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Monetary policy targets and the stabilization objective: a source of tension in the EMS

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This paper evaluates two different monetary regimes in the EMS: an asymmetric regime with EMS monetary policy oriented towards German targets and a symmetric regime with EMS-wide targets. Deterministic and stochastic simulations of a macroeconometric model are used to study spillovers, adjustment and stabilization in EMS economies. They show that there exists a significant trade-off between the two regimes in terms of output and price deviations from target. While Germany enjoys more stability under the asymmetric regime, the other EMS economies are stabilized more effectively by a symmetric target. The resulting tension must have been at least partly responsible for the recent EMS crises. (JEL E52, F42).

There seems to be widespread consensus in the policy literature that the European Monetary System (EMS) has effectively functioned as a D-Mark zone.[1] Germany is viewed as the center country of the EMS which chooses its money supply independently and thereby provides a nominal anchor for the system. The other member countries devote monetary policy to keeping the DM exchange rate fixed. By tying themselves to the Deutsche mark and to the Bundesbank's stable monetary policy EMS members such as France and Italy were able to credibly commit to and achieve lower inflation rates. An important question arising in such a fixed exchange rate system is how to spread the adjustment necessary in response to macroeconomic shocks across the mem-

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bers of the system. This depends crucially on the target chosen for monetary policy in the system and the commitment to fixed parities. The paper focusses on two alternatives:

(i) an *asymmetric regime*, under which Germany conducts monetary policy for the whole system by targeting domestic variables and thus minimizing the impact of macroeconomic shocks on its economy. The other EMS members peg their currencies to the Deutsche mark, follow Germany's monetary policy and thereby take on most of the adjustment burden with respect to real exchange rates, output and prices required in response to shocks to the system.

(ii) a *symmetric regime*, under which the center-country Germany orients its monetary policy towards EMS-wide targets and spreads the adjustment burden more equally across EMS economies.

The first regime captures the main aspects of the EMS between 1987 and 1992. Before this period the EMS was characterized by infrequent realignments, capital controls and exchange rate bands. This combination gave EMS members significant leeway with respect to the center country's policy, but it also limited the extent to which they could gain credibility from tying their monetary policy to Germany's policy through a fixed parity. It prevented these countries from fully taking advantage of the Bundesbank's reputation for low inflation policy in reducing their own inflation rates. After 1987 no more realignments were undertaken and capital controls were abolished. Central banks increasingly intervened intramarginally to reduce exchange rate variability inside the band rather than wait until the exchange rate threatened to breach the band. As a result inflation rates in the EMS economies converged.

During the early 1990s the drive towards European Monetary Union (EMU) gained momentum and led to the Maastricht treaty. However soon afterwards, the exchange rate crisis of fall 1992 put an end to this period of convergence among EMS members and triggered the exit of Italy and the UK from the system. Recurring speculative attacks lead to huge losses of foreign exchange reserves in most EMS countries, while high interest rates worsened the recession in Europe. On 1 August, 1993 EMS members decided to widen the exchange rate bands to $+/-15$ percent and de-facto abolished or at least suspended the EMS. Between 1987 and 1993 European policymakers had relinquished policy instruments such as capital controls and realignments and EMS monetary policy came to resemble more and more the asymmetric regime described above. Capital mobility and seemingly permanently fixed exchange rates resulted in more pressure on real exchange rates, output and prices in EMS countries to adjust in response to macroeconomic shocks. Germany was targeting domestic variables and provided a nominal anchor for the EMS while the other members accommodated German monetary policy to be able to remain in the system and achieve low long-run inflation rates. As long as fixed exchange rates in Europe are considered viable, the alternatives to the asymmetric regime are, either a more flexible system with wider bands allowing for more monetary independence but also more exchange rate variability, or a symmetric system with Germany targeting EMS-wide macroeconomic aggre-

gates. In the latter case all EMS members would undergo adjustment processes in response to macroeconomic shocks and adjustment costs would be shared more equally.[2]

The trade-off between these policy regimes can be illustrated with a textbook two-country model, but a policymaker will be concerned with the quantitative importance of this trade-off. This paper provides a quantitative evaluation of an asymmetric versus a symmetric operation of EMS monetary policy. At this point the best way to assess the size of spillover effects and the effectiveness of policy rules in the real world is by simulating the response of an empirical macroeconometric model to macroeconomic shocks under different policy regimes. We use an empirical model of the seven largest OECD economies developed by John Taylor and associates at Stanford and described in detail in Taylor (1993). A short summary of its basic properties is given in the appendix. The model is forward-looking[3] and assumes that expectations of future exchange rates, prices, interest rates, wages and income are formed rationally. Capital is perfectly mobile and exchange rates and interest rates adjust quickly while prices and wages are sticky. The model is solved by the extended path method, which implies guessing a future path for the expectational variables in the model and then iterating over these guesses until the algorithm converges to a fixed point. Such a fixed point is equivalent to a rational (or model-consistent) expectations equilibrium. Deterministic and stochastic simulations of this model are used to study symmetric and asymmetric monetary policy regimes. Symmetry is defined on the level of monetary policy targets rather than on the level of foreign exchange intervention and sterilization.[4] Monetary policy is modeled in the form of nominal income rules defined as short-term real interest rate reaction functions. A symmetric rule has weighted EMS nominal income as target while an asymmetric rule targets German nominal income. I have also explored fixed money growth rules but these rules, symmetric and asymmetric, generally perform worse since they do not automatically account for velocity shocks.

The simulation results show that an asymmetric regime allows the Bundesbank to strongly reduce price and output variations in the German economy. Instead the other EMS countries, which in the model are France, Italy and the UK, bear the full adjustment burden. Output and price variability in these countries, especially in France and Italy, could be reduced considerably by moving to a symmetric EMS regime with EMS-wide targets, but only at the cost of higher variability in Germany. The increased adjustment burden for non-center EMS countries under the asymmetric regime without capital controls must have been a crucial factor in the exchange rate crises in fall 1992 and summer 1993.

The paper proceeds as follows: Section I measures the size of spillover effects between EMS countries and the adjustment path in response to specific shocks under symmetric and asymmetric monetary policy. This is done by simulating deterministic fiscal shocks in the macroeconometric model discussed above. Section II presents the results from stochastic simulations which subject the behavioral equations of the model to continual disturbances. Thereby one can assess how effective symmetric and asymmetric EMS regimes are in

counteracting a large variety of shocks and reducing the variability of output and prices. Section III concludes.

