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CREDIBILITY AND INFLATION PERSISTENCE IN THE EMS

1. INTRODUCTION

There is wide agreement that inflation differentials within the European Monetary System (EMS) have narrowed dramatically during the 1980s, as inflation rates in member countries have converged to German standards. There is less consensus, however, as to the role the EMS itself has played in the disinflation process. For some analysts, the benefits of EMS membership have come primarily from the enforcement of disinflationary policies via an exchange rate constraint (the discipline effect). For others, EMS membership has yielded an additional credibility bonus, which has reduced the output and employment costs of disinflation. According to the latter view, put forth most forcefully in Giavazzi and Giovannini (1989), Giavazzi and Pagano (1988) and Mélitz (1985), by tying the exchange rate to a "hard" currency such as the deutschemark (DM), member countries have increased the credibility of their announced anti-inflation stance, thereby lowering inflation expectations and thus the costs of disinflation. In Giavazzi and Pagano's words, the EMS has allowed member countries to "borrow counter-inflation reputation" from the Bundesbank, hence enhancing the credibility of their own monetary authorities.

Despite the prominence this argument has attained in the EMS literature, the empirical evidence regarding the credibility effects of EMS membership is mixed. Artis (1987), Collins (1988), Weber (1991), and Egebo and Englander (1992), among others, find little evidence of a downward shift in inflation expectations and a change in labor and product market behavior under the EMS. De Grauwe (1990) goes as far as arguing that disinflation within the EMS has, if anything, been slower and more costly than outside the system. On the other hand, Giavazzi and Giovannini (1989), and more recently Robertson and Symons (1992), find that membership in the EMS has lowered the costs

of deflation for high-inflation countries, but increased them for low-inflation members. Single-country studies by Christensen (1986) and Kremers (1990) on Denmark and Ireland respectively, argue that in both of those countries disinflation policies derived credibility from participation in the EMS, albeit only gradually. Finally, attempts at estimating credibility and reputation directly, as in Weber (1992), suggest that "borrowing counter-inflation reputation" from the Bundesbank in order to disinflate, has worked for some countries (Denmark, Ireland, the Netherlands, and to some extent Belgium), but not for others (France and Italy).

Inflation performance during the 1980s in the seven original EMS countries tends to support the discipline argument. As is made clear in Table 1, inflation rates have fallen substantially within the EMS, and particularly so among the highest-inflation countries such as Denmark, Ireland and France. These three countries have reduced their inflation rates from over 10% in the late 1970s to under 3% in 1991. Nevertheless, it is also true that inflation rates fell significantly in the three countries that did not join the EMS until the end of the decade and were therefore not bound by the exchange rate constraint --Spain, Portugal and the United Kingdom. Average inflation for the initial EMS members fell from 10.10% in 1974-79 to 5.37% in 1980-92, while inflation for the wider EMS (including the "latecomers") fell from 12.63% to 6.74% over the same period. In the other non-EMS European countries, inflation rates declined substantially less, from an average of 9.14 in 1974-79 to 7.83 in 1980-92.

The evidence as to whether the EMS has reduced the costs of disinflation is much weaker. As Table 1 shows, the decrease in inflation rates among EMS members has been accompanied by a substantial increase in unemployment. The average unemployment rate in the original EMS members rose by nearly 5 percentage points during the 1980s, from an average of 4.5% in 1974-79 to 9.27% in 1980-92. Unemployment rose even more in the new EMS countries, although that result is driven primarily by the Spanish experience. In contrast, unemployment increased by only 1.5 percentage points in the non-EMS countries over the same period. Figure 1, which plots the cumulative

rise in unemployment versus the reduction in inflation for the 1974-79 and 1980-92 periods, suggests little improvement in the tradeoff between those two macro variables under the EMS; or in other words, disinflation in the EMS has not been achieved at less cost than in the 1970s. Figure 2, which plots similar "sacrifice ratios" while distinguishing between the "early" EMS (1980-86) and the "new" post-1987 EMS, supports the same conclusion. Although these measures of the cost of disinflation are extremely crude, they would seem to contradict the existence of "credibility gains" associated with EMS membership.

The purpose of this paper is to examine further the discipline and credibility effects of the EMS. Using the approach developed in Alogoskoufis (1990, 1992), the paper first analyzes whether the persistence of inflation in member countries falls with entry into the EMS. A decrease in inflation persistence would be consistent with the existence of a disciplinary effect of the exchange rate commitment on domestic policies. The paper then goes a step further and attempts to link the change in the inflationary process directly to the credibility of the announced exchange rate target, which is taken as a proxy for the perceived credibility of policymakers' anti-inflation stance.[1/] The paper hypothesizes that establishing a commitment to a fixed exchange rate, by itself, is not sufficient to lower inflation expectations and thus reduce persistence. Rather, what is required is that the exchange rate link be part of a credible policy package. It is this link between the credibility of announced policies and inflation persistence that the paper seeks to explore.

The paper finds that inflation persistence was lower under the EMS than under the previous flexible exchange rate regime in all member countries. However, this decline cannot be convincingly linked to the choice of exchange rate regime, since a similar drop in persistence is observed for non-EMS countries. Results from pooled regressions that attempt to distinguish between the experience of EMS members and

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1/ Agénor and Taylor (1992) perform a similar exercise to study the relationship between policy credibility and inflation persistence in Brazil.

non-members suggest that, in fact, the behavior of inflation followed very similar patterns in both groups of countries until the mid-1980s. From 1985 onwards, though, the processes appear to diverge, with a larger decline in inflation inertia within the EMS as compared to outside the system. Overall, these findings provide only weak evidence to support the claim that the EMS has served as an effective disciplinary device for monetary policy in member countries. It appears that, if anything, the so-called disciplinary effect did not materialize until the second half of the decade.

The analysis of the relationship between inflation persistence and policy credibility under the EMS reveals a significant negative relationship between those two variables in six of the member countries -- France, Italy, Ireland, the Netherlands, Denmark and the United Kingdom. This suggests that participation in the EMS has reduced inflation persistence only in proportion to the credibility of the announced "hard" currency policy. In other words, the commitment to a fixed exchange rate per se did not suffice to reduce inflation inertia; only when the change in regime was perceived as sufficiently credible, in the sense that policies were consistent and believed by the public, did inflation persistence start to fall. There is no evidence to support a link between policy credibility and inflation in the case of Spain, which could simply reflect its late entry into the System.

The results obtained using panel data are consistent with those obtained from the single-country credibility regressions. Average persistence under the EMS is lower than under the previous regime, and decreases with the degree of credibility of announced exchange rate targets. Thus, the more credible the "hard" currency stance of member countries, the lower average inflation persistence.

The rest of the paper is organized as follows. Section 2 briefly reviews the methodology used in previous literature to test for credibility effects, and presents the empirical strategy to be followed here. This strategy is based on a simple open-economy model with

staggered wage contracts a la Taylor (1979, 1980).[2/] Section 3 applies the methodology to test for the existence of discipline and credibility effects in the EMS. The final section summarizes the main results and discusses the implications of these findings.

2. CREDIBILITY EFFECTS AND THE EMS: EMPIRICAL STRATEGY

2.1 Summary of Recent Studies: Methodologies and Empirical Evidence

Most econometric studies of the credibility effect of the EMS have relied, in one form or another, on the analysis of prediction errors from structural or reduced-form models of the price- and wage-setting processes. The usual approach is to estimate a model for the relevant variable (inflation, wage growth and/or the nominal interest rate) for the pre-EMS period, and then form predictions of the dependent variable under the EMS. If the estimated model consistently overpredicts price and/or wage inflation for the EMS period, this is taken as evidence that the policy regime change was rapidly believed. If, on the other hand, the quality of the forecasts deteriorates only slowly, this is interpreted as evidence that agents did not initially believe the change in policy but gradually revised their beliefs (see Blanchard, 1984).

As pointed out by Christiansen (1986), Kremers (1990) and Agénor and Taylor (1992), the prediction-error approach can be criticized on the grounds that these errors can reflect almost anything not explicitly included in the model, and not necessarily just a credibility effect. In other words, a rapid deterioration of the forecasts could be due simply to a mispecification of the model. Furthermore, when prediction errors are based on vector autoregressions (VARs) as in Giavazzi and Giovannini (1989), it becomes even more difficult to interpret instability in the coefficients as shifts in the structural parameters. These considerations question the reliability of the results obtained through this methodology.

2/ See also Alogoskoufis (1990) and Agénor and Taylor (1992).

An alternative methodology for estimating credibility effects is followed by Christiansen (1986) for Denmark, and by Agénor and Taylor (1992) for Brazil. Both studies adopt proxy variables for the credibility of announced policy changes and explicitly include this proxy in the estimated model. The credibility variable in Christiansen's paper is the variance of the nominal exchange rate, while Agénor and Taylor use the spread between the parallel and the official exchange rates. Like the prediction-error method, however, this approach is fraught with problems. First, proxy variables for credibility are usually defined in a rather arbitrary way. Second, such variables are likely to be endogenous.

