Seminar Paper No. 325

EXCHANGE RATE POLICY, WAGE FORMATION
AND CREDIBILITY

by

Henrik Horn and Torsten Persson

INSTITUTE FOR INTERNATIONAL ECONOMIC STUDIES

University of Stockholm

Seminar Paper No. 325

EXCHANGE RATE POLICY, WAGE FORMATION
AND CREDIBILITY*

by

Henrik Horn and Torsten Persson

Seminar Papers are preliminary material circulated to stimulate discussion and critical comment.

April, 1985

Institute for International Economic Studies
S-106 91 Stockholm
Sweden

November 1984Revised April 1985

EXCHANGE RATE POLICY, WAGE FORMATION, AND CREDIBILITY*

Henrik Horn and Torsten Persson

Institute for International Economic Studies

S-106 91 Stockholm, Sweden

1. Introduction and Summary

Most of the small and trade dependent European economies have maintained a fixed exchanged rate regime after the breakdown of the Bretton Wood system. A further characteristic of these economies is the prominent role of trade unions in wage setting, as manifested in annual (or even less frequent) wage settlements at an economy-wide level where the average wage increases are determined. In some countries, exchange rate policy has increasingly been directed towards maintaining the international competitiveness of the traded goods sector during recent years.¹ Devaluations have been used in the wake of domestic "wage disturbances" - that is, wage settlements that are high enough relative to realized world market prices and productivity levels to threaten domestic employment. While such policies may restore competitiveness and employment, at least in the short run, they have a cost in the form of higher inflation.

When determining its exchange rate policy the government thus balances unemployment against inflation.² The decision problem is complicated by the fact that rational wage setters understand the government's objectives and take them into account in their wage decisions. In economies with centralized bargaining, the government can therefore be portrayed as involved in a game with the wage

setters - the government taking into account how its stabilization policy affects wage settlements, and wage setters considering the policy measures induced by wage agreements.

In this paper we analyze this interaction between exchange rate policy and wage formation in a small open economy where the government attempts to minimize unemployment and inflation, and where a trade union sets nominal wages in order to reach its objective concerning employment and real wages. In particular, we look at the government's optimal exchange rate policy under different assumptions about the union's expectation formation.³

The general importance of casting the analysis of macroeconomic policy in a game-theoretic framework is forcefully emphasized by Chiappori and Mongin (1983). Our particular application draws on the recent work by Barro and Gordon (1983a, b), dealing with time consistency of monetary policy in a closed economy. In line with those papers, we consider setups in which formal commitments to policy rules are not possible, but where reputational forces might substitute for formal commitments. As developed further below, we introduce the reputational possibility in two ways, both different, and in our view more satisfactory, than the possibility explored by Barro and Gordon.

Another important feature that distinguishes our analysis from that by Barro and Gordon is that the government here faces a single agent - a union - that explicitly optimizes, rather than an atomistic private sector represented by a "reaction function" of e.g. the Lucas-Rapping "surprise supply" function type. On this point, our approach is related to earlier work on trade union-government interactions by Calmfors (1982), Calmfors and Horn

(1983), Driffill (1983), Gylfason and Lindbeck (1982), Hersoug (1985), among others.⁴ Like Driffill (1985) and Söderström (1985), our approach goes somewhat further in that it looks at repeated rather than one-shot games.

The paper proceeds as follows: In Section 2 we present a highly stylized model to be employed in the subsequent three sections. Section 3 derives the optimal exchange rate policy when the government can once-and-for-all commit itself to a certain policy rule. In Section 4 that case is confronted with its opposite extreme without any commitment possibilities that forces the government to rely entirely on discretionary policy making. Sections 3 and 4 set the stage for the subsequent analysis by illuminating the well-known rules-discretion dichotomy; a celebrated theme in the macroeconomic literature since the seminal paper by Kydland and Prescott (1977). It is shown how optimal discretionary exchange rate policy yields higher inflation but the same employment outcome as does the optimal rule.

In Section 5 we introduce an expectation formation mechanism where the union's beliefs about future exchange rate policy are linked to the government's current actions. More precisely, we assume that the union always expects the government to pursue a similar policy in period $t + 1$ as it did in t . Since the union sets wages accordingly, the resulting strategy might be described as "tit-for-tat"; it increases the wage if the government devalued in the previous period and keeps the wage down if there was no devaluation. That gives room for "reputational" considerations in policy making and we show how those considerations might substitute for formal commitments to non-expansionary policy. While this

set-up has some appealing features, the underlying rule of thumb for expectations formation is ad-hoc (although in most of the equilibria expectations are self-fulfilling).

In section 6 we consider an alternative set-up without that weakness. Like in Backus' and Driffill's (1984a, b) extensions of Barro's and Gordon's analysis we study a situation with incomplete information where the true identity - that is the preferences - of the government are uncertain.⁵ Here, the union makes rational use of the information made available during the course of the game by updating its prior about the government's true type. It is this learning process that gives a role for reputation in the government's policy making, and again the result is an exchange rate policy leading to less inflation than under discretion. Formally, our approach in this section is an application of the "sequential equilibrium" analysis developed by Kreps and Wilson (1982a). To simplify the analysis, we look at a special case of the model employed in Sections 2-5, where the two parties can only make binary choices regarding the exchange rate and the wage rate.

Section 7, finally, offers concluding comments. Some mathematical details are collected in an appendix.

2. The Model

Consider a small open economy producing a single traded good with world market price Q_t in period t . Denoting the exchange rate by R_t , the law of one price requires that the domestic price P_t obeys

$$(2.1) \quad P_t = R_t Q_t.$$

Domestic firms are perfectly competitive and their total demand for labor L_t is

$$(2.2) \quad L_t = l^U \ln(P_t/W_t),$$

where l^U is a "productivity" parameter and W_t the nominal wage rate.

The labor market is imperfectly competitive and all workers are organized by an encompassing Union.⁶ In order to focus on the interaction between the Government and the Union, we assume that ~~the Union is able to set its most preferred wage unilaterally -~~ that is, we adopt what has been referred to as the "monopoly union approach".⁷

The timing of events in each time period is the following. First the Union sets its preferred nominal wage, then the Government sets the exchange rate and firms make their employment decision. We rule out any indexing in the wage settlements by assumption. The resulting nominal stickiness is important because without it there would be no incentive for the Government to pursue an interventionist exchange rate policy. In most of the paper, we study only perfect foresight equilibria, however, and then the assumption of no indexation turns out to be unimportant from the Union's point of view; in this respect the wage settlements here are analogous to the one-period contracts in Fischer (1977).⁸

The Union is here depicted as a rational agent that trades off real wages against employment possibilities for its members. The wage bill maximization hypothesis, dating back at least to Dunlop (1944), is a particularly tractable representation that well

serves our purposes. Hence, we assume that in each period the Union sets the nominal wage so as to maximize its (expected) real wage bill. Formally

$$\max_{W_t} W_t L_t / P_t$$

$$\text{subject to } L_t = \lambda^U \ln(P_t / W_t),$$

$$\text{and } P_t = R_t Q_t.$$

Assuming that the Union takes the exchange rate as given, the solution to (2.3) is to set the elasticity of employment with respect to the real wage equal to unity. It is easy to show that this condition implies the following "target values" for wages and employment:

$$(2.4) \quad W_t^U = R_t Q_t / e,$$

$$(2.5) \quad L_t^U = \lambda^U,$$

where e is the base of natural logarithms.

To capture the Government's preferences for price stability and high employment, we specify a Government cost function. The costs in period t , Z_t increase quadratically in the percentage deviation of employment from an employment target λ^G and in the rate of inflation (the inflation target is set to zero). Thus we have

$$(2.6) \quad Z_t = \beta \left(\frac{\lambda^G - L_t}{\lambda^G} \right)^2 + (1 - \beta) \left(\frac{P_t - P_{t-1}}{P_t} \right)^2,$$

where β indicates the relative weight of the two targets.⁹ The Government's overall objective is to minimize

$$Z = \sum_t^{\infty} \delta^{t-t} Z_t, \quad 0 < \delta < 1,$$

the present value of instantaneous costs.

It will be convenient to illustrate the choices by the Union and the Government graphically in the following. Denote the logarithms of W_t , P_t , Q_t and R_t by w_t , p_t , q_t and r_t , respectively. Then from (2.4) we have

$$(2.7) \quad w_t^U = r_t + q_t - 1.$$

As we show in Figure 1, this is a straight line tracing out the combinations of w_t and r_t that fulfills the Union's wage and employment target. Since the real wage is maximized along this line it is clear that we can interpret it as a "reaction function" for the Union.