I. Spillover effects and macroeconomic adjustment in the EMS

The choice of monetary policy target will determine to what extent prices and real variables in the EMS economies adjust to macroeconomic shocks emanating from outside and inside the EMS. Country-specific shocks inside the EMS will require different real and nominal adjustments in the member countries and more so as fixed parities are maintained. Even outside shocks may affect EMS economies differently depending on the size of demand and supply elasticities. As a consequence the optimal monetary policy rule will be different for each EMS country and the trade-off between a center-country-oriented and a symmetric monetary policy may be quite large. This trade-off cannot be studied adequately in a theoretical two-country model since the direction and magnitude of the adjustment processes will be ambiguous. Instead, a multi-country model with estimated parameters is needed to determine direction and magnitude of adjustment in the EMS economies. I have studied a variety of fiscal and monetary shocks by means of deterministic simulations of the multi-country model described in the appendix. This section reports the results for two specific exogenous shocks which exemplify the spillover effects and adjustment in the EMS: (i) a permanent unanticipated fiscal expansion in Germany — the center country of the EMS; and (ii) a permanent unanticipated fiscal expansion in the non-EMS countries — USA, Japan and Canada. Monetary policy is modeled in the form of short-term real interest rate reaction functions targeting nominal income. Intra-EMS exchange rates are fixed, short-term interest rates in the EMS countries are tied to German rates and EMS monetary policy is either targeting German nominal income or a weighted average of EMS nominal incomes.

I.A. A fiscal expansion in Germany

Given a model with sluggish price adjustment one expects a fiscal expansion to raise domestic output at least temporarily. In the long run the German price level will increase but until then excess demand for domestic products puts upward pressure on interest rates and real exchange rates. If the exchange rate is flexible, the D-mark will appreciate with respect to the foreign currency thereby reducing foreign demand for domestic goods and increasing domestic demand for foreign goods. Under fixed nominal rates the real appreciation is eventually brought about by an increase in the domestic to foreign price ratio. The impact on foreign output depends on the exchange rate system in place. With respect to non-EMS countries a nominal appreciation will reduce German net exports and raise net exports and output abroad. Inside the EMS the effect on foreign output is ambiguous. On the one side government spending increases German demand for foreign products resulting in a positive direct demand effect on the other EMS economies. On the other side capital mobility will drive up interest rates in all EMS economies and all EMS currencies will

have to appreciate vis-à-vis non-EMS currencies due to their fixed parities with the D-mark. Consequently investment and net exports in the non-center EMS countries will fall and they are likely to experience a recessionary and deflationary period due to the German expansion. Rising German output and prices will trigger a tight monetary policy stance by the Bundesbank which will put further upward pressure on EMS interest rates. An asymmetric policy will prevent inflationary pressures in Germany and accelerate crowding-out of the government spending increase but exacerbate the recession and deflation in the rest of the EMS. A symmetric target instead would accommodate the recessionary impact outside of Germany while allowing some increase in German output and inflation.

The multi-country model is designed so that in the long run output returns to potential output given by an exogenous trend which has been estimated separately for each country. Inflation is assumed to return eventually to a stable rate of 3 percent driven by capital mobility and credible monetary policies. Therefore no shock will have permanent effects on output growth and inflation, which is why the analysis in this paper is only concerned with short- and medium-run stabilization. In the long run the government spending increase is completely crowded out. The German price level rises, real money balances fall and higher interest rates ensure a large enough decline in investment and consumption shares of GDP to accommodate the increase in government spending. The appreciation of the real exchange rate reduces the share of net exports in GDP and contributes to the crowding-out effect.

The fiscal expansion simulated is an unanticipated permanent debt-financed increase in government expenditure by 1 percent of GDP. Tables 1 and 2 summarize the behavior of the EMS economies and the USA under the asymmetric and symmetric EMS regimes respectively. As expected German output increases temporarily (0.2 percent and 1.2 percent above trend respectively), EMS interest rates rise (0.3 and 0.6 percentage points) and the DM/$ exchange rate initially appreciates strongly (4 and 2.5 percentage points respectively). The impact of the German fiscal shock on output and prices in other EMS economies is highly negative. The results show a significant trade-off between the asymmetric and the symmetric regime in terms of short- and medium-term output and price deviations as depicted in Figure 1.

Under the asymmetric regime German monetary policy very effectively stabilizes German domestic output and prices. At the same time the restrictive monetary stance enhances the negative effect of the German fiscal shock on the other EMS countries. Output in these countries is substantially lower than potential during the first four to five years following the fiscal shock (up to -1.2 percent in France, -2 percent in Italy and -0.55 percent in the UK). In addition they experience strong deflationary pressures during the first four to five years. Average annual inflation rates during this period are considerably lower than the long-run target inflation rate of 3 percent (up to 2.7 percentage points in Italy and up to 0.9 percentage points in the UK and France). Italy experiences a much stronger contractionary effect and Italian output and prices are characterized by stronger fluctuations in the medium term than in the other EMS countries. This seems to be due to the stronger responsiveness