Table 2 summarizes the results of the main econometric studies on the existence of credibility effects in the EMS. As discussed above, the majority rely overwhelmingly on the analysis of prediction errors and the search for structural shifts in the model parameters. On the whole the evidence supporting the existence of said credibility effects is fairly weak. Only the studies by Christiansen (1986), Kremers (1990), and Weber (1992) find relatively strong evidence in favor of the credibility hypothesis, and then only for the smaller EMS countries --Denmark, Ireland and the Netherlands.

2.2 Persistence and Credibility: An Empirical Framework

The starting point for our analysis is an autoregressive process for inflation of the form:

$$\Delta p_t = \rho_0 + \rho_1 \Delta p_{t-1} + \eta_t \qquad (1)$$

$$\textit{where } \eta_t \textit{ is } N(0, \sigma_\eta^2)$$

and where p represents the logarithm of the consumer price index. As demonstrated in Alogoskoufis (1990, 1992), this process can be derived from a simple open-economy model with overlapping wage contracts in

the spirit of Taylor (1979, 1980).[3/] It is easily shown that in this type of model, the degree of inflation persistence (ρ_1) depends on: (i) the extent to which monetary and exchange-rate policy accomodate price developments; and (ii) the credibility of an announced non-accomodative policy.[4/] The intuition behind these results is straightforward. The persistence of inflation is higher under more accomodating monetary and exchange-rate policies, because wage setters are assumed to understand the policy rules. When policies are accomodating, wage setters will be less concerned about the unemployment consequences of wage increases, and hence wages and prices will adjust more slowly to shocks. Similarly, if a pre-announced disinflationary policy is not credible, wage setters will expect policies to accomodate price shocks, and will thus fail to moderate their wage demands.

In the EMS context, the simple open-economy staggered wage contracts model suggests two testable hypotheses. First, by tying the exchange rate to a "hard" currency, participation in the EMS should force member countries to follow non-accomodative monetary and exchange-rate policies. This should translate into a reduction in inflation persistence. Second, the persistence coefficient should vary with the credibility of the announced exchange-rate target. The more credible the commitment to a fixed parity, the lower the persistence coefficient.

In this paper, I first estimate equation (1) separately for each EMS member and test the hypothesis that ρ_1 is lower under the EMS than during the previous flexible exchange rate period. Comparing persistence coefficients under both exchange rate regimes, however, is not enough to establish the existence of a disciplinary effect of EMS

3/ For notational simplicity, the model presented in this section is assumed to be AR(1). However, the extension to higher-order processes is straightforward.

4/ See Appendix 1 for an example of a 2-period Taylor-type model that generates a first-order autoregressive process for inflation. Note that the analysis can easily be extended to involve a n-period wage contracts model (with n>2), which would result in a higher-order process for inflation.

membership, since the nature of the underlying aggregate shocks driving inflation could have changed between the two regimes. To control for this possibility, I estimate similar autoregressive inflation processes for several non-EMS OECD countries over the same period, and compare their experiences with those found for the EMS members. In addition to running individual regressions, I estimate a single inflation equation on pooled data for both EMS members and non-members and test directly for differences in inflation behavior between the two groups of countries.

I then examine the existence of a credibility effect on inflation behavior, by estimating a varying parameter version of equation (1). Following the underlying model, I postulate that under the EMS ρ_1 is a function of the credibility of the anounced "tough" anti-inflation stance, and approximate this relationship through a linear function of the form:

$$\rho_1 = \gamma_0 + \gamma_1 c_t \qquad (2)$$

where c_t is a proxy variable for the credibility of the announced non-accomodative policy and γ_1 is assumed to be negative. Combining (1) and (2) yields the equation to be estimated in Section III:

$$\Delta p_t = \rho_0 + (\gamma_0 + \gamma_1 c_t) \cdot \Delta p_{t-1} + \eta_t \qquad (3)$$

The key implementation issue is then the choice of an appropriate proxy by which to measure the degree of anti-inflation credibility. I

choose to identify policy credibility with the credibility of the commitment to a given fixed exchange rate vis a vis the deutschemark. As a first measure of credibility, I then use the negative of the differential in long-term interest rates between the home country and Germany, $(R_t - R_t^G)$. Under the assumption of uncovered interest-rate parity, this differential should capture the market's expectations regarding the evolution of the exchange rate over the relevant horizon.

The long-term interest rate differential, however, may not be an appropriate proxy variable to use, since it is an endogenous variable which responds both to "fundamentals" and to the degree of policy credibility. To the extent that the interest rate differential may itself depend on the level of inflation, the use of this proxy variable could introduce simultaneity bias into our estimates. To address this potential problem, I experiment with the use of an alternative proxy for credibility, defined (following Agènor and Taylor (1992)) as that part of the differential that is orthogonal to current and past "fundamentals". I thus decompose the long-term interest rate differential into a component explained by observable pre-determined variables and an error component. The latter should capture, to some degree, the market's expectations regarding the future path of fundamentals, as well as other factors affecting policy credibility. As such, it should provide an appropriate measure of the credibility of the commitment to a fixed exchange rate parity. Yet, to the extent that it is orthogonal to past and current movements in the fundamentals -- including inflation behavior-- it should avoid the problem of simultaneity.

The procedure suggested is as follows. I begin by assuming a "structural" relationship between the long-term interest rate differential and a vector of pre-determined variables or fundamentals, z_t:

$$R_t - R_t^G = Z_t\Pi + c_t \qquad (4)$$

where the error component, c_t, reflects the unexplained variation in the differential; or in credibility terms, the variation in the perceived degree of policy credibility associated with expectations of future government policies and economic fundamentals. Solving for c_t and then substituting back into equation (3) yields:

$$\Delta p_t = \rho_0 + \gamma_0 \Delta p_{t-1} - \gamma_1 [(R-R^G)_t - Z_t\Pi] \bullet \Delta p_{t-1} + \eta_t \qquad (5)$$

Equations (4) and (5) can be estimated jointly using generalized least squares (GLS).[5/]

In addition to estimating separate time-varying parameter equations for the inflationary process by country, I also estimate a pooled version that allows for country fixed effects. This approach allows one to take advantage of both the cross-section and time-series dimension of the data, and tends to yield more robust estimates.

3. RESULTS

3.1 Inflation Persistence

Following the methodology described above, I begin by estimating separate autoregressive processes for inflation for each of the member

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5/ An alternative is to use a 2-step estimation procedure, which involves first estimating the structural equation (4) to obtain a residual series $\hat{c}_t$, and then using the estimated residual as an exogenous variable in equation (3). If this approach is chosen, it becomes necessary to adjust the standard errors in the second stage.

countries. I use quarterly data for the 1960:1-1992:4 period, and distinguish between three successive policy regimes -- Bretton Woods, the "flexible" exchange-rate period, and the EMS.[6/] The dependent variable in the estimated equations is the change in the log of the consumer price index relative to the same quarter, previous year. The regressors include lagged inflation, and interactions between lagged inflation and dummy variables for the Bretton Woods and EMS regimes.[7/] One would expect the coefficients on both interaction terms to be negative, reflecting lower persistence of inflation under both fixed-exchange rate regimes. The regressors also include country-specific dummies to capture institutional changes and other developments that the model cannot explain.[8/] A detailed description of the data and data sources is presented in Appendix 2. For details on the exact specification of the estimated equations, procedures and tests, see notes at the bottom of Table 3a.

6/ Note that during the 1970's nearly all of the EMS countries participated at one time or another in the "snake" mechanism. Some adhered to it for longer periods of time (Belgium, the Netherlands), while others jumped in and out (France, Italy, and the U.K). For the latter countries, the regime in-between Bretton Woods and the EMS can thus be more or less accurately described as one of flexible exchange rates. For the former, however, it is harder to distinguish between the exchange-rate regime prevailing in the 1970's and that under the EMS.

7/ All regressions include more than one lag of the dependent variable among the regressors, as required to eliminate residual autocorrelation. The precise number of lags are the following: France (2), Italy (3), Belgium (4), Germany (4), Netherlands (4), Denmark (4), Ireland (4), United Kingdom (2) and Spain (5). The coefficients reported in the table represent the sum of the coefficients on the individual lags and were obtained by reparametrizing the equation using second-differences.