Let us also rewrite the Government's cost function as

$$(2.8) \quad Z_t = \beta \left(\frac{\lambda^G - \lambda^U (r_t + q_t - w_t)}{\lambda^G} \right)^2 + \\ (1 - \beta) \left((r_t - r_{t-1}) + (q_t - q_{t-1}) \right)^2,$$

where we have used (2.1), (2.2), and the approximation

$(P_t - P_{t-1})/P_t = p_t - p_{t-1}$. From (2.2), the combinations of w_t and r_t that satisfy the Government's employment target are

$$(2.9) \quad w_t^G = r_t + q_t - \lambda^G/\lambda^U.$$

If $\lambda^G > \lambda^U$, as we shall typically assume, the Government thus prefers a lower wage than the Union as illustrated by the dotted line in Figure 1. The Government's "bliss point" B when $Z_t = 0$, is the point on this line where there is no inflation. That is, when

$$(2.10) \quad r_t = r_{t-1} - (q_t - q_{t-1}).$$

Figure 1

Since the Government's indifference curves are ellipses in $(L_t, p_t - p_{t-1})$ space and L_t and $p_t - p_{t-1}$ are linear functions of w_t and r_t , they are ellipses also in (w_t, r_t) space as illustrated in Figure 1. Differentiating (2.8) we see that when Government's employment target is fulfilled, that is on the line given by (2.9), the indifference curves must be vertical. Also, when there is no inflation so (2.10) holds, the slope of the indifference curves is unity. Hence, the Government's reaction function - AA in the diagram - defining the optimal r_t for each given value of w_t must be upward sloping and steeper than the reaction function of the Union.

3. Rules

In our first case the Government can commit itself to a preannounced rule for the exchange rate. The game starts with the Government's announcement of its policy rule. In each period the Union sets the wage rate so as to solve its optimization problem (2.3), after which the exchange rate is set according to the rule. The equilibrium in this repeated game where the policy rule and the wage in each period are chosen optimally can thus be described as a Stackelberg equilibrium with the Government acting as the leader.

Let us describe in two steps how the optimal policy rule is chosen. Obviously, it matters what variables the exchange rate is conditioned on. Let us first look at the case when the exchange rate in each period r_t is conditioned on the present world market price q_t (as well as previous values of r and q) only. Using $\bar{r}$ to denote the optimal exchange rate, the best rule is given by

$$(3.1) \quad \bar{r}_t = \bar{r}_{t-1} - (q_t - q_{t-1}).$$

This rule prescribes zero inflation, so if world market prices are constant the exchange rate should be kept fixed, while it should be revalued in the event of positive world inflation. The intuition is simple. Since the Union knows the exchange rate, they will set the wage to achieve its target employment. Given that, the best the Government can do in each period is to choose the point on the Union's reaction function that is associated with zero inflation, as illustrated by point S in Figure 1. The costs associated with this rule are thus

$$(3.2) \quad \bar{z}_t = \beta \left(\frac{\lambda^G - \lambda^U}{\lambda^G} \right)^2 = \beta u^2,$$

where $u \equiv (\lambda^G - \lambda^U)/\lambda^G$ corresponds to what is sometimes referred to as "union voluntary-individual involuntary" unemployment.

The suggested rule is completely analogous to the optimal rule discussed by Barro and Gordon (1983a, b) which involves zero inflation at the natural rate of unemployment. Here, the Government can do better, however. If we let the Government condition its exchange rate also on the wage chosen by the Union, it can effectively determine the Union's choice set. When this is done in an appropriate way, the Government achieves not only its target inflation 0, but also its target employment λ^G . One such possible rule is depicted in Figure 1 as the schedule ABC, where the Government adopts a "punishment strategy" such that the Union finds it optimal to set $w_t^G = \bar{r}_{t-1} + q_{t-1} - \lambda^G/\lambda^U$; the Government's target wage with zero inflation.¹⁰

It is well-known from game theory that it is often of great value to a player to be able to commit himself to a certain strategy. In the present context this ability makes the Government almost omnipotent, while the Union that must optimize during the course of the game is left in an extremely adverse position.

It is instructive to contrast the above result to the aforementioned result in Barro and Gordon. There, as in much of the rational expectations literature, private sector behavior is summarized in a Lucas-Rapping "surprise-supply" function. This assumption and the fact that the private sector does not explicitly choose any other variable than its inflationary expectations, in fact amounts to assuming precisely that the private sector can also commit itself to a certain reaction function given by the surprise supply function.

We should emphasize at this stage that the equilibria we have discussed above are not plausible if the commitments are not binding. The equilibrium at point B in Figure 1 is, in the language of game theory, not a perfect equilibrium because it relies on threats that would not be carried out if the Union in fact deviated. If the punishment strategy required the Government to set the exchange rate along the segment BC, it would instead be optimal to choose the exchange rate along the reaction function. Similarly, if the Union believed in the rule given by (3.1) and set its wage accordingly, there would also be an incentive for the Government to renege on its promises and devalue so as to reduce underemployment. Hence, both the rules proposed above are time-inconsistent without binding commitments. By assumption this is not a problem, since we have assumed that once-and-for-all

commitments are in fact possible. For many cases that is not a reasonable assumption, however, since the costs of such commitments might be exceedingly high. In the remaining sections of the paper we will therefore study situations where formal commitments are not possible, and impose the requirement that the Government's optimum policy is indeed a credible one.

4. Discretion

When there are no commitment possibilities the game takes another form. In each period the Union sets the wage. Then the Government chooses the optimal exchange rate given the wage and the world market price. For the Government such discretionary behavior involves balancing the potential gains of increased employment against the losses from increased inflation.

The period t outcome in the perfect Nash equilibrium of this repeated game is illustrated by point N in Figure 1. At this point the Union sets its optimal wage according to its reaction function (2.4) taking the strategy of the Government as given. The Government is also on its reaction function, playing its optimal response given the strategy of the Union.¹¹ Differentiating (2.8) with respect to r_t and using (2.4), we find the equilibrium exchange rate $\hat{r}_t$ as

$$(4.1) \quad \hat{r}_t = r_{t-1} - (q_t - q_{t-1}) + \frac{\beta}{(1 - \beta)} \frac{\lambda^U}{\lambda^G} u.$$

With discretion the optimal policy thus prescribes a constant and positive inflation rate

$$(4.2) \quad \hat{\pi} = \frac{\beta}{(1 - \beta)} \frac{\lambda^U}{\lambda^G} u,$$

associated with a higher rate of devaluation than under the optimal rules discussed in the previous section. In equilibrium, the Union who realizes the Government's incentives thus anticipates a devaluation in each period and increases the wage accordingly, whereupon the Government in fact "accommodates" this wage increase.

Consequently, compared to the optimal rules, employment is the same but inflation is higher under discretion, so costs

$$(4.2) \quad \hat{z}_t = \beta u^2 + (1 - \beta) \pi^2$$

must be higher. If both policies were feasible the policy maker would hence prefer to commit himself to an exchange rate policy rule.

A fairly common description of results like this is that "the optimal policy rule is time-inconsistent". We would like to point out, however, (as do also Barro and Gordon) that such a statement is not very precise. Any policy that is said to be "optimal", is optimal under some constraint on the choice set of the Government. Either commitments are possible, in which case time-inconsistency of the optimal policy by assumption isn't a problem, or they are not, in which case the optimal policy has to be time-consistent by definition. If commitments are not possible then it obviously doesn't help that the optimal policy with commitments yields a better outcome.

5. "Reputation"

So far there has been no intertemporal links in the model and the analysis has been carried out by piecewise optimization. In this section we shall introduce such links, however, by assuming

that the Union bases its expectations about the Government's future policy on its current behavior. This introduces dynamic considerations into the Government optimization problem since the Union's future wage setting depends on the present exchange rate policy. At a general level, the approach is therefore similar to that in Barro and Gordon (1983b).

Let the Government announce an exchange rate r_t^* before the Union sets its wage. Then we assume that the exchange rate that the Union expects r_t^e satisfies

$$(5.1) \quad r_t^e = \begin{cases} r_t^* & \text{iff } r_{t-1} = r_{t-1}^* \\ \hat{r}_t = r_{t-1} - (q_t - q_{t-1}) + \hat{\pi} & \text{otherwise.} \end{cases}$$

That is, if the Government did what it announced period $t-1$, the Union expects it to stick to its announcement also in t . If the Government reneged on its announcement in $t-1$, the discretionary policy (discussed in the previous section) is expected in t .

We want to investigate what the optimal time consistent policy is under these circumstances. To simplify, we shall restrict ourselves to the following class of exchange rate policies

$$(5.2) \quad r_t^* = r_{t-1}^* - (q_t - q_{t-1}) + \pi^*,$$

That is, to informal rules that lead to an arbitrary but constant rate of inflation. Of course, we are most interested in policies such that $\pi^* < \hat{\pi}$, and in particular we wish to investigate whether a policy that sets $\pi^* = 0$ is a credible one.

Note that (5.1) and (5.2) in conjunction with (2.7) imply that the Union sets the wage in the following way

$$(5.3) \quad w_t = \begin{cases} r_{t-1} + q_{t-1} - 1 + \pi^* & \text{iff } r_{t-1} = r_{t-1}^* \\ r_{t-1} + q_{t-1} - 1 + \hat{\pi} & \text{otherwise.} \end{cases}$$

This pattern for wage setting has the character of a "tit-for-tat" strategy; as long as the Government sticks to its announcement the Union keeps back its wage increases, but if the Government falls back on its promise the Union responds with a higher wage increase in the next period. Another consequence of (5.1) is that in order to scale down the Union's expectations of expansionary policy once the Government has cheated, it has to make a one period "investment" in the form of lower employment by setting the exchange rate r^* when the Union has set w_t anticipating (the higher) $\hat{r}$.¹²

Before discussing the Government's problem, we need some new notation. Let Z_t^* denote the Government's costs when it sticks to its informal rule (5.2); let $\tilde{Z}_t$ be the cost when the Union believes the announcement r_t^* but the Government cheats by setting $\tilde{r}_t$; conversely Z_t' is the cost when $\hat{r}_t$ is expected and the Government invests in the future by instead setting r_t^* ; $\hat{Z}_t$ as before denotes the costs under (expected) discretion.

