ESSAYS ON MACROECONOMIC INTERDEPENDENCE AND POLICY COORDINATION

A Dissertation

Presented to

the Faculty of the Departmeent of Economics

University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

By

Pierre Canac

August 1987

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ABSTRACT

The major purpose of the dissertation is to determine under which conditions monetary policy coordination between two members of the European Monetary System (EMS) is welfare improving. If the two countries are exactly identical coordination is welfare improving and the exchange rate between them fixed. If they are extremely different a Nash solution will emerge and the EMS is unlikely to survive. If they differ slightly coordination is welfare improving and the EMS should be considered a flexible exchange rate system.

The dissertation then goes on to test empirically whether various countries respond to the United States' monetary and fiscal policy. It is found that the Canadian reaction is very strong, that West Germany, unlike Japan, would expand its economy if the United States reduced her budget deficit, and that France reacts more to Germany than to the United States. The behavior of the United Kingdom is not satisfactorily explained.

TABLE OF CONTENTS

Introduction

Most analysts describe the European Monetary System (EMS) as a fixed exchange rate system, similar to the Bretton Woods agreement. I describe it as a monetary arrangement between countries which have decided to coordinate their macroeconomic policies and to let their currencies float. This interpretation is preferable because it explains why the EMS, unlike the Bretton Woods system, has survived many changes in exchange rates (in seven years the D-Mark has gained more than 40% against the Italian lira and there has been 12 realignments). No country has exited the system since its creation in March 1979 and the inclusion of additional members such as the United Kingdom is likely to occur soon.

Moreover, most authors assume that countries are identical except Jacques Melitz (1985), who assumes that they have different target levels of inflation and output in their social (loss of) utility functions. The first assumption leads to a welfare improving cooperative solution as countries respond exactly in the same manner when they are subject to a supply shock common to both of them. This result is not realistic as it does not explain why countries followed different policies in response to the oil shocks of the 1970's. Under the second assumption countries do not harmonize their policies exactly in response to an external shock and there are welfare gains, relative to the Nash

solution, from belonging to the EMS. However, because Melitz describes the EMS as a fixed exchange rate system, non-sterilized currency interventions and occasional realignments are required for the system not to breakdown. I could have used Melitz's assumption in my "flexible" EMS system but did not because it was mathematically more tractable to assume instead that countries had the same targets but divergent relative desires to reach them. What seems to matter the most is that countries be different, which is the case in my model and in Melitz's, not how they differ, although this point may need further investigation. On the other hand the fact that I interpret the EMS as a flexible exchange rate system is in direct opposition to Melitz's view. My conclusions are also different.

If two countries have diametrically different preferences chapter two of the dissertation shows that policy coordination is unlikely as it is not a pareto improving solution. If they have similar, but not identical preferences, policy coordination is welfare improving. The exchange rate of the high inflation country depreciates and this may lead to speculation against that country's currency unless capital controls are imposed or interest rates are allowed to reach extremely high levels. Because France has chosen to impose capital controls my model assumes perfect capital immobility. If the two countries have exactly the same preferences, not only will policy coordination be possible but

it will result in the exchange rates between the EMS countries being very stable.

The main weakness of this model is to ignore the fact that there are countries outside the EMS that have some influence on the decisions taken by EMS members. To my knowledge this has never been shown to be the case. The behavior of West German policymakers may be expected to depend upon policy actions of the United States' (U.S.) government. Chapter three tests whether West Germany and other industrial countries such as Japan, Canada, France and the United Kingdom react to U.S. monetary policy and budget deficits. It is shown that Canada's reaction is very strong. West Germany, unlike Japan, would likely expand its economy if the U.S. cut her budget deficit. France reacts more strongly to German than to U.S. actions while the model fails to explain the behavior of British policymakers.

In order to fully take these interactions into account chapter two should be extended to include a third country. This third country would stay outside the monetary arrangement signed by the other two countries and would be linked to one or both of the EMS countries through the capital market (the Uncovered Interest Rate Parity holds). This will be the object of future research.

CHAPTER ONE

LITERATURE REVIEW

International policy coordination is difficult to analyze with the traditional tools of economic analysis used in competitive theory. The world is characterized by a small number of influential countries and groups of countries such as the United States, West Germany, Japan and the European Economic Community. With the development of transportation and communications technology, the goods and assets of these countries have become closer substitutes for one another. The extreme examples of this are the Purchasing Power Parity (PPP) relationship in goods markets and Uncovered Interest Parity (UIP) relationship in assets markets. International policy coordination has been analyzed using the tools of oligopoly theory, such as static or dynamic game theory.

Koichi Hamada (1974, 1976, 1978) is one of the pioneers who used static game theory to the problem of policy coordination. The models described in this review make use of the so called "optimizing approach" developed by Niehans (1968). The first element of this approach is a social welfare function where the target values for various objectives are ranked. The second element specifies the way the economy works. The policy instruments are then choosen such that the social welfare function is maximized given the feasible region of target combinations. Hamada (1974) uses a two-country Keynesian fixed price model, with perfect capital mobility, first developed by Mundell (1963),

appropriate when the economy is at less than full employment. He analyzes the interdependence of monetary policies across countries under alternative exchange rate systems. He concludes that "a system of fixed exchange rate is more likely to bring about the confrontation of economic policies analogous to the prisoner's dilemna". A system of floating exchange rates offers more room for independent monetary policies and, thus, less need for cooperation. Some conflict may still exist with respect to the real rate of interest.

Hamada (976) applies the monetary approach to the balance of payments, as developed by Johnson (1972), in order to study the interdependent and strategic nature of monetary policies across countries under a fixed exchange rate system. The utility functions of the monetary authorities depend on the rate of inflation and the balance of payments situation. The world rate of inflation is derived under non-cooperative (Cournot/Nash and Stackelberg) and cooperative equilibriums. The non-cooperative equilibriums are generally non pareto optimal.

While the 1974 and 1976 papers correspond respectively to the fixed price and the flexible price solutions, the 1978 paper (written with Sakurai) assumes that there is a trade off between inflation and unemployment. In this model the domestic Phillips curve approach and the international monetary approach are combined. This is a two-country,

continuous time model where expectations are formed adaptively. Each country is specialized in the production of a single commodity but their consumers consume both commodities which are traded across countries (PPP holds). Money is the only financial asset. The interest elasticity of money demand is zero while the income elasticity is assumed to be equal to one. The nature of economic interdependence between the two countries is compared under fixed and flexible exchange rates but there is no strategic analysis in this paper.

Leif Johansen's (1982) two-country model has much in common with Hamada's work. The major difference is that its two countries are capacity constrained and that he is concerned with monetary policy and the employment/balance of trade trade off while Hamada was interested in the inflation/balance of trade trade off. He finds that noncooperative equilibriums are generally not optimal.

Canzoneri and Gray (1984, 1985) use one period, three-country models. One of the countries is OPEC; the other two countries, the United States and ROW (Rest Of the World), are oil importers and are perfectly symmetrical or identical in all respects. They import oil, the price of which is set by OPEC in terms of US dollars and is partially indexed to the US consumer price index. There are three assets in their model: US money, ROW money and a real bond held by the residents of the three countries. The monetary author-

ities of the oil importing countries set their monetary policies with a view toward the employment/long run inflationary expectations trade off in their respective countries. It is found that a cooperative equilibrium is always better than a non-cooperative equilibrium. However whether the cooperative equilibrium results in a more or less expansionary monetary policy than the non-cooperative Nash equilibrium depends upon the sign of the monetary policy spillover which is indeterminate in their model. The sign of the spill over effect depends upon the degree of capital mobility (negative sign) as formally introduced by Mundell (1963), the existence of two or more goods in the model and the demand for them (positive sign), the nature of the wage indexation scheme (positive sign) and the nature of OPEC's pricing policy (asymetric and ambiguous sign). Thus if the spillover effect is negative the Nash solution is too expansionary and vice versa if the spillover effect is positive.

The following models are direct extensions of the standard Dornbusch (1976) framework. They describe two economies each specializing in the production of a distinct good and trading a single common bond (UIP holds but PPP does not hold). Gilles Oudiz (1986) considers such a model which he simplifies by assuming that expectations are static in order to concentrate on the strategic interactions and not on the dynamic aspects of the adjustment process which

has been studied by other authors as we will see below. In this model, like in the ones previously mentioned, the two countries are exactly identical. This model differs because it analyzes the policy response of two European economies to inflationary shocks of different magnitude. A non-cooperative solution results in too contractionary monetary policies in both countries. In the cooperative solution, the country affected by the inflationary shock of gratest magnitude contracts its economy while the country affected by the shock of least magnitude expands its economy slightly in order to import some inflation from the country most affected. Oudiz's paper underlines two important points: Two countries which cooperate do not necesarily have the same rate of money growth and the exchange rate between their two currencies should not be fixed. This implies that the European Monetary System (EMS) should leave room for exchange rate fluctuations and that it will be empirically difficult to test whether two countries cooperate with each other since cooperation does not necesarily imply equality of the growth rates of money or any other variables.

What is not clear in Oudiz's model is why two exactly identical countries would not be affected by the same external shocks. Oudiz's example is certainly not convincing: He argues that an appreciation of the dollar would result in more inflation in one European country than in another. There is no reason why this should be the case in

his model. The key to this problem lies in making the two countries somewhat different. The next paper by Jacques Melitz (1985) does just that. Again Melitz uses the Dornbusch (1976) framework and, like Oudiz, he assumes static expectations and perfect capital mobility. This model is supposed to represent two countries which are members of the EMS. However these countries are different in one aspect. They have different targets for output and inflation and more particularly, in each country, the target level of employment is greater than the natural level of employment. This assumption is justified by quoting Barro and Gordon (1983a): "In the presence of unemployment compensation, income taxation, and the like, the natural unemployment rate will tend to exceed the efficient level, that is privately chosen quantities of marketable output and employment will tend to be too low." (p.593) Melitz interprets the EMS as a fixed exchange rate system ("an exchange rate union") and thus ignores completely the existence and function of the 2.25 percent margins around the central rates. He specifies an intervention rule that requires all the members to share equally in the burden of the intervention unlike the intervention rule of the Bretton Woods agreement. He shows that if the members of the EMS were to sterilize their foreign exchange interventions the system would break down, and, that generally the Europecn countries are better off to stay within the EMS. He also

shows that when the two countries are different there exists a cooperative solution better that the EMS.

The following authors again assume that all countries are alike but they use a multiperiod model with rational expectations and dynamic game theory. Such a framework is useful to study the timing of cooperative policy actions and the time consistency problem analyzed first by Kydland and Prescott (1977) and Barro and Gordon (1983b) in the closed economy context. I will mention only papers by Miller and Salmon (1985), Oudiz and Sachs (1985) and Rogoff (1985) although the list of papers in this area is much longer. Miller and Salmon's model incorporate a Keynesian determination of aggregate production, an augmented Phillips curve governing inflation and the assumption of perfect capital mobility with forward looking expectations in the foreign exchange market. This model leads to an unfavorable performance of the cooperative solution. This outcome is due to the fact that there are no conflict of objectives. Thus, in each country, the equilibrium level of output is determined by the long run Phillips curve and the desired inflation rate is achieved without coordination because the flexible exchange rate system works so well in this simplified model that the various economies have recovered their total independence.

Oudiz and Sachs, who use Dornbusch (1976) framework, obtain results which are more favorable to the cooperative

argument. They are able to show that the cooperative path dominates the non cooperative path. Moreover the cooperative equilibrium is superior in welfare terms to the non-cooperative equilibrium. While the cooperative solution is more inflationary, it is not too inflationary in a welfare sense. In addition cooperation eliminates the time consistency problem in Oudiz and Sach's model because coordination rules out certain actions by national governments.

On the other hand, in Rogoff's model cooperation exacerbates the time consistency problem. In this model wage setters set wages before monetary policy is set. Once the wages are set the central bank has an incentive to expand the economy to reduce real wages and raise output. Wage setters anticipate these policies and choose inflationary wage settlements in anticipation. If the government can precommit to avoid inflationary policies, the economy can get the same ex post output levels at a lower rate of inflation. Unfortunately such a precommitment is not credible since the government has an incentive to renege on it once wages are set. International policy coordination may further exacerbate this inflationary bias because it eliminates each country's concern about currency depreciation.

Finally I will comment briefly on the present state of empirical work in the area of macroeconomic coordination. First some empirical work is yet to be performed in order to

establish the sign, size and symmetry of the intercountry spillover effects. Does a fiscal or a monetary expansion in one country have a positive or negative effect on another country? Until we are able to answer this question with confidence, the degree of uncertainty about these interactions is so high that no policy maker will try to assess foreign reaction curves and cooperation is unlikely to occur. Second some empirical studies are needed to estimate directly policy reaction functions. I am not aware of any empirical work that has touched upon this last matter.

So far the existing empirical literature has only verified some of the theoretical propositions by using two-country simulation models that are either constructed as hypothetical numerical examples or estimated with actual data. The most important papers in this area are by Oudiz and Sachs (1984); Turnovky and d'Orey (1986); Ishii, McKibbin and Sachs (1985) and McKibbin and Sachs (1986). The first two papers use a static framework while the last two use dymamic game theory.

Oudiz and Sachs evaluate the outcomes of cooperative and non cooperative policy making among the United States, West Germany and Japan using the EPA or Economic Planning Agency model and the MCM or Multicountry Model. They find that generally the gains from policy coordination are small.

Turnovsky and d'Orey apply static game theory to a multiperiod, two-country model with rational expectations.

Their two countries are exactly identical and their work is both theoretical and empirical although it does not add much to what is already known. Their simulation experiments show that demand shocks are less problematical than supply shocks from the viewpoint of macro stabilization, and that the gains from cooperation are positive but small. They also find that the Consistent Conjectural Variation (CCV) equilibrium, which is not considered in the other papers of this review and which is a non-cooperative solution in which each policy maker takes the reaction of other policy makers to their action into account, may be dominated by the Nash equilibrium.

Ishii, McKibbin and Sachs simulate a medium scale macromodel of the world economy developed by Sachs and McKibbin (1985). They find that fiscal and monetary policies are both positively transmitted between the United States and Japan but monetary policy not significantly so, and that optimal policies would call for a greater US fiscal contraction, a greater Japanese and rest of OECD fiscal expansion and a generalized monetary expansion.

One of the main problem which is recognized by this literature on policy coordination is the efficiency/enforce-ability trade off. The Nash solution is not efficient but enforceable while the cooperative solution is efficient but difficult to enforce. The solution as first proposed by Hamada and then evaluated in the empirical piece by McKibbin

and Sachs is to design rules of the game (reform the international monetary system) such that the non-cooperative solution is as close as possible to the cooperative solution. The equilibrium reached would then be both enforceable and almost efficient. Among the new rules of the game which have been proposed we might mention the "target zone" system advocated by John Williamson (1983, 1986) and the system of fixed exchange rates between the United States, Germany and Japan, in which the weighted sum of the money stocks of the three countries is to be held constant (or set cooperatively), proposed by Ronald McKinnon (1984). McKibbin and Sachs compare the various non-cooperative solutions obtained from different exchange rate arrangements, the flexible exchange rate, the fixed exchange rate a la Bretton Woods and two versions (corresponding to a fixed and non fixed weighted sum of the money stocks of the US, Germany and Japan) of McKinnon's proposal. The results they obtain from this simulation exercise are at best only suggestive. Under the fixed exchange rate a la Bretton Woods US fiscal policy may be transmitted negatively while foreign fiscal policy is positively transmitted to the US. Under floating exchange rates, transmission of fiscal policy tends to be positive. Under McKinnon's system of fixed exchange rate fiscal policy can be negatively transmitted. However it is generally not possible to tell which system is best in its ability to accomodate external shocks. It

depends upon the nature of the disturbances. On the whole the results are relatively hostile to fixed exchange rates.

Since today's international monetary system (or non-system) is not well defined (the rules of the game are not well specified) policy makers do not know the exact nature of the links that exist between their countries and cannot predict the reactions of other policy makers to their actions. No cooperative decision making process is to be expected in such an environment. Rules of the game are better defined within the EMS although they probably have not yet been modelled appropriately. Moreover institutions such as the EMS, by imposing additional constraints, can contribute to solve the "credibility problem" and the consistency problem which result from the application of differential game theory.

CHAPTER TWO

MONETARY POLICY COORDINATION WITHIN THE EUROPEAN MONETARY SYSTEM: A GAME-STRATEGIC APPROACH

I. Introduction.

Economic policy coordination between two or more countries is a topic which is attracting the attention of both policymakers and economists in and out of government. Policy coordination has been attempted by members of the European Monetary System (EMS) since 1979 in order to reduce exchange rate fluctuations and by members of the Group of 5 since 1985 to reverse the appreciation of the dollar.

The arguments in favor of policy coordination rely upon the classical case of externality and upon the fact that there are no markets where countries can trade policies. Suppose that two countries are interdependent in such a way that an expansionary policy at home boosts demand abroad and thus has a positive effect on foreign variables such as employment. However, since the domestic government was not elected by foreign voters, the domestic country does not place much weight on this in making its own plans. As the domestic country's policies have some impact on foreign variables they tend to have less impact on domestic variables. In order to achieve its target the domestic country will be forced to adjust its instruments by a larger amount than it would be necessary if there was no spill over effects of its policies onto foreign variables. If there is a trade-off between inflation and unemployment in the short run, a country will have to accept a higher than desired inflationary cost in order to achieve its employment

target. The foreign country, on the other hand, benefits from the domestic expansion but does not have to pay a price for the benefit it receives.

A way to solve this externality problem would be to create a market where various countries could trade macroeconomic policies. Thus the foreign country would have to pay a price in order to benefit from the expansionary domestic policy. Most likely the foreign country would expand also in such a way that it would pay a price in terms of higher inflation. The domestic country would be able to achieve its employment target at a lower inflationary cost since it would not have to expand as much as it did before the foreign country inflated its economy. Therefore coordination can be in the selfish interest of each country. There are problems, however, in achieving coordination. It is necessary for the proper institutions to exist in order to solve the externality problem and, even if these institutions exist, coordination may still not be achieved as section IV below will show.

