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"Monetary Policy Interaction Within the EMS"

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Abstract

A simple two-country stochastic model is used to analyze monetary policy interaction in a system of exchange rate bands such as the EMS, in the context of internationally-integrated financial markets. We consider the widely-acknowledged asymmetry of the system, as it pertains to member countries' use of monetary policy to offset shocks that impinge on their national incomes. Our results suggest, among other things, that tightening the exchange-rate bands would lead to more intervention by all members, even if formal responsibility for keeping exchange rates within the bands lay only with the peripheral countries.

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Summary

The European Monetary System (EMS) was established in 1979, a time of high and variable inflation rates, in order to create a "zone of monetary stability" in Europe. A noteworthy feature of the system is its asymmetry; it is widely agreed that the Federal Republic of Germany plays a pivotal role in the system. The monetary policy of the Bundesbank provides the anchor for the system by maintaining a stable medium-term path for the German money supply; the other members in turn take responsibility for maintaining their bilateral exchange rates vis-á-vis the deutsche mark within the agreed bands.

In this paper, a simple theoretical model is used to explore this asymmetry as it pertains to the ability of the member countries' monetary authorities to offset shocks impinging on their national incomes. The model is a two-country variant of the Mundell-Fleming model, incorporating rational expectations. Capital is assumed to be highly mobile, reflecting the increasing integration of European financial markets associated with Project 1992.

The model is developed in three different directions. First, it is used to trace the implications of alternative simple monetary arrangements --symmetric or asymmetric--for the transmission of shocks to national incomes. The analysis reveals that, if the variance of shocks in one of the countries is relatively large, both countries may benefit from an asymmetric arrangement in which this country stabilizes the exchange rate while the other controls its own money supply.

Second, the paper examines the interaction of two countries' choice of monetary policy and shows how this interaction may be influenced by a pre-existing bilateral commitment to maintain the exchange rate within specified bands. An example is constructed in which such a commitment creates an incentive, rather than satisfies a need, for policy coordination. Such coordination is not generally beneficial, as it results in greater stability of exchange rates at the expense of greater variability of real income. A narrowing of the exchange rate bands in this context would lead to more intervention by both countries, even if formal responsibility for maintaining the currency within the bands lies only with one country.

Third, the paper examines the loss of monetary autonomy as exchange rate bands become arbitrarily narrow. In this case, given perfect capital mobility, shocks in one country are transmitted to both countries' incomes and require similar policy responses; for this reason, the need, as well as the scope, for autonomous policy vanishes as the bands become arbitrarily narrow.

I. Introduction

The European Monetary System (EMS) was established in 1979, a time of high and variable inflation rates, to create "a zone of monetary stability" in Europe. It is generally accepted that this meant creating an environment in which the participating countries would gradually reduce their inflation rates while avoiding pronounced realignments of real exchange rates. The fixed central rates, which can be realigned only with the consent of all members, embody this stabilizing element of the EMS. The bands around the central rate inside which exchange rates are allowed to fluctuate 1/ were meant to give the authorities some freedom to use monetary policy in the short run even if they accept the commitment to keep their intra-EMS exchange rate stable on average in the long run.

A prominent feature of the EMS is its asymmetry. Germany plays a pivotal role in the system: there is evidence that the monetary policy of the Bundesbank provides the anchor for the system by maintaining a stable medium-term path for the money supply in Germany; the "peripheral" countries, in turn, take responsibility for stabilizing their own currencies' values vis-à-vis the deutsche mark (Giavazzi and Giovannini (1987), Gros and Thygesen (1988)). This arrangement may entail asymmetry of two distinct types. One is an asymmetry of strategic role: it is argued that Germany acts as "dominant player," setting its policy in the knowledge that other members will take it into account in setting theirs. The other is an asymmetric assignment of central banks to targets: Germany pursues macroeconomic targets while the other members pursue exchange-rate targets. It would be desirable to explore the implications of both kinds of asymmetry.

The most common explanation of the asymmetry of the EMS is associated with the idea of credibility. Participation in the exchange-rate mechanism may enhance the credibility of an anti-inflationary monetary policy, by reducing the authorities' incentive to deviate from their stable-money-growth policies in the attempt to stimulate output in the short run (Melitz (1987)). It has been argued that, from the perspective of the peripheral countries, accepting the constraint of the bands is similar to hiring a "conservative central banker," namely the Bundesbank (Giavazzi and Pagano (1986), Giavazzi and Giovannini (1987). 2/ This credibility argument suggests that the central bank of the least inflationary country should set its money supply first, in the light of macroeconomic conditions; the other countries' policies are then constrained by the need to prevent their currencies' values from fluctuating outside the agreed bands.

The concept of credibility does shed light on the asymmetry of policy interaction within the EMS. However, it does not provide a complete

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1/ In general, ± 2.25 percent except for Italy which has ± 6 percent.

2/ This and other ways of establishing credibility are discussed in Canzoneri (1985) and Rogoff (1987).

characterization of the system. For one thing, it provides no explanation of exchange-rate bands of non-zero width (Lane and Rojas-Suarez (1988)). In order to explain such bands, there must be some reason for preserving flexibility in the monetary policies of the peripheral countries; this suggests considerations related to the literature on stabilization policy, in which the authorities attempt to "lean against the wind" to an optimal degree in order to offset the effects of shocks that impinge on the economy (e.g., Boyer (1978), Bhandari (ed. (1985)), Roper and Turnovsky (1980)). Even if the authorities are required to keep the exchange rate within a band established by international agreement, as under the EMS, there may be some remaining scope for stabilization policy (Gros (1988)). The resulting variability of real income will thus depend on the extent to which such an existing international agreement acts as a constraint which influences policy choices.

The loss of the peripheral countries' autonomy in carrying out stabilization policy has been of significant concern since the system's foundation in 1979 (see Ungerer, et al. (1986). However, as 1992 approaches, with the promise that by that date all remaining barriers to capital mobility within the European Community will be eliminated, discussion of this issue has intensified. There is concern that, as capital markets become completely integrated, the remaining degree of autonomy of all EMS members but Germany will vanish. This concern has stimulated discussion of other alternatives, including negotiated coordination of policies or even the establishment of a European central bank (see Gros and Thygesen (1988)).

In this paper, we wish to explore the implications of, and rationale for, the asymmetrical structure of the EMS, in a context in which the authorities in each country wish to stabilize real income in the face of random shocks to aggregate supply and money demand and the equilibrium real exchange rate. We present a model, incorporating the assumption of perfect capital mobility, in Section II of the paper; we then proceed to use this model to explore in three different directions. First, in Section III we examine the implications of some simple policy rules for the transmission of various shocks to real income in the two countries; we show that an asymmetric system in which one country controls its money supply and the other stabilizes exchange rate may, under some circumstances, be to the benefit of both countries. Second, in Section IV we examine the interaction of two countries' choice of exchange-market-intervention policy, first in the absence of any institutional constraint and then in the case in which the central banks regard themselves as constrained by an agreement on exchange-rate bonds which has been made by their respective governments; we find that such an existing agreement may give scope to asymmetry in policy making and create a "need" for policy coordination, even where none would otherwise exist. We also find that, even if only the peripheral country is directly constrained by the exchange-rate band, tightening this band may lead to more intervention by the German authorities as well. Our third exercise, presented in Section V, is an examination of the interaction of interest-rate feedback policy when the exchange-rate bands are arbitrarily narrow;

we re-establish the familiar result that policy autonomy vanishes with fixed exchange rates when capital mobility is perfect; however, we also find that under these same conditions, the desirability of policy autonomy also vanishes, as the effects of country-specific shocks are transmitted equally to both countries. Each of these explorations highlights a different aspect of asymmetrical policy interaction within the EMS.

II. The Model

The model is a somewhat modified two-country version of the standard Mundell-Fleming framework with perfect capital mobility. The model is simplified by assuming stochastic purchasing-power parity. There are also random shocks to aggregate supply and to money demand in each country, as well as to worldwide demand. Rational expectations are assumed. The model is further simplified through the assumption that many parameters are identical across the two countries, and in many cases are unitary. 1/ The reason that we are assuming that countries are identical in many respects, even though our goal is to explain asymmetry in the EMS, is that we wish to isolate particular sources and implications of asymmetry. For convenience, we shall refer to the two countries as "Germany" and "France."

The equations of the model are as follows:

$$(1)\quad y_t = \gamma(p_t - E_{t-1}p_t) + w_t^s$$

$$(2)\quad y_t^* = \gamma(p_t^* - E_{t-1}p_t^*) + w_t^{s*}$$

$$(3)\quad p_t = p_t^* + s_t + u_t^p$$

$$(4)\quad m_t - p_t = y_t - \delta i_t + v_t$$

$$(5)\quad m_t^* - p_t^* = y_t^* - \delta^* i_t^* + v_t^*$$

1/ Without such simplifying assumptions, it is difficult to derive many analytical results in a two-country model with policy interaction. An alternative taken by several authors in this area (for instance Oudiz and Sachs (1984) and some papers collected in Buiter and Marston (ed., 1985)) is to simulate results using particular parameter values. We prefer to use a simplified analytical model, in order to facilitate intuitive interpretation of our results.

