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Evaluating the EMS and EMU Using Stochastic Simulations: Some Issues 1/

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Abstract

Evaluations of European monetary integration using model simulations have given conflicting results, and the paper attempts to elucidate the reasons for the differences. Several features stand out: how to model realignments; how monetary policy is set for individual countries or for Europe; and how large are risk premium shocks in exchange markets. We quantify the effects of different assumptions relating to these features using MULTIMOD.

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Summary

Since the Delors Report was published in April 1989, a lively debate has ensued about the costs and benefits of economic and monetary union (EMU) in Europe. The EC Commission's study on monetary union, "One Market, One Money," which used stochastic simulations of the IMF's MULTIMOD model to compare variability of output and inflation under different exchange rate arrangements, was sanguine about the favorable effects of monetary union. Their simulations suggested that although the European Monetary System (EMS) of the mid-1980s produced more output variability (but less inflation variability) than freely floating rates, the evolving EMS and, even more so, EMU would produce improvements in both output and inflation variability for the EMS countries taken together.

This study was, however, criticized by Patrick Minford and collaborators, who presented their own simulations of the operation of the EMS and of monetary union, using a different model, the Liverpool World Model. They concluded that EMU is unambiguously bad for the United Kingdom, and also bad for the other three major EC countries if the United Kingdom joins. Especially where the EMS countries pursue monetary targets (either independent targets, as under floating, or a joint target, as would be the case in EMU), floating dominates monetary union. They criticize the EMS even more strongly; it is destabilizing, and the system itself is subject to instability, which throws doubt on whether it can survive in its current form.

This paper attempts to understand the sharply contrasting conclusions of these two significant model simulation studies of monetary union. Its major conclusion is that the EMS seems to be much less of an engine of instability than is implied by the studies of Minford and associates. At the same time, the paper does not, on the basis of stochastic simulations that admittedly account for only a limited set of factors, find a strong case for EMU.

The differences in findings seem to relate to fairly arbitrary choices in modeling realignments and in estimating the size of risk premiums in foreign exchange markets. On the one hand, the treatment of realignments by Minford and associates appears to account for the instability in their results. The paper does not find their choice of the rule as a description of how the EMS actually operates to be particularly convincing. Moreover, the fact that the rest of the world seems to be equally, or even more severely, affected by the EMS than the member countries themselves throws doubt on their results. On the other hand, the EC Commission's method of estimating risk premiums produces much larger gains from EMU than those obtained using other methods. It may well be, however, that existing econometric models are not well suited to capture the advantages of a common currency insofar as they do not capture the saving of transactions costs and the anti-inflationary discipline resulting from a multilateral central bank.

I. Introduction

Since the Delors Report was published in April 1989, a lively debate has ensued about the costs and benefits of economic and monetary union in Europe (EMU). However, relatively little has been done using empirically-based macroeconomic models to evaluate the economic performance of monetary union relative to alternatives of floating exchange rates or the EMS as it currently operates, with occasional realignments. A notable exception was the EC Commission's study on monetary union: "One Market, One Money" (European Economy, No. 44, October 1990), which used stochastic simulations of the IMF's MULTIMOD model to compare variability of output and inflation under different exchange rate arrangements. This study was however criticized by Patrick Minford and Anupam Rastogi. 1/ In a series of papers, Minford and collaborators have presented their own simulations of the operation of the EMS and of monetary union, using a different model, the Liverpool World Model.

The EC Commission was sanguine about the favorable effects of monetary union: their simulations suggested that though the EMS of the mid-1980s produced more output variability (but less inflation variability) than freely floating rates, the evolving EMS and, even more so, EMU, would produce improvements in both output and inflation variability for the EMS countries taken together. The favorable overall result was only tempered by the fact that not all countries would necessarily improve both inflation and output variability when moving to a (symmetric) EMU; 2/ for instance, both German and Italian GDP exhibited higher variability than under freely floating exchange rates (though inflation variability was lower for both countries).

In contrast, MR (1990) concluded that EMU is unambiguously bad for the United Kingdom, and also bad for the other three major EC countries if the U.K. joins. Especially in the case where the EMS countries pursue monetary targets (either independent targets as under floating or a joint target, as would be the case in EMU), floating dominates monetary union. MRHH (1991) go further and say "...if exchange rate stability is of no consequence, then EMU is unattractive. Such gains as EMU contributes in macroeconomic stability overwhelmingly consist in greater exchange rate stability" (p. 21). The EMS is criticized even more strongly; it is destabilizing, and the system itself is subject to instability which throws doubt on whether it could survive in its current form (Hughes Hallett, Minford, and Rastogi, 1993).

The current paper attempts to understand the difference between the conclusions reached by the two sets of studies. We focus on several aspects that seem to be crucial for the simulation exercise: (i) how to model the

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1/ Initially, in Minford and Rastogi (1990)--MR (1990) for short; and subsequently in Minford, Rastogi, and Hughes Hallett (1991), or MRHH (1991).

2/ That is, EMU in the context of Europe-wide targets for monetary policy, as opposed to an asymmetric EMU in which Germany sets monetary policy for Europe.

EMS (in particular, realignments); (2) how monetary policy would be determined in EMU; and (3) what structural changes would result from EMU--in particular, how to estimate the effects of reductions in the risk premia in interest rates. Some of these methodological issues have already been raised by the EC Commission (1990), Minford and Rastogi (1990), and Emerson and Italianer (1990), but it may be useful for participants in the debate to get an outsider's view. Since we are able to redo the simulations on MULTIMOD, we may be able to discover how much of the difference in results is due to different assumptions or to different models. 1/ We also raise the issue of what the criterion for evaluating EMU relative to alternatives should be: do national inflation rates matter, or just EC-wide inflation?

Since agreement was reached at Maastricht in December 1991 to proceed to full monetary union, 2/ it may be thought that the costs and benefits of monetary union are largely an academic question at this point. Even if this were true, the methodology would have wider application, and might have practical interest for evaluating other monetary unions--among the former Soviet republics, for instance--or other countries wanting to join EMU (including the United Kingdom). But more than this, the variability of output and inflation when monetary union is achieved in Europe might have implications for other macroeconomic policies, even if national exchange rate policies were no longer at issue. In particular, how to run EC monetary policy still has to be determined--subject to the general objective of price stability--and national fiscal policies may have to be operated with more flexibility to compensate for constraints on monetary policies. 3/

II. Methodology

1. Stochastic simulations

The method of stochastic simulations was used both by the EC Commission and by Minford and his associates; it is also used in the results presented below. This method, since it is familiar, can be briefly described. 4/ A model, with estimated parameters, contains behavioral equations for private sector variables, including exchange rates, as well as variables for policy instruments, which may or may not be endogenous. The purpose of the exercise is to see to what extent different policy rules for the instruments

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1/ We are not able to simulate the Liverpool World Model, however, so we cannot replicate the EC Commission's methodology on that model. A further caveat is that MULTIMOD has evolved somewhat since the version used by the Commission.

2/ By the 11 of the 12 EC countries--with the United Kingdom able to "opt out."

3/ See Masson and Mélitz (1991) and Hughes Hallett and Vines (1991).

4/ A more complete description is given in the Appendix to Frenkel, Goldstein, and Masson (1989), hereafter abbreviated FGM (1989) and in Masson and Symansky (1993).

affect the variability of macroeconomic variables such as output and inflation. Stochastic simulations assume that the error terms in behavioral equations are drawn from a given joint distribution--usually that estimated from historical data. In order to evaluate the policy rules, repeated drawings are made from that distribution, so that the policies are evaluated on the basis of the variance across drawings of the variables of interest. 1/ This variability is calculated relative to a baseline path--in particular, the model's solution with errors set to zero. 2/ Policies are judged more desirable, the more effective they are at stabilizing target variables around baseline paths. 3/

While the general method is not contentious, 4/ there are at least two aspects as it applies to EMU that are: how to estimate the historical covariance matrix of the errors, and what measure of variability to use to evaluate the outcomes.

a. Risk premiums

Risk premium estimates are important because by moving to a single currency (and hence removing exchange rate risk between the EMU countries), 5/ EMU will change the error covariance matrix by eliminating risk premium shocks to interest parity. 6/ The covariance matrix emerges straightforwardly from the estimation of behavioral equations that do not

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1/ The model contains expectations variables that are consistent with the model's solution in the absence of shocks, but these expectations may be falsified by errors in subsequent periods. A drawing for the errors in period t is made, the model is solved forward to calculate model-consistent expectations, then a drawing for the errors in period t+1 is made, and so on.

2/ More properly, the mean path of the endogenous variables when a large number of drawings is made for the errors. In practice, this path is likely to be well approximated by the deterministic simulation with errors equal to zero.

3/ In principle, the level of variables would also be of interest; for instance, lower inflation might permanently raise output above its baseline value. However, most models do not incorporate such linkages; instead, inclusion of the inflation rate in the objective function is intended to capture them in an ad hoc way.

4/ There is, of course, the objection that the model may not be "structural," in the sense of not invariant to the policy rule, and hence open to the Lucas (1976) critique. McCallum (1992) also argues that the assumption that rules aim at baseline paths for target variables may give misleading results.

5/ EMU does not remove all exchange rate risk; there is still risk between the ECU and the currencies of the non-EMU countries. MULTIMOD expresses the exchange rate risk relative to the dollar, so the equations for EMU countries were rewritten relative to either the mark (for asymmetric EMU) or the ecu (for the symmetric system).