Most empirical research, such as that of Oudiz and Sachs (1984), has shown that the potential gains from policy coordination are small. However those authors have only estimated what would be the potential welfare gains if the United States, West Germany and Japan coordinated their policies. The welfare gains from policy coordination between European countries which are institutionally

interdependent, similar in size and geographically close have the potential to be much larger.

In addition, the European Economic Community (EEC) and the European Monetary System provide an institutional framework which is conducive to successful coordination. In doing so these institutions impose some constraints upon its members. For example the EEC requires that its 13 members do not impose certain barriers that would restrict the movement of goods between them. Thus the model presented below will assume that Purchasing Power Parity (PPP) holds while there may exist restrictions on the movement of capital.

Since the issue of policy coordination would not arise if countries were independent of each other, it is necessary to examine first how countries are linked. It is particularly important to determine the sign and the size of the spill-over coefficient which measures the responsiveness of domestic output to a foreign fiscal or monetary unanticipated policy change. If the sign is positive (negative) an expansionary policy in one country would cause output to increase (decrease) in the other country.

In the model of this paper the sign of the spill-over effect is positive due to the presence of two factors:

1. The existence of two or more goods as the positive spill over effect operates directly through the demand for goods. Following an expansionary monetary policy at home,

domestic ouput and income increase and so do domestic expenditures. Some, but not all, of the increased expenditures falls on each country's goods. Therefore there wil be an excess supply of the expanding country's goods and an excess demand for the foreign country's goods. Thus the relative price of the foreign country's good increases and the output of the foreign country rises.

2. The positive, but not perfect, indexation of wages to a price level index that includes the prices of imported goods as well as home goods. Thus, following an expansionary policy at home, the foreign currency appreciates and the price of imported goods abroad will drop. Foreign nominal wages will fall and, if the price of own goods in the foreign country does not fall or falls by less than nominal wages, the real product wage will fall and ouput will increase in the foreign country.

Generally the sign of the spill-over coefficient is indeterminate as in the models of Canzoneri and Gray (1985), Turnovsky (1986) and Oudiz and Sachs (1984). It may be negative as in Mundell's (1964) model. The negative effect will follow if one assumes perfect capital mobility. In this case an expansionary monetary policy at home leads to lower domestic interest rates, capital outflows and an appreciation of the foreign currency which will have a deflationary effect in the foreign country. This is Mundell's classical result. Oudiz and Sachs have shown that

this result can be reversed if wages are indexed to a consumer price index which includes both the price of home goods and of imported goods, and if the coefficient of wage indexation in the foreign country is large enough.

Once we have defined the nature of the interdependence between two or more countries, those countries have two possible choices: They can set their policies as if they were not interdependent reaching the Nash equilibrium or they can coordinate their policies in such a way that they internalize the externality problem. Thus whether policies are set cooperatively or not depends upon the outcome of a strategic game and the kind of cooperative agreement that will result depends upon the nature of the links (the sign of the spill-over effect) which exist between countries.

In this paper I look at the theoretical arguments under which monetary policy coordination between two European countries is welfare improving. I show that, if the two countries have the same preferences regarding inflation and unemployment, a cooperative fixed exchange rate system is a possible outcome. If the two countries have very divergent preferences a non cooperative Nash equilibrium within a flexible exchange rate system will most likely emerge. The intermediate case, where the two countries have somewhat similar preferences, may lead to two possible outcomes. These are a non cooperative fixed exchange rate and a cooperative flexible exchange rate solution. Both of these

may have characterized the relationship between France and West Germany after March 1983.

The paper will proceed as follow. Section II describes and solves the model for the two basic relationships which characterize the nature of the linkages that make the two countries in our model interdependent: the effect on own output of a change in domestic and foreign monetary policy and the effect of such policy changes on the exchange rate. Section III will use those relationships derived in section II to analyze the game theoretic aspects of the model. Section IV will use the model to explain the behavior of France and West Germany between 1979, when the European Monetary System was created, and the present time. Section V concludes the paper and points at the direction in which it might be extended in the future.

II. The Model.

This is a one-period, discrete time model written in log form where small letters denote log of variables while capital letters denote unlogged form. The symbol * is used to denote foreign variables. There are two countries. Each country specializes in the production of one good. Both countries consume the two goods. The domestic country produces commodity 1 denoted by X_1. The foreign country produces commodity 2 denoted by X_2^*. We focus our attention on fluctuations in employment and prices. We assume that

capital and factors of production other than labor are constant and that net capital accumulation is negligible:

$$x_{1t}=ßn_t+\mu_t \qquad (1)$$

$$x_{2t}^*=ßn_t^*+\mu_t \qquad 0<ß<1 \qquad (1')$$

where μ_t is (the log of) a productivity disturbance which affects all countries in the same way and has a mean of zero and is i.i.d.[1] n_t and n_t^* are the quantities of domestic and foreign labor used in the production of good 1 and good 2 respectively. Labor demand is given by the following marginal conditions:

$$w_t=p_{1t}+\ln ß-(1-ß)n_t+\mu_t \qquad (2)$$

$$w_t^*=p_{2t}^*+\ln ß-(1-ß)n_t^*+\mu_t \qquad (2')$$

where w_t is the nominal wage rate and p_{1t} is the price of good 1 in the domestic country, and w_t and p_{2t}^* are the equivalent variables in the foreign country. Combining (1) with (2) and (1') with (2') and taking the first difference of the log terms we obtain:

$$w_t-w_{t-1}=(p_{1t}-p_{1t-1})-[(1-ß)/ß](x_{1t}-x_{1t-1})+(1/ß)(\mu_t-\mu_{t-1}) \qquad (3)$$

$$w_t^*-w_{t-1}^*=(p_2^*{}_t-p_2^*{}_{t-1})-[(1-ß)/ß](x_2^*{}_t-x_2^*{}_{t-1})+(1/ß)(\mu_t-\mu_{t-1}) \qquad (3')$$

The law of one price holds between the two countries. Thus we can write after taking the first difference of the log terms:

$$p_{1t}-p_{1t-1}=(e_t-e_{t-1})+(p_1^*{}_t-p_1^*{}_{t-1}) \qquad (4)$$

$$p_{2t}-p_{2t-1}=(e_t-e_{t-1})+(p_2^*{}_t-p_2^*{}_{t-1}) \qquad (4')$$

where e is the exchange rate (number of units of domestic currency per unit of foreign currency).

Like Hamada and Sakurai[2] I assume that individuals in each country spend the same constant fraction (α) of their expenditures on commodity 1 and the same constant fraction ($1-\alpha$) of their expenditures on commodity 2:

$$P_{1t}C_{1t}=\alpha(P_{1t}C_{1t}+P_{2t}C_{2t}) \text{ and } P_{2t}C_{2t}=(1-\alpha)(P_{1t}C_{1t}+P_{2t}C_{2t}) \quad (5)$$

$$P_{1t}^*C_{1t}^*=\alpha(P_{1t}^*C_{1t}^*+P_{2t}^*C_{2t}^*) \text{ and}$$

$$P_{2t}^*C_{2t}^*=(1-\alpha)(P_{1t}^*C_{1t}^*+P_{2t}^*C_{2t}^*) \quad (5')$$

where C_{1t} and C_{2t} stand for the domestic consumption of good 1 and good 2 respectively, and C_{1t}^* and C_{2t}^* define the equivalent foreign variables. These expenditure functions imply the following price indices, expressed in terms of the rates of price increases, for consumers in the two countries:

$$P_t-P_{t-1}=\alpha(p_{1t}-p_{1t-1})+(1-\alpha)(p_{2t}-p_{2t-1}) \quad (6)$$

$$p^*_t-p^*_{t-1}=\alpha(p_1^*{}_t-p_1^*{}_{t-1})+(1-\alpha)(p_2^*{}_t-p_2^*{}_{t-1}) \quad (6')$$

Substituting (4) and (4′) into (6) and using (6′) we obtain the Purchasing Power Parity (PPP) relationship expressed in difference form:

$$P_t-P_{t-1}=(e_t-e_{t-1})+(p^*_t-p^*_{t-1}) \quad (7)$$

We can rewrite (5) and (5′) as follows:

$$(1-\alpha)P_{1t}C_{1t}=\alpha P_{2t}C_{2t} \quad (8)$$

$$(1-\alpha)P_{1t}^*C_{1t}^*=\alpha P_{2t}^*C_{2t}^* \quad (8')$$

By taking the first difference of the log terms of (8) and (8′) we obtain:

$$(c_{1t}-c_{1t-1})-(c_{2t}-c_{2t-1})=(p_{2t}-p_{2t-1})-(p_{1t}-p_{1t-1}) \quad (9)$$

$$(c_1^*{}_t-c_1^*{}_{t-1})-(c_2^*{}_t-c_2^*{}_{t-1})=(p_2^*{}_t-p_2^*{}_{t-1})-(p_1^*{}_t-p_1^*{}_{t-1}) \quad (9')$$

Substracting (4′) from (4), we get:

$$(p_{1t}-p_{1t-1})-(p_{2t}-p_{2t-1})=(p_1^*{}_t-p_1^*{}_{t-1})-(p_2^*{}_t-p_2^*{}_{t-1}) \quad (10)$$

Thus from (9) and (9′) with (10) we get:

$$(c_{1t}-c_{1t-1})-(c_{2t}-c_{2t-1})=(c_1^*{}_t-c_1^*{}_{t-1})-(c_2^*{}_t-c_2^*{}_{t-1})$$
$$=(p_{2t}-p_{2t-1})-(p_{1t}-p_{1t-1}) \quad (11)$$

Equation (11) implies that the elasticities of substitution in consumption between the two commodities are equal to unity in both countries. Taking the ratio of (5) over (5′), and using the purchasing power parity relationship in its absolute form, we obtain:

$$C_{1t}/C_{1t}^*=C_{2t}/C_{2t}^* \quad (12)$$

and by introducing the equilibrium conditions for commodity markets:

$X_{1t}=C_{1t}+C_{1t}^*$ and $X_{2t}^*=C_{2t}+C_{2t}^*$ we get:

$$X_{1t}/C_{1t}^*=X_{2t}^*/C_{2t}^* \quad (13)$$

Taking the first difference of the log terms of (13) and using (11) and (10), we obtain:

$$(x_{1t}-x_{1t-1})-(x_2^*{}_t-x_2^*{}_{t-1})=(c_1^*{}_t-c_1^*{}_{t-1})-(c_2^*{}_t-c_2^*{}_{t-1})=$$
$$(p_{2t}-p_{2t-1})-(p_{1t}-p_{1t-1})=(p_2^*{}_t-p_2^*{}_{t-1})-(p_1^*{}_t-p_1^*{}_{t-1}) \quad (14)$$

Money is the only financial asset in each country. This assumption is equivalent to assuming perfect capital immobility between the two countries. For the case of France and West Germany making this assumption should not be too restrictive, as Germany imposed capital controls until 1975 and France, which is actually talking about removing most restrictions on the movement of capital, has not yet done so, and, instead, strengthened them in June 1981 and from March 1983 to January 1984 (although they have been weakened beginning in 1986). On the other hand, as required by the rules of the EEC, these two countries impose relatively little restrictions upon the movement of goods and services. Therefore it might be appropriate to say that the present analysis applies to countries which allow more mobility in the movement of commodities than in the movement of capital.

Total expenditures are given by:

$$P_{1t}C_{1t}+P_{2t}C_{2t}=VM_t \qquad (15)$$

$$P_{1t}^*C_{1t}^*+P_{2t}^*C_{2t}^*=VM_t^* \qquad (15')$$

where V is the consumption velocity of money (assumed to be constant) and M and M^* are the stocks of money outstanding in the two countries.

In this model nominal wages are indexed, but not completely, to the actual inflation rate (the indexing parameter is ø). The absence of completely flexible wage

rates ($\phi<1$) introduces the possibility of short run deviation of output from the full employment level.

$$w_t - w_{t-1} = \phi(p_t - p_{t-1}) \tag{16}$$

$$w_t^* - w_{t-1}^* = \phi^*(p_t^* - p_{t-1}^*) \tag{16'}$$

Under a system of perfectly flexible exchange rates, the exchange rate is determined in such a way that the balance of payments is always equal to zero:

$$P_{1t}X_{1t} = P_{1t}C_{1t} + P_{2t}C_{2t} \tag{17}$$

$$P_{2t}^*X_{2t}^* = P_{1t}^*C_{1t}^* + P_{2t}^*C_{2t}^* \tag{17'}$$

Combining equations (15) with (17) and (15') with (17') we obtain:

$$P_{1t}X_{1t} = VM_t \tag{18}$$

$$P_{2t}^*X_{2t}^* = VM_t^* \tag{18'}$$

Taking the first difference of the log terms of (18) and (18') we obtain:

$$m_t - m_{t-1} = (P1t - P1t-1) + (x_{1t} - x_{1t-1}) \tag{19}$$

$$m_t^* - m_{t-1}^* = (p_2^*{}_t - p_2^*{}_{t-1}) + (x_2^*{}_t - x_2^*{}_{t-1}) \tag{19'}$$

Under a system of flexible exchange rates countries can decide on their rates of monetary expansion:

$$m_t - m_{t-1} = \theta \tag{20}$$

$$m_t^* - m_{t-1}^* = \theta^* \tag{20'}$$

Combining (19) with (20) we obtain:

$$P1t - P1t-1 = \theta - (x_{1t} - x_{1t-1}) \tag{21}$$

From (19') and (20') we get:

$$p_2^*{}_t - p_2^*{}_{t-1} = \theta^* - (x_2^*{}_t - x_2^*{}_{t-1}) \tag{22}$$

From (14) and (21) we get:

$$p_{2t}-p_{2t-1}=\theta-(x_2^*{}_t-x_2^*{}_{t-1}) \tag{23}$$

From (14) and (22) we get:

$$p_1^*{}_t-p_1^*{}_{t-1}=\theta^*-(x_{1t}-x_{1t-1}) \tag{24}$$

Substituting (21) and (23) into (6) we obtain:

$$p_t-p_{t-1}=\theta-\alpha(x_{1t}-x_{1t-1})-(1-\alpha)(x_2^*{}_t-x_2^*{}_{t-1}) \tag{25}$$

Substituting (22) and (24) into (6′) we obtain:

$$p^*{}_t-p^*{}_{t-1}=\theta^*-\alpha(x_{1t}-x_{1t-1})-(1-\alpha)(x_2^*{}_t-x_2^*{}_{t-1}) \tag{26}$$

From (4), (21) and (24) or (4′), (22) and (23) we find:

$$e_t-e_{t-1}=\theta-\theta^* \tag{27}$$

According to (27), the rate of exchange depreciation is equal to the difference between the growth rate of the domestic and foreign money supplies.[3]

Using (16) and (3) we can write:

$$(p_{1t}-p_{1t-1})-[(1-ß)/ß](x_{1t}-x_{1t-1})+(1/ß)(\mu_t-\mu_{t-1})=\phi(p_t-p_{t-1}) \tag{28}$$

Using (16′) and (3′) we can write:

$$(p_2^*{}_t-p_2^*{}_{t-1})-[(1-ß)/ß](x_2^*{}_t-x_2^*{}_{t-1})+(1/ß)(\mu_t-\mu_{t-1})=\phi^*(p^*{}_t-p^*{}_{t-1}) \tag{29}$$

Substituting (21) into (28), (22) into (29) and rearranging terms we obtain:

$$x_{1t}-x_{1t-1}=ß[\theta-\phi(p_t-p_{t-1})]+(\mu_t-\mu_{t-1}) \tag{30}$$

$$x_2^*{}_t-x_2^*{}_{t-1}=ß[\theta^*-\phi^*(p^*{}_t-p^*{}_{t-1})]+(\mu_t-\mu_{t-1}) \tag{30′}$$

Substituting (25) into (30), (26) into (30′) and rearranging terms, we get:

$$x_{1t}-x_{1t-1}=\Gamma(1-\phi)ß\theta+\Gamma ß\phi(1-\alpha)(x_2^*{}_t-x_2^*{}_{t-1})+\Gamma(\mu_t-\mu_{t-1}) \tag{31}$$

$$x_2^*{}_t - x_2^*{}_{t-1} = \Gamma^*(1-\phi^*)ß\theta^* + \Gamma^* ß\phi^*\alpha(x_{1t} - x_{1t-1}) + \Gamma^*(\mu_t - \mu_{t-1}) \qquad (31')$$

where:

$$\Gamma = 1/(1-ß\phi\alpha) > 0$$

$$\Gamma^* = 1/(1-ß\phi^*(1-\alpha)) > 0$$

From (31) and (31') it is easy to see that each country's output change is a linear function of the unanticipated changes in the model's two policy variables θ and θ^*, and of the change in the productivity shock from one period to the next. Therefore we can rewrite (31) and (31') as follows:

$$x_{1t} - x_{1t-1} = \pi_1\theta + \pi_2\theta^* + \pi_3(\mu_t - \mu_{t-1}) \qquad (32)$$

$$x_2^*{}_t - x_2^*{}_{t-1} = \pi_1^*\theta^* + \pi_2^*\theta + \pi_3^*(\mu_t - \mu_{t-1}) \qquad (32')$$

where the π's are dependent upon all the parameters in (31) and (31'). Each country's output responds positively to an increase in the growth rate of its own money stock (π_1 and π_1^* are positive) as long as ϕ and ϕ^* are smaller than one, or as long as wages are not fully indexed or not completely flexible in the short run.

Also if $0<\phi<1$ an expansionary monetary policy in one country has a positive impact on the output of the other country (π_2 and π_2^* are positive).

It can also be seen that as the coefficient of wage indexation in the foreign (domestic) country increases, the impact of domestic (foreign) monetary policy on home (foreign) output decreases relative to its impact on foreign (domestic) output or π_1/π_2^* falls (π_1^*/π_2 falls).

If the indexation coefficients are equal in both countries, $\phi=\phi^*$, and if both countries spent the same fraction, $\alpha=0.5$, of their expenditures on the domestic good and on the foreign good, then: $\pi_1=\pi_1^*>0$ and $\pi_2=\pi_2^*>0$. This simplifying assumption will be shown to be convenient to use later on.[4]

III. Monetary Policy Games.

The game-theoretic aspects of monetary policy in an interdependent world has been formally analyzed by Hamada (1974, 1976, 1978), Canzoneri and Gray (1984, 1985) and Rogoff (1985) among others.