(6) $i_t = i_t^* + E_t s_{t+1} - s_t$

(7) $y_t + y_t^* = - i_t + E_t p_{t+1} - p_t + \frac{1}{2} u_t^p + u_t^d$

Here y_t, y_t^* are the logs of real national income in Germany and France, respectively, expressed as deviations from their trend levels; p_t, p_t^* are the logs of the two countries' price levels; s_t is the log of the nominal exchange rate, that is the price of francs in terms of deutsche marks; m_t and m_t^* are the logs of the money supplies in the two countries; i_t and i_t^* are the nominal interest rates in the two countries; δ and γ are parameters. The supply shocks w_t^s and w_t^{s*}, money demand shocks v_t and v_t^*, purchasing power parity shock u_t^p and world demand shock u_t^d are all assumed to be independently distributed with zero mean and variances σ_s^2, σ_{s*}^2, σ_v^2, σ_v^{*2}, σ_p^2, and σ_d^2, respectively.

Equations (1) and (2) are aggregate supply equations based on one-period labor contracts as in Fischer (1977). Equations (3) and (4) are semilog money demand equations with unitary income elasticity. Equation (5) is a stochastic purchasing-power parity relationship, 1/ while equation (6) requires uncovered interest parity. 2/ Equation (7) is a world demand equation, indicating that world demand depends on real interest rates; the reason that the purchasing-power-parity shock u_t^p appears in this equation is that it is associated with a temporary divergence between real interest rates in the two countries. 3/

Next, we must specify how each country's money supply is determined. We shall be assuming for simplicity (as in Barro (1976)) that the authorities wish to stabilize real income around its natural or full-information level; given the structure represented in equations (1) to (7), this also means minimizing the variance of unanticipated price

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1/ Since we do not have an explicit two-good framework this shock should perhaps be interpreted as random variation in the cost of arbitrage.

2/ There is no shock to the uncovered interest parity condition (6); this reflects the liberalization of capital movements in connection with Project 1992, which should remove any significant barriers to interest arbitrage.

3/ The reason that the PPP shock enters with a weight of 1/2 is that the foreign real interest rate exceeds the domestic rate by the amount of the shock; we assume that the two countries have equal weight in world demand.

movements. 1/ The authorities may also be concerned about the expected rate of inflation; under rational expectations such concerns can be addressed by selecting an appropriate expected or target money supply, m_t^T and m_t^{*T}, respectively. We shall assume that the authorities can observe interest rates and exchange rates, but cannot immediately observe the current levels of income and prices. The authorities may choose to deviate from their money-supply targets in response to movements of interest rates and/or the exchange rate, as these incorporate information about this period's shocks. Because the model is log-linear, the appropriate monetary feedback can be represented as follows: 2/

$$(8)\quad m_t = m_t^T - \kappa(s_t - s_t^T) + \chi(i_t - i_t^T)$$

$$(9)\quad m_t^* = m_t^{T*} + \kappa^*(s_t - s_t^{T*}) + \chi^*(i_t^* - i_t^{T*})$$

This formulation implies that policy is conducted either through open-market operations (as in the case of "dirty floating") or through foreign-exchange-market intervention whose effects on the domestic money supply are unsterilized while its effects on the foreign money supply are sterilized (in contrast to Lane (1987, 1988)).

Various simple rules can be represented as special cases, depending on the policy parameters in equations (8) and (9):

(1) Flexible exchange rates with money supply rules in both countries implies that $\kappa = \kappa^* = \chi = \chi^* = 0$.

(2) Interest-rate targeting with flexible exchange rates implies that $\kappa = \kappa^* = 0$ but $\chi, \chi^* \geq 0$.

(3) Bilateral foreign-exchange-market intervention implies that κ, $\kappa^* \neq 0$. The exchange-rate feedback parameters are positive if the authorities "lean against the wind," although cases in which leaning with the wind is appropriate have also been found in similar models in the

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1/ The assumption that the full-information level of income is optimal rules out the time-consistency problem which is central to other analyses of the EMS, e.g., Giavazzi and Pagano (1986), Giavazzi and Giovannini (1987), Lane and Rojas-Suarez (1988). This means assuming that the only departure from a Pareto optimal competitive equilibrium is associated with the fact that wages are pre-set without knowledge of this period's shocks, as reflected in the deviation of output from its full-information level $y_t - w_t^s$.

2/ We do not include a feedback response of one country's money supply to the other's interest rate because this would be redundant given the uncovered interest parity condition (6).

literature (Roper and Turnovsky (1980), Buiter and Eaton (1985), Lane (1988)).

(4) A two-sided fixed-exchange-rate system, in which both parties attempt to maintain the exchange rate at its target level, implies that $s_t^T = s_t^{T*}$ and κ, $\kappa^* \rightarrow \infty$.

(5) A "greater deutschmark area" implies that $\kappa^* \rightarrow \infty$ while $\kappa = 0$.

(6) A greater deutschmark area with a strictly monetarist Bundesbank implies that $\kappa = \chi = \chi^* = 0$ while $\kappa^* \rightarrow \infty$.

Let us first explore the general case in which we admit the possibility that κ, κ^*, χ and $\chi^* \neq 0$.

For notational convenience, let us define the sum of the interest-rate feedback parameter and the interest elasticity of money demand, $\lambda \equiv \chi + \delta$ and $\lambda^* \equiv \chi^* + \delta^*$. We then obtain the following solution for real income in Germany, expressed in terms of its deviation from the full-information level:

$$(10)\quad y_t - w_t^s = (\gamma/\Delta)\left\{\pi_{11}w_t^s + \pi_{12}w_t^{s*} + (\pi_{13} + \tfrac{1}{2}\pi_{16})\, u_t^p + \pi_{14}v_t + \pi_{15}\, v_t^* + \pi_{16}\, u_t^d\right\}$$

where

$$\Delta = -\left\{\gamma^2(1+\lambda + \lambda^*) + (1+\gamma)(\kappa+\kappa^*) + (1+2\gamma)(1+\lambda+\lambda^* + \lambda\lambda^* + \kappa\lambda^* + \lambda\kappa)\right\}$$

$$\pi_{11} = (1+\gamma)(1+\lambda+\lambda^*) + \kappa^* + \lambda^*(\lambda+\kappa) + \lambda\kappa^*$$

$$\pi_{12} = \lambda + \kappa + \lambda\lambda^* + \lambda\kappa^* + \lambda^*\kappa$$

$$\pi_{13} + \tfrac{1}{2}\pi_{16} = -\ [(1+\gamma)\kappa + (\gamma+\tfrac{1}{2})(\lambda\lambda^* + \lambda\kappa^* + \lambda^*\kappa) + \tfrac{1}{2}\ (1+\gamma)\lambda]$$

$$\pi_{14} = (1+\gamma)(1+\lambda^*) + \kappa^*$$

$$\pi_{15} = \kappa - \gamma\lambda$$

$$\pi_{16} = -[(1+\gamma)\lambda + \lambda^{*}\kappa + \lambda^{*}\kappa + \lambda\lambda^{*}]$$

Next, we can solve for income in France, obtaining

$$(11)\ y_t^{*} - w_t^{s*} = (\gamma/\Delta)\Big\{\pi_{21}w_t^{s} + \pi_{22}w_t^{s*} + (\pi_{23} + \tfrac{1}{2}\pi_{26})\ u_t^{p} + \pi_{24}v_t + \pi_{25}v_t^{*} + \pi_{26}u_t^{d}\Big\}$$

where

$$\pi_{21} = \lambda^{*} + \kappa^{*} + \lambda\lambda^{*} + \lambda\kappa^{*} + \lambda^{*}\kappa$$

$$\pi_{22} = (1+\gamma)(1+\lambda+\lambda^{*}) + \kappa + \lambda(\lambda^{*}+\kappa^{*}) + \lambda^{*}\kappa$$

$$\pi_{23} + \tfrac{1}{2}\pi_{26} = (1+\gamma)\kappa^{*} + (\gamma+\tfrac{1}{2})\ (\lambda\lambda^{*} + \lambda^{*}\kappa + \lambda\kappa^{*}) + \tfrac{1}{2}\ (1+\gamma)\lambda^{*}$$

$$\pi_{24} = \kappa^{*} - \lambda\kappa^{*}$$

$$\pi_{25} = (1+\gamma)(1+\lambda) + \kappa$$

$$\pi_{26} = -[(1+\gamma)\lambda^{*} + \lambda\kappa^{*} + \lambda^{*}\kappa + \lambda\lambda^{*}]$$

We can also find the exchange rate:

$$(12)\ s_t = (1/\Delta)\ \Big\{\pi_{31}w_t^{s} + \pi_{32}w_t^{s*} + (\pi_{33} + \tfrac{1}{2}\pi_{36})u_t^{p} + \pi_{34}\ v_t + \pi_{35}\ v_t^{*} + \pi_{36}u_t^{d}\Big\}$$

where

$$\pi_{31} = (1+\gamma)(1+\lambda) + \gamma\lambda^{*}$$

$$\pi_{32} = -[(1+\gamma)(1+\lambda^{*}) + \gamma\lambda]$$

$$\pi_{33} + \frac{1}{2}\pi_{36} = \gamma(1+\gamma)(1+\lambda+\lambda^*) + \frac{1}{2}(1+\gamma)(\lambda^*-\lambda)$$

$$\pi_{34} = 1 + \gamma + (1+2\gamma)\lambda^*$$

$$\pi_{35} = -[(1+\gamma) + (1+2\gamma)\lambda]$$

$$\pi_{36} = (1+\gamma)(\lambda^* - \lambda)$$

There are several important features of these solutions. First, we may note the fact that the effect of each of the shocks on income in each country depends on the policies being pursued in both countries. Despite the simplicity and log-linearity of the model, the transmission of shocks depends on nonlinear combinations of the feedback parameters, as indicated by the fact that many of the coefficients in equations (10) and (11) depend on products of policy parameters in the two countries. Second, these reduced-form solutions reflect the symmetry that is built into the structure: the effects of German and French shocks on German and French income depend on the two countries' policy parameters in a parallel fashion, mutatis mutandis. Domestic shocks do not necessarily have a larger impact on domestic income than do foreign shocks; the relative magnitude of the two effects depends upon the policies being pursued in both countries. World demand shocks have parallel effects on both countries' incomes, while PPP shocks have parallel and opposite effects. Shocks in the two countries have parallel and opposite effects on the exchange rate, while the exchange rate is affected by world demand shocks only to the extent that the two countries' interest-rate feedback parameters differ.