When is a rule like (5.2) time consistent? Because no commitments can be made like in Section 4, time consistency requires that the costs of following the rule

$$(5.4) \quad Z_t^* + \delta Z_{t+1}^* + \delta^2 Z_{t+2}^* + \dots,$$

are lower than the costs of deviating so that the Government indeed finds it optimal not to renege on its announcements in any period. What we want to find out is thus under what conditions the sequence of costs (5.4) is lower than the costs under any alternative strategy. One can show that it is then sufficient to look at the following two strategies:¹³ In the first one, the Government

cheats in period t and pursues a policy of (expected) discretion thereafter, which gives costs

$$(5.5) \quad \tilde{Z}_t + \delta \hat{Z}_{t+1} + \delta^2 \hat{Z}_{t+2} + \dots$$

In the second strategy there is cheating in period t . Then the Government invests in credibility in $t + 1$, cheats again in $t + 2$, etc., which yields

$$(5.6) \quad \tilde{Z}_t + \delta Z'_{t+1} + \delta^2 \tilde{Z}_{t+2} + \delta^3 Z'_{t+3} + \dots$$

Since Z^* , $\tilde{Z}$, Z' and $\hat{Z}$ are independent of t , the sufficient conditions for a rule like (5.2) to be time-consistent follow from (5.4)-(5.6) as:

$$(5.7) \quad Z^* - \tilde{Z} \leq \frac{\delta}{1 - \delta} (\hat{Z} - Z^*).$$

and

$$(5.8) \quad Z^* - \tilde{Z} \leq \delta(Z' - Z^*)$$

The LHS of these conditions is the gain from cheating in the present, what Barro and Gordon (1983b) labelled the "temptation", while the RHS is the costs born in the future, the "enforcement". After finding the optimal amount of cheating, evaluating the costs Z^* , $\tilde{Z}$, $\hat{Z}$ and Z' using (2.6), (2.8), (4.2) and (5.1)-(5.3), and a lot of algebra, one can rewrite the conditions (5.7) and (5.8) as

$$(5.7') \quad \pi^{*2} - \frac{2}{\gamma + 1} \pi^* \hat{\pi} \leq \frac{\gamma - 1}{\gamma + 1} \hat{\pi}^2$$

and

$$(5.8') \quad \pi^* \leq \hat{\pi} + \frac{2/(1 - u)}{1 - 1/\delta\epsilon(1 + \epsilon)},$$

$$\text{where } \gamma \equiv \frac{\delta}{(1 - \delta)(1 - \beta)} \left(\frac{l^U}{l^G} \right)^2 \text{ and } \epsilon \equiv \frac{\beta}{(1 - \beta)} \left(\frac{l^U}{l^G} \right)^2.$$

We can now investigate whether an announced exchange rate policy that promises zero inflation is time-consistent.

Substituting $\pi^* = 0$ into the conditions (5.7') and (5.8'), it is easy to verify that both are fulfilled unless δ , β and l^U/l^G are too low. For instance, if $\varepsilon = \beta(l^U)^2 / (1 - \beta)(l^G)^2 > 1$ and $\delta > 1/2$ this is clearly sufficient. The intuition is simple. The benefits of increased employment of deviating from a non-inflationary exchange rate policy occur now, while the costs are born in the future in the form either of a positive inflation rate $\hat{\pi}$ as in (5.5), or as decreased employment when the Government has to purchase back its credibility, as in (5.6). Consequently, the higher δ - the discount factor - and the higher β - the weight on employment in the Government cost function - (leading to a higher $\hat{\pi}$) the higher the costs.

What happens if $\pi^* = 0$ is not time-consistent? Then, at least for many parameter constellations, one can find a range of positive $\pi^* \leq \hat{\pi}$ which fulfill (5.7') and (5.8'). In that case, picking the lowest of these π^* yields the optimal time-consistent policy.¹⁴

We have thus seen how informal, "reputational", considerations of the Government might fully or partially substitute for formal commitments. If $\pi^* = 0$ is credible, in the sense discussed above, the Government achieves point S in Figure 1, if some other π^* , $0 < \pi^* < \hat{\pi}$, is credible it achieves a point in between S and N. One way to understand what is going on here is to recall our remark that with our assumption about expectations the Union in effect becomes committed to a "tit-for-tat" strategy in its wage

setting. Such strategies not only have some empirical support but are also known to sometimes foster cooperative behavior.¹⁵

Although the set-up we have discussed in this section gives some nice insights, there are a couple of important qualifications. First, the rule of thumb we have assumed for expectations formation is ad hoc and has no foundation in optimizing behavior. As a result, the equilibria in the present set-up are not perfect. (Note, however, that in an equilibrium where the Government sticks to its announcements, the Union's expectations are self-fulfilling.) Second, the notion of reputation, which we find

important in macroeconomic policy-making, is not properly captured here. It seems to us that to create a reputation the Government should try to use its actions to influence the Union's beliefs about its character. As long as the Union has complete information about its preferences there is nothing the Government can do in that way. The next section is an attempt to remedy both these weaknesses by looking at a situation where information is incomplete.

6. Reputation and the Rational Union

The essence of the previous section's model is the notion that the Union does not know what actions the Government will undertake, and therefore uses the last policy action as a prediction for current policy; that is, it forms expectations adaptively. Although not without some intuitive appeal, the Union's way of using the available information is hence not rational. We will therefore in this section consider a version of our model where

both players as far as possible act rationally, and where the Union is uncertain about the true nature (preferences) of the Government - the Union has, in game theoretic terminology, incomplete information about the Government.

In order to investigate the incomplete information game, we apply a slightly modified version of the analysis developed by Kreps and Wilson (1982a). The equilibrium concept in this game is that of "sequential equilibrium", which is a sub-game-perfect Nash equilibrium, where the Government's policy thus will be time-consistent by definition. The sequential equilibrium also requires that players use Bayesian inference along the equilibrium path.¹⁶ The concept "reputation" therefore plays a well-defined and meaningful role.

In order to make the analysis manageable we restrict both players' possible actions to a subset of all the feasible actions above, namely to either of two actions. We prefer to think of these actions more in terms of policies than of particular levels for the nominal wage and exchange rate, and in order to avoid making the presentation too messy we leave these rates unspecified. The appendix does, however, provide an example of how this section's analysis is consistent with the model presented in Section 2. As before, the Union moves first and chooses either a more aggressive stance, and hikes the wage in period t (denoted H_t), or sets a lower wage (L_t). The Government then responds by either an accommodating exchange rate policy (A_t), or a non-accommodating one (N_t). The one-shot game is depicted in extensive form in Fig. 2.

Ranking of Outcomes

Figure 2.

The pay-offs in the various outcomes of the one-shot game are related as follows. Let $V(U\text{'s action}, G\text{'s action})$ denote the Union's pay-off. We assume that it is common knowledge that

$$(6.1) \quad V(H, A) \geq V(L, N) > V(H, N), \quad V(L, A) = 0$$

That is, the Union's preferred outcomes are those where it matches the Government's choice of exchange rate policy, setting a low wage if the Government doesn't accommodate and hiking the wage if the Government accommodates.

In order to capture the Union's uncertainty about the intentions of the Government, we assume that there are two types of governments, differing in the relative weight of inflation and unemployment in the cost function (i.e. differing in the value of β). For the sake of simplicity we transform the Government's minimization problem into one of maximization. We use the notation $\bar{Z}$ (U's action, G's action) for the (desired) pay-off the Government gets in the one-shot game. It is the negative of the corresponding cost plus $Z(H, A)$, i.e.

$$(6.2) \quad \bar{Z}(L, N) \equiv Z(H, A) - Z(L, N); \quad \bar{Z}(L, A) \equiv Z(H, A) - Z(L, A);$$

$$\bar{Z}(H, N) \equiv Z(H, A) - Z(H, N); \quad \bar{Z}(H, A) \equiv 0.$$

Both types of governments strive to maximize the expected discounted sum of pay-offs:

$$(6.3) \quad \max E \sum_1^T \delta^{t-1} \bar{Z}_t,$$

where T is the (possibly infinite) horizon of the game. A "T"-government has instantaneous pay-offs

$$(6.4) \quad \bar{Z}(L, N) > \bar{Z}(L, A), \text{ and } \bar{Z}(H, N) > \bar{Z}(H, A);$$

that is, a T-government always prefers to maintain a tight, anti-inflationary exchange-rate policy regardless of the employment

consequences. We can therefore think of "T" as referring to "Tough" (or maybe to Thatcher). An "S"-government, on the other hand, is characterized by the instantaneous pay-offs

$$(6.5) \quad \bar{Z}(L, A) > \bar{Z}(L, N) > \bar{Z}(H, A) > \bar{Z}(H, N).$$

Hence, the S-government prefers to increase employment at the expense of price stability irrespective of whether or not the Union has chosen to hike the wage. "S" may abbreviate Soft (or Social-democratic). We also restrict pay-offs of the S-government by

$$(6.6) \quad \bar{Z}(L, A) = \bar{Z}(L, N) - \bar{Z}(H, N).$$

If the Government is known to be of the T-type, the Union knows that the Government will pursue a non-accommodating exchange rate policy irrespective of the Union's choice of wage. The best the Union can do is to set the low wage, and the perfect Nash equilibrium is (L, N) in each period. On the other hand, if the Government is known to be of the S-type, the Union will hike the wage in each period, knowing that the Government's best response is to accommodate. The perfect Nash equilibrium with the S-government is therefore (H, A) in each period. Threats by the S-government to pursue a non-accommodating exchange rate policy are disregarded by the Union, which knows that once the Government is faced by the high wage, it will accommodate. This equilibrium hence corresponds to the equilibrium under discretion in Section 4.