Like in Rogoff the monetary authorities in our two countries are assumed to be concerned with actual deviations of own-country employment and inflation from their optimal (socially-desired) values:

$$U=-(x_{1t}-x_{1t-1})^2-\sigma(p_t-p_{t-1})^2 \qquad (33)$$

$$U^*=-(x_2^*{}_t-x_2^*{}_{t-1})^2-\sigma(p^*{}_t-p^*{}_{t-1})^2 \qquad (33')$$

Here $x_{1t}-x_{1t-1}$ and $x_2^*{}_t-x_2^*{}_{t-1}$ represent deviations of output from their full employment levels in the home country and the foreign country.[5] The socially optimum rate of inflation is assumed to be equal to zero.

In order to rationalize the use of monetary policy we can assume that a shock (μ_t), which originates outside the model causes a temporary fall in the production of commodity 1 at home and commodity 2 abroad. Monetary policy can be

used to increase the levels of output in the two countries all the way back to the potential levels of output but at the cost of higher inflation rates.

The rates of inflation that will emerge at home and abroad if the respective levels of output in the two countries are not allowed to deviate from their potential levels are simply:

$$P_t - P_{t-1} = \theta \tag{34}$$

$$P^*_t - P^*_{t-1} = \theta^* \tag{34'}$$

To see this note that at full employment equilibrium $x_{1t} = x_{1t-1}$ and $x_2{}^*_t = x_2{}^*_{t-1}$. Thus from (21) and (23) we have:

$$P1_t - P1_{t-1} = P2_t - P2_{t-1} = \theta \tag{35}$$

and from (22) and (24) we have

$$P1^*_t - P1^*_{t-1} = P2^*_t - P2^*_{t-1} = \theta^* \tag{35'}$$

Substituting (35) into (6) we obtain (34) while substituting (35′) into (6′) we obtain (34′). Substituting (34) and (34′) into the utility functions (33) and (33′) we obtain:

$$U = -(x_{1t} - x_{1t-1})^2 - \sigma(\theta)^2 \tag{36}$$

$$U^* = -(x_2{}^*_t - x_2{}^*_{t-1})^2 - \sigma(\theta^*)^2 \tag{36'}$$

In response to the productivity shock, both countries set the rate of growth of their money supplies to maximize their utility functions (36) and (36′) subject to the constraints (32) and (32′)

Substituting (32) into (36) and (32′) into (36′) we obtain:

$$U = -[\pi_1\theta + \pi_2\theta^* + \pi_3(\mu_t - \mu_{t-1})]^2 - \sigma\theta^2 \tag{37}$$

$$U^*=-[\pi_1\theta^*+\pi_2\theta+\pi_3(\mu_t-\mu_{t-1})]^2-\sigma\theta^{*2} \qquad (37')$$

Nash Solution.

Maximizing the utility functions in (37) and (37'), with respect to θ and θ^* respectively, and rearranging terms, we obtain:

$$\theta=-[\pi_1\pi_2/(\sigma+\pi_1^2)]\theta^*-[\pi_1\pi_3/(\sigma+\pi_1^2)](\mu_t-\mu_{t-1}) \qquad (38)$$

$$\theta^*=-[\pi_1\pi_2/(\sigma+\pi_1^2)]\theta-[\pi_1\pi_3/(\sigma+\pi_1^2)](\mu_t-\mu_{t-1}) \qquad (38')$$

In deriving the reaction functions (38) and (38'), note that we have assumed a positive symmetric spill over effect ($\pi_i=\pi_i^*$) and identical preferences of the monetary authorities (σ's are the same for both countries). Equations (38) and (38') tell us that each country will respond to an expansionary monetary policy of the other country by reducing its money growth rate, and to a negative productivity shock ($\mu_t-\mu_{t-1}<0$) by increasing its money growth rate. The spill over effect being positive, when the foreign country follows a more expansionary monetary policy, the home country enjoys an increase in employment that allows it to decrease its money growth rate.

The reaction curves of the domestic country, $\theta(\theta^*)$, and foreign country, $\theta^*(\theta)$, have been plotted in figure 1 for the perfectly symmetric case. Note that all the indifference curves are positively sloped in the $\theta-\theta^*$ space and that the domestic country's indifference curves have an infinite slope at the points where they intersect the domestic Nash

reaction curve. The foreign reaction curves have a zero slope at the points where they intersect the foreign Nash reaction curve.[6] Note also that the direction of preferences is South-West for the domestic country which is better off when the foreign country expands its money supply while it reduces its own; for the foreign country the direction of preferences is North-East for similar reasons.

For a stable Nash equilibrium, the slope of the domestic reaction curve must be less steep than the slope of the foreign reaction curve. It is easy to show that a necessary and sufficient condition for stability is that domestic monetary policy has a larger impact on domestic output than foreign monetary policy or that $\pi_1>\pi_2$.[7]

The noncooperative Nash solution is obtained at point N in figure 1 where the two reaction curves intersect. It also can be found by solving equations (38) and (38′) for θ and θ^* in terms of the productivity shock and the parameters of the model. We get:

$$\theta_N=\theta_N^*=-[\pi_1\pi_3/(\sigma+\pi_1^2+\pi_1\pi_2)](\mu_t-\mu_{t-1})>0 \qquad (39)$$

Expression (39) shows that if the shock has a larger impact on output (an increase in π_3), then monetary policy will have to be more expansionary in the two countries. It also shows that if a foreign monetary expansion has a larger impact on domestic output (an increase in π_2), then monetary policy will be less expansionary in the domestic country. Similarly if a domestic monetary expansion has a larger

impact on foreign output, the foreign country will follow a less expansionary monetary policy following a negative productivity shock. However the impact of an increase in the effectiveness of one coutry's own policy (an increase in π_1) is uncertain. If one country's own policy becomes more effective, this country will not expand by as much following a shock only if $\sigma<\pi_1^2$.[8]

Now we substitute θ_N and θ_N^* from (39) into the utililty functions (37) and (37') in order to get the levels of welfare in each country associated with the non cooperative Nash solution. We obtain:

$$U_N=[\pi_3^2+\{\pi_1^2\pi_3^2(\pi_1+\pi_2)^2/(\sigma+\pi_1^2+\pi_1\pi_2)^2\}-\{2\pi_1\pi_3^2(\pi_1+\pi_2)/(\sigma+\pi_1^2+\pi_1\pi_2)^2\}-\{\sigma\pi_1^2\pi_2^2/(\sigma+\pi_1^2+\pi_1\pi_2)^2\}](\mu_t-\mu_{t-1}) \quad (40)$$

Due to the symmetry of the model the same expression will hold true for U_N^* although this, in no circumstances, means that I am comparing the level of utility of one country against that of the other. Comparison can only be made between the levels of utility under different regimes in a single country. Expression (40) above is used later, after we derive the utility levels under the fixed exchange rate and the fully cooperative regimes.

Introducing some assymetry into the model is an easy task although it makes some tedious computations even more tedious. Figures 2 and 3 represent the assymetric case, the only difference between them resides in the size of σ^* relative to σ. In the present model I will assume, without

loss of generality, that the domestic country dislikes inflation more than the foreign country. This is the same thing as assuming that $\sigma>\sigma^*$. Thus, in figure 3, σ^* is much smaller relative to σ than in figure 2. Then σ is replaced by σ^* in the reaction function of the foreign country (38'), while the reaction function of the domestic country (38) is unchanged. Thus, as can be seen from figures 2 and 3, the reaction curve of the foreign country rotates counterclockwise around the point where it intersects with the vertical axis.[9] Now the two reaction curves intersect at a point below the 45 degree line, which means that the domestic country, which dislikes inflation the most, follows a less expansionary monetary policy than the foreign country. This is verified by computing the new values of θ_N and θ_N^* to replace those of equation (39). They are:

$$\theta_N=-\{[\pi_1\pi_3(\sigma^*+\pi_1^2-\pi_1\pi_2)]/[(\sigma+\pi_1^2)(\sigma^*+\pi_1^2)-\pi_1^2\pi_2^2]\}(\mu_t-\mu_{t-1}) \quad (41)$$

$$\theta_N^*=-\{[\pi_1\pi_3(\sigma+\pi_1^2-\pi_1\pi_2)]/[(\sigma+\pi_1^2)(\sigma^*+\pi_1^2)-\pi_1^2\pi_2^2]\}(\mu_t-\mu_{t-1}) \quad (41')$$

From (41) and (41') we see that $\theta_N^*>\theta_N$ or the country which dislikes inflation the most will expand its money supply by less (while in the symmetric case we had $\theta_N=\theta_N^*$).

Fixed rate regime.

The fixed rate regime proposed by Canzoneri and Gray (1985) is a leader/follower regime with a non cooperative

solution.[10] In this section, I will show that this regime is not sustainable when the two countries have very divergent preferences. I assume that the domestic country plays the role of leader while the foreign country follows.[11] In this regime the follower attempts to fix its exchange rate by matching the leader's money growth rate. According to equation (27) this is sufficient to ensure that the exchange rate is fixed. (The fixed rate solution obtains at points F in figures 1,2 and 3.) The leader maximizes utility by taking as given the follower's reaction curve which is $\theta^*=\theta$. Substituting this restriction into the expression for $x_{1t}-x_{1t-1}$ given in (32) gives:

$$x_{1t}-x_{1t-1}=(\pi_1+\pi_2)\theta+\pi_3(\mu_t-\mu_{t-1})$$

Substituting the expression for $x_{1t}-x_{1t-1}$ above into (36) we get:

$$U_F=-[(\pi_1+\pi_2)\theta+\pi_3(\mu_t-\mu_{t-1})]^2-\sigma\theta^2$$

Maximizing U_F with respect to θ we obtain the expression for θ_F and θ_F^*:

$$\theta_F=\theta_F^*=-\{\pi_3(\pi_1+\pi_2)/[\sigma+(\pi_1+\pi_2)^2]\}(\mu_t-\mu_{t-1})>0 \qquad (42)$$

It is important to note that the expression above holds for all values of σ^*. Only the preferences of the leader country matter for the determination of monetary growth rate in the two countries. Thus if the leader country has a strong aversion toward inflation, σ would be large, and both θ_F and θ_F^* would be reduced. Under a non-cooperative fixed

rate regime the leader could force the follower to follow anti-inflationary policies.

It is straightforward to show that under the fixed rate regime, and for values of σ close enough to σ^*, both countries increase their money growth rates relative to the Nash solution. If both countries are better off under this regime, it is likely to be adopted. Effectively it can be shown that in the symmetric case:

$U_F > U_N$ and $U_F^* > U_N^*$.

Obviously those results are dependent upon the assumptions which have been made concerning the form of the utility function, the fact that the foreign country is allowed to choose the reaction curve it offers the domestic country and the symmetry of the model. The only assumption I have weakened somewhat, by allowing preferences to diverge between the two countries, is the last one mentioned.

For example as σ^* becomes smaller and smaller relative to σ, the Nash solution is reached at a point where the foreign country expands more and more and the domestic country expands less and less[12] (compare figures 1, 2 and 3). Due to the positive spill over effect the domestic country's welfare under a Nash regime becomes higher as σ^* falls. Thus, as the foreign country cares less and less about inflation, the domestic country's welfare at the fixed rate solution becomes worse and worse relative to the Nash solution. There will come a point where the domestic

country is better off under a Nash solution than under a fixed rate regime (see figure 3). Therefore, because it is not pareto improving, a fixed rate regime will not exist if the countries involved in the monetary arrangement have very different preferences.

Is the fixed rate regime pareto optimal?

In order to be able to answer this question in a formal manner (in the assymetric case only since in the symmetric case the fixed rate solution is pareto optimal) suppose the two monetary authorities collude to maximize their aggregate utility functions:

$$U+U^*=-[\pi_1\theta+\pi_2\theta^*+\pi_3(\mu_t-\mu_{t-1})]^2-\sigma\theta^2$$
$$-[\pi_1\theta^*+\pi_2\theta+\pi_3(\mu_t-\mu_{t-1})]^2-\sigma^*\theta^{*2} \qquad (43)$$

The monetary authority of the home country will differentiate the above equation with respect to θ and the monetary authority of the foreign country will differentiate it with respect to θ^*. It can be readily shown that the solutions thus obtained are:

$$\theta_{op}=-\{(\pi_1+\pi_2)\pi_3/[(\pi_1+\pi_2)^2+\sigma]\}(\mu_t-\mu_{t-1}) \qquad (44)$$

$$\theta_{op}{}^*=-\{(\pi_1+\pi_2)\pi_3/[(\pi_1+\pi_2)^2+\sigma^*]\}(\mu_t-\mu_{t-1}) \qquad (44')$$

Thus, by comparing (44) and (44') to (42) respectively, it is readily seen that $\theta_{op}=\theta_F(=\theta_F{}^*)$ while $\theta_{op}{}^*>\theta_{op}$. The pareto optimal point is located to the right hand side of the fixed exchange rate equilibrium point (point OP in figure 2). It is optimal for the foreign country, which

does not dislike inflation as much as the domestic country, to expand more than at the fixed exchange rate equilibrium point, while the domestic country expands by the same amount under the fixed rate and the perfectly cooperative regimes. Since the monetary authorities of the two countries collude to maximize the aggregate utility function, the pareto optimal equilibrium point thus obtained corresponds to a perfectly cooperative solution.[13] At the perfectly cooperative solution, a fixed exchange rate solution is not optimal if the different countries have different preferences. Thus, if the EMS is to survive, it should not be conceived as a fixed exchange rate system but, instead, as a system in which countries cooperate in a way that differences between monetary growth rates is linked to the difference between preferred rates of inflation.

IV. The French/German experience after March 1979.

In March 1979, eight European countries, Germany, France, Italy, Ireland, Netherlands, Belgium, Luxembourg and Denmark joined the European Monetary System (EMS) and agreed in principle to coordinate their monetary policies. (These countries belong also to the European Economic Community or EEC). This is a major example of de jure and de facto policy coordination and this section uses the model developed above to analyze whether Germany and France, the two

largest countries of the system, have behaved, since 1979, in accordance with the intent of the agreement.

Following the second oil shock in 1979 caused by the fall of the Shah of Iran and the Iran/Iraq war, neither country responded with a large increase in the growth rate of its money supply. Between March 1979 and May 1981 a conservative Prime Minister, Raymond Barre, was at the head of the French government. In 1979 and 1980 Germany had a balance of payment deficit of $5 billion and $16 billion respectively and the German authorities were following relatively restrictive fiscal and monetary policies to reduce this deficit. German interest rates rose to record levels in early 1981, German GDP grew by less than 2% in 1980 and fell both in 1981 and 1982. Between March 1979 and May 1981 the exchange rate between the French franc (FF) and the German mark (DM) was very stable. This evidence seems to indicate that both countries had rather similar preferences, but the fact that deflationary policies were pursued in both of them seems to indicate that policies were not set cooperatively and, instead, a Nash equilibrium was reached at point N either in figure 1, if preferences were exactly the same, or in figure 2, if preferences were somewhat divergent. The fact that the exchange rate was stable would insure the stability of the EMS even though France and Germany were not abiding by the rules of the game which would have required them to coordinate their policies. Thus

they failed to reach point OP in figure 2 where they both would have been better off.

In March 1981 a socialist government is elected in France with very different preferences from the conservative government that it replaced and from the West German government. This new government put more emphasis on reducing unemployment and worried little about the inflationary consequences of such an action. The equilibrium obtained was definitively Nash, reached at point N in figure 3, where France is following very expansionary policies[14] and Germany is not. Clearly these policies are not consistent with the monetary arrangement of March 1979. There were three foreign exchange crisis; one in October 1981, the second in June 1982 and the last one in March 1983, which taken together led to a 32.2% devaluation of the franc vis a vis the Deutschmark. Capital controls were strengthened in France in June 1981 and from March 1983 to January 1984, and there were talks about France leaving the EMS and let the franc fall freely. However, at this point the French government understood the inflationary consequences of leaving the EMS and decided to stay within the system as inflation considerations were becoming more important. Thus, in 1983, as σ^* increases, we move back to the situation in figure 2, where the three possible outcomes are at points N, F or OP. Because so little data are available it is not very easy to choose one of them. However the Nash

equilibrium might be safely discarded and the cooperative solution accepted for the possible two reasons reported by Padoa-Schioppa (1985): First, the new parities have become the outcome of a collective decision making process, while the first realignments (September 1979, November 1979 and March 1981) were essentially unilateral. Second, the changes in parities, starting in March 1983, have coincided with the adoption of substantial policy measures.

Because the French franc has continued to be occasionally devalued against the Deutsch-mark since 1983, we might wish to discard point F as well. It is certainly true that the exchange rate between the franc and the mark was not as stable after 1983 as it was between March 1979 and March 1981. However it was much more stable than between March 1981 and March 1983. The following story, which is consistent with our model, might be told: Toward the end of 1982 and early 1983 the French government was pressured by the German authorities to change its policy (it was often mentionned in the news-media that France changed its policy because of the deterioration of its external accounts, not because it preferred to do so). As was noted in section III, at the fixed rate solution (F) the money supply growth in the two countries depends only upon the preferences of the domestic country (Germany) and not upon the preferences of the foreign country (France). Thus if the French authorities were pressured to stabilize their exchange rate

by setting the rate of growth of their money supply very close to the German money growth rate, then the German government could force the French authorities to follow more restrictive policies. I contend that this might have been happening in early 1983. Later on during that year it is possible that the regime changed from a leader/follower fixed rate type to a more cooperative regime as French preferences became more similar to German preferences and there was no need to force the French into a specific type of behavior. This cooperative solution, reached at point OP in figure 2, is consistent with the facts that France's preferences, after 1983, became more similar to those of Germany, that France followed slightly more expansionary monetary policies than Germany and that the franc, as a result, continued to be occasionally devalued against the mark.