This model provides a setting in which alternative policy rules can be compared, and in which the interaction between the two countries' choice of policy can be analyzed. We follow each of these directions in the following sections of the paper, considering various policy rules that might be special cases of the EMS and comparing them to various alternatives.

III. Some Simple Policy Rules

In this section, we shall consider some alternative simple rules for monetary policy, and examine these rules' implications for the transmission of shocks within and between the two economies. We find that, depending on the variances of different kinds of shocks, the regimes have different implication for the variance of national income in the two countries.

1. Monetarist isolationism

By "monetarist isolationism," we mean a regime in which each country adheres to a constant-growth-rate monetary rule, while maintaining a flexible exchange rate vis-à-vis rest of the world. In this case, since each central bank fixes its money supply irrespective of observations of the exchange rate or the interest rate, $\kappa = \kappa^* = \chi = \chi^* = 0$. This implies that German income is

$$(13)\ y_t - w_t^s = (\gamma/\Delta^{MI}) \left\{\pi_{11}^{MI} w_t^s + \pi_{12}^{MI} w_t^{s*} + (\pi_{13}^{MI} + \frac{1}{2}\pi_{10}^{MI}) u_t^p + \pi_{14}^{MI} v_t + \pi_{15}^{MI} v_t^* + \pi_{16}^{MI} u_t^d\right\}$$

where

$$\Delta^{MI} = -[(1+\gamma)^2(1+\delta+\delta^*) + (1+2\gamma)\delta\delta^*]$$

$$\pi_{11}^{MI} = (1+\gamma)(1+\delta+\delta^*) + \delta\delta^*$$

$$\pi_{12}^{MI} = \delta(1+\delta^*)$$

$$(\pi_{13}^{MI} + \frac{1}{2}\pi_{16}^{MI}) = -[(\gamma+\frac{1}{2})\ \delta\delta^* + \frac{1}{2}\ (1+\gamma)\delta]$$

$$\pi_{14}^{MI} = (1+\gamma)(1+\delta^*)$$

$$\pi_{15}^{MI} = -\ \gamma\delta$$

$$\pi_{16}^{MI} = -[(1+\gamma)\delta + \delta\delta^*]$$

Similar results hold, mutatis mutandis, for French income. Therefore, under this regime of monetarist isolationism in each country, neither country's income is insulated from shocks occurring in the other country, or from PPP or world demand shocks. A positive supply shock in either country leads both countries' incomes to rise by less than the amount of the shock. A positive money demand shock will lower income at home and raise it abroad. A PPP shock also raises income in one country and lowers it in the other, while a positive world demand shock raises both countries' incomes. All of these, as well as domestic supply and portfolio shocks, lead national income to deviate from its natural level. (However, under this regime domestic shocks have a greater impact on domestic income than foreign shocks.)

The reason that exchange-rate flexibility does not insulate an economy against external shocks is the following: the exchange rate reflects various shocks, both internal and external. We can see this by examining the reduced form for the exchange rate:

$$(14)\quad s_t = (1/\Delta)\left\{\pi_{31}^{MI} w_t^s + \pi_{32}^{MI} w_t^{s*} + (\pi_{33}^{MI} + \frac{1}{2}\pi_{36}^{MI})\, u_t^p + \pi_{34}^{MI} v_t + \pi_{35}^{MI} v_t^* + \pi_{36}^{MI} u_t^d\right\}$$

where:

$$\pi_{31}^{MI} = (1+\gamma)(1+\delta) + \gamma\delta^*$$

$$\pi_{32}^{MI} = -(1+\gamma)(1+\delta^*) - \gamma\delta$$

$$(\pi_{33}^{MI} + \frac{1}{2}\pi_{36}^{MI}) = \gamma(1+\gamma)(1+\delta+\delta^*) + \frac{1}{2}(1+\gamma)(\delta^*-\delta)$$

$$\pi_{34}^{MI} = 1+\gamma + (1+2\gamma)\delta^*$$

$$\pi_{35}^{MI} = -\left[(1+\gamma) + (1+2\gamma)\delta\right]$$

$$\pi_{36}^{MI} = (1+\gamma)(\delta^*-\delta)$$

As we see, all the shocks except the worldwide demand shock affect the exchange rate, with the effects of shocks in Germany being the opposite of those of shocks in France. The exchange rate, in turn, is linked with interest rates via the interest-arbitrage condition (6). For example, a positive transitory supply shock in France temporarily raises the value of the franc; since a temporary appreciation is associated with the expectation of a subsequent depreciation, this leads interest rates to increase in France and decrease in Germany, thereby affecting demand for money and the price level in both countries.

This interpretation is borne out by considering the case in which the demand for money is interest-inelastic in both countries ($\delta = \delta^* = 0$). In this case,

$$(15)\quad y_t - w_t^s = (\gamma/1+\gamma)(w_t^s + v_t)$$

As we see, if the interest elasticity of money demand in both countries were zero, under flexible exchange rates and money-supply rules, German income is affected only by German shocks. Similarly, in this case, French income is affected only by French supply and money-demand shocks. The exchange rate then absorbs all the effect of the PPP shock, as well as the difference between French and German shocks:

$$(16)\quad s_t = (1/1+\lambda)\left\{w_t^s - w_t^{s*} + \gamma u_t^p + v_t - v_t^*\right\}$$

An examination of this special case highlights the role of the interest elasticity of money demand in the transmission of shocks from one country to another, even under a regime of monetarist isolationism. This transmission would be reinforced by any interest-rate targeting in monetary policy.

2. A monetarist "Greater Deutschmark Area" (GDA)

In a monetarist "Greater Deutschmark Area," the Bundesbank adheres strictly to a money-supply target, while the Banque de France stabilizes the franc-DM exchange rate; thus $\chi = \chi^* = \kappa = 0$ while $\kappa^* \to \infty$. In this asymmetrical case, German income is

$$(17)\quad y_t - w_t^s = (\gamma/\Delta^{DA})\left\{\pi_{11}^{DA} w_t^s + \pi_{12}^{DA} w_t^{s*} + (\pi_{13}^{DA} + \frac{1}{2}\pi_{16}^{DA})u_t^p + \pi_{14}^{DA} v_t + \pi_{15}^{DA} v_t^* + \pi_{16}^{DA} u_t^d\right\}$$

where

$$\Delta^{DA} = -[(1+\gamma) + (1+2\gamma)\delta]$$

$$\pi_{11}^{DA} = 1 + \delta$$

$$\pi_{12}^{DA} = \delta$$

$$\pi_{13}^{DA} + \frac{1}{2}\pi_{10}^{DA} = -(\gamma+\frac{1}{2})\delta$$

$$\pi_{14}^{DA} = 1$$

$$\pi_{15}^{DA} = 0$$

$$\pi_{16}^{DA} = -\delta$$

Thus, German income is insulated from French portfolio shocks, which are absorbed by the French demand for money; all other shocks have some effect on German income (although French supply shocks have a smaller impact than similar shocks in Germany). Supply shocks in either country lead to negative price surprises, leading income to fall short of its natural level (although, in general, by less than the amount of the shock). A positive shock to German money demand leads to a decrease in German income. A rise in world demand increases income in Germany. French supply shocks and PPP shocks are transmitted to German income via prices and interest rates; this interpretation is borne out by the observation that if the interest elasticity of German demand for money $\delta = 0$, German income is

$$(18)\quad y_t - w_t^s = (\gamma/1+\gamma)\left\{w_t^s + v_t\right\}$$

Thus, if the interest elasticity of demand for money were zero, a German supply shock would lead to an equal but opposite deviation of German income from its natural level, leaving the level of real income unchanged; this exact result is derived from the unitary elasticity of the aggregate demand and money demand curves. German income would also be affected one-for-one by German money demand shocks. At the same time, German income would in this case be insulated from the effects of French supply and portfolio shocks, of PPP shocks and of global demand shocks.