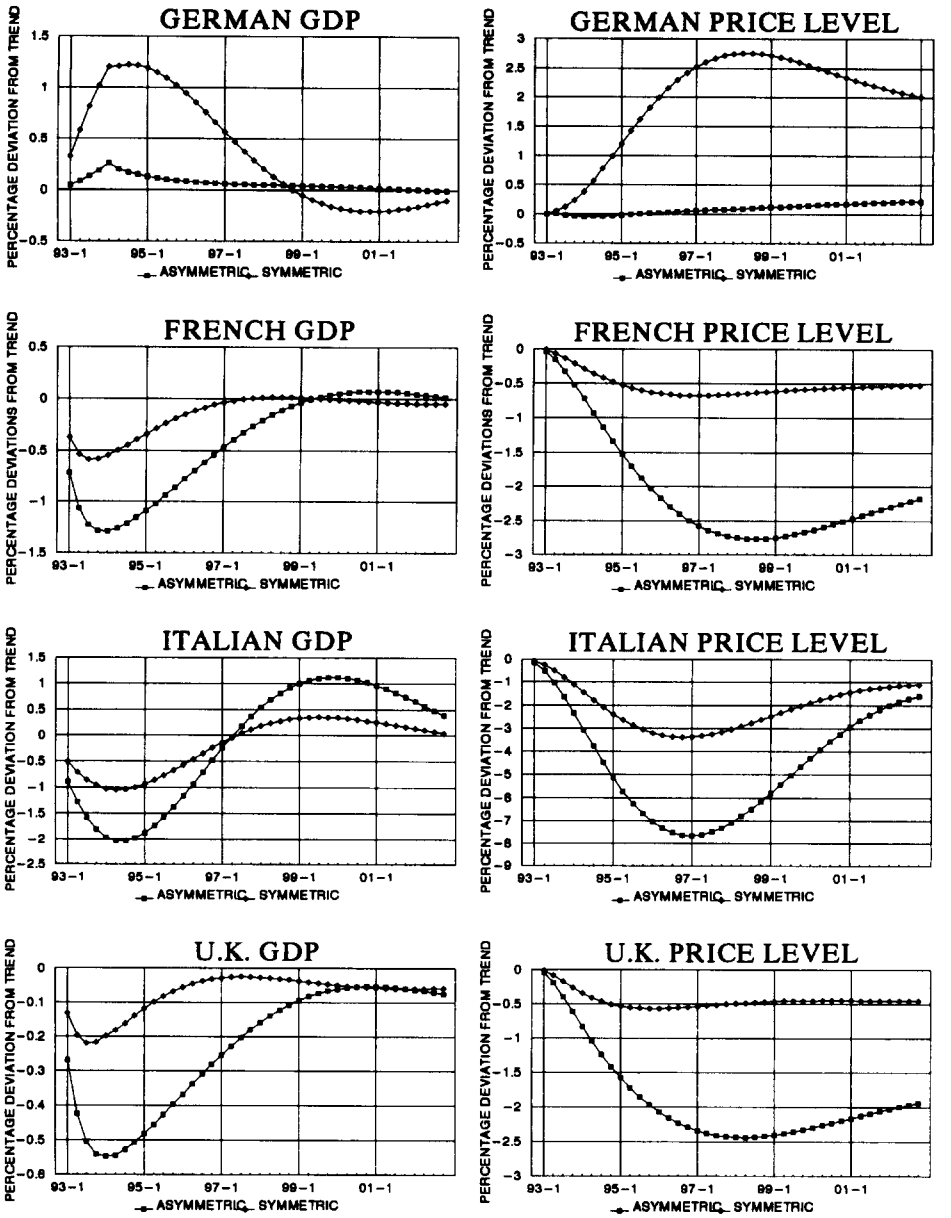

FIGURE 1. Impact of a German fiscal expansion in the EMS economies.

of the Italian wage and price-setting mechanism which translates into larger variations in the real interest rate.

The symmetric monetary policy is more accommodative and clearly alleviates the negative impact on non-center EMS economies. In France, Italy and the UK the negative deviations of output from potential are much smaller, generally only half the size than under the asymmetric rule, and inflation and prices

are stabilized more effectively (see Figure 1). However German performance deteriorates and the loosening of monetary policy results in a boost to inflation (the price level rises 2.6 percent beyond target) and a crowding-in effect which contributes to the multiplier of 1.2 percent. At the peak the difference between the adjustment paths under symmetric and asymmetric policies comes to 1

TABLE 1. German fiscal expansion in an asymmetric EMS (deviations from trend).

Deviations/Year	1993	1994	1995	1996	1997	1998	1999	2000
US$–DM exchange rate	4.07	3.96	3.86	3.81	3.76	3.68	3.57	3.44
EMS money-market rate	0.14	0.30	0.23	0.22	0.24	0.27	0.31	0.33
German bond rate	0.22	0.27	0.23	0.23	0.25	0.29	0.32	0.34
Real long-term rates								
Germany	0.23	0.23	0.19	0.20	0.22	0.26	0.29	0.31
France	0.97	1.04	0.79	0.55	0.35	0.23	0.17	0.16
Italy	2.77	2.96	1.76	0.38	−0.68	−1.19	−1.20	−0.87
UK	1.07	0.90	0.64	0.44	0.31	0.23	0.20	0.20
Real GDP								
Germany	0.11	0.20	0.11	0.07	0.06	0.05	0.04	0.03
France	−1.07	−1.23	−0.98	−0.66	−0.36	−0.14	0.00	0.06
Italy	−1.39	−2.00	−1.65	−0.82	0.07	0.74	1.07	1.08
UK	−0.43	−0.53	−0.44	−0.32	−0.22	−0.13	−0.08	−0.06
GDP deflator								
Germany	−0.02	−0.03	0.01	0.05	0.08	0.10	0.14	0.17
France	−0.26	−1.03	−1.79	−2.34	−2.66	−2.76	−2.71	−2.57
Italy	−0.84	−3.42	−5.95	−7.38	−7.51	−6.64	−5.23	−3.76
UK	−0.31	−1.13	−1.78	−2.19	−2.39	−2.43	−2.37	−2.25
Inflation rate								
Germany	−0.03	−0.01	0.04	0.04	0.03	0.03	0.03	0.03
France	−0.37	−0.80	−0.79	−0.59	−0.34	−0.11	0.05	0.15
Italy	−1.19	−2.70	−2.73	−1.58	−0.14	0.99	1.57	1.62
UK	−0.44	−0.86	−0.68	−0.43	−0.21	−0.04	0.07	0.13
Consumption								
Germany	0.04	0.04	0.02	−0.01	−0.04	−0.07	−0.10	−0.13
France	−0.99	−1.24	−1.03	−0.72	−0.42	−0.18	−0.04	0.02
Italy	−0.69	−1.48	−1.61	−1.19	−0.49	0.21	0.71	0.94
UK	−0.35	−0.53	−0.50	−0.41	−0.31	−0.23	−0.17	−0.14
Investment								
Germany	−0.56	−1.01	−1.02	−1.07	−1.19	−1.36	−1.56	−1.74
France	−1.41	−1.90	−1.70	−1.31	−0.90	0.58	−0.38	−0.29
Italy	−7.58	−10.90	−9.29	−5.35	−1.00	2.38	4.18	4.42
UK	−0.65	−0.92	−0.78	−0.58	−0.41	−0.28	−0.21	−0.19

continued overleaf

TABLE 1. (*Continued*).

Deviations/Year	1993	1994	1995	1996	1997	1998	1999	2000
Net exports, % of GDP								
Germany	−0.30	−0.62	−0.69	−0.70	−0.67	−0.63	−0.58	−0.54
France	−0.12	−0.01	0.07	0.10	0.11	0.11	0.11	0.11
Italy	0.50	1.02	1.15	0.94	0.56	0.15	−0.17	−0.35
UK	−0.10	−0.04	0.01	0.03	0.05	0.06	0.06	0.06
Wage								
Germany	0.17	0.41	0.56	0.64	0.68	0.70	0.71	0.70
France	−0.96	−2.26	−2.94	−3.13	−3.03	−2.79	−2.53	−2.29
Italy	−3.91	−9.07	−11.12	−10.55	−8.37	−5.63	−3.15	−1.44
UK	−0.62	−1.49	−1.99	−2.20	−2.22	−2.15	−2.04	−1.94

Notes: Government spending in Germany increases by 1% of GDP. Monetary policy is modeled in the form of interest rate reaction functions targeting nominal income. EMS monetary policy is oriented towards German nominal income. The reaction coefficient is set equal to 1.6. The values reported are annual averages of percentage deviations from trend except for interest rates and exchange rates which are percentage point deviations.

percent of GDP concerning output deviation and 0.8 percentage points concerning the annual inflation rate. The easing of adjustment in non-center EMS economies is achieved through three effects: first, the initial increase in real interest rates is smaller; second, the appreciation *vis-à-vis* the US dollar is smaller; and third, the short-term output increase in Germany results in a stronger direct demand effect on output in other EMS countries. How the multi-country model works is best understood by focussing on inflationary expectations and their effect on real interest rates and exchange rates. Different inflationary expectations in the short-run imply different real interest rates which account for different short-run real adjustment paths under asymmetric and symmetric monetary regimes. For example in Germany the large short-run multiplier effect under the symmetric regimes comes partly from an increase in investment demand in response to declining real interest rate which is mostly due to higher inflationary expectations.