Thus if one can possibly argue that there was a short period of transition in early 1983 during which the exchange rate might be considered fixed between the franc and the mark, it seems more plausible, however, to argue that the EMS, following this transition period, became and still remains today a flexible exchange rate arrangement. This argument is based upon the fact that the EMS arrangement is very different in nature and functionment from the Bretton Woods agreement. Thus, under the EMS, realignmemts after 1983 occured quite frequently and were not accompanied by

foreign exchange crisis, while parity changes were very rare under the Bretton Woods agreement.

However it is also certainly true that the EMS has some features of a fixed exchange rate system. The eight currencies of the system move freely within a band. When one of the edges of the band is reached, though, the parities are quickly adjusted (and so are monetary policies to some extent). A remarkable fact is that the "minor" devaluations which have occured have not caused speculative forced to unravel and threaten the existence of the system. A possible reason for this might be the existence of capital controls which are imposed by the weak currency countries of the system, mainly France and Italy.[15]

If the model is correct, it is predictable that those controls will not be removed any time soon as long as France and Italy do not share the exact same preferences as Germany and as long as there are gains from coordinating policies. The fact that, in March 1986, a conservative government was elected in France with the promise that it would eliminate all capital controls as soon as it took office but has not yet done so can be cited as supportive evidence. This is in accordance with the implications of the model which predicts that capital controls will not be removed as long as France wants to keep on belonging to the EMS and does not want to let interest rates increase and as long as the Deutsch-mark keeps on being the strong currency of the system.

The model is able to explain why the EMS has lasted longer than its detractors predicted. They based their gloomy forecast upon the argument that the EMS was not a monetary arrangement but a fixed exchange rate arrangement similar to the Bretton Woods agreement. Thus they failed to see the potential welfare gains which come from policy coordination and instead remembered the 1973 breakdown of the fixed exchange rate system.

This model predicts that if such gains are indeed possible, then other countries should enter the system. The most obvious case that one may have in mind is that of the United Kingdom. If the United Kingdom has preferences similar to those of the strong currency countries which are already members of the system (this is a necessary condition since the United Kingdom removed all capital controls in 1979), then the British government should realize that Britain's welfare could be enhanced by entering the arrangement. If this is not a good enough reason for Britain to enter then a case can be made that the Thatcher government might want to enter anyway in order to tie the hands of a future labor government which might be more enclined to go down a more inflationary path.

V. Conclusion.

Strategic game theory was used to analyze the welfare impact of monetary policy coordination between two members

of the European Monetary System (EMS). Using a two-country model we show that: If the two countries have the same preferences regarding inflation and unemployment, then they both gain from setting their monetary policy cooperatively within a fixed exchange rate system. If their preferences are widely divergent, the outcome will be a non-cooperative Nash solution within a flexible exchange rate system. If their preferences are somewhat divergent two outcomes, both of which are preferable to the non-cooperative Nash solution, are possible. These are a non-cooperative fixed exchange rate system in which the strong currency country behaves as the leader while the other countries follow and a flexible exchange rate system in which monetary policy is set cooperatively and the exchange rate depreciation depends upon the difference between the two countries' preferred rate of inflation.

This model is used to explain the behavior of West Germany and France which belong to the European Economic Community and entered a monetary arrangement in 1979. It was argued that between the time the EMS was formed and the elections of March 1981 in France, policies were not set cooperatively. The two countries did not understand fully the cooperative nature of the agreement they had just signed. There would have been welfare gains if they had coordinated their policies. Between March 1981 and March 1983 we had again a Nash equilibrium. However, since the

two countries had very different preferences a cooperative solution could not be welfare improving and there was some tremendous stress imposed upon the system. After 1983, it is possible to argue that there was some cooperation between the French and German monetary authorities, although there was probably a short period of transition during which external considerations forced France to follow more contractionary policies in order to stabilize the value of the franc against that of the mark.

The model explains why the EMS has not died prematurely, why capital controls imposed by some weakcurrency countries cannot be removed if those countries wish to continue belonging to the system, and why other countries such as the United Kingdom might enter the arrangement sometimes in the near future.

This model has some serious limitations, the main one being that it is a two-country model while a three-country model might be more appropriate. Policy coordination has largely been made necessary by the increasing interdependence which exists among all countries of the world. When some countries desire to coordinate their policies they also have to take the policies of other countries which have stayed outside the monetary arrangement into account. Thus when Germany and France decide to set their monetary policies jointly it is also the case that Germany must keep an eye on what is going on in the United States. This is

particularly true since Germany does not impose capital controls and thus must consider that there might be large movements of capital out of Germany and into the United States if France and Germany decided jointly to expand their economies beyond a certain limit. This was particularly relevant to the 1983-1985 time period when the dollar was strong against European currencies due to high interest rates in the United States relative to the rest of the world. Since then U.S. interest rates and the dollar have fallen and Germany is still reluctant to lower its interest rates although it is under pressure to do so from some countries, particularly the United States and France. Even though such policy is consistent with a tremendous fear of inflation in Germany, I would feel more confortable calling the present experience between France and Germany as one of monetary cooperation if policies were generally somewhat more expansionary than they are today.

For further research, a third country should be added to our present two-country model, and the implications of perfect capital mobility between this third country, which might not enter the monetary arrangement, and one (or both) of the other two countries, which have entered the arrangement, should be studied.

Notes

1 The only type of shocks I consider are supply shocks which are common to the two countries. Output and money demand shocks are not considered here because I was only interested in introducing some kind of shock in order to motivate the use of monetary policy. Using a different model from the one used here, Turnovsky (1986) studies the impact of other types of shocks. (In addition Turnovsky does not assume that the productivity and the demand shock have the same impact on the two economies.) However I was not indifferent between using supply shocks or demand shocks. Worldwide supply shocks were selected because they impose much more serious stabilization problems than do worldwide demand shocks as explained by Turnovsky:

> "Demand shocks are much less problematical that supply disturbances, from the viewpoint of macro stabilization. In all cases, a country-specific demand disturbance of a given magnitude gives rise to less aggregate welfare costs than does a supply disturbance of equal magnitude. Moreover, worldwide demand shocks pose no problem whatsoever. Their effects can be eliminated entirely, provided each country simply adjusts its respective money supply so as to ensure that the interest rate in its economy rises sufficiently so as to exactly neutralize the effects of the shocks on aggregate demand. Worldwide supply shocks, on the other hand, are mutually compounding and their effects can never be eliminated."

Taylor agrees that stabilizing supply shocks is difficult.

2 Turnovsky assumes that individuals in each country spend a fraction δ of their income on domestic goods and a fraction $1-\delta$ of their income on foreign goods. Canzoneri and Gray (1985), and Rogoff (1985), on the other hand, make the same assumption as Hamada and Sakurai. My choice in this paper is based upon the fact that using Hamada and Sakurai's assumption is mathematically more tractable.

3 With a non unitary elasticity of substitution in consumption Hamada and Sakurai show that equation (27) does not hold except in equilibrium. Otherwise we should have:
$e_t - e_{t-1} = (\theta - \theta^*) + (1/\sigma - 1)[(x_{1t} - x_{1t-1}) - (x_2{}^*_t - x_2{}^*_{t-1})]$
where σ $(0<\sigma<\infty)$ is the elasticity of substitution.

4 If we assume that $\alpha = 1-\alpha$, it can be shown that:
$\pi_1 = (1-\phi)(1-ß\phi^*\alpha)ß/[(1-ß\phi\alpha)(1-ß\phi^*\alpha) - ß^2\alpha^2\phi\phi^*]$;

$\pi_2=ß^2\alpha ø(1-ø^*)/[(1-ßø\alpha)(1-ßø^*\alpha)-ß^2\alpha^2 øø^*]$;
$\pi_1^*=(1-ø^*)(1-ßø\alpha)ß/[(1-ßø\alpha)(1-ßø^*\alpha)-ß^2\alpha^2 øø^*]$;
$\pi_2^*=ß^2\alpha ø^*(1-ø)/[(1-ßø\alpha)(1-ßø^*\alpha)-ß^2\alpha^2 øø^*]$.

Thus:

$\pi_2^*/\pi_1 = ß\alpha ø^*/(1-ß\alpha ø^*)$;
$\pi_2/\pi_1^* = ß\alpha ø/(1-ß\alpha ø)$.

These are the expressions which are used to show that as countries become more interdependent monetary policy becomes less effective in the country where it originates while it becomes more effective in other countries.

If we assume that $\alpha=1-\alpha=0.5$ and $ø=ø^*$, it can be shown that:

$\pi_1=\pi_1^*=(1-ø)(1-ßø\alpha)ß/(1-ßø) > 0$ if $ø<1$;
$\pi_2=\pi_2^*=ß^2\alpha ø(1-ø)/(1-ßø) > 0$ if $0<ø<1$.

Thus if we assume that wages are somewhat indexed, but not totally, to a consumer price index which includes both the price of home goods and the price of imported goods, not only will monetary policy be effective, but also the spill-over effect will necesarily be positive.

Moreover it is also true that:

$\pi_3=\pi_3^*=1/(1-ßø) > 0$ if $ø<1/ß$.

As ø increases toward 1, there is more real wage resistance by workers and supply shocks lead to more unemployment if monetary policy remains passive. On the other hand if ø is small, a negative supply shock will have less impact on unemployment as real wages will fall. If $ø=0$ then $\pi_3=1$.

5 "For a number of reasons, the natural unemployment rate is probably not the optimal unemployment rate. Because oftaxes and unemployment compensation that make the social cost of unemployment exceed the private cost, and because of monopoly power, it is likely that social welfare rises whenever unemployment drops below the natural rate. But [...] macro policy cannot influence the average rate of unemployment. It can only influence the fluctuations of unemployment about the natural rate. Based on this logic we define the unemployment loss as the average squared departure of unemployment from the natural rate."
(Quote from Macroeconomics Theory performance and policy, by Robert E. Hall and John B. Taylor, Norton & Company, Inc., New York, London, 1986.)
A similar specification of the social utility function is used by Kydland and Prescott (1977) and Barro and Gordon (1983).

6 Along any indifference curve, we have U=k where k is a constant. Differentiating totally, we obtain:

$(\delta U/\delta\theta)d\theta + (\delta U/\delta\theta^*)d\theta^* = 0$; thus:

$$d\theta/d\theta^* = -[(\delta U/\delta\theta^*)/(\delta U/\delta\theta)].$$

Applying this formula to expression (37) in the text we get:

$$d\theta/d\theta^* = -\{(\pi_1\theta+\pi_2\theta^*+\pi_3\Omega)\pi_2/[(\pi_1\theta+\pi_2\theta^*+\pi_3\Omega)\pi_1+\sigma\theta]\}$$

where $\Omega=\mu_t-\mu_{t-1}$.

Set $A = (\pi_1\theta+\pi_2\theta^*+\pi_3\Omega)\pi_2$, $B = (\pi_1\theta+\pi_2\theta^*+\pi_3\Omega)\pi_1$, $C = \sigma\theta$.

Thus $d\theta/d\theta^* = -A/(B+C)$

If we start from a point where $\theta=\theta^*=0$ we have:

$$A=\pi_2\pi_3\Omega \qquad B=\pi_1\pi_3\Omega \qquad C=0.$$

Since $\pi_1>\pi_2$ and $\Omega<0$, B is more negative than A and B+C is negative. Let's compute the increase in θ (keeping θ^* constant) which is necessary in order to make B+C=0. We find that if θ increases from zero to $-\pi_1\pi_3\Omega/(\sigma+\pi_1^2) > 0$ then B+C=0. When this happens we find that:

$$A=\pi_2\pi_3\Omega[1-\pi_1^2/(\sigma+\pi_1^2)] < 0.$$

From that point where A<0 and B+C=0 we can increase θ marginally. We find that

$$\delta A/\delta\theta=\pi_1\pi_2 \text{ and } \delta(B+C)/\delta\theta=\pi_1^2+\sigma.$$

Therefore B+C increases faster than A and, thus, it must be the case that by increasing θ marginally we must have B+C > 0 and A < 0. We have shown that $d\theta/d\theta^* > 0$ or that the slope of any domestic indifference curve is positive, at least locally. However this local area is the relevant one since

$$-\pi_1\pi_3\Omega/(\sigma+\pi_1^2) > \theta_N = -\pi_1\pi_3\Omega/(\sigma+\pi_1^2+\pi_1\pi_2) > 0$$

(from equation (39) in the text). Using a similar argument it is possible to show that foreign indifference curves are also positively sloped.

Not only can we show that the domestic indifference curves are positively sloped, but we can also show that $d\theta/d\theta^*$ is increasing at a decreasing rate. In order to do this we differentiate $d\theta/d\theta^*$ with respect to θ^*; we get:

$$\delta(d\theta/d\theta^*)/\delta\theta^* = -\pi_2^2\sigma\theta < 0.$$

Using a similar method we would find that $d\theta/d\theta^*$ increases at an increasing rate along a foreign indifference curve. For the domestic indifference curves to have an infinite slope at the points where they intersect with the domestic reaction curve, we need to show that the denominator of $d\theta/d\theta^*$ above, after replacing θ by expression (38) in the text, is equal to zero. The reader can verify that this is the case. The equivalent method can be used to show that the foreign indifference curves are flat at the points where they intersect with the foreign reaction curve.

In conclusion we found that the domestic indifference curve has an infinite slope at the Nash equilibrium point, then that it is positively sloped and finally that it becomes flatter as θ and θ^* increase. Similar-

ly the foreign indifference curve is flat at the Nash equilibrium, then it becomes positively sloped and its slope increases as θ and θ^* increase.

7 As the diagrams in figure 4 show only when the foreign Nash curve is steeper than the domestic reaction curve will the Nash equilibrium obtained be stable. In diagram (a), if the domestic country chooses θ_1 the foreign country will respond with θ_1^*. Then the domestic country will respond with θ_2 and so on until the Nash equilibrium is reached at point N. On the other hand, if the domestic reaction curve is steeper than the foreign curve, as in diagram (b), starting from θ_1, we get farther away from the Nash equilibrium. Algebraically, using expression (38) and (38') in the text, this means that we must have:

$$(\sigma+\pi_1^2)/\pi_1\pi_2 > \pi_1\pi_2/(\sigma+\pi_1^2) \text{ or}$$
$$(\sigma+\pi_1^2)^2 > \pi_1^2\pi_2^2.$$

We can derive a sufficient condition for stability by setting $\sigma=0$. We obtain $\pi_1>\pi_2$.
Thus a sufficient, but not necessary condition for the Nash equilibrium to be stable is that a domestic monetary expansion has a larger effect on domestic output than a foreign monetary expansion does.

8 In order to find out how an increase in the effectiveness of monetary policy in one country affects the size of the monetary expansion in that country, following a negative productivity shock, we need to take the derivative of the coefficient of expression (39) with respect to π_1. Since we suspect that the more effective monetary policy is the smaller the monetary expansion should be, the sign of this derivative should be negative. This will be the case if $\sigma<\pi_1^2$.

9 In order to show that the foreign Nash reaction curve rotates counterclockwise, when σ^* falls, we need to manipulate equation (38') in the text in order to express θ as a function of θ^* and the shock, $\Omega=\mu_t-\mu_{t-1}$; we get:

$$\theta = -[(\sigma^*+\pi_1^2)/\pi_1\pi_2]\theta^* - (\pi_3/\pi_2)\Omega$$

As σ^* falls the slope of the foreign reaction curve is smaller in absolute value while the intercept term with the vertical axis is unchanged. Therefore the foreign Nash curve rotates counterclockwise around the point where it intersects with the vertical axis.

10 Many authors,among them turnovsky (1986) consider the fixed rate regime to be a cooperative regime. The truth of the matter is that a fixed exchange rate regime, like a flexible exchange rate regime, can be either a cooperative or a non cooperative system. In

the present model, a fixed exchange rate cooperative system would result if both countries had the same preferences and the policy solution was obtained by maximizing the aggregate utility function $U+U^*$.

11 In industrial organization literature, the leading firm is usually the largest producer in the industry. It is often the case that this firm is the largest because it has the lowest marginal cost. In section IV of the paper West Germany is the leader and all the other countries which belong to the EMS (and France is one of them) follow because Germany has the lowest marginal cost: the cost to Germany, in terms of higher inflationary expectations, of following a more expansionary monetary policy is lower than that of France. Moreover a monetary expansion in Germany would have a larger chance to be thought as temporary than a monetary expansion in France.

12 In the symmetric case, we have $\theta_F=\theta_F^* > \theta_N=\theta_N^*$ as can be seen from figure 1. In the assymetric case we have shown that as σ^* falls the foreign reaction curve rotates counterclockwise around the point where it intersects with the vertical axis (see figure 2 and 3). As the foreign reaction curve rotates the Nash equilibrium moves toward the South East, while the fixed rate solution does not change as only σ^* changes while σ stays constant. Thus as σ^* falls, θ_N^* increases and θ_N falls. A point will eventually be reached where θ_N^* will have increased so much that that we will have:

$$\theta_N^* > \theta_F=\theta_F^* > \theta_N$$

which says that the foreign country expands less under a non cooperative fixed rate regime than under a Nash regime. This point will be reached when:

$$\sigma^* < 2\sigma\pi_1^2/(\pi_1^2+\pi_1\pi_2-\sigma).$$

13 Once the optimal point is reached in figure 2, the domestic country (for example) might wish to reduce the growth rate of its money supply and reach point A if the foreign country does not retaliate by also reducing the growth rate of its money supply. However when the foreign country retaliates we move from OP, to A, to B and so on until we get back to point N, the Nash equilibrium, where the two countries are worse off than at OP. This type of argument is similar in nature to the one made in the international trade literature where it is shown that when countries impose ever higher restrictive tariffs on one another all countries end up being worse off. The General Agreement on Tariffs and Trade (GATT) was designed to prevent the use of welfare worsening anti-trade measures. An

international monetary arrangement would have a similar effect in the area of monetary policies which have beggar-thy-neighbor effects and make all countries worse off in the end when they are uncoordinated.

14 In 1981 the newly elected French government increased government spending while taxes remained almost unchanged. In France it has traditionally been the case that when fiscal policy is expansionary, monetary policy is accomodative. This is due to the fact that, on the one hand, capital markets are not as well developed in France as they are in the United States or the United Kingdom, and, thus, the government is limited in its ability to sell bonds to the general public, and, on the other hand, it is not possible to finance the deficit through additional tax collections because of the tax evasion problem which is quite pervasive in France.