French income is determined differently:

$$(19)\quad y_t^* - w_t^{s*} = (\gamma/\Delta^{DA})\Big\{\pi_{21}^{DA} w_t^s + \pi_{22}^{DA} w_t^{s*} + (\pi_{23}^{DA} + \frac{1}{2}\pi_{26}^{DA})\, u_t^p$$
$$+ \pi_{24}^{DA} v_t + \pi_{25}^{DA} v_t^* + \pi_{26}^{DA} u_t^p\Big\}$$

where:

$$\pi_{21}^{DA} = 1 + \delta$$

$$\pi_{22}^{DA} = \delta$$

$$(\pi_{23}^{DA} + \frac{1}{2}\,\pi_{26}^{DA}) = [(1+\gamma) + (\gamma + \frac{1}{2})\delta]$$

$$\pi_{24}^{DA} = 1$$

$$\pi_{25}^{DA} = 0$$

$$\pi_{26}^{DA} = -\delta$$

Thus, in a GDA, French income is affected by all of the shocks except French portfolio shocks, which are absorbed by the French money supply in the course of stabilizing the exchange rate. French income falls below its full-information level in case of positive supply shocks or German money-demand shocks, or in the case of negative world demand shocks; it is also affected by PPP shocks. To see the extent to which these results hinge on the interest-sensitivity of money demand, we can consider the case in which $\delta* = 0$: here,

$$(20)\quad y_t^{*} - w_t^{s*} = (\gamma/1+\gamma)\left\{w_t^s + v_t + (1+\gamma)\ u_t^p\right\}$$

Thus, with interest-inelastic money demand, French income is affected inversely one-for-one by German supply and portfolio shocks, while it is affected more than one-for-one by PPP shocks. On the other hand, French supply and money demand shocks, as well as world demand shocks, leave French income unaffected; instead, given the French policy of using the money supply to keep the exchange rate unchanged, all of these shocks are absorbed by the French money supply.

We can begin to see why, purely on the basis of stabilization policy, two countries might choose to link the values of their currencies: if the variance of French portfolio shocks were relatively large, having these shocks absorbed by the French money supply rather than by interest rates, prices and incomes could reduce the variability of income in both countries. French supply shocks also have a smaller effect on French income in a GDA than under flexible exchange rates, although they also have a greater effect on German income; however, since only the French have to intervene to stabilize the franc-mark exchange rate, it is only their choice between flexible rates and a GDA that matters. However, the Germans also have the choice of intervening, resulting in a bilateral currency area, which will be examined in the next subsection.

3. A monetarist bilateral currency area (BCA)

In this regime, both central banks adjust their money supplies in order to stabilize their bilateral exchange rate; on the other hand, we ignore any attempt to stabilize interest rates. Therefore, κ, $\kappa^* \to \infty$ while $\chi = \chi^* = 0$. Accordingly, German income is given by

$$(21)\ y_t - w_t^s = (\gamma/\Delta^{BI})\Big\{\pi_{11}^{BI} w_t^s + \pi_{12}^{BI} w_t^{s*} + (\pi_{13}^{BI} + \tfrac{1}{2}\pi_{16}^{BI})u_t^p + \pi_{14}^{BI} v_t + \pi_{15}^{BI} v_t^* + \pi_{16}^{BI} u_t^d\Big\}$$

where:

$$\Delta^{BI} = -[2(1+\gamma) + (1+2\gamma)(\delta+\delta^*)]$$

$$\pi_{11}^{BI} = 1 + \delta + \delta^*$$

$$\pi_{12}^{BI} = 1 + \delta + \delta^*$$

$$\pi_{13}^{BI} = -\ [(\gamma+\tfrac{1}{2})(\delta+\delta^*) + (1+\gamma)]$$

$$\pi_{14}^{BI} = 1$$

$$\pi_{15}^{BI} = 1$$

$$\pi_{16}^{BI} = -(\delta+\delta^*)$$

while French income is determined symmetrically. Thus, under this regime, a supply or money-demand shock in France affects German income to the same degree as an equal shock in Germany. It is also noteworthy that, under this regime, a positive French money-demand shock lowers German income, while under the flexible exchange rate (MI) regime, it raises it. Furthermore, if money demand were interest-inelastic, income in both countries would still depend on all the shocks, although in a simplified way:

$$(22)\ y_t - w_t^s = \frac{\gamma}{2(1+\gamma)} \left\{ w_t^s + w_t^{s*} - (1+\gamma)u_t^p + v_t + v_t^* \right\}$$

Therefore, under the BCA regime, exchange-market intervention is an additional channel for the transmission of shocks.

We are now ready to compare the transmission of shocks under alternative regimes. By comparing corresponding coefficients in equations (13), (17), (19), and (21), we can rank the impact of shocks. Here, a ranking of 4 denotes the largest impact in absolute value, while a ranking of 1 denotes the smallest impact. Here, GDA-G and GDA-F denote the asymmetrical currency union seen from the standpoint of the nonintervening and the intervening parties, respectively.

	Regime			
Shocks	MI	GDA-G	GDA-F	BCA
Home supply	4	3	1	2
Foreign supply	1	2	4	3
Home money	4	3	1	2
Foreign money	2	1	4	3
Purchasing power parity	1	2	4	3
World demand ($\delta > \delta^*$)	4	3	1	2
World demand ($\delta < \delta^*$)	1	2	4	3

(a sufficient condition for these rankings of the effects of a home supply shock is that δ, $\gamma \leq 1$).

We can draw a number of conclusions from these results. One is that, if foreign supply shocks or PPP shocks are relatively large, a country that wishes to stabilize its real income around its natural or full-information level would prefer to maintain a flexible exchange rate regime, or to be the nonintervening party in an asymmetrical currency area. If foreign money shocks are large, being the nonintervening party is first choice and flexible exchange rates second. If home supply or money demand shocks are large, one would prefer to be the intervening party (France) in an asymmetrical currency area. The ranking of the impact of world demand shocks can go either way, depending on whether the interest elasticity of money demand is greater at home or abroad.

In practice, all of these types of shock are presumably of some importance; the choice of regime depends on the variances of all of the shocks. Empirical evidence suggesting that supply and money demand shocks in the non-German EMS countries are large relative to those in Germany would suggest that a German-led EMS may have a stabilizing effect on income in both Germany and the other member countries. Evidence presented in Stockman (1988) might be interpreted as suggesting that this may be true for supply shocks.

Two particular issues arise as qualifications to the analysis in this section. For one, the authorities in each country may have the option of exchange-rate management ($\kappa \neq 0$ but $\kappa < \infty$), rather than the extremes of floating or establishing a currency area. This is particularly important within the EMS, where the rules of the system require, not that the exchange rate be kept at fixed parity levels but that it be kept within certain bands and that realignments be infrequent.

A second issue is that the authorities have the option of smoothing interest rates: the importance of smoothing for the choice of exchange-rate regime can be seen by replacing δ, δ^* with $\lambda = \delta + \chi$, $\lambda^* = \delta^* + \chi^*$ in equations (13), (16), (18), and (20) above. As can be seen, this change does not affect the relative rankings of the impact of shocks with two exceptions: with a home supply shock, sufficiently strong monetary feedback from interest-rate movements may reverse the rankings presented in the table above. A high degree of feedback from interest rates by one central bank or the other may also reverse the rankings of the impact of a world demand shock. The reason for these changes is that interest-rate feedback on the money supply reinforces the effect of a change in interest rates, which is one of the main channels of transmission in this model. Exchange-rate and interest-rate feedback had probably best be viewed as two interdependent features of the monetary policy rule, each of which affects the other.

In the following two sections, we will consider, in a limited way, the two issues just mentioned. First we will examine, in a simplified setting, the choice of an optimal degree of monetary feedback to exchange-rate movements, examining the implications of the constraint that the EMS imposes on exchange-rate movements; then we will examine the system's implications for the appropriate degree of interest-rate feedback.

IV. Optimal Bilateral Intervention

We now proceed to consider the case of two central banks each of which wishes to minimize the variance of its country's real income around its natural (full-information) level. Each central bank can use information from the exchange rate in setting its money supply; accordingly, it chooses an exchange-rate feedback parameter κ or κ^*, respectively. For simplicity, we shall ignore the possibility of interest-rate feedback, by assuming that $\chi = \chi^* = 0$; we shall also assume that $\delta = \delta^* = 0$.

1. Without exchange-rate bands

The first case we would like to consider is one in which there is no international agreement requiring that the exchange rate be kept within a specified band. The authorities may still carry out some foreign-exchange-market intervention as a way of using the information embodied in the exchange rate in stabilizing domestic income. In this case, the authorities care about exchange-rate fluctuations not for their own sake but because they are associated with fluctuations in domestic real income and prices.