8/ The precise list of dummies is the following. France: 1963:4-1964:4, price freeze; 1968:2-1968:3, "May 68"; 1969:1-1970:4, price freeze; 1973:4-1974:1, 1977:1-1977:4, 1982:3-1983:4, wage and price controls. Italy: 1969:2-1970:1, "Autumno Caldo"; 1973:3-1974:1, price freeze; 1984:1, dismantling "scala mobile". United Kingdom: 1967:4, devaluation of sterling; 1973:4-1974:4, wage controls. Belgium: 1982:1-82:4, wage controls. Netherlands: 1980:1-1981:1, change in indexation mechanism. Spain: 67:2-70:2, 73:3-77:4, wage pressures; 86:1, introduction of VAT.

The individual country equations are estimated using OLS, with heteroskedasticity robust standard errors computed following White's (1980) procedure. Results are presented in Table 3a.

The diagnostics tests for the different country equations suggest that the autoregressive specification provides an acceptable model for the inflationary process in almost all of the countries analyzed. Although not reported in Table 3a because of space constraints, Durbin's h test is insignificant in all the estimated equations, indicating a rejection of first-order autocorrelation. Similarly, autocorrelation of up to fourth-order is rejected in all cases except in the Italian equations, and in the equations with 1979:1 break points for Belgium and Denmark. When the break point is moved to 1983:1, the diagnostics improve for all equations. Finally, note also that the Dickey-Fuller tests reject the unit root hypothesis for all countries.

The estimates suggest that in all countries except Germany, inflation has shown less persistence under the EMS than under the previous flexible exchange rate regime.[9/] For most countries, however, the decline in persistence does not occur until the EMS is well underway (circa 1983:1).[10/] The coefficient on the interaction term between lagged inflation and the EMS dummy is negative and significant at the 5% level for the Netherlands starting in 1979:1 and for the rest of the initial EMS members starting in 1983:1. The fact that for almost all of the initial EMS countries, the shift in the persistence coefficient does not occur until 1983 is consistent with the perception that, in its early phase, the EMS was implemented by some member countries more as a

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9/ Although I do not comment explicitly on the coefficient on the interaction between lagged inflation and the Breton Woods system, this coefficient systematically comes in negative and significant, indicating that persistence of inflation was also lower under the Breton Woods regime.

10/ The exact date is somewhat arbitrary, but was chosen based on the evidence found in other studies and because of its coincidence with the Miterrand turn-around. Also there were seven realignments between 1979 and 1983, but only four between 1983 and 1992:3. A more careful analysis would probably reveal different break points for each country. Note that the turmoil in the EMS in the last quarter of 1992 is largely ignored in this paper.

"crawling peg", with frequent realignments to offset accumulated competitive differentials.

The point estimate of the change in the persistence coefficient under the EMS varies from -.055 for France to -.177 for Denmark. Note that for almost all the initial members the decline in the persistence parameter gets stronger over time, which is again consistent with the perception that the exchange rate constraint became more binding in the second half of the 1980s, as countries moved away from policies of frequent realignments towards more truly "fixed" parities.

In the case of the "new" EMS members, Spain and the United Kingdom, the break points for shifts in the persistence coefficients are chosen to match their entry dates into the system --1989:3 and 1990:4 respectively. The results for the U.K. indicate a clear drop in inflation persistence at the end of the decade. The coefficient on the interaction between lagged inflation and the EMS dummy is negative and strongly significant. However, it is not clear whether this drop is due to the EMS itself or to the imposition of tough, anti-inflation policies during the period immediately preceding EMS membership. To test this possibility, I estimate an autoregressive process for inflation allowing for an earlier breakpoint (1989:1). This yields a negative and significant shift parameter of -.086, suggesting that at least part of the drop in persistence precedes the entry into the EMS. In the case of Spain, the interaction term between lagged inflation and the EMS dummy comes in negative but is not quite significant. The problem could be that the period of EMS membership is just too short to draw significant conclusions.

Since Germany had disciplined monetary and exchange rate policy before entering the EMS, one would not expect the inflationary process for Germany to change significantly with the move towards the new regime. It is then a bit surprising to find a significant drop in Germany's inflation persistence for the post-1983 period. Although the result is weak --when the break-point is moved to 1985, the coefficient becomes statistically insignificant-- it is nevertheless a source of concern, and suggests that something other than just the disciplinary

effect of EMS membership may be at work. One possibility is that the nature of the shocks driving inflation changed during the 1980s, becoming less persistent. Certainly the experience with the two oil shocks during the 1970s, suggests that this is likely to have been the case. Such a change in the nature of the underlying shocks could be reflected in a drop in inflation persistence during the 1980s, which would be independent of EMS membership.

Testing this possibility requires comparing the inflation experience of the EMS members to that of countries who did not participate in the exchange rate mechanism. Table 3b presents the results obtained from inflation regressions for a group of non-EMS OECD nations. These estimates show a clear downward shift in the persistence coefficient for most non-EMS countries starting in 1983:1. Thus, the behavior of inflation persistence follows a pattern very similar to that found for the EMS members. The only exceptions to this pattern are Sweden and New Zealand. For both of these countries, the interaction term between lagged inflation and the period dummies comes in negative but is not statistically significant.

From the autorregressive equations it is possible to infer the mean of the inflationary process in each country.[11/] These means are presented in Table 4 for the two periods of interest, corresponding to the flexible exchange rate regime and the EMS. Two facts stand out: (i) the means of the inflation process declined substantially during the 1980s throughout the OECD; and (ii) the decline was greater in those countries that participated in the EMS.

11/ Following the notation used in equation (1), the mean of the inflationary process is given by:

$$\mu = \frac{\rho_0}{(1-\rho_1)}$$

A more direct test of the difference between inflation behavior in EMS and non-EMS countries can be obtained from a pooled regression of the type:

$$\Delta p_{it} = \rho_{0i} + \rho_1(\Delta p_{it-1} \bullet EMS_{it}) + \rho_2(\Delta p_{it-1} \bullet NON\text{-}EMS_{it}) + \nu_{it} \quad (6)$$

where EMS_{it} ($NON\text{-}EMS_{it}$) is a dummy variable that takes the value 1 if i is in the EMS (not in the EMS) at time t, and ρ_{0i} is a country fixed effect. The test of a differential "EMS effect" is then equivalent to a test of the null hypothesis H_0: $\rho_1 = \rho_2$.

Estimates obtained from the pooled regressions, and F-tests of the null hypothesis are presented in Table 5. Columns (1) and (2) contain the results obtained for the model with a 1979:1 break point, with and without fixed effects. Columns (3) and (4) present similar regressions with a 1983:1 shift dummy, while columns (5) and (6) present those obtained with a 1985:1 shift term.

The results in column (1) indicate a small drop in persistence for both EMS and non-EMS countries starting in the first quarter of 1979. The test of the difference between the EMS and non-EMS coefficients cannot reject the null hypothesis that the two are equal. Results in columns (3) and (5) follow an identical pattern, suggesting a clear drop in inflation persistence in the 1980s, which appears unrelated to EMS membership.

The results are somewhat different when one introduces country fixed effects (thus allowing the means of the inflationary process to vary across individual countries within each broad EMS/non-EMS grouping). The estimates still indicate a parallel drop in persistence from 1979 onwards in both EMS participants and non-participants, but the evidence suggests that the decline was statistically larger within the EMS, at least since 1985. This difference could, in principle, be interpreted as evidence in favor of the existence of a disciplinary effect associated with the exchange rate regime.

The above analysis has yielded only partial evidence to support the claim that EMS membership lowered inflation persistence. This finding

can be interpreted in several ways. One possibility would be to conclude that the presumed discipline effect is either nonexistent or negligible, and that what matters rather is the nature of the underlying shocks driving inflation. Since said shocks have become less persistent in the 1980s, the inflationary process has consequently demonstrated less inertia throughout the OECD. An alternative interpretation would argue that what the equations are reflecting is the imposition of tough disinflationary policies throughout the OECD in response to the high inflation experiences of the 1970s, independent of the choice of exchange rate regime. Both of these interpretations certainly seem to fit the broad facts, in particular, the larger importance of supply shocks in the 1970s versus the 1980s, and the disinflation success of countries with a flexible exchange rate regime (such as the U.S. and the U.K. prior to EMS membership). However, it is also true that the "correct" exercise in determining the existence of an EMS effect is necessarily a counterfactual: irrespective of the experience in non-EMS countries, how would have inflation behaved in the EMS members in the absence of the exchange rate constraint? One could argue that such traditionally high-inflation countries as France, Italy, Denmark, Ireland, or Spain required an exchange rate constraint to be able to impose disciplinary policies at all, and that such discipline would not have been enforced in the absence of the exchange rate mechanism. Such a counterfactual is, of course, impossible to test.

A third possible interpretation of the results would be to claim that the "disciplining" mechanism of the EMS does exist, but that our simple estimates fail to capture it. In line with this argument, it seems useful to examine somewhat more complex formalizations of the inflationary process, and in particular, to address the potential link between credibility of the exchange rate commitment and inflation behavior. After all, in order for the exchange rate constraint to serve as a disciplining mechanism it must be perceived as credible by agents involved in the wage and price setting process. The apparent failure of the EMS to have a sizeable independent effect on the inflationary process, at least during the first half of the 1980s, could simply reflect the failure of member countries to credibly commit to a fixed exchange rate.