6/ Provided there are no differential credit risks.

have expectational variables. The real problem concerns the interest parity condition, which does not contain parameters to estimate, but in which shocks may be present that reflect "risk premia." Uncovered interest parity between Germany and another EMS country can be written as follows:

$$R = R_G + E^e - E + u, \quad (1)$$

where R is the domestic interest rate (a G subscript indicates a German variable), E the log of the exchange rate (e.g., FF/DM), an "e" superscript indicates the expectation of next period's value, and u is a risk premium shock.

The significance of risk premium shocks to the evaluation of EMU comes from the fact that when realignments are ruled out (and even more clearly, when there is just a single currency), the risk premium shocks between European currencies simply disappear. Therefore, monetary union reduces an element of uncertainty, which is larger or smaller depending on how large those shocks are judged to have been historically. The problem is however that expectations of the exchange rate are not observable, so that we cannot distinguish ex post deviations from uncovered interest parity from expectations errors--i.e., making a wrong forecast of the exchange rate.

The EC Commission (1990) gives a cogent account of four possible strategies for estimating those shocks (here R^* is the U.S. interest rate).

(a) Use the actual exchange rate next period (call it E(+1)) in place of its expected value, and calculate u as

$$u = R^* - R - E(+1) + E.$$

(b) Assume that expectations are governed by the hypothesis of a random walk, so that the interest differential itself represents a risk premium: 1/

$$u = R^* - R.$$

(c) Use the model to solve for E^e, and calculate u accordingly.

(d) Use a small, partial model to generate E^e such that it is consistent with gradual adjustment to an assumed value for the long-run real interest rate.

1/ This assumption was made by Masson and Symansky in the stochastic simulations of MULTIMOD reported in Bryant and others, eds. (1993).

The EC Commission chooses option (d), after pointing out some of the pitfalls associated with the other options. Minford and Rastogi (1990) also strongly reject options (a) and (b), the first as wrong and the second because it is inconsistent with MULTIMOD, but they criticize the Commission for choosing (d) on the grounds that it is also inconsistent with MULTIMOD. Furthermore it gives shocks which Minford and Rastogi consider "strain credulity" because they are so large--standard deviations of 5 to 11 percent. According to them, the closest to being correct is option (c).

We disagree that option (c) is the correct one in principle, and in practice implementing it involves formidable difficulties. To use the model to disentangle historical expectations errors from risk premium shocks requires that expectations of all the exogenous variables be specified over a sufficiently long horizon that terminal conditions on the jumping variables (i.e., exchange rates, interest rates, inflation, human wealth, and the market value of the capital stock) have no significant effect. Since the model includes government spending, oil prices, monetary targets, etc., as exogenous variables, all these variables would have to be modeled for each country--pushing the needed inputs to the exercise into higher dimensions of complexity. Obviously it is not enough simply to assume that expectations of exogenous variables are the same as their ex post outcomes; this simply shifts the mistake of option (a) onto another set of variables.

Instead of estimating models of the exogenous variables, our preferred approach is to use time series models to proxy exchange rate expectations, ensuring that expectations are consistent with the historical data in at least a rough sense. Such a method is analogous to an instrumental variable approach to estimation. 1/ The issue is not model consistency; it is rather to get reasonable empirical estimates of the size of the risk premiums. As Svensson (1991) argues, even with a large coefficient of relative risk aversion, risk premia would be only a small fraction of interest differentials. Since the latter are in the order of only a few percentage points within the EMS, the EC Commission's estimates seem much too large.

We therefore agree with Minford and Rastogi (1990) that these risk premium shocks are unreasonably large, but disagree that option (c) is the correct method. Getting a reasonable empirical estimate was the rationale for the random walk assumption of (b); in fact in FGM (1989) time series model were identified, and not surprisingly (given what we know, e.g., from Meese and Rogoff, 1983), a unit autoregressive (i.e., AR(1)) coefficient, or something near it, describes the exchange rate data well. 2/ For exchange rates, it would therefore be unrealistic to assume that market forecasts are very different from the current rate, if one is considering a short-term horizon (one year in MULTIMOD). The fact that these forecasts are very

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1/ Because of the size of MULTIMOD and the number of exogenous variables, full information estimation methods are not possible.

2/ For the other variables for which expectations need to be generated, e.g. short-term interest rates, we estimated more complicated AR models.

different in the Commission study--the result of using option (d)--explains the very large risk premium errors that they find. What is needed are estimates of the shocks that are consistent with the historical data, and a generalized option (b) seems to us the best way of achieving this. We will consider below, in Section IV, how the size of the estimates of risk premium shocks affects estimated gains from EMU.

b. Measuring variability

The second important issue in evaluating EMU is what measure of variability to use. Essentially, this amounts to asking what is the appropriate objective function (though in this paper we do not assume anything about the relative importance of output versus inflation variability). The issue is whether we care about the variance of European aggregates (whatever their variability across countries) or rather about the variability of each country's variable.

This issue does not seem to have received any attention in the literature. 1/ Welfare evaluations usually assume that the European objective function is a simple average of each country's objective function, which is typically quadratic in deviations from target (see, e.g., HHMR 1991). For instance, if each country's objective function is

$$L_i = E\{(q_i)^2 + \alpha(\pi_i)^2\} \quad (2)$$

(where E is the mathematical expectation) and the global welfare function is

$$G = L_1 + L_2, \quad (3)$$

then the global objective function is a simple weighted average of the variability of national output and inflation in the two countries:

$$G = E[(q_1)^2 + (q_2)^2] + \alpha E[(\pi_1)^2 + (\pi_2)^2] \quad (4)$$

This is the procedure followed by Minford and associates, and also implicitly by the EC Commission, since they calculate European variability by weighting together mean square deviations from baseline of each country's variable, and taking the square root of the result.

While this seems plausible for output, it does not make as much sense for inflation. In a single currency area, changes in relative prices should

1/ However, Hughes Hallett and Vines (1991) in their evaluation of EMU assume that national objective functions change.

not matter in themselves, if they do not have harmful real effects. On the contrary, relative price changes are necessary for real adjustment. In the long run, all regions will share the same rate of inflation, which will be the result of the currency area's common monetary policy. The distribution of money balances across regions will be endogenous, as will be movements in relative prices. It is the overall inflation rate and its variance in the face of shocks that are the source of important welfare costs. Just as there would only be a single money target in a currency union, there would likely only be a single objective for inflation--although the Maastricht Agreement does not specify how "price stability" should be defined. Flexibility of prices across regions in response to asymmetric shocks would be a desirable feature because it would facilitate adjustment--provided the overall inflation rate was not affected.

This reasoning suggests that the proper variability measure is $E[(\pi_1 + \pi_2)/2]^2$, the variability of European inflation, which depends on the covariances between inflation rates in the following way:

$$E[(\pi_1 + \pi_2)/2]^2 = [E(\pi_1)^2 + E(\pi_2)^2 + 2\mathrm{cov}(\pi_1, \pi_2)]/4$$

Exchange rate changes between EMS currencies due to risk premium shocks tend to induce a negative covariance, lowering the variability of aggregate EC inflation. EMU, by eliminating those exchange rate changes, may not therefore reduce this measure of inflation variability as much as the average of national inflation variances.

In the simulations presented below in Sections III and IV, we therefore use a hybrid set of measures for European variability: for output, we calculate an average of each country's root mean square errors, since it matters whether some countries are adversely hit even if others benefit. For inflation, in contrast, we report the variability of European inflation, calculated as the variability of a GDP-weighted average of the constituent countries' inflation rates (or equivalently, the variability of the change in the European price level). In Section IV, we consider the effect of using other criteria.

Furthermore, the choice of what variables to use in evaluating different regimes is obviously important. To quote HHMR (1993, Appendix), who calculate welfare functions that depend on various combinations of output, the price level, real interest rates, the real exchange rate, and money supply growth: "What this shows is that the evaluation of EMS regimes is extremely sensitive to weights on preferences." An alternative approach, followed by the EC Commission (1990) is to cite RMSE values for a large set of variables, and allow the reader to impose his preferences. 1/ In what follows, for conciseness we present graphs of output and inflation

1/ HHMR (1993) also give the components of their calculations.

variability (calculated as described above), but details on other variables are available in the appendix.

2. Modeling monetary policy

Important issues are the choice of the baseline rule for monetary policy and how to model it in the EMS and EMU. These choices are critical from a number of aspects. First, the benchmark of floating exchange rates requires an anchor for monetary policy: is this a money target or a target for nominal income, for instance, or rather the optimal uncoordinated setting of a monetary instrument, leading to a Nash equilibrium as each country optimizes independently? Second, since there are margins of fluctuations for exchange rates within the EMS, monetary policy is only constrained when obliged to defend the band: what does it do within the band? Finally, EMU requires a rule for European monetary policy, which can range over a number of alternatives, just as it can for an individual country operating a floating exchange rate. It is conceivable that EMU might be better than floating for one intermediate target, but worse for another.

The various studies differ in the choice of monetary policy assumptions. MULTIMOD has, in its standard version, the default assumption that countries target base money, but in such a way that they smooth interest rate fluctuations (otherwise, an attempt to hit money exactly each period might provoke large fluctuations in rates). 1/ Such a rule for monetary policy is assumed to apply to each of the industrial countries, except for those in the EMS; the latter are assumed to change interest rates in order to resist movements away from their central parities against the deutsche mark, while Germany targets base money.

The EC Commission chose a different intermediate target, namely a modified form of nominal income targeting in which the target depends on the rate of inflation (not the price level) and the log of output relative to its baseline level. Moreover, a greater weight was put on inflation (2.0) than on output (0.4). The use of inflation was justified by the argument that central banks do not care about the price level per se and hence do not try to roll back past price increases.

