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COORDINATION OF MONETARY AND FISCAL POLICIES IN THE OECD

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ABSTRACT

Discontent with the functioning of the world monetary system has led to many proposals for international monetary reform. These proposals range from enhanced consultations under the current regime of floating exchange rates to a regime of fixed exchange rates, as proposed by Ronald McKinnon. In this paper we examine the implications of several alternative monetary arrangements for fiscal policy in the world economy. In particular we focus upon two issues. The first is the effects of alternative monetary arrangements on the international transmission of fiscal policy. The second is the implications of the alternative regimes for strategic aspects of fiscal policymaking.

As is generally the case in the discussion of exchange regimes we find that the choice of the monetary system is crucially dependent upon the source and nature of the shocks hitting the world economy. In this paper we show that the monetary regime also has important implications for the transmission of fiscal policy in the world economy and for the nature of the strategic games played by fiscal authorities. Rigid rules of the game, as under fixed exchange rates, do not necessarily eliminate the inefficient equilibria that can occur when fiscal authorities behave non-cooperatively.

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I. Introduction

The volatility of the world economy since the breakdown of the Bretton Woods par value system of exchange rates has led many policymakers and economists to call for reform of the international monetary system. Many economists have argued that domestic macroeconomic policies in the major OECD economies should be geared, at least in part, to maintain exchange rates within ranges set cooperatively among the major countries. Proposals vary from the "target zone" system, as advocated by Williamson [1983] and Roosa [1984], to a much more stringent system of fixed exchange rates, as advocated by McKinnon [1984]. There are several possible arguments in the case for a return to a more managed system, as described in recent surveys by Obstfeld [1985] and Sachs [1985b]. One crucial argument has been that the equilibrium of noncooperative macroeconomic policymaking under flexible exchange rates is likely to be inefficient, as countries fail to take into account the external effects of their policies on their trading partners. More rigid rules of the game, as embodied in a managed exchange rate system, are seen as a way to reduce the inducements to beggar-thy-neighbor policies. It has been frequently noted that there are many institutional forms that greater cooperation might take, ranging from the give and take of bargaining at economic summit meetings, to the implicit form of cooperation that takes place when each country adheres to externally imposed exchange rate targets. The exchange rate alternative is seen as particularly attractive in that it reduces the needs for constant, face-to-face bargaining. The hope is that by changing the rules of the game, policymakers can then be free to act independently (i.e. noncooperatively) within the confines of the international agreement. Tighter margins for exchange rate fluctuations might eliminate the most noxious forms of international competition, in the same way that the GATT has significantly reduced the international competition via tariff setting.

There are of course limits to the gains that will be achieved by a change in the international rules of the game. Every set of exchange arrangements will generate its own forms of strategic behavior, that will tend to cause some forms of inefficient strategic behavior. For example, while much of recent writing in this area has considered the gaming aspects of flexible exchange rates (see Canzoneri and Gray [1985], Oudiz and Sachs [1985], Currie and Levine [1985], and the other studies in Buiter and Marston [1985]), many others studies have shown that similar strategic issues arise in fixed exchange rate systems. Indeed the original analytical work in this area, by Hamada [1974], considered the case of monetary management under a fixed exchange rate regime. Even the classical gold standard, the self-regulating system par excellence, offered up incentives for inefficient strategic behavior, as argued by Eichengreen [1985] and Matsuyama [1985]. An important aspect of research in this area is to make quantitative judgements about the gains and losses from alternative forms of exchange rate management.

This paper studies the properties of four alternative international monetary regimes, both with respect to their operating characteristics, and with regard to the incentives for strategic behavior under each regime. We consider alternatively a floating exchange rate system as now, with three forms of fixed exchange rate systems. In the floating rate system, we assume that policymakers in each country can choose monetary and fiscal instruments in order to maximize a national social welfare function, without having to gear the policy choices to a particular exchange rate target. In the fixed exchange rate systems, some or all of the countries are required to peg the exchange rate as a side condition on their policy actions. We then study the implications of the exchange rate constraints. However, we do not ask the more fundamental question as to whether the exchange rate system itself would be viable, or instead whether the countries would choose to bow out of the arrangement.

As is well known, a fixed exchange rate system must be specified by much more than the constraint that bilateral or multilateral rates be fixed. It is crucial to specify which countries have the obligation to intervene in order to preserve a given peg. The so-called "N-1 problem" underlines the fact that in a fixed regime of N countries, only N-1 countries need to undertake the obligation to stabilize. The N-th country, presumably, can act without direct regard for the consequences of its policies on the exchange rate. The "problem", generally speaking, is to decide how the responsibilities for pegging are allocated among the countries.

We consider three alternatives that are widely discussed. The first is an asymmetric "dollar standard", in which the United States assumes no responsibility in pegging the exchange rate, while the other countries (specifically Japan, and the rest of the OECD, named ROECD) both peg to the dollar. This system makes the U.S. the "N-th" country, and is considered by many to be a reasonable description of how the Bretton Woods system actually operated (see Swoboda [1978]). In fact, it should be remembered that under the Bretton Woods arrangement, the U.S. had the side condition to peg the dollar price of gold at $35 per ounce, though it is difficult to find an important effect of this constraint on U.S. policy actions through most of the Bretton Woods period.

The other two systems that we study are symmetric solutions to the N-1 problem, à la the gold standard. Recently, McKinnon [1984] has proposed a fixed exchange rate arrangement for the U.S., Germany, and Japan, in which the cross rates among these countries are fixed, and in which the weighted sum of the money stocks of the three countries is to be held constant. This means that any expansion of money in one country must be matched by a compensating contraction in the other countries. Note that a strict gold standard, with a constant world stock of gold reserves, would work this way: any increase in money in one country (backed by 100% gold reserves) would necessarily require a contraction in money in rest of the world. Subject to this monetary constraint, the countries would be free to pursue independent fiscal policies.

This monetary standard is extremely strict, in making the aggregate stock of world money invariant to underlying conditions. As a third fixed exchange rate arrangement, we experiment with a modified McKinnon plan (dubbed McKinnon II) in which the exchange rates across regions are fixed, but in which the weighted world money stock is controlled cooperatively by the participating countries, to forestall large swings in world economic activity. Using a numerical model later, we attempt to find an equilibrium set of rules for fiscal policy in each country and for the global money stock, which has the following properties: the fiscal rules are optimal for each country, taking as given the fiscal rules in the other countries, and the rule for the management of the global money stock, while at the same time, the cooperative money rule is optimal taking as given the fiscal rules in each of the countries.

Within each of these exchange rate systems, we analyze the behavior and characteristics of fiscal policy, and examine how a changes in the rules of the game affect the incentives to use fiscal and monetary policies. In particular, we examine whether the various inefficiencies of floating rates caused by the strategic behavior of individual countries can be muted by a move to a more managed system. Under various circumstances, it is true that a move to managed rates can indeed blunt the inefficient deployment of fiscal policies, but we also find that there are many circumstances in which the introduction of fixed rates would itself lead to serious inefficiencies of other sorts. As is common in this kind of research, the desirability of one type of monetary arrangement over another will depend importantly on the nature of the underlying shocks hitting the world economy.

The paper is set out as follows. In section II, we examine the transmission of fiscal policies under alternative exchange rate arrangements, using an extremely simple version of the Mundell-Fleming model for heuristic purposes. We then move on to a large-scale empirical model of the world economy in section III, in which the same fiscal experiments are performed. We find that the cross-country transmission of fiscal policy is affected in crucial quantitative ways according to the global monetary arrangements in which the fiscal expansion takes place. In Section IV we take up the strategic aspects of monetary and fiscal policies under the alternative monetary arrangements that we are examining, and present illustrations in which a return to fixed rates would indeed raise the efficiency of macroeconomic management. In Section V the large-scale empirical model is then used to study strategic aspects of policymaking in a differential game format. We examine a game of disinflation, in which all of the major economies begin the game with an excessively high inflation rate, and in which all then use monetary and fiscal policies (subject to the rules of the exchange regime) in order to disinflate optimally. Once again, we confirm the crucial quantitative importance of alternative exchange regimes for policy choices and macroeconomic outcomes. Finally, in Section VI, we introduce a useful methodology for judging the "long-run" efficiency of alternative forms of monetary arrangements. Some concluding remarks are offered in Section VII.

II. Fiscal Policy Transmission in a simple Mundell-Fleming Model

We now introduce a simple, static two-country model in order to illustrate the implications for fiscal policy of alternative monetary regimes. We introduce the barest bones model here for illustrative purposes only, since in the next section we study a richly specified and empirically calibrated model of the world economy. It turns out, however, that even the simplest fixed price model can give us a good understanding of the properties of the short-run policy multipliers in the large-scale model.

Consider the following standard set-up, as in Mundell [1968]. We assume that domestic and foreign goods prices (p and p*) are fixed, and that there is perfect capital mobility ($i = i^*$). e is the exchange rate between the two countries, in units of the home currency per unit of foreign currency. An asterisk (*) denotes foreign country. The model is specified with two money demand equations, and two IS curves. The notation is standard: m is (log) money balances; p is (log) prices; q is (log) output; i is the nominal interest rate; and g is the measure of fiscal policy. The equations are as follows:

$$m-p = \phi q - \beta i \quad (1)$$

$$m^*-p^* = \phi q^* - \beta i \quad (2)$$

$$q = -\delta(p-e-p^*) - \sigma i + \lambda g + \gamma q^* \quad (3)$$

$$q^* = \delta(p-e-p^*) - \sigma i + \lambda g^* + \gamma q \quad (4)$$

We assume, as is standard, that the interaction term in the IS equations, γ, is positive and less than one in value. We consider four monetary regimes, and study the fiscal policy multipliers in each case. The regimes are:

(a) Floating exchange rate (the change in the exchange rate, de, is unrestricted, and pure fiscal policy is studied with $dm = dm^* = 0$)

(b) Dollar standard (U.S. monetary policy is held fixed, so that $dm = 0$ and the foreign money supply adjusts endogenously so that $de = 0$)

(c) McKinnon rule (the exchange rate is fixed, $de = 0$, and a weighted average of the money stocks $m^W = \alpha m + (1 - \alpha) m^*$ is held fixed).

(d) modified McKinnon rule ($de = 0$, dm^W is allowed to change).

We now turn to the fiscal policy multipliers.

