

## THE ADVANTAGE OF TYING ONE'S HANDS\*

### EMS Discipline and Central Bank Credibility

Francesco GIAVAZZI

*Universita' di Venezia and CEPR, 30123 Venice, Italy*

Marco PAGANO

*Universita' di Napoli and CEPR, 80138 Naples, Italy*

It is often argued that the EMS is an effective disciplinary device for inflation-prone countries in Europe, since it forces the respective policy-makers to pursue more restrictive monetary policies than they would otherwise. It is not clear, however, why these countries should submit themselves to such discipline. This paper argues that, to answer this question appropriately, one must consider that EMS membership brings potentially large credibility gains to policy-makers in inflation-prone countries: the reason is that not only it attaches an extra penalty to inflation (in terms of real appreciation), but makes the public aware that the policy-maker is faced with such penalty, and thus helps to overcome the inefficiency stemming from the public's mistrust of the authorities.

### 1. Introduction

So far, in the EMS experience, countries with above-average inflation have lost competitiveness relative to the low inflation countries of the system. This loss originates from two distinct factors. First, between successive realignments, excess inflation (combining with the fixity of the nominal exchange rate) results in a one-for-one appreciation of the real exchange rate. Second, at realignment dates, excess inflation countries obtain devaluations which are generally insufficient to make-up for the real appreciation experienced since the previous realignment.

If each realignment were to compensate high inflation countries for their entire real appreciation – i.e., if the first factor were to operate in isolation – their real exchange rate would fluctuate between realignments, but would exhibit no long-run trend (and, for an appropriate choice of the initial level, could in fact fluctuate around PPP). What the second factor instead does is to introduce a trend of real appreciation in the exchange rates of high inflation countries: for instance, between 1978 and 1986 Denmark and Italy

\*First draft October 1986; revised July 1987. We thank Franco Bruni, Alberto Giovannini, Guido Tabellini and the ISOM seminar participants for valuable comments. Financial support from Consiglio Nazionale delle Ricerche is gratefully acknowledged.

have experienced real appreciations relative to Germany of 9 and 11 percent respectively.<sup>1</sup>

The obvious question that arises is then: why should a high inflation country ever want to belong to an agreement such as the EMS? Credibility of central banks' commitments to low inflation is often advanced as the rationale for participation of these countries in the EMS:<sup>2</sup>

'The EMS is currently an arrangement for France and Italy to purchase a commitment to low inflation by accepting German monetary policy'. [Fischer (1987)].

Even perspective members of the EMS see the main advantage of membership as arising from gains in credibility:

'If sterling does join, the biggest change will be the transfer of responsibility for Britain's monetary policy from the Bank of England to Germany's Bundesbank which, as the central bank keenest on sound money, sets the pace for others to follow. This would be a blessing: Tory governments may like appointing City gents as governors of the Bank, but Mr. Karl Otto Poehl would do a better job'. (*The Economist*, September 21, 1985).

The argument behind these statements presumably runs as follows. The EMS countries where inflation is above-average are presumably those that have the highest incentive to use inflation surprises and the level of inflation as tools of monetary policy: the incentive to use inflation surprises is strong when the response of output and employment to unanticipated inflation is large, and when the government has a high outstanding stock of nominal liabilities; the incentive to produce a high level of inflation (even if perfectly anticipated) is strong when money demand is inelastic, and thus the potential revenue from the inflation tax is high.<sup>3</sup> However, when the monetary authority has an incentive to raise output and to reduce the value of the public debt via unanticipated inflation, the public will rationally discount such incentive in forming their forecast of inflation, so that the equilibrium has the two following features: (a) the policy-maker does not succeed in surprising the public systematically (and thereby permanently increase

<sup>1</sup>Real appreciation is measured in terms of relative unit labor costs, accounting for competition on third markets. Source: *EEC*.

<sup>2</sup>Thygesen (1979) makes the point that this incentive is what kept the European 'snake' together between 1972 and 1978.

<sup>3</sup>This incentive is particularly strong in countries like Italy, Spain, Portugal and Greece, where the ratio of base money to GDP is much higher than in the rest of Europe, despite the fact that these countries are also characterized by inflation rates above the European average [see Fischer (1982) for cross-country evidence on the revenue from seignorage].

employment and government revenue); (b) the expected, and actual, rate of inflation is higher than the inflation rate that would prevail if the policy-maker could credibly precommit.<sup>4</sup> In other words, the set of incentives is such that the result of the non-cooperative game between the monetary authority and the public is an excessively high equilibrium inflation rate. In this setup, if the monetary authority is able to reduce its incentive to produce inflation surprises, it will be able to induce the public to expect lower inflation, so that the solution to the game will get closer to the cooperative outcome.

Joining the EMS can be seen precisely as a way of changing the set of incentives faced by the monetary authority: as explained above, all inflation in excess of the EMS average translates into (possibly permanent) real exchange rate appreciation. This, by reducing the policy maker's incentive to inflate, leads to lower inflation in the non-cooperative equilibrium, and eliminates part of the inefficiency that arises from the lack of credibility of the monetary authority. The result parallels that in Rogoff [1985], who shows that the non-cooperative rate of inflation can be reduced 'through a system of rewards and punishments which alters the incentives of the central bank', for example by placing 'some direct weight on achieving a lower rate of growth for a nominal variable, such as the price level, nominal GNP or the money supply'. In the case of EMS membership the relevant nominal variable is the exchange rate, that the system constrains to zero growth except at realignments dates.

Below we offer a formal statement of this argument and we investigate the conditions under which the gains in credibility delivered by membership in the EMS outweigh the implied losses (choosing as benchmark an idealized flexible exchange rate system where the monetary authority cannot affect the real exchange rate). It should be stressed that the central issue is not whether the EMS is an effective *disciplinary* device for inflation-prone countries, but whether it is a *welfare-improving* arrangement from the viewpoint of the monetary authority of those countries. It is obvious that their inflation rate will be lower inside than outside the EMS – what is less obvious is whether, after paying the implied cost the monetary authorities will be better off, so that they will be happy to tie their hands. This is in fact the only guarantee that they will feel committed to the system – and, in turn, only if their commitment can be expected to last, the system will enhance their current credibility. This point – the welfare issue – is obviously the relevant one both for current members and for countries which are now weighing the costs and benefits of joining the EMS.

<sup>4</sup>The inefficiency associated with the incentive to create surprise inflation is discussed in Barro and Gordon (1983); see also Fischer (1986). Barro (1983) and Grossman and Van Huyck (1984) discuss the inefficiency that arises from the incentive to generate revenue from seignorage.

## 2. The basic model

Consider a country that produces two goods: one is sold at home; the other is exported. On the domestic market, prices are set with a fixed mark-up over wages, whereas on the foreign market firms are price-takers, so that, for given exchange rate and foreign prices, an increase in domestic wages reduces the profits of exporters (equivalently, one could assume that the country produces a single good and that firms are able to sell at different prices at home and abroad). Let  $\pi_t$  denote the rate of price inflation on the domestic market – by assumption equal to the rate of wage inflation. Let  $q_t$  be the (log of the) real exchange rate, defined as the price on foreign markets, in units of domestic currency, relative to the price of goods sold at home. Since we assume wages to be uniform across the economy, it is clear that the profitability of the exporting firms is an increasing function of  $q_t$  (i.e., it is raised by a real depreciation).