In MR (1990) and Hughes, Hallett, Minford, and Rastogi (1991a, 1991b), two alternatives are given with respect to monetary policies. In the first, there is a fixed target for the money supply, which is hit exactly (the fixed money case), while in the second, governments are assumed to set their money supplies in an optimal way in response to shocks (the strategic response case). Thus, in the latter case monetary policy is actively adjusted, at least in the case of floating rates. Under EMU, the European money supply is again alternatively forced to follow a fixed target or set

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1/ However, this is much less true in the current version of the model, in which money demand contains no lagged interest rate.

optimally to respond to shocks, while exchange rates among EC countries remain fixed.

In the simulations reported below, we alternatively assume a nominal income target or a money supply target. These targets apply under floating rates, under an EMS regime, and (for an EC-wide aggregate) under EMU. Using alternative targets helps in assessing the sensitivity of the results to the choice of intermediate target. We do not consider strategic responses by policymakers.

3. Modeling the EMS

How to model the existing EMS is important for judging whether the status quo is better or worse than EMU. There is a consensus for assuming that Germany sets monetary policy for the EMS; that is, either its money supply, value of nominal income, or optimal policy setting is taken as given by other countries, who must devote their monetary policy instruments to defending their parities vis-à-vis the deutsche mark (at least when the band is threatened). However, there are two major areas of disagreement: (a) how countries defend their parities, including the way monetary policy operates within the band; and (b) how realignments are modeled.

a. Intervention to defend the band

In the standard MULTIMOD (see Masson, Symansky, and Meredith, 1990), other EMS countries vary their interest rate or their money supply as a function of the deviation of the exchange rate from its central parity. The function chosen is a cubic, following Edison, Miller, and Williamson (1987), but rewritten in terms of the money supply (with the interest rate determined by the equality with money demand). The equation was rewritten in terms of deviations of the money supply from an exogenous target since this formulation permitted various alternative specifications to be nested in a common specification. In the model used in the simulations reported below, the monetary policy function (e.g., for France) is written

$$M - MT = a(E - E_p)^3, \qquad (5)$$

where M is the log of the French money supply, MT the log of its money target, a is a parameter, E is the log of the exchange rate (in FF per DM), and the "p" subscript refers to its central parity. 1/ In this formulation, there is no explicit band; however, choice of the value of "a" will determine how close the exchange rate stays to its parity, in the face of shocks. As it is currently parameterized in MULTIMOD, we have found that even in the face of sizable shocks, EMS exchange rates stay within about

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1/ It is assumed for convenience here that in the baseline, the exchange rate is always equal to its parity. Note that the notation here also differs somewhat from that used in MULTIMOD.

±1 percent of parity (which is consistent with the practice of some EMS countries, in particular Belgium and the Netherlands, to aim for smaller bands than the statutory ±2.25 percent that is mandated by commitment to the narrow band of the ERM). Equation (5) implies that the closer E is to its parity, the closer M will be to MT, that is, the more importance will be given to the domestic money target.

In EC Commission (1990), bands are also not explicitly defended, but a different function is used, in order to impose very strong nonlinearity beyond ±1 percent. This is also combined with a weight on the hybrid nominal income target described above, so that when the exchange rate is close to the center of the band, the monetary authorities set policy to aim at the domestic target. The resulting function is

$$R - R^b = 200[(E-E_p) + 2.1 \times 10^{18} (E-E_p)^{11}] + 100[2(\pi - \pi^b) + 0.4(q - q^b)] \quad (6)$$

where here, the interest rate is varied relative to its baseline value R^b, π is the rate of inflation and q is the log of output. Both rules (5) and (6) allow for intramarginal intervention.

Finally, Minford and associates assume that within the band, money is exogenous (when money is not adjusted strategically). They assume an explicit band, however, which has to be defended, and at the edge of the band, money becomes endogenous. It changes by whatever amount is necessary to prevent the exchange rate from going outside the band, and intervention only occurs at the edges of the band.

b. <u>Realignments</u>

The EC Commission and Minford and others differ fundamentally on how to model realignments--what triggers them and how the amount of realignment is determined. The EC Commission bases its model on historical experience of realignments in the 1985-87 period, during which the average size of realignments was 3.5 percent, and realignments offset about 50 percent of price differentials. Consequently, they assume that a realignment is triggered by an 8 percent overvaluation (or undervaluation) of price levels relative to Germany, but the size of the realignment against the DM is limited to 4 percent, and it occurs in the following period.

In contrast, Minford and others assume that realignments are triggered by the knowledge (assuming perfect foresight) that, in the absence of new shocks, the exchange rate, if it were flexible, would be outside of the band next period. However, parities have to be defended this period; there is a one-period lag in making the parity adjustment that has been decided. The amount of the realignment is the multiple of ±5 percent necessary to put the exchange rate back in the band next period, in the absence of future shocks (of course, new shocks next period may force the authorities to defend the new band by varying the money supply).

III. Simulating the Existing EMS

As discussed above, there is disagreement concerning how to model the current operation of the EMS, or at least, the EMS as it operated from the 1985-87. During the February 1987-August 1992 period, there were no realignments, while the operation of the ERM has been thrown into question by the September 1992 exchange market turmoil, which forced several realignments and the withdrawal of Italy and the United Kingdom from the ERM. However, understanding how the EMS operated in the past is still important.

Hughes Hallett, Minford and Rastogi (1991b) consider that the EMS induces instability, because realignments occur at discrete intervals, after potentially destabilizing attempts of monetary policy to prevent the exchange rate from going outside the band:

> The EMS is a system prone to acute instability in the face of shocks. Particularly vulnerable are the dependent-EMS countries. The reason for this instability seems to lie in the nonlinearity of the fixed-but-adjustable system's response to shocks, with large shocks creating a sharp response, and in deflationary circumstances the perverse trade-off in dependent-EMS countries inducing monetary over-reaction. (p. 92)

In contrast, the simulation results of the EC Commission show that the EMS reduces average inflation variability but increases average output variability of the EMS countries taken together. The reasons for the tradeoff in effects is described as follows in EC Commission (1990)--henceforth, ECC (1990):

> The reduction in inflation variability is the consequence of the reduction in asymmetric intra-Community exchange rate shocks and wage and price discipline effects... The increase in output variability is due to the constraint on monetary policy from the peg to the DM for the countries other than Germany. The wage and price discipline effects.... [are] apparently not large enough to compensate for the reduced room for manoeuvre in monetary policy, except in Germany... (p. 154)

All in all, however, the impact of the EMS relative to floating is not dramatic, unlike in HHMR (1991a, 1991b). In the stochastic simulations reported by the latter, welfare losses from the EMS under fixed money 1/ are many multiples of the welfare costs that shocks produce in a floating rate regime (see, for instance, their Table 2 on page 33 of HHMR, 1991a).

1/ This is the case we will discuss; the welfare losses under strategic policymaking are even larger.

Not only are EMS countries, except Germany (which has a small gain), dramatically worse off (especially the United Kingdom, with a multiple of 64.9), but the same is true of non-EMS countries, especially Canada, which has welfare costs under the EMS regime that are 169.9 times those under floating!

In order to understand the source of the difference in results, we simulated both sets of realignment rules with MULTIMOD, and compared the results, which are plotted in Chart 1 (a more complete set of variables is reported in Table 2 of the Appendix). This chart gives the two alternatives described above: (1) a 4 percent realignment is triggered by prices being out of line by 8 percent relative to Germany but is delayed until the next period (the EC Commission's rule); and (2) a realignment in multiples of 5 percent is triggered by a forward looking assessment of whether, given monetary policy, the exchange rate would be outside the band next period, but the realignment is also delayed until next period (the rule of Minford and associates). The chart also looks at the effect of not realigning at all--that is, of having fixed central parities with bands around them--and the effects of the band width 1/ on the variability of output and inflation. Obviously, the narrower the band width, the closer the regime with fixed parities resembles EMU, while the wider the bands, the closer it resembles freely floating rates.

It can be seen from Chart 1 that stochastic simulations of MULTIMOD strongly suggest that the instability found by HHMR is a result of their choice of realignment rule. For all EMS countries except Germany, output and inflation variability are dramatically higher when this rule is in place. It should be noted that we did not modify wage setting behavior to reflect anticipated devaluations, as did HHMR, but our inflation equation embodies a combination of forward- and backward-looking elements, 2/ so that when downward realignments are triggered, inflation is increased immediately, before the realignment occurs. It seems that even for the EC Commission's realignment rule, that effect produces the result that absence of realignments lowers inflation variability in all countries.