(a) Floating Exchange Rate

The system (1)-(4) is differentiated and solved, along with the conditions that $dm = dm^* = 0$. The multipliers for fiscal and monetary policy are:

$$dq = \frac{\lambda}{2[1 - \gamma + \sigma\phi/\beta]} (dg + dg^*)$$

$$+ \frac{1 - \gamma + 2\sigma\phi/\beta}{2\phi[1 - \gamma + \sigma\phi/\beta]} dm - \frac{1-\gamma}{2\phi[1 - \gamma + \sigma\phi/\beta]} dm^*$$

$$dq^* = \frac{\lambda}{2[1 - \gamma + \sigma\phi/\beta]} (dg + dg^*)$$

$$- \frac{1 - \gamma}{2\phi[1 - \gamma + \sigma\phi/\beta]} dm + \frac{1-\gamma + 2\sigma\phi/\beta}{2\phi[1 - \gamma + \sigma\phi/\beta]} dm^*$$

$$de = \frac{\lambda}{2\delta} (dg^* - dg) - \frac{1-\gamma}{2\delta\phi} (dm^* - dm)$$

In this symmetric case fiscal policy is positively transmitted across countries (given that $\gamma < 1$) with the the country having the largest fiscal expansion experiencing an appreciation of its currency. Monetary policy is negatively transmitted, since a money supply expansion at home causes the exchange rate to depreciate, and thereby shifts demand from the foreign country to the home market.

b) Dollar Standard

The system is again solved , this time using the assumptions that de = 0, dm exogenous, and dm* endogenous. In this case we find:

$$dq = \frac{\lambda}{\Delta} (dg + \gamma \, dg^*) + \frac{\sigma(1+\gamma)/\beta}{\Delta} dm$$

$$dq^* = \frac{\lambda[\gamma - \sigma\phi/\beta]}{\Delta} dg + \frac{\lambda\,[1 + \phi\sigma/\beta]}{\Delta} dg^* + \frac{\sigma(1+\gamma)/\beta}{\Delta} dm$$

$$dm^* = \frac{\phi\lambda[\gamma - \sigma\phi/\beta - 1]}{\Delta} dg + \frac{\phi\lambda[1 - \gamma + \phi\sigma/\beta]}{\Delta} dg^* + dm$$

where

$$\Delta = [1 - \gamma^2 + (\phi/\beta)(1+\gamma)\,] > 0$$

A foreign fiscal expansion is again transmitted positively to the home country, while a domestic fiscal expansion will actually be negatively transmitted if $\sigma\phi$

$> \beta\gamma$. This surprising result occurs because the fiscal expansion by the home country tends to appreciate the currency. The foreign country is thereby required to undertake a monetary contraction in order to prevent its currency from depreciating. The contractionary effects of this endogenous monetary response can be sufficient to offset the normal expansionsary effect coming through a rise in exports to the home country. Note that a rise in home-country money, $dm > 0$, raises output in both countries, and induces a corresponding increase in the foreign money supply.

There is admittedly something artificial in the way that we study this case, in that g and g* are assumed to be exogenous, so that m* is the "automatic" instrument which the foreign country uses to peg the exchange rate. If, for example, we were instead to assume that g* is altered to keep $de = 0$, then a home fiscal expansion ($dg > 0$) would necessarily raise foreign output. In the later empirical sections, the foreign country chooses the combination of dg* and dm* optimally in order to maximize a social welfare function, subject to the constraint that $de = 0$.

c) McKinnon Rule

In the fixed exchange rate regime proposed by McKinnon [1984], the exchange rate between the major countries would be fixed, together with an exogenously set growth rate of a weighted average world money stock. The implications of this regime for fiscal policy in this simple model can be found by setting $dm^W = \alpha dm + (1-\alpha)dm^*$ as an exogenous variable, and requiring that $de = 0$. Monetary policy in both countries is endogenous. Doing this we find:

$$dq = \frac{\lambda}{\theta} dg + \frac{\lambda\,[\gamma\beta/\phi(1-\alpha) - \sigma]}{\theta\,[\sigma + \beta/\phi(1-\alpha)]} dg^*$$

$$dq^* = \frac{\lambda}{\theta^*} dg^* + \frac{\lambda\,[\gamma\beta/\phi\alpha - \sigma]}{\theta\,[\sigma + \beta/\phi\alpha]} dg$$

where $$\theta = 1 - \gamma^2 + \frac{(1+\gamma)\sigma[\gamma + \alpha/(1-\alpha)]}{[\sigma + \beta/\phi(1-\alpha)]}$$

$$\theta^* = 1 - \gamma^2 + \frac{(1+\gamma)\sigma[\gamma + (1-\alpha)/\alpha]}{[\sigma + \beta/\phi\alpha]}$$

In this case both home and foreign fiscal policies will be negatively transmitted if $\sigma\phi(1-\alpha) > \gamma\beta$ for a foreign expansion and $\sigma\phi\alpha > \gamma\beta$ for a domestic expansion.

The form of the monetary regime has been shown to have important implications for the transmission of fiscal policy in the world economy. Later, we will see that the nature of the transmission will have important consequences for policy coordination among the major economies. In the next section we use a large-scale simulation model in an attempt to better quantify the fiscal policy multipliers.

III. Fiscal policy in an Empirical Model

In this section we use the MSG (McKibbin -Sachs Global) simulation model to examine the international transmission of fiscal policy. The MSG model was developed in Sachs and McKibbin [1985]. The reader is also referred to recent papers by Ishii, McKibbin and Sachs [1985], McKibbin and Sachs [1985] and Sachs [1985a] for several applications and refinements. The model is a rational expections, dynamic general equilibrium macroeconomic model of the world economy. A full list of equations is provided in the Appendix. The world economy is divided into five regions consisting of the U.S., Japan, the rest of the OECD (hereafter ROECD), OPEC and the Developing countries. Each region is linked via flows of goods and assets. Stock-flow relationships and intertemporal budget constraints are carefully observed. Budget deficits cumulate into a stock of government debt which must eventually be financed, while current account deficits cumulate into a stock of foreign debt. Asset markets are forward looking so the exchange rate and long term interest rate are conditioned by the entire future path of policy.

There are equations for the internal macroeconomic structure of the three industrialized regions of the U.S., ROECD and Japan, while the OPEC and developing country regions have only their foreign trade and financial structures incorporated. Each region produces a good which is an imperfect substitute in the consumption baskets of each of the other regions. Consumption of each good therefore depends on income and relative prices. Private absorption depends on financial wealth, disposable income and long-term and short-term real interest rates along conventional lines. Nominal wages are predetermined in each period, with the nominal wage change between periods a function of lagged consumer price inflation, the output gap and the change in the output gap. With the assumption that the GDP deflator is a fixed markup over wages, we derive a standard Phillips curve equation. In essence, the model is a generalized version of the Dornbusch [1976] model, in which the goods markets clear less rapidly than the asset markets.

Residents in different countries hold their own country's assets as well as foreign assets (except foreign money), based on the relative expected rates of return, with expectations being formed rationally. While we specify the asset demand functions in a general portfolio balance fashion, the parameter values that we impose make the model behave almost as if assets are perfect substitutes. Money demand is specified according to a standard transactions demand formulation.

The model is parameterized using actual 1983 trade shares and asset stocks. Behavioural parameters are chosen to be consistent with values found in the empirical literature. We have shown elsewhere (see Sachs [1985a]) that the model is able to explain the macreconomic experience of the 1980's including the strong dollar and trade imbalances by shifts in macroeconomic policies in the U.S., Japan and the ROECD.

We simulate non-linear and linear versions of the model using numerical techniques which take into account the forward looking variables in the model. Specifically we use a procedure described by Fair and Taylor [1983]. The linearized version of the model is amenable to policy optimization exercises and has previously been used to consider the gains to policy coordination using dynamic game theory techniques (see Sachs and McKibbin [1985]). Throughout the paper we use the linearized version of the model because of the reliance on dynamic programming in later sections. We have verified in earlier work that there is little difference between the policy multipliers in the linearized and nonlinear versions of the model in the exercises studied here.

A. Fiscal Policy Multipliers Under Alternative Regimes

We simulate a fiscal expansion by assuming a permanent 1% of GNP increase in real government expenditures on domestic goods, commencing in 1984 which is financed by government debt. We assume that the expenditure increase is permanent, and expected to be permanent on impact, with the budget deficit remaining 1% of GNP above the baseline path. Because of rising interest payments on the accumulating public debt, the deficit would tend to grow over time in the absence of compensating cuts in expenditure or increases in taxes. We assume that over time the increase in interest repayments is paid for through higher tax revenues. Note that the economies all possess a steady state growth rate of 3 percent per annum. In steady-state equilibrium, a constant deficit is compatible with a fixed debt-GDP ratio as long as the increase in debt due to the deficit causes the total debt stock to grow at the 3 percent annual rate. This requirement means that the steady-state Debt-GDP ratio equals the steady-state deficit-GDP ratio divided by 0.03. For example, a permanent increase in the budget deficit, that raises the deficit from zero to 1% of GDP, causes the steady-state debt-GDP ratio to rise from zero to 33% of GDP.

Table 1 contains the results for a fiscal expansion in the U.S. under a pure floating exchange rate. The absence of Ricardian consumers and the presence of price stickiness is obvious in the results. The real output multiplier follows a familar hump shape: output rises initially, but over time rising interest rates , rising prices, a strong dollar, and rising taxes to finance the growing debt burden, crowd out the fiscal stimulus. Crowding out is complete by 1989. Note that the dollar appreciates on impact, by 3.3 percent against the ECU (the currency of the ROECD) and the Yen. Interest rates rise throughout the world, although by more in the U.S. than abroad. The differential in large part captures the expectation of a future depreciation of the U.S. dollar (remember, though, that because of the portfolio balance assumptions, there is also a slight and growing risk premium on dollar denominated assets). The fiscal impulse is positively transmitted to the rest of the world as Japanese and ROECD trade balances improve due both to the demand stimulus from higher U.S. output, and from the strong dollar. The positive transmission quickly fades as rising world interest rates have their effect. Note that inflation initially falls in the U.S. This result follows from our somewhat artificial assumption that home goods prices do not respond at all within the first year to higher domestic output, while import prices fall in response to the appreciation of the dollar.