15 The problem with a system in which currencies are allowed to fluctuate within a band of a given width is that, as soon as one of the edges of the band is reached, speculation on the weak currency unravels and an exchange rate crisis develops. Wyplosz (1986) shows that if the weak currency country adopts measures to control the mobility of capital (we are not con cerned here about the inefficiencies associated with capital controls as we are only analysing why they are used) no such crisis will develop. In his model domestic residents cannot hold foreign currency denominated assets, and foreign residents are allowed to hold domestic money in order to finance their trade transactions with the domestic country which are unrestricted. Thus if the domestic currency has depreciated such that a devaluation is expected, foreign residents will get rid of their finite amount of domestic money balances; the domestic central bank will comply by reducing its foreign reserve balances by the same finite amount since domestic residents are not allowed to lend domestic currency to foreign residents. Following this reduction of foreign reserves held by the domestic central bank, the exchange rate will be devalued enough so that the new exchange rate is credible and foreign residents will want to hold domestic money for their international trade transactions with the domestic country. The devaluation will also cause the trade balance to improve (assuming that the Marshall-Lerner condition holds). Thus the domestic central bank will accumulate international reserves until the higher inflation in the domestic country will have caused the real exchange rate to appreciate so much that the price of domestic goods

will become too high relative to the price of foreign goods. Then the trade balance will deteriorate and foreign reserves will be lost again. When the level of foreign reserves is low enough foreign residents will expect a depreciation of the domestic currency and they will exchange their domestic money for the remaining foreign reserves held by the domestic central bank. The nominal (and real) exchange rate will be devalued again and so on. Such a mechanism seems to be a fairly good description of the way the EMS functions since 1983, especially with respect to France and Italy which impose capital controls of the sort described above. The French franc (and the other weak currencies of the system such as the Italian lira, the Irish pound, the Belgian franc and the Danish crown) depreciates against the German mark (and the Dutch guilder) as the inflation rate of the weak currency countries is higher than that of the strong currency countries. A devaluation of the weak currencies and a revaluation of the strong currencies follow.

If this is the way the EMS really works, it suggests that PPP does not hold and, thus, that my model is not quite correct. Further research is needed to develop tractable model which assumes neither uncovered interest parity nor purchasing power parity.

FIGURE I

SYMMETRIC CASE: $\sigma = \sigma^*$

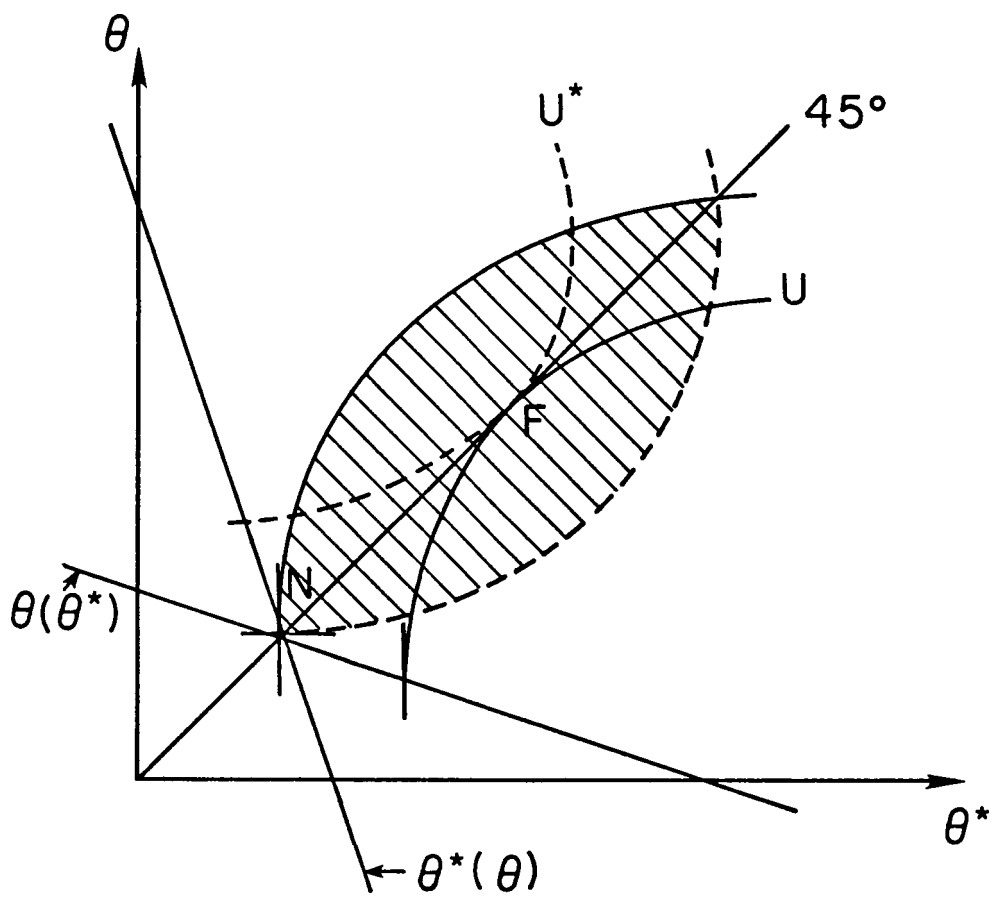


FIGURE 2

ASYMMETRIC CASE: $\sigma > \sigma^*$

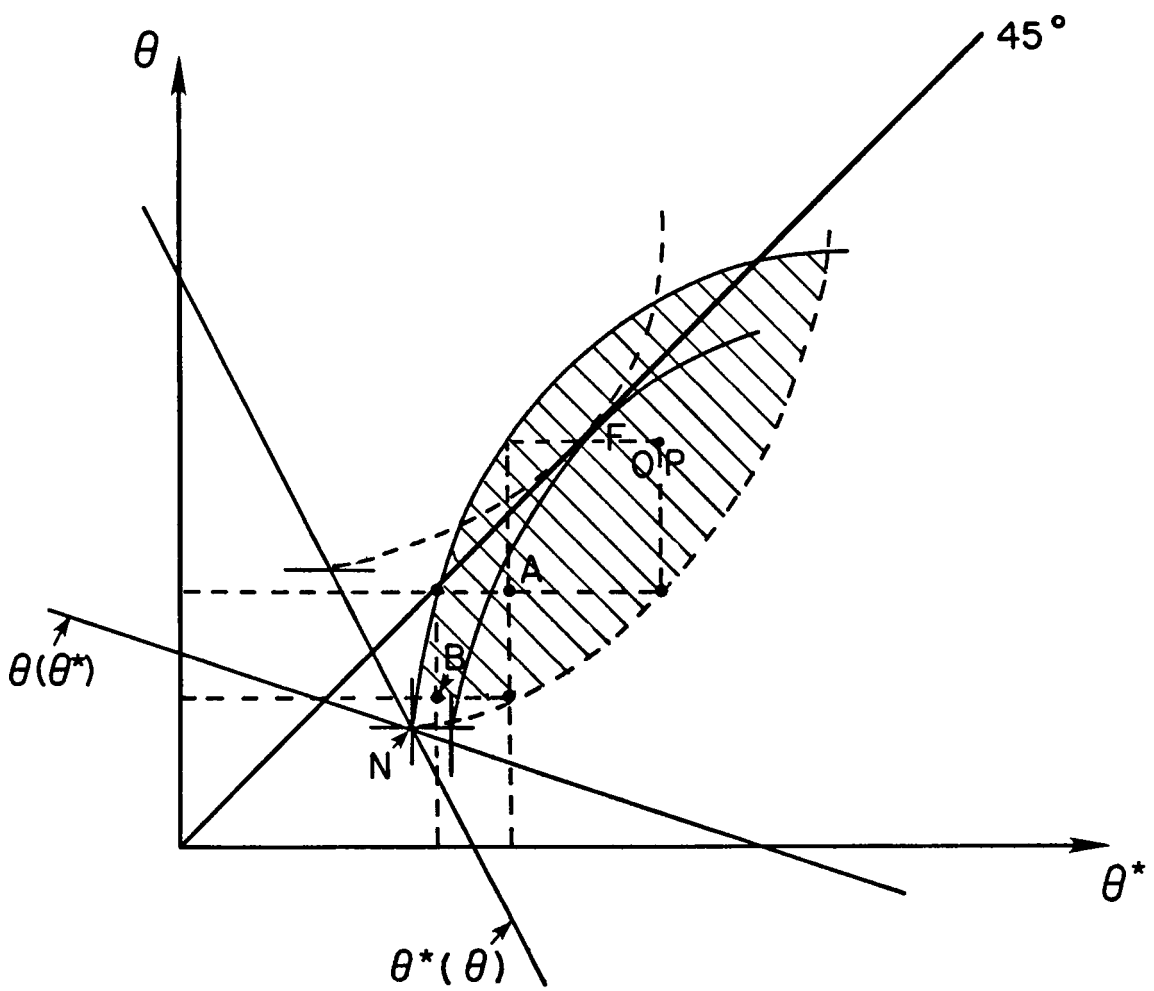


FIGURE 3

ASYMMETRIC CASE: $\sigma >> \sigma^*$

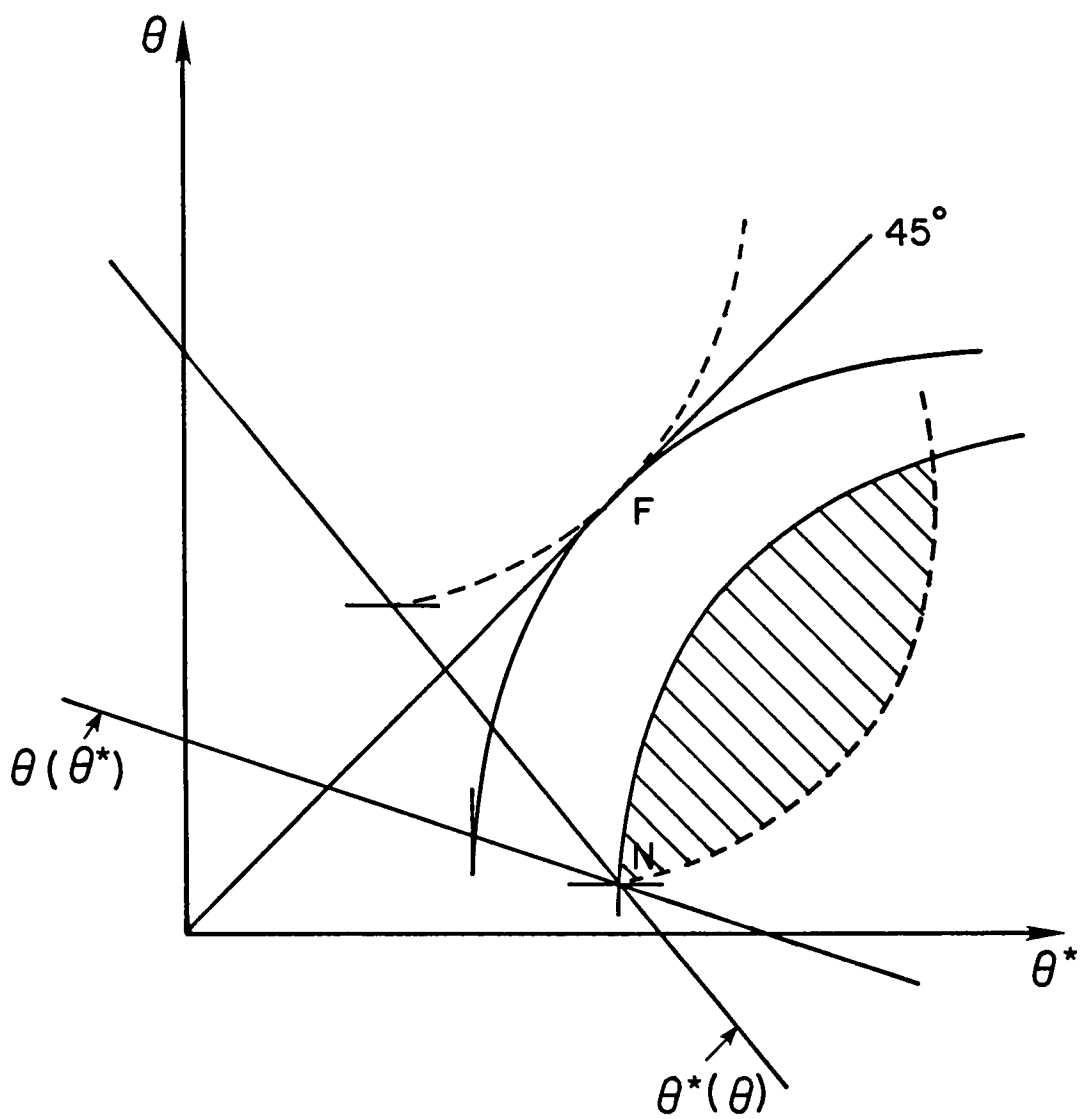
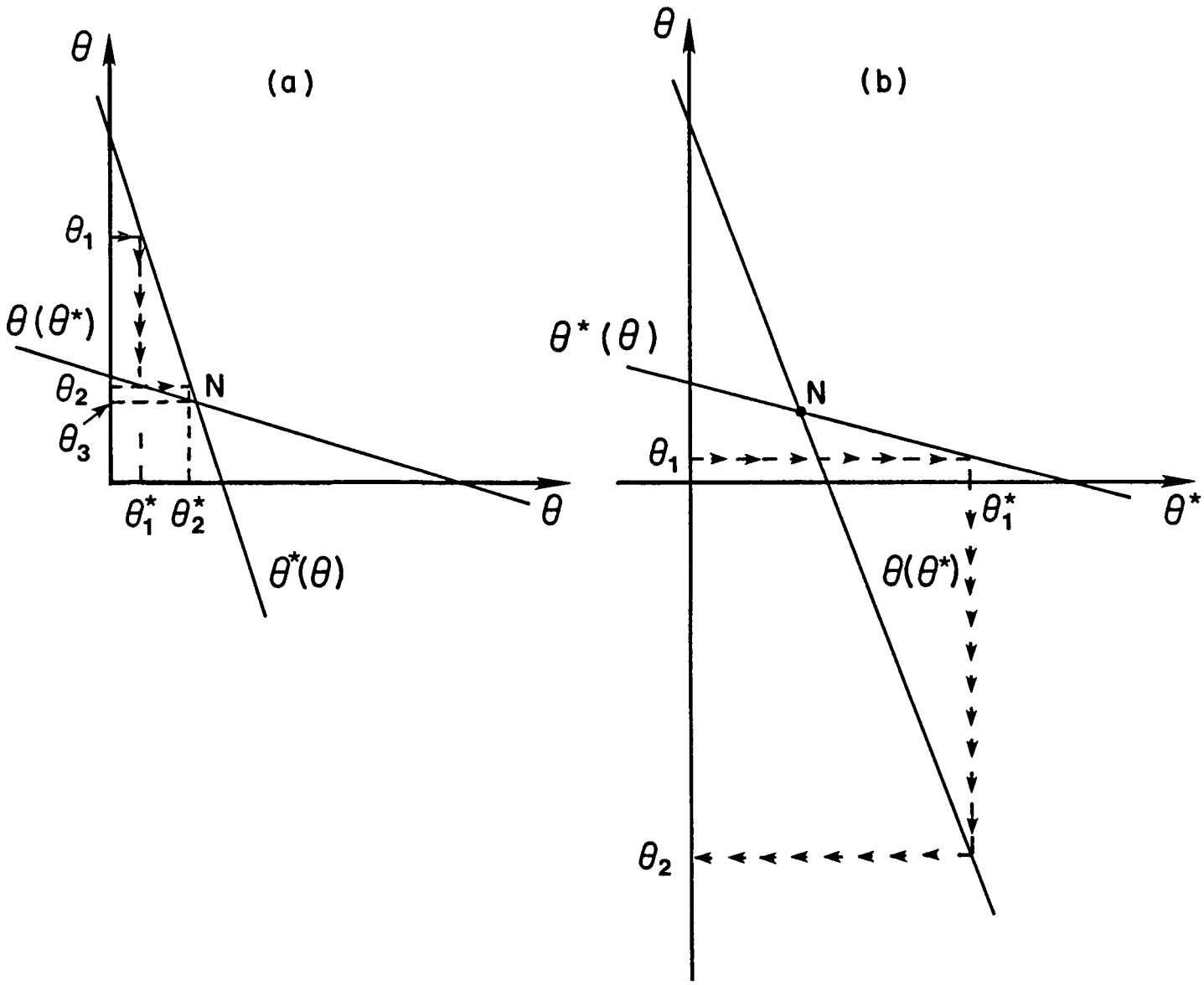


FIGURE 4

CONDITIONS FOR STABILITY OF THE NASH EQUILIBRIUM



CHAPTER THREE

HOW DO OTHER INDUSTRIAL COUNTRIES REACT TO BUDGET DEFICITS AND MONETARY POLICY IN THE UNITED STATES?

I. Introduction

In a world of flexible exchange rates, countries are free in principle to choose the kind of monetary policy they wish to follow independently of the policies followed by other countries. They can select their own inflation rates without facing imbalances in their balance of payments. However, even under a flexible exchange rate system, countries are still interdependent. They are linked through two mechanisms: (1) the terms of trade and (2) the capital market. For example following a monetary disturbance in one country that is assumed to have real effects in that country, at least in the short run, the terms of trade will be affected and this, in turn, will have real effects on another country. Subsequently the affected country may react to the change in its terms of trade by changing its monetary policy even though, in principle, it does not have to do so.