One of the concerns of the domestic policy-maker is the profitability of the export sector: we thus assume that the real exchange rate  $q_t$  enters with a positive weight in the authorities' objective function. On the other hand, the authorities have an incentive to create inflation surprises ( $\pi_t - \pi_t^e$ ) in order to reduce the product wage faced by firms selling to the home market, thereby raising their output.<sup>5</sup> The interaction between the monetary authority and the workers' unions therefore takes the form of a non-cooperative game (as for example in Fischer [1986]).<sup>6</sup> The new twist here is that the wage and domestic price inflation resulting from this interaction affects the profits of exporters (for a given nominal exchange rate); since the authorities care about the profitability of the export sector, their behaviour in the game with the union takes into account this side effect of domestic inflation.<sup>7</sup> Finally the authorities dislike price instability, and this is captured by a quadratic term in inflation ( $\pi_t^2$ ) in their objective function. This can thus be written as<sup>8</sup>

$$V = \int_0^{\infty} e^{-\rho t} [h q_t + c(\pi_t - \pi_t^e) - (a/2)\pi_t^2] dt, \quad h, a, c > 0, \quad (1)$$

<sup>5</sup>This incentive to raise domestic output can be motivated by the fact that distortions keeps its equilibrium level below the optimal level.

<sup>6</sup>In its simplest form this game can be described assuming that workers contract nominal wages before prices are set, according to  $w_t = p_t^e + \beta y_t$ , where the last term captures the sensitivity of wages to demand, and  $p_t^e$  is the expectation of domestic prices at the time the contract is signed. Domestic prices are set as a mark-up over wages ( $p_t = w_t$ ). Aggregate demand is simply  $y_t = m_t - p_t$ , neglecting the spillover effect from the profits of the exporting sector. In a rational expectations equilibrium  $y_t = (1/\beta)(p_t - p_t^e)$ , and  $p_t = (\beta m_t + p_t^e)/(1 + \beta)$ . The last equation shows how the moves of the two players interact in determining the price level in a non-cooperative (Nash) equilibrium: the union plays its expectation  $p_t^e = p_t$ ; the policy-maker plays the nominal money supply  $m_t$ , so as to maximize its objective function.

<sup>7</sup>An additional incentive to produce surprise inflation comes from the fact that inflation reduces the real value of the nominal liabilities issued by the government, thus replacing distortionary taxes with a non-distortionary capital levy.

<sup>8</sup>Most of the results in the paper do not depend upon the specific form of the objective function in eq. (1). See footnote 16.

where  $\rho$  is the authorities' rate of time preference. The objective function (1) neglects the constraints imposed upon the monetary authorities by the financial behaviour of the private sector in a system characterized by periodic exchange rate realignments. It is thus only consistent with an economy that operates prohibitive exchange controls. We analyze the case of perfect capital mobility in section 5.

In the EMS regime the (log of the) real exchange rate at time  $t$ ,  $q_t$ , is equal to the (log of the) real exchange rate established at the time of the last realignment minus the cumulated inflation differential. We shall suppose that: (i) the length between realignments is exogenously fixed at  $T$  periods;<sup>9</sup> (ii) at each realignment the real exchange rate is set back to a pre-assigned level  $q_0$ . The expression for  $q_t$  is thus

$$q_t = q_0 - \int_{kT}^t \pi_s ds, \quad t \in (kT, (k+1)T), \quad k = 1, 2, 3, \dots, \quad (2)$$

which can be substituted in eq. (1), yielding the following expression for the objective function:

$$V = \sum_{k=0}^{\infty} \int_{kT}^{(k+1)T} e^{-\rho t} [h(q_0 - \int_{kT}^t \pi_s ds) + c(\pi_t - \pi_t^e) - (a/2)\pi_t^2] dt. \quad (3)$$

The policy-maker's problem is to maximize  $V$ . His control variable is the rate of money creation, and thus inflation  $\pi_t$ ; the solution is an optimal rule for  $\pi_t$ , to be denoted  $\pi_t^*$ . For this rule to be time-consistent, the policy-maker must regard expected inflation  $\pi_t^e$  to be independent of its own actions, treating it as exogenous in the maximization problem [see Barro and Gordon (1983, pp. 595–596), and Cohen and Michel (1985, pp. 10–14)]. Clearly, in a rational expectations equilibrium,  $\pi_t^e = \pi_t$ , so that no gain will accrue to the government from unanticipated inflation. The authorities' incentive to create surprises is thus merely a source of inefficiency, and it is precisely this inefficiency that EMS membership is supposed to correct.

The time interval between realignments,  $T$ , and the initial level of the real exchange rate,  $q_0$ , are also outside the control of the domestic policy-maker: they are parameters of the EMS regime. However, we shall see below that if the country's membership in the EMS is to be sustainable in the long run these two parameters cannot be chosen independently from each other. (The issue of sustainability is extensively dealt with in section 3.) For the time being, let us assume that  $q_0$  is equal to zero, i.e., that at each realignment the exchange rate is set back to PPP.

<sup>9</sup>See Giavazzi and Pagano (1985) for a model where realignment dates are endogenously determined.

Maximization of (3) yields the following path for inflation:<sup>10</sup>

$$\pi_t^* = (1/a) \left[ c - \frac{h}{\rho} (1 - e^{-\rho(T-t)}) \right] \quad \text{for } t \in (0, T). \quad (4)$$

Eq. (4) immediately brings out the fact that the optimal inflation path has precisely the same shape between any two realignments: inflation rises monotonically from the date following one realignment until the date of the next, when it reaches its maximum – before falling once again, back to the initial level. Thus, over an extended period of time, inflation displays a saw-tooth pattern. The reason why it rises smoothly between realignments is that it is best to concentrate inflation at the end of the interval, so as to carry over for a shorter period the implied loss of competitiveness. The slope of the time-profile of inflation is steeper the smaller is  $\rho$ , and flattens out for  $\rho \rightarrow \infty$ , as the authorities give less and less weight to the effect of current inflation on the future level of competitiveness.

The optimal level of inflation, on the other hand, is decreasing in  $T$ , the length of the interval between realignments, since more infrequent opportunities to devalue increase the time period for which a given increase in inflation remains embodied in the real exchange rate, and thus reinforce the disciplinary role of the system. Moreover, as  $T$  increases, the profile of inflation between realignments flattens out, and for  $T \rightarrow \infty$  it settles at a constant value (to be denoted  $\pi_\infty^*$  hereafter). The role of the other parameters of the problem also accords with intuition: inflation is increasing in  $c$  (the incentive to produce inflation surprises); it is decreasing in  $h$  (the marginal value of a real depreciation) and in  $a$  (the marginal cost of price instability).

What would inflation be if the country were not a member of the EMS? The answer to this question depends on what the exchange rate regime would be outside the EMS. We assume that the alternative is an idealized system of flexible exchange rates in which the real exchange rate cannot be systematically affected by domestic monetary policy, and PPP continuously prevails. Incidentally, this is giving more than a fair chance to flexible rates in the welfare comparison with the EMS, since it overlooks what many people regard as one of the main drawbacks of flexible rates – namely the experience of large and unpredictable fluctuations in real exchange rates stemming from ‘overshooting’ or speculative bubbles in the behaviour of nominal exchange rates.