I.B. Sensitivity of the simulation results

I have thoroughly investigated how sensitive the trade-off between symmetric and asymmetric policies is to the specification of these policy rules. First, I find the results to be insensitive to small changes in the weights of the symmetric nominal income target. Simulations with equal weights and with GDP weights deliver similar size estimates of the trade-off. Second, the reaction coefficient chosen for the simulations reported in this paper is 1.6, which means that a 1 percent deviation from the nominal income target demands a 1.6 percentage point change in the interest rate. Different reaction coefficients lead to

somewhat different quantitative results but the trade-off remains qualitively the same and considerable in size. Third, nominal income rules imply specific weights on the output and inflation objective of monetary policy. Changing these weights affects the short-run inflation–output trade-off of monetary policy but does not change the qualitative trade-off between symmetric and

TABLE 2. German fiscal expansion in a symmetric EMS (deviations from trend).

Deviations/Year	1993	1994	1995	1996	1997	1998	1999	2000
US$–DM exchange rate	2.53	2.12	1.73	1.48	1.35	1.32	1.32	1.33
EMS money market rate	0.45	0.60	0.50	0.37	0.26	0.20	0.18	0.19
German bond rate	0.51	0.56	0.45	0.32	0.23	0.19	0.18	0.19
Real long-term rates								
Germany	−0.17	−0.26	−0.17	0.00	0.18	0.31	0.38	0.39
France	0.77	0.77	0.55	0.34	0.21	0.15	0.15	0.17
Italy	1.66	1.75	1.08	0.34	−0.19	−0.40	−0.37	−0.19
UK	0.84	0.64	0.40	0.25	0.17	0.16	0.18	0.20
Real GDP								
Germany	0.69	1.22	1.12	0.80	0.43	0.10	−0.11	−0.20
France	−0.52	−0.47	−0.26	−0.10	−0.01	0.01	0.00	−0.02
Italy	−0.76	−1.03	−0.81	−0.40	−0.01	0.25	0.35	0.31
UK	−0.19	−0.17	−0.09	−0.04	−0.03	−0.03	−0.04	−0.05
GDP deflator								
Germany	0.20	0.88	1.71	2.35	2.68	2.74	2.62	2.42
France	−0.11	−0.39	−0.58	−0.66	−0.67	−0.64	−0.60	−0.56
Italy	−0.40	−1.61	−2.74	−3.31	−3.28	−2.84	−2.25	−1.71
UK	−0.13	−0.43	−0.55	−0.56	−0.52	−0.48	−0.46	−0.45
Inflation rate								
Germany	0.28	0.72	0.85	0.65	0.34	0.06	−0.12	−0.20
France	−0.15	−0.29	−0.20	−0.09	−0.01	0.03	0.04	0.03
Italy	−0.57	−1.26	−1.19	−0.61	0.03	0.47	0.63	0.58
UK	−0.18	−0.31	−0.13	0.00	0.04	0.04	0.02	0.01
Consumption								
Germany	0.67	1.25	1.24	0.89	0.42	0.02	−0.26	−0.38
France	−0.43	−0.45	−0.29	−0.14	−0.05	−0.02	−0.03	−0.05
Italy	−0.37	−0.79	−0.85	−0.64	−0.32	−0.02	0.17	0.24
UK	−0.16	−0.20	−0.15	−0.10	−0.07	−0.07	−0.08	−0.09
Investment								
Germany	1.31	2.32	2.30	1.41	0.15	−1.04	−1.89	−2.32
France	−0.88	−1.16	−1.00	−0.74	−0.51	−0.36	−0.30	−0.30
Italy	−4.35	−6.15	−5.33	−3.35	−1.28	0.20	0.88	0.87
UK	−0.42	−0.54	−0.40	−0.27	−0.18	−0.15	−0.16	−0.17

continued overleaf

TABLE 2. (*Continued*).

Deviations/Year	1993	1994	1995	1996	1997	1998	1999	2000
Net exports, % of GDP								
Germany	−0.48	−0.99	−1.07	−1.00	−0.85	−0.69	−0.57	−0.50
France	−0.05	0.07	0.15	0.16	0.14	0.11	0.09	0.08
Italy	0.31	0.64	0.74	0.64	0.43	0.22	0.07	0.00
UK	−0.02	0.05	0.07	0.07	0.05	0.04	0.03	0.03
Wage								
Germany	1.01	2.54	3.45	3.76	3.63	3.29	2.92	2.60
France	−0.31	−0.68	−0.79	−0.77	−0.70	−0.64	−0.61	−0.59
Italy	−1.85	−4.27	−5.13	−4.76	−3.74	−2.60	−1.71	−1.21
UK	−0.17	−0.36	−0.44	−0.45	−0.45	−0.46	−0.48	−0.50

Note: Government spending in Germany increases by 1% of GDP. Monetary policy is modeled in the form of interest rate reaction functions targeting nominal income. EMS monetary policy is oriented towards a weighted average of EMS nominal incomes. The reaction coefficient is set equal to 1.6. The values reported are annual averages of percentage deviations from trend except for interest rates and exchange rates which are percentage point deviations.

asymmetric policies. However once the money supply is used as a target of monetary policy the results change. Money supply rules generally perform worse than nominal income rules and there is little difference between an asymmetric rule targeting German money supply and a symmetric rule targeting total EMS money supply. The advantage of nominal income rules in the form of interest rate reaction functions is that they automatically take into account the sizeable velocity shocks in the model.

I.C. A fiscal expansion in the non-EMS countries

An outside shock such as a fiscal expansion in the non-EMS countries affects all member countries similarly but I find it still generates a significant trade-off with respect to the choice of monetary policy target inside the EMS. Given flexible exchange rates and sluggish price adjustment one would expect an exchange rate appreciation, rising interest rates, and an initial output increase inside and outside the EMS. In the longer run prices will rise and output will return to potential in all countries as dictated by the long-run properties of the multi-country model. A stabilization-oriented monetary policy in the EMS economies will counteract this increase in output and prices. In the asymmetric case monetary policy will be just restrictive enough to keep German output and price level close to target, but it is an open question whether it will be too restrictive or not restrictive enough for the other EMS countries. Similarly it depends on the estimated parameters of the multi-country model whether a symmetric target will result in a more or less restrictive policy than the asymmetric regime.

The fiscal expansion simulated is an unanticipated permanent increase in government spending of 1 percent of GDP in Japan, Canada and the USA where it has the expected impact. The ensuing effects in the EMS countries under asymmetric and symmetric monetary policy rules are summarized in Table 3. A large initial appreciation of non-EMS currencies results in a surge of export demand in the EMS countries. Under the asymmetric regime monetary policy is contractionary for Germany but it turns out not restrictive enough for the other EMS countries. Italy, the UK and France experience a short-run boom in real output and an eventual increase in price levels. The boom in France is especially strong not only because of German interest rate policy but also because the depreciation of the French franc against the US dollar is much larger when tied to the D-mark rather than completely flexible (by three percentage points). The symmetric monetary policy target consequently results in a more restrictive monetary policy leading to a short-run decline in German output. Figure 2 depicts the differences in terms of output and price adjustment. Clearly the trade-off between the symmetric and asymmetric regime is smaller than in the case of the German fiscal shock inside the system — about half the size in terms of output and inflation rate deviations. However, the choice of a symmetric versus an asymmetric monetary policy target still has a sizeable effect on the adjustment process even in the case of an outside shock which hits all EMS economies in the same way.

