4.1 Inflation Targeting under Partial Precommitment

We now derive the conditions under which the ex ante optimal outcome is a subgame perfect Nash–equilibrium of the repeated policy game, given the inflation rate is targeted and precommitment is only partial. In doing so, it is useful to make specific assumptions on the productivity shock ξ_t and the control error ψ_t. Both disturbances are taken to be identically, independently, and uniformly distributed. Denoting the compact supports by $[-s_\xi, s_\xi]$ and $[-s_\psi, s_\psi]$, one has $\sigma_\xi^2 = s_\xi^2/3$ and $\sigma_\psi^2 = s_\psi^2/3$. Furthermore, the density functions are given by

$$f(\xi_t) = \frac{1}{2s_\xi} \quad \text{and} \quad f(\psi_t) = \frac{1}{2s_\psi}, \qquad 0 < s_\xi, s_\psi < \infty. \tag{31}$$

Although a uniform distribution of ψ_t may at first sight be associated with a rather imprecise control of the inflation rate, it should be kept in mind that a small support may in fact allow for very accurate control.[19]

strategies"; see, for example, Barro and Gordon (1983), Horn and Persson (1988), de Kock and Grilli (1993), or Agénor (1994). However, this approach is problematic because the folk theorem implies the existence of a multiplicity of possible equilibria. As pointed out by, among others, Backus and Driffill (1985) and Rogoff (1987), it is therefore not clear how individuals in a competitive labor market can coordinate on playing any one of the possible equilibrium strategies. This coordination problem might be less severe if individual inflation expectations can be coordinated by the existence of a trade union; see al Nowaihi and Levine (1994) for a further discussion.

[19]Note that Canzoneri (1985) analyzed a similar incomplete information problem for a normal distribution of ψ_t. He obtained essentially the same results as will be

Suppose that a representative individual expects the ex ante optimal policy (18) for period t, i.e. $\pi_t^e(opt) = 0$. On the one hand, if the ex ante optimal inflation rate is targeted in all periods, then the expected discounted value of the sum of all utilities from period t onward follows from (14) as

$$E\Big(V_t(opt)\Big|\tilde{I}_t\Big) = -\frac{c}{2(1+c)}\Big[\xi_t^2 + 2\xi_t\kappa + \frac{\beta}{1-\beta}\sigma_\xi^2\Big] - \frac{1}{2(1-\beta)}\Big[c\kappa^2 + (1+c)\sigma_\psi^2\Big]. \tag{32}$$

On the other hand, the policy maker may plan to deviate from the ex ante optimal rule in period t through the creation of surprise inflation,[20]

$$\pi_t^p(dev) = \frac{c}{1+c}\xi_t + \varepsilon \qquad \varepsilon > 0. \tag{33}$$

The expected discounted period t value of the sum of all future utilities after such a deviation is

$$E\Big(V_t(dev)\Big|\tilde{I}_t\Big) = E\Big(V_t(opt)\Big|\tilde{I}_t\Big) - \Big[\frac{(1+c)}{2}\varepsilon^2 + P(\varepsilon)K - c\kappa\varepsilon\Big], \tag{34}$$

where $P(\varepsilon) \equiv min\{1, \varepsilon/(2s_\psi)\}$ is the probability that after a planned deviation of ε the realized inflation rate is larger than s_ψ. The deviation then is detected because this realization of π_t would be impossible if the policy maker followed (18). Hence $P(\varepsilon)$ is the probability with which the policy maker actually incurs the cost K when deviating by ε. The incomplete information problem about the policy maker's actions determines whether this probability is less than one.

The ex ante optimal policy is sustainable as a subgame perfect Nash–equilibrium of the infinitely repeated policy game under inflation targeting, if and only if the expected utility of the authority for any deviation $\varepsilon > 0$ is not larger than the one for the ex ante optimal rule

derived now. A uniform distribution is mainly assumed here to maintain analytical tractability in the signalling game of the subsequent section.

[20]It is sufficient to consider $\varepsilon > 0$ since deviations with $\varepsilon < 0$ decrease expected utility.

(18),

$$E\Big(V_t(dev)\Big|\tilde{I}_t\Big) \leq E\Big(V_t(opt)\Big|\tilde{I}_t\Big) \quad \forall \varepsilon > 0. \tag{35}$$

Appendix C contains the derivation of a necessary and sufficient condition for (35) to be true:

Lemma 3 *Under the policy regime of inflation targeting, the ex ante optimal policy rule is a subgame perfect Nash–equilibrium of the infinitely repeated game if and only if*

$$2c\kappa s_{\psi} \leq K. \tag{36}$$

Hence, given a cost K, if the policy maker can control the inflation rate relatively precisely and if the distortion κ and the relative weight c he attaches to output stimulation are not too large, then the ex ante optimal policy is sustainable when he targets the inflation rate under a floating exchange rate. This holds true despite the lack of full precommitment. In the opposite case, the incomplete information problem creates too large a possible net gain from excess surprise inflation, because the probability with which a deviation is detected is too low. The ex ante optimal inflation policy rule is then not sustainable as a Nash–equilibrium under a regime of inflation targeting.

In part D of the appendix, the Nash–equilibrium inflation rate is characterized provided condition (36) is violated. This leads to

Lemma 4 *If the ex ante optimal policy rule is not sustainable under inflation targeting, then the equilibrium policy rule of the infinitely repeated game exhibits an inflationary bias on average,*

$$\pi_t^p(bias) = \frac{c}{1+c}\xi_t + \rho c\kappa, \tag{37}$$

where

$$\rho \equiv 1 - \frac{K}{2c\kappa s_{\psi}}. \tag{38}$$

The inflationary bias $\rho c \kappa$ is the larger, the larger the relative weight c attached to output stimulation, the larger the distortion κ, and the less precise the control over the inflation rate (i.e. the larger s_ψ). In the limiting case of totally imperfect inflation control, i.e. s_ψ close to ∞, the subgame perfect Nash–equilibrium of the repeated game under partial commitment in every period is the discretionary policy rule (27) of the one shot game.