First, let us consider a Nash equilibrium, defined as follows:
Nash equilibrium: a combination (κ, κ^*) such that

(a) κ is chosen to minimize $\mathrm{Var}(y_t - w_t{}^s)$, given κ^*; and

(b) κ^* is chosen to minimize $\mathrm{Var}(y_t{}^* - w_t{}^s)$ given κ.
The Nash equilibrium involves the solution of each country's optimization problem. The German problem is as follows:

$$(23)\ \min \mathrm{Var}(y_t - w_t^s) = (\gamma^2/\Delta^2)\left\{\pi_{11}^2\sigma_s^2 + \pi_{12}^2\sigma_{s*}^2 + (\pi_{13} + \tfrac{1}{2}\pi_{16})^2\sigma_p^2 + \pi_{14}^2\sigma_u^2 + \pi_{15}^2\sigma_{v*}^2\right\}$$

where:

$$\Delta = -[(1+\gamma)(\kappa+\kappa^*) + (1+\gamma)^2]$$

$$\pi_{11} = 1 + \gamma + \kappa^*$$

$$\pi_{12} = \kappa$$

$$\pi_{13} + \frac{1}{2}\pi_{16} = -(1+\gamma)\kappa$$

$$\pi_{14} = \gamma + \kappa^* + 1$$

$$\pi_{15} = \kappa$$

The first-order condition for this problem requires that

$$(24)\ \partial Var(y-w^s)/\partial\kappa$$

$$= (\gamma^2/\Delta^3)\Big\{(1+\gamma+\kappa^*)^2(1+\gamma)\sigma_s^2 - (1+\gamma+\kappa^*)(1+\gamma)\kappa\sigma_{s*}^2$$

$$- (1+\gamma)^3(1+\gamma+\kappa^*)\kappa\sigma_p^2 + (1+\gamma+\kappa^*)^2(1+\gamma)\sigma_v^2$$

$$- (1+\gamma+\kappa^*)(1+\gamma)\kappa\sigma_{v*}^2\Big\}$$

$$= 0$$

This expression yields a simple solution for the optimal degree of foreign-exchange-market intervention:

$$(25)\ \kappa = \frac{\sigma_s^2 + \sigma_v^2}{\sigma_{s*}^2 + \sigma_{v*}^2 + (1+\gamma)^2\sigma_p^2}\ (1+\gamma+\kappa^*)$$

The degree of intervention that Germany would choose in a Nash equilibrium thus depends positively on the intervention being carried out by France: more intervention by France tends to cushion the exchange rate from the effects of French aggregate supply and money demand shocks, increasing the information the information about German shocks that is embodied in exchange-rate movements. The optimal degree of monetary exchange-rate feedback also depends positively on the variances of both supply and demand shocks in Germany: if the German economy is subject to large shocks, exchange rate movements will reflect these shocks, and this will make it desirable to adjust the money supply to offset these exchange-rate movements and thereby to offset the effects of the shocks on German income. A higher variance of supply and money-demand shocks in France, and a higher variance of PPP shocks, conversely, reduce the extent to which it is desirable to attempt to stabilize the exchange rate, by increasing the extent to which the exchange rate will reflect shocks other than German supply and demand shocks, and thus the extent to which varying the money supply in response to exchange-rate movements will transmit these shocks to Germany.

The first-order condition and the resulting optimal degree of monetary exchange-rate feedback for France is symmetrical:

$$(26)\ \kappa^* = \frac{\sigma_{s*}^2 + \sigma_{v*}^2}{\sigma_s^2 + \sigma_v^2 + (1+\gamma)^2\sigma_p^2}\ (1+\gamma+\kappa)$$

The French response to exchange-rate movements thus depends positively on the German response; it also depends positively on the variances of French shocks and negatively on the variances of German shocks and of terms-of-trade shocks.

The exchange-rate feedback responses given in equations (25) and (26) can be characterized as the reaction functions of the two central banks. A Nash equilibrium is obtained by solving these reaction functions simultaneously for κ and κ^*:

$$(27)\quad \kappa = \frac{\sigma_s^2 + \sigma_v^2}{(1+\gamma)^2 \sigma_p^2}$$

$$(28)\quad \kappa^* = \frac{\sigma_{s*}^2 + \sigma_{v*}^2}{(1+\gamma)^2 \sigma_p^2}$$

Thus, the Nash equilibrium has a distinctive property: each country's equilibrium degree of foreign-exchange-market intervention depends only on the variances of shocks occurring in that country, as well as on the PPP shock: Germany's Nash-equilibrium degree of foreign-exchange-market intervention is independent of the variances of French shocks, and vice versa. This separation occurs for the following reason: the optimal French policy, which sets the money supply using all the information provided by the exchange rate in order to minimize the variance of French income, makes the price surprise in France orthogonal to the exchange rate.

In order to interpret the Nash equilibrium, we would also like to compare it with two other solutions:

Stackelberg equilibrium: a combination (κ, κ^*) such that

(a) κ^* is chosen to minimize $\mathrm{Var}(y_t^* - w_t s^*)$ given κ.

(b) κ is chosen to minimize $\mathrm{Var}(y_t - w_t s)$ given the decision rule implied by (a).

Pareto optimum: a combination (κ, κ^*) chosen to minimize

$\mathrm{Var}(y_t - w_t s) + \omega \mathrm{Var}(y_t^* - w_t s^*)$ for some $\omega > 0$.

It is easiest to compare Nash, Stackelberg and Pareto solutions using graphical techniques: we plot the German reaction curve as the solutions for κ minimizing the variance of German income given κ^* as given in equation (25); the French reaction curve is derived in a similar way from (26). We also plot indifference curves for each country, each denoting a set of combinations of κ and κ^* yielding a given variance of income for one country. The Nash solution is found at the intersection of the two countries' reaction curves; the Stackelberg solution, with Germany as the "leader," is found at a point of tangency between the French reaction curve and a German indifference curve; Pareto solutions are found at points of tangency between French and German indifference curves (see e.g., Hamada (1974)).

In order to examine these solutions, we must find the equation of the indifference curves for each country. Along a German indifference curve,

$$(29)\quad \frac{\partial \mathrm{Var}\,(y_t - w_t^s)}{\partial \kappa}\, d\kappa + \frac{\partial \mathrm{Var}(y_t - w_t^s)}{\partial \kappa^*}\, d\kappa^* = 0$$

By totally differentiating equation (10), still assuming that $\lambda = \lambda^* = 0$, and simplifying, we obtain

$$(30)\quad -\kappa d\kappa^* = (1+\gamma+\kappa^*)d\kappa$$

Integrating, we find the equation for the German indifference curves:

$$(31)\quad \kappa = C(1+\gamma+\kappa^*)$$

where C is a constant of integration. Therefore, we find that in this case the indifference curves do not have their usual convex shape, but are lines radiating from a point on the negative horizontal axis (they do not cross, however, as these indifference curves are not defined at the point from which they radiate). Comparing equations (31) and (25), we can see that the German reaction function is itself an indifference curve (and therefore necessarily the highest indifference curve). The German indifference map and reaction function are plotted in Figure 1; the French reaction curve and indifference map, which is similar, is also plotted.

As we see in Figure 1, the Nash, Stackelberg and Pareto solutions in this case are all the same. Point E is the Nash equilibrium because it is at the intersection of the two reaction curves. It is also a Stackelberg equilibrium because it is Germany's most-preferred point on France's reaction curve. Finally, it is a Pareto optimum because there is no other point in κ, κ^* space that would reduce the variance of real income in both countries. Therefore, in this case, there is no need for coordination in the choice of policy rules by the two countries: if each country chooses its own policy rule taking the other's as given, they can achieve a Pareto optimum.

This result is an application of the principle that, if the number of policy targets and instruments is equal, there is no need for policy coordination (see e.g., Buiter and Eaton (1985)). This principle is