II. Stabilization performance with asymmetric and symmetric policy targets

II.A. Methodology

So far, investigating the impact of specific exogenous shocks has provided valuable insights into the nature of spillovers between EMS countries and the role of the monetary regime in smoothing adjustment processes in the EMS. However, in order to assess the overall effectiveness of monetary regimes in terms of stabilization it is necessary to take into account a large variety of macroeconomic shocks which could play a role in practice. Many of these shocks would result in adjustment paths quite different from the adjustment following exogenous demand-side shocks which has been analyzed in the previous section. This problem can be dealt with appropriately by simulating the empirical multi-country model stochastically. Stochastic simulations are performed by adding shocks to all behavioral equations of the model for each quarter of the simulation period and then calculating the rational expectations solution of the model. Thus, not only are all equations shocked simultaneously, but also in each time period. Compared to deterministic simulations, stochastic simulations involve much higher computational costs. In the case of a single deterministic shock, which is a one time ceteris paribus event, the extended path method has to be applied only once to solve the model in the first period, because from the second period on everything is known. In the case of a stochastic simulation, after solving the model for the shocks in the first period,

the solution procedure has to be applied again taking the results for the first period as given and starting with the shocks in the second period, and so on throughout the full simulation period. Consequently, finding the fixed point which is the rational expectations equilibrium solution for a stochastic simulation takes considerably longer than for a single deterministic shock.

TABLE 3. Fiscal expansion outside the EMS (deviations from trend).

Deviations/Year	1993	1994	1995	1996	1997	1998	1999	2000
Asymmetric EMS								
US$–DM exchange rate	−7.23	−6.91	−6.61	−6.38	−6.16	−5.97	−5.77	−5.59
EMS money market rate	0.47	0.66	0.59	0.51	0.45	0.42	0.40	0.39
German bond rate	0.55	0.63	0.55	0.48	0.43	0.41	0.40	0.39
Real long-term rates								
Germany	0.36	0.55	0.54	0.50	0.47	0.44	0.42	0.41
France	−0.28	−0.03	0.15	0.31	0.42	0.48	0.50	0.51
Italy	−0.18	0.21	0.54	0.77	0.87	0.83	0.72	0.59
UK	−0.33	0.05	0.30	0.42	0.47	0.49	0.48	0.47
Real GDP								
Germany	0.07	0.06	−0.02	−0.07	−0.07	−0.06	−0.04	−0.03
France	1.28	1.32	0.92	0.59	0.36	0.22	0.16	0.14
Italy	0.44	0.49	0.23	−0.05	−0.26	−0.35	−0.35	−0.29
UK	0.48	0.51	0.34	0.22	0.16	0.12	0.11	0.11
GDP deflator								
Germany	0.10	0.30	0.38	0.40	0.38	0.34	0.31	0.29
France	0.30	1.12	1.18	2.24	2.43	2.46	2.40	2.29
Italy	0.23	0.88	1.32	1.36	1.09	0.66	0.22	−0.11
UK	0.37	1.30	1.85	2.09	2.14	2.10	2.02	1.94
Symmetric EMS								
US$–DM exchange rate	−6.56	−6.23	−5.87	−5.57	−5.32	−5.11	−4.92	−4.76
EMS money market rate	0.46	0.61	0.51	0.45	0.42	0.24	0.43	0.44
German bond rate	0.54	0.57	0.58	0.44	0.42	0.43	0.44	0.44
Real long-term rates								
Germany	0.64	0.79	0.67	0.53	0.43	0.38	0.38	0.40
France	−0.11	0.10	0.23	0.35	0.43	0.49	0.51	0.51
Italy	0.47	0.85	0.89	0.82	0.67	0.52	0.39	0.32
UK	−0.16	0.17	0.37	0.45	0.48	0.49	0.49	0.48
Real GDP								
Germany	−0.28	−0.47	−0.46	−0.31	−0.15	−0.03	0.02	0.01
France	0.98	0.95	0.59	0.34	0.18	0.11	0.08	0.07
Italy	0.08	−0.03	−0.20	−0.27	−0.24	−0.15	−0.05	0.04
UK	0.35	0.34	0.19	0.11	0.08	0.07	0.07	0.07

Continued

TABLE 3. (*Continued*).

Deviations/Year	1993	1994	1995	1996	1997	1998	1999	2000
GDP deflator								
Germany	0.00	−0.10	−0.33	−0.51	−0.60	−0.61	−0.57	−0.52
France	0.24	0.88	1.36	1.64	1.73	1.73	1.67	1.60
Italy	0.01	0.00	−0.26	−0.64	−1.02	−1.27	−1.37	−1.33
UK	0.29	1.01	1.38	1.48	1.46	1.40	1.34	1.29

Note: Government spending in the countries outside the EMS, the U.S., Canada and Japan, increases by 1% of GDP. Monetary policy is modeled in form of interest rate reaction functions targeting nominal income. EMS monetary policy is oriented towards German nominal income. The reaction coefficients are set equal to 1.6. The values are annual averages of percentage deviations from trend except for interest rates and exchange rates which are percentage point deviations.

The set of possible shocks to the model includes demand shocks which affect demand for residential, non-residential and inventory investment, durables, non-durables and services consumption, exports and imports; supply shocks which hit the contract wage equations of the staggered-wage setting model and the mark-up relations of prices of domestic goods and export and import prices; and financial shocks affecting the term structure, money demand and exchange rates. The average size and correlation of these stochastic shocks is similar to that observed in the 1970s and 1980s, since the variance–covariance matrix of the distribution from which these shocks are drawn has been estimated using data from 1971–86. More precisely, shocks are assumed to be normally distributed with zero mean and the sample variance–covariance matrix of the structural residuals. Structural residuals[5] have to be distinguished from the residuals of the estimated regression equations, which are composed of structural residuals and forecast errors due to the expectational variables on the right-hand side of the equations. Using an empirically estimated distribution of shocks constitutes a major advance over using an assumed distribution. The covariance matrix obtained from the equations of the multi-country model exhibits a significant amount of correlation between shocks to different equations with size and correlation of disturbances differing across countries. Although we implicitly assume future disturbances to be similar to those in the past and normally distributed, this can at least partly be dealt with by sensitivity analysis. Some important nonlinearities could be taken into account by using the actual shocks of the historical period for simulations under different policy regimes. Shocks are drawn from a random number generator and the model is simulated for each realization of the stochastic process under all the different monetary policy regimes. One draw covers a period of 40 quarters and the performance of macroeconomic variables is averaged over 10 draws.[6] In the context of stabilization policy economic performance seems best to be measured with respect to variability of target variables and their components.