In summary, although following the ex ante optimal policy rule (18) in each period is clearly preferable, it may not be feasible when precommitment is only partial. This is due to the incomplete controllability of inflation and the resulting incomplete information about the policy maker's actions, which reduces the expected cost of deviating from the ex ante optimal policy rule. Therefore it is of interest to find out whether the policy rule implied by an exchange rate peg is supportable as a subgame perfect Nash equilibrium under partial precommitment, and also under what conditions this rule leads to a higher expected utility than (37).

4.2 Exchange Rate Pegging under Partial Precommitment

As explained above, every creation of unexpected inflation through a devaluation is detected when the nominal exchange rate is pegged, and there is no incomplete information problem about the actions of the policy maker. It is thus fairly straightforward to determine when a given cost K is sufficiently large to deter unexpected devaluations of the pegged exchange rate. Provided individuals expect the nominal exchange rate to be pegged, the domestic policy maker has two options:

On the one hand, if he does not devalue in period t, then the planned rate of domestic period t inflation equals zero. After substituting $\pi_t^p(peg) = \pi_t^e(peg) = 0$ into (14), the conditional expected period t value of the discounted sum of all utilities from period t onward follows as

$$E\Big(V_t(peg)\Big|\tilde{I}_t\Big) = -\frac{c}{2}\Big[\xi_t^2 + 2\xi_t\kappa + \frac{\beta}{1-\beta}\sigma_\xi^2\Big] \\ -\frac{1}{2(1-\beta)}\Big[c\kappa^2 + (1+c)\sigma_{\psi^*}^2\Big]. \tag{39}$$

On the other hand, given that K is fixed and that individual inflation expectation are zero, the optimal rate of surprise inflation in case of a devaluation can be shown to equal $\varepsilon = c(\xi_t + \kappa)/(1+c)$. This rate of surprise inflation rate is achieved by an unexpected devaluation of the same magnitude, leading to

$$E\Big(V_t(dev)\Big|\tilde{I}_t\Big) = E\Big(V_t(peg)\Big|\tilde{I}_t\Big) - \Big[K - \frac{c^2}{2(1+c)}(\xi_t + \kappa)^2\Big]. \tag{40}$$

The exchange rate peg is sustainable as a subgame perfect Nash–equilibrium of the infinitely repeated policy game, if and only if the conditional expected utility of the authority after the (optimal) devaluation is not larger than after pegging the exchange rate. Using (40), this can, for any given $\xi_t \in [-s_\xi, s_\xi]$, be written as

$$\frac{c^2}{2(1+c)}(\xi_t + \kappa)^2 \leq K. \tag{41}$$

Since the productivity shock ξ_t is revealed after wages are negotiated and before money demand is determined, (41) has to be satisfied for all possible values of ξ_t.[21] Hence we get the following result:

Lemma 5 *In the infinitely repeated policy game, exchange rate pegging is a subgame perfect Nash–equilibrium if and only if*

$$\frac{c^2}{2(1+c)}(s_\xi + \kappa)^2 \leq K. \tag{42}$$

[21]Exchange rate escape clauses that allow for a devaluation when an unusual large shock materializes are not considered here. For a discussion of the sense and nonsense of such arrangements, compare Obstfeld (1991).

As above, provided partial precommitment is strong enough, it will be optimal for the policy maker not to devalue the nominal exchange rate unexpectedly though he is not fully precommited. For a given value of K, this is more likely to hold true, the smaller are the relative costs c of deviations of real output from equilibrium and the distortion κ. More interestingly, the support of the asymmetric productivity shock ξ also needs to be small enough if the peg is to be sustainable as a Nash–equilibrium. In contrast, when too large a realization of ξ is possible, then exchange rate pegging is not a subgame perfect Nash–equilibrium, because the possible gain from offsetting a devaluation can be too large.

4.3 Imports of Credibility Through Exchange Rate Pegging

Comparing the two equilibrium conditions (36) and (42), one finds

Proposition 1 *In the infinitely repeated policy game, the following condition is necessary and sufficient so as to ensure that the ex ante optimal policy rule is a subgame perfect Nash–equilibrium when the exchange rate is pegged but not when the inflation rate is targeted:*

$$\frac{c^2}{2(1+c)}(s_\xi + \kappa)^2 \leq K \leq 2c\kappa s_\psi. \tag{43}$$

A necessary condition for (43) to be fulfilled is that the support s_ξ of the domestic productivity shock is small relative to the support s_ψ of the domestic control error. (43) will certainly be satisfied if the first inequality holds and if s_ψ is very large, i.e. if control over inflation is very imprecise. The discretionary policy rule (27) then is the Nash–equilibrium under a float in every period; compare (37). Hence there exist parameter values such that partial precommitment to exchange rate pegging is possible, and at the same time the discretionary outcome of the one shot game obtains in every period when the exchange rate floats. A distinct feature of the present analysis is that this outcome has endogenously been derived from the transparency difference between both policy regimes. In contrast, it is usually justified by *ad hoc* assumptions in the literature on the credibility effects of exchange rate pegging; see, for example, Currie et al. (1992) or de Kock and Grilli (1993).