As to the effect of changes of the band width, differences are not dramatic although the wider band width dominates for all countries if there are no realignments. In principle, two effects are involved (the same as when considering the stabilization effects of a currency union): a narrower band enhances inflation discipline, while a wider band allows monetary policy greater flexibility to respond to shocks. In these simulations, however, we keep the money supply exogenous within the band (i.e., unless the exchange rate threatens to go outside it), so that the latter effect only operates through the mechanism that a change in real income and prices

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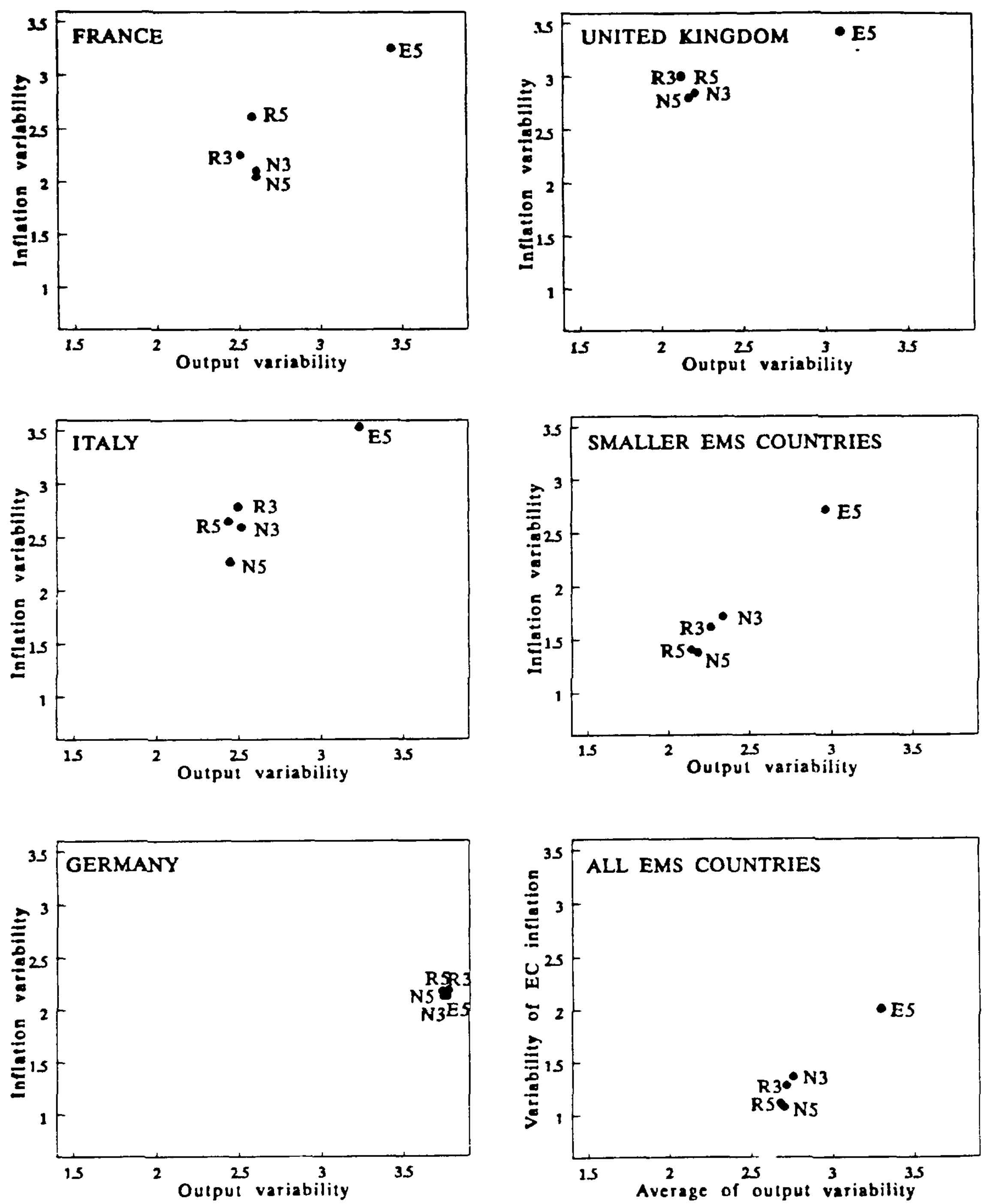
1/ The band widths--3 and 5 percent on either side of the central parity--are meant to be illustrative. They were chosen to be the same as in HHMR, rather than to conform to the existing narrow or wide bands of the ERM, respectively ± 2.25 and ± 6 percent.

2/ See Chadha, Masson, and Meredith (1992).

Chart 1

Realignment Rules, when Money is Exogenous within the Band



N3 = No realignment, 3% bands
N5 = No realignment, 5% bands
E5 = Equilibrium realignment next period, 5% bands
R3 = Real exchange rate trigger, 3% bands
R5 = Real exchange rate trigger, 5% bands

(for instance, due to a negative demand shock) will lower the demand for money, and hence allow lower interest rates. For all countries, a wider band when there are no realignments leads to somewhat lower output variability, but differences are small. When realignments are allowed the superiority of a wider band no longer holds. Only the smaller EMS countries 1/ and Italy are clearly better off with the wider bands.

As for effect on non-EMS countries, not reported in the chart, we found no evidence that the operating rules of the EMS (nor the choice of EMS countries between floating and EMU) had anything more than a trivial effect on their output and inflation variability (or on other variables). For instance, under floating rates and the various alternatives plotted in Chart 1, U.S. output variability was between 2.12 and 2.14, and U.S. inflation variability was between 1.38 and 1.39, while comparable ranges for Canada were 2.75-2.80 and 1.99-2.00, respectively. As one would expect, a monetary arrangement among European countries, which have the largest amount of trade among themselves, does not in itself seem to have major impacts on foreign countries. 2/

IV. Simulating EMU

In this section, we present our simulations of monetary union, and compare the resulting variability of output and inflation to their values under floating or the EMS. We consider two key aspects of the comparison, namely the assumption concerning the stance of monetary policy, and the method chosen to calculate the risk premium errors, discussed in Section II above. The studies by Minford and associates and by the EC Commission differ in these two aspects, and it is important to understand how they contribute to the difference in conclusions.

As is the case for the EMS, it is important to specify what is the default stance for monetary policy. MR (1990) and MRHH (1991) present two alternatives: money targets and "strategic money," that is, the choice of the optimal money supply setting in a Nash, noncooperative setting. The EC Commission uses nominal income, or, more precisely, a combination of inflation and output, with greater weight on the former (see Section II above). The simulations we have done with MULTIMOD assume either a money target (hit exactly period by period, rather than with smoothing of interest rates as in the published version of MULTIMOD, in order to be as close as

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1/ What we term "smaller EMS countries" are in fact the countries of the smaller industrial country block of MULTIMOD, so that some non-EMS countries are also included in this group.

2/ Other possible effects of EMU--also judged to be small by the EC Commission (1990) and Alogoskoufis and Portes (1992)--include international seigniorage and effects on the G-7 coordination process. These factors are in any case not considered in the stochastic simulations.

possible to other studies), 1/ or a nominal income target. In choosing the latter, instead of the EC's weighted average of output and inflation, we verified that simulations using either gave similar root mean square errors--so we are not deviating substantially from what the EC Commission did. Nominal income has the advantage of simplicity, and, for our model, gave much easier convergence to a solution--perhaps because a nominal anchor in the form of the level of prices or the money supply is necessary to prevent nominal variables from wandering off--i.e., being indeterminate in long-run equilibrium--as we have argued elsewhere, e.g., in FGM (1989).

Chart 2 gives a comparison of EMU with floating rates for European countries, under the alternative assumptions of money targets and nominal income targets; Table 3 of the Appendix provides more details. 2/ EMU is modeled as completely fixed rates among all EC countries, which we assume to be equivalent to a single currency. 3/ EMU is assumed to be a symmetric regime, in the sense that Germany no longer has a preponderant role in setting monetary policy. Instead, the European central bank targets a European aggregate, defined as either the aggregate monetary base of the member countries (whose demand is assumed to be consistent with aggregating existing money demand functions), or European nominal income calculated as the sum of national variables. The non-European countries are in each case assumed to target the monetary base, and to float their currencies.

Some care must be taken in interpreting the chart. While the comparison of EMU and floating is straightforward (for the same targeted variable, money or nominal income), comparison of money with nominal income targeting is sensitive to the choice of feedback parameter on the latter. The money supply in the simulations is equal to its target, but instrument instability prevents hitting a nominal income target exactly. Larger feedback parameters can achieve lower variability for output and inflation, but at the expense of much higher interest rate variability. However, we have verified that the ranking of EMU and floating under a nominal income target seems unaffected by the choice of feedback parameter.