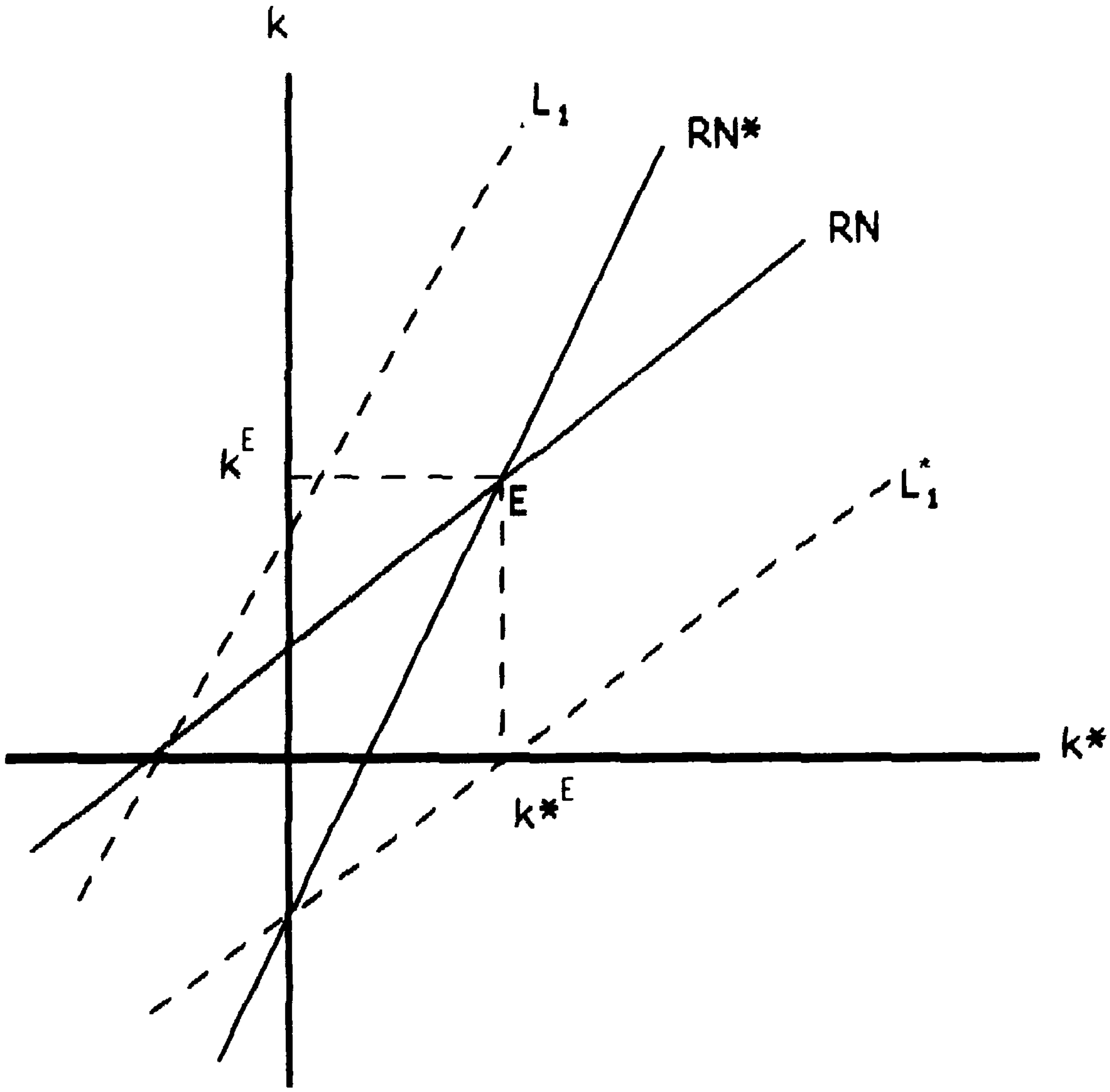


Figure 1

usually formulated in a linear nonstochastic setting, but it also applies to the choice of policy rule in a stochastic model. It is important to notice that there is no coordination problem here even though there are spillovers from one country's policy to another's income. The reason is that these spillovers are taken care of when each country formulates an optimal feedback policy: policy that makes one country's price surprise orthogonal to the exchange rate prevents the exchange rate from transmitting that country's shocks to another country.

This result suggests that, in the absence of exchange-rate bands, there may be differences in the degree of intervention carried out by the two central banks, but no strategic leader-follower relationship. Neither country can improve on the Nash equilibrium by influencing the other country's policy choices. In the equilibrium that emerges, each central bank's policy rule depends only on the supply and demand shocks occurring in its own country, as well as on the PPP shock.

2. With exchange-rate bands

Under the EMS, countries are required to prevent their currencies' relative values from moving outside pre-established bands. These bands can be changed periodically, subject to negotiation with the other members, but such realignments are supposed to be infrequent. Responsibility for keeping the exchange rate within the band is shared by both governments, as the probability that the exchange rate will stay within the band depends on the actions taken by both governments, although obviously that does not necessarily mean that both countries will make an equal effort to keep the exchange rate within the band.

In this model, the exchange rate bands can be represented as follows: a country incurs a penalty if the exchange rate goes outside the target band or the target has to be realigned. In a discrete-time model, it is awkward to distinguish between a failure to keep the exchange rate within the band and a realignment within the period. Therefore, we shall simply assume that, under the EMS, the country attaches a cost to the probability that the exchange rate goes outside the band, that is it faces a cost $\beta \Pr(|s_t - s^T| > \omega)$, where β is the penalty for failing to keep the exchange rate within the band.

In analyzing the EMS in this way, we are assuming a kind of hierarchy of policy formulation: the country's commitment to participate in the exchange-rate mechanism is made first and this commitment, considered binding, has an influence on the way that the authorities control the money supply. The rationale for this approach is that the exchange-rate bands are, in fact, set by international agreement; it can be argued that this agreement is motivated at least in part by political considerations. Once such an agreement is in place, it is difficult to alter, and may thus be viewed as one of the conditions under which policy is formulated. Here, we are interested with analyzing how the existence of such an agreement affects the policy outcome. An analysis in which entering into such an agreement is itself a policy choice in a game-theoretic setting is an interesting topic for further research.

If the disturbances are distributed normally, the probability that the exchange rate passes outside the band depends only on the mean and variance of the exchange rate. The mean of the exchange rate depends only on the money-supply targets m^T and m^{T*}, not on the way in which the authorities deviate from these targets in response to exchange-rate movements. The implication of the band is therefore to penalize a higher variance of the exchange rate. We can accordingly write the loss function of the German authorities within the EMS as

$$(32)\quad L = \mathrm{Var}(y_t - w_t^s) + \alpha \,\mathrm{Var}\, s_t$$

while that of the French authorities is

$$(33)\quad L^* = \mathrm{Var}(y_t^* - w_t^{s*}) + \alpha^* \mathrm{Var}\, s_t$$

In order to explore the implications of a bilateral responsibility to keep the exchange rate within its band, we must solve each country's optimization problem, as we did in the previous subsection: in a Nash equilibrium, Germany chooses κ to minimize $L = \mathrm{Var}(y_t - w_t^s) + \alpha \mathrm{Var}\, s_t$ given κ^*, where $\mathrm{Var}\,(y_t - w_t^s)$ is as given in equation (23) above while $\mathrm{Var}\, s_t$ is given by

$$(34)\quad \mathrm{Var}\, s_t = (1/\Delta^2)\left\{\pi_{31}^2\sigma_s^2 + \pi_{32}^2\,\sigma_{s*}^2 + (\pi_{33} + \tfrac{1}{2}\pi_{36})^2\sigma_p^2 + \pi_{34}^2\sigma_v^2 + \pi_{35}^2\sigma_{v*}^3\right\}$$

where Δ is as defined in equation (23) and

$$\pi_{31} = 1 + \gamma$$

$$\pi_{32} = -(1+\gamma)$$

$$\pi_{33} + \frac{1}{2}\pi_{36} = \gamma(1+\gamma)$$

$$\pi_{34} = (1+\gamma)$$

$\pi_{35} = -(1+\gamma)$

From the first-order conditions we obtain the reaction function for the German authorities, while we obtain the EMS-constrained German indifference map by totally differentiating L with respect to κ and κ^*. The resulting reaction curves RR and indifference curves L_i, along with the corresponding constructs for France, RR^* and L_i^* are shown in Figure 2. As a point of reference, we also show the non-EMS reaction curves RN and RN^*, and at their intersection the non-EMS Nash-Stackelberg-Pareto equilibrium E.

In Figure 2, the Nash equilibrium given the exchange-rate bands is found at the intersection of the reaction functions RR and RR^*, at point N; here, the German intervention parameter is κ^N while French intervention is κ^{*N}. A Stackelberg equilibrium in this case, however, is different: at point S, where German indifference curve L_i is tangent to the French reaction function, the German authorities are choosing a higher degree of intervention κ^S in order to give rise to a greater degree of French intervention κ^{*S}. Essentially, what is happening is that in the Stackelberg equilibrium both countries intervene more than they would in the Nash equilibrium, in order to pursue their common goal of reducing the probability that the exchange rate will move outside the band. In this model, however, the relative burden of intervention is heavier on the leader country; this implication of the model is at odds with the EMS experience. In an asymmetric regime characterized by Stackelberg equilibrium, therefore, exchange rate variability is reduced below the level that would obtain under Nash equilibrium. However, this reduction in exchange-rate variability is achieved at the cost of an increase in the variability of both countries' real national income. This can be seen by comparing both Nash and Stackelberg equilibria under the EMS to the equilibrium that would obtain in the absence of exchange-rate bands: under the EMS, we move away from point E, the variability of both countries' real incomes is minimized.

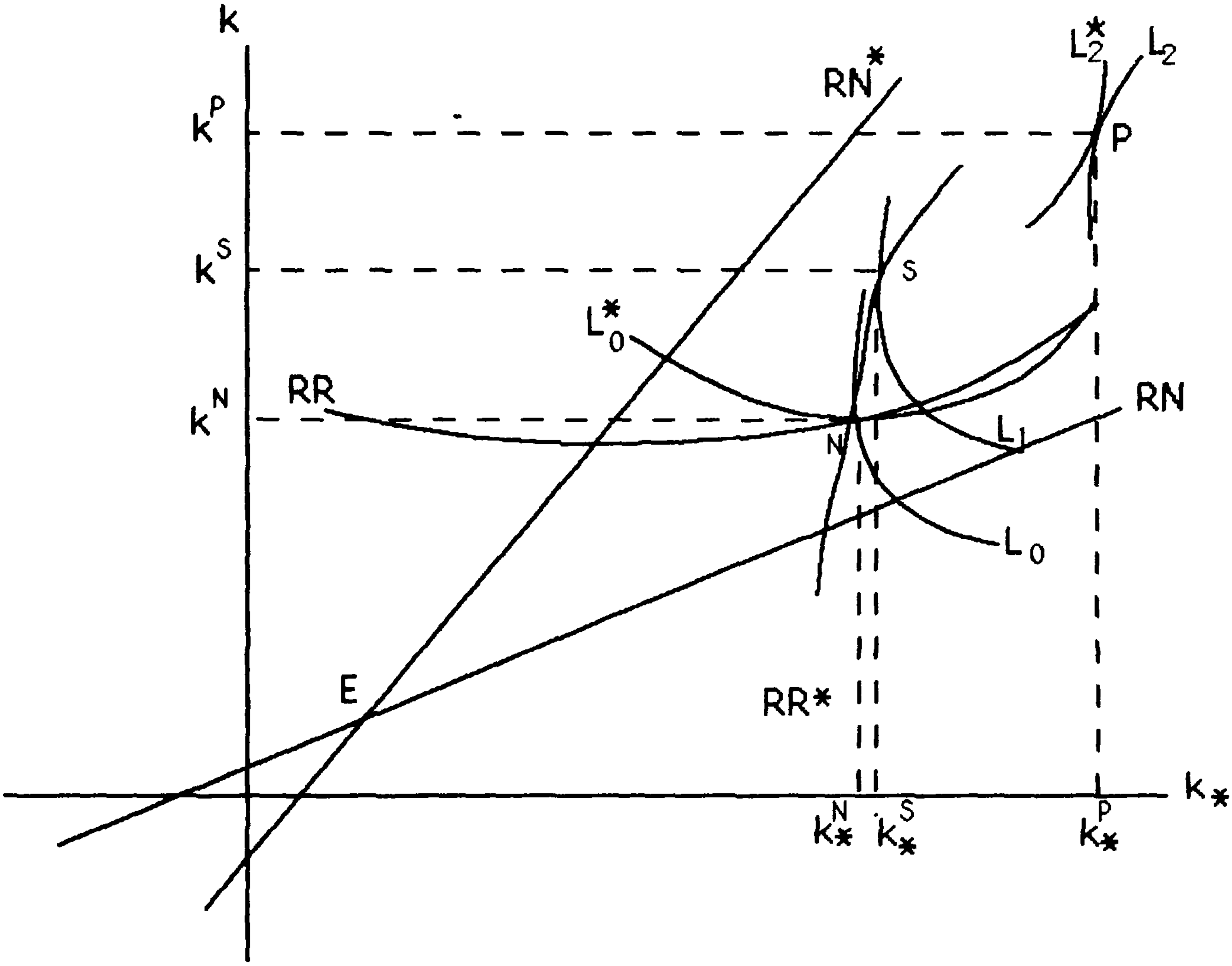
Another feature of the EMS is that it introduces gains from policy coordination even where none would otherwise have existed. This can be seen by examining a Pareto optimal solution, as given by the tangency of the two countries' indifference curves as at point P. With successful coordination between the two countries, such a Pareto optimum could in principle be achieved, enabling both countries to reduce their expected losses form exchange-rate and real-income variability. Again, however, this movement to a Pareto optimum entails a reduction in the variance of the exchange rate at the expense of an increase in the variance of the countries' real incomes.