Table 2 contains corresponding results for an ROECD fiscal expansion under a flexible exchange rate. The results are similar to those for the U.S. fiscal stimulus, with a positive transmission of output to the U.S. and Japan. The ROECD exchange rate appreciates against the dollar by 3.4 percent on impact,

TABLE 1 U.S. Fiscal Expansion Under a Flexible Exchange Rate

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	0.9	0.9	0.6	0.4	0.1	-0.1
Inflation	D	-0.2	0.2	0.3	0.4	0.4	0.4
Nominal Interest Rate	D	0.8	1.1	1.4	1.7	2.0	2.2
Exchange Rate (Ecu/$)	%	3.3	3.2	3.4	3.4	3.3	3.2
Trade Balance	%GNP	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Budget Deficit	%GNP	1.0	1.0	1.0	1.0	1.0	1.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0

Japanese Economy:

Real GNP	%	0.6	0.2	0.1	-0.1	-0.2	-0.2
Inflation	%	0.2	0.4	0.3	0.3	0.3	0.2
Nominal Interest Rate	D	0.6	1.1	1.2	1.5	1.6	1.7
Exchange Rate (YEN/$)	%	3.3	3.1	3.2	3.2	3.1	2.9
Trade Balance	%GNP	0.3	0.2	0.2	0.2	0.2	0.2
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0

ROECD Economies:

Real GNP	%	0.8	0.1	0.0	-0.2	-0.3	-0.4
Inflation	%	0.2	0.5	0.3	0.3	0.2	0.2
Nominal Interest Rate	D	0.7	1.2	1.3	1.5	1.6	1.6
Trade Balance	%GNP	0.3	0.3	0.3	0.3	0.3	0.3
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 2 ROECD Fiscal Expansion Under a Flexible Exchange Rate

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	0.7	0.2	0.1	-0.2	-0.3	-0.5
Inflation	D	0.2	0.4	0.4	0.4	0.3	0.2
Nominal Interest Rate	D	0.6	1.2	1.4	1.6	1.7	1.7
Exchange Rate (Ecu/$)	%	-3.4	-3.1	-3.1	-2.9	-2.6	-2.3
Trade Balance	%GNP	0.3	0.3	0.3	0.3	0.3	0.3
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0

Japanese Economy:

Real GNP	%	0.5	0.1	0.1	-0.1	-0.2	-0.4
Inflation	%	0.2	0.4	0.3	0.3	0.2	0.1
Nominal Interest Rate	D	0.4	1.0	1.2	1.4	1.4	1.4
Exchange Rate (YEN/$)	%	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8
Trade Balance	%GNP	0.3	0.3	0.3	0.2	0.2	0.1
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0

ROECD Economies:

Real GNP	%	1.1	1.1	0.7	0.4	0.0	-0.4
Inflation	%	-0.2	0.3	0.5	0.6	0.5	0.5
Nominal Interest Rate	D	0.9	1.4	2.0	2.4	2.6	2.8
Trade Balance	%GNP	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3
Budget Deficit	%GNP	1.0	1.0	1.0	1.0	1.0	1.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0

and against the Yen by 3.1 percent on impact.

The results for a U.S. fiscal expansion under a dollar standard regime are shown next in table 3. In specifying this regime, we make several crucial assumptions. First, the comparative dynamic exercises assume that the non-U.S. economies peg their exchange rates to the dollar via monetary policy, rather than via fiscal policy. In other words, the U.S. fiscal multipliers assume that foreign fiscal policies are held fixed, while foreign monetary policies are wholly endogenous. Second, the form of monetary intervention must be made clear. The authorities could choose to stabilize the exchange rate with intervention on the foreign exchange markets or via intervention in the domestic credit markets (e.g. open-market operations, rediscounting, etc.). In a world of perfect capital mobility, all of these alternatives would be identical from the point of view of macroeconomic outcomes, while in a world of imperfect capital mobility, differences will arise depending on the nature of exchange rate pegging. Since our model assumes very high, though not fully perfect substitutability, the choice of intervention mechanism is quantitatively of some, but only minor importance. In fact, in all of our specifications used in the paper, we assume that the exchange rate is stabilized through interventions in the domestic money market.

Several results are striking. The first is the negative transmission of the U.S. fiscal expansion to the rest of the world. In this case both Japan and the ROECD adopt severely contractionary monetary policies in order to maintain the fixed exchange rate. The result is severe recession in both regions. The recessionary effect of the contractionary monetary policies quickly feeds back

TABLE 3 U.S. Fiscal Expansion Under a Dollar Standard

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	1.7	0.6	0.1	-0.4	-0.5	-0.3
Inflation	D	0.0	0.6	0.3	0.1	-0.2	-0.4
Nominal Interest Rate	D	1.4	2.0	1.8	1.4	0.9	0.4
Exchange Rate (Ecu/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	-0.3	-0.4	-0.6	-0.7	-0.8	-0.8
Budget Deficit	%GNP	1.0	1.0	1.0	1.0	1.0	1.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0

Japanese Economy:

Real GNP	%	-1.0	-1.6	-1.6	-1.4	-0.8	0.0
Inflation	%	0.0	-0.5	-0.9	-1.2	-1.4	-1.3
Nominal Interest Rate	D	1.4	1.9	1.7	1.3	0.8	0.2
Exchange Rate (YEN/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.1	0.1	0.1	0.1	0.2	0.3
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	-1.0	-2.5	-3.8	-4.9	-5.8	-6.4

ROECD Economies:

Real GNP	%	-2.1	-3.2	-2.7	-1.6	0.2	2.4
Inflation	%	0.0	-0.8	-1.5	-1.9	-1.9	-1.4
Nominal Interest Rate	D	1.4	1.9	1.7	1.2	0.5	0.0
Trade Balance	%GNP	0.2	0.4	0.5	0.6	0.6	0.5
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	-1.4	-3.6	-5.7	-7.2	-8.0	-7.8

to the U.S., and does much to dampen the U.S. fiscal multiplier (it turns negative by 1987). The asymmetry in the dollar standard regime is illustrated in table 4, which shows the results for an ROECD fiscal expansion. In contrast to the U.S. fiscal expansion, the ROECD fiscal expansion is positively transmitted to the rest of the world. The Ecu tends to appreciate, so that the ROECD monetary authorities are obligated to expand the domestic money supply. This leads to an enormous expansion in the ROECD, and positive transmission to the other economies.

Table 5 illustrates the consequence of a fiscal expansion under the McKinnon regime. In this case, we study the effects of a fiscal expansion under the assumption that a geometric weighted average of the money supplies in the U.S., ROECD, and Japan is fixed, and that the exchange rates are similarly fixed. The weights used (somewhat arbitrarily) are the GNP weights for 1983. In this case, as with the U.S. expansion under the dollar standard, the transmission of fiscal policy is negative. Once again, the non-U.S. economies are obligated to contract their money stocks while the U.S. expands its money stock. The result is a rise in interest rates abroad that is sufficient to overwhelm the direct effects of the U.S. stimulus. The extent of the recession abroad is less than in the Dollar standard, since in the McKinnon case, the U.S. is obligated to expand its money supply in line with the fiscal expansion.

The effects of an ROECD fiscal expansion under the McKinnon rule are shown in table 6. Now the ROECD fiscal expansion is negatively transmitted to the rest of the world. Clearly, the McKinnon rule on world money supplies imposes more symmetry than does the dollar regime. In the case of an ROECD

TABLE 4 ROECD Fiscal Expansion Under a Dollar Standard

		1984	1985	1986	1987	1988	1989
U.S. Economy:							
Real GNP	%	0.1	0.5	0.6	0.5	0.1	-0.5
Inflation	D	0.0	0.2	0.5	0.7	0.9	0.8
Nominal Interest Rate	D	0.1	0.6	1.3	2.2	3.0	3.4
Exchange Rate (Ecu/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.3	0.4	0.6	0.7	0.7	0.6
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	0.0	0.0	0.0	0.0	0.0	0.0
Japanese Economy:							
Real GNP	%	0.6	0.9	0.8	0.6	0.1	-0.5
Inflation	%	0.1	0.4	0.7	1.0	1.1	0.9
Nominal Interest Rate	D	0.1	0.5	1.2	2.0	2.7	3.0
Exchange Rate (YEN/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.2	0.4	0.5	0.5	0.5	0.3
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	0.2	0.6	0.9	1.2	1.4	1.6
ROECD Economies:							
Real GNP	%	4.7	4.5	3.2	1.1	-1.6	-4.3
Inflation	%	0.1	1.8	2.6	2.8	2.4	1.5
Nominal Interest Rate	D	0.1	0.8	1.7	2.8	3.8	4.4
Trade Balance	%GNP	-0.3	-0.4	-0.5	-0.6	-0.6	-0.6
Budget Deficit	%GNP	1.0	1.0	1.0	1.0	1.0	1.0
Money Supply	%	1.7	4.2	6.2	7.5	7.8	7.0

TABLE 5 U.S. Fiscal Expansion Under the McKinnon Rule

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	2.3	1.9	1.4	0.7	0.0	-0.8
Inflation	D	0.0	0.9	1.1	1.1	1.0	0.8
Nominal Interest Rate	D	0.6	1.0	1.3	1.5	1.7	1.9
Exchange Rate (Ecu/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	-0.2	-0.3	-0.4	-0.6	-0.7	-0.7
Budget Deficit	%GNP	1.0	1.0	1.0	1.0	1.0	1.0
Money Supply	%	0.6	1.5	2.4	3.1	3.6	3.8

Japanese Economy:

Real GNP	%	-0.2	-0.4	-0.4	-0.3	-0.2	-0.1
Inflation	%	0.0	0.0	-0.1	-0.2	-0.2	-0.2
Nominal Interest Rate	D	0.6	1.0	1.2	1.4	1.5	1.6
Exchange Rate (YEN/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.1	0.2	0.2	0.2	0.3	0.3
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	-0.4	-0.8	-1.3	-1.7	-2.1	-2.3

ROECD Economies:

Real GNP	%	-0.5	-0.9	-0.7	-0.5	-0.1	0.4
Inflation	%	0.0	-0.2	-0.3	-0.4	-0.3	-0.2
Nominal Interest Rate	D	0.6	1.0	1.2	1.4	1.5	1.5
Trade Balance	%GNP	0.2	0.3	0.4	0.4	0.5	0.5
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	-0.5	-1.2	-1.9	-2.5	-2.9	-3.0

TABLE 6 ROECD Fiscal Expansion Under the McKinnon Rule

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-0.6	-0.8	-0.6	-0.3	0.0	0.4
Inflation	D	0.0	-0.1	-0.2	-0.2	-0.2	-0.1
Nominal Interest Rate	D	0.9	1.5	1.8	2.0	2.0	1.9
Exchange Rate (Ecu/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.2	0.3	0.4	0.5	0.6	0.5
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	-0.6	-1.5	-2.2	-2.7	-2.9	-2.8

Japanese Economy:

Real GNP	%	-0.2	-0.4	-0.3	-0.2	-0.1	0.0
Inflation	%	0.1	0.0	0.0	0.0	0.0	0.0
Nominal Interest Rate	D	0.9	1.4	1.7	1.8	1.8	1.6
Exchange Rate (YEN/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.2	0.3	0.4	0.4	0.4	0.3
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	0.0
Money Supply	%	-0.5	-1.0	-1.5	-1.7	-1.8	-1.7

ROECD Economies:

Real GNP	%	3.1	2.3	1.5	0.4	-0.8	-1.8
Inflation	%	0.0	1.2	1.4	1.4	1.1	0.7
Nominal Interest Rate	D	0.9	1.6	2.1	2.5	2.7	2.8
Trade Balance	%GNP	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6
Budget Deficit	%GNP	1.0	1.0	1.0	1.0	1.0	1.0
Money Supply	%	0.8	1.8	2.7	3.3	3.5	3.4

fiscal expansion under the McKinnon rule, the U.S. and Japan contract monetary policy and the ROECD expands monetary policy in order to maintain the fixed exchange rate. The consequence of the contractionary monetary policies is to cause a recession in Japan and the U.S.