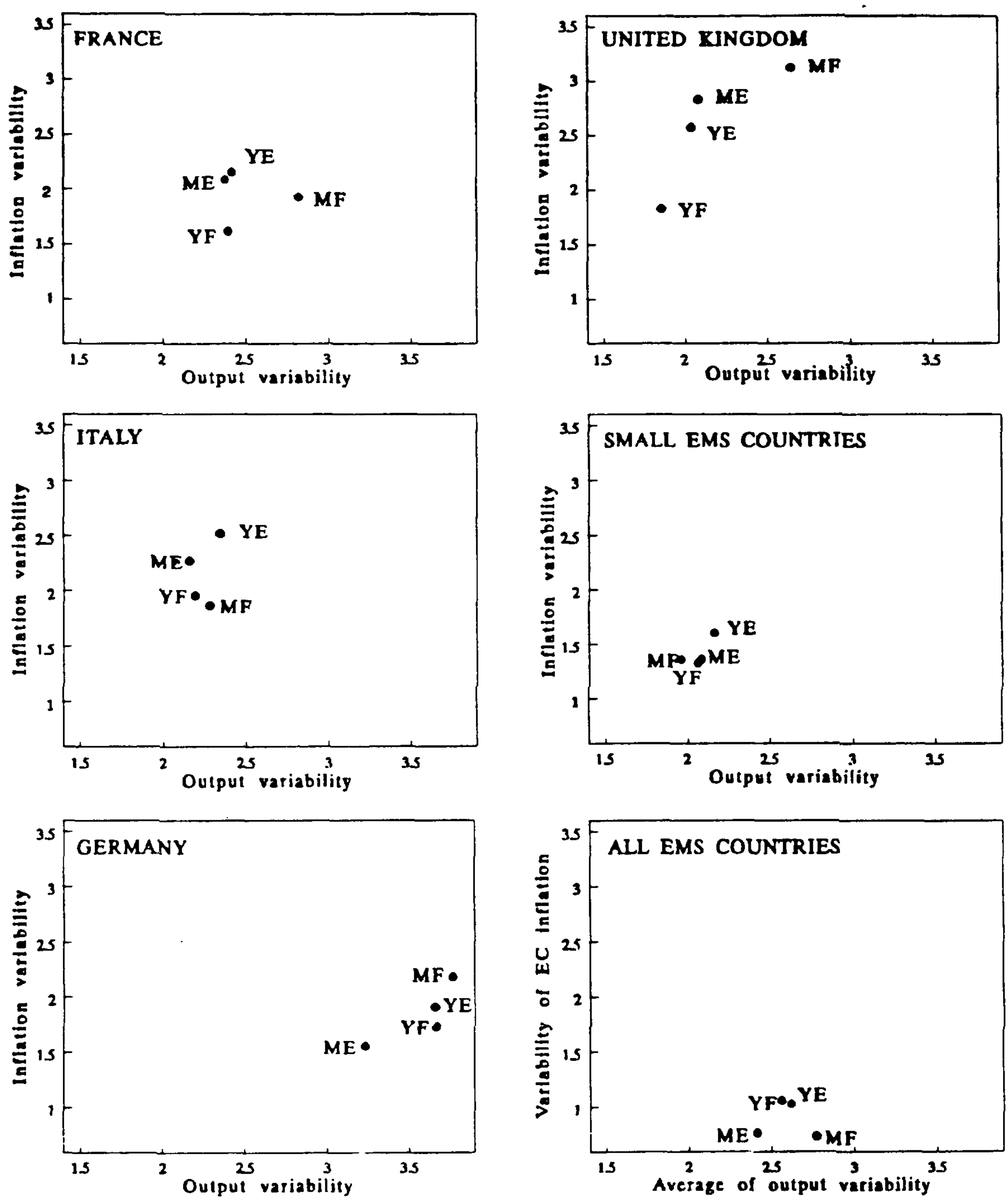
1/ Minford and Rastogi (1990) for instance state: "A systematic comparison with our results is difficult because the Multimod study takes interest rate reaction functions as given, whereas we assume money supplies as given under 'fixed money' ... " (p. 59)

2/ The parameters for the nominal income rule used in this paper were made as close to the EC Commission values as possible. However, with real income and inflation targets their parameterization did not always converge and we therefore used somewhat smaller reaction coefficients. The same feedback coefficient was then used in the nominal income rule. It turned out that a substantially larger coefficient (by a factor of 10) could have been used for targeting nominal income. It should be noted that the EC Commission reduced the size of their shocks by a factor of 10 in order to do the simulations--perhaps an indication of convergence problems when the larger shocks were used.

3/ There are of course other features of EMU, including savings of transactions costs, which are not captured by the model.

Chart 2

Money vs. Nominal Income Targeting, with Floating Rates or EMU



MF = Money target, floating rates
ME = Money target, symmetric EMU
YF = Nominal income target, floating rate
YE = Nominal income target, symmetric EMU

The chart suggests that the ranking of the regimes differs across countries: there is no obvious dominance of either EMU or floating over the other. Though the variability of European output and inflation is lowest under EMU with money targeting, the difference for Europe between floating and EMU with nominal income targeting is very small. This reflects our choice of measures for European variability, which imply a concern for individual countries' output fluctuations but only for aggregate European inflation variability. Floating rates give lower inflation variability than EMU under nominal income targets for every country (using national criteria), but for aggregate EMS inflation, the dominance of floating disappears. For one country, the United Kingdom, floating with nominal income targeting seems to give the best outcome in terms of both output and inflation variability--but floating with fixed money the worst.

To some extent (though not as concerns money, which they assume is the target), our results echo those of Minford and associates, who found that in some circumstance France, Germany and Italy would benefit from EMU, while the United Kingdom would not. 1/ However, we do not find, for the aggregate EC, that floating dominates under fixed money, contrary to MR (1990) or MRHH (1991). Though the numerical results in those two papers differ, they both report that under fixed money, floating gives a significantly lower welfare cost than EMU for an EC constituted of Germany, France, Italy and the U.K. 2/ On the contrary, we find that for money targeting, EMU would be preferred to floating. Since we do not calculate welfare function values, we present the variability of EC inflation, and we include smaller EC countries in our calculations, our results cannot be compared directly; 3/ however, it would seem that differences derive mainly from the models used (and their associated historical error distributions) rather than from the way monetary policy is specified.

If EMU does not seem to be clearly preferable to floating, how do we explain the strong EC Commission conclusions in favor of EMU? To elucidate this question, we present a range of simulations that includes the alternatives that are given prominence in their report. Their results indicate that for the EC as a whole, a move from floating to the mid-1980s version of the EMS led to lower inflation variability but somewhat higher output variability, but further moves to a tighter EMS and to EMU lead to

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1/ Our results with money targeting show that the United Kingdom benefits from EMU.

2/ In MR (1990), the comparison is of a welfare cost of 1.3 for floating and 2.3 for EMU (Table 1); in MRHH (1991), corresponding results are 3.0 and 4.8 (Table 2).

3/ Appendix B to MRHH (1991) does present welfare costs in terms of just two variables, output and the price level (not inflation), which gives welfare losses under EMU that are 4.3 times those under floating. Table 1 below presents results that come closer to those of MRHH since they are based on only the four major EC countries and include MRHH's measure of variability. Table 3 of the Appendix also provides individual country results in detail.

improvements in both dimensions, and results that dominate floating (Graph 6.10 of ECC, 1990, p.154, reproduced below as Chart 3).

In Chart 4, which presents our simulation results (and also Table 4 of the Appendix), there is no clear progression in terms of reduction in variability when moving from the EMS to monetary union. As in ECC (1990), two forms of monetary union are considered for illustrative purposes, (both use money as target, since it dominated nominal income for EMU in Chart 2): one in which Germany continues to set EC monetary policy (asymmetric EMU), and one in which a joint European target prevails (symmetric EMU). The latter does better than the former for all countries individually, and also for the aggregate--a result consistent with what the EC Commission found. However, contrary to their findings, for the aggregate of EMS countries floating dominates the EMS of the mid-1980s and both of these regimes dominate an asymmetric EMU. For the EC as a whole, however, floating does about as well as symmetric EMU in reducing the variability of aggregate EC inflation.

It is clear that for some shocks the differences in outcomes must be considerable, but on average there does not seem to be too great a difference among the four regimes in our simulations, using the historical distribution of shocks. This result seems somewhat surprising on the face of it, especially concerning inflation. But it must be recalled that there is nothing in the model that captures the "monetary discipline" argument in favor of either the EMS or EMU, because under all regimes, monetary targets are assumed to be consistent with the same long-run rate of inflation. As discussed above, the levels of variables (including inflation) are not assumed to be affected by the stochastic shocks, and the stance of monetary policy is not tighter on average in one regime than in another. We suggest that this possibility is no doubt an important feature of EMU, but more in the realm of political economy, and one that depends importantly on the incentives facing those who will run the new European Central Bank. 1/ It is not, to our knowledge, captured in simulations reported by either the EC Commission or Minford and associates.

How then to square our results with the large gains from EMU found by the EC Commission? To understand the role of the risk premium shocks and the measurement of variability, we present some alternative calculations in Table 1 that are closer conceptually to those of the EC Commission. For the risk premium, we compare our estimates (which use the predictions of a random walk model for the exchange rate, and which are labeled "method b" in the Table), with the estimates of the EC Commission for those shocks, labeled "method d" (see Table E.7 of ECC, 1990, p. 321). It can be seen that the standard deviations of the latter are several times those used in our simulations.

In order to see the effect of the larger shocks, we simulate floating and EMU, assuming money supply targets, with errors drawn from these two

