Rochester Center for
Economic Research

Exchange Rate Policy, Wage Formation, and Credibility

Horn, Henrik and Torsten Persson

Working Paper No. 48
June 1986.

University of
Rochester

EXCHANGE RATE POLICY, WAGE FORMATION, AND CREDIBILITY[0]

Henrik Horn and Torsten Persson

Institute for International Economic Studies

S-106 91 Stockholm, Sweden

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June 1986

[0] This paper was largely written when the second author visited Princeton University. We wish to thank Robert Barro, Bill Branson, Avinash Dixit, Anders Forslund Peter Garber, Gene Grossman, Thorvaldur Gylfason, Jim Markusen, Alan Stockman, Lars Svensson, John Vickers and seminar participants at Western Ontario, The World Bank, Princeton, Pennsylvania, Rochester, Keio, Tel-Aviv, IIES, The Paris International Workshop and LSE for helpful comments. The research was supported by grants from the Royal Swedish Academy of Sciences, the Bank of Sweden Tercentary Foundation, the Sweden-America Foundation and the Carl Mannerfeldt Foundation.

1. Introduction

Even though the major currencies in the world are effectively floating since the early seventies, many small European economies have maintained fixed exchange rates. In some of these countries, in particular in Scandinavia, the fixed exchange rate regime of recent years has been quite different from that under the Bretton Woods system, however. While the Bretton Woods agreement was a multilateral and essentially irrevocable commitment to fixed parities, the exchange rate has now become much more of a discretionary policy instrument. To improve the employment situation in the wake of high nominal wage settlements, repeated devaluations have been used in an attempt to increase the international competitiveness of the traded goods sector. The outcome might be described as a devaluation-wage spiral with small (if any) gains in terms of employment, but with substantial losses in terms of higher inflation.[1]

To understand these policy failures, we argue, one needs to look at the close interplay between exchange rate policy and wage formation. In the economies we have in mind, an important institutional feature is the prominent role played by trade unions in wage setting. This is manifested in annual (or less frequent) rounds of centralized bargaining, which result in economy-wide wage settlements. When rational and forward looking, wage setters come to understand the objectives behind the government's exchange rate policy - such as trading off employment against inflation - they will anticipate exchange rate changes and take

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[1] See Calmfors (1985) for an account of stabilization policy during recent years in European economies with centralized wage bargaining.

them into account in their wage decisions. There will then be strategic interactions between the government who takes into account how its policy will affect wages, and wage setters who consider how their decisions will affect the exchange rate.

The traditional analysis of exchange rate policy is not well suited to shed light on this kind of process. Although it does stress the importance of the degree of nominal wage rigidity for the effects of devaluations, it typically treats wage formation as exogenous (or endogenizes it in a very mechanic way). Similarly, government decisions are taken as exogenous. In this paper, by contrast, we endogenize wage formation as well as policy formation by postulating well-defined objectives for trade unions and the government. Further, we model the interaction between exchange rate policy and wage formation as a repeated game between unions and the government. To keep the analysis transparent, we use a very simplistic model of the underlying economy

We show how such a game in a small open economy with nominal wage settlements and a high government employment target might indeed give rise to a devaluation-wage spiral. The equilibrium when the government acts under discretion is typically worse than the equilibrium when the government can commit itself to a rule for the exchange rate. This is, of course, yet an example of the "time-consistency problem", or alternatively, the "rules-discretion dilemma"; well-known in macroeconomics since Kydland and Prescott (1977)

While a rule for the exchange rate - like that prevailing under the Bretton Woods system - might be desirable, a unilateral commitment to such a rule by the government in a small open economy may not be credible.[2] The question then arises whether the costs associated with discretionary policy-making are inevitable. We show that under certain circumstances reputational forces might substitute for formal commitments to a rule for the exchange rate and that such reputational mechanisms might make the equilibrium approach the rules outcome when governments have finite as well as infinite planning horizons.

Our analysis is related to various strands of literature. First, as already explained, it extends the traditional analysis of exchange rate policy -- such as that in Dornbusch (1980) and Sachs (1980) -- by endogenizing wage formation as well as policy itself. Second, it relates to earlier work on wage formation and government-trade union interaction by Calmfors (1982), Calmfors and Horn (1986), Driffill (1984), Gylfason and Lindbeck (1986), and Hersoug (1985) among others. It differs from this literature in considering exchange rate policy rather than fiscal policy, and goes further than most previous work in analyzing repeated rather than one-shot games. Third, our approach is related to recent research on credibility problems of monetary policy in a closed economy by Barro and Gordon (1983), Backus and Driffill (1985), and several others; see Barro (1986a) and Cukierman (1985) for surveys of this literature.[3] Our analysis is similar to that work in modelling policy as

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2 The EMS and its predecessor "the snake" is somewhat of a compromise between unilateral pegging of the exchange rate and a full-fledged international agreement like Bretton Woods.

3 Another related literature which also models stabilization policy as a repeated game, although the strategic interaction is typically between different governments, is the recent studies of international policy coordination. See Buiter and Marston (1985) for some representative contributions.

a strategy in a repeated game, but differs in that the government faces an agent capable of strategic consideration rather than an atomistic private sector. Further, for the problem we consider it is natural to look at a game with sequential rather than simultaneous decisions.