IV. Implications of the Exchange Regime for Strategic Interactions of Monetary and Fiscal Policy

As we noted in the beginning, one of the most attractive aspects of monetary reform is the possibility of reducing the inefficient strategic behavior of national macroeconomic authorities. It is well known that if policymakers in the U.S., the ROECD, and Japan independently select their monetary and fiscal policies, taking as given the actions of the other countries, the resulting (Nash) equilibrium of macroeconomic policies is likely to be inefficient, in the sense that another vector of policy parameters could simultaneously raise the level of social welfare in all of the countries. In this brief theoretical section, we illustrate how a change of regime could possibly make the independent actions of national policymakers more efficient.

Consider an illustration in which two symmetric countries choose monetary and fiscal policies to maximize a social welfare function in output, the fiscal deficit, and the level of prices (in the dynamic model, the target will be the inflation rate). For simplicity, we assume that the welfare functions are identical and of the following quadratic form:

$$W = -(q^2 + \mu\, p_c^{\,2} + \nu\, g^2) \qquad (5)$$

where p_c is the (log) level of consumer prices (the foreign welfare function is of course a function of the corresponding foreign variables). The bliss points for each country are zero levels of (log) output, consumer prices, and fiscal expenditure. We use the earlier static model of Section II, with the addition that consumer prices in each country are a weighted average of home prices and import prices (valued in domestic currency):

$$p_c = \eta\ p + (1 - \eta)\ (p^* + e)$$

$$p_c^* = \eta\ p^* + (1 - \eta)\ (p - e)$$

Maintaining the assumption that domestic and foreign output prices are fixed, with $p = p^* = p_0$, we have that fluctuations in the exchange rate is the only factor that can cause p_c and p_c^* to change in the short run.

In the case of symmetric countries, it will necessarily be the case that the exchange rate equals zero (e = 0). Given this fact, consumer prices in each country are fixed at the level p_0. Since p_c cannot be reduced in both countries simultaneously, the best symmetric solution is merely to live with the fact that p_c is above the bliss level, and then to set $g = g^* = 0$, and $m = m^* = p_0$, so that output is kept at $q = q^* = 0$. In other words, the economies should sit at "full employment" and zero budget deficit, suffering the inevitable fact that consumer prices are above their bliss level.

Unfortunately, in noncooperative policymaking under floating exchange rates, this efficient equilibrium will not be reached. Each country's policy authorities will believe that a strong currency option is available that will allow them to reduce p^c, and therefore to import price stability (and to export inflation!). Each country will therefore aim its monetary policy in a contractionary direction and its fiscal policy in an expansionary direction in order to exploit the possible anti-inflationary gains of a strong currency. Of course, this noncooperative outcome has all of the trappings of a prisoners' dilemma game, in that both symmetric countries will not be able, simultaneously, to each enjoy a strong currency vis-a-vis the other! The results of the noncooperative game will therefore be:

(1) a policy mix geared towards fiscal expansion cum monetary contraction, with a socially undesirable level of fiscal deficits;

(2) overly contractionary policies in total, with output reduced below the efficient symmetric level of $q = q^* = 0$.

(3) an exchange rate $e = 0$, with $p_c = p_c^* = p_0$, i.e., no success in either country of manipulating the exchange rate to its own advantage.

These results are easy to confirm algebraically. The home country maximizes the social welfare function (5) with respect to m and g, taking as given the level of m^* and g^*. The foreign country makes the comparable policy analysis, arriving at values of m^* and g^*, taking as given m and g. At the Nash equilibrium in this symmetric case, $m = m^*$ and $g = g^*$, with the specific values of the target variables given as follows (note that the multipliers dy/dx in the equations are as given in the derivations in Section II):

$$q = q^* = -[\mu\, p_0\, (1 - \eta)(de/dm)]/(dq/dm) \quad < \quad 0$$

$$p_c = p_c^* = p_0 > \quad 0$$

$$g = g^* \; = -[q\, (dq/dg) + \mu\, p\, (1 - \eta)(de/dg)]/\nu \quad > \quad 0$$

Remember that $de/dm > 0$, $de/dg < 0$, $dq/dm > 0$, $dq/dg > 0$, in order to derive the signs of the preceeding expressions. Thus, output is below zero, while government spending is above zero. By simple substitution, it is easy to see that $m = m^* < p_0$. In sum we have established the early conclusions: m is too tight and g is too loose relative to the efficient equilibrium, and aggregate demand overall is too tight (since $q = q^* < 0$).

It is important to note that the inefficiency in this game would hold if the players had only one instrument, either m or g, instead of two. If m and m* were fixed, with the authorities setting g and g*, there would still be a bias towards inefficiently large fiscal deficits; while on the contrary, if g and g* are fixed, while the game is played with m and m*, then the bias is towards overcontractionary policies. In both cases, the countries attempt to manipulate the exchange rate in their favor (i.e. towards an appreciation).

Now, consider how this game would be played under the McKinnon standard. In that case, policymakers choose only g and g*, since monetary policy is set according to the two rules that m^W is fixed and that the exchange rate is fixed (in this case at $e = 0$). The cooperative optimum equilibrium is again the same, with $q = q^* = 0$, $g = g^* = 0$, and $p_c = p_c^* = p_0$. To achieve this equilibrium, m^W should be set at p_0, and fiscal policy in both countries should be set at zero.

Assume now that the McKinnon rule is in place, but with each fiscal policy authority free to choose the level of fiscal spending in a noncooperative way. Suppose also that m^W is fixed exogenously at p_0 (more on this assumption in a moment). It now turns out that the independent actions of the fiscal authorities will lead to the social optimum. The policymaker has no incentive to try to deviate from the point of zero fiscal expenditure. Higher fiscal spending no longer improves the price performance, as it did under the floating system, since now the exchange rate is fixed at zero. Therefore fiscal expenditure merely worsens the budget deficit without any compensating benefits. These results are verified formally by maximizing the social welfare function at home with respect to g, and abroad with respect to g*. It is easy to verify that $g = g^* = 0$ constitutes a Nash equilibrium.

To see this formally, we simply differentiate the utility function with respect to g, and set the results equal to zero. Under the McKinnon rule, $de/dg = 0$, so that the result of differentiation is: $dW/dg = 0 = -[q(dq/dg) + \nu g]$. With m^W at p_0, and $g^* = 0$, this first-order condition is satisfied at $q = 0$, and $g = 0$. The same result holds for the foreign country when $g = 0$, so that the pair $g = g^* = 0$ constitutes a Nash equilibrium.

Thus, we have a case in which a change in monetary regime eliminates the inefficient strategic interactions of the two governments. The essential inefficiency of the game under floating resulted from the fact that the two sides had inconsistent exchange rate targets, that obviously could not be simultaneously satisfied. Under the McKinnon rules, neither player attempts nor is able to influence the exchange rate in his favor. It must be stressed that the efficiency of the McKinnon solution relied heavily on two facts. First, it was assumed that the world money stock m^W was at the global optimum. In fact, McKinnon has opted for a fixed level of m^W in most discussions of his proposal, and there is no reason to believe that the selected value of m^W would necessarily be at an efficient level. Second, the symmetry of the model and the symmetry of the "shock" (both countries had prices equally above the optimum) meant that the exchange rate did not have to adjust in order to adapt efficiently to the shock. In later sections, we will study asymmetric cases, in which efficiency requires a change in the nominal exchange rate.

V. Strategic Interactions Under Alternative Regimes in the MSG Model

We now employ the large-scale simulation model to study strategic interactions in the dynamic case. For this purpose we use two types of methodologies. In the first, we place the countries in a particular historical situation, and study the optimal strategies of each country over time. A benchmark "cooperative" equilibrium is used as a benchmark with which to compare the performance in the alternative monetary regimes. In the second and more novel approach, introduced in Section VI, we study the asymptotic properties of the system under alternative exchange arrangements. In that case we assume that the system is buffeted through time by various stochastic disturbances, in output markets, money markets, and elsewhere. Using a technique described in that section, we can calculate the steady-state variance-covariance structure of the target variables in each exchange regime, and thereby measure the average operating properties of each system. In general, the MSG model is particularly well suited to this kind of analysis, since the model is easily reducible to a first-order difference equation system, which is easy to analyze using standard techniques of dynamic analysis.

To study the dynamic games involved in setting national policy we specify a social welfare function for each of the three OECD regions. Social welfare in each region is specified as a function of various macroeconomic targets, such as the inflation rates, the GDP gap, the current account deficit, and the budget deficit. The intertemporal social welfare functions are written as additively separable quadratic functions of the targets in each period. The specific form that we employ makes social welfare a function of the output gap Q, CPI inflation π, the current account deficit as a percent of GDP, denoted CA, and the level of the budget deficit relative to GDP, denoted D. The specific function that we employ is as follows:

$$W = -\sum_{t=0}^{\infty} \delta^{t} [0.5\ Q_t^2 + \pi_t^2 + 0.5\ CA_t^2 + 0.6\ D_t^2] \tag{6}$$

δ is the social rate of time discount. Clearly, macroeconomic "bliss" is achieved when the GDP gap is zero, CPI inflation is zero, the current account is in balance, and the budget is in balance.

Corresponding welfare functions are assumed for ROECD and Japan. A couple of preliminary comments should be made about this welfare function. First, the results are obviously specific to a given numerical specification. The inefficiency of a strategic noncooperative interaction will depend quantitatively on the weights attached to the countries' target variables. In the simple example of the last section, for example, the inefficiency resulted from the fact that both countries were attempting simultaneously to reduce their price levels, via exchange rate appreciation. The inefficiency of the noncooperative solution in that case depends crucially on the relative weight placed by the countries on the inflation target. For purposes of study of our large-scale model, we have not yet determined any way to study the dynamic games except through the specification of particular loss functions. The second point is that the loss function relates to macroeconomic targets (inflation, unemployment, etc.) rather than to more basic categories of real consumption over time. Our model does not have strong enough microeconomic foundations at this point to write policy targets in terms of the "primitives" of consumption expenditure, as might be desirable in a more sophisticated treatments.