Thus, to derive the optimal inflation path in the alternative regime we solve the policy-maker’s problem under the assumption that  $q_t$  is exogenous.

<sup>10</sup>Differentiation of the objective function makes use of the fact that

$$d\pi_t^d \int_0^T \pi_s ds e^{-\rho t} dt = \int_t^T e^{-\rho s} ds = (1/\rho)(e^{-\rho t} - e^{-\rho T}).$$

The result is the constant inflation rate:

$$\tilde{\pi}_t^* = c/a, \tag{5}$$

where the twiddle ( $\tilde{\phantom{x}}$ ) denotes values associated with the flexible exchange rate regime. Clearly  $\pi_t^* < \tilde{\pi}_t^*$ , for all  $t < T$ , and  $\pi_T^* = \tilde{\pi}_T^*$ : inflation is always lower in the EMS regime, except at realignments dates – when it reaches the same level that would prevail under flexible rates. The average inflation rate is thus strictly smaller when the country belongs to the EMS, witness to the fact that the system's discipline is effective.

The result  $\pi_t^* \leq \tilde{\pi}_t^*$  is quite obvious; what is less intuitive is whether participation to the EMS is also superior from a normative standpoint. To perform this comparison, we need to compute the difference between the equilibrium value of the policy-maker's welfare inside the EMS ( $V^*$ ) and outside the EMS ( $\tilde{V}^*$ ), respectively, substituting the inflation rates computed in (4) and in (5) in the objective function. The equilibrium welfare in the flexible rates regime is  $\tilde{V}^* = -c^2/2a\rho$ : it is a decreasing function of  $(c/a)$ , the incentive to generate unanticipated inflation, relative to the cost of inflation, because in a time-consistent equilibrium that incentive is perfectly understood and acted upon by the public, and therefore is only a source of inefficiency. As shown in the appendix, the difference between the equilibrium welfare in the two regimes,  $V^* - \tilde{V}^*$ , is

$$\Delta = V^* - \tilde{V}^* = \frac{h^2}{a\rho^3} \left[ (1/2)(1 - e^{-\rho T}) - \frac{\rho T e^{-\rho T}}{1 - e^{-\rho T}} \right]. \tag{6}$$

$\Delta$  measures the discounted welfare gain of EMS membership. For  $T \rightarrow 0$  the EMS regime coincides with flexible rates so that  $\Delta$  vanishes. We show in the appendix that  $\Delta$  is positive, uniformly increasing in  $T$ , and has a finite asymptote

$$\lim_{T \rightarrow \infty} \Delta = \frac{a}{2\rho} (\pi_\infty^* - \tilde{\pi}^*)^2 = \frac{1}{2a\rho} (h/\rho)^2, \quad \text{where}$$

$$\pi_\infty^* = \lim_{T \rightarrow \infty} \pi_T^* = \frac{1}{a} (c - h/\rho).$$

Thus, as  $T$  becomes large, and the discipline imposed by the system tightens, the welfare gain increases. The lowest possible level of the inflation rate in the EMS regime is  $\pi_\infty^*$ , which obtains when  $T \rightarrow \infty$  and the EMS regime coincides with fixed exchange rates; the reduction in inflation ( $\tilde{\pi}^* - \pi_\infty^*$ ) is then equal to a constant,  $h/a\rho$ , and the welfare gain from EMS membership

(that is then at its maximum) is simply proportional to the square of the reduction in inflation.

The intuition for this result runs as follows. In this economy inflation is only a source of inefficiency. By attaching an extra penalty to inflation, the EMS reduces the incentive to inflate; since this disincentive scheme is public knowledge, a low inflation policy will be credible, and the EMS will partly overcome the inefficiency deriving from the public's mistrust for the authorities. Moreover, as  $T$  increases, the incremental efficiency gain exceeds the corresponding cost, so that the appeal of EMS membership increases the less frequently the country is allowed to realign its parity with the EMS average.

A difficulty is that the penalty that the system attaches to inflation makes the EMS regime unsustainable in the long-run: the credibility gains stemming from indefinite membership are thus not really available. The reason is that our assumption that  $q_0=0$  implies that the real exchange rate fluctuates *below* PPP: it is set back at PPP at each realignment, and gradually falls between one realignment and the next, thus shifting domestic demand towards foreign goods and worsening the trade balance: with no capital mobility, foreign exchange reserves will be gradually depleted (or an unbounded stock of foreign debt accumulated). Eventually the country will have to drop out of the system.<sup>11</sup> There are two ways to deal with this problem: the first is to allow the real exchange rate to fluctuate *around* PPP, rather than *below* PPP, thus making the system sustainable in the long run; the second is to ask whether, if *permanent* membership is ruled out, *temporary* membership can still yield a benefit.

### 3. Welfare gains from permanent EMS membership

The way to make EMS membership sustainable in the long run is to design the system so that the real exchange rate fluctuates around PPP, rather than below PPP. This implies granting high-inflation countries a sufficiently large real depreciation at each realignment, so that they will initially run trade surpluses large enough as to compensate subsequent deficits.<sup>12</sup> If we assume that the trade balance (and thus the change in reserves) is a linear function of the (log of the) real exchange rate, the sustainability condition imposes the following relationship between  $q_0$  and  $T$ :<sup>13</sup>

<sup>11</sup>The welfare gain  $\Delta$  should thus be computed over a finite horizon, rather than over an infinite horizon, as in eq. (6).

<sup>12</sup>We overlook the complications that arise from any lag in the response of the trade balance to changes in the real exchange rate.

<sup>13</sup>In the absence of capital mobility, we assume that the current account is identically equal to the trade balance. We also assume that the latter is a linear function of the real exchange rate,  $q_t$ , and that the authorities' rate of time preference,  $\rho$ , equals the fixed rate of interest at which the central bank can borrow or lend in the world financial market. The accumulation of foreign reserves,  $R$ , is therefore described by  $\dot{R}_t = \rho R_t - CA_t = \rho R_t - \alpha q_t$ , and the path of foreign reserves is  $R_t = R_0 e^{\rho t} + e^{\rho t} \int_0^t e^{-\rho s} (-\alpha q(s)) ds$ . Assuming  $R_0 = 0$ , the condition for the stock of reserves to go back to zero at each realignment is  $R_T = e^{\rho T} \int_0^T e^{-\rho s} R_s ds = 0$ .

$$q_0^* = (1/T) \int_0^T \int_0^t \pi_s^* ds dt, \quad (7)$$

i.e., on the date of the realignment the real exchange must be above PPP by an amount exactly equal the average loss of competitiveness that the country incurs between one realignment and the next.