The paper proceeds as follows: In section 2 we present our highly stylized, macroeconomic model of a small open economy. We also discuss the objectives of the trade union and the government, which underlie optimal wage formation and exchange rate policy, respectively. Section 3 looks at rules versus discretion. Thus it considers a government that can commit itself once-and-for-all to a certain rule for the exchange rate as well as a government that lacks commitment possibilities and instead optimizes in each period. It is shown that the equilibrium outcome under discretion is worse than the rules outcome.

Section 4 shows how a reputational possibility might arise if current wages decisions are linked to previous exchange rates, which implicitely assumes that the union bases its expectations absout future policy on current policy. Then, provided that the game has an infinite horizon, there exist "reputational" equilibria which yield the same outcome as under an optimal rule even though the government acts under discretion. In section 5 we consider an alternative set-up where, unlike before, the trade union has incomplete information about the government's preferences over employment versus inflation and learns only gradually about the government's true type. This learning process gives a role for reputation in policy-making and the optimal exchange rate policy under discretion might approach the rules outcome even with a finite horizon.

Section 6, finally, offers some concluding comments. Some mathematical details are collected in an appendix.

2. The Model

Consider a small open economy producing a single traded good with given world market price. Domestic firms are competitive and have a well-defined neoclassical demand for labor. Apart from the firms, there are two actors in the economy: a Union that sets the nominal wage and a Government that determines the exchange rate. The Government cares about its "popularity".[4] Its popularity in period t, G_t, depends on the real wage, determining the income of employed workers as well as capitalists, on the employment level, and on the rate of inflation π_t. The Union leadership also cares about its popularity which, in general, depends on the real wage, deciding the income of employed workers, employment and inflation.

The timing in each period is as follows: To capture the fact that the economy-wide wage settlements are made at discrete intervals, while the exchange rate can be changed at very short notice, we assume that the Union sets its preferred nominal wage before the Government sets the exchange rate (knowing the Union's decision). After that firms make their employment decisions on the basis of the real product wage implied by world prices, the nominal wage and the exchange rate. We rule out any

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4 We model the government's objective as maximizing its popularity rather than a social welfare function; see Cuikerman (1985) for a discussion of the two approaches. A more satisfactory treatment would make the voting outcome endogenous in the model as in Rogoff and Siebert (1985), for example.

indexing in the wage settlements by assumption.[5] The resulting nominal stickiness is important because without it there would be no incentive for the Government to pursue an interventionist exchange rate policy.

Obviously, the popularity of both the Union and the Government are affected by the actions undertaken by the other party. We assume throughout that they are both fully aware of how their respective actions may influence the other side's present and future actions, and that they both take this into account in their optimization. The interaction between the Government and the Union can hence be viewed as a repeated game.

We now set out to model the set-up described above in the simplest possible way. Although most of what we shall say can be said in a fairly general framework, we deliberately make some very drastic assumptions in the interest of obtaining simple solutions on closed form.

Let Q_t be the world market price in period t of the single traded good. Denoting the exchange rate by R_t, the law of one price requires that the domestic price P_t obeys

(1) $$P_t = R_t Q_t$$

We assume that world market prices are constant over time and adopt the normalization

(2) $$\ell n\, Q_t = \ell n\, Q = 1$$

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[5] Within the model nothing explains why indexing could not occur or why wage settlements are made at discrete intervals. This is unsatisfactory but reflects the state of the art: except for vague references to costs of bargaining and state-contingent contracts, little work has been done that attempts to explain formally the empirically important observation that indexing is so rare.

for all t.[6] The demand for labor is given by

(3) $\qquad L_t = \ell^U \ell n(P_t/W_t)$

where W_t is the nominal wage and ℓ^U a productivity factor.

We assume that the Government's instantaneous popularity G_t is maximized when it achieves a full employment target ℓ^G and a zero inflation target, and that the real wage does not change popularity other than through its effect on employment. Further, for computational conveniency, deviations of L_t from ℓ^G affects popularity linearly and deviations of π_t from 0 quadratically, viz.,

(4) $\qquad G_t = \alpha(L_t - \ell^G) - \beta\pi_t^2/2,$

where G_t is only defined for $L_t \leq \ell^G$. The Government's overall objectives is to maximize the present value of its popularity: $\Sigma_t^T \ \delta^{\tau-t} \ G_\tau$, where T is the possibly infinite horizon of the optimization problem and δ a discount factor.

In the case of the Union, we abstract from any effects of inflation, and assume that the wage setters' instantaneous popularity U_t is proportional to the real wage bill, or

(5) $\qquad U_t = W_t L_t / P_t$

The overall objective of the Union is to maximize $\Sigma_t^T \ \gamma^{\tau-t} \ U_\tau$, where γ is the Union (leadership's) discount factor.

A main theme of this paper is the fruitfulness of viewing exchange rate policy in a unionized economy as a repeated game. It is nevertheless instructive to start by considering wage and exchange rate setting when done once-and-for-all - i.e. the equilibrium in the

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6 Non-zero world inflation can be handled very easily, see Horn and Persson (1985).

constituent game. This is also the equilibrium of the repeated game in the special case where neither the Union nor the Government care about the future, that is when $\delta = \gamma = 0$.