Using results of dynamic game theory, we calculate (with numerical dynamic programming methods) a set of fiscal policy rules in the three OECD regions that have the following "equilibrium" property: the rules for each country are optimal for the given country (in that they maximize the dynamic social welfare function), taking as given the rules that are being employed in the other regions. A more rigorous statement of the equilibrium conditions and a discussion of the solution technique is given in Oudiz and Sachs [1985]. The optimum we calculate it time consistent. That is, there is no incentive to choose a different set of policies if the optimization problem is solved again at some point in the future. The policies are therefore also credible to the forward looking private agents and other countries in the model. We have shown elsewhere (see Sachs and McKibbin [1985]), that as in the static model of the previous section, such an equilibrium does not necessarily yield very attractive outcomes. These rules will likely contain some types of beggar-thy-neighbor policies, and will therefore show some of the disadvantages of the classic prisoners' dilemma. For example, in the case where both monetary and fiscal policies are chosen according to such rules under a flexible exchange rate regime, we will see that the equilibrium rules are likely to produce excessive budget deficits and high real interest rates in an inflationary environment, just as we found for the static model.

It is therefore very likely the case that the social welfare of all of the countries can be enhanced by a different set of policies, chosen cooperatively. We can find such a set new rules by assuming that a single "world" planner maximizes a single social welfare function, which is a weighted average of the social welfare functions of the U.S., Japan, and the ROECD, where the weights are GNP shares. The result of this global optimization is a new set of rules that avoids prisoners' dilemmas. These optimal "cooperative" rules can then be compared with the "non-cooperative" rules found in the first stage. In general, it will be the case that "cooperative" policies result in some form of managed float, in that global efficiency of policy setting will almost surely require changes in the nominal exchange rates of the three countries in the course of macroeconomic adjustment.

We use this technique to generate non-cooperative rules for fiscal policy given the monetary regime in place, as well as a set of cooperative rules. In the case of the flexible exchange rate regime we assume that policymakers choose both monetary and fiscal policies to reach targets for output, inflation, the current account and budget deficits. In the dollar standard case the U.S. is allowed to optimize on both monetary and fiscal policies whereas Japan and the ROECD are only given the option of choosing fiscal policy. Their money supplies are made endogenous, and set at the levels necessary to keep the exchange rate unchanged, given the levels of the state variables of the world economy, and given the levels of their own fiscal policies, and of the monetary and fiscal policies in the other economies. In the McKinnon regime, each region chooses fiscal policy to reach its given targets. In the "simple" McKinnon regime, the global money stock is held fixed, while in the "modified" McKinnon regime, the three regions cooperatively set the global money stock, m^W, while they choose their fiscal policies independently. In each case the dynamic welfare function is the one that we have just introduced.

A word must be said about how we implement the modified McKinnon proposal. Remember that in that case, the global money stock is set cooperatively, while the individual countries set the fiscal policies noncooperatively. To find a "good" rule for the global money stock, we employed the following iterative procedure. We found the rule for global money that maximizes a global social welfare function (a GNP-weighted average of the individual region social welfare functions) assuming that fiscal policies were also chosen cooperatively. Then, given the resulting rule for global money, we let the individual policymakers choose optimal fiscal policies in a noncooperative manner. Taking as given these resulting rules for fiscal policy, we then recalculated an optimal cooperative rule for global money, and used that one as the rule to control the evolution of m^W. Ideally, it would be best to find the linear rule for m^W that maximizes the global welfare, subject to the constraint that the fiscal rules are choosen noncooperatively by the separate regions. This formulation would make the cooperative monetary authorities Stackelberg leaders with respect to the fiscal authorities of the individual countries. Unfortunately, we have not yet been able to implement this more ambitious approach.

As a formal matter, the MSG model can be written in a standard state space representation in the following way:

$$X_{t+1} = AX_t + Be_t + CU_t + Z\epsilon_t \qquad (7)$$

$$_t(e_{t+1}) = DX_t + Fe_t + GU_t + W\epsilon_t \qquad (8)$$

$$\tau_t = MX_t + Le_t + NU_t + O\epsilon_t \qquad (9)$$

where:

X_{t+1} is a vector of state variables (in this case 37x1)

U_t is a vector of control variables

e_t is a vector of non-predetermined (or "jumping") variables

τ_t is a vector of target variables

ϵ_t is a vector of stochastic shocks (9x1)

$_te_{t+1}$ is the expectation taken at time t of the jumping variables at time t+1 based on information available at time t

The model variables are divided into state variables X_t, historically given at any moment; "jumping" or forward-looking variables e_t, which are fixed in order to place the system on the stable dynamic manifold; control variables U_t including fiscal and monetary policies; and stochastic shocks ϵ_t. Assuming that in each period the policy variables must be set before the stochastic shocks are observed, the policy rules are all written in the form:

$$U_t = \Gamma X_t \tag{10}$$

In other words, the general specification of rules links the control variables to the state variables in any period via a fixed set of linear rules. Of course the linearity results from the assumption of linearity of the underlying model and the assumption of a quadratic social welfare function in each region.

The dynamic game that we study in this section has the policy authorities all confronting an unanticipated jump in nominal wage inflation of 10 percent per year, after being on a baseline path of zero inflation, zero GDP gap, budget balance, and current account balance. The shock hits in 1984, raising domestic prices in the year by 10 percent, and setting in motion several years of high inflation given the inflationary momemtum built into the Phillips curve equation (which makes current nominal wage change a function of lagged nominal price change). In each region, monetary and fiscal policies are deployed in order to engineer an optimal rate of disinflation, subject to the social welfare function (which trades off output, inflation, budget, and current account deficits) and subject to the policy rules taken abroad. In this analysis, we assume that the system is nonstochastic (that is, all ϵ are zero), returning to the stochastic case in the next section when we look at the steady-state operating properties of the alternative regimes.

Table 7 illustrates the case of optimal cooperative disinflation. Since all countries begin with a shock of 10 percent wage inflation, it is optimal to pursue tight macroeconomic policies in order to bring inflation down to zero in the period of a few years. In this case, the nominal money stock growth is kept low and falling, so that real money balances (not shown) fall sharply in the early period of disinflation. Since domestic prices in each of the three regions has risen by 10 percent in 1984, the fact that nominal money stocks are falling in 1984 relative to the baseline means that real money balances are declining by more that 10 percent in 1984, i.e. that monetary policy is highly nonaccomodative in the year of the price shock. Also, fiscal policy is restrictive in the U.S. (where there is a surplus of 0.5 percent of GNP in 1984), and Japan (where there is a surplus of 0.8 percent of GNP), while fiscal policy is neutral in the ROECD. In all countries, there is a sharp recession in 1984 of about 10 percent of GDP relative to potential, and actual GDP reapproaches its potential level only slowly over time. Note that because of the monetary stringency, there is a sharp rise in nominal short-term interest rates, with interest rates rising by 15.4 percentage points in the U.S. in 1984, by 16.1 percentage points in Japan, and by 14.8 percentage points in the ROECD. Interest rates fall gradually over time, in line with the gradual disinflation.

Table 7 showed the optimal cooperative response. Now table 8 shows what happens when policy makers act independently and noncooperatively, under a regime of floating exchange rates. Suddenly, everybody tries to maintain a strong currency in order to help fight off the inflationary shock. Each country

TABLE 7 Cooperative Response to an Inflationary Shock Under a Flexible Exchange Rate

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-10.1	-8.0	-6.4	-5.2	-4.1	-3.3
Inflation	D	10.0	5.9	4.8	3.8	3.0	2.4
Nominal Interest Rate	D	15.4	12.3	9.7	7.6	6.1	5.0
Exchange Rate (Ecu/$)	%	0.6	0.0	-0.5	-1.0	-1.4	-1.9
Trade Balance	%GNP	0.2	0.2	0.1	0.1	0.1	0.1
Budget Deficit	%GNP	-0.5	-0.3	-0.2	-0.1	-0.1	0.0
Money Supply	%	-0.8	2.0	6.9	12.2	17.0	21.2

Japanese Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-9.8	-7.9	-6.4	-5.1	-4.2	-3.4
Inflation	%	9.2	5.4	4.4	3.5	2.9	2.3
Nominal Interest Rate	D	16.1	12.9	10.0	7.8	6.2	4.9
Exchange Rate (YEN/$)	%	-5.1	-4.5	-3.9	-3.5	-3.3	-3.1
Trade Balance	%GNP	-0.8	-0.6	-0.6	-0.5	-0.4	-0.2
Budget Deficit	%GNP	-0.8	-0.5	-0.4	-0.3	-0.3	-0.2
Money Supply	%	-1.1	0.8	5.3	10.3	15.0	19.0

ROECD Economies:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-10.3	-8.0	-6.4	-5.1	-4.0	-3.2
Inflation	%	9.9	5.8	4.6	3.6	2.9	2.3
Nominal Interest Rate	D	14.8	11.6	8.9	6.8	5.3	4.2
Trade Balance	%GNP	0.4	0.2	-0.1	-0.2	-0.3	-0.2
Budget Deficit	%GNP	0.0	0.0	0.0	0.0	0.0	-0.1
Money Supply	%	-0.5	2.3	7.3	12.6	17.4	21.4

TABLE 8 Non-Cooperative Response To an Inflationary Shock Under a Flexible Exchange Rate

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-10.2	-8.0	-6.4	-5.2	-4.1	-3.3
Inflation	D	9.9	5.9	4.7	3.8	3.0	2.4
Nominal Interest Rate	D	19.3	14.7	11.8	9.4	7.7	6.3
Exchange Rate (Ecu/$)	%	1.5	0.5	-0.1	-0.7	-1.2	-1.7
Trade Balance	%GNP	0.2	0.1	0.1	0.1	0.1	0.1
Budget Deficit	%GNP	1.3	0.8	0.6	0.6	0.5	0.4
Money Supply	%	-2.5	-0.1	4.9	10.3	15.3	19.6

Japanese Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-10.1	-7.8	-6.3	-5.1	-4.1	-3.3
Inflation	%	9.1	5.3	4.3	3.5	2.8	2.3
Nominal Interest Rate	D	19.9	15.6	12.7	10.3	8.6	7.3
Exchange Rate (YEN/$)	%	-5.2	-4.6	-4.1	-3.7	-3.5	-3.3
Trade Balance	%GNP	-0.7	-0.6	-0.5	-0.5	-0.4	-0.3
Budget Deficit	%GNP	1.4	0.9	0.7	0.6	0.5	0.5
Money Supply	%	-2.9	-1.4	2.8	7.8	12.5	16.6

ROECD Economies:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-10.3	-8.0	-6.3	-5.0	-4.0	-3.2
Inflation	%	10.0	5.8	4.6	3.7	2.9	2.3
Nominal Interest Rate	D	18.3	14.0	11.1	8.9	7.2	5.9
Trade Balance	%GNP	0.6	0.3	0.0	-0.2	-0.3	-0.3
Budget Deficit	%GNP	1.6	1.0	0.8	0.6	0.5	0.5
Money Supply	%	-2.1	0.5	5.5	10.9	15.8	19.9

therefore has more expansionary fiscal policy than in the cooperative solution (the U.S. for example runs a budget deficit of 1.3 percent of GNP in 1984) and has more contractionary monetary policy than in the cooperative case. The result is that noncooperation under floating leads to very high world interest rates, since the whole world is tilted towards fiscal expansion and monetary contraction. U.S. nominal interest rates jump by 19.3 percentage points in the noncooperative floating rate case, whereas they increased by only 14.8 percentage points in the cooperative policy response.