Another result that may be obtained from this model pertains to the effect of varying the width of the exchange-rate band. Narrowing the band increases α and α^* and therefore shifts the reaction curves in Figure 2 outward. Consider, for simplicity, Nash equilibrium in the case in which only France is penalized if the exchange rate moves outside the band, so that $\alpha = 0$ while $\alpha^* > 0$. In that case, narrowing the band would shift the French reaction curve RR^* rightward along the German reaction curve, which in this case would be RN. The result would be an increase in both κ and κ^*, that is an increase in the degree of foreign-exchange-market intervention by both countries. From equation (25) we know that, if the variance of shocks in Germany is less than or equal to that in France, the German reaction curve RN has a slope less than unity; thus, tightening the bands results in some increase in intervention by both countries, but in a greater increase in intervention by the peripheral country.

In this section, we have provided a theoretical example whose import can be summarized in the following argument: if the authorities in both countries are primarily interested in exchange-rate variability to the extent that it affects overall macroeconomic stability, there may be no need for policy coordination; even in the absence of any coordination, both countries can choose monetary rules with feedback from exchange rates that minimize the variances of both countries' incomes given the information that is available to the authorities. Under these circumstances, there is no scope for asymmetry in choosing policy rules: even if one country could choose its policy rule with an awareness of its influence on the other country's policy rule (in short, to behave as a Stackelberg leader), this would not make any difference to its choice of policy. On the other hand, if bands for exchange-rate movements are established, this may in itself introduce a scope for asymmetry in policy-making, and also create a need for policy coordination when none would otherwise exist. This is because, subject to these bands, the variance of the exchange rate becomes an additional independent target of monetary policy, rather than just an information variable. Because the exchange rate is a variable whose movements are affected by both countries' policy regimes, and which both countries have a responsibility to keep within the agreed-upon band, one country may choose its degree of intervention with a view to influencing the other country's intervention policy. Policy coordination also becomes desirable in order to achieve a higher degree of exchange-rate stability: in effect, under these circumstances exchange-rate stability is a public good. However, the greater degree of exchange-rate stability that would result from coordination is achieved at the cost of a higher degree of variability of income. Coordination would result in a <u>lower</u> degree of welfare, <u>unless</u> the implicit penalties for exchange-rate variability that are imposed by international agreement correspond to some real economic cost of exchange rate variability.

This analysis suggests, therefore, that if the exchange-rate mechanism imposed under the EMS is inspired by political considerations (such as European unity) rather than corresponding to some true collective cost of exchange-rate variability (that is, some cost other than the associated price and output variability which is incorporated in this model), then this system entails a loss in economic welfare. As the analysis shows, under these circumstances the agreement leads the central banks to pay too much attention to exchange-rate variability, at the cost of increasing the variability of real income. Moreover, in this case, coordination only makes matters worse--as it may in general when the

Figure 2



authorities are maximizing the wrong objective function (Rogoff (1985) and Canzoneri and Henderson (1988)). Policy coordination within a system of bands therefore lowers economic welfare, unless there is some collective benefit of reducing exchange-rate variability in addition to its role is stabilizing real income.

We also find that, in Nash equilibrium, tightening the exchange-rate bands would lead to more intervention by both countries, even if formal responsibility for keeping the exchange rate within the bands lay only with the peripheral country. This result reflects the distinction between the rules of the exchange-rate mechanism and the central banks' behavior subject to these rules.

V. Interest-Rate Feedback Within the EMS

In the previous section, we have been examining the interaction of different countries' monetary-policy response to exchange-rate movements, while setting aside the possibility that the authorities might also wish to make use of information provided by interest rates. In this section, we do the reverse: we shall assume that the EMS imposes arbitrarily narrow bands on exchange-rate movements, and that both countries are responsible for adhering to these bands. In this case, both countries may still attempt to pursue monetary policies that incorporate feedback from interest-rate movements, as reflected in their policy parameters χ and χ^*.

Let us consider a Nash equilibrium of policies under these circumstances: if both countries set κ, $\kappa^* \to \infty$ in order to eliminate exchange-rate movements, Germany then chooses χ to minimize $\mathrm{Var}(y_t - w_t^s)$ given χ^*: the solution to this optimization problem is then

$$(35)\quad \lambda = \left\{2\gamma(\sigma_s^2 + \sigma_{s*}^2) + (1+2\gamma)(\sigma_v^2 + \sigma_{v*}^2) + (\gamma+2)(\gamma+\tfrac{1}{2})(\gamma+1)\sigma_p^2\right\}$$

$$/ \left\{2\gamma(\sigma_s^2+\sigma_{s*}^3) + (\gamma+2)(\gamma+\tfrac{1}{2})^2\sigma_p^2 - \gamma\sigma_d^2\right\}$$

$$- \lambda^*$$

Similarly, for France, the problem is to choose χ^* to minimize $\mathrm{Var}(y_t^* - w_t^{s*})$ given χ^*; the solution is

$$(36)\quad \lambda^* = \left\{2\gamma(\sigma_s^2 + \sigma_{s*}^2) + (1+2\gamma)(\sigma_v^2+\sigma_{v*}^2) + (\gamma+2)(\gamma+\tfrac{1}{2})(\gamma+1)\sigma_p^2\right\}$$

$$/ \left\{2\gamma(\sigma_s^2 + \sigma_{s*}^2) + (\gamma+2)(\gamma+\tfrac{1}{2})^2\sigma_p^s - \gamma\sigma_d^2\right\} - \lambda$$

As we can see, under these circumstances, the Nash equilibrium combination of χ and χ^* is not unique: rather, any combination satisfying (35) or (36) satisfies both. The reason is essentially the following: if the EMS becomes a unified currency area, and if capital is mobile as we have been assuming throughout this analysis, shocks in each country are transmitted to prices in both countries. For this reason, an interest-rate feedback policy that minimizes the variance of Germany's income around its full-information level also minimizes the variance of France's income around its respective full-information level. Moreover, with fixed exchange rates, perfect capital mobility equalizes interest rates in both countries, and with perfect capital mobility it does not matter which country's money supply is altered in response to interest-rate movements: capital movements ensure that any increase or decrease in the Community's money supply is distributed between the two countries in a way that is independent of its source. If both countries have the same goal of minimizing the variability of their respective incomes, any combination of intervention policies that achieves this goal for one country will achieve it for both.

In this context, there is some need for policy coordination of a different sort: since there are infinitely many Nash equilibria, some kind of agreement is needed in order to select one. This suggests a need for central banks, not to try to agree on a combination of policies that neither would choose on its own, but simply to share information about what policies they are trying to follow.

An alternative to sharing information, of course, is for one central bank to refrain from interest-rate feedback, leaving such operations up to the other central bank: this would take care of the problem of each central bank's trying to adapt its feedback rule to the other's. Such a division of responsibilities would be asymmetric in implementation but not in outcome: it would give rise to the same variances of income in the two countries as would result from any of the other Nash equilibria satisfying (34) and (35).

This example suggests, therefore, that although having a common currency area with perfect capital mobility does in some way restrict the policy alternatives open to the central banks of the member countries, this does not necessarily lead to a conflict of policy. The reason is that the exchange-rate fixity and capital mobility may create a greater degree of communality of goals. In the model presented here, in which each country's goal is merely wish to stabilize its own national income around its natural level, this acquired communality of interest becomes complete: in a common currency area with perfect capital mobility, the variances of different countries' incomes around their natural levels become related in an identical way to all the shocks, as supply and demand shocks in each country have the same effect on both countries and as terms-of-trade shocks have an equal and opposite effect on the two countries' real incomes. For this reason, even though with a lesser degree of capital mobility or with a greater degree of exchange-rate flexibility the variances of different countries' incomes may be conflicting goals, in a common currency area these goals may converge to a considerable degree.