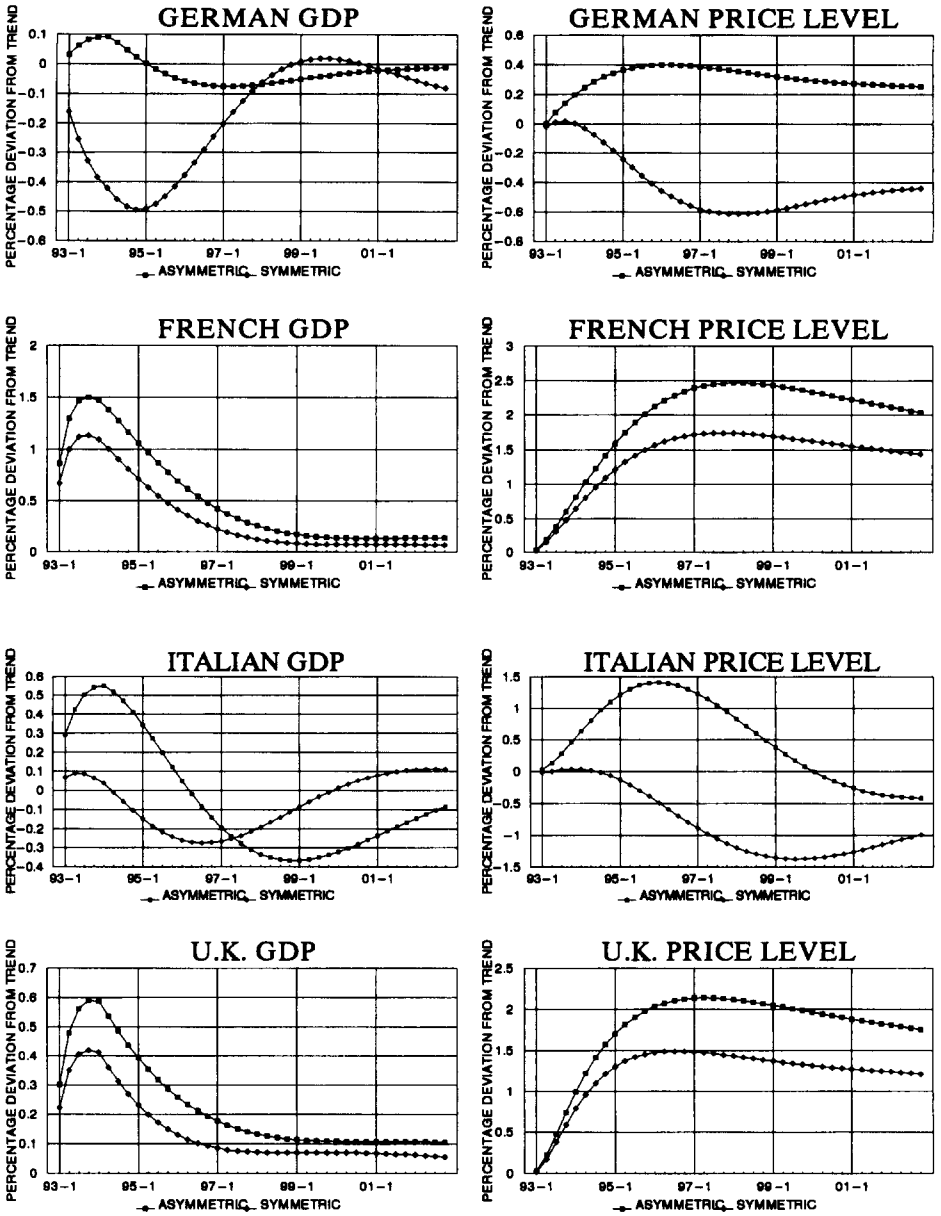

FIGURE 2. Impact of a fiscal expansion outside the EMS on the EMS economies.

Hereafer I use the standard deviation of percentage deviations from target (or baseline) to establish a ranking of monetary policy rules.

II.B Simulation results

This section compares the performance of asymmetric versus symmetric nomi-

nal income rules in the form of interest rate reaction functions. Table 4 reports performance measures for output and price variability in the G-7 economies under asymmetric and symmetric regimes. The smaller the number in the table the better is the stabilization performance of the monetary policy rule with respect to the target variable. For the purpose of sensitivity analysis two different symmetric targets are used, one of which assigns equal weights to each EMS country's nominal income while the other assigns GDP weights. The performance of each monetary regime is measured against the same 10 sets of stochastic shocks.

There are three main observations to be made with respect to the results in Table 4: first, as expected from the analysis in Section I, there is a significant trade-off in terms of output and price stability in the EMS economies between the asymmetric and symmetric policy rule. German output and price variability is higher under the symmetric than under the asymmetric regime, while in the other EMS countries — France, Italy and the UK — it is lower under the symmetric regime. Given the performance measures are actually root mean squared percentage differences from baseline, the magnitude of these numbers turns out to be very similar to the results obtained in Section I. For example, percentage deviations of German ouptut in response to deterministic fiscal shocks were between 0.5 percent and 1 percent larger under the symmetric monetary regime than under the asymmetric regime. This can be compared to the performance measure in Table 4 which is by 0.8 larger in the symmetric case. The variability measures in the first three columns of Table 8 are averages over 10 simulations but as can be seen from the fourth column in the table the trade-off between asymmetric and symmetric targets holds for most of the simulations and is not just due to one or two outliers.

Second, the non-EMS countries — Canada, Japan and the USA — are basically unaffected by the choice of monetary regime in the EMS. Thus the combination of flexible exchange rates and a monetary policy which targets domestic nominal income allows these countries to isolate themselves from the effects of changes in EMS monetary policy. This also implies that there is no additional feedback from German leadership via the other EMS countries which would alter the impact on output and inflation of non-EMS countries. However, the use of nominal income targeting is crucial for this result. If for example, non-EMS central banks target domestic money supplies, the choice of operating target in the EMS will affect the economic performance of non-EMS countries.

Third, small variations in the weights of the symmetric EMS target have only a minimal effect on the stabilization result. In Table 4 we report variability measures for two different symmetric targets, one using equal weights and the other using GDP weights which account for differences in economic size. Equal weights imply a factor of 0.25 for each country, while GDP weights assign factors of 0.35 to Germany, 0.25 to France and 0.2 to Italy and the UK. This result suggests that a search for optimal weights would not significantly improve upon simple weighting schemes such as the two considered here.

The sensitivity of these results to changes in the specification of the policy rules has been investigated just as described in Section I.B. Furthermore I find

TABLE 4. Output and price stability in the asymmetric and symmetric EMS (root mean squared deviations).