It is apparent from (7) that the competitiveness 'bonus' granted to the country at each realignment is an increasing function of the level of inflation at each point in time. If the policy-maker could exploit the sustainability condition (7) in choosing the optimal path  $\pi_t^*$ , any credibility gain arising from membership in the EMS would vanish, since he could set  $q_0$  high enough as to cancel, on average, all losses due to real appreciation.<sup>14</sup> Thus, a crucial condition for EMS membership to be sustainable and still yield credibility gains is that the policy-maker does not regard the choice of  $q_0$  as something he can affect. This, for example, could be enforced by letting the country know that  $q_0$  will not be changed if it deviates from the path  $\pi_t^*$  chosen assuming  $q_0$  exogenous, i.e., the path shown in eq. (4). For that inflation path, and with  $q_0^*$  given by eq. (7), the welfare gain from permanent membership is equal to

$$\Delta' = (h/\rho)q_0^* + \Delta, \quad (6')$$

where  $\Delta$  is the gain calculated assuming  $q_0=0$  and shown in eq. (6) above.  $\Delta'$  is higher than  $\Delta$  because the country is now granted a competitiveness 'bonus' at each realignment. For  $c > h/\rho$ , i.e., when the policy-maker's incentive to create inflation surprises exceeds the discounted penalty, the EMS regime is unambiguously superior.<sup>15</sup> The welfare gain is still uniformly increasing in  $T$  and has a finite asymptote

$$\lim_{T \rightarrow \infty} \Delta' = \lim_{T \rightarrow \infty} \Delta + \frac{h}{a\rho^2}(c - h/\rho),$$

where the second term is the discounted value of the initial competitiveness bonus - because  $\lim_{T \rightarrow \infty} q_0^* = (1/a\rho)(c - h/\rho)$ .

If however the discounted penalty exceeds the incentive to create inflation surprises ( $c < h/\rho$ ), the EMS regime is no longer unambiguously superior. In particular, for  $c < h/2\rho$  the EMS regime is inferior to flexible rates for all  $T$ ;

<sup>14</sup>One can see this by substituting the value of  $q_0^*$  from eq. (7) into the objective function (3), thus assuming that the policy-maker is able to exploit the relationship between  $q_0^*$  and  $T$ . For the value of  $q_0^*$  given by (7)  $\int_0^T e^{-\rho t}(q_0^* - \int_0^t \pi_s ds) dt = 0$  and the real exchange rate drops out of the objective function. Any disciplinary effect arising from membership in the EMS vanishes because the real exchange rate is independent of the actions of the domestic policy-maker.

<sup>15</sup>The discount factor appears in this comparison because an inflationary impulse translates into a temporary increase in government revenue but into a lasting loss of competitiveness.

for  $(h/2\rho) < c < h/\rho$  the EMS regime is superior only if its discipline is sufficiently strict – i.e., if  $T$  is sufficiently large. (The different cases are summarized in fig. 1; derivations are shown in the appendix.) Equilibrium inflation is increasing in  $(c-h/\rho)$ , that describes the incentive to produce inflation in the EMS (net of the discounted penalty). As the net incentive becomes smaller, the equilibrium level of inflation falls. But with lower inflation, the competitiveness bonus that the country must be granted at each realignment is also smaller. This reduces welfare.<sup>16</sup>

3.1. *Seignorage as a further incentive to inflate*

The temptation to reduce the real value of its nominal liabilities creating inflation surprises is not the only incentive that a government has to produce inflation: even perfectly anticipated inflation yields a benefit generating a revenue from seignorage. It is often argued, in this respect, that EMS membership, by raising the cost of inflation, and thereby reducing the equilibrium level of inflation, is not beneficial for a government that needs to

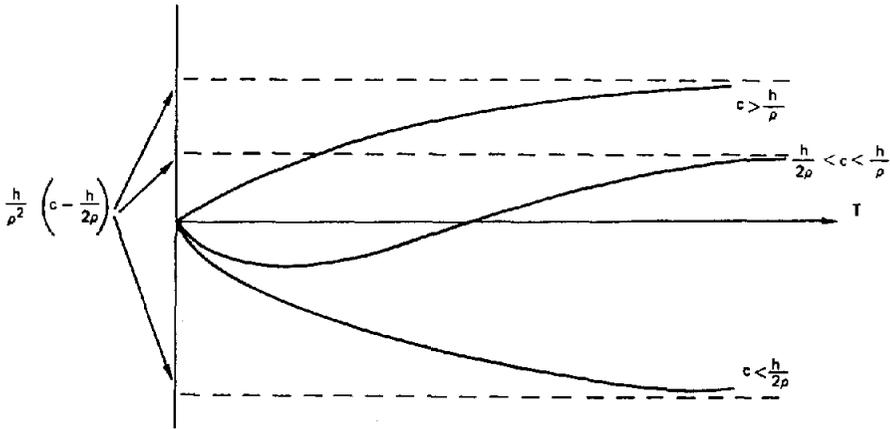


Fig. 1. Welfare gain from permanent EMS membership.

<sup>16</sup>Consider for example the limiting case as  $T \rightarrow \infty$ . In this case, as we have seen, the optimal inflation path is the constant inflation rate  $\pi_{\infty}^* = (c - h/\rho)/a$ . If the discounted cost of a real appreciation is higher than the incentive to generate unanticipated inflation ( $c < h/\rho$ ), the optimal inflation rate is negative. Sustainability now requires that the country starts off with a real appreciation equal to  $(1/a\rho)|c - h/\rho|$ . Rather than a competitiveness bonus, sustainability now requires that the country starts off with a penalty. If the cost associated with this penalty exceeds the benefit that arises from the reduction in the inflation inefficiency, the EMS regime may be inferior to flexible rates; the condition is  $(h/\rho^2)|c - h/\rho| > h^2/(2a\rho^3)$ , or  $c < h/2\rho$ . A similar argument applies for  $T$  finite. The particular form of the objective function – linear in  $q_t$  – may be responsible for this ambiguity. Giavazzi and Giovannini (1987) using an objective function quadratic in  $q_t$  show that for small values of  $T$  a sustainable EMS regime is unambiguously superior.

tap the inflation tax. We investigate this issue by adding a linear term in inflation to the instantaneous objective function of the government

$$V' = \int_0^{\infty} e^{-\rho t} [h q_t + c(\pi_t - \pi_t^e) - (a/2)\pi_t^2 + b\pi_t] dt, \quad b > 0, \quad (1')$$

where the term  $b\pi_t$  describes the authorities' incentive to collect revenue from seignorage. Maximization of (1') now yields the following path for inflation:

$$\pi_t^{*'} = \pi_t^* + \frac{b}{a} \quad \text{for } t \in (0, T), \quad (4')$$

where  $\pi_t^*$  is the optimal inflation rate when  $b=0$ , shown in eq. (4). The shape of the inflation path between realignments remains unchanged, relative to the case when  $b=0$ , but at each point in time the level of inflation is higher by an amount equal to the value that the central bank attaches to seignorage, relative to the cost of inflation.