3.2 The Role of Policy Credibility

To examine the link between policy credibility and inflation persistence, I estimate an autoregressive process for inflation allowing the persistence parameter under the EMS regime to vary with the apparent credibility of the anti-inflation stance (as in equation (3)).

I identify policy credibility with the credibility of the exchange-rate commitment. I assume that an exchange rate target will be credible only if Government policies are consistent with the exchange-rate objective and believed by the public. As a first proxy for credibility I use the negative of the long-term interest rate differential between the home country and Germany.[12/] Under the assumption of uncovered interest rate parity, this differential equals financial markets' evaluations of the probability of exchange-rate depreciation over the relevant horizon, and thus reflects the credibility of the current exchange rate level. Long-term differentials versus Germany are plotted in Figure 3. Clearly, these differentials have declined significantly since the early 1980s and particularly since 1987, reflecting an improvement in the credibility of the exchange rate grid. Note that, nevertheless, at the end of 1991, interest rate differentials for Spain and Italy remained sizeable.

The estimates from this time-varying parameter model are presented in the first three columns of Table 6. The estimates reveal a negative and significant EMS shift coefficient (γ_0) in the equations for France, Italy, the Netherlands, Denmark and the U.K. The credibility variable (γ_1), however, comes in negative and significant only in the regressions for France, Denmark and the U.K. In all other equations, γ_1 is negative, as expected, but not significantly different from zero.

As discussed in Section 2, a potential problem with using the long-term interest rate differential as a measure of credibility is that this variable is likely to be endogenous, reflecting the behavior of the "fundamentals" driving the inflation process, as well as the intrinsic

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12/ These rates are the yields on 3-year Government Bonds.

credibility of announced policies. I thus turn towards a second proxy for policy credibility, which I try to purge of the influence of current fundamentals. This measure of credibility is defined as in equations (4) and (5), where the vector of pre-determined variables, Z_t, is assumed to include: lagged money growth, lagged values of the current account and the fiscal deficit (as percent of GDP), the lagged real exchange rate (to capture accumulated losses in competitiveness), the unemployment rate, the change in the unemployment rate, dummies for exchange controls when appropriate, the interest rate differential lagged one period, and a time trend.[13/] Following the methodology described in Section 2, these equations were estimated jointly using generalized least squares.

Results for the second set of credibility regressions are presented in columns (4) through (6) of Table 6. These estimates are fairly similar to those obtained with the first unadjusted credibility measure. In the equations for France, Italy, the Netherlands and Denmark, the coefficient on the credibility variable appears negative and significant, indicating that persistence drops under the EMS as the credibility of the exchange rate target improves. In the case of Ireland and the U.K., both the EMS shift parameter and the coefficient on the credibility variable are negative and significant. On the other hand, the regressions for Belgium yield a negative but not-quite-significant credibility coefficient. Finally, in the equation for Spain, the EMS shift parameter (γ_0) comes in negative and significant (it was insignificant in the simple persistence equations presented in Table 3a), but the coefficient on the credibility measure (γ_1), although negative, is not statistically significant. On the whole, the results support a varying-parameter approach for most EMS member countries, and indicate that the decline in inflation persistence under the EMS is a function of the credibility of the exchange rate target.

13/ The exact specification of the Z vector varies by country. The strategy followed was to begin with the broadest definition of Z, and sequentially eliminate those variables that were not significant.

In order to exploit the cross-country dimension of the data set, I also estimate pooled versions of the credibility regressions, with and without fixed effects. These results are presented in Table 7.[14/] The estimates can be interpreted as averages of the individual country coefficients. Not surprisingly, the results follow the pattern laid out in the single-country regressions. The interaction term between the persistence coefficient and the EMS dummy is negative and significant in all regressions, as is the coefficient on the credibility variable. This provides support for the hypothesis that inflation persistence declined under the EMS, and did so more rapidly when the credibility of the anti-inflation stance was higher.

The behavior of inflation persistence for the pooled group of countries is shown in Figure 4. The graph shows a clear drop in persistence starting in late 1983. This would seem to indicate that individual agents' evaluation of the policy stance and hence their inflationary expectations shifted at that time; that is, well after the actual change in regime. This result seems consistent with the perception that the exchange rate constraint did not really become binding until 1983 for the major countries, and with the fact that 1983 marked a move towards tougher anti-inflation policies in many member countries.

4. CONCLUSIONS

This paper examined whether as a result of the change in the exchange rate regime, inflation persistence declined in the EMS countries during the 1980s. The paper first estimated separate autoregressive processes for inflation for a set of EMS members and non-members, and found parallel downward shifts in persistence starting in 1983:1 in all countries irrespective of their choice of exchange rate regime. This finding was confirmed by the pooled data analysis, which was unable to reject the hypothesis that inflation within and outside the EMS followed an identical process during the first half of the decade. Only since 1985, did inflation processes in

14/ Germany is excluded from these regressions.

EMS participants and non-participants appear to diverge, with the decline in persistence being more marked in the former.

The paper then estimated a varying-parameter version of the inflation equation, allowing persistence to vary linearly with the perceived credibility of the exchange rate policy. The analysis of the relationship between persistence and credibility revealed a negative relationship between those two variables in six countries --France, Italy, Ireland, the Netherlands, Denmark and the U.K. Thus, in these countries inflation persistence fell only as the credibility of the announced "hard" currency policy increased. The paper also estimated similar varying-parameter inflation equations on pooled data for all member countries. This approach yielded results very similar to those obtained individually, namely that average inflation persistence under the EMS decreased with the degree of credibility of announced exchange rate targets.

On the whole, the results offer some evidence to support the hypothesis that the EMS served as an effective disciplinary device for member countries. However, they also suggest that the commitment to a fixed exchange rate per se was not sufficient to bring down persistence; rather inflation inertia was broken only when the announced "hard" currency stance was perceived to be credible.

APPENDIX 1

This Appendix presents an example of a simple open-economy model that can generate a first-order autoregressive process for inflation. This model is the open-economy extension of the Taylor (1979) model with overlapping wage contracts, and was first presented in Dornbusch (1982), and more recently in Alogoskoufis (1990), and in Agénor and Taylor (1992).

Assume firms are monopolistically competitive price setters, setting prices as a markup over unit labor costs. Let y_t, p_t and e_t represent the log of output, prices and the nominal exchange rate, expressed in terms of deviations from their long-run equilibrium levels. Assume aggregate demand is given by:

$$y_t = \alpha(m_t - p_t) + \beta(e_t - p_t) + v_t \qquad (A1)$$

where m is the log of the money supply and the log of foreign prices has been normalized to zero. v is a stochastic demand shock. As in Taylor (1979, 1980), wage setting is staggered with one-half of contracts signed each period. The optimal average price each period is then an average of wages set in the current and previous period, less any productivity shocks:

$$p_t = 1/2 \cdot (w_t + w_{t-1}) - q_t \qquad (A1)$$

where q_t reflects any productivity shocks.

One half of wage contracts are set each period, for two periods duration.[15/] Wage setters aim at maintaining a constant real wage for the duration of the contract. The target wage is then given by:

$$w_t = 1/2[\delta p_t + (1-\delta)e_t] + 1/2[\delta E_t p_{t+1} + (1-\delta)E_t e_{t+1}] + \gamma/2[y_t + E_t y_{t+1}] \quad (A3)$$

where E_t denotes the expectation operator conditional on information available at time t.

Let the money and exchange rate policy rules be formulated in terms of the extent to which the authorities acommodate disturbances in the price level through increases in the money supply and/or through depreciations in the exchange rate:

$$\begin{aligned} e_t &= \bar{e} + \Theta p_t, \quad 0 \le \Theta \le 1 \\ m_t &= \phi p_t + \mu_t, \quad 0 \le \phi \le 1 \end{aligned} \qquad (A4)$$

where μ_t represents money supply shocks, and Θ and ϕ are the accomodation coefficients for the exchange rate and monetary policy rules respectively. A fixed exchange rate regime can be roughly characterized by $\Theta = 0$, and a flexible exchange rate regime by a positive Θ. Note that, in the absence of complete sterilization of international reserve flows, the exchange rate and monetary policy rules are not really separate. In principle, a commitment to hold a fixed parity against another currency (such as the DM) amounts to a commitment to follow a path for monetary growth equal to that of the other country. For simplicity, however, we do not explicitly introduce a second country in the model.

15/ This model is easily extended to include mutli-period contracts. The result would be a higher order process for inflation.