Consider first the problem facing the Government. When it sets the exchange rate it knows the nominal wage set by the Union. Using (1)-(4) and letting lower case letters denote logs, we can rewrite the Government's objective G_t as

$$(6) \qquad G_t = G(r_t, w_t) = \alpha[\ell^U(r_t - w_t + 1) - \ell^G] - \beta(r_t - r_{t-1})^2/2.$$

Hence, the Government can achieve its employment target by setting the exchange rate

$$(7) \qquad r_t = w_t + \ell^G/\ell^U - 1,$$

while the zero inflation target is achieved by holding the exchange rate fixed

$$(8) \qquad r_t = r_{t-1}.$$

The optimal exchange rate, given (6), is

$$(9) \qquad r_t^G = \arg\max_{r_t} G(r_t, w_t) = r_{t-1} + \alpha\ell^U/\beta$$

and thus independent of the wage rate.[7]

Let us turn to the Union. Given r_t and with U_t on the form (5), the optimal wage sets the elasticity of employment with respect to the real wage equal to unity. With the labor demand function (2), this yields a constant employment target equal to ℓ^U and a target wage

$$(10) \qquad w_t^U = r_t$$

We shall assume that $\ell^U < \ell^G$ throughout. When setting the nominal wage,

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[7] This does not happen with a more general formulation of the objective function. Horn and Persson (1985) looks at the case where the employment term is quadratic.

the Union takes into account the behavior of the Government. The Union will therefore rationally set the wage

(11) $$\hat{w}_t \equiv \arg\max_{w_t} U(\arg\max_{r_t} G(r_t, w_t), w_t) = r_{t-1} + \alpha\ell^U/\beta,$$

which will induce the Government to set the exchange rate

(12) $$\hat{r}_t \equiv \arg\max_{r_t} G(r_t, \hat{w}_t) r_{t-1} + \alpha\ell^U/\beta$$

It is clear that $(\hat{r}_t, \hat{w}_t)$ is the unique Nash equlibrium in the constituent game. In that equilibrium employment is at ℓ^U - the Union's target level - and the Government is lead to devalue by $\hat{r}_t - r_{t-1} = \alpha\ell^U/\beta$, which yields a positive rate of inflation.

3. Rules versus Discretion

The equilibrium $(\hat{w}_t, \hat{r}_t)$ corresponds to the "discretionary equilibrium" or the "time-consistent solution" in the terminology of the current macro literature. We saw that the optimal discretionary policy prescribes a devaluation: the Union that realizes the Government's incentives anticipates a devaluation and increases the wage accordingly, whereupon the Government in fact "accommodates" this wage increase.

The discretionary equilibrium is clearly characterized by Pareto inefficiency: there are combinations of a lower nominal wage and a lower exchange rate that would reduce inflation and make both parties better off. The problem is, of course, that once the Union has set the lower nominal wage, the Government faces a temptation to behave individually rational and set a higher exchange rate than agreed upon - a temptation that is irresistible when there are no future repercussions of the discretionary behavior.

It may seem as if the Government's problem is due to the artificial assumption that the wage and exchange rate setting is just once-and-for-all. To see that this is not necessarily so, consider the case where the parties are involved in what they perceive of as a finite game. We can think of T as the length of an election period. It is important that neither the Union nor the Government believe that events during the present election period have any repercussions on the future after period T. To fix ideas, assume that both the Government and the Union leadership for constitutional reasons are forced to resign after period T, but that they are both interested in their respective popularity during the periods up to and including T, since it affects their prospects (for other employment) after period T.

Consider now the last period before resignation. After the Union has set the nominal wage, the Government has an irresistible temptation to choose the discretionary exchange rate, since it will not result in any future repercussions. The outcome in the last period will hence be independent of previous outcomes. Therefore, in the second to last period the parties do not have to worry about how their current actions will affect the outcome in the last period - the situation is effectively as if the second to last period were the last. The backward induction can of course be continued all the way back to period t, from which the economy remains in the discretionary equilibrium with repeated nominal wage hikes and devaluation.

As a result of this wage-devaluation cycle, there is a constant employment level given by

$$(13) \qquad L_t = \hat{\ell} = \ell^U$$

and a constant rate of inflation

$$(14) \qquad \hat{\pi}_t = \hat{\pi} = \alpha\ell^U/\beta,$$

above the world inflation rate (which is zero by assumption). The Government's instantaneous popularity is consequently constant and equal to

$$(15) \qquad G_t = \hat{G} = -\alpha(\ell^G - \ell^U) - \beta\hat{\pi}^2/2.$$

The Union achieves its target employment and real wage in each period and therefore enjoys maximum popularity.

What then, if the Government as often suggested instead announced a <u>rule</u> for the exchange rate? In this context, a rule like (8) -- prescribing a fixed exchange rate and yielding zero inflation -- would be an obvious candidate. However a simple declaration to stick to this rule would not be trusted by the Union. The latter would rationally be aware of that nothing prevents the Government from doing something different once the wage is set. Furthermore, it would know that it would be in the Government's interest to devalue. Anticipating the optimal discretionary exchange rate $\hat{r}_t$ it would set the wage $\hat{w}_t$ and despite the announced rule the economy would end up in the discretionary equilibrium.

One way out of the dilemma would be open if the Government could make a <u>*binding commitment*</u> to a predetermined rule. A commitment to a fixed exchange rate as in (8) would give zero inflation and the same employment level ℓ^U as under discretion. However, due to the sequentiality of the wage and exchange rate setting the government could do even better than that if binding commitments could be made. Since the exchange rate is set after the wage, the Government could actually achieve its employment target as well by making the rule for the exchange rate contingent on the wage.[8] Consider for example the rule

$$(16) \qquad r_t = \begin{cases} (1-\sigma)w_t \\ r_{t-1} \\ (1-\sigma)w_t \end{cases} \qquad \text{if } w_t \lesseqgtr r_{t-1} = 1 - \ell^G/\ell^U$$

which "punishes" wage deviations from the level that gives full employment ℓ^G. It is easy to verify that the Union finds it optimal to abide by the rule so that full employment and zero inflation obtains simultaneously.