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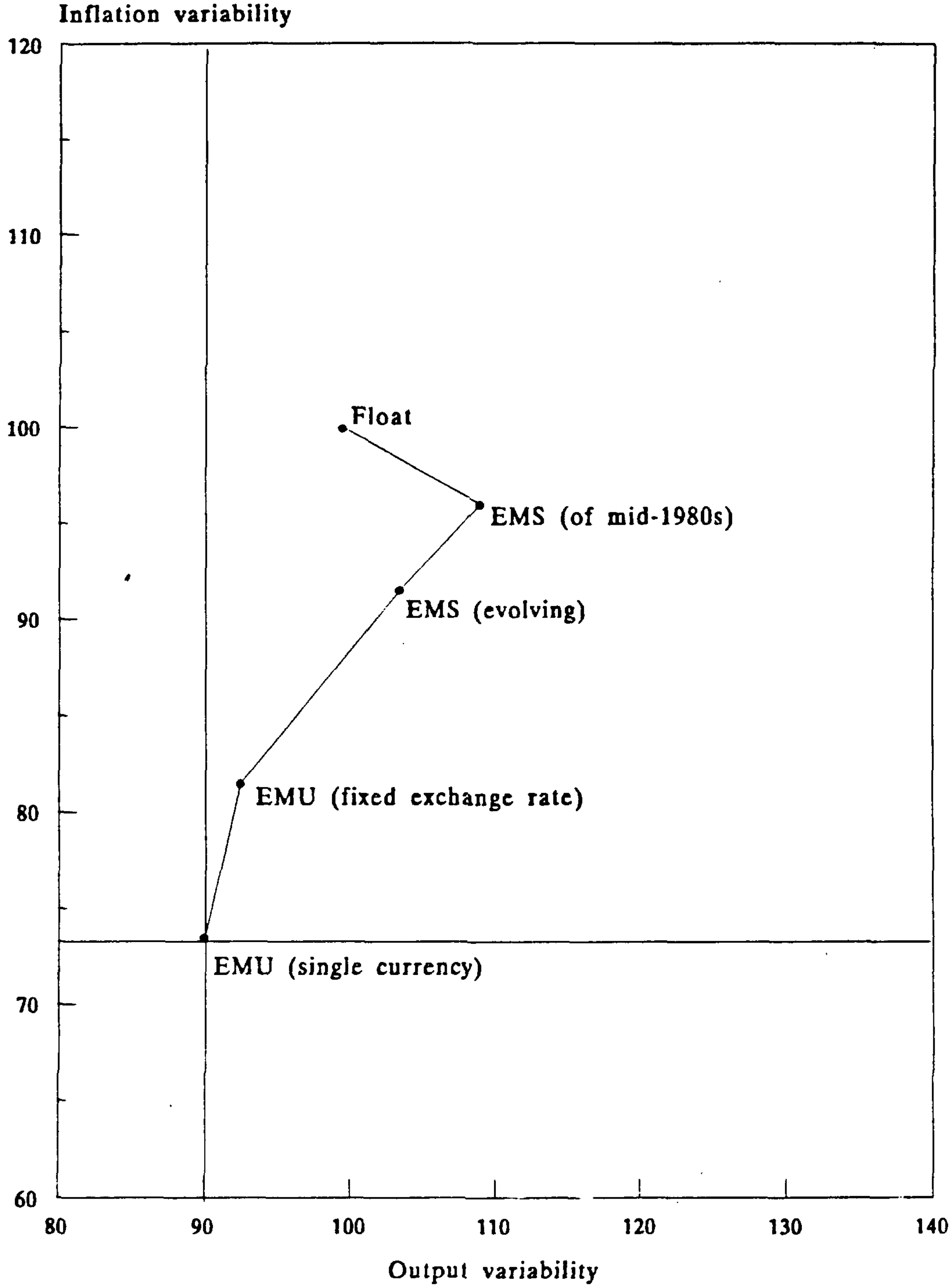
1/ See, for instance Alesina and Grilli (1992).

Chart 3

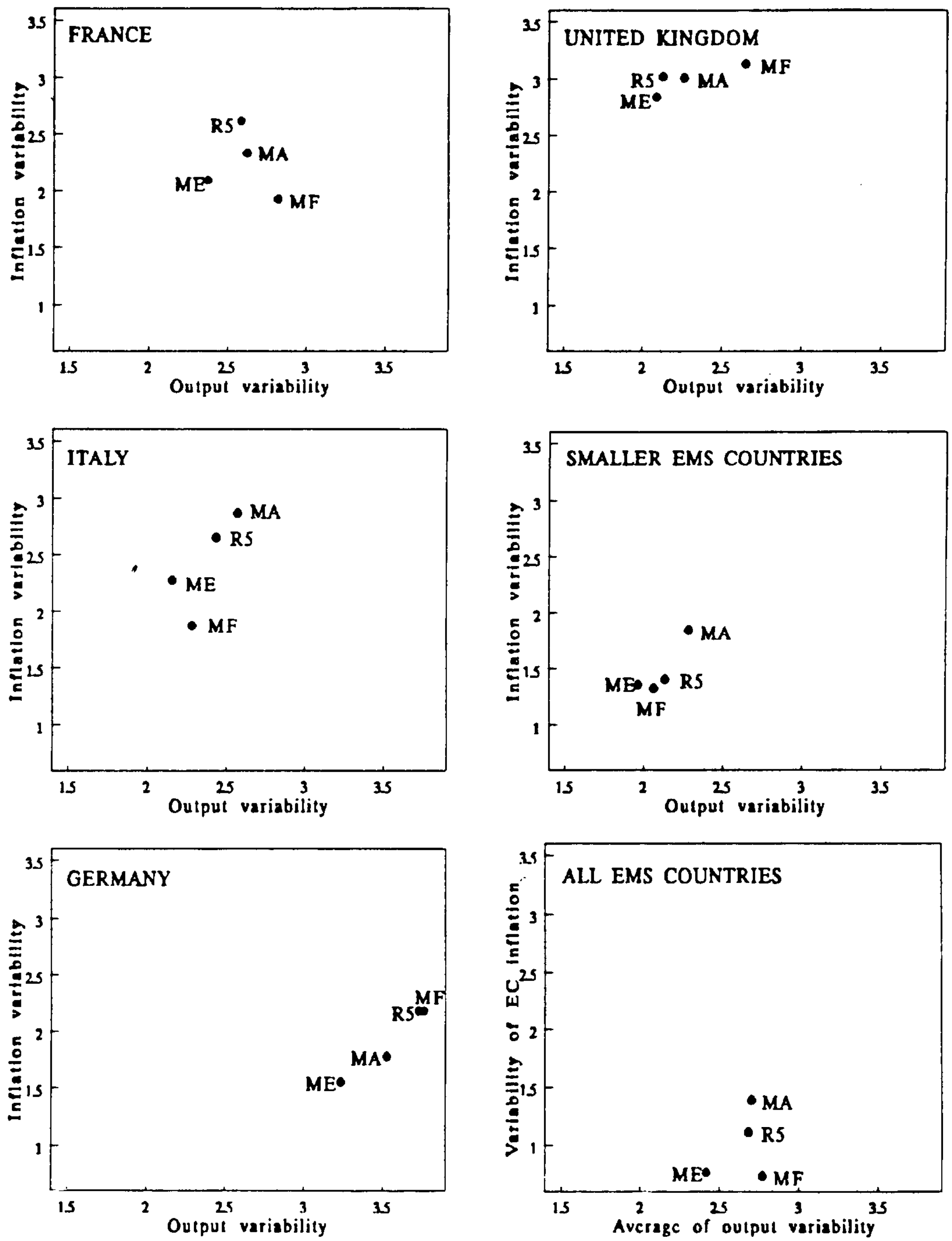
Macroeconomic stability of EMU



Indices EC average, free float = 100
Source: EC Commission (1990), Graph 6.10, p.154.

Chart 4

Floating Exchange Rates vs. the EMS and Symmetric or Asymmetric EMU, with Money Exogenous



MF = Floating rates
R5 = EMS with realignment triggered by real exchange rate
ME = Symmetric EMU, European money target
MA = Asymmetric EMU, German money target

Table 1. Four EC Countries: Standard Deviations of Risk Premium Shocks and Simulated Output and Inflation Variability

(In percent)

	Standard deviation of risk premium shocks relative to DM		Output variability 1/				Inflation variability 1/			
			Float		EMU		Float		EMU	
	Method b 2/	Method d 3/	Method b 2/	Method d 3/	Method b 2/	Method d 3/	Method b 2/	Method d 3/	Method b 2/	Method d 3/
Germany	-	-	3.8	5.2	3.2	3.3	2.2	4.0	1.6	1.7
France	1.3	4.2	2.8	2.9	2.4	2.4	1.9	2.1	2.1	2.1
Italy	1.5	2.9	2.3	2.6	2.2	2.2	1.9	2.9	2.3	2.4
United Kingdom	1.7	6.5	2.6	2.7	2.1	2.1	3.1	3.3	2.8	2.8
EC4 Average Variability 4/			3.1	3.8	2.6	2.7	2.3	3.2	2.2	2.2
Variability of EC4 Aggregate 5/			1.8	2.0	1.6	1.6	1.1	1.2	0.9	0.9

1/ Root mean square percentage deviations from baseline. Money is assumed to be exogenous in each case.
2/ Method b assumes random walk hypothesis to generate exchange rate expectations. It was used in the simulations in the rest of this paper. The figure given is the standard error of a regression over the period 1979-90 of the interest differential on its lagged value and a time trend.
3/ Method d uses a small model to generate risk premiums; it was used by the EC Commission. Figures taken from Table E.7, ECC (1990), p. 321.
4/ The result of averaging the 4 countries mean square errors using GDP weights, and taking the square root.
5/ EC4 aggregate is calculated by summing the 4 countries' percentage deviations from baseline using GDP weights. Its variability is then calculated.

sets of estimates. 1/ In order to parallel more closely their results, we aggregate over only the four largest EC countries. Table 1 shows that the EC Commission's method implies much more dramatic improvement from EMU compared to floating. This is not surprising, since under their assumptions about risk premiums, exchange markets under floating are subject to major speculative shifts that would be eliminated by EMU. In this view of the world, major instability in exchange markets can be eliminated by a move to a single currency (or irrevocably fixed rates). Our estimates of the risk premium, in contrast, attribute a relatively small role to these shocks in causing macroeconomic instability.

A second comparison that can be made from the table is between the variability of European variables (e.g., the sum of EC output or average European inflation) and the weighted average of the four countries' variability. Recall that our EMS results in Charts 1, 2, and 4 use the first measure for inflation, and the second measure for output, while the studies by Minford and associates and the EC Commission use the second measure (weighted variability) for both output and inflation. The second measure indicates a much larger improvement of inflation variability when comparing floating with EMU, when the larger risk premium shocks are imposed (those estimated by the EC Commission). In contrast, if the criterion is EMS inflation (not national inflation rates), risk premium shocks have little importance for inflation variability, since they increase one country's prices but reduce another's, leaving the average roughly unchanged. So this dimension also helps explains the larger gains from EMU in reducing inflation variability in the EC Commission results compared to ours.