Assuming that  $q_0$  is again chosen so as to allow the country to remain in the system in the long run, the welfare gain from *permanent* membership is now

$$\Delta'' = (h/\rho)q_0^{*'} + \Delta - (hb/a\rho^2)[1 - \rho T/(1 - e^{-\rho T})], \quad (6'')$$

where  $\Delta$  is the welfare gain computed assuming  $q_0=0$  and  $b=0$ , shown in eq. (6), and  $q_0^{*'}$  is the level of  $q_0$  which guarantees that the EMS regime is sustainable, now equal to

$$q_0^{*' } = q_0^* + (b/a\rho)[1 - \rho T/(1 - e^{-\rho T})]. \quad (7')$$

One can see immediately that substituting  $q_0^{*'}$  in (6'') all terms in  $b$  cancel out and  $\Delta'' = \Delta'$ : the welfare gain is identical to that which obtains when seignorage has no value in the government's objective function. The reason is that the value of the seignorage loss [arising from the fact inflation is lower inside than outside the EMS, and appearing as the last term in eq. (6'')] is exactly compensated by a higher value of the competitiveness bonus that the country must be granted at each realignment to sustain its permanent membership.<sup>17, 18</sup>

<sup>17</sup>In (1') we overlook the fact that the revenue from seignorage is really a non-linear function of  $\pi_t$ : the linear term is an approximation to the rising portion of the revenue schedule. If non-linearity were important, it could easily be accommodated in the analysis by approximating the revenue function with a linear-quadratic form in  $\pi_t$ ; this would simply increase the coefficient ( $a$ ) on  $\pi_t^2$  in (1'). Since all welfare comparisons are proportional to  $(1/a)$ , this would reduce  $\Delta''$ : the condition for the EMS to be a superior regime remains unaffected, but the size of the welfare gain is uniformly lower.

<sup>18</sup>This is most clearly seen considering again the limiting case as  $T \rightarrow \infty$ . In this case  $\Delta'' = (h\rho_{\infty}/\rho^2) + (1/2\rho)(\Delta\pi)^2 - (b/\rho)\Delta\pi = (1/a\rho)[(h/\rho)(c + b - h/\rho) + (h^2/2a\rho^2) - (hb/\rho)]$ , where and

### 3.2. Permanent membership: Summing up

We conclude this section summing up the two main points that have been made: (i) the first is that an EMS designed to be sustainable in the long run, not only is an effective disciplinary device – in the sense that it keeps inflation lower than in a regime of flexible exchange rates – but may also be a welfare improving device. To improve welfare, however, the system must satisfy two conditions: (a) the competitiveness ‘bonus’ that the country must be granted at each realignment, and which is necessary to make the system sustainable, must be kept outside the control of the domestic monetary authorities – otherwise all credibility gains vanish; (b) the central bank’s incentive to produce inflation surprises, net of the discounted cost of real appreciation, must be relatively high; (ii) if the EMS regime is designed to be sustainable in the long run, the welfare comparison with flexible exchange rates is unaffected by the incentive to produce a high anticipated level of inflation.

### 4. Temporary EMS membership

As we have shown in the last section, sustainability requires that the real exchange rate fluctuates around PPP. This conclusion, however, is at odds with the EMS experience so far: as a matter of fact EMS members with above-average inflation have never succeeded in securing realignments so large as to bring their real exchange rate above PPP [see, e.g., Collins (1987)] and it may well be that the system, as currently designed, is not indefinitely sustainable. In principle, however, it could still be the case that *temporary* participation to the EMS makes excess-inflation countries better off.

To check this conjecture, we now assume that each realignment brings back to PPP, so that  $q_0=0$ , and let  $T\bar{K}$  be the length of time for which the EMS regime can be sustained:  $T\bar{K}$  could correspond to the time when foreign exchange reserve vanish, or when the central bank thinks it cannot cumulate more foreign debt. We assume that at time  $T\bar{K}$  the authorities abandon the EMS and return to flexible rates: provided that their decision is public knowledge, at time  $T\bar{K}$  the economy moves from a time-consistent equilibrium where the inflation rate is given by eq. (4), to a different time-consistent equilibrium where the inflation rate is equal to  $c/a$ .<sup>19</sup> Temporary

$\Delta\pi = (\bar{\pi}^* - \pi_0^*) = h/ap$  is the difference between the equilibrium inflation rate outside and inside the EMS. The last term on the right-hand-side of the expression for  $\Delta$  is the discounted value of the seignorage loss; the first term is the discounted value of the competitiveness bonus. The value of the seignorage loss is exactly compensated by the competitiveness bonus.

<sup>19</sup>Notice that we rule out the possibility that at any time before  $T\bar{K}$  (say, towards the end, right before  $T\bar{K}$ ) the central bank may suddenly decide – with a *surprise* move – to abandon the EMS, inflating wildly without having to bear the competitiveness cost of the this decision. Allowing for such a possibility would add a new dimension to the time-consistency problem faced by the central bank. The reason for ruling it out is that the decision to abandon the EMS cannot be treated on the same grounds as the decision to change the money supply: it is unlikely that the government could abandon the EMS with a surprise move.

membership in an EMS regime that would be unsustainable in the long run may thus be beneficial so long as the country remains in the system. What is crucial for temporary membership to yield credibility is that the authorities' commitment to stay in the system for  $T\bar{K}$  periods is credible. It will be credible if the decision to join the system for  $T\bar{K}$  periods improves the authorities' welfare function.

Assuming  $q_0=0$  and EMS membership for  $\bar{K}$  periods, the welfare gain relative to flexible rates is

$$\Delta(\bar{K}) = (1 - \exp(-\rho T\bar{K}))\Delta, \quad (7)$$

where  $\Delta$  is the gain calculated over an infinite horizon, assuming  $q_0=0$ , and shown in eq. (6).  $\Delta(\bar{K})$  is a monotone transformation of  $\Delta$ : it is thus always positive, provided of course that the country can afford to stay in the system at least for one interval of length  $T$ . Thus, despite the fact that EMS membership now implies a real appreciation, temporary participation in the system may still be beneficial.

It could be objected that this conclusion overlooks the fact that in this case the country pays an additional cost in terms of the foreign exchange reserves that it burns throughout the period of membership in the system. This, however, can easily be captured by the analysis, assuming that the cost of burning foreign exchange reserves raises the value of  $h$ , the shadow cost of a real appreciation (having assumed that the trade balance is a linear function of the real exchange rate, the loss of foreign exchange reserves is also linearly related to the real exchange rate). It will be recalled that  $\Delta$  is increasing in  $h$ : thus also  $\Delta(\bar{K})$ , the welfare gain from temporary membership is higher, if  $h$  is larger. Therefore, the fact that now a real appreciation not only lowers output, but also burns foreign exchange reserves, increases (rather than lowering) the attraction of EMS membership: the higher the penalty attached to inflation, the more effective is the system at correcting the inflation inefficiency.<sup>20</sup>

#### 4.1. *Persistent real appreciation as a further disincentive to inflate*

Above we have assumed that, at each realignment, excess-inflation countries are granted devaluations that bring them back to the same level of the real exchange rate ( $q_0$ , that in particular we have assumed to be the PPP level  $q_0=0$  in the previous paragraph). What happens if instead they are granted devaluations which are *insufficient* to make up for the entire loss of competitiveness cumulated since the previous realignment? Essentially, at each realignment they move to a lower value of  $q_0$  and their real exchange

<sup>20</sup>Notice that while in the sustainable case the welfare gain depends on the difference between the efficiency gain and the penalty paid to secure that gain, here a higher penalty unambiguously improves welfare. The reason is that here, as in the basic model of sec. 2,  $q_0$  is unaffected by the equilibrium path of inflation, and thus by the penalty attached to inflation.

rate, rather than fluctuating around a stable level (as in all the cases studied so far) fluctuates around a trend of real appreciation. As mentioned in the introduction, there are reasons to believe that this is a closer approximation to how realignments actually take place in the EMS.