It was suggested in the Introduction that the Bretton-Woods system may have provided commitment possibilities that held back wage-devaluation spirals. Today, however, without an international agreement on fixed parities the situation may appear troublesome. But, as we shall see, there are other circumstances under which the Government's dilemma may be resolved.

The argument concerning the inevitability of the discretionary outcome in the absence of commitment possibilities, rests heavily on two assumptions. First, there is a known final period of interaction. Second, the Union knows the preferences of the Government; otherwise it could not be certain that the Government has an incentive to renege on its promise to adhere to the rule in the last period. It appears, however, as if neither of these assumptions are particularly plausible. In the rest of the paper we will therefore consider how two alternative assumptions affect the equilibrium. In the next section we will examine wage and exchange rate setting in the case where the horizon is infinite and information is perfect, and in section 5 the opposite case of

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8 In game-theoretic terms this is a "closed-loop" strategy as opposed to the "open-loop" strategy considered in (8).

imperfect (or incomplete) information and a finite horizon. It is in both cases the repeated character of the wage and exchange rate setting that permits the existence of equilibria with less inflation and lower wage hikes.

4. Reputation with an Infinite Horizon

The purpose of this section is to show how an equilibrium without a wage-devaluation sprial can be maintained even in the absence of commitment possibilities. We will now assume that both the Union and the Government perceive their interaction as infinite. We could think of an economy with an infinite sequence of election terms of length T periods, but since the essence of the argument is most easily conveyed without this interpretation, we simply assume that the parties maximize their overall objective function with an infinite horizon.

It is clear that there exists a Nash equilibrium in the infinite game, in which the strategy of both the Union and the Government is to always act discretionary, that is to set the wage and the exchange rate according to (11) and (12) This follows from the fact that $\hat{w}_t$ and $\hat{r}_t$ are individually rational by definition. In terms of game theory, this equilibrium is therefore subgame perfect, that is, the strategies are optimal for all histories It is well-known, however, that there may be many equilibria in infinitely repeated games With an infinite horizon the discretionary equilibrium is just one of several other possible outcomes and some of the other outcomes will dominate it in a Pareto sense.

Under discretion the Union achieves its target real wage and employment. Therefore, for another equilibrium to be Pareto superior it must entail the same real wage; the superiority stemming from a lower rate of inflation. Clearly, this can only happen if the Union sets a lower nominal wage than in the discretionary equilibrium. For the Government to resist the temptation to devalue at this wage there must be some future consequence it prefers to avoid. The Pareto superior equilibrium must hence rest on intertemporal links between Government and Union behavior.

To examine non-discretionary exchange rate policies by the Government, it seems natural to consider simple rules. In our stationary context without uncertainty, an obvious candidate is a rule that yields a constant inflation rate π^*:

$$(17) \qquad r^*_t = r_{t-1} + \pi^*.$$

For the rule to be interesting it clearly has to be that $\pi^* < \hat{\pi}$. As we are about to show, a rule postulating a fixed exchange rate yielding $\pi^* = 0$ may actually support an equilibrium.

Consider now the following simple strategies for the Union and the Government:

$$(18) \qquad w_r = \begin{cases} \arg\max U(r^*_t, \,_t) \equiv w^*_t & \text{if } w_{t-1} = w^*_{t-1} \text{ and } r_{t-1} = r^*_{t-1} \\ w_t & \text{otherwise} \end{cases}$$

$$(19) \qquad r_t \begin{cases} r^*_t \text{ if } w_t = w^*_t \text{ and } r_{t-1} = r^*_t \\ \arg\max G(w_t, r_t) = \hat{r}_t \text{ otherwise} \end{cases}$$

The Union thus sets the wage w^*_t, which is optimal provided that the Government adheres to the rule, if it correctly anticipated the rule to be followed in the previous period. In all other cases it sets the discretionary equilibrium wage $\hat{w}_t$. Similarly, the Government follows the rule if the rule was followed in the previous period, and the Union has set the wage w^*_t. Otherwise it behaves discretionary. This type of strategy is similar (but not identical) to those introduced by Friedman (1971). As further explained below, it introduces an intertemporal trade-off in the choices by linking expectations about future policy to current policy. In particular, if the Government devalues today the Union will anticipate a new devaluation when setting wages tomorrow.

Let us introduce the following notation:

(20) $\qquad G^* \equiv G(r^*_t, w^*_t) = -\alpha(\ell^G - \ell^U) - \beta\pi^{*2}/2$

(21) $\qquad \tilde{G} \equiv G(\arg\max G(r_t, w^*_t), w^*_t) = -\alpha(\ell^G - \ell^U) + \alpha\ell^U(\hat{\pi} - \pi^*) - \beta\hat{\pi}^2/2.$

Thus, G^* is the period-invariant popularity of the Government when the rule is expected and followed and is obtained by using (3), (17) and, from (11) $w^*_t = r^*_t$, to evaluate (4). $\tilde{G}$ is the period-invariant pay-off when the Government "cheats" and sets the discretionary exchange rate but the Union expects the rule to be followed. The value of $\tilde{G}$ follows from (3), (4), (12) and (14). It is clear that $\hat{G} < G^* < \tilde{G}$.