In Tables 9 and 10 we ask what happens when the same shock occurs in a regime of fixed exchange rates, first under a dollar standard, and then under a modified McKinnon rule. The notable point about the dollar standard is that the U.S. still has an incentive to pursue fiscal expansion and monetary contraction, just as under the floating rate case. A fiscal expansion in the U.S. reduces output abroad (we noted the negative transmission in Sections II and III), and thereby lowers foreign inflation. Lower foreign inflation in turn lowers U.S. import prices. Similarly, a U.S. monetary contraction has the same side-effect. Thus, the U.S., as center of monetary system, shifts its policy mix in a direction intended to promote very sharp disinflation abroad. In the other countries, expansionary budget policies are undertaken defensively, in order to limit the extent of disinflation and economic contraction implicit in the U.S. policies. The result is that, like the floating rate case, each country is led to pursue a policy mix of large budget deficits and very contractionary monetary policies. World interest rates shoot up, and the world falls moves into recession.

TABLE 9 Non-Cooperative Response to an Inflationary Shock Under a Dollar Standard

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-10.5	-8.3	-6.6	-5.2	-4.1	-3.3
Inflation	D	9.9	5.7	4.5	3.5	2.8	2.2
Nominal Interest Rate	D	22.8	18.1	14.4	11.5	9.3	7.6
Exchange Rate (Ecu/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.2	0.1	0.0	0.0	-0.1	0.0
Budget Deficit	%GNP	2.8	2.2	1.9	1.5	1.3	1.1
Money Supply	%	-4.2	-2.7	2.0	7.5	12.7	17.1

Japanese Economy:

Real GNP	%	-9.8	-7.7	-6.2	-5.0	-4.1	-3.4
Inflation	%	9.7	5.8	4.7	3.7	3.0	2.4
Nominal Interest Rate	D	22.8	18.2	14.6	11.7	9.6	8.0
Exchange Rate (YEN/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.1	0.0	-0.2	-0.3	-0.4	-0.4
Budget Deficit	%GNP	1.3	0.9	0.7	0.6	0.6	0.5
Money Supply	%	-4.1	-2.5	2.4	7.9	13.1	17.6

ROECD Economies:

Real GNP	%	-10.7	-8.1	-6.3	-4.8	-3.8	-2.9
Inflation	%	9.8	5.6	4.5	3.6	2.9	2.4
Nominal Interest Rate	D	22.8	18.4	15.0	12.3	10.2	8.6
Trade Balance	%GNP	0.4	0.2	0.0	-0.2	-0.3	-0.3
Budget Deficit	%GNP	4.4	3.2	2.5	1.9	1.4	1.0
Money Supply	%	-4.3	-2.9	1.7	7.2	12.4	17.0

TABLE 10 Non-Cooperative Response to an Inflationary Shock Under the McKinnon Rule

U.S. Economy:

		1984	1985	1986	1987	1988	1989
Real GNP	%	-10.0	-8.0	-6.5	-5.2	-4.2	-3.4
Inflation	D	9.9	5.9	4.7	3.7	3.0	2.3
Nominal Interest Rate	D	16.6	13.3	10.6	8.4	6.8	5.6
Exchange Rate (Ecu/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	0.1	0.1	0.0	0.0	0.0	0.0
Budget Deficit	%GNP	0.2	0.3	0.4	0.4	0.4	0.4
Money Supply	%	-1.2	1.2	6.0	11.2	16.0	20.1

Japanese Economy:

Real GNP	%	-8.3	-7.0	-6.0	-5.1	-4.4	-3.8
Inflation	%	9.7	6.3	5.2	4.2	3.3	2.6
Nominal Interest Rate	D	16.6	13.1	10.2	7.9	6.2	5.0
Exchange Rate (YEN/$)	%	0.0	0.0	0.0	0.0	0.0	0.0
Trade Balance	%GNP	-0.1	-0.3	-0.4	-0.5	-0.5	-0.5
Budget Deficit	%GNP	-1.3	-1.1	-0.9	-0.7	-0.4	-0.2
Money Supply	%	-0.7	2.4	7.7	13.2	18.3	22.5

OECD Economies:

Real GNP	%	-10.5	-8.1	-6.3	-5.0	-3.9	-3.0
Inflation	%	9.8	5.7	4.5	3.7	3.0	2.4
Nominal Interest Rate	D	16.6	13.3	10.6	8.4	6.8	5.6
Trade Balance	%GNP	0.3	0.1	0.0	-0.1	-0.1	-0.1
Budget Deficit	%GNP	1.2	0.9	0.7	0.5	0.2	0.1
Money Supply	%	-1.4	0.8	5.6	10.8	15.7	19.9

Table 10, under the Modified McKinnon regime, shows the advantage of this regime in fighting a global inflationary shock. As we saw in the theoretical analysis of Section IV, countries no longer have the incentive to run large budget deficits under the McKinnon regime, since they know that they cannot get disinflationary benefits from such a policy mix. Therefore, they all choose to have lower budget deficits than in the noncooperative equilibrium under floating, and than in the noncooperative equilibrium under the dollar standard. In this sense, the shift in regime almost substitutes for the cooperation assumed in Table 7. World interest rates rise much less under the modified McKinnon plan than under the other noncooperative regimes.

We can make a formal comparison of the outcomes of the four regimes by measuring the intertemporal welfare function, starting in 1984, for all of the countries given the different adjustment paths. The results of this comparison are shown below:

Intertemporal welfare measurement, in:

	U.S.	Japan	ROECD
Cooperative case	-14.884	-13.416	-14.626
Non-Cooperative case	-14.983	-13.441	-14.886
Dollar standard	-15.381	-14.286	-15.644
Modified McKinnon	-14.739	-14.239	-14.695

Comparing the non-cooperative case with cooperation we see that each country has a lower loss under cooperation. The dollar standard leads uniformally to the largest loss. For the U.S. and the ROECD, the McKinnon rule performs well relative to the non-cooperative case, but is worse for Japan. The ranking of non-cooperation and the McKinnon Rule is therefore ambiguous.

The results have shown that national welfare in responding to an exogenous shock will be altered by the nature of the monetary regime, and that at least for one shock (a global inflationary disturbance), the symmetric fixed exchange rate regime envisioned by McKinnon might have some merit. However, it is extremely inappropriate to draw conclusions about the relative merits of exchange rate regimes from one type of shock. In the next section, we enrich the comparison among regimes by using a technique that allows us to examine regime performance under a variety of disturbances.

VI. Asymptotic Properties of Alternative Regimes

Our second approach to comparing interactions under alternative exchange regimes uses a technique developed in McKibbin and Sachs [1985], in which we calculate the steady-state variances of a set of targets when the model is subject to a range of stochastic shocks, and when national policymakers optimize their policy choices with respect to a social welfare function. Related methods have been employed by Currie and Levine [1984]. In the illustration in this section, the stochastic shocks are included in equations for aggregate demand, prices and money demand in both the U.S. and ROECD. It is assumed that in each period the shocks hit after the policies are in place, so that the policy choices are not conditioned on the realizations of the disturbances hitting the system within the period.

Under our assumption of an additively separable, quadratic social welfare function, average operating welfare of an economy in a particular monetary regime can be written in terms of the variances and covariances of the target variables under the particular regime. The numerical techniques in this section allow us to determine the asymptotic variance-covariance matrices for the target variables for each of the countries, and thereby to determine the average welfare levels of the economies under each of the regimes. For each regime, we proceed as follows. Optimal rules of adjustment, in the form

$$U_t^i = \Gamma^i X_t \qquad i = \text{U.S., ROECD, and Japan}$$

are calculated for each country, using the dynamic programming solutions shown in the previous section of the paper. We may then substitute these rules back into the structural equations of the model. Given the asymptotic variance-covariance structure of the shocks, we can then solve for the asymptotic variance-covariance structure of the target variables. Given these results, it is possible to calculate the asymptotic level of expected welfare for each country under each regime, by a method described later in this section. In this way, we can find out which regimes are most attractive independent of the initial conditions of the economy, in other words, in the long-run operating characteristics.

Since the technique is somewhat technical, it is worth spelling out in some detail, as we now proceed to do. Once again, we begin with the state-space representation of the model, as reproduced here from equations 7 to 9:

$$X_{t+1} = AX_t + Be_t + CU_t + Z\epsilon_t \quad (7')$$

$$_t(e_{t+1}) = DX_t + Fe_t + GU_t + W\epsilon_t \quad (8')$$

$$\tau_t = MX_t + Le_t + NU_t + O\epsilon_t \quad (9')$$

We now make several assumptions about the stochastic disturbances. They all enter additively so certainty equivalence holds. All shocks have persistent effects in the model. This is because the shocks enter into dynamic equations which cause the effects of the shocks to propagate over time. The shocks to the aggregate demand equation (ϵ^a) are entered explicitly in the following way:

$$\mu_{t+1} = .75 \ (\mu_t) + \epsilon^a_t$$

where μ_t becomes part of the state vector X_t.

The other shocks, although serially uncorrelated, are persistent because of the dynamic specification of the model: the price shocks are built into a wage-price spiral in the model, and disturbances to money demand affect future money demand because of a lagged adjustment specification of the money demand equation (which makes the future demand for real money balances a function of the lagged level of real money balances).

The shocks also satisfy the following conditions:

$$E_{t-1}(\epsilon_t) = 0$$

$$E_{t-1}(\epsilon_t \epsilon_t^T) = \Sigma$$

Policy rules are written in the form:

$$U_t = \Gamma_1 X_t \qquad (10')$$

where U_t is the stacked vector consisting of the policy instruments of the individual regions, U_t^i, i= U.S., ROECD, Japan.

The policy rule may be the result of an optimization procedure (the case that we study in this section), or may be chosen by some other arbitrary technique. In other words, the technique in the section can be used to analyze each individual's favorite "optimal" policy rule, whether or not that rule is derived from a formal optimization procedure.

Given a specification of a policy rule, and given the structural equations of the system in (7') to (9') we find the stable manifold for the "jumping" variables e_t :

$$e_t = H_1 X_t + H_2 \epsilon_t \qquad (11)$$

(This equation can be derived through various procedures, including the closed-form solutions of Blanchard and Kahn [1981], or by various iterative techniques, one of which we have developed and used here).