Solving equations A1 through A4 for expected inflation yields:

$$E_{t-1}p_t = \frac{\sigma}{4}[2E_{t-1}p_t + E_{t-1}p_{t+1}] + E_{t-1}x_t - E_{t-1}q_t$$

$$with\ \sigma = \delta + (1-\delta)\theta - \gamma\alpha(1-\phi) - \gamma\beta(1-\theta)$$

$$x_t = \gamma\alpha/4[\mu_t + E_t\mu_{t-1} + \mu_{t-1} + E_{t-1}\mu_t + \nu_t + E_t\nu_{t+1}]$$

Solving this second-order difference equation, one obtains:

$$E_{t-1}p_t = \rho_1 p_{t-1} - \frac{1}{\sigma\rho_2}\sum_{j=0}^{\infty}\rho_2^{-j}E_{t-1}(x_{t-j} - q_{t-j})$$

where ρ_1 , ρ_2 *are the roots of the system,*

$$0<\rho_1<1<\rho_2,$$

$$\rho_1 = \frac{(2-\sigma)}{\sigma} - [\frac{(2-2\sigma)^2}{\sigma^2} - 1]^{1/2}.$$

To get a closed-form solution assume that the shocks affecting aggregate demand, money supply and productivity are random walks with drift. The inflation can be written as:

$$\Delta p_t = \rho_1\Delta p_{t-1} + \frac{4}{\sigma(\rho_2 - 1)}(d + \xi_{t-1}) \qquad (A7)$$

where d is a combination of the drifts in the demand, money supply and productivity processes, and ξ is a combination of the white noise processess driving those random walks.

Thus, according to this simple model, inflation follows an AR(1) process with an autoregressive parameter ρ_1 . This parameter is a positive function of the money (ϕ) and exchange rate (Θ) accomodation coefficients.

Now suppose policymakers announce a non-accomodative policy of the type $\Theta = 0$ and $\phi = 0$. Assume agents believe that the policy will actually be implemented with probability λ, where $0 < \lambda < 1$. Then the probability that equation (A4) will hold is $1-\lambda$. The model can be solved as before, to show that ρ_1 is a negative function of λ. The more credible the announced non-accomodative policy, the lower the persistence parameter.

In the EMS context, this simple model suggests two testable conclusions: (i) participation in the EMS, by imposing a commitment to a quasi-fixed exchange rate vis a vis other member currencies and especially the DM, should reduce inflation persistence; and (2) the persistence coefficient should vary with the credibility of the announced exchange rate target.

APPENDIX 2
Data and Data Sources

Inflation. Change in the log of the consumer price index relative to the same quarter, previous year. Quarterly data for the 1960:1-1992:4 period. Source: Bank of Spain database.

Interest Rates. Yields on 3-year Government Bonds. Quarterly data, available for most countries for the 1978:1-1992:4 period. Source: Bank of Spain database.

Money Growth. Change in the log of broad money (M2). Quarterly data for the 1978:1-1992:4 period. Source: IMF, International Financial Statistics.

Current Account (as % of GDP). Calculated from current account and GDP data. Quarterly, 1978:1-1992:4. Source: IMF, International Financial Statistics (line 77a.d).

Fiscal Deficit (as % of GDP). Fiscal deficit of the consolidated central government. Quarterly data, 1978:1-1992:4. Source: IMF, International Financial Statistics (line 80).

Unemployment Rate. Standardized unemployment rate. Quarterly data, 1978:1-1992:4. Source: OECD.

Real Exchange Rate. Real effective exchange rate relative to the industrialized countries, based on consumer price indices. Quarterly data, 1978:1-1992:4. Source: Bank of Spain database.

Table 1

Average Inflation and Unemployment in EMS and Non-EMS Countries

Countries	Inflation (%)			Unemployment (%) [a]		
	1970-73	1974-79	1980-92	1970-73	1974-79	1980-92
Initial EMS						
Germany	5.94	4.41	2.99	0.82	3.19	5.67
Belgium	5.61	8.24	4.31	2.39	6.30	9.96
France	6.69	10.83	6.03	2.67	4.53	9.15
Italy	7.40	16.87	9.46	5.78	6.55	9.60
Netherlands	7.38	7.03	2.88	1.68	4.93	9.11
Denmark	8.14	10.65	5.45	1.43	5.99	9.37
Ireland	9.92	15.38	7.55	----	---	12.04
Luxembourg	5.42	7.39	4.29	----	---	---
Avg. Initial EMS	7.06	10.10	5.37	2.11	4.50	9.27
Recent EMS						
Spain	9.44	18.36	8.93	2.76	5.15	17.25
United Kingdom	8.76	16.12	6.65	3.40	4.95	9.64
Portugal	10.36	23.62	15.57	---	---	4.74
Avg. Recent EMS	9.52	19.36	10.38	3.08	5.05	10.54
Avg. All EMS	7.73	12.63	6.74	2.09	4.16	9.65
Other European						
Austria	6.27	6.02	3.66	2.00	1.92	4.63
Finland	9.01	12.30	6.31	2.23	4.35	5.49
Greece	11.15	14.96	19.03	---	---	---
Norway	8.21	8.41	7.04	1.58	1.79	3.40
Sweden	9.64	9.95	7.47	2.30	1.88	2.57
Switzerland	7.75	3.21	3.47	---	---	---
Avg. Other	8.22	9.14	7.83	2.03	3.84	5.34
Avg. All Countries	7.91	11.40	7.12	2.07	3.68	8.04

[a] Standardized unemployment rate. Source: OECD Main Economic Indicators and OECD database.

Table 2

Summary of Econometric Evidence on the Existence of Credibility Effects in the EMS

Author(s)	Methodology	Countries Covered	Main Results
Giavazzi and Giovannini (1989)	Examine predictions from VAR on prices, wages and output.	Germany, Denmark, France, Italy, U.K.	No significant shifts in parameters except for France. Dynamic simulations of the VARs overpredict actual price inflation starting 1982/83.
Artis and Ormerod (1991)	Estimate AR(4) eqs. for price inflation and error-correction models of the real wage.	Germany, France, Italy, Belgium, Netherlands.	Stable price eq. for Germany. For France and Italy, German inflation enters strongly for EMS period. Some evidence of change in wage process under EMS for France and Italy.
Christiansen (1986)	Estimates modified Fisher interest rate model including, as a proxy for "credibility", the variance of the exchange rate.	Denmark.	Evidence that the nominal interest rate responds to exchange rate variance and German interest rate. Finds evidence of a relationship between model parameters and the credibility variable.
Kremers (1990)	Estimates small structural model of inflation.	Ireland.	Finds evidence of change in inflation process starting with entry into EMS in 1979. Credibility gains occurred gradually over 1979-82.
Anderton, Barrell and McHugh (1992)	Examine prediction errors from dynamic real wage eqs. over pre-EMS and EMS period.	Germany, France, Italy, UK and smaller European countries.	Evidence of structural change for Italy and UK, but associated with institutional changes not EMS. Structural shift for Spain in 1986. Structural change for Belgium and Denmark.
Weber (1992)	Estimates empirical measure of counterinflation reputation.	Germany, France, Italy, Denmark, Ireland, Belgium, Netherlands.	Reputation gains associated with the EMS for Denmark, Ireland, the Netherlands, and to a lesser extent Belgium.
Robertson and Symons (1992)	Estimate pooled eqs. for output-inflation tradeoff and for output variability with dummy for EMS.	OECD countries.	Membership in EMS increased cost of deflation for low-inflation countries and lowered for high-inflation countries. After 1983, EMS countries experienced lower inflation and output variability.
Egebo and Englander (1992)	Examine prediction errors from Phillips curves and from VARs on wage and price inflation.	France, Italy, Netherlands, Belgium, Denmark, Ireland.	No significant evidence of credibility effects.