The first mechanism of transmission operates via real output effects and thru the terms of trade and is often referred to as the Locomotive effect. The second mechanism operates through the capital account, or current account imbalances, and depends on the international mobility of capital. This second mechanism assumes that a bond-financed fiscal expansion does not lead directly to extra private savings in the country concerned that are sufficient to finance the deficit. Instead it is assumed that a budget

deficit which is not monetized is financed by foreign savings, by a diversion of domestic savings away from investments and by some rise in domestic savings. Therefore a U.S. increase in government expenditures that is bond financed is expansionary and raises the interest rate. I make this assumption even though I recognize that there may be some tendency to such an offsetting rise in savings as taxpayers foresee the increase in the future tax burden to meet government interest payments (Ricardian Equivalence Proposition).[1]

In this paper, I will use a methodology similar to the one used by Abrams, Froyen and Waud (1980, 1983) to estimate policymakers' reaction functions. This framework has been extended by Bradley and Potter (1986) in order to study the interdependence between the monetary and fiscal authorities of the same country. Thus, between the 1969:2 and 1984:3 period, Bradley and Potter find that monetary and fiscal policies were not coordinated in the United States (U.S.). Rather they appear to be set by a Nash equilibrium in a non cooperative game. I propose to extend this same framework further in order to study the interdependence not only between the fiscal and monetary authorities of the same country but also between domestic and foreign policymakers. Thus the reactions of West German, Japanese, Canadian, British and French policymakers to the actions of U.S.

policymakers and those of British and French policymakers to the actions of German policymakers will be estimated. One should care about the results of these reaction functions because if it can be shown that other countries react to U.S. policies and if the U.S. does not take the reactions of those countries into account when she sets her own policies then the outcome for the world as a whole would not be pareto optimal. There is an externality and welfare can be improved by internalizing this externality. Policy coordination is a way to do just that and therefore leads to welfare gains.

It will be shown that West Germany, Japan, Canada, the United Kingdom (U.K.) and France react to US policy actions but not in the same manner. The U.K. and France also react to German policies. Canada reacts very strongly to U.S. actions. West Germany does not react as strongly but she is likely to cut her discount rate and reduce her taxes, as U.S. policymakers are asking her to do, if the U.S. cuts her budget deficit. Japan, on the other hand, is unlikely to react the same as Germany is if the U.S. reduces her budget deficit. The Japanese seem to be more concerned about keeping the U.S. market open to their products. The reaction functions of British policymakers were rather inconclusive.

In the next section the results of some Granger (1969) causality tests will be presented. These tests can tell us

if we may expect to find some kind of relationship between variables of different countries. In order to understand the nature of these relationships, though, a reduced form equation has to be derived from a structural model. This will be done in the third section. The fourth section will present how policymakers are assumed to make their forecasts of target variables. The fifth section will present the estimates of the reduced form equation derived in the third section and will interpret the results obtained for each of the countries considered. The final section concludes the paper, draws some possible lessons to be learnt from it and points at some possible ways to extend it.

II. Some Vector Autoregression results.

In order to run some Granger causality tests two vector autoregressions of the form below must be estimated:

$$y_t = a_0 + \Sigma a_i y_{t-i} \qquad (1)$$

$$y_t = b_0 + \Sigma b_i y_{t-i} + \Sigma c_j z^*_{t-j} \qquad (2)$$

where the Σ of equation (1) and the first one of equation (2) extend from i=1 to i=k-1 and the second Σ of equation (2) extends from j=1 to j=n. In equation (1) a domestic variable is regressed on a constant term and the lagged values of itself. In equation (2) the same domestic variable is regressed on a constant term, the lagged values of itself and the lagged values of a foreign variable (foreign variables are denoted with a star). Thus equation

(1) is a restricted version (n restrictions) of equation (2).

Before running the Granger-Causality tests it is necessary to specify the order of lags for the univariate (equation (1)) and bivariate (equation (2)) autoregressive processes. Akaike (1969) has suggested a decision procedure on the order of a univariate stationary autoregressive process based on the minimum final prediction error (FPE) criterion. The FPE is defined as the (asymptotic) mean square prediction error:

$$\text{FPE of } y_t = E(y_t - \hat{y}_t)^2$$

where $\hat{y}_t$ is the predictor of y_t. Moreover it will not be assumed that the two variables in the bivariate autoregressive model have identical lag lengths as this assumption is probably too restricting and may lead to inefficient and biased results. In this paper a procedure similar to the one suggested by Hsiao (1981) will be used as it does not impose equality of lag lengths in the bivariate model. This procedure consists in the following steps:

1. Determine the order to the one-dimensional autoregressive process (the value of k in equation (1)) using the estimate of the FPE of y which Akaike defines by:

$$FPE_y(k) = [(N+k)/(N-k)]*[RSS(k)/N]$$

where RSS = Restricted Sum of Squared Residuals obtained from equation (1),

N = number of observations,

k = number of independent variables, including the constant term, in the restricted equation (the number of a's).

The results of this first step are summarized in table 1 where various FPE's have been calculated for lags 1 to 12 of the following variables: CM (Canadian Money), CS (Canadian Budget Surplus), GM (German Money), GS (German Budget Surplus), KM (U.K. Money), KS (U.K. Budget Surplus), FM (French Money), FS (French Budget Surplus), JM (Japanese Money) and JS (japanese Budget Surplus).[2,3] The underlined values in table 1 correspond to the minimum FPE's.

TABLE 1

The FPE of fitting a one dimensional autoregressive process for CM, GM, KM, FM, JM, CS, GS, KS, FS, JS.

The order of lags	FPE's of CM	GM	KM	FM	JM
1			909672		
2		1.26308	945132	225.99	1082345
3		1.30921			988282
4	1.4964	1.38318	1019011	226.252	1052824
6	1.49238	1.47612	1085796	228.405	1160401
8	1.64834	1.64881	1206017	215.064	1177364
10	1.68598	1.87556	1363903	200.437	1107827
12			1391067	176.225	1088125

	CS	GS	KS	FS	JS
2	1.59937	19.8106		1178.35	6177922
3	1.46451				
4	1.59237	11.7731	2599055	228.967	4372949
5			2118289		4064637
6	1.83784	11.5217	2199552	239.600	4391373
8	2.2278	11.5053	2267864	241.395	4748641
10		10.4326	2653394	282.233	5660394
12		11.5736	2782831	280.557	5834332

2. Call y the controlled variable of the system and z^* the manipulated variable (following Hsiao's terminology) which controls the outcome of y. Use the FPE criterion to determine the lag order of z^* using the number of lags of y found in step 1. The results of this step are reported in table 2 below. The estimate of the FPE of y is now defined by:

$$FPE_y(k,n) = [(N+k+n)/(N-k-n)]*[URSS(k,n)/N]$$

where URSS = Unrestricted Sum of Squared Residuals obtained from equation (2),

n = number of restrictions (the number of c's in equation (2),

and the other terms are as defined earlier. The first column of table 2 lists the names of the controlled variable followed by the number of lags determined in step 1 in parenthesis. The second column lists the manipulated variables which are: UM (U.S. Money), US (U.S. Budget

Surplus), GM (German Money) and GS (German Budget Surplus). GM and GS are assumed to influence only French and U.K. variables. The third column lists the optimum lag of the manipulated variable which corresponds to the minimum $FPE_y(k,n)$. Column four lists the number of observations and the last column the minimum FPE. N.E. indicates that the manipulated variable has no explanatory power whatsoever.

TABLE 2

The optimum lags of the manipulated variable and the FPE of the controlled variable.

Controlled variable	Manipulated variable	The optimum lag of manipulated variable	Number of Observations	FPE
CM(6)	UM	10	42	.836142
CM(6)	US	8	44	1.39866
CS(3)	UM	5	36	1.31167
CS(3)	US	3	36	1.23154
GM(2)	UM	2	50	1.23266
GM(2)	US	2	50	1.27208
GS(10)	UM	12	40	4.80381
GS(10)	US	12	40	10.0348
KM(1)	UM	2	50	956644
KM(1)	US	8	44	1055131
KM(1)	GM	6	46	866013
KM(1)	GS	4	48	976058
KS(5)	UM	2	47	2026033
KS(5)	US	4	47	1301674
KS(5)	GM	2	47	2310200
KS(5)	GS	2	47	2029368
FM(12)	UM	N.E.	39	
FM(12)	US	7	39	164.996
FM(12)	GM	12	39	130.304
FM(12)	GS	5	39	114.829
FS(4)	UM	N.E.	47	
FS(4)	US	2	47	173.910
FS(4)	GM	N.E.	47	
FS(4)	GS	1	47	226.676
JM(3)	UM	4	47	1056309
JM(3)	US	8	43	913810
JS(5)	UM	N.E.	43	
JS(5)	US	8	40	3994280

3. Compare the smallest FPE's of step 1 and 2. If the latter is less than the former a bivariate autoregressive representation for y is used (the second variable being z^*). Hsiao shows that using the minimum FPE criterion as in step 1 and 2 is equivalent to applying an approximate F-test with varying significance levels (in which the choice of a significance level such as 5% or 1% is ad hoc). This procedure takes a more generous attitude towards the inclusion of a variable than the conventional F-test. For example Table 1 shows that the minimum FPE of GM is 1.26308. Adding UM to the autoregressive process of GM causes the minimum FPE to fall to 1.23266 as shown in table 2. Based upon these results one may conclude that UM helps to predict GM. However table 3 will show later on that according to a F-test UM does not help to predict GM neither at the 5% level nor at the 1% level. The same phenomenon in France where according to the minimum FPE criterion US helps to predict FM but not according to the F-test (F=2.17 is less than the critical value 2.39 at the 5% level). Again in France GS helps to predict FS according to the minimum FPE criterion but not according to the F-test.

The F-test just mentioned is thus another method which is used in order to find out whether including z^* helps to predict (or Granger causes) y. The F statistic is given by:

$$F = (RSS/URSS - 1) * (N - k)/n$$

where the various terms have already been defined. The F values thus computed are compared to their critical value F(n,N-k) given by statistical tables. When they are larger than the critical value we may conclude that the variable z^* helps to predict y or that it Granger causes y. The F values thus obtained are presented in table 3 below where (a) indicates significance at the 5% level and (b) indicates significance at the 1% level.

TABLE 3

F-tests for the influence of foreign variables on domestic variables.

	Germany		Canada		U.K.		France		Japan	
	GM	GS	CM	CS	KM	KS	FM	FS	JM	JS
UM	2.60	9.05[b]	7.38[b]	3.13[a]	.73	4.01[a]	N.E.	N.E.	1.46	N.E.
US	1.79	2.42[a]	2.92[a]	4.38[a]	1.54	7.49[b]	2.17	9.15[b]	3.70[b]	2.86[a]
GM					2.67[a]	.81	5.88[b]	N.E.		
GS					1.03	1.40	5.15[b]	2.29		

In table 3, the y variables are the column variables, GM, GS, CM, CS, KM, KS, FM, FS, JM and JS. The z^* variables are the row variables, UM, US, GM and GS. Only the United Kingdom and France are assumed to react to German policy actions as these three countries belong to the European Economic Community (E.E.C.), and two of them, France and West Germany belong to the European Monetary system (EMS). Thus the economies of these three countries are so inter-

dependent that the behavior of French and British policymakers is not independent of policy decisions made in West Germany.

The F values in table 3 seem to indicate that U.S. policies matter. The French central bank clearly does not react to the Federal Reserve Board's policies. Instead it reacts to the policies of the Bundesbank. This is not surprising since the rules of the EMS, of which both France and West Germany are members, require that the exchange rate between the Deutsch mark (DM) and the French franc be stabilized through central banks' intervention if necessary. The British central bank seems to react more to the Bundesbank's policies than to the Fed's policies. This may indicate that British policymakers are more concerned about the value of the pound against the DM than against the U.S. dollar even though the U.K. does not belong to the EMS (at the time this paper is being written) and is thus not required to stabilize the value of its currency against the DM. The Bundesbank seems to react to the policies of the Fed as can be seen from the F-values of 2.60 which is borderline significant (and also according to the minimum FPE criterion as discussed above). The reaction of the Canadian central bank is quite strong as indicated by a F-value of 7.38. Moreover the Canadian and Japanese central banks seem to react to U.S. fiscal deficits. Table 3 also shows that all the fiscal authorities considered seem to

react strongly to U.S. fiscal actions. The fiscal authorities of West Germany, the U.K. and Canada react strongly to the policies of the Federal Reserve Board.

If vector autoregressions are useful to uncover the existence of relationships between variables of different countries, they cannot tell us anything about the nature of those relationships; therefore it is necessary to develop a structural model.

III. Theoretical Framework

The theoretical framework used for deriving both the domestic country's monetary and fiscal policy reaction functions is given by:

$$\text{Min } L_{Mt} = a_1(U_t - U^T_t)^2 + a_2(\pi_t - \pi^T_t)^2 + a_3(\theta_t - \theta^T_t)^2 \quad (3)$$

with respect to θ_t, subject to:

$$U_t = \alpha_1\theta_t + \alpha_2 S_t + \alpha_3\theta_t^* + \alpha_4 S_t^* + f(X_t) \quad (4)$$

$$\pi_t = \beta_1\theta_t + \beta_2 S_t + \beta_3\theta_t^* + \beta_4 S_t^* + g(X_t) \quad (5)$$

and

$$\text{Min } L_{Ft} = b_1(U_t - U^T_t)^2 + b_2(\pi_t - \pi^T_t)^2 + b_3(S_t - S^T_t)^2 \quad (6)$$

with respect to S_t, subject to (4) and (5).

where:

U = unemployment rate,

π = the inflation rate,

S = the fiscal policy instrument, the actual budget surplus,

θ = the monetary policy instrument, the growth in the money stock,

the stars (*) indicate the foreign country.

$f(X_t)$ and $g(X_t)$ are linear functions of the predetermined variables in the system. They determine the process used for forecasting unemployment and inflation in the absence of policy.

U^T, π^T, S^T and θ^T are the policymakers' targets or desired levels for the unemployment rate, the inflation rate, the budget surplus and the money growth rate. Like in the studies mentionned in the introduction, the thrust of fiscal policy is assumed to be measured by a single variable S.

Equations (3) and (6) are the monetary and fiscal domestic policymakers' loss functions respectively. The arguments of the loss functions are the deviations of unemployment and inflation from their targets as well as the deviations of the policy instruments from their targets. Note that the monetary and fiscal authorities share the same target for inflation and unemployment. On the other hand they have different preferences, in the sense that they rank their various objectives differently. They also share the same generating functions for inflation and unemployment (equations (4) and (5)).

The following sign pattern is assumed to hold (at least in the short run):

$$\alpha_1 < 0; \quad \alpha_2 > 0;$$

$$\beta_1 > 0; \quad \beta_2 < 0 \text{ (or } >0);$$

while the signs of the cross-country coefficients (α_3, α_4, β_3 and β_4) are generally undeterminate. On the one hand they depend upon whether the locomotive or the capital market effect dominates and on the other hand upon the assumptions which are imposed on the model.

If the locomotive effect dominates, the issue can be settled. Both an expansionary monetary policy and an expansionary fiscal policy abroad have a positive impact on the domestic terms of trade. Thus they lead to higher output (because exports to the foreign country increase) and lower inflation (because the domestic currency appreciates) at home. Therefore:

$$\alpha_3 < 0; \quad \alpha_4 > 0;$$

$$\beta_3 < 0; \quad \beta_4 > 0.$$

If the capital market effect dominates, the issue is somewhat more difficult to settle. It will depend upon the assumptions which are made. One may use the two-country version of the Mundell-Fleming model which has dominated the analysis of the international transmission of disturbances through the capital market. The main drawback of this model is its assumption that the average price level and the nominal wages are fixed. Unfortunately the average price level will certainly be affected (at least much more so than the price level of home produced goods) by movements of the

exchange rate and the nominal wage may also be expected to react to exchange rate fluctuations. A Mundell-Fleming model modified so that it incorporates these changes may give different results. Nevertheless if the original Mundell-Fleming model were correct the following sign pattern would be expected to hold: α_3, $\alpha_4 > 0$. Following an expansionary monetary policy in the foreign country and assuming that the domestic country does not react, interest rates will fall, the demand for money in the domestic country will increase, there will be an excess demand for money and real domestic income (employment) must fall in order to restore money market equilibrium at home (the appreciation of the domestic currency will bring this about). Thus $\alpha_3 > 0$. Following an expansionary fiscal policy in the foreign country, and assuming that the domestic country does not react, the resulting increase in interest rates requires a rise in domestic real income for the domestic money market to stay in equilibrium (the depreciation of the domestic currency will bring this about). Thus $\alpha_4 > 0$. Since the average price level is unrealistically assumed to be fixed in the Mundell-Fleming model we have: $\beta_3 = \beta_4 = 0$.

To summarize, the Mundell-Fleming model argues that a contractionary monetary policy combined with an expansionary fiscal policy in one country, for example the U.S., would be expansionary on the output of other countries. However this

view has recently been challenged by various authors. Among them we can mention Sachs and Oudiz (1984), Sachs and Bruno (1985) and Fitoussi and Phelps (1986).

According to this alternative view, an expansionary monetary policy in the foreign country will cause interest rates to fall, capital to flow out of the foreign country and the foreign currency to depreciate. The terms of trade of the domestic country will improve, which means that the constant-employment income real wage will be higher (the domestic product real wage will be obviously unchanged). The domestic short run Phillips curve will have shifted in a favourable direction so that the optimal point chosen by the domestic policymakers will involve both less inflation and less unemployment. Thus α_3 and β_3 are negative. An expansionary fiscal policy in the foreign country will cause interest rates to rise, capital to flow into the foreign country and the foreign currency to appreciate. The terms of trade of the domestic country will deteriorate. For the reason mentionned above, the domestic short run Phillips curve will shift in an adverse direction so that the optimal point chosen will involve both higher inflation and higher unemployment. Thus α_4 and β_4 are negative.[4]

To summarize the results of this alternative view a contractionary monetary policy combined with an expansionary fiscal policy in the U.S. would have a stagflationary impact

(leading to higher inflation and higher unemployment) on other countries.

The sign pattern of the cross-country coefficients resulting from the three models considered is summarized in table 4 below:

TABLE 4

Sign pattern of the cross-country coefficients.