V. Conclusions

Our aim has been to understand the sharply contrasting conclusions of two significant model simulation studies of monetary union--those done by the EC Commission and by Minford and associates. In so doing, we have raised some methodological issues and also perhaps helped to identify areas which are particularly important for an evaluation of exchange rate regimes. Our major conclusion is that the EMS seems to be much less of an engine of instability than is implied by the studies of Minford and associates, but we also do not, on the basis of stochastic simulations that admittedly account for only a limited set of factors, find a strong case for EMU.

The differences relate seemingly to fairly arbitrary choices in modelling realignments and in estimating the size of risk premiums in foreign exchange markets. On the one hand, the treatment of realignments by Minford and associates seems to be the cause of instability in their

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1/ Correlation coefficients among the errors were assumed to be unaffected, so both the relevant diagonal and the off-diagonal elements of the error covariance matrix were rescaled to reflect the estimated variability of risk premium shocks.

results, and their choice of the rule as a description of how the EMS actually operates does not seem to us particularly convincing, even in the light of the exchange market turbulence that has occurred recently. Moreover, the fact that the rest of the world seems to be equally, or even more severely, affected by the EMS than the member countries themselves throws doubt on their results.

On the other hand, the EC Commission's method of estimating risk premia produces gains from EMU that are much larger than obtained when other methods are used. It may well be that our models are not well suited to capture the advantages of a common currency, because they do not capture the saving of transactions costs and the anti-inflationary discipline resulting from a more disciplined, multilateral central bank. In the absence of these model features, and if the uncertainty related to separate currencies is assumed to take the form of shocks to interest parity conditions, then these shocks have to be very large for the gains from EMU to offset the loss of flexibility to respond to other shocks. It is also important in the evaluation to decide whether in a monetary union individual countries' inflation rates are important in themselves, or only the union's inflation rate. The justification for the latter is that in a common currency area, there is only one underlying long-run inflation rate. However, this complicates the comparison with floating, because in the absence of a single currency, different national inflation rates are possible, and they are plausibly included separately in welfare functions. In our simulations, unlike those of the EC Commission, we do not find a clear improvement in average inflation variability (under either measure) when comparing EMU to floating exchange rates, though output variability does decline substantially.

It should also be recognized that in several respects our models are not completely adequate representations of either the EMS or EMU. They do not incorporate the "bias in the band" and "smooth pasting": in a perfectly credible target zone, there is a tendency for the exchange rate to revert toward the center of the band. 1/ At the edges, this implies that the exchange rate is certain to move in one direction rather than in another and this gives rise to "smooth pasting." However, empirical evidence in favor of this nonlinearity has been weak (see, for instance, Flood, Rose, and Mathieson (1990)). The difficulty in incorporating the results of this literature is that analytical solutions found there assume relatively simple processes for the "fundamentals" in continuous time, while our macromodels are in discrete time and have very complicated dynamic processes for the variables determining interest rates. Using a linear approximation, like Svensson's (1991), for the expected exchange rate within the band would be possible, but this would not incorporate "smooth pasting." However, its weak empirical support makes us agree with HHMR (1993) that "smooth pasting" would only produce a minor difference in the results.

1/ See Krugman and Miller, eds. (1991) for a compilation of some of the recent literature on target zone models.

A more serious limitation in our view is the treatment of credibility--both the credibility of the exchange rate commitment within the EMS and the commitment to price stability in EMU. In our (and other) stochastic simulations, expectations are formed on the basis of certainty equivalence, and this implies for instance that a realignment is either expected to occur with certainty, or else the peg is expected to be successfully defended. In practice, the shocks that occur next period may invalidate those expectations. A more satisfactory framework would allow for a nonzero probability to be given to the two outcomes, and would make that probability endogenous. A preliminary attempt along these lines, applied to disinflation policies, was made in Masson and Symansky (1993); we hope to extend this analysis to exchange rates in subsequent work. 1/ A conceptual framework for considering the effects of the formation of a European Central Bank on anti-inflationary credibility is presented in Currie (1992).

1/ Target zones with exogenous realignment probability are analyzed by Bartolini and Bodnar (1992).

APPENDIX

Table 2: Root Mean Squared Deviations from Baseline
For the Alternative Policy Rules in Chart 1

	No realignments		5% Band: Equilibrium Parity Adjustment (E5)	3% Band: Real Exchange Rate Parity Adjustment (R3)	5% Band: Real Exchange Rate Parity Adjustment (R5)
	3% Band (N3)	5% Band (N5)			
Germany					
GDP	3.74	3.74	3.76	3.73	3.73
Nominal GDP	5.71	5.77	5.75	5.73	5.78
Consumption	3.72	3.70	3.70	3.72	3.71
Investment	7.98	7.89	8.15	7.97	7.90
GNP Deflator	4.51	4.55	4.53	4.55	4.59
Inflation	2.14	2.17	2.14	2.17	2.19
Trade Balance	2.19	2.19	2.16	2.19	2.18
ST interest rate	2.50	2.45	2.62	2.49	2.45
LT Interest rate	1.59	1.58	1.60	1.60	1.60
Money	2.45	2.36	2.71	2.46	2.39
France					
GDP	2.61	2.61	3.44	2.56	2.59
Nominal GDP	5.57	5.37	7.28	7.55	7.75
Consumption	2.16	2.21	2.64	2.20	2.26
Investment	18.21	18.06	18.64	18.13	18.07
GNP Deflator	5.05	4.85	6.84	7.29	7.50
Inflation	2.11	2.05	3.26	2.46	2.62
Trade Balance	2.47	2.45	2.61	2.45	2.45
ST interest rate	3.63	4.80	10.75	4.69	5.27
LT Interest rate	1.70	1.81	2.72	1.77	1.83
Money	14.74	13.11	11.46	14.58	13.54
DM/FF rate	2.23	4.72	4.53	5.04	6.56
United Kingdom					
GDP	2.21	2.17	3.10	2.16	2.12
Nominal GDP	6.11	5.81	7.53	6.97	6.98
Consumption	3.36	3.32	3.67	3.37	3.31
Investment	10.33	10.89	12.64	10.50	10.88
GNP Deflator	5.80	5.37	7.34	6.80	6.71
Inflation	2.86	2.81	3.43	3.01	3.02
Trade Balance	1.64	1.73	1.81	1.66	1.72
ST interest rate	3.47	4.47	10.25	4.03	4.68
LT Interest rate	1.59	1.62	2.73	1.64	1.67
Money	17.13	15.00	13.25	16.73	15.49
DM/Sterling rate	2.25	4.81	4.24	4.17	5.96
Italy					
GDP	2.52	2.45	3.24	2.48	2.44
Nominal GDP	7.91	6.99	9.21	9.87	9.62
Consumption	3.38	3.32	3.86	3.38	3.38
Investment	11.17	10.74	12.04	11.01	10.56
GNP Deflator	7.14	6.31	8.71	9.16	8.93

Table 2: Root Mean Squared Deviations from Baseline For the Alternative Policy Rules in Chart 1 (concluded)

	No realignments		5% Band: Equilibrium Parity Adjustment (E5)	3% Band: Real Exchange Rate Parity Adjustment (R3)	5% Band: Real Exchange Rate Parity Adjustment (R5)
	3% Band (N3)	5% Band (N5)			
Inflation	2.60	2.28	3.54	2.82	2.65
Trade Balance	1.54	1.54	1.72	1.53	1.51
ST interest rate	4.99	5.47	9.60	5.76	5.97
LT Interest rate	3.02	2.89	2.99	3.09	2.92
Money	9.16	7.30	9.95	9.56	8.21
DM/Lira rate	2.16	4.44	3.66	4.17	5.73
Smaller EMS Countries					
GDP	2.34	2.18	2.97	2.25	2.14
Nominal GDP	4.87	3.85	6.45	4.76	4.21
Consumption	4.06	3.99	4.12	4.03	3.97
Investment	9.46	9.16	10.13	9.30	9.07
GNP Deflator	3.91	2.94	5.74	3.96	3.55
Inflation	1.73	1.38	2.73	1.59	1.41
Trade Balance	1.59	1.60	1.63	1.59	1.59
ST interest rate	3.14	3.68	6.59	3.63	4.20
LT Interest rate	1.41	1.37	1.64	1.44	1.39
Money	6.79	5.07	8.17	6.40	5.30
DM/local rate	2.13	4.28	2.95	3.40	5.14
EMS (Aggregates)					
GDP	2.01	1.89	2.34	1.99	1.90
Nominal GDP	4.22	3.32	5.20	4.21	3.70
Consumption	2.05	1.99	2.13	2.03	1.98
Investment	6.53	6.21	7.27	6.44	6.21
GNP Deflator	3.19	2.33	4.40	3.18	2.77
Inflation	1.37	1.08	2.01	1.29	1.11
Trade Balance	0.60	0.60	0.64	0.60	0.60
ST interest rate	2.86	3.10	5.92	3.18	3.40
LT Interest rate	1.31	1.23	1.37	1.29	1.20
Money	6.72	5.60	6.37	6.58	5.86
EMS (square root of average of national variances)					
GDP	2.76	2.71	3.30	2.72	2.69
Nominal GDP	5.82	5.35	7.03	6.66	6.55
Consumption	3.51	3.47	3.69	3.51	3.48
Investment	11.62	11.51	12.37	11.55	11.46
GNP Deflator	5.04	4.58	6.42	6.06	5.97
Inflation	2.20	2.06	2.94	2.30	2.28
Trade Balance	1.92	1.93	2.00	1.92	1.92
ST interest rate	3.44	4.07	7.98	4.03	4.44
LT Interest rate	1.80	1.79	2.24	1.84	1.81
Money	10.48	9.00	9.24	10.31	9.37