When is the rule (17) a time-consistent policy in the absence of commitments? This requires that the total pay-off from following the rule

(22) $\qquad G^*_t + \delta G^*_{t+1} + \delta^2 G^*_{t+2} \ldots = \frac{1}{1-\delta} G^*,$

is higher than that from any alternative behavior. To see what constitutes the best alternative behavior, note first that because the parties discount future popularity at a constant rate, if it is ever profitable to deviate from (18) and (19) it should be done at the first opportunity. Second, if the Union or the Government ever fails to set w_t^* or r_t^*, respectively, then all future instantaneous equilibria must be discretionary. This follows from the fact that both parties take into account not only the other party's last move, but also its own last move. For instance, suppose the Union deviated from the prescribed strategy by choosing the discretionary wage $\hat{w}_t$ even though the plays in t-1 were (w_{t-1}^*, r_{t-1}^*). According to (19) the Government should respond by discretion, which in turn would make the Union choose $\hat{w}_{t+1}$ according to (18) , etc. Although the Government could try and restore the good equilibrium by setting the exchange rate r_t^*, this would not be optimal since $\hat{r}_t$ is the best response to $\hat{w}_t$ and the Union would choose $\hat{w}_{t+1}$ anyway according to (18).

We thus have to compare the pay off in (22) with that when the Government "cheats" in period t and bears the cost of (expected) discretion thereafter:

(23) $$\tilde{G}_t + \delta\hat{G}_{t+1} + \delta^2\hat{G}_{t+2} + \ldots\ldots = \tilde{G} + \frac{\delta}{1-\delta}\hat{G}$$

Since G^*, $\tilde{G}$, and $\hat{G}$ are independent of time, the sufficient condition for the rule to be time-consistent is

(24) $$\tilde{G} - G^* \leq \frac{\delta}{1-\delta}(G^* - \hat{G}).$$

The LHS is the gain from cheating immediately (sometimes referred to as the "temptation") while the RHS is the discounted future cost of cheating (the "enforcement"). Substituting from (15), (20) and (21) into (24), we may rexpress the condition as:

(25) $$(1 - 2\delta)\hat{\pi} \leq \pi^*$$

Clearly, as long as the discount factor is above one half it does not pay for the Government to deviate from the informal rule of fixed exchange rates $\pi^* = 0$.[9] It is trivial to show that it is optimal for the Union to stick to its strategy (18), since that yields its target wage employment level. In other words, a fixed exchange rate and zero inflation is indeed a subgame perfect equilibrium, provided the future costs in terms of higher inflation are not too heavily discounted to fall short of the current employment gain from an unanticipated devaluation. Put differently (r_t^*, w_t^*) is an equilibrium where the Union's (and the Government's) expectations are rational and self-fulfilling.

We end this section with a few remarks. First, if the rule prescribing a fixed exchange rate indeed supports an equilibrium the rule is not arbitrary. On the contrary, the rule is Pareto optimal in that the Government achieves its inflation target and the Union its real wage-employment target. What remains is the fundamental conflict regarding the real wage.

Second, the fact that the wage and exchange rate are set sequentially affects the strategic interaction between the Union and the Government. Both parties have, in principle, the possibility of "forgiving" discretionary behavior by letting bygones be bygones and respond to discretion with behavior according to the rule. This "forgivingness" cannot be part of a subgame perfect equilibrium in our game, since it would be open to systematic exploitation. The "forgivingness" is indeed not optimal with the strategies specified in

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9 With a lower discount factor there is another inflation rate $0 < \Pi^* < \hat{\underline{\Pi}}$ which can be supported in equilibrium.

(18) and (19), since both agents take into account both their own and the agent's action in the previous period. Simple trigger strategies where the actions of each agent depended only on the previous actions of the other agent would therefore not be sufficient to support a "good equilibrium" if the interaction is sequential, although it would if the interaction was instead simultaneous as is typically assumed in the literature on monetary policy referred to in the Introduction.[10]

Finally, the message of this section has been that it is crucial for exchange rate policy whether or not the policy maker(s) and the wage setter(s) view their interaction as finite or infinitely repeated.[11] The answer to this question is indeed not self-evident. At the moment it appears as if our knowledge of the functioning of the political process is too limited to provide any clear guidance on this important issue.

5. Reputation with a Finite Horizon

We have just seen that a way out of the wage-devaluation cycle might be open if the Government and the Union perceive of themselves as being involved in an infinitely repeated interaction. In this section we shall see how uncertainty about the Government's true pay-off may open up some possibilities even if the game has a finite horizon like an election period.[12]

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10 See Barro and Gordon (1983), in particular.

11 Another possible interpretation, that would yield the same result as the infinite horizon, would be that there was an exogenous and constant probability of breakdown of the interaction in each period - because a loss of power of the Government, say.

12 Backus and Driffill (1985) and, in particular, Barro (1986b) have considered similar models in the context of monetary policy in a closed economy.

To capture the Union's uncertainty, we assume that there are two types of governments differing in the relative weights they attach to inflation and employment: Most governments, denoted E-governments, attach a value both to low inflation and high employment. As in previous sections they have pay-off functions with $\alpha > 0$, $\beta > 0$. However, now there also exist some governments, denoted I-governments, that get their popularity, or perceive of themselves as getting their popularity, solely from fighting inflation. That is, they have $\alpha = 0$, $\beta > 0$.

If the Union had complete information about the Government's true type the outcome would be trivial. With an E-government we would again get a wage-devaluation cycle like in the discretionary equilibrium in Section 3. With an I-government we would get a rules-like outcome, for the simple reason that this government would never have an incentive to devalue.