Model	α_3	α_4	β_3	β_4
Locomotive Approach	-	+	-	+
Mundell-Fleming Model	+	+	0	0
Alternative Model	-	-	-	-

In the minimization exercise which follows we will assume, for simplicity, that U^T and π^T the target values for unemployment and inflation are constants which will be set equal to zero. This is equivalent to eliminating the constant term of the reduced form equation obtained below ($\sigma_{10} = \sigma_{20} = 0$). Thus minimization of the loss functions (3) and (6) provides a set of simultaneous reaction functions for the domestic economy:

$$\theta_t = \sigma_{10} + \sigma_{11}\hat{U}_t + \sigma_{12}\hat{\pi}_t + \sigma_{13}S_t + \sigma_{14}\theta_t^* + \sigma_{15}S_t^* \quad (7)$$

$$S_t = \sigma_{20} + \sigma_{21}\hat{U}_t + \sigma_{22}\hat{\pi}_t + \sigma_{23}\theta_t + \sigma_{24}\theta_t^* + \sigma_{25}S_t^* \quad (8)$$

where:

$$\sigma_{11} = -\Gamma^{-1}(a_1\alpha_1)$$

$$\sigma_{12} = -\Gamma^{-1}(a_2\beta_1)$$

$$\sigma_{13} = -\Gamma^{-1}\{a_1\alpha_1\alpha_2+a_2\beta_1\beta_2\}$$

$$\sigma_{14} = -\Gamma^{-1}\{a_1\alpha_1\alpha_3+a_2\beta_1\beta_3\}$$

$$\sigma_{15} = -\Gamma^{-1}\{a_1\alpha_1\alpha_4+a_2\beta_1\beta_4\}$$

$$\Gamma = a_1\alpha_1^2+a_2\beta_1^2+a_3$$

$$\sigma_{21} = -\Phi^{-1}\{b_1\alpha_2\}$$

$$\sigma_{22} = -\Phi^{-1}\{b_2\beta_2\}$$

$$\sigma_{23} = -\Phi^{-1}\{b_1\alpha_2\alpha_1+b_2\beta_2\beta_1\}$$

$$\sigma_{24} = -\Phi^{-1}\{b_1\alpha_2\alpha_3+b_2\beta_2\beta_3\}$$

$$\sigma_{25} = -\Phi^{-1}\{b_1\alpha_2\alpha_4+b_2\beta_2\beta_4\}$$

$$\Phi = b_1\alpha_2^2+b_2\beta_2^2+b_3.$$

Here $\hat{U}_t$ and $\hat{\pi}_t$ are the forecasted or expected values of inflation and unemployment which would occur without policy response. The signs of the σ's coefficients depend upon the assumed signs for parameters in the constraints (4) and (5). If those assumptions are correct it should be the case that:

$$\sigma_{11} > 0; \quad \sigma_{12} < 0;$$

$$\sigma_{21} < 0; \quad \sigma_{22} > 0 \text{ if } ß_2 < 0;$$

$$\sigma_{22} < 0 \text{ if } ß_2 > 0;$$

$$\sigma_{13} > 0 \text{ if } ß_2 < 0 \text{ and undeterminate if } ß_2 > 0;$$

$$\sigma_{23} > 0 \text{ if } ß_2 < 0 \text{ and undeterminate if } ß_2 > 0.$$

Bradley and Potter interpret a positive sign for σ_{13} and σ_{23} as implying that fiscal and monetary policies within the same country would be coordinated. According to them, "coordination of monetary and fiscal policy would imply that, ceteris paribus, the two instruments are positively related. An increase in money growth forces prices up and

reduces unemployment, thus reducing the need for expansionary fiscal policy. Consequently, the budget is moved toward surplus. A similar scenario describes the impact of the budget surplus on money growth." (p. 146). I do not necessarily agree with this interpretation but my objective is different from theirs so I will not pursue the argument here.

We are mostly concerned about the signs of the remaining coefficients which depend upon the types of model used and are summarized in table 5 below:

TABLE 5

Sign pattern of reaction functions' coefficients.

			$ß_2 < 0$		$ß_2 > 0$	
Model	σ_{14}	σ_{15}	σ_{24}	σ_{25}	σ_{24}	σ_{25}
Locomotive Approach	?	?	?	?	+	-
Mundell-Fleming Model	+	+	-	-	-	-
Alternative Model	?	?	?	?	+	+

IV. Policymakers' forecasts of targets variables.

Before we examine the empirical results it is necessary to examine how to measure $\hat{U}_t$ and $\hat{\pi}_t$, the expected values of unemployment and inflation which would occur without policy response.

The methodology outlined below is well known and has been used by Mishkin (1984) among others. It will be conducted

only in terms of $\hat{\pi}_t$ and can be extended to $\hat{U}_t$ in a parallel fashion.

Assume that X_t is a set of variables that are included in the available information set $\varnothing_t$, variables that are correlated with $\hat{\pi}_t$. Then a logical choice for an estimate of expected inflation is the linear projection of $\hat{\pi}_t$ on X_t or $P(\hat{\pi}_t:X_t)$. The projection equation for $\hat{\pi}_t$ can also be written as:

$$\hat{\pi}_t = X_t\beta + \mu_t \qquad (9)$$

where μ_t is the projection equation error and where by construction $P(\mu_t:X_t)=0$.

If we assume that expectations are formed rationally, the forecast error of inflation ϵ_t will be such that:

$$\pi_t = \hat{\pi}_t + \epsilon_t \qquad (10)$$

where π_t is the ex post or actual inflation rate and where $E(\epsilon_t:\varnothing_t)=0$. This last condition implies that the forecast error of inflation ϵ_t is unforecastable, that is it is uncorrelated with any information available at time t including X_t. Thus ϵ_t is orthogonal to X_t and we can write $P(\epsilon_t:X_t)=0$.

Using (9) and (10) we can write:

$$\pi_t = X_t\beta + (\mu_t+\epsilon_t)$$

or $$\pi_t = X_t\beta + \Phi_t \qquad (11)$$

where $\Phi_t=\mu_t+\epsilon_t$. π_t and X_t being observable we can run OLS. We have seen above that μ_t and ϵ_t are orthogonal to X_t, the former by construction and the later by assumption.

Therefore Φ_t is orthogonal to X_t and the estimates of ß will be consistent. This indicates that although we cannot observe $\hat{\pi}_t$, we can infer information about its relationship with variables known at time t via actual inflation rates regression. Then we can use as our estimates of expected inflation, $\hat{\pi}_t$, in equations (7) and (8) the fitted values from the OLS regression:

$$\hat{\pi}_t = X_t\hat{ß}.$$

We are left with having to decide which variables constitute X_t. In the empirical analysis which follows we will use past inflation rates, a constant and a time trend. This solution will correspond to the "partly rational" expectations assumption described by McCallum (1976). The same methodology is used to measure the policymakers' expected values of unemployment (the only difference is that X_t includes past unemployment rates, a constant and a time trend).

A problem with such a solution, as reported by Abrams, Froyen and Waud (1980, 1983), is that it confers to agents, let's say in 1976, knowledge which they do not have about values of X_t in later years. Thus these authors suggest to proceed as follows in order to improve upon the measurement of the policymakers' forecasts of target variables:

First run OLS on $\pi_t=X_tß+\Phi_t$ using the same sample period as the one used to estimate the reaction function. Choose the best lag specification according to the criterion of

minimum standard error (adjusted for degrees of freedom) from among equations including one through eight period lags. Second, given the best predictive equation specification, a separate regression can be run for each quarter using only observations for the dependent and independent variables for the previous, let's say, 40 periods (10 years) to obtain the estimated coefficients ß for that quarter's predictive equation. Third, the ß thus found can then used to compute the current period inflation (and unemployment) rate forecasts. However this methodology was not used below as I do not have data that go back far enough into history.

V. Reaction functions estimates.

The estimated equations are of the form:

$$\theta_t = \sigma_{10} + \sigma_{11}\hat{U}_t + \sigma_{12}\hat{\pi}_t + \sigma_{13}S_t + \sigma_{14}\theta_t^* + \sigma_{15}S_t^* + \sigma_{16}\theta_{t-1} + W_t \qquad (12)$$

$$S_t = \sigma_{20} + \sigma_{21}\hat{U}_t + \sigma_{22}\hat{\pi}_t + \sigma_{23}\theta_t + \sigma_{24}\theta_t^* + \sigma_{25}S_t^* + \sigma_{26}S_{t-1} + Z_t \qquad (13)$$

where W_t and Z_t are error terms. Lagged values of S, θ^* and S^* in (12) and of θ, θ^*, and S^* in (13) have been included in the final results since the impact of monetary and fiscal policy on inflation and unemployment in the constraints (4) and (5) is unlikely to be instantaneous. The forecasts generated by the forecast equations are used as instruments for the true policymakers' forecasts which are unobservable. Thus this technique is similar to an instrumental

variable procedure and the estimates of σ_{ij} (for i=1,2 and j=1,2) will be consistent. A potential simultaneous equation problem has been avoided since, by forming estimates of expected inflation and unemployment the way we did, the feedback rule from the policy instruments to $\hat{U}_t$ and $\hat{\pi}_t$ has been broken and the error terms W_t and Z_t are uncorrelated with $\hat{U}_t$ and $\hat{\pi}_t$. Whether the same σ_{ij}'s are efficient depend on the correlation between the actual forecasts and our measures of these forecasts (see Kmenta 1971 pp. 309-311). The lagged values of the policy instruments, θ_{t-1} and S_{t-1}, appear as variables in the reaction functions (12) and (13) in order to impute a partial adjustment character to quarterly monetary and fiscal policy responses. The inclusion of these lagged dependent variables in the reaction functions would be the result of the arguments $(S_t-S_{t-1})^2$ and $(\theta_t-\theta_{t-1})^2$ being in the quadratic loss functions given by equations (3) and (6), involving costs to moving the setting of policy variables in the short run.

The reaction functions which have been estimated are presented next (t-statistics in parentheses) country by country.

1. West Germany.

The reaction function of the Bundesbank against the

actions of the U.S. monetary (θ^*) and fiscal (S^*) authorities is:

$$\theta = 9.14 - .005\hat{y} - .19\hat{\pi} - .07S - .002\theta^* + .27\theta^*_{-1}$$
$$(3.51) \quad (3.18) \quad (2.08) \quad (2.00) \quad (.02) \quad (2.25)$$
$$- .002S^* + .005S^*_{-1} - .005S^*_{-2} + .009S^*_{-3} + .005S^*_{-4}$$
$$(.21) \quad (.67) \quad (.6) \quad (2.12) \quad (.49)$$
$$+ .02\theta_{-1}$$
$$(.14)$$

$R^2 = .51$, Adjusted $R^2 = .34$, DW =2.01, Sample 75:1 85:4.

Note that $\hat{U}$, the expected unemployment, has been replaced by $\hat{y}$, the expected real GNP, as this adjustment gave better results.

The only coefficients of foreign variables which are significant are that of θ^*_{-1} and S^*_{-3}. When θ^* was dropped the estimates of the other coefficients did not change significantly. However when some lags of S^* other than the third lag were dropped the coefficient of S^*_{-3} became insignificant. Thus I decided to keep the insignificant lags in the equation presented above.

The Bundesbank reacts to contractionary monetary policy in the U.S. by following a more contractionary monetary policy. Such a behavior is consistent with trying to prevent the DM from depreciating against the dollar following the contractionary U.S. monetary policy. Likewise, following an expansionary fiscal policy in the U.S. causing the dollar to appreciate, the Bundesbank seems to react by

reducing its money growth rate. The coefficients of $\hat{y}$ and $\hat{\pi}$ are significantly negative confirming the strongly anti-inflationary policies of the Bundesbank.

The reaction function of the German fiscal authority against the policy actions of the U.S. monetary and fiscal authorities is:

$$S = -14.8 - 1.66\hat{U} + .92\hat{\pi} + 1.38\theta_{-1} + 1.44\theta^*_{-1}$$
$$(3.63) \quad (2.08) \quad (2.05) \quad (2.26) \quad (2.7)$$
$$- .116S^* + .14S^*_{-1} - .08S^*_{-2} - .12S^*_{-3} + .06S^*_{-4}$$
$$(1.93) \quad (2.22) \quad (1.4) \quad (2.41) \quad (1.25)$$
$$- .1S^*_{-5} - .11S^*_{-6} - .176S_{-1}$$
$$(1.7) \quad (1.94) \quad (1.1)$$

$R^2 = .66$, Adjusted $R^2 = .53$, DW = 1.98, Sample 74:4 85:4.

If the U.S. follows a contractionary monetary policy the West German fiscal authorities will follow an expansionary policy. This is consistent with trying to reduce exchange rate fluctuations (depreciation of the DM vis a vis the dollar in this case). The response to an increasing budget deficit in the U.S. is not as easy to interpret. Generally the coefficients of the various lags of S^* are more often negative than positive. The only one which is positive and significant is the coefficient of S^*_{-1}. This seems to suggest that if the U.S. follows an expansionary fiscal policy West Germany will increase its budget surplus. This makes sense in view of the fact that West German policy-makers are often heard to say that Germany would implement

an early tax cut (expansionary fiscal policy) if the U.S. would reduce its budget deficit. The positive coefficient of S^*_{-1} may indicate that German policymakers are also somewhat concerned about the impact of an expansionary fiscal policy in the U.S. on the exchange rate. An increase in the German budget deficit when the U.S. budget deficit increases reduces the fluctuation of the $/DM exchange rate.

In the case of West Germany, σ_{14}, σ_{15}, σ_{24} are positive while σ_{25} is sometimes positive (lags 1 and 4) and sometimes negative (lags 0, 2, 3, 5 and 6). Assuming that $ß_2$ is negative (because σ_{22} is positive) and referring back to table 5 we may conclude that either the locomotive approach or the alternative model may apply. If one is ready to accept that the capital market effect probably dominates the locomotive effect, because of the high capital mobility between the U.S. and Germany, the alternative model would be more likely.

The lessons from this exercise are clear: If the US authorities want the Bundesbank to cut its discount rate or follow a more expansionary monetary policy, the United States should cut its budget deficit. If the US authorities want the German fiscal authorities to follow more expansionary fiscal policies then the US should follow more contractionary fiscal policies. A more expansionary monetary policy in the U.S. would also cause the Bundesbank to cut its discount rate. However a contractionary monetary policy in

the U.S. would be required for the German fiscal authorities to reduce taxes. Thus we can conclude that the U.S. is more likely to get what it wants (both lower discount rate and lower taxes in Germany) if it takes the appropriate measures to reduce its budget deficit.

2. Japan.

The estimated reaction function of the Japanese central bank is:

$$\theta = 14 - .00005\hat{y} - .68\hat{\pi} - .00012S_{-1} - .000055S_{-2} - .00012S_{-3}$$
$$(5.02)\ (4.33)\quad (2.64)\quad (2.41)\qquad (.88)\qquad (2.57)$$
$$- .00012S_{-4} - .21\theta^{*} - .095\theta^{*}_{-1} - .15\theta^{*}_{-2} + .054\theta^{*}_{-3} - .19\theta^{*}_{-4}$$
$$(2.23)\qquad (2.39)\ (1.21)\quad (1.71)\quad (.63)\qquad (2.32)$$
$$- .016S^{*}_{-3} - .018S^{*}_{-4} + .005S^{*}_{-5} - .021S^{*}_{-6} + .016S^{*}_{-7}$$
$$(2.38)\qquad (2.87)\qquad (.87)\qquad (3.51)\qquad (2.40)$$
$$+ .13\theta_{-1}$$
$$(1.01)$$

$R^2 = .85$, Adjusted $R^2 = .74$, DW = 2.17, Sample 74:4 84:4.

As can be seen from the results above, the reactions of Germany and Japan to U.S. policies are quite different and this, obviously, makes the task of U.S. policymakers more difficult. Following a contractionary monetary policy in the U.S. Japan will increase the rate of growth of its money supply. Such a reaction is conducive to exchange rate instability but may cause interest rates to fluctuate less. Thus following the contractionary monetary policy in the

U.S. and the Japanese reaction described above the Japanese yen depreciates more against the dollar and (world) interest rates do not rise as much as they would otherwise do if there was no Japanese reaction.

Following an expansionary fiscal policy in the U.S., which causes interest rates to increase and the dollar to appreciate, the Japanese central bank responds by increasing the rate of growth of the money supply. Again such a behavior is consistent with causing the U.S. dollar to appreciate more and interest rates to be somewhat lower than they would otherwise be if there was no Japanese response. However seven quarters after the initial U.S. policy action the Japanese central bank will reverse its policy indicating that it may have become concerned, somewhat belatedly, about excessive exchange rates fluctuations.

Note also that an increase in the Japanese budget deficit is likely to be financed by a higher rate of growth of the money supply in Japan. Again this may be consistent with trying to reduce interest rates fluctuations. The coefficient of the forecasted future GNP is also very significantly negative indicating that if the economy is expected to grow fast in the future, pushing interest rates higher up, the Japanese monetary authority will try to slow it down. Similarly if inflation is expected to rise causing interest rates to rise the Japanese central bank will reduce the rate of growth of its money supply.

Thus, in conclusion, it seems fair to say that the Japanese central bank, contrary to the Bundesbank, is more concerned about reducing interest rates fluctuations than the volatility of its exchange rate vis a vis the dollar.

Let's turn our attention now to the behavior of the Japanese fiscal authority. The estimate of its reaction function is:

$$S = 863 - .034\hat{y} + 1028\hat{\pi} - 967\theta + 741\theta_{-1} + 1026\theta_{-2} - 477\theta_{-3}$$
$$(.12) \quad (1.4) \quad (1.26) \quad (1.69) \quad (1.38) \quad (2.06) \quad (1.07)$$
$$- 31.67S^*_{-5} - 40.46S^*_{-6} - 21.93S^*_{-7} + 65.03S^*_{-8} + 39.88S^*_{-9}$$
$$(1.34) \quad (2.31) \quad (1.22) \quad (3.77) \quad (1.23)$$
$$- .635S_{-1}$$
$$(3.55)$$

$R^2 = .78$, Adjusted $R^2 = .67$, DW = 2.13, Sample 75:2 84:4.