Given (43) holds, two policy rules are feasible, notably $\pi_t^p(peg)$ as implied by exchange rate pegging and the contingent rule $\pi_t^p(bias)$ as given by (37) under a float. It is therefore useful to take the analysis one step further and allow for the endogenous choice of the exchange rate regime. This choice needs to be made and announced before wages are negotiated, because individual inflation expectations depend on the policy regime in operation. Provided both policy rules are sustainable, the rule with the higher expectation of utility (conditional on I_{t-1}) will be the policy maker's equilibrium choice. In part E of the appendix the following is proved:

Proposition 2 *An exchange rate peg is the preferred policy regime in the infinitely policy game, if and only if*

$$\frac{c^2}{1+c}\sigma_\xi^2 \leq (\rho c \kappa)^2 + (1+c)(\sigma_\psi^2 - \sigma_{\psi^*}^2). \tag{44}$$

The left hand side of this condition represents an upper bound for the possible costs of pegging the exchange rate. These costs are incurred because it is impossible to accommodate the asymmetric productivity shock when the exchange rate is pegged. The expected gains from exchange rate pegging are shown on the right hand side. The first term captures the expected inflationary bias under floating due to the incomplete information about the policy maker's actions. The second term represents the difference between the expected domestic and foreign cost of incomplete control over inflation. This term reflects the fact that, if the foreign authority can control the inflation rate more precisely than the domestic one, then pegging the exchange rate results in a reduction of the variance of inflation and thus in an additional expected gain.[22]

[22]Note that this difference is likely to be of significant magnitude after a regime

Hence an exchange rate peg is the more likely to result as the equilibrium regime, the smaller is the support (and hence the variance) of the domestic productivity shock, the larger is the inflationary bias under a float, and the more imprecise is control over domestic inflation relative to the foreign country.

In summary, provided that the two conditions (43) and (44) hold, an exchange rate peg is the equilibrium policy regime. Since in this case pegging the exchange rate eliminates the (average) inflationary bias arising under inflation targeting, it may be interpreted as importing credibility from the foreign policy maker, who is credible because he was initially assumed to be fully precommited. The import of credibility is paid for by the costs of not offsetting asymmetric productivity shocks.

One weakness of this interpretation is that it reduces the notion of a credibility import to a reduction of the average equilibrium inflation rate. For this reason, a second example is now provided, in which the concept of credibility is more meaningfully defined.

5 A Finitely Repeated Policy Game with Incomplete Information about the Policy Maker's Type

In this second example, the analysis is restricted to a finite number of periods, which for reasons of analytical tractability is taken to be two. As it stands the unique Nash-equilibrium of the finitely repeated game would be the discretionary policy rule in any period of the game because of the well known "backwards unraveling effect". For this reason, it is assumed, as in the seminal paper of Backus and Driffill (1985), that there exist two possible types of policy makers, a strong one (denoted S) and a weak one (denoted W). The strong type is precommited to a policy rule that implies zero expected inflation. The two examples of such policy

shift, e.g. the implementation of a stabilization program. This holds true since money demand is typically instable in such situations.

rules considered below are the rule implied by a pegged exchange rate and the ex ante optimal policy rule. In contrast, the weak type has discretion to plan the inflation rate that ex post maximizes his utility (14),

$$V_0 = v_0 + \beta v_1 = -\frac{1}{2} \sum_{t=0}^{1} \beta^t \Big[c(\pi_t^p + \psi_t - \pi_t^e - \xi_t - \kappa)^2 + (\pi_t^p + \psi_t)^2 \Big]. \quad (45)$$

At the beginning of the game, a representative individual does not know which type it is facing, but holds a prior belief in form of a probability μ_0 that the policy maker is strong, $\mu_0 \in [0,1]$. This probability is usually referred to as the pre–game reputation for being strong. After the first period, the realized inflation rate is observed and the representative individual updates the pre–game reputation for being strong according to Bayes rule. On the basis of this update it forms inflationary expectations for the second period. As is standard by now, the appropriate solution concept for this class of games is the one of sequential equilibrium.[23]

In the remainder of this section, the policy game is analyzed given the exchange rate regime is either a peg (subsection 5.1) or a float (subsection 5.2). Subsection 5.3 then deals with the effects of the exchange rate regime choice on credibility and summarizes.

5.1 Pooling under Exchange Rate Pegging

As in the previous example, the planned rate of inflation under a pegged exchange rate is unambiguously zero and there is no uncertainty about the government's actions. It is assumed that the strong policy maker is precommited to peg the exchange rate, implying that he plans zero inflation. We now derive a condition under which the weak policy maker

[23] Examples for related signalling policy games when the nominal exchange rate is the policy instrument include Horn and Persson (1988), Andersen and Risager (1991), and Agénor (1994). In contrast, the inflation rate was the policy instrument in, among others, Backus and Driffill (1985), Barro (1986), Vickers (1986), Rogoff (1989), and Cukierman and Liviatan (1991), who all assumed that inflation can perfectly be controlled. Signalling policy games with imperfect control over the inflation rate were analyzed by Driffill (1989) and Cukierman and Liviatan (1992).

also finds it optimal not to devalue the exchange rate, thereby mimicking the action of the strong policy maker. However, in all sequential equilibria of the finitely repeated policy game, the weak policy maker will chose to devalue in the last period because he has discretion and this is ex post optimal. All one can therefore hope for is an equilibrium where the weak type pegs the exchange rate in the first period of the game. Such a sequential equilibrium is called a pooling equilibrium:

$$S(peg, pool, S) = (0, 0), \tag{46.a}$$

$$\begin{aligned} S(peg, pool, W) &= \Big(\pi_0^p(peg, pool), \pi_1^p(peg, pool)\Big) \\ &= \Big(0, \pi_1^p(peg, pool)\Big), \end{aligned} \tag{46.b}$$

where $\pi_1^p(peg, pool)$ is the ex post optimal policy rule under discretion. Since there is no updating of beliefs in a pooling equilibrium, inflation expectations for the second period are given by

$$\pi_1^e(peg, pool) = \mu_0 \cdot 0 + (1-\mu_0)\pi_1^p(peg, pool) = (1-\mu_0)\pi_1^p(peg, pool). \tag{47}$$