Table 3a
INFLATION PERSISTENCE IN THE EMS, 1960-92[a]

(Dependent Variable = Δp_t)

Country	Break Point[c]	Regressors[b]		R^2	LM4	Unit Root Test
		Δp_{t-1}	Δp_{t-1}*EMS			
France	1979:1	.957*	-.002	.972	5.36	-10.953
		(.018)	(.016)		[.252]	
	1983:1	.948*	-.055*	.977	4.32	--
		(.019)	(.022)		[.365]	
	1985:1	.925*	-.126*	.977	4.45	--
		(.024)	(.038)		[.348]	
Italy	1979:1	.923*	.028	.971	11.391	-5.482
		(.031)	(.028)		[.022]	
	1983:1	.949*	-.059*	.973	11.643	--
		(.022)	(.019)		[.020]	
	1985:1	.939*	-.056*	.974	11.092	--
		(.022)	(.022)		[.026]	
Belgium	1979:1	.929*	-.037	.947	11.819	-10.053
		(.028)	(.024)		[.019]	
	1983:1	.939*	-.058*	.954	7.242	--
		(.025)	(.024)		[.124]	
	1985:1	.926*	-.108*	.958	8.598	--
		(.025)	(.033)		[.069]	
Ireland	1979:1	.921*	-.007	.926	6.989	-9.680
		(.038)	(.037)		[.136]	
	1983:1	.913*	-.094*	.930	7.562	--
		(.034)	(.046)		[.109]	
	1985:1	.887*	-.249*	.939	5.989	--
		(.042)	(.072)		(.200]	
Netherlands	1979:1	.909*	-.105*	.888	12.913	-10.710
		(.027)	(.034)		[.012]	
	1983:1	.922*	-.101*	.911	8.477	--
		(.026)	(.046)		[.076]	
	1985:1	.936*	-.249*	.926	8.919	--
		(.025)	(.072)		[.063]	
Denmark	1979:1	.847*	.002	.806	11.074	-10.027
		(.048)	(.037)		[.026]	
	1983:1	.806*	-.177*	.837	7.107	--
		(.043)	(.042)		[.120]	
	1985:1	.757*	-.296*	.838	5.876	--
		(.055)	(.066)		[.256]	

Table 3a (cont)
INFLATION PERSISTENCE IN THE EMS, 1960-92[a]

(Dependent Variable = Δp_t)

Country	Break Point	Regressors		R^2	LM4	Unit Root Test
		Δp_{t-1}	Δp_{t-1}*EMS			
Germany	1979:1	.915*	-.024	.913	9.061	-9.858
		(.025)	(.025)		[.060]	
	1983:1	.903*	-.085*	.922	7.594	--
		(.026)	(.031)		[.108]	
	1985:1	.911*	-.068	.927	8.462	--
		(.027)	(.040)		[.076]	
United Kingdom	1990:4	.921*	-.126*	.949	8.142	-11.504
		(.035)	(.038)		[.086]	
Spain	1989:3	.897*	-.051	.954	2.492	-10.289
		(.029)	(.034)		[.646]	

Notes:

[a] P is the log of the consumer price index. Changes are relative to the same quarter, previous year. For sources and data details see the data appendix. Heteroskedasticity-consistent White standard errors are in parenthesis. * denotes significance at the 5% level.

[b] All regressions include more than one lag of the dependent variable among the regressors, as required to eliminate residual autocorrelation. The precise number of lags are the following: France (2), Italy (3), Belgium (4), Germany (4), Netherlands (4), Denmark (4), Ireland (4), United Kingdom (2) and Spain (5). The coefficients reported in the table represent the sum of the coefficients on the individual lags (the equation was reparametrized accordingly using second-differences). The regressors also include a constant term and an interaction between lagged inflation and a dummy for the Bretton Woods period. Thus, the coefficient on Δp_{t-1} presented in the table reflects the persistence coefficient for the flexible/managed exchange rate regime. The Bretton Woods dummy is equal to 1 for the 1960:1-67:4 period, and is set to 0 starting with the demonetization of gold and the devaluation of sterling in 1968:1.

[c] This reflects a "flexible" break point. The EMS dummy is set to equal 1 starting with the break point noted in this column.

[d] The regressors also include country-specific dummy variables to capture institutional changes and other developments that the model cannot explain. See footnote 8 in text for an exact list of dummies.

[e] LM4 = Lagrange multiplier test for up to fourth-order residual autocorrelation. Distributed as a $\chi^2(n)$, where n equals the number of lags. P values are in brackets. Unit root test is the augmented Dickey-Fuller test for unit root of the residual.

Table 3b
INFLATION PERSISTENCE IN NON-EMS COUNTRIES, 1960-92[a]

(Dependent Variable = Δp_t)

Country	Break Point[c]	Regressors[b]		R^2	LM4	Unit Root Test
		Δp_{t-1}	Δp_{t-1}*EMS			
United States	1979:1	.918*	-.023	.952	4.78	- 9.725
		(.031)	(.025)		[.311]	
	1983:1	.878*	-.093*	.953	3.10	--
		(.031)	(.034)		[.541]	
	1985:1	.886*	-.087*	.952	3.321	--
		(.031)	(.035)		[.506]	
Canada	1979:1	.944*	-.009	.953	9.926	-10.394
		(.024)	(.020)		[.042]	
	1983:1	.920*	-.082*	.958	5.863	--
		(.022)	(.027)		[.210]	
	1985:1	.918*	-.060	.956	7.167	--
		(.023)	(.037)		[.127]	
Australia	1979:1	.933*	-.026	.945	6.678	-9.608
		(.034)	(.028)		[.154]	
	1983:1	.932*	-.051*	.946	6.095	--
		(.031)	(.025)		[.192]	
	1985:1	.924*	-.025	.944	6.128	--
		(.029)	(.027)		[.190]	
Switzerland	1979:1	.863*	-.041	.862	6.934	-10.018
		(.046)	(.046)		[.139]	
	1983:1	.862*	-.086*	.860	7.750	--
		(.048)	(.044)		[.101]	
	1985:1	.862*	-.057	.857	9.346	--
		(.050)	(.041)		[.053]	
Sweden	1979:1	.733*	.006	.663	6.732	-10.297
		(.069)	(.046)		[.151]	
	1983:1	.745*	-.071	.662	8.670	--
		(.061)	(.043)		[.070]	
	1985:1	.751*	-.095	.661	8.087	--
		(.063)	(.058)		[.088]	
Norway	1979:1	.808*	-.016	.728	6.135	-11.322
		(.061)	(.037)		[.189]	
	1983:1	.791*	-.106*	.724	5.734	--
		(.057)	(.040)		[.220]	
	1985:1	.750*	-.397*	.722	5.417	--
		(.067)	(.110)		[.247]	

Table 3b (cont)
INFLATION PERSISTENCE IN NON-EMS COUNTRIES, 1960-92[a]

(Dependent Variable = Δp_t)

Country	Break Point	Regressors		R^2	LM4	Unit Root Test
		Δp_{t-1}	Δp_{t-1}*EMS			
Finland	1979:1	.864*	-.057	.770	7.054	-11.458
		(.043)	(.043)		[.133]	
	1983:1	.834*	-.153*	.777	7.523	--
		(.048)	(.056)		[.111]	
	1985:1	.846*	-.284	.772	8.593	--
		(.046)	(.082)		[.072]	
New Zealand	1979:1	.922*	-.007	.932	9.594	-9.386
		(.028)	(.031)		[.048]	
	1983:1	.930*	-.065	.935	8.8823	--
		(.024)	(.052)		[.066]	
	1985:1	.924*	-.037	.934	9.386	--
		(.026)	(.063)		[.052]	

Notes:

[a] P is the log of the consumer price index. Changes are relative to the same quarter, previous year. For sources and data details see the data appendix. Heteroskedasticity-consistent White standard errors are in parenthesis. * denotes significance at the 5% level.

[b] All regressions include more than one lag of the dependent variable among the regressors, as required to eliminate residual autocorrelation. The precise number of lags are the following: U.S. (4), Canada (4), Australia (4), Switzerland (4), Sweden (4), Norway (3), Finland (3) and New Zealand (4). The coefficients reported in the table represent the sum of the coefficients on the individual lags (the equation was reparametrized accordingly using second-differences). The regressors also include a constant term and an interaction between lagged inflation and a dummy for the Bretton Woods period. Thus, the coefficient on Δp_{t-1} presented in the table reflects the persistence coefficient for the 1968-79 period. The Bretton Woods dummy is equal to 1 for the 1960:1-67:4 period, and is set to 0 starting with the demonetization of gold and the devaluation of sterling in 1968:1.

[c] This reflects a "flexible" break point. The structural shift dummy is set to equal 1 starting with the break point noted in this column.

[d] LM4 = Lagrange multiplier test for up to fourth-order residual autocorrelation. Distributed as a $\chi^2(n)$, where n equals the number of lags. P values are in brackets. Unit root test is the augmented Dickey-Fuller test for unit root of the residual.