As was already mentionned in the vector autorereg-ression results of section II, the Japanese fiscal authority does not react to the Fed's actions. Coefficients of U.S. money growth rates were never close to being signif-icant. Following a U.S. fiscal expansion we may expect the Japanese budget deficit to be reduced first. Again this may be consistent with trying to push interest rates down. However, later on, there is a policy reversal in Japan where the budget deficit is subsequently increased. The later increase seems to be larger in size than the former reduc-tion. Because I am not able to interpret coherently such a behavior I will not attempt to do so. U.S. policymakers may

also find difficult to understand the Japanese behavior. There is no guarantee that if the U.S. budget deficit is reduced the Japanese will respond by pursuing more expansionary fiscal policies. We have already seen that the Japanese central bank is unlikely to respond to a reduction of the U.S. budget deficit by cutting its discount rate as the U.S. government wished it would do. The fact that Japanese policymakers complain so loudly about high U.S. budget deficit may be mainly due to their fear that the U.S. imposes protectionist tariffs against Japanese goods and is not captured by the simple model of this paper. Thus the Japanese blame the high U.S. budget deficit for the trade imbalance that exists between the two countries and, therefore, argue that imposing additional tariffs (and/or pushing the dollar further down) would be analogous to using the wrong remedy in order to solve a real problem.

In the case of Japan σ_{14} and σ_{15} are negative while $\sigma_{24} = 0$ and σ_{25} is negative and then positive. Assuming that $ß_2$ is negative like in Germany (because σ_{22} is positive although not quite significant) and referring back to table 5 one may reject the Mundell-Fleming model. Because of the relatively high mobility of capital between the U.S. and Japan the alternative model fits the Japanese situation probably better than the locomotive approach.

3. Canada.

In the case of Canada it was found that a lot of lags were significant and, because budget surplus data were not available prior to the second quarter of 1976, the number of degrees of freedom were very small. Also when many lags of the same variable are included we may have a multicollinearity problem leading to imprecise estimates of the lagged coefficients and difficulty in making useful inferences about them. For those two reasons (but mainly for the lack of degrees of freedom) an Almon lag was imposed upon the relevant independent variables. The estimated reaction function of the Canadian central bank resulting from such a procedure is:[5]

$$\theta = 8.16 - 2.73\hat{U} - .22\hat{\pi} + 1.52S$$
$$\quad (.4) \quad (1.56) \quad (.25) \quad (.76)$$
$$+ 3.8\theta^* + 2.64\theta^*_{-1} - .26\theta^*_{-2} - 2.6\theta^*_{-3} - 1.78\theta^*_{-4} + 5.15\theta^*_{-5}$$
$$(2.65) \quad (1.68) \quad (.24) \quad (2.07) \quad (.99) \quad (3.11)$$
$$- .25S^* - .42S^*_{-1} - .17S^*_{-2} + .12S^*_{-3} + .24S^*_{-4} + .12S^*_{-5}$$
$$(1.92) \quad (3.12) \quad (1.56) \quad (1.39) \quad (2.27) \quad (1.18)$$
$$- .17S^*_{-6} - .42S^*_{-7} - .28S^*_{-8} - .56\theta_{-1}$$
$$(5.94) \quad (6.7) \quad (2.08) \quad (4.25)$$

$R^2 = .83$, Adjusted $R^2 = .73$, DW = 2.24, Sample 76:2 85:4.

Following a contractionary monetary policy in the U.S. the Canadian monetary authority will immediately respond by reducing the growth of its money supply. Such a reaction is consistent with attempting to prevent its

currency from depreciating against the U.S. dollar. Only the coefficient of the third lag of θ^* is significantly negative while the coefficients of the other lags are either insignificant or significantly positive (the sum of the lagged coefficients of θ^* is 6.96 with a standard error of 4.71).

If the U.S. follows an expansionary fiscal policy, causing interest rates to increase, the Canadian monetary authority will react first by increasing its money supply may be in order to try to push interest rates down. Then, around a year later, the Canadian central bank reverses its policy and reduces the rate of growth of its money supply. It may be that it realizes that its money supply is growing too fast following its attempt to push interest rates down and thus reduces it. Finally during the sixth, seventh and eighth quarter following the initial U.S. expansionary fiscal policy the Canadian central bank returns to its original expansionary monetary policy (the sum of the lagged coefficients of S^* is -1.23 with a standard error of .24). Note that both the coefficients on forecasted unemployment and inflation are not significant and that the coefficient of the lagged dependent variable is negative. Such a negative coefficient is not consistent with a partial adjustment mechanism and/or the central bank targetting M1. It may be consistent with the central bank reversing its

policy from one period to the next in response to a specific U.S. policy action.

In any case it is obvious that the Canadian central bank does not react the same way as the Bundesbank does to various U.S. policy actions. For example a reduction of the U.S. budget deficit would be most likely followed by a tighter monetary policy in Canada (like in Japan) while the opposite would most likely occur in Germany. The reaction of the Bundesbank is more consistent with a greater concern for inflation.

The same Almon lag technique was used to estimate the reaction function of the Canadian fiscal authority:[6]

$$S = 8.96 - .8\hat{U} - .26\hat{\pi} - .006\theta$$
$$(6.68)\ (6.33)\ (4.08)\ (.55)$$
$$- .023\theta_{-1} - .031\theta_{-2} - .032\theta_{-3} - .025\theta_{-4} - .009\theta_{-5} + .014\theta_{-6}$$
$$(1.75)\quad (2.43)\quad (2.8)\quad (2.26)\quad (.98)\quad (1.46)$$
$$- .02\theta^* + .33\theta^*_{-1} + .2\theta^*_{-2} - .1\theta^*_{-3}$$
$$(.14)\quad (2.69)\quad (2.14)\quad (1.2)$$
$$- .35\theta^*_{-4} - .44\theta^*_{-5} - .34\theta^*_{-6} - .13\theta^*_{-7}$$
$$(3.85)\quad (4.57)\quad (3.00)\quad (1.06)$$
$$- .03S^* + .022S^*_{-1} + .03S^*_{-2} + .018S^*_{-3} + .002S^*_{-4} - .007S^*_{-5}$$
$$(3.3)\quad (3.07)\quad (4.22)\quad (4.38)\quad (.51)\quad (1.16)$$
$$- .006S^*_{-6} + .004S^*_{-7} + .016S^*_{-8} + .017S^*_{-9} - .012S^*_{-10}$$
$$(1.18)\quad (.77)\quad (2.23)\quad (2.44)\quad (1.15)$$
$$+ .02S_{-1}$$
$$(.21)$$

R^2 = .97, Adjusted R^2 = .95, DW = 2.9, Sample 76:3 85:4.

We see that following a contractionary monetary policy in the U.S. the budget deficit is likely to increase in Canada. The Canadian fiscal authority may be trying to reduce the depreciation of the Canadian dollar vis a vis the U.S. dollar. However subsequently there is a policy reversal in Canada and the Canadian budget deficit is being reduced.

Looking at the Canadian response to U.S. fiscal policy we note the significantly negative sign of the coefficient of S^*. It may indicate that as the U.S. budget deficit increases Canada will reduce its budget deficit perhaps in order to put downward pressure on world interest rates. Since Canada is likely to be unsuccessful in this attempt to reduce interest rates it decides to follow the U.S. lead and increases its budget deficit in order to appreciate its currency (the sum of the lagged coefficients of S^* is .055 with a standard error of .036). Thus the Canadian fiscal authority seems to be concerned about the consequences of U.S. policy actions on the exchange rate (and inflation in Canada). This is consistent with the significantly negative sign of the variable which measures expected inflation although it may suggest that, in the case of Canada, $ß_2$ in equation (5) may be positive and not negative (as suggested by the negative sign of the coefficient of $\hat{\pi}$). However it seems also to be concerned about unemployment as if it is

expected to rise there will be an increase in the budget deficit.

Since there are so many sign reversals it is not very meaningful to refer to table 5 in order to find out which model applies best to Canada.

4. United Kingdom.

The estimated reaction function of the British central bank is:

$$\theta = -38.76 - .137\hat{\pi} + 1.05\hat{y} + .001S_{-4} - .82\theta^{**}_{-2} - 1.37\theta^{*}_{-2}$$
$$(1.6) \quad (.75) \quad (2.46) \quad (2.02) \quad (1.5) \quad (1.8)$$
$$+ .15S^{*}_{-4} + .001\theta_{-1}$$
$$(2.72) \quad (.008)$$

where, in this case (*) refers to the U.S. and (**) to Germany.

$R^2 = .31$, Adjusted $R^2 = .18$, DW = 2.12, Sample 74:3 85:4.

The evidence that the U.K. reacts to both the actions of the Fed and the Bundesbank is not very strong although it is very conceivable because one would expect the U.K. to care about the exchange rate of the pound against both the U.S. dollar and the German Mark (this would suggest that the U.K. belongs de facto, if not de jure, to the EMS). However the negative signs of θ^{*} and θ^{**} are somewhat disturbing. They suggest that following a contractionary monetary policy in the U.S. or Germany the U.K. will adopt an expansionary monetary policy. Such reaction suggests that the U.K. is

little concerned about the value of the pound and tries instead to target interest rates. This would be consistent with the insignificant coefficient of $\hat{\pi}$, suggesting that the British central bank is little concerned about inflation, and the significantly positive coefficent of $\hat{y}$, the expected real GNP, suggesting that monetary policy is procyclical in the U.K. I must admit that I am not very comfortable with these results (see also the relatively low R^2 of the equation). Following an expansionary fiscal policy in the U.S. causing the pound to depreciate against the dollar, the U.K. responds by reducing its money growth rate, thus trying to reduce exchange rate fluctuations.

The estimated reaction function of the British fiscal authority is:

$$S = \underset{(2.06)}{13901} - \underset{(1.71)}{89.3\hat{\pi}} - \underset{(1.89)}{227\hat{y}} - \underset{(1.57)}{51.6\theta_{-4}} - \underset{(1.27)}{41.3\theta_{-5}} - \underset{(2.7)}{601\theta^*_{-1}}$$

$$+ \underset{(2.43)}{53.7S^*_{-3}} - \underset{(1.64)}{39.3S^*_{-4}} + \underset{(1.67)}{33.4S^*_{-5}} - \underset{(1.65)}{27.2S^*_{-6}} + \underset{(.83)}{22.1S^*_{-7}}$$

$$- \underset{(2.07)}{47.9S^*_{-8}} - \underset{(.16)}{.03S_{-1}}$$

$R^2 = .73$, Adjusted $R^2 = .625$, DW = 1.99, Sample 74:3 85:4.

Following a contractionary monetary policy in the U.S. there is a decrease in the budget deficit in the U.K. The response of the U.K. to an increase of the U.S. budget deficit starts occuring three quarters later and does not end until the eighth quarter. During that period, though,

the sign pattern ot the U.K. reaction becomes alternatively positive and negative. I will not attempt here to interpret these results as any interpretation is probably as wrong as any other.

Considering the somewhat disturbing results obtained for the U.K., it is likely that the theoretical model of equations (3)-(6) needs to be amended. It may be possible that the policymakers in the U.K. target some other variables (current account ?) besides (or instead of) unemployment and inflation.

5. France.

For France the only reaction function which has been estimated is that of the central bank (Banque de France):

$$\theta = 23 + .41\hat{\pi} - .005\hat{y} - .1S - .08S_{-1} + 1.04\theta^{**}_{-2} + 1.23\theta^{**}_{-3}$$
$$(2.11)\quad (1.18)\quad (1.29)\quad (4.08)\quad (3.54)\quad (1.8)\quad (2.33)$$
$$- 1.76\theta^{**}_{-4} + 1.26\theta^{**}_{-5} + .13S^{*}_{-2} - .01S^{*}_{-3} + .067S^{*}_{-4}$$
$$(3.13)\quad (2.19)\quad (2.9)\quad (.31)\quad (1.94)$$
$$- .46S^{**}_{-4} + .13S^{**}_{-5} + .61S^{**}_{-6} - .17\theta_{-1}$$
$$(3.87)\quad (1.05)\quad (4.98)\quad (1.46)$$

where (*) refers to the U.S. and (**) to West Germany.
$R^2 = .803$, Adjusted $R^2 = .701$, DW = 2.43, Sample: 74:3 85:3.
Note that the Banque de France reacts only to the rate of growth of the German money supply but to both the German and the U.S. budget deficit. This is consistent with the results of the Granger causality tests reported in section

II above. The response to a contractionary monetary policy in Germany seems to confirm (if one is willing to discard the significantly negative sign of θ^{**}_{-4}) that the Banque de France reacts in such a way as to stabilize the value of the French franc against the Deutsch mark. Such a behavior is expected since both France and Germany belong to the EMS which imposes some constraints upon its members. However it does not react until two quarters later suggesting that other means (sterilized foreign exchange intervention, capital controls) are used in the meantime to stabilize the exchange rate.

Following a contractionary fiscal policy in Germany it seems that France first reduces its money growth rate but then turns around the following two quarters and increases it. Since France imposes capital controls, a contractionary fiscal policy in Germany leads to an improvement in the current account of Germany vis a vis France and an appreciation of the DM against the FF. (The weakness of the interest rate linkage between the two countries insures that the DM does not depreciate against the FF.) This explains why France first cuts the rate of growth of its money supply. Later on this policy is reversed probably in order to increase domestic demand at a tioe when German demand for French products is low.

On the other hand if the U.S. fiscal deficit increases causing the demand for French goods in the U.S. to increase,

the Banque de France will follow contractionary policies in order to make room for the higher U.S. demand.

VI. Conclusion.

This paper has shown that U.S. policies do matter since they affect the behavior of foreign policymakers. All the countries examined react in different ways to U.S. policies. The reactions of the Canadian authorities are certainly the strongest as expected. U.S. policymakers should be particularly interested in the way the German and Japanese authorities react since they are not indifferent (i.e. the statements regularly made by the U.S. Treasury Secretary, James Baker) about the way these two countries set their monetary and fiscal policies. If the U.S. cuts her budget deficit it seems likely that the German authorities would react in a way that would please U.S. policymakers since they would expand their economy. However Japan will probably not follow the German example. If Japan, like Germany, complains about the U.S. budget deficit it is more likely because the Japanese government thinks that it is responsible for the large U.S. current account deficit and thus for the rise in the protectionist mood of both the legislative and the executive branches of the U.S. government.

In any case, since most other countries react to U.S. fiscal and monetary variables, the U.S. should take

their reactions into account when it sets its own policies. If it does not do so we are faced with a classical case of externality which leads to suboptimal outcomes if it is not internalized. Policy coordination, such as that exists today among the countries which belong to the EMS, is one way to internalize the externality in question. Meetings of the Finance ministers of the various industrialized countries, such as the G-5 countries, and economic summits are a step in the right direction but are probably not sufficient to eliminate all welfare losses caused by the externality.

For example more work has to be done in this area. The behavior of British policymakers needs to be investigated. A more serious criticism is underidentification (I cannot retrieve the structural parameters). With this problem there is probably more than one way to interpret the estimates of the reaction functions. I believe that my interpretations are valid but I do not deny that it is impossible to come up with even better explanations. A better specification of the objective functions and of the constraints is needed. In the meantime I still believe that this paper has something to offer for those who wish to understand why some countries behave the way they do. This type of framework may also be applied to the analysis of the behavior of two large groups of countries which are highly interdependent, namely the developed and the developing countries.

Notes.

1. For some evidence in support of the Ricardian Equivalence Proposition, see Plosser (1982) and Evans (1987) and references listed therein.

2. For more information about the data consult the data appendix at the end of the paper.

3. Actual budget surplus figures were used as they are probably the ones that the fiscal authorities try to target. A better measure of the thrust of fiscal policy would be the cyclically adjusted budget surplus (or the full employment budget surplus). Such a measure can be obtained from the residuals of an O.L.S. regression of the actual budget surplus on the unemployment rate or real GNP. Cyclically adjusted budget surplus data were thus computed and tried but they did not work as well as the actual budget surplus figures. Therefore all the regression results in this paper relate to the actual budget figures.

4. The authors mentionned in the text give a somewhat different explanation for the negative sign of $\tilde{a}_3$ and $\tilde{a}_4$. According to them high interest rates in the foreign country, due to a contractionary monetary policy or an expansionary fiscal policy abroad, will cause interest rates to rise in the domestic country because of high capital mobility between the foreign and domestic economies. This may cause investment to fall and unemployment to rise at home. Moreover the depreciation of the domestic currency against the foreign currency will cause a negative real balance effect through a higher price level at home.

5. The PDL procedure of ESP (the Econometric Software Package written for the IBM PC and Compatibles) calculates estimates of polynomial distributed ("Almon") lags using ordinary least Squares. In the case of the reaction of the Canadian central bank an Almon lag was imposed on both the rate of growth of the U.S. money supply and the U.S. budget surplus. For both variables the degree of the polynomial choosen was four. This degree was selected so that the adjusted R^2 of the reaction function was greatest. Zero restrictions were not applied.

6. In the case of the reaction function of the Canadian fiscal authority an Almon lag was imposed on three variables: the growth rate of the Canadian money supply, the growth rate of the U.S. money supply and the U.S. budget surplus. For each of these variables

the degree of the polynomial choosen was three, four and four respectively. These degrees were selected so that the adjusted R^2 of the reaction function was greatest. Zero restrictions were not applied.

DATA APPENDIX

Quaterly data from 1973:1 to 1985:4 were used for the U.S., Germany, Canada and the U.K. (except that Canadian budget surplus figures were not available before 1976:2). For Japan and France the sample ended in 1985:3 (except that Japanese budget surplus figures were not available after 1984:4). The money supply data are based on the monetary aggregates most directly targeted by the various central banks. They are: For the U.S., M1 which includes currency plus demand deposits and other checkable deposits plus travelers'checks. For Canada, M1 which includes currency plus demand deposits less private sector float. For Germany, Central Bank Money which includes currency plus minimum required reserves on domestic bank liabilities. For the U.K., Sterling M3 which includes currency plus private sector sterling demand and time deposits. For France, M2 which includes currency plus demand, savings and time deposits. For Japan, M2 + CD's which includes currency plus demand, savings and time deposits plus certificates of deposit. All the money supply figures have been detrended. Except for the following variables all the data come from the International Monetary Fund, International Financial Statistics. The source of French and Japanese money supply data is the O.E.C.D. main economic indicators; that of U.K. money supply data is the U.K. Central Statistical Office, Financial Statistics; and that of West Germany money

supply data is Stat. Beihefte Zu Den Monatsberichten Der Deutsche Bundesbank.

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