When information is incomplete the story is different, though. At the outset of the game - immediately after an election, say - the Union has a prior probability ρ_0 that the Government is of type I. As time proceeds the Union observes the Government's exchange rate policy and can use these observations to revise its assessment of the Government's type. The Union knows that an I-government would never devalue. As long as an E-government does not devalue it can thus successfully pretend to be a type I-government. Furthermore, it may have an incentive for such investments in its reputation. If it ever devalues it will reveal its true identity and the Union will anticipate future devaluations and hike the wage accordingly. If the E-government does not devalue, on the other hand, the Union may abstain from hiking the wage, knowing that both

I-governments and E-governments have incentives to refrain from devaluing.

These general ideas can be made more precise. To do that, we rely on the analysis of incomplete information games developed by Kreps and Wilson (1982). Specifically we adopt their equilibrium concept, namely sequential equilibrium. Such an equilibrium is again sub-game perfect, and so the equilibrium exchange rates and wages satisfy the credibility or time-consistency requirement by construction. The sequential equilibrium requires players to use Bayesian inference whenever applicable.

It is assumed that both types of governments and the Union maximize expected discounted pay-offs

(26) $\max \quad E_t \Sigma_t^T \delta^{\tau - t} G_t$

(27) $\max \quad E_t \Sigma_t^T \gamma^{\tau - t} U_t$

We now present a description of the equilibrium strategies and beliefs of the game; a formal demonstration that these in fact constitute an equilibrium is given in the Appendix. Let us denote by ρ_t the Unions prior when setting the wage in period t that the Government is of type I. The probability that an E-government devalues at t is denoted by $(1 - \theta_t)$. The Union's optimal strategy is then

(28) $w_t = r_t^e = [\rho_t + \theta_t(1 - \rho_t)]r_{t-1} + (1 - \theta_t)(1 - \rho_t)\hat{r}_t$,

an I-government simply sets

(29) $r_t = r_{t-1}$

and an E-government's strategy is

(30) $r_t = \begin{cases} r_{t-1} & \text{with probability } \theta_t \\ \hat{r}_t & \text{with probability } (1 - \theta_t) \end{cases}$,

where θ_t satisfies

$$(31)\quad \theta_t = \begin{cases} 1 & t < T - \tilde{\tau} \text{ if } r_s = r_{s-1} \text{ all } s \le t-1 \\ \dfrac{\rho_t}{1-\rho_t}\left(\dfrac{1}{\rho_{t+1}} - 1\right) & T - \tilde{\tau} \le t < T \text{ if } r_s = r_{s-1} \text{ all } s \le t-1 \\ 0 & \text{otherwise} \end{cases}$$

and where $\tilde{\tau}$ is given by

$$(32)\quad \tilde{\tau} = \inf\,[\tau : (2\delta)^{\tau+1} > 1/\rho_0].$$

The equilibrium beliefs develop according to

$$(33)\quad \rho_t = \begin{cases} \rho_0 & t \le T - \tilde{\tau} \text{ if } r_s = r_{s-1} \text{ all } s \le t-1 \\ 1/[(2\delta)^{t+1}] & t > T - \tilde{\tau} \text{ if } r_s = r_{s-1} \text{ all } s \le t-1 \\ 0 & \text{otherwise} \end{cases}$$

Notice that in this equilibrium the Union follows the same strategy independently of what type of Government that actually holds office. It sets the wage so as to maximize the <u>expected</u> wage bill in each period. When doing so, it rationally expects a devaluation of size $(\hat{r}_t - r_{t-1}) = \hat{\pi}$ with probability $(1 - \rho_t)(1 - \theta_t)$; the product of the probability that the Government is of type E and the probability that an E-government devalues at t. According to (33) as long as the Government abstains from devaluing, the Union's prior ρ is revised according to Bayes' law (see further Appendix). Whenever the Government defects from the fixed exchange rate, however, the Union concludes, again in consistency with Bayes' law, that it deals with an E-government and sticks to that belief for the remainder of the horizon.

As can be seen from (31)-(33), an E-government's exchange rate policy in general goes through three phases. In the first phase the incentive to invest in reputation is strong enough that the E-government abstains from devaluing with certainty. This incentive decreases over time and from a critical period $t = T - \tilde{\tau}$, there is a second, randomizing phase. Then the Government devalues with a non-zero probability which increases over time. In the final period, if it has not devalued by chance before, the E-government devalues with certainty since the incentive to invest in its reputation is gone.

The exact structure of the equilibrium depends on four factors: (i) the relative weights on inflation and employment in the E-government's popularity function, that is the parameters α and β, (ii) the length of the time horizon T, (iii) the Union's initial prior ρ_0, and (iv) the Government's discount factor δ. Rather than cataloging the different influences of these factors, we present a numerical example to illustrate the main points. Assume that $T = 5$, $\rho_0 = 0.20$ and $\delta = 0.75$, and that type E governments have $\alpha = 1/\ell^U$ and $\beta = 10$.[13] Consider then an equilibrium when an E-government holds office. The equilibrium outcome of the central variables can easily be computed from (3), (12) and (28)-(33), and is displayed in Table 1.

In periods 1 and 2 the E-government keeps the exchange rate fixed. The Union, which does not know what type of government it deals with but understands the E-government's incentives, rationally expects a fixed exchange rate and accordingly does not hike the wage. The outcome in these periods with respect to employment and inflation is thus like in the rules-type equilibria in the previous sections. In periods 3 through

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13 The parameter values for α and β imply that an E-government is indifferent between 10% inflation and 6.25% "underemployment", defined as $100(\ell^G - \ell^U)/\ell^U$, and 5% inflation and 10% underemployment.