Table 4

MEANS OF THE INFLATIONARY PROCESS, EMS MEMBERS AND NON-MEMBERS

Country	μ^{FLEX}	μ^{EMS}
EMS Members		
France	0.077	0.037
Italy	0.130	0.057
Belgium	0.066	0.034
Ireland	0.115	0.055
Netherlands	0.051	0.022
Denmark	0.082	0.043
Germany	0.041	0.022
United Kingdom	0.089	0.034
Spain	0.087	0.059
Non-Members		
U.S.	0.061	0.048
Canada	0.071	0.092
Australia	0.089	0.064
Switzerland	0.051	0.039
Sweden	0.071	0.073
Norway	0.073	0.067
Finland	0.096	0.067
New Zealand	0.103	0.094

Notes: Following the notation used in eq. (1), the mean of the inflationary process (μ) can be calculated from the estimatad coeficients ρ_0 and ρ_1 according to:

$$\mu = \frac{\rho_0}{(1-\rho_1)}$$

Table 5

INFLATION PERSISTENCE, PANEL EQUATIONS
1960-92

(Dependent Variable = Δp_t)

Regressors	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta p_{t-1} * EMS_{it}$	.972*	.957*	.956*	.957*	.947*	.940*
	(.007)	(.009)	(.006)	(.008)	(.005)	(.009)
$\Delta p_{t-1} * NON\text{-}EMS_{it}$	.972	.975	.956	.965	.949	.964
	(.006)	(.009)	(.006)	(.008)	(.006)	(.008)
$\Delta p_{t-1} \cdot EMS79_{it}$	-.013*	-.023	--	--	--	--
	(.006)	(.019)				
$\Delta p_{t-1} \cdot NON\text{-}EMS79_{it}$	-.021*	-.021*	--	--	--	--
	(.008)	(.008)				
$\Delta p_{t-1} \cdot EMS83_{it}$	--	--	-.072*	-.082*	--	--
			(.012)	(.012)		
$\Delta p_{t-1} \cdot NON\text{-}EMS83_{it}$	--	--	-.065	-.062	--	--
			(.010)	(.010)		
$\Delta p_{t-1} \cdot EMS85_{it}$	--	--	--	--	-.075*	-.090*
					(.018)	(.019)
$\Delta p_{t-1} \cdot NON\text{-}EMS85_{it}$	--	--	--	--	-.046	-.041
					(.011)	(.011)
Fixed Effects	no	yes	no	yes	no	yes
F-stat for HO: EMS=NON-EMS	0.60 [.43]	1.39 [.24]	0.21 [.65]	1.55 [.21]	1.80 [.18]	4.65 [.03]
No. Obs.	2159	2159	2159	2159	2159	2159
F-stat	8987.6	1508.5	7661.4	1594.7	7354.4	1547.4

Notes:
* EMS_{it} = 1 ($NON\text{-}EMS_{it}$ = 1) if i is in the EMS (not in the EMS) at time t. EMS79 (NON-EMS79) = EMS (NON-EMS) * dummy which takes the value 1 for the 1979:1-1992:4 period. EMS83 (NON-EMS83) = EMS (NON EMS) * dummy which equals 1 for the 1983:1-1992:4 period. The equation also includes a constant and an interaction term between lagged inflation and a dummy for the Bretton Woods period.

Table 6
CREDIBILITY AND INFLATION PERSISTENCE

Country	Eq. 1			Eq. 2		
	β_1	γ_0	γ_1	β_1	γ_0	γ_1
France	.981* (.024)	-.151* (.050)	-.030* (.010)	.991* (.020)	-.021 (.017)	-.042* (.010)
Italy	.975* (.039)	-.081* (.046)	.050 (.024)	.960* (.024)	-.016 (.022)	-.036* (.016)
Belgium	.954* (.039)	-.005 (.032)	-.034 (.027)	.960* (.023)	-.024 (.027)	-.037 (.031)
Ireland	.943* (.039)	.008 (.047)	-.097 (.082)	.945* (.029)	-.075* (.030)	-.066* (.024)
Netherland	.928* (.024)	-.056* (.039)	-.021 (.041)	.933* (.030)	-.041 (.030)	-.181* (.083)
Denmark	.855* (048)	-.155* (.079)	-.017* (.008)	.872* (.043)	-.043 (.057)	-.035* (.011)
U. K.	.940* (.040)	-.276* (.063)	-.143* (.080)	.948* (.027)	-.048* (.030)	-.066* (.032)
Spain	.929* (.032)	-.093 (.070)	-.002 (.011)	.948* (.026)	-.049* (.027)	-.016 (.013)

Notes:

(a) The estimated equations are of the form:

$$\Delta p_t = \beta_0(\Delta p_{t-1} * BW) + \beta_1 \Delta p_{t-1} + (\gamma_0 + \gamma_1 c_t)(\Delta p_{t-1} * EMS) + v_t$$

where p_t is defined as in Table 3, BW=1 for the Bretton Woods period, EMS=1 for the EMS period, and c_t is the proxy variable for credibility, defined as in note (b).

(b) Equation 1 defines the proxy for the credibility variable as the negative of the long-term interest rate differential relative to Germany. Equation 2 defines the credibility variable as in equations (4) and (5) in the text. The vector of "fundamentals" is assumed to include: lagged money growth, lagged values of the current account and the fiscal deficit (as % of gdp), the lagged real exchange rate, the unemployment rate, the change in the unemployment rate, dummies for exchange controls, the differential lagged once, and a time trend (see discussion in text). Equation 1 is estimated using OLS. Results listed under equation 2 were obtained through joint estmiation of expressions (4) and (5) in the text.

(c) Heteroskedasticity-consistent White Standard errors are in parenthesis. * denotes significance at the 5% level.

Table 7

CREDIBILITY AND INFLATION PERSISTENCE, PANEL EQUATIONS
1960-92

(Dependent Variable = Δp_{it})

Regressors	(1)	(2)	(3)	(4)
Δp_{it-1}	.963*	.959*	.961*	.956*
	(.006)	(.007)	(.006)	(.007)
$\Delta p_{it-1} \cdot EMS_{it}$	-.033*	-.029*	-.027*	-.028*
	(.013)	(.013)	(.008)	(.008)
$\Delta p_{it-1} \cdot EMS_{it} \cdot c_{it}$	-.003*	-.002*	-.019*	-.019*
	(.001)	(.001)	(.005)	(.006)
Fixed Effects	no	yes	no	yes
R^2-adjusted	.929	.928	.930	.929

Notes:

a The estimated equations are of the form:

$$\Delta p_{it} = \beta_0(\Delta p_{it-1} \bullet BW_{it}) + \beta_1 \Delta p_{it-1} + (\gamma_0 + \gamma_1 c_{it})(\Delta p_{it-1} \bullet EMS_{it}) + \mu_i + v_{it}$$

where p_{it} is defined as in Table 3, BW=1 for the Bretton Woods period, EMS=1 for the EMS period, c_{it} is the proxy variable for credibility, defined as in note (b), and μ_i is a country fixed-effect.

(b) Equation 1 defines the proxy for the credibility variable as the negative of the long-term interest rate differential relative to Germany. Equation 2 defines the credibility variable as in equations (4) and (5) in the text. See notes at the bottom of Table 6 for details.