Country	Asymmetric EMS	Symmetric EMS with equal weights	Symmetric EMS with GDP weights	Number of simulations
EMS				
Germany				Sym. > Asym.
Real GDP	1.660	2.442	2.235	7
GDP Deflator	1.500	2.540	2.346	9
France				Sym. < Asym.
Real GDP	3.957	3.325	3.370	10
GDP Deflator	4.384	3.527	3.567	9
Italy				Sym. < Asym.
Real GDP	3.907	3.192	3.299	9
GDP Deflator	7.427	5.372	5.675	9
UK				Sym. < Asym.
Real GDP	2.423	2.230	2.241	8
GDP Deflator	4.015	3.540	3.600	7
Non-EMS				
USA				
Real GDP	2.002	1.997	2.000	
GDP Deflator	1.158	1.160	1.159	
Canada				
Real GDP	3.992	3.950	3.948	
GDP Deflator	4.752	4.745	4.730	
Japan				
Real GDP	2.830	2.818	2.820	
GDP Deflator	4.386	4.357	4.360	

Note: Monetary policy is modeled by interest rate rules with nominal income targets. Results are given in root mean squared percentage deviations from baseline. They are averages over 10 stochastic simulations of which each covers 40 quarters.

that even large exchange rate bands would not completely avoid the pressure on non-center economies arising from an asymmetric regime. Simulations with flexible rates show that intra-EMS rates exhibit fairly large variations. As an example, the DM–French franc rate would breach $+/-15$ percent bands about 30 percent of the time and the DM–lira and DM–pound rates about 50 percent of the time. Naturally all the simulation results are conditional on the specific macroeconometric model used and depend on its design and basic properties. Bryant, Hooper and Mann (1993)[7] review several other multi-country models which can be used for studies such as the one here. Masson and

Symansky (1993) report results from stochastic simulations of MULTIMOD similar to the simulations performed in this section but they focus mainly on money supply rules.

The results for output and price variability under different monetary regimes can be better understood by looking at variability measures for the other variables in the multi-country model. Table 5 reports such measures for the components of real spending, nominal and real interest rates, exchange rates, export and import prices and wages in the EMS countries. In the case of Germany, as expected, the variability of investment and consumption demand is higher under the symmetric regime which goes along with more variability in real interest rates. In addition, net exports contribute to changes in output variability in Germany. The increase in German price variability under the symmetric regime is paralleled by an increase in wage variability. In the case of France, Italy and the UK the opposite pattern is observed. Output variability is higher under the asymmetic EMS regime and a large part of this is due to higher variability of investment demand. Consumption also varies more under the asymmetric regime but the difference is smaller than for investment. In Italy and France increased variability in investment and consumption under the asymmetric regime coincides with more variation in real interest rates. Export and import demand conform to the general pattern in being more stable under the symmetric target. However a look at real net exports as a percentage of GDP suggests that net exports contribute little to the trade-off in output variability between the asymmetric and symmetric regime. The reduction in price variability under the symmetric regime is largely explained by a reduction in wage variability which is closely linked to demand via the contract wage equation. Import prices also affect domestic prices directly but contribute little to the reduction in price variability under the symmetric target except maybe in France. Italian output and prices are characterized by stronger fluctuations in the medium term than in the other EMS economies. The higher output variability derives from a much higher variation of Italian investment demand compared to other EMS economies. This sensitivity of investment seems to be due to the greater responsiveness of the Italian wage and price-setting mechanism which translates into larger variations in the real interest rate.

III. Conclusion

This paper has shown that the choice of monetary policy target in the EMS has a quantitatively important effect on the stabilization performance of its member economies. Thereby it highlights a major factor which contributed to the currency crisis in fall 1992 triggering the exit of Italy and the UK from the system and even more so to the recent 1993 crisis which resulted in a considerable widening of the exchange rate bands. The main focus has been on comparing a monetary regime oriented towards domestic targets of the center-country Germany to a symmetric regime oriented towards EMS-wide targets by simulating an empirical macroeconomic model of the G-7 economies.

First, deterministic simulations of macroeconomic shocks inside and outside the EMS detect a considerable effect of the choice of policy target on the size

TABLE 5. Economic performance in the asymmetric and symmetric EMS (root mean squared deviations)

	Asymmetric	Symmetric with equal weights		Asymmetric	Symmetric with equal weights
Investment			*Short-term interest rates*		
Germany	8.621	11.498	Germany	2.712	2.940
France	6.451	5.772	France	2.712	2.940
Italy	19.723	17.186	Italy	2.712	2.940
UK	8.332	8.271	UK	2.712	2.940
Consumption			*Long-term interest rates*		
Germany	1.921	2.890	Germany	2.438	2.818
France	3.597	3.022	France	3.531	3.602
Italy	2.509	2.073	Italy	2.981	3.180
UK	2.407	2.292	UK	2.876	2.946
Export			*Real interest rates*		
Germany	5.441	5.346	Germany	2.851	3.399
France	7.669	6.653	France	4.278	4.105
Italy	5.227	4.906	Italy	7.375	7.052
UK	4.781	4.436	UK	4.436	4.482
Imports			*Wages*		
Germany	3.247	4.506	Germany	2.058	3.588
France	5.230	4.183	France	6.816	5.504
Italy	7.574	6.539	Italy	15.623	13.287
UK	4.969	4.816	UK	5.664	5.217
Net exports as % of GDP			*Export prices*		
Germany	1.615	1.901	Germany	2.659	3.097
France	1.399	1.371	France	4.953	4.524
Italy	1.698	1.669	Italy	6.731	6.278
UK	1.232	1.215	UK	5.567	5.241
US$ exchange rates			*Import prices*		
Germany	22.796	22.518	Germany	7.862	8.106
France	22.796	22.518	France	10.428	9.566
Italy	22.796	22.518	Italy	10.638	10.011
UK	22.796	22.518	UK	9.114	8.811

Note: Monetary policy is modeled in the form of interest rate rules with nominal income targets. Results are given in root mean squared percentage deviations from baseline. They are averages over 10 stochastic simulations of which each covers 40 quarters.

of spillover effects and adjustment processes in EMS economies. The asymmetric target minimizes adjustment in Germany while putting the full adjustment burden on the other EMS countries. The symmetric target reduces the adjustment necessary in the rest of the EMS at the cost of larger output and inflation deviations in Germany. In the case of a German fiscal shock of 1 percent of GDP the difference in adjustment under asymmetric versus symmetric targets can temporarily amount to 1 percent of GDP and 1 percentage point in the annual inflation rate or even more. In the case of an outside shock the differences are about half this size. Second, stochastic simulations of the multi-country model support the conclusions drawn from the deterministic simulations of demand-side shocks with respect to the full variety of shocks possible in the model. As far as the French, Italian and British economies are concerned, the symmetric EMS regime is found to dominate the asymmetric regime in stabilizing output and prices. Germany however enjoys more stability under the asymmetric regime. At the same time countries outside the EMS are barely affected by the choice of monetary policy target in the EMS as long as they use their monetary policy to stabilize domestic income and prices.