Then, by substituting (11) into (7'):

$$X_{t+1} = \bar{A} X_t + \bar{Z} \epsilon_t \qquad (12)$$

where $\bar{A} = A + BH_1 + C\Gamma_1$

and $\bar{Z} = Z + BH_2$

With the system written in the canonical form of a first-order stochastic difference equation, as in (12), it is straightforward, though tedious, to calculate the asymptotic variance-covariance structure of the state variables X. Once these are calculated, it is possible to use the equation for the target variables τ, in order to calculate the variance-covariance matrix of the target variables. A full description of the numerical techniques used to get to this point is provided in McKibbin and Sachs [1985].

Once the variance-covariance matrix of the target variables is known, we can also calculate the expected utility loss given some arbitrary welfare function.

Let $\Pi = E(\tau\tau^T)$, and utility $U = \sum_{t=0}^{\infty} \beta^t \tau^T W\tau$

where W is a diagonal matrix with weights for each target along the diagonal.

Then,

$$E(\tau^T W\tau) = TrE(W\tau\tau^T) = Tr(W\Pi). \qquad (13)$$

Thus we find

$$E(U) = Tr(W\Pi)/(1-\beta) \qquad (14)$$

Using the procedures just outlined we can now calculate the variance of targets under the alternative monetary regimes. For each regime, we calculate optimal policy rules of the form given in equation (10), and then we derive the asymptotic variance-covariance structures of the target variables. Rather than summarizing the results by presenting a single expected welfare level for each regime, as in the equation (14), we instead report the asymptotic variances of the key variables, so that the reader can see how well the alternative regimes do in stabilizing the target variables in the world economy. (For convenience, the results are actually reported as standard deviations, rather than variances).

These results are reported in tables 11 to 13, which present the standard deviations of output, inflation, the current account and the fiscal deficit in the U.S. and ROECD, given shocks to aggregate demand, prices and monetary velocity in each of these regions. Each row of numbers in the tables correspond to the asymptotic standard error of each target when the economy is subject to a given stochastic shock, within a given monetary regime. Results are reported for five types of monetary regimes: (1) a pure float, in which no policy actions are taken in any country (i.e. pure laissez-faire); (2) a cooperative float, in which all of the instruments in all of the countries are cooperatively controlled by a central authority, who maximizes a weighted sum of regional utilities; (3) a noncooperative float, in which monetary and fiscal policies are selected in a noncooperative way by the macroeconomic authorities in each of the countries; (4) the simple McKinnon rule, with fixed exchange rates, and a constant level of global money; and (5) a modified McKinnon rule, in which the global money is cooperatively controlled, in the way outlined in Section V.

Consider for example the effects of a unit shock to U.S. aggregate

Table 11: Variance of Targets Under Aggregate Demand Shocks

U.S. Demand Shock

	pure float	cooperative float	noncooperative float	McKinnonI	McKinnonII
U.S.					
output	2.164	1.534	1.490	3.253	3.197
inflation	0.932	0.539	0.508	1.276	1.221
current account	0.678	0.584	0.636	0.590	0.629
fiscal deficit	0.010	0.255	0.108	1.518	1.382
ROECD					
output	1.039	0.729	0.764	0.950	0.995
inflation	0.621	0.433	0.458	0.372	0.525
current account	0.557	0.474	0.525	0.497	0.530
fiscal deficit	0.002	0.048	0.093	0.506	0.905

ROECD Demand Shock

	pure float	cooperative float	noncooperative float	McKinnonI	McKinnonII
U.S.					
output	1.031	0.629	0.627	0.651	0.673
inflation	0.648	0.408	0.406	0.217	0.376
current account	0.251	0.236	0.234	0.222	0.352
fiscal deficit	0.015	0.053	0.089	0.355	0.803
ROECD					
output	2.114	1.383	1.382	3.636	3.554
inflation	0.929	0.456	0.456	1.407	1.342
current account	0.300	0.319	0.329	0.352	0.498
fiscal deficit	0.003	0.037	0.054	1.635	1.168

demand, under the alternative regimes given in table 11. The standard deviation of the shock itself is one percent of U.S. GDP (the corresponding shock in the ROECD has a standard deviation of one percent of ROECD GDP). Under a pure laissez-faire float, (denoted "flexible exchange rate" in the table), the unit shock to aggregate demand induces an asymptotic standard deviation in real output in the U.S. of 2.164 percent of GDP. Under a global cooperative arrangement, the standard deviation is reduced to 1.534 percent of U.S. GDP. If the U.S. is stabilizing by itself, in a noncooperative flexible exchange rate regime, and if the stabilization is such as to minimize the social welfare function introduced earlier, then the variability of U.S. GDP due to pure demand shocks is reduced still further, to 1.490 percent of U.S. GDP. The shock of course also induces fluctuations in inflation and in the current account-GDP ratio (the table records the standard deviation of both of these variables when measured in percentage points; i.e. the standard deviation of 0.932 in U.S. inflation, signifies a standard deviation of just under one percentage point of annual inflation).

The key point in table 11 is that the fixed exchange rate systems (McKinnon I and McKinnon II) are destabilizing for the real GDPs of both the U.S. and the ROECD when U.S. aggregate demand is hit by stochastic shocks. In a floating rate system, some of the demand shock is automatically muted as the floating rate appreciates, and thereby shifts some of aggregate demand abroad. Under the McKinnon rule, however, if the U.S. is hit by a positive aggregate demand shock, the U.S. money supply automatically expands, enough to forestall any appreciation of the exchange rate. The demand shock is then magnified in the U.S., as it is amplified by a monetary expansion. Abroad, we have already seen, the foreign money supply contracts under the rules of the game, and the foreign economy actually slumps. For this kind of shock, it doesn't really matter whether the global money stock is fixed (as in the basic McKinnon proposal) or varied cooperatively (as in the modified McKinnon proposal, labelled McKinnon II), though it is not clear to us why there is not more gain to a coordinated monetary response. Note finally, some policy is better than none, since the cooperative and noncooperative floating rate policies dominate the laissez-faire response in all cases.

When we turn our attention to price shocks, in table 12, little of this conclusion is changed. In almost all cases, cooperative or noncooperative floating is better than either laissez-faire or a fixed exchange rate. This result is really not surprising, in that a nominal price or wage shock in one country (due, for example, to a temporary productivity decline, or to wage militancy, etc.) is best absorbed in the world markets through a depreciation of the currency of the inflating country. In this way, there is a substantial gain in the stability of real output, with only a slight decline in the stability of the inflation rate (note that the Laissez-faire policies and the pure McKinnon rule have a very slightly lower variance of inflation than do the floating rate rules).

Why is it that the McKinnon rule seemed stabilizing in the inflation game of Section V, but seems rather unattractive in the present context? The reason is that the previous game studied a case in which all countries simultaneously are faced with a price shock, whereas in table 12, the price

Table 12 Variance of Targets Under Price Shocks

U.S. Price Shock

	pure float	cooperative float	noncooperative float	McKinnonI	McKinnonII
U.S.					
output	2.723	1.771	1.783	2.465	2.187
inflation	1.229	1.418	1.418	1.415	1.439
current account	0.377	0.266	0.278	0.692	0.670
fiscal deficit	0.012	0.083	0.150	1.346	1.111
ROECD					
output	0.517	0.198	0.185	0.318	0.399
inflation	0.374	0.163	0.157	0.236	0.562
current account	0.295	0.212	0.229	0.585	0.578
fiscal deficit	0.002	0.119	0.040	0.419	0.812

ROECD Price Shock

	pure float	cooperative float	noncooperative float	McKinnonI	McKinnonII
U.S.					
output	0.664	0.274	0.230	0.302	0.280
inflation	0.417	0.207	0.176	0.153	0.530
current account	0.149	0.134	0.092	0.235	0.469
fiscal deficit	0.005	0.118	0.044	0.310	0.758
ROECD					
output	2.972	1.899	1.922	2.952	2.624
inflation	1.281	1.482	1.504	1.637	1.597
current account	0.164	0.171	0.139	0.350	0.566
fiscal deficit	0.001	0.159	0.202	1.745	1.189

shocks in the U.S. or in the ROECD are considered to be independently distributed. This distinction is potentially very important, in that when the price shocks are independent, it is useful to allow for nominal exchange rate variability across the countries, while when the shocks are highly correlated, the need for exchange rate movements is very much reduced, and the benefits to reducing cross-country strategic actions that cancel each other out, is likewise enhanced. For that reason, the methodology in this section is somewhat biased against a fixed exchange rate system.

Table 13 refers to velocity shocks in the money demand equations in the U.S. and the ROECD. Once again, we study the case in which the shocks are independently distributed. Now we have an interesting, and intuitively plausible finding: a fixed rate regime stabilizes the economy of the country experiences the monetary shock, but destabilizes the economy of the other country. Consider concretely what happens when U.S. money demand rises, under the alternative systems (remember that the shock is unobserved within the period that it occurs). Under floating rates, the economy with rising money demand experiences a currency appreciation and a corresponding decline in aggregate demand, resulting from the fall in national competitiveness. The other economies experience either a modest gain or fall in output: competitiveness improves, but export markets shrink since the economy with rising money demand goes into recession. Now, under a McKinnon rule, the economy with rising money demand would automatically have an accomodating increase in money, as the monetary authority expands money enough to keep the exchange rate pegged. The other economy, however, would be forced to contract the money supply under the

Table 13 Variance of Targets Under Money Velocity Shocks

U.S. Money Shock

	pure float	cooperative float	noncooperative float	McKinnonI	McKinnonII
U.S.					
output	1.628	1.546	1.550	0.631	0.633
inflation	0.505	0.604	0.607	0.233	0.276
current account	0.162	0.168	0.174	0.077	0.063
fiscal deficit	0.001	0.041	0.070	0.164	0.019
ROECD					
output	0.272	0.122	0.126	0.936	0.888
inflation	0.112	0.046	0.048	0.337	0.347
current account	0.153	0.162	0.168	0.094	0.081
fiscal deficit	0.000	0.055	0.006	0.267	0.060

ROECD Money Shock

	pure float	cooperative float	noncooperative float	McKinnonI	McKinnonII
U.S.					
output	0.291	0.060	0.039	0.629	0.630
inflation	0.113	0.068	0.055	0.234	0.275
current account	0.068	0.058	0.033	0.079	0.063
fiscal deficit	0.002	0.071	0.015	0.172	0.019
ROECD					
output	2.184	1.955	1.976	0.935	0.885
inflation	0.666	0.772	0.787	0.339	0.346
current account	0.086	0.068	0.054	0.094	0.081
fiscal deficit	0.001	0.086	0.108	0.284	0.060

rules of the game, so that its economy could be greatly destabilized.