Table 3: Root Mean Squared Deviations from Baseline
For the Alternative Policy Rules in Chart 2

	Floating Rates, Money Exogenous (MF)	EMU, Money Targeting (ME)	Floating Rates, Nominal Income Targeting (YF)	EMU, Nominal Targeting Within the Band (YE)
Germany				
GDP	3.77	3.24	3.67	3.66
Nominal GDP	5.90	3.94	4.23	4.70
Consumption	3.67	3.62	3.75	3.71
Investment	7.70	7.74	7.33	7.49
GNP Deflator	4.57	3.88	3.60	4.44
Inflation	2.19	1.56	1.73	1.91
Trade Balance	2.14	2.11	2.23	2.15
ST interest rate	2.30	4.86	1.29	1.15
LT interest rate	1.59	1.46	1.14	1.00
Money	2.15	6.28	6.98	7.01
France				
GDP	2.83	2.38	2.40	2.42
Nominal GDP	5.90	5.07	3.74	5.23
Consumption	2.53	2.16	2.20	2.26
Investment	16.90	17.51	17.63	17.68
GNP Deflator	5.03	4.88	3.55	5.08
Inflation	1.93	2.09	1.62	2.16
Trade Balance	2.47	2.47	2.41	2.47
ST interest rate	12.65	4.86	1.10	1.15
LT interest rate	2.81	1.59	1.59	1.47
Money	--	10.97	14.64	13.86
DM/FF rate	12.60	--	3.79	--
United Kingdom				
GDP	2.65	2.08	1.86	2.04
Nominal GDP	7.20	5.88	2.84	5.60
Consumption	3.24	3.55	3.21	3.54
Investment	14.97	10.70	10.02	9.52
GNP Deflator	5.96	5.79	3.25	5.78
Inflation	3.14	2.84	1.84	2.59
Trade Balance	2.62	1.69	1.79	1.65
ST interest rate	11.16	4.86	0.87	1.15
LT interest rate	2.64	1.41	1.36	1.20
Money	--	15.37	17.99	18.57
DM/Sterling rate	14.38	--	4.68	--
Italy				
GDP	2.29	2.16	2.19	2.35
Nominal GDP	5.80	6.48	4.59	7.05
Consumption	3.21	3.42	3.14	3.51
Investment	9.68	8.74	9.93	9.43
GNP Deflator	5.35	6.07	4.21	6.51
Inflation	1.88	2.28	1.97	2.53
Trade Balance	1.59	1.44	1.54	1.45
ST interest rate	5.08	4.86	1.46	1.15

Table 3: Root Mean Squared Deviations from Baseline
For the Alternative Policy Rules in Chart 2 (concluded)

	Floating Rates, Money Exogenous (MF)	EMU, Money Targeting (ME)	Floating Rates, Nominal Income Targeting (YF)	EMU, Nominal Targeting Within the Band (YE)
LT interest rate	2.60	2.21	2.28	2.10
Money	--	5.42	7.77	7.97
DM/Lira rate	8.26	--	5.04	--
<u>Smaller EMS Countries</u>				
GDP	2.07	1.97	2.09	2.17
Nominal GDP	3.62	3.69	3.59	4.25
Consumption	3.89	3.78	3.99	4.01
Investment	8.60	8.53	8.90	9.16
GNP Deflator	2.75	3.14	2.93	3.56
Inflation	1.33	1.37	1.37	1.61
Trade Balance	1.62	1.58	1.58	1.59
ST interest rate	5.10	4.86	1.08	1.15
LT interest rate	1.43	1.36	1.02	0.93
Money	--	4.90	4.36	4.51
DM/local rate	7.16	--	2.35	--
<u>EMS Aggregates</u>				
GDP	1.56	1.50	1.83	1.78
Nominal GDP	2.26	2.25	2.86	2.89
Consumption	1.86	1.83	2.07	2.05
Investment	5.24	5.22	5.54	5.46
GNP Deflator	1.65	1.72	2.31	2.41
Inflation	0.74	0.77	1.06	1.03
Trade Balance	0.63	0.59	0.59	0.58
ST interest rate	4.52	4.86	0.90	1.15
LT interest rate	1.22	1.25	0.89	0.88
Money	0.48	--	6.09	5.78
<u>EMS (square root of average of national variances)</u>				
GDP	2.77	2.42	2.56	2.62
Nominal GDP	5.50	4.79	3.81	5.16
Consumption	3.45	3.42	3.45	3.54
Investment	11.58	10.92	11.02	11.00
GNP Deflator	4.54	4.52	3.43	4.84
Inflation	2.05	1.95	1.65	2.07
Trade Balance	2.08	1.90	1.93	1.90
ST interest rate	7.78	4.86	1.16	1.15
LT interest rate	2.13	1.56	1.42	1.29
Money	1.02	8.79	10.57	10.57

Table 4: Root Mean Squared Deviations from Baseline
For the Alternative Policy Rules in Chart 4

	Floating Rate, Money Exogenous (MF)	5% Band: Real Exchange Rate Parity Adjustment (R5)	Symmetric EMU, European Money Target (ME)	Asymmetric EMU, German Money Target (MA)
Germany				
GDP	3.77	3.73	3.24	3.53
Nominal GDP	5.90	5.78	3.94	4.92
Consumption	3.67	3.71	3.62	3.60
Investment	7.70	7.90	7.74	7.81
GNP Deflator	4.57	4.59	3.88	3.87
Inflation	2.19	2.19	1.56	1.79
Trade Balance	2.14	2.18	2.11	2.13
ST interest rate	2.30	2.45	4.86	4.26
LT interest rate	1.59	1.60	1.46	1.46
Money	2.15	2.39	6.28	--
France				
GDP	2.83	2.59	2.38	2.63
Nominal GDP	5.90	7.75	5.07	6.09
Consumption	2.53	2.26	2.16	2.13
Investment	16.90	18.07	17.51	18.40
GNP Deflator	5.03	7.50	4.88	5.70
Inflation	1.93	2.62	2.09	2.34
Trade Balance	2.47	2.45	2.47	2.53
ST interest rate	12.65	5.27	4.86	4.26
LT interest rate	2.81	1.83	1.59	1.59
Money	--	13.54	10.97	15.35
DM/FF rate	12.60	6.56	--	--
United Kingdom				
GDP	2.65	2.12	2.08	2.26
Nominal GDP	7.20	6.98	5.88	6.39
Consumption	3.24	3.31	3.55	3.48
Investment	14.97	10.88	10.70	10.76
GNP Deflator	5.96	6.71	5.79	6.17
Inflation	3.14	3.02	2.84	3.01
Trade Balance	2.62	1.72	1.69	1.67
ST interest rate	11.16	4.68	4.86	4.26
LT interest rate	2.64	1.67	1.41	1.42
Money	--	15.49	15.37	17.59
DM/Sterling rate	14.38	5.96	--	--
Italy				
GDP	2.29	2.44	2.16	2.58
Nominal GDP	5.80	9.62	6.48	8.80
Consumption	3.21	3.38	3.42	3.61
Investment	9.68	10.56	8.74	10.06
GNP Deflator	5.35	8.93	6.07	8.02
Inflation	1.88	2.65	2.28	2.88
Trade Balance	1.59	1.51	1.44	1.46
ST interest rate	5.08	5.97	4.86	4.26

Table 4: Root Mean Squared Deviations from Baseline For the Alternative Policy Rules in Chart 4 (concluded)

	Floating Rate, Money Exogenous (MF)	5% Band: Real Exchange Rate Parity Adjustment (R5)	Symmetric EMU, European Money Target (ME)	Asymmetric EMU, German Money Target (MA)
LT interest rate	2.60	2.92	2.21	2.45
Money	--	8.21	5.42	8.60
DM/Lira rate	8.26	5.73	--	--
Smaller EMS Countries				
GDP	2.07	2.14	1.97	2.29
Nominal GDP	3.62	4.21	3.69	5.42
Consumption	3.89	3.97	3.78	4.01
Investment	8.60	9.07	8.53	9.33
GNP Deflator	2.75	3.55	3.14	4.71
Inflation	1.33	1.41	1.37	1.85
Trade Balance	1.62	1.59	1.58	1.58
ST interest rate	5.10	4.20	4.86	4.26
LT interest rate	1.43	1.39	1.36	1.37
Money	--	5.30	4.90	8.10
DM/local rate	7.16	5.14	--	--
EMS Aggregates				
GDP	1.56	1.90	1.50	1.93
Nominal GDP	2.26	3.70	2.25	4.35
Consumption	1.86	1.98	1.83	1.98
Investment	5.24	6.21	5.22	6.45
GNP Deflator	1.65	2.77	1.72	3.48
Inflation	0.74	1.11	0.77	1.39
Trade Balance	0.63	0.60	0.59	0.60
ST interest rate	4.52	3.40	4.86	4.26
LT interest rate	1.22	1.20	1.25	1.31
Money	0.48	5.86	--	6.41
EMS (square root of average of national variances)				
GDP	2.77	2.69	2.42	2.71
Nominal GDP	5.50	6.55	4.79	6.11
Consumption	3.45	3.48	3.42	3.51
Investment	11.58	11.46	10.92	11.54
GNP Deflator	4.54	5.97	4.52	5.48
Inflation	2.05	2.28	1.95	2.28
Trade Balance	2.08	1.92	1.90	1.91
ST interest rate	7.78	4.44	4.86	4.26
LT interest rate	2.13	1.81	1.56	1.61
Money	1.02	9.37	8.79	10.92

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