To study the effects of persistent real appreciation, we introduce a single additional feature in the model: we assume that at each realignment countries with excess inflation are only allowed to devalue their nominal exchange rate by a proportion  $1-\lambda$  of the competitiveness they have lost since the previous realignment. In other words, a proportion  $\lambda$  of the cumulated inflation differential intervened between any two successive realignments remains embodied in the level of the real exchange rate so long as the country remains in the system. This apparently small change in assumptions alters the formal structure of the model considerably, since now the policy-maker will have to consider that a proportion  $\lambda$  of the competitiveness lost at each date is going to be lost forever: intervals between successive realignments are thus no longer independent in the maximization problem.

The policy-maker's instantaneous objective function remains that described in eq. (1). The difference is rather the real-exchange-rate-term that now becomes

$$\int_0^{T\bar{K}} e^{-\rho t} q_t dt = \sum_{k=0}^{\bar{K}} \int_{kT}^{(k+1)T} \left( q_0 - \int_{kT}^t \pi_s ds \right) e^{-\rho t} dt - \lambda \sum_{k=1}^{\bar{K}} \int_{kT}^{(k+1)T} e^{-\rho t} \int_0^{kT} \pi_s ds dt. \quad (8)$$

$T\bar{K}$  is the horizon of the policy-maker and corresponds to the time beyond which EMS membership is no longer sustainable. The last term in (8) represents the memory of the system, i.e., the discounted loss associated with the portion of real appreciation that the country is never allowed to recover (in fact it vanishes for  $\lambda=0$ ).

To keep things simple, and without loss of generality, assume that the system can only be sustained for two periods (i.e.,  $\bar{K}=2$ ). The optimal inflation path is

$$\begin{aligned} \pi_t^{**} &= \pi_t^*, & T \leq t \leq 2T \\ &= \pi_t^* - (\lambda h / \alpha \rho) e^{-\rho(T-t)} (1 - e^{-\rho T}), & 0 \leq t \leq T, \end{aligned} \quad (4'')$$

where  $\pi_t^*$  is the optimal inflation path when the real exchange rate has no trend, as shown in eq. (4). The optimal inflation path no longer has the same

shape between any two realignments: as time goes by, and the date when the system will have to be abandoned approaches, the average inflation rate rises, since the implied losses of competitiveness will have to be borne for a shorter period of time. The welfare gain relative to the flexible exchange rate regime, computed over the horizon  $0 \leq t \leq 2T$ , is now

$$\Delta(\bar{K}=2, \lambda > 0) = \Delta(\bar{K}=2) + (\lambda h^2 / a \rho^3) e^{-\rho T} (1 - e^{-\rho T}) [\rho T - (1 - e^{-\rho T}) + (\lambda/2)(1 - e^{-\rho T})^2], \quad (7')$$

where  $\Delta(\bar{K}=2)$  is the welfare gain when the real exchange rate reverts to PPP at each realignment, i.e., the expression in eq. (7), calculated over two periods. For  $\lambda > 0$ ,  $\Delta(\bar{K}=2, \lambda > 0) > \Delta(\bar{K}=2)$ : the penalty of persistent real appreciation raises the cost of inflation and unambiguously improves welfare.<sup>21</sup>

#### 4.2. Temporary membership: Summing up

The examples discussed in this section suggest that even when EMS membership is unsustainable in the long run, it may still yield temporary benefits. So long as the country can afford to stay in the system the authorities' welfare function improves. Their commitment to temporary membership is thus credible.

### 5. Credibility gains in an EMS without capital controls

Up to this point we have assumed that prohibitive capital controls insulate the domestic financial market from the international financial market. This assumption is not inconsistent with the facts: the two largest excess-inflation-countries in the EMS – France and Italy – have operated strict exchange controls for many years; among the small countries, Belgium has a dual exchange market that also serves the purpose of separating the domestic from the international financial market.

Capital controls have played an important role in the EMS: in fact the very success of the system is often attributed to the presence of exchange controls in countries where inflation is above the European average. The argument is that a regime of fixed but adjustable parities is bound to collapse under the impact of speculative attacks on central bank reserves in the anticipation of a realignment, unless the volume of speculative capital flows is limited by exchange controls [see, e.g., Wyplosz (1985)]. This argument however overestimates the need for exchange controls because it overlooks the role of interest rate differentials as an equilibrating mechanism

<sup>21</sup>Notice that the term in square brackets on the right-hand-side is always positive because  $(-1 + \rho T + \exp(-\rho T))$  tends to  $1/2$  for  $T \rightarrow 0$  and to  $+\infty$  for  $T \rightarrow \infty$ .

in the wake of a parity realignment. If the central bank does not attempt to peg domestic interest rates, these will move so as to compensate holders of interest-bearing assets for the anticipated capital loss (or gain) arising from a prospective realignment. The adjustment of domestic interest rates strongly dampens the speculative attack, and can make a system of fixed exchange rates with periodic realignments viable even in the absence of capital controls.<sup>22</sup> The resulting fluctuation of domestic interest rates may however be very large, so that any gain from free capital mobility should be weighed against the costs associated with the higher volatility of interest rates. The higher volatility, however, is concentrated on short rates, and tends to die-out as the maturity of the asset lengthens – the obvious reason being that long rates are less affected than short rates by a realignment of given magnitude. The costs of free capital mobility, in a system such as the EMS, are thus really the costs associated with a high volatility of short term interest rates.<sup>23</sup> There are good reasons why monetary authorities should worry about the volatility of short term rates. For example, in countries – such as Italy – where public debt is high and the liabilities of the government are mostly short term bills, an increase in the volatility of short term rates induces fluctuations in the budget deficit, and these, presumably, are undesirable.<sup>24</sup>

In this section we investigate whether, in the absence of exchange controls, the EMS may still yield credibility gains that exceed the cost of membership. We modify the basic model developed in section 2 in two ways: (i) domestic nominal rates are now linked to interest rates on the international financial market through the condition of uncovered interest rate parity; (ii) the policy-maker assigns a negative weight also to the volatility of nominal interest rates.<sup>25</sup> The objective function becomes:

<sup>22</sup>The adjustment of domestic interest rates eliminates the possibility of an unbounded speculative attack: this is thus confined to the size of the monetary base. Since the domestic interest rate on deposits of instantaneous maturity shoots up to  $\infty$  at the moment of a (perfectly anticipated) realignment, one could suppose that at that time money demand falls to zero, thus depleting all central bank reserves. In reality however, there exist no assets of instantaneous maturity, so that interest rates remain unbounded. Furthermore, the transaction motive suggests that money demand remains positive even for very high values of the rate of interest.

<sup>23</sup>Giavazzi and Pagano (1985) compare the variability of 3-month 'on-shore' and 'off-shore' interest rates in France and Italy over the period November 1980–August 1984. We find that in both countries capital controls have significantly reduced the variability of domestic rates: from (a standard deviation of) 5.2 to 0.5 in France; from 4.8 to 1.8 in Italy.

<sup>24</sup>Another reason why fluctuations in short term rates may be undesirable is an optimal tax argument: in a model where agents derive utility from holding money balances, the optimal level of the opportunity cost of holding money is zero. In the presence of taxes, however, the marginal cost of holding money has to equal the social marginal benefit of the revenue from seignorage: in this case the optimal level of the opportunity cost of holding money is positive. Moreover, the solution to the optimal tax problem requires that this opportunity cost be smooth over time: large fluctuations of short term nominal rates are thus sub-optimal.