When the Union is uncertain about the identity of the Government, i.e. when information is incomplete, the story is different, however. An S-government has now a possibility to pretend it is of the T-type, in order to persuade the Union that it is in the Union's best interest to refrain from wage hikes.

At the outset of the game (immediately after an election, say), the Union has a prior probability p_0 that the government is of the T-type. As the game proceeds the Union observes the Government's actions, and uses its observations, whenever possible in a Bayesian manner, in order to revise its assessment of the Government's type. The Union knows that a T-government would never accommodate wage hikes. As long as an S-government does not devalue, it can therefore successfully pretend to be of T-type. Furthermore, it has an incentive to do so, because if it ever accommodates it will reveal its true identity. The Union will then always choose to increase the wage in subsequent periods, knowing that the S-government's only reason to choose not to devalue - to invest in its reputation - is gone. If it doesn't accommodate, however, the S-government stands the chance of getting $\bar{Z}(L, N)$ rather than $\bar{Z}(H, A)$.

Let us first briefly consider the game with an infinite horizon. If the discount factor δ is large enough, it will pay for an S-government to postpone the revelation of its true identity indefinitely. If the Union chooses a low wage, the Government may make a short term gain by accommodating, increasing its immediate pay-off from $\bar{Z}(L, N)$ to $\bar{Z}(L, A)$. Its identity is revealed, however, so in all subsequent periods the Union will hike the wage and the Government will only get the pay-off 0 instead of $\bar{Z}(L, N)$ in each play. With an infinite number of plays left, the latter cost exceeds the short term gain, provided the discount factor is large enough.

The game is more interesting with a finite horizon. One interpretation is that we study the interaction during an election

period between a Union and a Government that does not consider possible consequences of its actions on possible future election periods. The Government declares after it has been elected that it is going to pursue a non-accommodating exchange rate policy, but the Union is uncertain about whether the Government is of the S or T-type. This uncertainty may, as we shall see, be exploited by the S-government.

Before specifying the equilibrium strategies we need to introduce some notations. L_t denotes L played at t, etc., and π_t is given by

$$(6.7) \quad \pi_t \equiv [V(H, A)/(V(H, A) + V(L, N) - V(H, N))]^{T-t+1}$$

Finally, let ρ_t denote the Union's posterior probability statistic for that the Government is of the T-type. It is shown in the appendix that if the Union, whenever possible, employs Bayesian updating of the posterior, the Union's equilibrium strategies are:

- (i) Set the low wage at t if $\rho_t > \pi_t$
- (6.8) (ii) Randomize with $\text{Prob}(L_t) = -\bar{Z}(H, N)/(\delta\bar{Z}(L, A))$ if $\rho_t = \pi_t$
- (iii) Hike the wage if $\rho_t < \pi_t$

The equilibrium strategy of the T-government is to never accommodate. The equilibrium strategies of the S-government are:

- (i) Accommodate at $t = T$
- (6.9) (ii) Non-accommodate at $t < T$ if $\rho_t \geq \pi_{t+1}$
- (iii) Randomize at $t < T$ with $\text{Prob}(N_t) =$

$$\rho_t(1 - \pi_{t+1})/((1 - \rho_t)\pi_{t+1}) \text{ if } \rho_t < \pi_{t+1}$$

The exact structure of the equilibrium depends on four factors: (i) the precise evaluation of the different outcomes in (6.1) and (6.5), (ii) the length of the time horizon T , (iii) the Union's initial prior p_0 , and (iv) the government's discount factor δ . The game with an S-government, if sufficiently long, goes through three phases:

(1) In the beginning of the game the Government never accommodates and the Union refrains from wage hikes each period. The higher is p_0 , or the longer the game, the longer is this phase.

(2) At some point the Government starts randomizing. It sets the probability for accommodation higher as the end of the game approaches. The less the difference between $V(L, N)$ and $V(H, N)$ the higher the probability for accommodation. The Union also randomizes from this point in the game, as long as no devaluation occurs.

(3) In the last period, if it has not devalued by chance before, the Government accommodates with certainty.

With a T-government the first phase of the game is as above. In the second and last phase, however, the T-government continues to pursue a non-accommodating policy. But the Union will nevertheless continue to randomize, occasionally hiking the wage. As time proceeds the Union becomes increasingly certain that it faces a T-government. It will nevertheless continue to randomize, knowing that if the Government is of the S-type the probability that it will accommodate increases steadily.

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 S-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 (1984a), this type of behavior provides an interesting alternative to the usual interpretation of the election cycle.

We have hence seen that also with an (almost) completely rational Union reputational considerations may help the S-government to avoid being trapped in a wage increase-devaluation cycle. What is required is that there is some genuine uncertainty on part of the Union about the intentions of the Government.

7. 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. It is interesting to note 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 accomodating devaluations. We have shown in

two different contexts that this bias might be counteracted if the government worries about its reputation and balances future losses of credibility against the immediate employment gains from increased competitiveness.

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.¹⁷ However, in an extended analysis incorporating uncertainty that solution would have a cost because it would be desirable for the government to affect the real wage, ex post.¹⁸

~~Such an extension would be interesting in its own right.~~

Suppose for instance that in the model of Sections 2-5, the productivity parameter λ^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 (provided that the government's cost function was quadric also in the deviation from the employment target). 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 (1983b) referred to as "biting-the-bullet" considerations; in order to de-value effectively in bad times (productivity outcomes), the government would be lead to revalue in good times.

To conclude, we would like to underline the usefulness of modelling macroeconomic policy-making in explicitly game theoretic terms.¹⁹ For one, such an approach makes it possible to analyze seriously concepts like credibility and reputation; concepts that policy-makers have been discussing for a long time, but traditional macroeconomic models have had very little to say about.

APPENDIX

We will in this appendix (A) complete the specification of the sequential equilibrium in the finite horizon game presented in section 6, (B) show that neither player gains from defecting from the prescribed strategies and (C) demonstrate that the assumed pay-offs of this game is compatible with the model in the previous sections

(A) Equilibrium specification

- (1) Initialization: $\rho_1 = \rho_0$, assuming $\rho_0 > \pi_0$
- (2) Strategies: As specified in (6.8) and (6.9), for the Union and the S-government, respectively. The T-government never accommodates.
- (3) Revision rules when equilibrium strategies are followed:
 - (i) If A_t , then $\rho_{t+\tau} = 0$ for $\tau = 1, \dots, T-t$
 - (ii) If N_t when $\rho_t \geq \pi_{t+1}$, then $\rho_{t+1} = \rho_t$
 - (iii) If N_t when $\rho_t < \pi_{t+1}$, then $\rho_{t+1} = \pi_{t+1}$
- (4) Revision rules when players defect
 - (i) If the Union defects at t , $\rho_{t+1} = \rho_t$
 - (ii) If A_t when $1 > \rho_t \geq \pi_{t+1}$, $\rho_{t+1} = 0$
 - (iii) If N_t when $\rho_t = 0$, $\rho_{t+1} = \pi_{t+1}$

B. Prescribed Strategies Are Best Responses

(4) The Union plays its best response

Using the strategies specified above we construct the following joint probability table, with marginal probabilities given in third row and column.

Government's type			
		S	T
N_t	ρ_t	$\frac{1-\pi_{t+1}}{\pi_{t+1}}$	ρ_t
			$\frac{\rho_t}{\pi_{t+1}}$
A_t	$\frac{\pi_{t+1} - \rho_t}{\pi_{t+1}}$		$\frac{\pi_{t+1} - \rho_t}{\pi_{t+1}}$
		$1-\rho_t$	ρ_t

Consider first the rationality of the revision rules (3). A T-government never accommodates, hence (3:i). When $\rho_t \geq \pi_{t+1}$ neither type of government accommodates, so no information is obtained from the observation N_t , and hence (3:ii). When $\rho_t < \pi_{t+1}$ the S-government randomizes. Bayes' formula yields

$$\rho_{t+1} = \frac{\rho_t \text{Prob}(N_t|T)}{\rho_t \text{Prob}(N_t|T) + (1-\rho_t) \text{Prob}(N_t|S)}$$

Using the joint probability table we can verify that the revision rules (3) are Bayesian and hence rational. The rules in (4) are specified for zero probability events, making Bayesian inference

inapplicable. These rules are hence in this sense ad hoc, even though they may seem reasonable.