Using this and following exactly the same steps as for the derivation of (27), appendix B shows that

$$\hat{e}_1(peg, pool) = \pi_1^p(peg, pool) = \frac{c}{1+c}\xi_1 + \frac{c}{1+\mu_0 c}\kappa. \tag{48}$$

Hence the weak policy maker's expected utility in the pooling equilibrium can be written as:

$$E\Big(V_0(peg, pool)\Big|\tilde{I}_0\Big) = -\frac{1}{2}\Big[c(\xi_0+\kappa)^2 + \beta\frac{c}{1+c}\sigma_\xi^2 + \beta\frac{c(1+c)}{(1+\mu_0 c)^2}\kappa^2\Big] - (1+c)(1+\beta)\sigma_{\psi^*}^2. \tag{49}$$

A devaluation in the first period unambiguously reveals the weak policy maker's type, implying that the discretionary outcome is expected for the second period,

$$\pi_1^e(peg, dev) = c\kappa. \tag{50}$$

If the weak policy maker devalues, he will therefore choose the rate of devaluation that maximizes the conditional expectation of his first period utility. Since individual inflation expectations for the first period are zero in a pooling equilibrium, the optimal rate of devaluation turns out to be

$$\hat{e}_0(peg, dev) = \pi_0^p(peg, dev) = \frac{c}{1+c}(\xi_0 + \kappa). \tag{51}$$

The weak policy maker's conditional expected utility after a devaluation thus is

$$\begin{aligned} E\Big(V_0(peg, dev)\Big|\tilde{I}_0\Big) = &-\frac{1}{2}\Big[\frac{c}{1+c}(\xi_0+\kappa)^2 + \beta\frac{c}{1+c}\sigma_\xi^2 + \beta c(1+c)\kappa^2\Big] \\ &-\frac{1}{2}(1+c)(1+\beta)\sigma_{\psi^*}^2. \end{aligned} \tag{52}$$

The strategies $S(peg, pool, W)$ constitute a sequential equilibrium if and only if there exists a prior belief μ_0 such that, for all possible realizations of ξ_0, the expected utility with a devaluation in the first period is not larger than without one,

$$E\Big(V_0(peg, dev)\Big|\tilde{I}_0\Big) \leq E\Big(V_0(peg, pool)\Big|\tilde{I}_0\Big). \tag{53}$$

Substituting (49) and (52) into this inequality, we get:

Lemma 6 *Under a policy regime of exchange rate pegging, a pooling equilibrium exists in the finitely repeated signalling game if and only if*

$$\frac{c}{(1+c)\kappa}(s_\xi + \kappa)^2 \leq \beta(1+c)\kappa\Big[1 - \frac{1}{(1+\mu_0 c)^2}\Big]. \tag{54}$$

If (54) holds, the weak policy maker pegs the exchange rate in the first period even though he has full discretion. The intuition behind this result is as follows: Provided that $\pi_0^e(peg, pool) = 0$, the weak policy maker's expected gain from mimicking the strong one in the first period comes from maintaining the pre–game reputation for being strong until the last period of the game. However, as in the previous example, this has a cost because the realization of the asymmetric shock ξ_0 cannot be offset. In contrast, if he devalues and collects the gains from the resulting surprise inflation, he can offset this shock, but his type is revealed in the first period already. The costs of a devaluation are therefore to be seen in the fact that the suboptimal discretionary Nash–equilibrium of the one shot game (with the unwanted inflationary bias) materializes in the second period. Hence, provided that the support of the productivity shock is not too large and the discount factor is not too small, W finds it optimal to postpone the devaluation to the second period if the resulting stimulation of second period output is large enough, i.e. if μ_0 is sufficiently high.

5.2 Pooling under Inflation Targeting

Now the question is addressed under which conditions a pooling equilibrium exists with inflation targeting. Given that the strong policy maker is precommited to the ex ante optimal policy rule (18), consider first the expected payoff of the weak policy maker in a pooling equilibrium. Since he imitates the strong type in the first period of the game, one has

$$\pi_0^p(float, pool) = \frac{c}{1+c}\xi_0 \quad \text{and} \quad \pi_0^e(float, pool) = 0. \tag{55}$$

Hence there is no updating of beliefs after the first period and inflation expectations for the second period are

$$\pi_1^e(float, pool) = (1-\mu_0)\pi_1^p(float, pool). \tag{56}$$

After substitution of (55) and (56) into $E(v_1(float, pool)|\tilde{I}_1)$, one finds for the ex post optimal second period policy rule

$$\pi_1^p(float, pool) = \frac{c}{1+c}\xi_1 + \frac{c}{1+\mu_0 c}\kappa. \tag{57}$$

The conditional expectation of the weak policy maker's utility in a pooling equilibrium can then be shown to equal:

$$E\Big(V_0(float, pool)\Big|\tilde{I}_0\Big) = -\frac{1}{2}\left\{\frac{c}{1+c}\left[\xi_0^2+2\xi_0\kappa+\beta\sigma_\xi^2\right] + \left[1+\frac{\beta(1+c)}{(1+\mu_0 c)^2}\right]c\kappa^2\right\}$$

$$-\frac{1}{2}(1+c)(1+\beta)\sigma_\psi^2. \tag{58}$$

The derivation of the policy maker's expected utility after a deviation from the ex ante optimal policy rule is quite tedious. In part F of the appendix, it is proved that

$$\begin{aligned}
E\Big(V_0(float, dev)\Big|\tilde{I}_0\Big) &= E\Big(v_0(float, dev)\Big|\tilde{I}_0\Big) \\
&+ \beta\frac{\varepsilon}{2s_\psi}E\Big(v_1(float, dev)\Big|\tilde{I}_0, \text{revelation}\Big) \\
&+ \beta\Big[1-\frac{\varepsilon}{2s_\psi}\Big]E\Big(v_1(float, dev)\Big|\tilde{I}_0, \text{no revelation}\Big) \\
&= E\Big(V_0(float, pool)\Big|\tilde{I}_0\Big) \\
&- \frac{1}{2}\Big\{(1+c)\varepsilon^2+\Big[1-\frac{1}{(1+\mu_0 c)^2}\Big]\frac{c(1+c)\beta\kappa^2}{2s_\psi}\varepsilon-2c\kappa\varepsilon\Big\}.
\end{aligned} \tag{59}$$