<sup>25</sup>As discussed above, there are good reasons why the government may care about the volatility of *nominal* interest rates. The volatility of nominal rates is here also an approximation

$$V' = \int_0^T e^{-\rho t} [h q_t + c(\pi_t - \pi_t^e) - (a/2)\pi_t^2 - (f/2)(\bar{i}_t^* - i_t^*)^2] dt, \quad (9)$$

with  $f > 0$  and  $q_t$  defined as in eq. (2).  $i_t^*$  is the interest rate on a deposit issued at time  $t$  and that will mature at time  $t + \tau$ ;  $\bar{i}_t^*$  is the mean of  $i_t^*$  over an interval of length  $T$ . We treat  $\tau$  as a parameter of the problem because the welfare gain depends on the value of  $\tau$ , i.e., on the maturity of the asset that the authorities care about.<sup>26</sup> We assume that the foreign nominal interest rate on deposits of maturity  $\tau$  is fixed and equal to zero for convenience; realignments take place every  $T$  periods, and bring the real exchange rate back to PPP (we thus concentrate on the case where the real exchange rate fluctuates below PPP, with no long run trend, i.e.,  $q_0 = 0$ ). The path of domestic interest rates is given by

$$\begin{aligned} \bar{i}_t^* &= 0, & 0 \leq t \leq T - \tau \\ &= \tau^{-1} \int_0^T \pi(t) dt, & T - \tau \leq t \leq T. \end{aligned} \quad (10)$$

The nominal interest rate is zero on all deposits maturing before the date of the realignment because we assume interest rates to be zero abroad; it jumps to compensate for the capital loss incurred on the day of the realignment at time  $T - \tau$ , and stays at that level until the realignment date, when it goes back to zero. The same path repeats in between any two successive realignments. Notice that  $\bar{i}^* = (1/T) \int_0^T \pi(s) ds$ , so that the average *real* rate of interest is zero and is unaffected by the fluctuations of the nominal rate.

The optimal inflation path is now

$$\hat{\pi}_t^* = \pi_t^* - (f/\rho)(1/\tau - 1/T)^2 e^{-\rho(T-t)} (e^{\rho\tau} - 1) \left( \int_0^T \hat{\pi}_t^* dt \right), \quad (11)$$

where  $\pi_t^*$  is the inflation path reported in eq. (4). The welfare gain *relative to an EMS with capital controls* (assuming  $q_0 = 0$  in both cases) is (see appendix for derivation):

$$(e^{\rho\tau} - 1)(1/\tau - 1/T)^2 F(T) > 0 \quad \text{for all } T, \quad (12)$$

---

to the volatility of real rates because, in between realignments, nominal interest rates fluctuate much more than the rate of inflation.

<sup>26</sup>In writing eq. (9) we also implicitly assume that the interest rate elasticity of money demand is zero, and that output demand does not respond to fluctuations in interest rates. These assumptions seem reasonable in view of the fact that the interest rate fluctuations we are considering are short-run phenomena, concentrated around realignment dates.

The expression (12) is positive: thus, in this setup, the assumption of perfect mobility improves welfare in the EMS regime. The welfare improvement is *decreasing* in  $\tau$ , the maturity of the deposits whose interest rate enters the objective function. The intuition for the latter result is that for a given path of inflation the volatility of interest rates is increasing in  $1/\tau$  and is unbounded for  $\tau \rightarrow 0$  (the interest rate on an asset of instantaneous maturity shoots up to infinity at the date of realignment, if we suppose that this is perfectly anticipated, as we do here). Since now the policy-maker is also concerned about the volatility of interest rates, he will have to be all the more cautious about generating inflation, the more he cares about short-term (as opposed to long-term) rates: higher inflation translates into a larger devaluation at the time of the following realignment, and this will then require a larger rise in interest rates, particularly towards the short-end of the maturity structure. This is why the shorter the maturity  $\tau$ , the lower the equilibrium path of inflation, and the larger the credibility and the welfare gain relative to the flexible rate regime.

## Appendix

### 1. Derivation of $\Delta$ , $\Delta'$ and $\Delta''$ (eqs. (6), (6') and (6'') in the text)

The value of the objective function [eq. (3) in the text] along the optimal path in the EMS regime is

$$V^* = \sum_{k=0}^{\infty} e^{-\rho T k} \left\{ \int_0^T \left[ h q_0 - h \int_0^t \frac{1}{a} [c - (h/\rho) + (h/\rho)e^{-\rho(T-s)}] ds - \frac{1}{2a} [c - (h/\rho) + (h/\rho)e^{-\rho(T-t)}]^2 \right] dt \right\}, \quad (\text{A.1})$$

which, noticing that  $\sum_{k=0}^{\infty} e^{-\rho T k} = (1 - e^{-\rho T})^{-1}$ , can be written as

$$V^* = (1/\rho) \left[ h q_0 - \frac{c^2}{2a} + \frac{h^2}{a\rho^2} \left[ \frac{1}{2} - e^{-\rho T} \left( \frac{\rho T}{1 - e^{-\rho T}} - \frac{1}{2} \right) \right] \right]. \quad (\text{A.2})$$

The correspondence expression in the flexible exchange rates regime is instead simply

$$\bar{V}^* = -\frac{c^2}{2a} \int_0^{\infty} e^{-\rho t} dt = -\frac{c^2}{2a\rho}. \quad (\text{A.3})$$

For  $q_0 = 0$  the differences  $V^* - \bar{V}^*$  yields the value  $\Delta$  reported in eq. (6). At the limits, when the EMS regime coincides with fixed and flexible exchange

rates respectively, we have

$$\lim_{T \rightarrow \infty} \Delta = \frac{h^2}{2a\rho^3} \quad \text{and} \quad \lim_{T \rightarrow 0} \Delta = 0.$$

$\Delta$  is uniformly increasing in  $T$ , as can be seen noticing that

$$\frac{\partial \Delta}{\partial T} = -\frac{h^2}{a\rho^2} e^{-\rho T} \left[ \frac{1}{2} + \frac{1 - e^{-\rho T} - \rho T}{(1 - e^{-\rho T})^2} \right], \quad (\text{A.4})$$

where the last term inside the square brackets  $(1 - e^{-\rho T} - \rho T)/(1 - e^{-\rho T})^2$  tends to  $-(1/2)$  for  $T \rightarrow 0$ , and to  $-\infty$  for  $T \rightarrow \infty$ .

For  $0 < T < \infty$ , this term is monotonically decreasing in  $T$  since

$$\begin{aligned} \frac{\partial}{\partial T} \left[ \frac{1 - e^{-\rho T} - \rho T}{(1 - e^{-\rho T})^2} \right] &= \frac{\rho T e^{-\rho T}}{(1 - e^{-\rho T})^3} (e^{-\rho T} - e^{\rho T} + 2\rho T) \\ &= \frac{\rho e^{-\rho T}}{(1 - e^{-\rho T})^3} (\rho T - \sinh(\rho T)) < 0, \end{aligned} \quad (\text{A.5})$$

recalling that  $x \sinh(x) = -[(x^3/3!) + (x^5/5!) + (x^7/7!) + \dots]$ .