5, the Union expects a 10% devaluation with positive probability and increases the wage accordingly. Notice that although the Union's expectation about the exchange rate is completely rational, it will turn out to be falsified ex post, whether the Government devalues (by chance in periods 3 or 4 and with certainty in period 5) or not. Since the wage is set before the exchange rate, employment will turn out below the Union's target level as long as the exchange rate is kept fixed and it will turn out above the target level when the first devaluation occurs. These real effects when a descrete devaluation is rationally expected to occur with positive probability is a close analogy to the "peso problem" discussed by Blanco and Garber (1985) among others.

With an I-government actually in office the equilibrium looks similar as shown in Table 2. But here, of course, the Government never devalues, not even in the final period. The result is zero inflation, but also lower employment towards the end of the horizon.

We have thus seen that also with a finite horizon reputational considerations may help the E-government to avoid being completely trapped in a wage devaluation cycle. What is required is some genuine uncertainty on part of the Union about the intentions of the Government.

At a general level, the model thus predicts a tight exchange rate policy leading to low inflation in the early phase of the election period of both types of government, and a more lenient policy leading to higher inflation towards the end of the election period of an E-government. With both governments the Union shows wage restraint in the first phase, and is more prone to hike the wage later on. As discussed by Backus and

Driffill (1985b), this provides an interesting alternative to the usual interpretation of the election cycle.

6. Concluding comments

We have shown how the existence of economy-wide nominal wage settlements and a high employment target creates a temptation for the government to pursue a devaluation policy and how this in turn tends to induce inflationary wage increases. A formal commitment to a rule, if it is possible, might help out of this situation We would like to note again that in many small countries the commitment to fixed exchange rates during the Bretton Woods system up to the early seventies, seems to have been much stronger than mere promises to stick to a certain exchange rate policy during the last decade. Furthermore, our analysis suggests that in the essentially non-inflationary world economy of the fifties and sixties, a commitment to fixed exchange rates might have come close to an optimal rule.

In situations where commitments are not possible, pure discretion would bias the outcome towards an inflationary process of wage increases and accommodating devaluations similar to that in some of the European countries. We have shown in two different contexts how this bias might be overcome by a government who worries about its reputation and balances future losses of credibility against the immediate prospective employment gains.

In the framework that we have studied another way to remove the inflationary bias would be to encourage indexed wage settlements, since that would remove the incentive to devalue. However, in an extended analysis incorporating uncertainty indexing would have a cost because it would be desirable for the government to affect the real wage, ex post.

An extension incorporating uncertainty would be interesting in its own right. Suppose for instance that the productivity parameter ℓ^U was stochastic and realized after the wage settlement. Then the benefit of devaluing would not be constant, but would increase with bad outcomes and vice versa. This would not only change the optimal discretionary policy but also alter the optimal rules (whether supported by commitments or reputation). In particular, the rules would involve what Barro and Gordon (1983) referred to as "biting-the-bullet" considerations; in order to devalue effectively in bad times (productivity outcomes), the Government would be lead to revalue in good times.

Finally, we would like to underline the usefulness of modelling macroeconomic policy-making in explicitly game theoretic terms. Such an approach makes it possible to seriously analyze concepts like credibility and reputation: concepts that policy-makers have been discussing for a long time, but traditional macroeconomic models have very little to say about.

Appendix

In this Appendix we show that (28)-(32) indeed constitute a sequential equilibrium. There are two points to this demonstration: First, we show that the beliefs held at t about the history of the game as summarized by ρ_t are consistent with the equilibrium strategies. We also show that the beliefs are rational in the sense that they are consistent with Bayesian inference whenever possible. Second, we show that given these beliefs, none of the players has an incentive to deviate from his postulated strategy.

Rational beliefs

When there is no devaluation at t Bayes' law requires that the prior ρ_t is updated according to

$$\text{(A1)}\qquad \begin{aligned}\rho_{t+1} &= \text{prob (type I} \mid r_t = r_{t+1}) \\ &= \frac{\text{prob (type I and } r_t = r_{t+1})}{\text{prob } (r_t = r_{t-1})}\end{aligned}$$

$$= \frac{\text{prob } (r_t = r_{t-1} \mid \text{type I) prob (type I)}}{\text{prob}(r_t = r_{t-1}|\text{type I)prob(type I)+prob}(r_t = r_{t+1}|\text{type E)prob(type E)}}$$

Clearly (A1) can be written

$$\text{(A2)}\qquad \rho_{t+1} = \frac{\rho_t}{\rho_t + (1 - \rho_t)\theta_t} ,$$

Given the strategies specified in (28)-(30) it is easy to show that (A2) is consistent with the updating rule (31) on the equilibrium path.

Similarly, when there is a devaluation at t, Bayes' law requires

$$\text{(A3)}\quad \rho_{t+1} = \frac{\text{prob}\,(r_t = \hat{r}_t \mid \text{type I})\ \text{prob}\,(\text{type I})}{\text{prob}(r_t=\hat{r}_t|\text{type I})\text{prob}(\text{type I})+\text{prob}(r_t=\hat{r}_t|\text{type E})\text{prob}(\text{type E})}$$

which is consistent with setting $\rho_{t+1} = 0$ on the equilibrium path.