Using (58) and (59), appendix G derives the following equilibrium condition:

Lemma 7 *Under a policy regime of inflation targeting, a pooling equilibrium exists in the finitely repeated signalling game if and only if*

$$4s_\psi \leq (1+c)\beta\kappa\Big[1-\frac{1}{(1+\mu_0 c)^2}\Big]. \tag{60}$$

Hence, if control over the inflation rate is relatively precise and the pre-game reputation for being strong is sufficiently high, then a pooling equilibrium exists despite the incompleteness of information about the policy maker's actions under inflation targeting. On the other hand, if control over inflation is very imprecise, then the expected gain from imitation may be reduced so considerably that a pooling equilibrium does not exist under inflation targeting. This is due to the fact that a large amount of noise makes the detection of excess surprise inflation fairly unlikely.

If a pooling equilibrium does not exist, then the sequential equilibrium strategy of the weak policy exhibits an average inflationary bias.

Under the condition that the support of the control error is sufficiently large, i.e. $c\kappa \leq s_{\psi}$, part H of the appendix shows:

Lemma 8 *Given condition (60) is violated under a policy regime of inflation targeting, the equilibrium policy rule in the finitely repeated signalling game is*

$$\pi_0^p(float, bias) = \frac{c}{1+c}\xi_0 + \omega c\kappa, \tag{61}$$

where

$$\omega \equiv 1 - \left[1 - \frac{1}{(1+\mu_0 c)^2}\right]\frac{(1+c)\beta\kappa}{4s_{\psi}}. \tag{62}$$

First, notice that $\omega \in [0,1]$ if (60) does not hold. Secondly, one may observe that the inflationary bias is the larger, the more imprecisely inflation can be controlled, i.e. the larger is the support of ψ. This comes about because for a larger amount of noise, the probability of incurring the adverse consequences of revelation in the first period is lower. In the limit s_{ψ} is infinite and the discretionary inflation rate is the sequential equilibrium strategy of the weak policy maker in the first period of the game. Finally, it is worth mentioning that the sequential equilibrium may no longer be a standard pooling or separating equilibrium when signals are noisy. Instead, there are positive probabilities $(\omega c\kappa)/(2s_{\psi})$ and $1-(\omega c\kappa)/(2s_{\psi})$ with which the weak policy maker's type is revealed or not revealed, respectively.

5.3 Imports of Credibility Through Exchange Rate Pegging

In this final subsection, we are interested in characterizing a condition under which exchange rate pegging imports credibility. Comparing expressions (54) and (60) leads to

Proposition 3 *In the finitely repeated signalling game, the following condition is necessary and sufficient for pooling to be a sequential equi-*

librium when the exchange rate is pegged but not when the inflation rate is targeted:

$$\frac{c}{(1+c)\kappa}(s_\xi+\kappa)^2 q \leq \beta(1+c)\kappa\left[1-\frac{1}{(1+\mu_0 c)^2}\right] < 4s_\psi. \qquad (63)$$

There certainly exist parameter constellations for which both of these inequalities are satisfied. For example, if the support s_ξ of the domestic productivity shock is small, the relative weight on output stimulation c large, and the pre–game reputation μ_0 large too, then the first inequality is satisfied. For a large support s_ψ of the control error the second inequality can also be ensured. As in the infinitely repeated game, it is therefore possible that exchange rate pegging is a sequential equilibrium strategy while targeting the ex ante optimal policy rule under a floating exchange rate is not.

Using the previous results, we can now study what happens to the credibility of the weak policy maker in this case, i.e. if (63) holds. As in Drazen and Masson (1994), credibility is defined as the (expected) posterior, that is, as the (expectation of the) probability after the first period of the policy game that the policy maker is strong. Under a pegged exchange rate regime, this probability equals the pre–game probability $\mu_1 = \mu_0$, witnessing the fact that the equilibrium is pooling. In contrast, since the equilibrium is no longer pooling under a float, the reputation of the weak policy maker after the first period depends on the inflationary bias $\omega c\kappa$ and the realization of the inflation rate. More precisely, the expected probability for being strong is

$$E(\mu_1|\tilde{I}_0) = \left[1-\frac{\omega c\kappa}{2s_\psi}\right]\mu_0. \qquad (64)$$

Since this expression clearly is smaller than μ_0 if $0 < \omega$, we finally have:

Proposition 4 *Given condition (63) is satisfied in the finitely repeated signalling game, the transparency advantage of a pegged exchange rate leads to an import of credibility from the credible foreign policy maker* *and eliminates an average inflationary bias that arises under inflation targeting.*

6 Conclusion

In this paper, the credibility of monetary policy has been analyzed under two different nominal exchange rate regimes. When the exchange rate floats, the domestic policy maker targets the inflation rate. Since inflation is in part uncontrollable due to stochastic disturbances, there prevails incomplete information about the policy maker's actions in this case. In contrast, the public knows about the actions of the policy maker when he pegs the nominal exchange rate to a low inflation currency governed by a precommited foreign policy maker. This comes about because the nominal exchange rate can perfectly be controlled if it is consistent with economic fundamentals and if there is sufficient access to international reserves. Hence pegǵing the exchange rate is the more transparent policy regime.