Let us now consider the Union's prescribed strategy (6.8).

- (i) If $1 > \rho_t \geq \pi_{t+1}$ both governments play N_t . The best response to N_t is L_t , as prescribed by (6.8:i).
- (ii) If $\rho_t < \pi_{t+1}$ the S-government randomizes. The Union is indifferent between L_t and H_t if

$$\text{Prob}(N_t) V(L, N) + \text{Prob}(A_t) V(L, A) =$$

$$= \text{Prob}(N_t) V(H, N) + \text{Prob}(A_t) V(H, A)$$

i.e. if

$$\text{Prob}(N_t) = V(H, A) / (V(H, A) + V(L, N) - V(H, N))$$

$$= \pi_t / \pi_{t+1},$$

and the Union prefers L_t (H_t) if $\text{Prob}(N_t) > \pi_t / \pi_{t+1}$ ($< \pi_t / \pi_{t+1}$). The joint probability table yields $\text{Prob}(N_t) = \rho_t / \pi_{t+1}$. The prescribed strategies (6.8) are hence best responses to the Governments' strategies.

(5) The S-government's expected pay-off

Let $n(\rho) \equiv \sup\{t \mid \pi_t < \rho\}$; since π_t is increasing in t , $n(\rho_0)$ is the last game without randomization. Furthermore, let $U(t, \rho_t)$ be the S-government's expected pay-off from the rest of the game when entering period t with the reputation ρ_t . The "Government" refers subsequently, unless differently stated, to

the S-government

(i) When $\rho_t < \pi_t$ ($< \pi_{t+1}$) the Government randomizes so that if N_t is drawn $\rho_{t+1} = \pi_{t+1}$. The Union definitely hikes the wage. The Government's expected pay-off from the rest of the game is

$$\begin{aligned} U(t, \rho_t) &= \text{Prob } (N_t | S) \cdot \left[\bar{Z} (H, N) + \delta U (t+1, \pi_{t+1}) \right] + \\ &+ \text{Prob } (A_t | S) \cdot \left[\bar{Z} (H, A) + \delta U (t+1, 0) \right] \\ &= \text{Prob } (N_t | S) \left[\bar{Z} (H, N) + \delta U (t+1, \pi_{t+1}) \right]. \end{aligned}$$

This must be equal to zero, for the Government to be indifferent between A_t and N_t .

(ii) When $\rho_t = \pi_t$ both parties randomize. Either action by the Government must hence yield the same expected utility. It is easiest to determine the expected pay-off from A_t , which is

$$\begin{aligned} &\text{Prob } (L) \cdot \left[\bar{Z} (L, A) + \delta U (t+1, 0) \right] \\ &+ \text{Prob } (H) \cdot \left[\bar{Z} (H, A) + \delta U (t+1, 0) \right] = \\ &= \text{Prob } (L) \bar{Z} (L, A) \\ &= - \bar{Z} (H, N) / \delta \end{aligned}$$

(iii) When $\rho_t > \pi_t$ the game consists of two parts. First, the game from t to $n(\rho_t)$, which evolves without any randomization, with (L, N) played in each period. This yields the pay-off $\left[(1-\delta)^{n-t+1} / (1-\delta) \right] \bar{Z}(L, N)$. Second, there is a randomization phase with expected pay-off $-\bar{Z}(H, N)/\delta$.

Summarizing, the Government's expected pay-off entering period t with posterior ρ_t is

$$U(t, \rho_t) = \begin{cases} 0 & \text{if } \rho_t < \pi_t \\ -\bar{Z}(H, N)/\delta & \text{if } \rho_t = \pi_t \\ \left[(1-\delta)^{n(\rho_t)-t+1} / (1-\delta) \right] \bar{Z}(L, N) - \bar{Z}(H, N)/\delta & \text{if } \rho_t > \pi_t \end{cases}$$

(6) The Government plays its best response

(i) When $\rho_t \geq \pi_{t+1}$ the Union refrains with certainty from hiking the wage and the Government never accommodates, implying $\rho_{t+1} = \rho_t$. The prescribed strategy hence yields

$$\bar{Z}(L, N) + \delta U(t+1, \rho_t) = \bar{Z}(L, N) - \bar{Z}(H, N) + \delta \left[(1-\delta)^{n(\rho_t)-t} / (1-\delta) \right] \bar{Z}(L, N)$$

Deviation from the prescribed strategy yields $\bar{Z}(L, A)$ immediately and 0 subsequently. It is clear from (6.6) that the prescribed strategy is optimal.

(ii) When $\rho_t < \pi_t$ ($< \pi_{t+1}$) the Union definitely hikes the wage. Accommodation at t yields expected pay-off

$$\bar{Z}(H,A) + \delta U(t+1,0) = 0,$$

whereas non-accommodation results in

$$\bar{Z}(H,N) + \delta U(t+1, \rho_{t+1}) = 0.$$

(iii) When $\rho_t = \pi_t$ ($< \pi_{t+1}$) the Union randomizes.

(a) Suppose the low wage is drawn. The expected pay-off from accommodation is then

$$\bar{Z}(L,A) + \delta U(t+1,0) = \bar{Z}(L,A),$$

while non-accommodation yields

$$\bar{Z}(L,N) + \delta U(t+1, \rho_{t+1}) = \bar{Z}(L,N) - \bar{Z}(H,N) = \bar{Z}(L,A)$$

b) If the high wage is drawn, the expected pay-off from accommodation is

$$\bar{Z}(H,A) + \delta U(t+1,0) = 0,$$

whereas non-accommodation results in

$$\bar{Z}(H,N) + \delta U(t+1, \rho_{t+1}) = 0.$$

(iv) Finally, when $\pi_t < \rho_t < \pi_{t+1}$ the Union chooses with certainty not to hike the wage. Accommodation then yields

$$\bar{Z}(L,A) + \delta U(t+1, 0) = \bar{Z}(L,A),$$

and non-accommodation imply the expected pay-off

$$\bar{Z}(L,N) + \delta U(t+1, \rho_{t+1}) = \bar{Z}(L,N) - \bar{Z}(H,N) = \bar{Z}(L,A).$$

To summarize, when $1 > \rho_t \geq \pi_{t+1}$ the Government loses from defecting from the prescribed strategy. When $\rho_t < \pi_{t+1}$ the Government is indifferent between its two feasible actions, and randomization is hence a best response. We have seen that neither side stands to gain by defecting at any decision point from the strategies specified in (6.8-9), and we hence have a subgame-perfect Nash equilibrium.

C. Pay-offs Are Compitable With The Model In Section 2

In this last part of the appendix we provide an example indicating that the four possible outcomes in the one-shot game in section 6 can be viewed as pertaining to the economy described in section 2.

Let a and b be positive constants (to be defined), and let w_t^L and w_t^H denote (the log of) the Low and the High nominal wage. Assume for simplicity world prices are constant and equal to unity. Let the wages be

$$(A.1) \quad w_t^L = r_{t-1}^{-1} \text{ and } w_t^H = r_{t-1}^{-1} + a + b$$

The Government chooses between a (partly) Non-accommodating and a (partly) Accommodating exchange rate policy. If the Union has

chosen the Lower wage, (the log of) the implied exchange rates are for N_t and A_t , respectively,

$$(A.2) \quad r_t^{LN} = r_{t-1} \quad \text{and} \quad r_t^{LA} = r_{t-1} + a,$$

whereas the corresponding exchange rates with a Hiked wage are

$$(A.3) \quad r_t^{HN} = r_{t-1} + b \quad \text{and} \quad r_t^{HA} = r_{t-1} + a+b.$$

Using (A.1-3) we get

$$r_t^{LN} - w_t^L = 1 ; \quad r_t^{HA} - w_t^H = 1 ; \quad r_t^{LA} - w_t^L = 1+a ;$$

$$r_t^{HN} - w_t^H = 1-a$$

That is (L,N) and (H,A) both yield the Union's most preferred real wage (c.f.(2.7)), whereas (L,A) and (H,N) and the Union's utility function (2.3) results in worse outcomes for the Union. (A.1-3) are hence consistent with the Union's pay-offs as specified in (6.1).

Let us turn to the S-government's pay-offs. Inserting (A.1-3) into the Government's cost-function (2.8) and using (6.2), we get:

$$\bar{Z}(L,A) = \beta \ell a (2 u - \ell a) + (1-\beta) b (2 a + b)$$

$$\bar{Z}(L,N) = (1-\beta) (a + b)^2$$

$$\bar{Z}(H,A) = 0$$

$$\bar{Z}(H,N) = \beta \ell a (2u + \ell a) + (1 - \beta) a (2b + a),$$

where $\ell \equiv \ell^U / \ell^G$. It is easily confirmed that (6.6) is fulfilled if

$$(A.4) \quad b = \frac{\beta}{1-\beta} \ell^2 a.$$

Let b be given by (A.4) and assume that

$$(A.5) \quad a < \frac{2\beta u \ell}{1 - \beta + \beta \ell^2}.$$

It is then straightforward to show that (6.5) is fulfilled.