VI. Conclusion

In this paper, we have considered several aspects of monetary policy within the EMS. We have examined the implications of alternative policy regimes for the transmission of shocks, showing that an asymmetrical regime--a caricature of the existing EMS, in which one country follows a fixed money-supply rule and the other stabilizes the bilateral exchange rate--may reduce the variability of income in both countries if the variance of shocks in the second country is relatively large.

Next, we examined the interaction of two optimal monetary feedback policies; we demonstrated that if both countries pursue policies chosen to minimize the variability of their respective incomes, each taking the other's feedback rule as given, then in the resulting Nash equilibrium each country's optimal policy depends only on its own supply and demand shocks and on the terms-of-trade shock, but not on shocks occurring in the other country. Such a Nash equilibrium is Pareto optimal, so that there is no scope for asymmetric policy and no gains from policy coordination. However, if the countries adopt an exchange-rate agreement that penalizes exchange-rate variations, this creates an additional objective of policy on which both countries' choice of policy rules has an influence. For this reason, within a system of exchange-rate bands there is some scope for asymmetry in policy formulation: under these circumstances, both countries can achieve a lower expected loss if one country acts as a Stackelberg leader, choosing the appropriate degree of foreign-exchange-market intervention taking account of the fact that this will influence the choice made by the other country. Moreover, within the bands there is a reason for policy coordination, in a model in which none would exist in the absence of an exchange-rate agreement; this suggests that the EMS may actually create a need for coordination rather than facilitating such coordination. In this context, we can also trace the influence of the width of the bands on the outcome of policy interaction: we show that, even if only the peripheral countries were formally responsible for maintaining exchange rates within the bands, narrowing the band would lead to more intervention by both Germany and the peripheral countries.

In the last section of the paper, we examined the interaction of two countries' interest-rate feedback policies in the limiting case in which the exchange-rate bands are arbitrarily narrow and in which both countries share the obligation to maintain the exchange rate at its target level. In this case, we re-establish the familiar result that both countries can no longer formulate their monetary policies independently; this loss of independence may result in one country's acting as leader, establishing its policy in the knowledge that it will be taken into account in the other's policy formulation. It may also create a need for coordination, at least at the level of the central banks' sharing information about the policies that they are planning to pursue. An important result of this model is that this loss of policy independence does not really matter: with perfect capital mobility and fixed exchange rates, shocks occurring in each country are transmitted to the other country in such a way that, if each central bank wishes to stabilize its national income around the natural level, both would desire the same combined monetary response to interest-rate fluctuations. This result cannot, of course, be accepted without qualification, depending as it does on a particular specification of both the structure and the authorities' objectives. It does, however, point to a factor that may mitigate the loss of monetary independence that results from exchange-rate stability under high capital mobility.

The price to be paid for the explicit solutions we were able to obtain from our model was the assumption that the two economies are symmetric in the parameters that describe the structure of their economies although they might differ in terms of the relative variability of the shocks they are subject to and in the size of two elasticities. The income elasticity of money demand and the intertemporal elasticity of consumption were both set equal to one. These assumptions enabled us to obtain solutions that can be interpreted intuitively, and which illustrate principles whose relevance is not limited to the specific model used.

We have examined several implications of the EMS for the interaction of the member countries' monetary policies as this influences the impact of shocks on their economies. One feature that is clearly missing from our analysis--and which may be an important reason for the adoption of the system to begin with--is the credibility of policy rules in a world in which the optimal policy may be time-inconsistent, as discussed in the paper's introduction. In the present paper, this complication is eliminated using the assumption that the authorities wish to stabilize national income around its natural or full-information level. However, this issue is examined in another recent paper (Lane and Rojas-Suarez (1988)). The credibility of monetary policy rules and these rules' role in transmitting shocks are both important considerations in evaluating the likely role of the EMS in contributing to or detracting from the macroeconomic stability of Europe.

Bibliography

Barro, Robert S., "Rational Expectations and the Role of Monetary Policy," Journal of Monetary Economics, Vol. 2, No. 1 (Jan. 1976), pp. 1-32.

Bhandari, Jagdeep S. (ed.), Exchange Rate Management Under Uncertainty (Cambridge MA: MIT Press, 1985).

Boyer, Russell S., "Optimal Foreign Exchange Market Intervention," Journal of Political Economy, Vol. 86, No. 6 (Dec. 1978), pp. 1045-56.

Buiter, Willem H., and Jonathan Eaton, "Policy Decentralization and Exchange-Rate Management in Interdependent Economies," in Exchange Rate Management Under Uncertainty, edited by Jagdeep S. Bhandari (Cambridge, MA: MIT Press, 1985), pp. 31-54.

_____, and Richard C. Marston, International Economic Policy Coordination (Cambridge: Cambridge University Press, 1985).

Canzoneri, Matthew B., "Monetary Policy Games and the Role of Private Information," American Economic Review, Vol. 75, No. 5 (December 1985), pp. 1056-1070.

_____, and Jo Anna Gray, "Monetary Policy Games and the Consequences of Non-Cooperative Behavior," International Economic Review, Vol. 26, No. 3 (Oct. 1985), pp. 547-64.

_____, and Dale W. Henderson, "Is Sovereign Policymaking Bad?" in Stabilization Policies and Labor Markets, edited by Karl Brunner and Allan H. Meltzer, Carnegie-Rochester Conference Series 28 (Amsterdam: North-Holland, 1988), pp. 93-140.

_____, and Nic Vidalis, "International Cooperation and Reputation in an Empirical Two-Bloc Model," in Global Macroeconomics: Policy Conflict and Cooperation (New York: St. Martin's Press, 1987), pp. 75-127.

Fischer, Stanley, "Long-Term Contracts, Rational Expectations and the Optimal Money-Supply Rule," Journal of Political Economy, Vol. 85, No. 1 (February 1977), pp. 191-205.

Giavazzi, Francesco, and Alberto Giovannini, "Models of the EMS: Is Europe a Greater Deutschmark Area?," in Global Macroeconomics: Policy Conflict and Cooperation (New York: St. Martin's Press, 1987), pp. 237-72.

_____, and Marco Pagano, "The Advantage of Tying One's Hands: EMS Discipline and Central Bank Credibility," CEPR Discussion Paper No. 135 (October 1986).

Gros, Daniel, "Stabilization Policy Within the Band," unpublished paper (Washington: International Monetary Fund, December 1988).

_____, and Niels Thygesen, The EMS: Achievements, Current Issues and Directions for the Future, CEPS Paper No. 35 (Centre for European Policy Studies, 1988).

Hamada, Koichi, "Alternative Exchange Rate Systems and the Interdependence of Monetary Policies," in National Monetary Policies and the International Financial System, edited by Robert Z. Aliber (Chicago and London: University of Chicago Press, 1974), pp. 13-33.

_____, "A Strategic Analysis of Monetary Interdependence," Journal of Political Economy, Vol. 84, No. 3 (July-Aug. 1976), pp. 677-700.

Lane, Timothy D., "National Sovereignty and International Monetary Order," paper presented at Canadian Economics Association meeting (June 1987).

_____, "Economic Interdependence and Optimal Foreign Exchange Market Intervention: A Case for Capricious Policy?," unpublished paper (Michigan State University, August 1988).

_____, and Liliana Rojas-Suarez, "Credibility, Capital Controls, and the EMS," draft (Washington: International Monetary Fund, December 1988).

Melitz, Jacques, "Monetary Discipline, Germany and the European Monetary System" (Washington: International Monetary Fund) Working Paper, (February 1987).

Oudiz, Gilles, and Jeffrey Sachs, "Macroeconomic Policy Coordination Among the Industrialized Economies," Brookings Papers on Economic Activity (1984), pp. 1-64.

Rogoff, Kenneth, "Can International Monetary Policy Coordination be Counterproductive?," Journal of International Economics, Vol. 18, No. 3-4 (May 1985), pp. 199-217.

_____, "Reputational Constraints on Monetary Policy," in Bubbles and Other Essays, edited by Karl Brunner and Allan H. Meltzer, Carnegie-Rochester Conference Series on Public Policy 26 (Spring 1987), pp. 141-81.

Roper, Don E., and Stephen J. Turnovsky, "Optimal Exchange Market Intervention in a Simple Stochastic Macro Model," Canadian Journal of Economics, Vol. 13, No. 2 (May 1980), pp. 296-309.

Stockman, Alan C., "Sectoral and National Aggregate Disturbances to Industrial Output in Seven European Countries," Journal of Monetary Economics, Vol. 21, No. 2 (March/May 1988), pp. 387-409.

Turnovsky, Stephen J., Tamer Basar, and Vasco d'Orey, "Dynamic Strategic Monetary Policies and Coordination in Interdependent Economies," American Economic Review, Vol. 78, No. 3 (June 1988), pp. 341-61.

Ungerer, Horst, Owen Evans, Thomas Mayer, and Philip Young, The European Monetary System: Recent Developments (Washington: International Monetary Fund), Occasional Paper No. 48 (December 1986).

Weber, Warren, "Output Variability under Monetary Policy and Exchange Rate Rules," Journal of Political Economy, Vol. 89, No. 4 (August 1981), pp. 733-51.