The incomplete information problem prevailing under a floating exchange rate increases the expected gains from a deviation from the ex ante optimal low inflation policy as perceived by the policy maker. In two repeated policy games, parameter constellations have been identified under which an (average) inflationary bias arises when the inflation rate is targeted. The transparency difference between a pegged exchange rate and a targeted inflation rate under a float thus explains why pegging the exchange rate may import credibility from a precommited foreign policy maker. The costs of this import of credibility are to be seen in the lost flexibility of monetary policy, which cannot be used to accommodate asymmetric productivity shocks when the exchange rate is pegged. Imports of credibility are therefore only possible if the real shocks impinging on both economies are not too different.

It should be stressed that these results have not been derived from the credibility of any sort of mutual exchange rate agreement designed so as to make unexpected devaluations more costly than the creation of inflation surprises under a floating exchange rate. Instead the analysis has deliberately been restricted to a *unilateral* peg. Moreover, constitutional arrangements that require the exchange rate to be pegged have not been assumed. An example of such an arrangement is the constitutional amendment by which Sweden precommited to the gold standard.

In conclusion, some limitations of this paper are discussed, which may indicate possibilities for further research. To begin with, it has been assumed that the domestic policy maker can either partially precommit or that there is a positive pre–game probability that he can fully precommit. If with certainty there is complete discretion, then credibility *cannot* be imported through exchange rate pegging in the present set–up. Moreover, only two different policy regimes have been analyzed. One might be tempted to argue that this is misleading since interest rate pegging has not been considered despite the fact that it might be as transparent as exchange rate pegging. However, if the real interest rates are equal in the two countries, if capital is perfectly mobile, and if domestic and foreign bonds are perfect substitutes, a zero planned inflation rate in the domestic country implies the equality of the two nominal interest rates. The no–arbitrage condition then requires that the expected rate of exchange devaluation be zero, that is, that the nominal exchange rate be pegged. Excluding interest rate pegging from the analysis thus does not appear to invalidate the case for exchange rate pegging.

Furthermore, the analysis was restricted to situations in which a pegged exchange rate is in principle consistent with the economic fundamentals. The possibility of speculative attacks has therefore been ruled out. Consequently, the results derived here do not apply to situations in which the policy maker pegs the exchange rate *and* at the same time expands the domestic money supply so as to achieve a higher domestic than foreign inflation rate.[24] And finally, we have abstracted from optimal taxation considerations. In particular, situations in which the domestic authority optimally collects a significant share of government revenues from the inflation tax, resulting from a significantly positive

[24]This qualifier certainly applies for the Uk, Italy, and Spain before the EMS crisis in 1992.

inflation rate, have not been dealt with. In a related paper, Herrendorf (1994) showed that pegging the exchange rate may in such situations *no longer* be credible, even though it would be if the optimal inflation rates from a public finance point of view were similar between the two countries.

Appendix

A. Derivation of Expression (18)

For a policy rule from the set $\mathcal{R}$, inflation expectations are $\pi_t^e = b$. Substituting this into (14) gives:[25]

$$E\Big(v_t(opt)\Big|I_{t-1}\Big) = -\frac{1}{2}\Big\{\Big[c(a-1)^2 + a^2\Big]\sigma_\xi^2 + c\kappa^2 + b^2 + (1+c)\sigma_\psi^2\Big\}. \quad \text{(A.1)}$$

(A.1) implies that it is optimal to set $b = 0$. Moreover, taking the first order condition with respect to a shows that

$$a = \frac{c}{1+c}. \quad \text{(A.2)}$$

Hence the optimal policy rule under precommitment is (18).

B. Derivation of Expression (27)

In order to derive the equilibrium rule under discretion, one starts out with a rule from the set $\mathcal{R}$. Analogously to the derivation under precommitment, it can be shown that

$$a = \frac{c}{1+c}. \quad \text{(B.1)}$$

[25] Note that it is appropriate to consider the expectation conditional on I_{t-1} since the ex ante optimal policy rule is to be specified *before* wages are negotiated.

Hence the rule under discretion is of the form

$$\pi_t^p(dis) = \frac{c}{1+c}\xi_t + b. \tag{B.2}$$

The substitution of (B.2) into (14) yields

$$E\Big(v_t(dis)\Big|\tilde{I}_t\Big) = -\frac{1}{2}\Big\{c\Big[-\frac{1}{1+c}\xi_t + b - \pi_t^e(dis) - \kappa\Big]^2 + \Big[\frac{c}{1+c}\xi_t + b\Big]^2 + (1+c)\sigma_\psi^2\Big\}. \tag{B.3}$$

Taking the first order condition with respect to b while treating $\pi_t^e(dis)$ as given leads to the policy maker's reaction function under discretion,

$$b = \frac{c}{1+c}\Big[\pi_t^e(dis) + \kappa\Big]. \tag{B.4}$$

Since $\pi_t^e(dis) = b$ under the policy rule (B.2), (B.4) implies that in equilibrium

$$b = c\kappa, \tag{B.5}$$

which proves (27).

C. Proof of Lemma 3

If we use (32) and (34), we find that (35) is equivalent to

$$0 \leq \frac{(1+c)}{2}\varepsilon^2 + \Big[\frac{K}{2s_\psi} - c\kappa\Big]\varepsilon \quad \forall\varepsilon > 0. \tag{C.1}$$

Dividing (C.1) by ε and letting ε converge to zero yields the necessary condition

$$2c\kappa s_\psi \leq K. \tag{C.2}$$

Since the coefficient of ε in (C.1) is positive when (C.2) holds, (C.2) is also sufficient for ensuring (35).