The welfare gain in the sustainable case,  $\Delta'$  in eq. (6') is obtained substituting in the expression for  $V^*$  in (A.2) the value of  $q_0^*$  obtained from eq. (7), and equal to

$$q_0^* = (c - h/\rho)/(a\rho) - (1/a\rho)e^{-\rho T} \left[ (c - h/\rho) \frac{\rho T}{1 - e^{-\rho T}} + (h/\rho)(1 - \rho T - e^{-\rho T}) \right].$$

It is straightforward to show that  $\lim_{T \rightarrow 0} q_0^* = 0$ ,  $\lim_{T \rightarrow \infty} q_0^* = (c - h/\rho)/a\rho$  and  $\lim_{T \rightarrow 0} \partial q_0^*/\partial T = (1/2a)(c - h/\rho)$ . Using these results, together with the results shown above for the case  $q_0 = 0$ , we obtain  $\lim_{T \rightarrow 0} \Delta' = 0$ ;  $\lim_{T \rightarrow \infty} \Delta' = (h/a\rho^2)(c - h/2\rho)$ ; and  $\lim_{T \rightarrow 0} \partial \Delta'/\partial T = (h/2a\rho)(c - h/\rho)$ .  $\Delta'$  is uniformly increasing in  $T$  for  $c > h/\rho$ , and uniformly decreasing in  $T$  for  $c < h/2\rho$ . For  $h/2\rho < c < h/\rho$ ,  $\Delta'$  is negative for small values of  $T$  (because  $\partial \Delta'/\partial T$  is negative around  $T = 0$ ), but eventually turns positive and has a positive asymptote.

Finally, when seignorage enters the authorities' objective function, as in eq. (1'), the value of  $V$  along the optimal path in the EMS regime and in the flexible rates regime are, respectively

$$V^* = (1/\rho) \left\{ hq_0 - \frac{(c+b)^2}{2a} + \frac{h^2}{a\rho^2} \left[ \frac{1}{2} - e^{-\rho T} \left( \frac{\rho T}{1 - e^{-\rho T}} - \frac{1}{2} \right) \right] \right\}$$

$$+ (b/a) \left[ c + b - (h/\rho) \left( 1 - \frac{\rho T e^{-\rho T}}{1 - e^{-\rho T}} \right) \right]. \quad (\text{A.6})$$

$$\tilde{V}^* = - \frac{c^2 - b^2}{2a} \int_0^\infty e^{-\rho t} dt = - \frac{c^2 - b^2}{2a\rho}. \quad (\text{A.7})$$

The difference  $V^* - \tilde{V}^*$  is the value of  $\Delta''$  reported in eq. (6'').

## 2. Derivation of the welfare gain with perfect capital mobility [eq. (12)]

Substituting the expression for  $i_t^*$  from eq. (10) into the objective function (9) we obtain

$$V'' = V - f(1/\tau - 1/T)^2 \left[ \int_0^T \pi_t dt \right]^2 \frac{e^{-\rho T}(e^{\rho T} - 1)}{2\rho},$$

where  $V$  is the objective function in eq. (1).

Eq. (12) is obtained calculating  $V''$  along the optimal inflation path shown in eq. (11), and subtracting the welfare gain  $\Delta$  [eq. (6)]. The value of  $F(T)$  in eq. (12) is

$$F(T) = \frac{f e^{-\rho T}}{2a\rho^2} \left[ c \frac{\rho T}{1 - e^{-\rho T}} - \frac{h(1 - \rho T - e^{-\rho T})}{\rho^2(1 - e^{-\rho T})^2} \right].$$

## References

- Barro, Robert J., 1983, Inflationary finance under discretion and rules, *Canadian Journal of Economics* 16, Feb., 1-16.
- Barro, Robert, J. and David B. Gordon, 1985, Rules, discretion and reputation in a model of monetary policy. *Journal of Political Economy* 12, July, 101-121.
- Cohen, Daniel and Philippe Michel, 1985, Dynamic consistency of government's behaviour: A user guide (1), Mimeo.
- Collins, Susan M., 1987, PPP and the peso problem: Exchange rates in the EMS, Mimeo.
- Fischer, Stanley, 1982, Seignorage and the case for a national money, *Journal of Political Economy* 90, no. 2, April, 295-313.
- Fischer, Stanley, 1986, Time consistent monetary and fiscal policies: A survey, Mimeo.
- Fischer, Stanley, 1987, British monetary policy, in: R. Dornbusch and R. Layard, eds., *The performance of the British economy* (Oxford University Press, Oxford).
- Giavazzi, Francesco and Alberto Giovannini, 1987, Models of the EMS: Is Europe a greater Deutsche Mark area?, in: R. Bryant and R. Portes, eds., *Global macroeconomics: Policy conflict and cooperation* (Macmillan, London).
- Giavazzi, Francesco and Marco Pagano, 1985, Capital controls and the European monetary system, in: *Capital controls and foreign exchange legislation*, Euromobiliare occasional papers no. 1.
- Grossman, H.I. and J.B. Van Hujck, 1984, Seignorage, inflation and reputation, Working paper no. 1505 (NBER, New York).

- Rogoff, Kenneth, 1985, The optimal degree of commitment to an intermediate monetary target, *Quarterly Journal of Economics* 100, no. 4, Nov., 1169–1190.
- Thygesen, Niels, 1979, The emerging European monetary system: Precursors, first steps and policy options, in: R. Triffin, ed., *EMS – The emerging European monetary system*, off-print bulletin of the National Bank of Belgium, Vol. I, no. 4, April.
- Wyplosz, Charles, 1985, Capital controls and balance of payments crises, *Journal of International Money and Finance*, Dec.

## COMMENTS

### **'The Advantage of Tying One's Hands: EMS Discipline and Central Bank Credibility'**

by **Francesco Giavazzi and Marco Pagano**

David K.H. BEGG

Giavazzi and Pagano have given us an interesting and elegant paper. Their starting point is a small country with a credibility problem. Its central bank faces a temptation to resort to surprise inflation to secure higher output. As first explained in Barro and Gordon (1985) the private sector will anticipate such behaviour and the resulting equilibrium has an inefficiently high rate of inflation. One solution, suggested in Rogoff (1985), is the appointment of an unduly conservative central banker. Giavazzi and Pagano do not explain why this solution is unattractive or infeasible; rather they explore whether a similar precommitment can be achieved by joining the EMS. Clearly what they have in mind is that inflation prone countries such as France and Italy effectively delegate monetary policy to the Bundesbank when they join the EMS.

Before discussing the analysis in detail, it is worth noting which aspects of the EMS this approach can and cannot explain. First, although the interpretation of the EMS as a device for securing inflation discipline has become increasingly popular during the 1980s, it should be remembered that such considerations may have been less important at the outset when a major goal of the EMS was to reduce exchange rate volatility. Second, to the extent the authors' analysis is about whether a small country should join a system with given rules of the game, the analysis explains neither the initial bargain to establish the EMS nor the continuing conflicts within it.

With these preliminary comments, let me turn to the substance of the paper. In a world of flexible prices, the policy maker chooses monetary growth and inflation knowing that the period between EMS realignments is exogenous (and for simplicity constant) and that the real exchange rate reverts to a given point (PPP) after each realignment. Against the apparent benefits of surprise inflation the policy maker trades off two costs – a dislike of inflation and the knowledge that it is making the economy less competi-