To summarize, the set of actions described by (A.1-3), where b is defined by (A.4) and a fulfills (A.5), are consistent both with the production and the utility functions defined in section 2 and the pay-off structure given in section 6.

REFERENCES

- Axelrod, R. (1984), The Evolution of Cooperation, (New York: Basic Books).
- Backus, D. and J. Driffill (1984a), "Inflation and Reputation", Discussion Paper No. 560, Department of Economics, Queen's University.
- _____ (1984b), "Rational Expectations and Policy Credibility Following a Change in Regime", Discussion Paper No. 564, Department of Economics, Queen's University.
- Barro, R. (1985), "Reputation in a Model of Monetary Policy with Incomplete Information", University of Rochester (mimeo).
- Barro, R. and D. Gordon (1983a), "A Positive Theory of Monetary Policy in a Natural Rate Model", Journal of Political Economy 91, No. 4, 589-610.
- _____ (1983b), "Rules, Discretion and Reputation in a Model of Monetary Policy", Journal of Monetary Economics 12, 101-121.
- Calmfors, L. (1982), "Employment Policies, Wage Formation and Trade Union Behavior in a Small Open Economy", Scandinavian Journal of Economics 84, pp. 245-373.
- _____ (1984), "The Roles of Stabilization Policy and Wage Setting for Macroeconomic Stability -- The Experiences of Economies with Centralized Bargaining", Seminar Paper No. 286, Institute for International Economic Studies.
- Calmfors, L. and H. Horn (1983), "Employment Policies and Centralized Wage Setting", Seminar Paper No. 238, Institute for International Economic Studies.
- Chiappori, P.A. and P.L. Mongin (1983), "Credibility, Game-Theoretic Uncertainty and the Theory of Monetary Policy", Laboratoire d'Economie Politique, Ecole Normale Supérieure, Paris.
- Driffill, J. (1983), "Can Stabilization Policy Increase the Equilibrium Unemployment Rate?", Discussion Paper in Economics and Econometrics No. 8312, University of Southampton.
- _____ (1985), "Macroeconomic Stabilization Policy and Trade Union Behavior as a Repeated Game", Scandinavian Journal of Economics, May (forthcoming).
- Dunlop, J. (1944), Wage Determination under Trade Unions, Macmillan, New York.

- Eaton, J. (1984), "Optimal and Time Consistent Exchange Rate Management in an Overlapping Generations Economy", Yale University (mimeo).
- Fischer, S. (1977), Long-Term Contracts, Rational Expectations and the Optimal Money Supply Rule", Journal of Political Economy 85, 191-205.
- Gylfason, T. and A. Lindbeck (1982), "The Macroeconomic Consequences of Endogenous Governments and Labor Unions", Seminar Paper No. 232, Institute for International Economic Studies.
- Hamada, K. (1976), "A Strategic Analysis of Monetary Integration", Journal of Political Economy 84, 667-700.
- Hersoug, T. (1985), "Workers vs. Government -- Who Adjusts to Whom?", Scandinavian Journal of Economics, May (forthcoming).
- Kreps, D., Milgrom, P., Roberts, J. and R. Wilson (1982), "Rational Cooperation in the Finitely Repeated Prisoners' Dilemma", Journal of Economic Theory 27, 245-52.
- Kreps, D. and R. Wilson (1982a), "Reputation and Imperfect Information", Journal of Economic Theory 27, 253-79.
- _____ (1982b), "Sequential Equilibrium", Econometrica 50.
- Milgrom, P.R. (1984), "Axelrod's the Evolution of Cooperation", Rand Journal of Economics 15, 305-309.
- Oswald, A. (1985), "The Economic Theory of Trade Unions: An Introductory Survey", Scandinavian Journal of Economics (forthcoming).
- Pencavel, J. (1985), "Wages and Employment Under Trade Unionism: Microeconomic Models and Macroeconomic Applications", Scandinavian Journal of Economics (forthcoming).
- Rogoff, K. (1983), "Productive and Counterproductive Cooperative Monetary Policies", International Finance Discussion Paper No. 233, Board of Governors of the Federal Reserve System.
- Söderström, H. (1985), "Non-Accommodation as a Stabilization Strategy under Stochastic Disturbances", Scandinavian Journal of Economics (forthcoming).

Footnotes

*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 and seminar participants at Western Ontario, The World Bank, Princeton, Pennsylvania, Rochester, Keio, Tel-Aviv, and IIES for helpful comments. The research was supported by grants from the Royal Swedish Academy of Sciences, the Bank of Sweden Tercentenary Foundation and the Sweden-America Foundation.

1. See Calmfors (1984) for a survey of the stabilization policies pursued in European countries with centralized wage setting since the first oil shock.
2. Here, as well as throughout in the paper, we abstract from situations where devaluations are triggered off by speculation against the central bank. Similarly, we will not analyze how the interventions to support the exchange rate are carried out, and will simply assume that the government can support whatever exchange rate it wants to.
3. Eaton (1984) discusses optimal exchange rate policies, paying careful attention to time consistency issues as we do below, in a context where the government is concerned with providing a stable store of value and with the seignorage of money creation.

4. A similar approach is taken by Rogoff (1983) although he does not model trade union behavior in an explicit way.
5. See also the subsequent paper by Barro (1985).
6. An alternative interpretation to the encompassing union is the following. The total labor force of the economy consists of two groups. One is non-unionized and payed reservation wages. The other group consists of union members. The demand function (2.2) gives the demand for workers in excess of the non-unionized fringe. Unionized workers will typically have higher (expected) utility, so in order to maintain their positions they don't allow any entry into the union.
7. See Oswald (1985) for a survey of recent advances in the modelling of the microeconomics of trade unions, and Pencavel (1985) for a survey of empirical aspects.
8. An interesting extension, which we comment on in the last section, is when world market prices and/or productivity are uncertain and the resolution of this uncertainty takes place after the wage has been set but before the exchange rate is determined.
9. The government cost function might also not unreasonably be interpreted as a social welfare function. As for the first term, it makes sense that in the presence of imperfect labor markets the socially optimal employment level would be higher than that set by the union. For example, although capital owners are not explicitly modeled, their income would be decreasing in the real wage and hence increasing in

employment. The social costs of inflation are harder to motivate other than with the conventional "shoe-leather" costs.

10. Formally, the government should set the exchange rate according to any arbitrary function $\ln \bar{R}_t = \bar{r}_t = \bar{r}(w_t, q_t)$ such that for all $w_t \neq w_t^G$

$$\frac{w_t \ell^n(\bar{R}_t Q_t / w_t)}{\bar{R}_t Q_t} < \frac{w_t^G \ell^G}{\bar{R}_t Q_t},$$

where $\ln w_t^G = w_t^G$.

11. It is easily seen from the figure that restricting our analysis to Nash behavior is not an important restriction. Since the union already achieves its maximum wage bill at point N, it can not really exploit its advantage of playing first in any way. Put differently, in the present setup, the Stackelberg equilibrium with the union as a leader, coincides with the Nash equilibrium.
12. Note the crucial difference with the expectation formation mechanism adopted by Barro and Gordon (1983b), who assume (with analogous notation) $\pi_t = \begin{cases} \pi_t^* & \text{if } \pi_{t-1} = \pi_{t-1}^e \\ \pi_t & \text{otherwise} \end{cases}$.

Then, if the government cheats in t , the private sector believes its announcement π_{t+2}^* automatically without the government incurring any costs whatsoever.

13. All other strategies involve choices that are already made at an earlier point when choosing between sticking to the rule and the two strategies described below. Hence, they cannot yield lower costs.
14. Note that the LHS of (5.7') is a parabola, while the RHS is a constant. If the RHS is negative, the equality in (5.7') is a second order equation in π^* with two positive roots: $\underline{\pi}^*$ and $\hat{\pi}$. Provided $\underline{\pi}^*$ satisfies (5.8'), equation (5.2) with $\pi^* = \underline{\pi}^*$ describes the optimal policy.
15. See the recent study by Axelrod (1984) and the review by Milgrom (1984).
16. To quote Kreps et al. (1982):

"[s]equential equilibrium in a game of incomplete information requires that the action taken by any player at any point in the game tree must be part of an optimal strategy from that point forward, given his beliefs about the evolution of the game to this point (which must, to the extent possible, be consistent with Bayesian updating on the hypothesis that the equilibrium strategies have been used to date) and given that future play will be governed by the equilibrium strategies."
17. Wage settlements indexed to the price level in the model of sections 2-5 would effectively change the order of play in the games we consider. In terms of Figure 1 the union would then be committed to its reaction function, and the optimal discretionary policy of the government would be to set the exchange rate so as to achieve zero inflation, that is point S in the figure.