D. Proof of Lemma 4

In order to derive (37), assume that the policy rule is of the form

$$\pi_t^p(bias) = \frac{c}{1+c}\xi_t + \rho c\kappa, \qquad \rho \in (0,1]. \tag{D.1}$$

Given this is an equilibrium policy rule, individual inflation expectations are $\pi_t^e(bias) = \rho c\kappa$. The expected utility from following (D.1) therefore is

$$\begin{aligned} E\Big(V_t(bias)\Big|\tilde{I}_t\Big) = &-\frac{c}{2(1+c)}\left[\xi_t^2 + 2(1+c\rho)\xi_t\kappa + \frac{\beta}{1-\beta}\sigma_\xi^2\right] \\ &-\frac{1}{2(1-\beta)}\left[(1+c\rho^2)c\kappa^2 + (1+c)\sigma_\psi^2\right]. \end{aligned} \tag{D.2}$$

Now, consider a deviation from (D.1) of the form

$$\pi_t^p(dev) = \frac{c}{1+c}\xi_t + \rho c\kappa + \varepsilon, \qquad \rho \in (0,1],\ \varepsilon \neq 0. \tag{D.3}$$

The expected utility of the policy maker from this deviation can be shown to equal

$$E\Big(V_t(dev)\Big|\tilde{I}_t\Big) = E\Big(V_t(bias)\Big|\tilde{I}_t\Big) - \left[\frac{(1+c)}{2}\varepsilon^2 + P(\varepsilon)K - (1-\rho)c\kappa\varepsilon\right], \tag{D.4}$$

where $P(\varepsilon) = \varepsilon/2s_\psi$. Hence, (D.1) is a subgame perfect Nash–equilibrium, if and only if

$$0 \leq \frac{1+c}{2}\varepsilon^2 + \left[\frac{K}{2s_\psi} - (1-\rho)c\kappa\right]\varepsilon \qquad \forall\varepsilon \neq 0. \tag{D.5}$$

Since the right hand side is a quadratic function in ε that becomes zero for $\varepsilon = 0$, (D.5) can only hold if that quadratic function has a minimum in zero. Taking the first order condition with respect to ε, this is found to be true if and only if

$$0 = \frac{K}{2s_\psi} - (1-\rho)c\kappa, \tag{D.6}$$

which yields (37).

E. Proof of Proposition 2

On the one hand, the expected present value of utility under exchange rate pegging can be shown to equal

$$E\Big(V_t(peg)\Big|I_{t-1}\Big) = -\frac{1}{2(1-\beta)}\Big[c\sigma_\xi^2 + c\kappa^2 + (1+c)\sigma_{\psi^*}^2\Big]. \tag{E.1}$$

On the other hand, one finds for a float with a policy rule (37)

$$E\Big(V_t(bias)\Big|I_{t-1}\Big) = -\frac{1}{2(1-\beta)}\Big[\frac{c}{1+c}\sigma_\xi^2 + (1+c\rho^2)c\kappa^2 + (1+c)\sigma_\psi^2\Big], \tag{E.2}$$

where ρ is given by (38). (E.1) and (E.2) imply that (44) is a necessary and sufficient condition for ensuring

$$E\Big(V_t(bias)\Big|I_{t-1}\Big) \leq E\Big(V_t(peg)\Big|I_{t-1}\Big). \tag{E.3}$$

F. Derivation of Expression (59)

A deviation from pooling may take the following form,

$$\pi_0^p(float, dev) = \frac{c}{1+c}\xi_0\varepsilon, \qquad \varepsilon > 0. \tag{F.1}$$

The conditional expectation of policy maker's utility in the first period after this deviation turns out to be

$$\begin{aligned} E\Big(v_0(float, dev)\Big|\tilde{I}_0\Big) = &-\frac{1}{2}\Big\{\frac{c}{1+c}\Big[\xi_0^2 + 2\xi_0\kappa\Big] + c\kappa^2 + (1+c)\sigma_\psi^2\Big\} \\ &-\frac{1}{2}\Big[(1+c)\epsilon^2 - 2c\kappa\epsilon\Big]. \end{aligned} \tag{F.2}$$

Moreover, after a deviation, individual inflation expectations for the second period depend on the realization of the disturbance ψ_0 in the first period. Two possible cases are to be distinguished. In the first case,

$$\pi_0^p(float, dev) + \psi_0 \leq \pi_0^p(float, pool) + s_\psi, \tag{F.3}$$

or equivalently

$$\psi_0 \leq s_\psi - \varepsilon. \tag{F.4}$$

If such a realization of the shock occurs, then the deviation cannot be detected, because the resulting inflation rate could also occur if the policy maker followed the ex ante optimal rule. By Bayes rule, there is no updating of beliefs in this case and the posterior equals the prior,

$$\mu_1 = prob(S|\pi_0) = \mu_0.$$

For a deviation $\varepsilon \in (0, 2s_\psi)$, this outcome occurs with probability $1 - \varepsilon/(2s_\psi)$. In this case, we get

$$\pi_1^p(float, dev) = \frac{c}{1+c}\xi_1 + \frac{c}{1+\mu_0 c}\kappa \quad \text{and}$$
$$\pi_1^e(float, dev) = \frac{c}{1+\mu_0 c}\kappa, \tag{F.5}$$

which implies for the expected second period utility of the policy maker:

$$E\Big(v_1(float, dev)\Big|\tilde{I}_0, \text{no revelation}\Big) = -\frac{1}{2}\Big[\frac{c}{1+c}\sigma_\xi^2 + \frac{c(1+c)}{(1+\mu_0 c)^2}\kappa^2 + (1+c)\sigma_\psi^2\Big]. \tag{F.6}$$