FIGURE 1

SACRIFICE RATIOS EMS Vs. NON–EMS

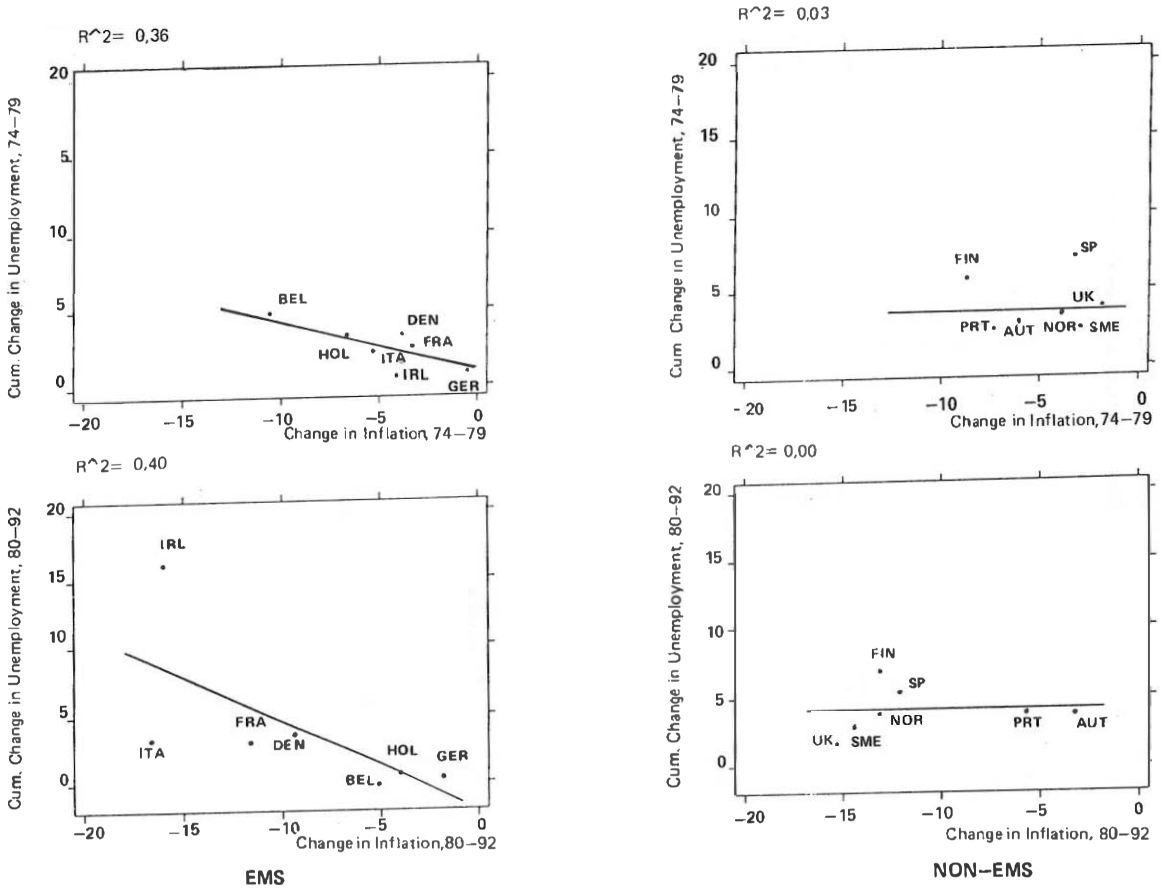


FIGURE 2

SACRIFICE RATIOS, ALL EMS MEMBERS

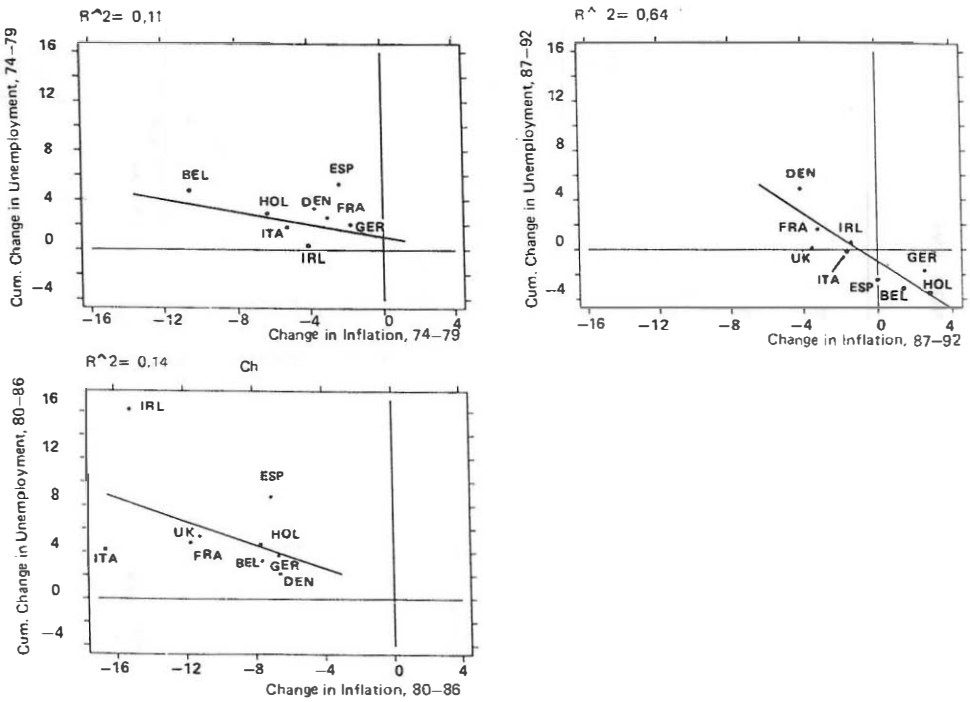


FIGURE 3

LONG–TERM INTEREST RATE DIFFERENTIALS VS. GERMANY

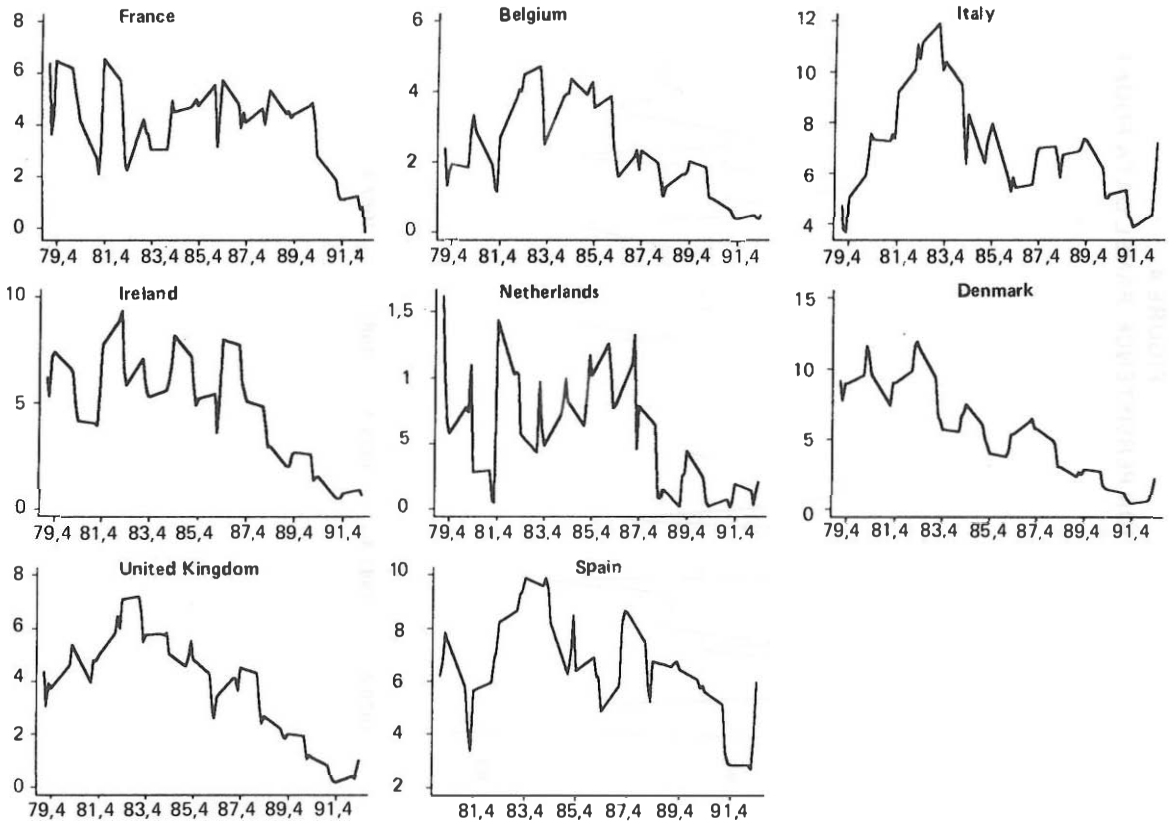
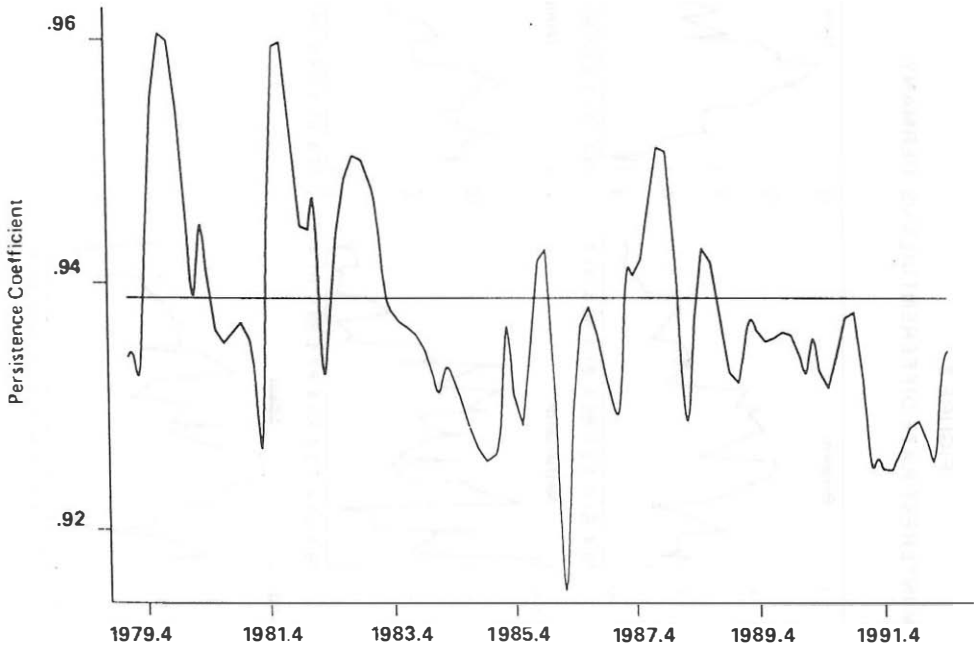


FIGURE 4
INFLATION PERSISTENCE, PANEL DATA EQUATIONS



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