-
18. Some readers might argue that state contingent wage contracts should be the optimal solution. Given the assumed imperfections in the labor market, the outcome of such contracts might not be socially desirable, however, cf. Footnote 9.
 19. Such an approach has been taken in modeling the interaction between different governments in a lot of recent papers on international policy coordination, extending the seminar work by Hamada (1976).
-

SEMINAR PAPER SERIES

The series was initiated in 1971. For a complete list of Seminar Papers see the Institute's annual brochure.

1982

193. *Michael Bruno:*
Adjustment and Structural Change Under Supply Shocks. 39 pp.
194. *Assaf Razin and Lars E.O. Svensson:*
The Current Account and the Optimal Government Debt. 21 pp. (Also as Reprint No. 214)
195. *W.M. Corden and J.P. Neary:*
Booming Sector and De-Industrialisation in a Small Open Economy. 45 pp. (Also as Reprint No. 204)
196. *Torsten Persson and Lars E.O. Svensson:*
Is Optimism Good in a Keynesian Economy? 19 pp. (Also as Reprint No. 221).
197. *Lars E.O. Svensson:*
On Variable Capital Utilization and International Trade Theory. 14 pp. (Also as Reprint No. 210)
198. *Wilfred J. Ethier:*
International Trade and Labor Migration. 30 pp.
199. *Harry Flam, Torsten Persson and Lars E.O. Svensson:*
Optimal Subsidies to Declining Industries: Efficiency and Equity Considerations. 28 pp. (Also as Reprint No. 223*)
200. *Lars E.O. Svensson:*
Factor Trade and Goods Trade. 37 pp. (Also as Reprint No. 239)
201. *Thorvaldur Gylfason and Michael Schmid:*
Do Devaluations Cause Stagflation? 27 pp. (Also as Reprint No. 224)
202. *Lars Hörnigren, Johan Myhrman, Per-Ake Nilsson, Staffan Viotti and Anders Vredin:*
The SSEM Model - A Brief Description. 24 pp.
203. *Hans Tson Söderström and Eva Uddén-Jondal:*
Does Egalitarian Wage Policy Cause Wage Drift? An Empirical Study of Sweden 1960-1979. 49 pp.
204. *Jonathan Eaton and Henryk Kierzkowski:*
Oligopolistic Competition, Product Variety and International Trade. 36 pp.
205. *Pehr Wessén:*
Growth Models for Open Economies with Non-Shiftable, Malleable Capital and Nontraded Goods. 63 pp.
206. *Carl Hamilton and Lars E.O. Svensson:*
Should Direct or Total Factor Intensities be Used in Tests of the Factor Proportions Hypothesis in International Trade Theory? 22 pp. (Also as Reprint No. 219)
207. *John T. Cuddington:*
Portfolio Balance and IS-LM: A Marriage under Fixed Exchange Rates. 40 pp.

208. *Carl Hamilton and Lars E.O. Svensson:*
Revealed Comparative Advantage: The Case of Sweden. 20 pp.
209. *Carl Hamilton and Lars E.O. Svensson:*
Testing Theories of Trade among Many Countries. 62 pp.
210. *Avnash Dixit:*
Growth and Terms of Trade under Imperfect Competition. 25 pp.
211. *M June Flanders:*
The Balance-of-Payments Adjustment Mechanism: The Doctrine According to Ohlin. 31 pp.
212. *Ronald W. Jones and Douglas D. Purvis:*
International Differences in Response to Common External Shocks: The Role of Purchasing Power Parity. 38 pp. (Also as Reprint No. 227)
213. *Ake Blomquist and Henrik Horn:*
Public Health Insurance and Optimal Income Taxation. 32 pp. (Also as Reprint No. 249)
214. *Carl Hamilton:*
Agricultural Protection in Sweden 1970-1980. 25 pp.
215. *Thorvaldur Gylfason:*
Why Rational Expectations do not Neutralize Monetary Policy. 8 pp.
216. *John T. Cuddington:*
Currency Substitution, Capital Mobility and Money Demand. 25 pp. (Also as Reprint No. 220)
217. *Michael Schmid:*
International Adjustment to an Oil Price Shock - The Role of Competitiveness. 49 pp.
218. *Wilfred J. Ethier:*
Higher Dimensional Issues in Trade Theory. 96 pp.
219. *Paul R. Krugman, Torsten Persson and Lars E.O. Svensson:*
Inflation, Monetary Velocity and Welfare. 27 pp.
220. *Assaf Razin and Lars E.O. Svensson:*
An Asymmetry between Import and Export Taxes. 11 pp.
221. *Wilfred Ethier and Henrik Horn:*
A New Look at Economic Integration. 39 pp.
222. *Assar Lindbeck:*
The Recent Slowdown of Productivity Growth. 58 pp. (Also as Reprint No. 206)
223. *Henrik Horn:*
Product Diversity, Trade, and Welfare. 32 pp.
224. *Thorvaldur Gylfason and Assar Lindbeck:*
Competing Wage Claims, Cost Inflation, and Capacity Utilization. 38 pp. (Also as Reprint No. 228)
225. *Thorvaldur Gylfason and Assar Lindbeck:*
Wage Rigidity and Wage Rivalry: An Oligopolistic Approach. 20 pp. (Also as Reprint No. 233)
226. *Harry Flam:*
A Heckscher-Ohlin Analysis of the Law of Declining International Trade. 21 pp.
227. *Bruno S. Frey and Friedrich Schneider:*
International Political Economy: An Emerging Field. 94 pp.

228. *Torsten Persson and Lars E. O. Svensson:* Misperceptions and Welfare. 21 pp.
229. *Charles P. Kindleberger:* The World Economic Slowdown Since the 1970s. 31 pp. (Also as Reprint No. 215)
230. *W.M. Corden:* The Normative Theory of International Trade. 120 pp.
231. *Charles P. Kindleberger:* Standards as Public, Collective and Private Goods. 27 pp. (Also as Reprint No. 217)
232. *Thorvaldur Gylfason and Assar Lindbeck:* The Macroeconomic Consequences of Endogenous Governments and Labor Unions. 34 pp.
- 1983
233. *Kalyan K. Sanyal:* Trade in Raw Materials in a Simple Ricardian Model. 17 pp.
234. *Charles P. Kindleberger:* Financial Institutions and Economic Development: A Comparison of Great Britain and France in the Eighteenth and Nineteenth Centuries. 42 pp. (Also as Reprint No. 258)
235. *Lennart Ohlsson:* Structural Adaptability of Metropolitan Sweden to Changing Comparative Advantages During Periods of Growth and Stagnation. 43 pp.
236. *Parameswar Nandakumar:* Government Policies in Mixed Open Economies. 31 pp.
237. *Torsten Persson:* Real Transfers in Fixed Exchange Rate Systems and the International Adjustment Mechanism. 38 pp. (Also as Reprint No. 234)
238. *Lars Calmfors and Henrik Horn:* Employment Policies and Centralized Wage Setting. 48 pp.
239. *John T. Cuddington:* A Fix-Price Trade Model with Perfect Capital Mobility: Fixed versus Flexible Exchange Rates. 38 pp.
240. *Bruno S. Frey, Henrik Horn, Torsten Persson and Friedrich Schneider:* A Formulation and Test of a Simple Model of World Bank Behavior. 17 pp.
241. *Pekka Ahtiala:* A Synthesis of the Macroeconomic Approaches to Exchange Rate Determination. 37 pp.
242. *Kalyan K. Sanyal:* Tariffs, Tradable Intermediate Goods and the Balance of Payments. 12 pp.
243. *Kalyan K. Sanyal:* Foreign Exchange Constraint, Sectoral Terms of Trade and Aggregate Expenditure in a Dual Economy. 19 pp.
244. *J. Peter Neary:* The Heckscher-Ohlin Model as an Aggregate. 30 pp. (Also as Reprint No. 265)
245. *John T. Cuddington and Jeremy A. Gluck:* Exchange Rate Forecasting and the International Diversification of Liquid Asset Holdings. 42 pp.
246. *Marian Radetzki and Carl Van Duyn:* The Demand for Scrap and Primary Metal Ores after a Decline in Secular Growth. 37 pp.
247. *Ephraim Kleiman:* Fear of Confiscation and Redistribution. (Notes towards a theory of revolution and repression). 37 pp.
248. *Nancy Peregrin Marion and Lars E.O. Svensson:* Structural Differences and Macroeconomic Adjustment to Oil-Price Changes: A Three-Country Approach. 51 pp.
249. *Anne O. Kreuger:* Trade Policies in Developing Countries. 94 pp.
250. *Dennis J. Snower:* Structural Uncertainty and Monetary Stabilization Policy. 16 pp.
251. *Gene M. Grossman:* International Competition and the Unionized Sector. 31 pp. (Also as Reprint No. 247)
252. *Hans Tson Söderström and Peter Brundell:* Macroeconomic Causes of Unbalanced Productivity Growth in Open Economies. 48 pp.
253. *Carl Hamilton:* Voluntary Export Restraints, Trade Diversion and Retaliation. 27 pp.
254. *Gene M. Grossman and Assaf Razin:* The Pattern of Trade in a Ricardian Model with Country-Specific Uncertainty. 16 pp.
255. *Carl Hamilton:* Australian Manufacturing Industry during the 1970s: An International Comparison and Implications for the ASEAN Countries. 48 pp.
256. *Gene M. Grossman:* The Gains from International Factor Movements. 17 pp. (Also as Reprint No. 244)
257. *Lars E.O. Svensson:* Walrasian and Marshallian Stability. 19 pp.
258. *Thorvaldur Gylfason and Ole Rissager:* Does Devaluation Improve the Current Account? 49 pp. (Also as Reprint No. 237)
259. *John T. Cuddington:* Disequilibrium Analysis in Open Economies: A One-Sector Framework. 34 pp.
260. *Gene M. Grossman:* International Trade, Foreign Investment, and the Formation of the Entrepreneurial Class. 22 pp. (Also as Reprint No. 250)
261. *Mils Gottfries:* Price Dynamics of Exporting and Import Competing Firms. 22 pp.
262. *Ole Rissager:* Devaluation, Profitability and Investment. 64 pp.
263. *Dennis J. Snower:* Imperfect Competition, Underemployment and Crowding-Out. 51 pp.