In the opposite case, one has

$$\pi_0^p(float, dev) + \psi_0 > \pi_0^p(float, pool) + s_\psi, \tag{F.7}$$

which is equivalent to

$$\psi_0 > s_\psi - \varepsilon. \tag{F.8}$$

The realized inflation rate then is such that it could not result if (18) were followed. Hence revelation of the weak policy maker's type occurs, implying a zero probability of being strong,

$$\mu_1 = prob(S|\pi_0) = 0. \tag{F.9}$$

For a given $\varepsilon > 0$, the probability of revelation is $\varepsilon/2s_\psi$. In this case,

$$\pi_1^p(flaot, dev) = \frac{c}{1+c}\xi_1 + c\kappa \quad \text{and} \quad \pi_1^e(float, dev) = c\kappa, \tag{F.10}$$

and the expected utility of the policy maker amounts to

$$E\Big(v_1(float, dev)\Big|\tilde{I}_0, \text{revelation}\Big) = -\frac{1}{2}\Big[\frac{c}{1+c}\sigma_\xi^2 + c(1+c)\kappa^2 \\ +(1+c)\sigma_\psi^2\Big]. \tag{F.11}$$

Since inflation expectations for the first period are zero in a pooling equilibrium, expression (59) for the conditionally expected utility after a deviation follows directly from the previous results.

G. Proof of Lemma 7

The necessary and sufficient condition for the existence of a pooling equilibrium under a float is implied by (59),

$$0 \leq (1+c)\varepsilon^2 + \left\{\left[1 - \frac{1}{(1+\mu_0 c)^2}\right]\frac{c(1+c)\beta\kappa^2}{2s_\psi} - 2c\kappa\right\}\varepsilon \qquad \forall\varepsilon > 0. \tag{G.1}$$

Dividing this inequality by ε and letting ε go to zero, one finds a necessary condition for (G.1) to be satisfied,

$$4s_\psi \leq (1+c)\beta\kappa\left[1 - \frac{1}{(1+\mu_0 c)^2}\right]. \tag{G.2}$$

Since this condition implies that the coefficient of ε in (G.1) is positive, it is also sufficient for the existence of a pooling equilibrium.

H. Proof of Lemma 8

Consider a policy rule of the form

$$\pi_0^p(float, bias) = \frac{c}{1+c}\xi_0 + \omega c\kappa, \qquad \omega \in (0,1]. \tag{H.1}$$

If this rule is a sequential equilibrium strategy for the first period of game, then

$$\pi_0^e(float, bias) = \omega c\kappa. \tag{H.2}$$

We restrict the analysis to situations in which $c\kappa \leq s_\psi$. Revelation then occurs with probability $(\omega c\kappa)/(2s_\psi)$. Using this, (F.6), and (F.11), one may write the expected utility from following rule (H.1) as:

$$\begin{aligned}
E\Big(V_0(float, bias)\Big|\tilde{I}_0\Big) &= E\Big(v_0(float, bias)\Big|\tilde{I}_0\Big) \\
&\quad +\beta\frac{\omega c\kappa}{2s_\psi}E\Big(v_1(float, bias)\Big|\tilde{I}_0, \text{revelation}\Big) \\
&\quad +\beta\Big[1-\frac{\omega c\kappa}{2s_\psi}\Big]E\Big(v_1(float, bias)\Big|\tilde{I}_0, \text{no revelation}\Big) \\
&= -\frac{1}{2}\Big[\frac{c}{1+c}\xi_0^2 + c\kappa^2 + \frac{2c\xi_0\kappa}{1+c}(1+\omega c) + (\omega c\kappa)^2\Big] \\
&\quad -\frac{\beta}{2}\frac{\omega c\kappa}{2s_\psi}\Big[\frac{c}{1+c}\sigma_\xi^2 + c(1+c)\kappa^2\Big] \\
&\quad -\frac{\beta}{2}\Big[1-\frac{\omega c\kappa}{2s_\psi}\Big]\Big[\frac{c}{1+c}\sigma_\xi^2 + \frac{c(1+c)}{(1+\mu_0 c)^2}\kappa^2\Big] \\
&\quad -\frac{1}{2}(1+c)(1+\beta)\sigma_\psi^2.
\end{aligned} \tag{H.3}$$

In order to derive a condition under which (H.1) is a sequential equilibrium strategy of the weak policy maker for the first period of the game, consider a deviation of the form

$$\pi_0^p(float, dev) = \frac{c}{1+c}\xi_0 + \omega c\kappa + \varepsilon, \qquad \varepsilon \neq 0. \tag{H.4}$$

Such a deviation results in an expected utility of

$$E\Big(V_0(float, dev)\Big|\tilde{I}_0\Big) = E\Big(V_0(float, bias)\Big|\tilde{I}_0\Big) \tag{H.5}$$

$$-\frac{1}{2}\Big[(1+c)\varepsilon^2 - 2(1-\omega)c\kappa\varepsilon\Big]$$
$$-\frac{\beta\varepsilon}{4s_\psi}\Big[1-\frac{1}{(1+\mu_0 c)^2}\Big]c(1+c)\kappa^2.$$

Hence, (H.1) is a sequential equilibrium strategy if and only if

$$0 \leq \frac{1+c}{2}\varepsilon^2 + \left\{\left[1-\frac{1}{(1+\mu_0 c)^2}\right]\frac{c(1+c)\beta\kappa^2}{4s_\psi} - (1-\omega)c\kappa\right\}\varepsilon \quad \forall\varepsilon \neq 0. \tag{H.6}$$

Since the right hand side is quadratic function in ε that becomes zero for $\varepsilon = 0$, (H.6) can only hold if the right hand side has a minimum in zero. This is equivalent to

$$0 = \left[1-\frac{1}{(1+\mu_0 c)^2}\right]\frac{(1+c)\beta\kappa}{4s_\psi} - (1-\omega), \tag{H.7}$$

which gives (62).

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