Given this trade-off between an asymmetric and a symmetric EMS regime, it is not surprising that the Bundesbank was quite comfortable with the role of anchor of the EMS as long as it could focus on domestic stabilization targets. The question remains why the other EMS members tolerated the asymmetric operation of EMS monetary policy. This may have been the price to be paid for taking advantage of the Bundesbank's reputation for a credible low-inflation policy. However with respect to a future European Monetary Union there would certainly be strong pressure for the European Central Bank to implement a more symmetric policy. This may be the cause of Germany's reluctance to move in this direction. The impact of German unification on the asymmetric EMS must have increased the adjustment burden for non-center economies even more. The subsequent currency crises in 1992 and 1993 might have been avoided, if policymakers had not combined an asymmetric monetary policy target with a strong commitment to keep EMS exchange rates in a very narrow band and to abstain from any restrictions on the free flow of capital. There would have been at least two alternatives: namely either to orient EMS monetary policy towards a symmetric target, or to give non-center EMS members more monetary independence by taking full advantage of exchange rate bands and allowing realignments.

Appendix

The empirical macroeconometric model used for this study was developed by John Taylor and associates at Stanford University and is described in detail in Taylor (1993). It is a model of the G-7 countries: USA, Canada, France, Germany, Italy, Japan and the UK, consisting of 98 equations and a number of identities. The parameters of the model are estimated using quarterly data from the first quarter of 1971 through the fourth quarter of 1986. The rational expectations equilibrium of the model can be solved for by the extended path algorithm described in Fair and Taylor (1983). The central properties of the model are:

(1) *Nominal wages and prices are sticky.* Nominal wages are determined according to the staggered contracts model by Taylor (1979) and prices are set as a markup over wage costs

and imported input costs. This markup is variable and prices adjust slowly to changes in costs. Import and export prices adjust with a lag to domestic and world prices. Long run homogeneity conditions are imposed so that a permanent change in the money supply has no effect on real variables in the long run, once prices and wages have fully adjusted.

(2) *Aggregate demand determines production in the short run*; but if the model is not continually shocked, production eventually returns to an exogenously growing level of potential output. With wages and prices sticky in the short run, changes in monetary policy affect real money balances and aggregate demand and thereby have an impact on real output.

(3) *Government purchases are considered exogenous* as are all other components of fiscal policy. The primary instrument of monetary policy is the short-term interest rate.

(4) *Financial capital is mobile across countries* and within each country bond markets are efficient. However time varying 'risk premia' exist both in foreign exchange markets and in domestic bond markets.

(5) *Expectations are assumed to be rational.* This assumption seems appropriate when examining long-run issues such as the choice of a monetary regime supposed to remain in place for an extended period. Many of the equations in the model are forward-looking in nature. Consumption and investment demand depend on the real interest rate and permanent income (or future sales), which are related to inflationary expectations and expected future income, respectively. Interest rate differentials are related to the expected depreciation rate. Thus over- or undershooting of the exchange rate is possible. The long-term interest rate is related to expected future short-term rates via the term structure equation.

(6) *In the long run* potential output grows at a trend estimated for each country. The long-run inflation rate is set to 3 percent for all countries.

I have investigated a large variety of exogenous shocks to the EMS such as monetary and fiscal expansions outside and inside the system in the presence of different monetary policy rules such as nominal income rules, real income rules and money supply rules. Thus the results presented in Sections I and II have been subjected to an extensive sensitivity analysis. The policy regimes discussed in the paper model monetary policy as short-term interest rate reaction functions with nominal income as target variable:

$$\langle \text{A1} \rangle \qquad RS_j - RS_j^* = (LP_j(+4) - LP_j) + k(LP_j - LP_j^*) + k(LY_j - LY_j^*)$$

where RS is the nominal short-term interest rate; LP is the natural logarithm of the price level; LY is the log of real output; LP^* and LY^* denote the target levels of the logs of price and output. RS^* is the short-term interest rate consistent with the target. k is the reaction coefficient.

Since the deviation of price from target and the deviation of real output from target is multiplied by the same k, this is a nominal income target. $LP(+4)$ is the rational forecast of the four-quarter ahead log of the price level. Therefore $LP(+4)$-LP is the expected inflation rate as calculated by the rational expectations model and the rule above effectively becomes a real interest rate rule. The interest rate adjusts in response to deviations of nominal income from target. The intensity of the monetary policy response depends on the size of the reaction coefficient. For the simulations reported above a value of 1.6 was chosen. This implies that a 1 percent deviation of nominal income from target would require a 1.6 percentage point increase in the interest rate. Equation ⟨A1⟩ is truncated below 1 percent because otherwise the policy may call for negative nominal interest rates.

The EMS is treated as a fixed exchange rate system where short-term interest rates are determined by German monetary policy. Interest rates in the other member countries cannot be set independently since this would trigger capital flows threatening the fixed exchange rate. In the asymmetric regime German nominal income is chosen as target variable for the EMS monetary policy, while in the symmetric regime price and output in the reaction function are weighted EMS averages. Two versions of the symmetric rule are

simulated, one with each EMS countries target deviation receiving equal weight (0.25), and the other with GDP weights (GE = 0.35, FR = 0.25, UK = 0.2, IT = 0.2).

Notes

1. See for example McKinnon (1993), Russio and Tullio (1988) and Giavazzi and Giovannini (1989). A theoretical underpinning of asymmetry in the EMS motivated by game theoretic considerations has been developed by various authors and is also discussed in Giavazzi and Giovannini (1989). The empirical literature surveyed in Wieland (1992) does not provide a clear-cut conclusion on whether the EMS developed into a DM zone. The strongest empirical evidence in favor of German leadership has been provided by Herz and Röger (1992) while others, for example Fratianni and von Hagen (1992), only find support for an independent but not a dominant role of Germany.
2. A system in which monetary policy is carried out cooperatively with the objective of keeping intra-EMS exchange rates fixed and targeting an EMS aggregate would yield similar results as a Germany-centered system with EMS-wide targets for German monetary policy. However, a low inflation target in such a cooperative regime may be less credible than in a regime with German policy providing the nominal anchor.
3. Given the nature of the international spillovers to be studied, it is crucial to use a model which explicitly models the effects of expectations on exchange rates, prices and interest rates. Further assumptions are perfect capital mobility, sticky wages and prices, consumption smoothing and slowly adjusting import prices and import demands.
4. Although the intervention rules of the EMS are designed symmetrically, at least as far as obligatory intervention at the margins is concerned, the practice of sterilization can very well result in an asymmetric policy. For example, the use of DM-denominated assets by EMS members as reserves for foreign exchange intervention results in automatic sterilization. Furthermore, the Bundesbank regularly takes into account the effects of interventions and other transactions involving foreign exchange inflows and outflows to and from Germany when estimating its desired monetary base as emphasized by Mastropasqua *et al.* (1988).
5. Structural residuals are obtained by solving the model dynamically and using data through each sample point to calculate model-consistent expectations. Then these are used to substitute out for expectation variables in each equation (Taylor, 1993).
6. The small number of draws is due to the fact that the stochastic simulations are very computation intensive. The algorithm used to solve this rational expectations model is the Fair–Taylor extended path algorithm. One stochastic simulation takes up to 8 hours on a Sun Sparc 2 Workstation.
7. The chapter by Hughes Hallett, Minford and Rastogi (1993) uses the LIVERPOOL Model to study several issues concerning the EMS.

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