264. W. M. Corden: Macroeconomic Policy Interaction Under Flexible Exchange Rates: A Two-Country Model. 28 pp.
265. Alan S. Blinder: Credit, Working Capital, and Effective Supply Failures. 40 pp.
266. John T. Gunnington and Per Olov Johansson: Optimum Tariffs, Revenue-Maximizing Tariffs and Unemployment: A General Disequilibrium Analysis. 19 pp.
267. Lars E.O. Svensson: Money and Asset Prices in a Cash-in-Advance Economy. 74 pp.
268. Thorvaldur Gylfason: Credit Policy and Economic Activity in Developing Countries: An Evaluation of Stabilization Programs Supported by the IMF, 1977-79. 49 pp.
269. Lars E.O. Svensson: Currency Prices, Terms of Trade, and Interest Rates: A General Equilibrium Asset-Pricing Cash-in-Advance Approach. 36 pp.
- 1984
270. Lars Calmfors and Henrik Horn: Classical Unemployment, Accommodation Policies and the Adjustment of Real Wages. 35 pp.
271. Henrik Horn: Trade Union Determined Wages, Unemployment and the Size of the Public Sector. 34 pp.
272. Lars Calmfors: Job Sharing, Employment and Wages. 21 pp.
273. Lars E.O. Svensson and Torsten Persson: Time-Consistent Fiscal Policy and Government Cash-Flow: A note. 15 pp.(Also as Reprint No.251)
274. Christopher Findlay: Optimal Taxation of International Income Flows. 14 pp.
275. Carl Hamilton: Voluntary Export Restraints. ASEAN Systems for Allocation of Export Licences. 22 pp.
276. Carl Hamilton: Voluntary Export Restraints on Asia: Tariff Equivalents, Rents and Trade Barrier Formation. 30 pp.
277. Torsten Persson and Lars E.O. Svensson: Current Account Dynamics and the Terms of Trade: Harberger-Laursen-Metzler Two Generations Later. 37 pp.
278. Parameswar Nandakumar: Oil Price Increases and the Structure of Small Open Economies. 52 pp.
279. Parameswar Nandakumar: Supply Side Disturbances, International Competitiveness and Employment. 33 pp.
280. Ronald W. Jones: Income Effects and Paradoxes in the Theory of International Trade. 31 pp.
281. Stanislaw Wellisz and Ronald Findlay: Central Planning and the "Second Economy" in Soviet-Type Systems. 27 pp.
282. Assar Lindbeck and Dennis Snower: Involuntary Unemployment as an Insider-Outsider Dilemma. 47 pp.
283. Torsten Persson and Lars E.O. Svensson: International Borrowing and Time-Consistent Fiscal Policy. 32 pp.
284. Chris Doyle and Sveder van Wijnbergen: Taxation of Foreign Multinationals: A Sequential Bargaining Approach to Tax Holidays. 30 pp.
285. Ronald Findlay and John D. Wilson: The Political Economy of Leviathan. 28 pp.
286. Lars Calmfors: The Roles of Stabilization Policy and Wage Setting for Macroeconomic Stability - The Experiences of Economies with Centralized Bargaining. 43 pp.
287. Ole Rissager: Devaluation, Profitability and Investment: A Model with Anticipated Future Wage Adjustment. 26 pp.
288. James R. Markusen and Lars E.O. Svensson: Factor Endowments and Trade with Increasing Returns Versus Constant Returns to Scale. 34 pp.
289. Refik Erzaan and Samuel Laird: Intra-industry Trade of Developing Countries and Some Policy Issues. 34 pp.
290. Carl Hamilton: Economic Aspects of "Voluntary" Export Restraints. 27 pp.
291. Carl Hamilton: The Upgrading Effect of Voluntary Export Restraints. 9 pp.
292. Harry Flam: Equal Pay for Unequal Work. 30 pp.
293. Frank G. Barry: An Optimizing Approach to Factor and Production Subsidies in a Small Open Economy with Classical Unemployment. 38 pp.
294. Frank G. Barry: Fiscal Policy in a small Open Economy: An Integration of the Short-Run, Heckscher-Ohlin and Capital Accumulation Models. 37 pp.
295. David Brownstone, Peter Englund and Mats Persson: Effects of Tax Reform on the Demand for Owner-Occupied Housing: A Microsimulation Approach. 32 pp.
296. Andrew J. Oswald: On Union Preference and Labour Market Models: Neglected Corners. 37 pp.
297. Henrik Horn and Lars E.O. Svensson: Trade Unions and Optimal Labor Contracts. 32 pp.

298. *Assar Lindbeck*: Redistribution Policy and the Expansion of the Public Sector. 41 pp.
299. *Assar Lindbeck and Jörgen W. Wetbüll*: Intergenerational Aspects of Public Transfers, Borrowing and Debt. 49 pp.
300. *Lars E.O. Svensson*: Sticky Goods Prices, Flexible Asset Prices, and Optimum Monetary Policy. 31 pp.
301. *E.J. Driffill*: Macroeconomic Stabilization Policy and Trade Union Behaviour as a Repeated Game. 33 pp.
302. *R. Jackman*: Counter-Inflationary Policy in a Unionised Economy with Non-Synchronised Wage Setting. 36 pp.
303. *Torsten Persson*: Deficits and Intergenerational Welfare in Open Economies. 27 pp.
304. *Elhanan Helpman*: Imperfect Competition and International Trade: Evidence from Fourteen Industrial Countries. 35 pp.
305. *John Fender*: Monetary and Exchange Rate Policies in an Open Macroeconomic Model with Unemployment and Rational Expectations. 26 pp.
306. *John Pencavel*: Wages and Employment under Trade Unionism: Microeconomic Models and Macroeconomic Applications. 44 pp.
307. *Tor Hersoug*: Workers vs Government - Who Adjusts to Whom? 44 pp.
308. *Andrew J. Oswald*: The Economic Theory of Trade Unions: An Introductory Survey. 49 pp.
309. *Assar Lindbeck and Dennis Snower*: Strikes, Lock-outs and Fiscal Policy. 52 pp.
310. *Assar Lindbeck and Dennis Snower*: Labour Turnover, Insider Morale and Involuntary Unemployment. 41 pp.
311. *John McCallum*: Wage Gaps, Factor Shares, and Real Wages. 34 pp.
312. *Christopher A. Pissarides*: Dynamics of Unemployment, Vacancies and Real Wages with Trade Unions. 27 pp.
313. *John Fender and Parameswar Nandakumar*: An Intertemporal Macroeconomic Model with Oil and Fiscal Policy. 39 pp.
314. *Thorvaldur Gylfason and Marian Radetzki*: Does Devaluation Make Sense in the Least Developed Countries? 33 pp.
315. *Edmund S. Phelps*: The Significance of Customer Markets for the Effects of Budgetary Policy in Open Economies. 29 pp.
316. *Peter Englund, Lars Hörngren and Staffan Viotti*: A Short-Term Model of the Swedish Money Market. 31 pp.
317. *Lars-Gunnar Svensson and Jörgen W. Wetbüll*: Bounds on Optimal Linear Income Taxes. 22 pp.
318. *Mats Persson*: Voting over the Size of Government. 27 pp.
319. *Alan C. Stockman and Lars E.O. Svensson*: Capital Flows, Investment, and Exchange Rates. 48 pp.
320. *Hans Tson Söderström*: Union Militancy, External Shocks, and the Accommodation Dilemma. 34 pp.
321. *Assar Lindbeck and Dennis D. Snower*: Cooperation, Harassment, and Involuntary Unemployment. 52 pp.
322. *A. Sommariva and G. Tullio*: Inflation and Currency Depreciation in Germany 1920-1923: A Disequilibrium Model of Prices and the Exchange Rate. 35 pp.
323. *Robert M. Solow*: Insiders and Outsiders in Wage Determination. 28 pp.
324. *Lars Calmfors*: Trade Unions, Wage Formation and Macroeconomic Stability. 32 pp.
325. *Henrik Horn and Torsten Persson*: Exchange Rate Policy, Wage Formation, and Credibility. 43 pp.