Off the equilibrium path Bayes' law does not apply (since we are dealing with zero probability events), but we nevertheless have to specify how the beliefs are revised. We then have to deal with the following situations. First, if the Government deviates from the fixed exchange rate as $t < T - \tilde{\tau}$, we make the "reasonable" assumption that the Union sets $\rho_{t+1} = 0$. Second, when $t \geq T - \tilde{\tau}$ and the Government makes a (first) deviation from the fixed exchange rate that is different from the optimal one, i.e. that is different from $r_t = \hat{r}_t = r_{t-1} + \hat{\pi}$, then the Union also sets $\rho_{t+1} = 0$. Finally, if the Government has devalued before so that $\rho_t = 0$, but nevertheless deviates from $r_t = \hat{r}_t$, the Union still sets $\rho_{t+1} = 0$. All these assumptions follow from the specification in (33) where <u>any</u> deviation from $r_t = r_{t-1}$ leads the Union to set $\rho_t = 0$ for the remainder of the game. While these assumptions may seem reasonable they are essentially ad hoc. Other revision rules for these zero probability events could, however, as discussed by Kreps and Wilson (1982) support the same equilibrium.

<u>The Union cannot gain from deviating</u>

For the Union, the wage setting in each period can be seen as a separate problem. Given its beliefs about previous play summarized by ρ_t, and the strategies of I- and E-governments, setting the wage as in (28) clearly maximizes the expected value of the Union's objective function (5).

The I-government cannot gain from deviating

Since the I-government has $\alpha = 0$, its maximum popularity occurs as $\pi = 0$. Setting $r_t = r_{t-1}$ at each t trivially yields this outcome.

The E-government cannot gain from deviating

First, note that any deviation from the fixed exchange rate is "punished" equally by the Union. Hence, any contemplated deviation should be made short-run optimal and therefore, by the argument in Section 2 satisfy $\hat{r}_t = r_{t-1} + \hat{\pi}$.

To show that it is optimal to set $\theta_t = 1$ when $t < T - \hat{\tau}$, it suffices to demonstrate that it pays an E-government to postpone an (optimal) devaluation by one period. Devaluing at t would, given the Union's strategy and revision rules, yield the payoff,

(A4) $\qquad G(r_{t-1}, \hat{r}_t) + \delta\, G(\hat{r}_{t+1}, \hat{r}_{t+1}) + \ldots.$

while postponing the devaluation would yield

(A5) $\qquad G(r_{t-1}, r_{t-1}) + \delta\, G(r^e_t, \hat{r}_{t+1}) + \ldots.$

Because the payoffs from t+2 are the same in (A4) and (A5) postponement is optimal if

(A6) $\qquad G(r_{t-1}, \hat{r}_t) - G(r_{t-1}, r_{t-1}) + \delta[G(r^e_t, \hat{r}_{t+1}) - G(\hat{r}_{t+1}, \hat{r}_{t+1})] < 0.$

Using (3), (4) and (14) to rewrite (A6) and simplifying one can express the condition as

(A7) $\qquad (1 - 2\delta)\alpha\ell^U\hat{\pi} \le 0$,

which is fulfilled as long as $\delta > 1/2$. ((A7) applies when $t < T - \tilde{\tau} - 1$; for $t = T - \tilde{\tau} - 1$ the expression is slightly different.)

For randomization to be optimal at t as $T - \tilde{\tau} \le t < T$, given that the exchange rate has been fixed up to t-1, an E-government should be indifferent between devaluing at t and t+1. In analogy with the argument above, this requires:

(A8) $$G(r_t^e, \hat{r}_t) - G(r_t^e, r_{t-1}) + \delta[G(r_{t+1}^e, \hat{r}_{t+1}) - G(\hat{r}_{t+1}, \hat{r}_{t+1})] = 0$$

From (3), (4), (14), and (2), (A8) can be rewritten

(A9) $$[\frac{1}{2\delta} - 1 + (1 - \rho_{t+1})(1 - \theta_{t+1})]\alpha \ell^U \hat{\pi} = 0$$

It is easy to see that (A9) holds provided that θ_{t+1} and ρ_{t+1} satisfy (31) and (33).

Finally, if a devaluation has occurred in the past, so that $\rho_t = 0$, the situation is identical to that in the finite horizon game in Section 3. Consequently, it is optimal to set $r_t = \hat{r}_t$ with probability one.

Table 1
Equilibrium outcomes with E-government
Numerical Example: $T = 5$, $\rho_0 = 0.2$, $\delta = 0.75$, $\alpha = 1/\ell^U$, $\beta = 10$

t	1	2	3	4	5
ρ	0.2	0.2	0.2	0.44 (1)	0.67 (1)
θ	1	1	0.31	0.4 (0)	0 (0)
$(1-\rho)(1-\theta)$	0	0	0.55	0.33 (1)	0.33 (1)
π	0	0	0 (0.1)	0 (0.1)	0.1 (0.1)
ℓ/ℓ^U	1	1	0.945 (1.055)	0.967 (1)	1.067 (1)

Note: Bracketed expressions denote outcomes when a devaluation occurs (has occurred).

Table 2

Equilibrium outcomes with I-government
Numerical Example: Parameter values as in Table 1

t	1	2	3	4	5
ρ	0.2	0.2	0.2	0.44	0.67
e	1	1	0.31	0.4	0
$(1-\rho)(1-e)$	0	0	0.55	0.33	0.33
π	0	0	0	0	0
ℓ/ℓ^U	1	1	0.945	0.967	0.967

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