Once again, the conclusions would look much more appealing to the McKinnon rule once we allow for a negative correlation across countries in the money shocks. Suppose, for example, that the money shocks in the U.S. and ROECD are perfectly negatively correlated. The results for this case are given in table 14. In this case the McKinnon rule is close to being perfectly stabilizing, since the country with expanding money demand automatically has a rising money supply, while the country with the contracting money demand automatically has a falling money supply. The other regimes perform far worse than the McKinnon rule for this particular type of shock, which indeed is the type of shock stressed by McKinnon.

A full analysis of the costs and benefits of the alternative systems would require a more complete investigation of the covariance structure of the underlying shocks, something that we hope to do in future work.

VII. Conclusions

This paper has analyzed the implications of alternative monetary regimes in the OECD for the transmission of fiscal policy, and for the efficiency of strategic interactions across the major OECD economies. While the work is tentative, we have already arrived at several useful conclusions. First, the nature of fiscal interactions will vary greatly depending on the nature of the monetary regime. Under floating exchange rates, transmission of fiscal policy tends to be positive, while under a fixed rate system of the sort propounded by McKinnnon, fiscal policy can actually be negatively transmitted. In asymmetric

Table 14: Variance of Targets Under Negatively Correlated U.S. and ROECD Money Shocks

	pure float	cooperative float	noncooperative float	McKinnonI	McKinnonII
U.S.					
output	1.608	1.490	1.518	0.002	0.002
inflation	0.430	0.549	0.569	0.001	0.001
current account	0.174	0.188	0.176	0.000	0.000
fiscal deficit	0.004	0.111	0.058	0.000	0.000
ROECD					
output	2.386	2.076	2.101	0.003	0.003
inflation	0.680	0.794	0.812	0.001	0.001
current account	0.135	0.173	0.164	0.000	0.000
fiscal deficit	0.001	0.141	0.103	0.001	0.000

monetary systems, such as a dollar standard, U.S. fiscal policy may well be negatively transmitted, while foreign fiscal policy is almost surely positively transmitted to the U.S. These theoretical findings are supported by simulation experiments in a large-scale multi-region model of the world economy (the MSG model). The quantitative estimates show that negative transmission of fiscal policy under a fixed exchange rate regime is more than a theoretical curiosity, and is at the least a real empirical possibility, if not likelihood.

One of the alleged advantages of a move to fixed exchange rates is that it would mute the incentives for beggar-thy-neighbor policies under flexible exchange rates. We illustrated that proposition in two ways, first using a simple theoretical model, and then by examining a differential game in which the large three OECD regions all inherit a high inflation rate and then use macroeconomic policies in the attempt to pursue an optimal disinflation. As we show, the noncooperative floating regime tends to create an incentive towards fiscal expansion and monetary contraction that is inefficient from the point of view of the social welfare functions in the individual countries.

A new methodology is then used at the end, to examine the "average" operating properties of the alternative systems. The question of which system is best is shown to depend on which stochastic disturbances are dominant, a standard result in the analysis of fixed versus flexible rates. The results on the whole are relatively hostile to fixed exchange rates, but that might depend on our specification of the shocks. As is described in the text, price shocks which are positively correlated across countries, or money demand shocks which are negatively correlated across countries, will both tend to be relatively well handled by fixed exchange rate regimes.

References

Blanchard, O. and C. Kahn (1980) "The Solution of Linear Difference Models Under Rational Expectations", Econometrica 48(5), July, PP 1305-1312.

Buiter, W. and R. Marston (1985) International Economic Policy Coordination, Cambridge University Press.

Canzoneri, M. and J. A. Gray (1985) "Two Essays on Monetary Policy in an Interdependent World", International Economic Review (forthcoming)

Currie, D. and P. Levine (1985) "Macroeconomic Policy Design in and Interdependent World" in Buiter and Marston (1985), pp228-267.

Eichengreen, B. (1985) "International Policy Coordination in Historical Perspective: A view from the Interwar Years" in Buiter and Marston (1985), pp 139-178.

Fair, R. and J. Taylor (1983) "Solution and Maximum Likelihood Estimation of Dynamic Non-Linear Rational Expectations Models." Econometrica 51(4), pp 139-178.

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

Ishii N., McKibbin W., and J. Sachs (1985) "The Economic Policy Mix, Policy Cooperation, and Protectionism: Some Aspects of Macroeconomic Interdependence Among the United States, Japan, and Other OECD Countries", Journal of Policy Modeling 7(4) (forthcoming).

Matsuyama, K. (1985) "Strategic Aspects of the International Gold Standard" mimeo, Harvard University.

McKibbin, W. and J. Sachs (1985) "Comparing the Global Performance of Alternative Exchange Arrangements" forthcoming.

McKinnon, R. (1984) "An International Standard for Monetary Stabilization," Policy Analyses in International Economics, No. 8, Institute for International Economics, March

Mundell, R. (1968) International Economics New York: Macmillan. chapter 18.

Obstfeld, M. (1985) "Floating Exchange Rates: Experience and Prospects", Bookings Papers on Economic Activity 2; pp 369-450.

Oudiz, G. and Sachs, J. (1985) "International Policy Coordination in Dynamic Macroeconomic Models" in Buiter and Marston (1985).

Roosa, R. (1984) "Exchange Rate Arrangements in the Eighties" in The International Monetary System, Federal Reserve Bank of Boston Conference Series No 28.

Sachs, J. (1985a) "The Dollar and The Policy Mix: 1985" Brookings Papers on Economic Activity, 85:1 pp 117-185 .

Sachs, J. (1985b) "The Case for More Managed Exchange Rates" Paper presented to the Federal Reserve Bank of Kansas City Conference on the U.S. Dollar, Jackson Hole Wyoming, August 1985

Sachs, J., and W. McKibbin (1985) "Macroeconomic Policies in the OECD and LDC External Adjustment" NBER Working Paper 1534, January, forthcoming in F. Colaco and S. van Wijnbergen, eds (1986) International Capital Flows and the Developing Countries.

Swoboda, A. (1978) "Gold, Dollars, Euro-Dollars amd the World Money Stock Under Fixed Exchange Rates" American Economic Review (September).

Williamson, J. (1983) "The Exchange Rate System," Policy Analyses in International Economics, No. 5, Institute for International Economics, September

Appendix: MSG Model of the World Economy

U.S. Equations

$$Q^U = D^U + G^U + (C_U^O + C_U^J + C_U^L + C_U^P) - (\Lambda^O C_O^U + \Lambda^J C_J^U + \Lambda^L C_L^U + \Lambda^P C_P^U)$$

$$\Lambda^O = P^O E^O / P^U$$

$$\Lambda^J = P^J E^J / P^U$$

$$\Lambda^L = P^L / P^U$$

$$\Lambda^P = P^P / P^U$$

$$D^U = (1-s)(Q^U - T^U) + \delta H^U - .5\nu r^U - .5\nu R^U$$

$$H^U = B^U + A_L^U - A_U^O - A_U^P - A_U^J$$

$$B_{t+1}^U = (B_t^U + DEF_t^U)/(1+n)$$

$$DEF^U = G^U + r^U B^U - v^U B_L^U - T^U$$

$$M_t^U / P_t^U = \{ Q_t^{U\phi} (1+i_t^U)^{-\beta} \}^{.5} \{ M_{t-1}^U / P_{t-1}^U \}^{.5}$$

$$i_t^U = r_t^U + \pi_{t+1}^U$$

$$r_t^U = R_t^U - ({}_tR_{t+1}^U - R_t^U)/R_t^U$$

$$v_t^U = .13 r_t^U + .82 v_{t-1}^U$$

$$\pi_{t+1}^U = (P_{t+1}^U - P_t^U)/P_t^U$$

$$\pi_{t+1}^{CU} = (P_{t+1}^{CU} - P_t^{CU})/P_t^{CU}$$

$$\pi_{t+1}^U = \pi_t^{CU} + \Omega Q_t^U + \tau(Q_t^U - Q_{t-1}^U)$$

$$P^{CU} = (P^U)^{\gamma_1}(P^O E^O)^{\gamma_2}(P^L)^{\gamma_3}(P^J E^J)^{\gamma_4}(P^P)^{(1-\gamma_1-\gamma_2-\gamma_3-\gamma_4)}$$

$$C_O^U = \alpha_0(D^U+G^U)(\Lambda^O)^{-1.5}$$

$$C_L^U = \alpha_1(D^U+G^U)(\Lambda^L)^{-1.0}$$

$$C_P^U = \alpha_2(D^U+G^U)(\Lambda^P)^{-0.2}$$

$$C_J^U = \alpha_3(D^U+G^U)(\Lambda^J)^{-1.5}$$

$$TB^U = (C_U^O+C_U^L+C_U^P+C_U^J) - (C_O^U\Lambda^O+C_L^U\Lambda^L+C_P^U\Lambda^P+C_J^U\Lambda^J)$$

Japan Equations

$$Q^J = D^J + G^J + (C_J^U+C_J^O+C_J^L+C_J^P) - (C_U^J+C_O^J\Lambda^O+C_L^J\Lambda^L+C_P^J\Lambda^P)/\Lambda^J$$

$$D^J = (1-s^J)(Q^J-T^J) - \nu r^J + \delta H^J$$

$$H^J = B^J + A_U^J/\Lambda^J + A_{LJ}^J + A_{LU}^J/\Lambda^J - A_J^P$$

$$B_{t+1}^J = (B_t^J+DEF_t^J)/(1+n)$$

$$DEF^J = G^J + r^J B^J - v^J B_L^J - T^J$$

$$M_t^J/P_t^J = \{ Q_t^{J\phi}(1+i_t^J)^{-\beta} \}^{.5} \quad \{ M_{t-1}^J/P_{t-1}^J \}^{.5}$$

$$i_t^J = r_t^J + \pi_{t+1}^J$$

$$v_t^J = .82v_{t-1}^J + .13r_t^J$$

$$\pi_{t+1}^J = (P_{t+1}^J-P_t^J)/P_t^J$$

$$\pi^{CJ}_{t+1} = (P^{CJ}_{t+1}-P^{CJ}_{t})/P^{CJ}_{t}$$

$$\pi^{J}_{t+1} = \pi^{CJ}_{t} + \Omega Q^{J}_{t} + \tau(Q^{J}_{t}-Q^{J}_{t-1})$$

$$P^{CJ} = (P^{J})^{\gamma_5}(P^{U}/E^{J})^{\gamma_6}(P^{O}E^{O}/E^{J})^{\gamma_7}(P^{L}/E^{J})^{\gamma_8}(P^{P}/E^{J})^{(1-\gamma_5-\gamma_6-\gamma_7-\gamma_8)}$$

$$C^{J}_{U} = \alpha_4(D^{J}+G^{J})(\Lambda^{J})^{1.5}$$

$$C^{J}_{O} = \alpha_5(D^{J} + G^{J})(\Lambda^{O}/\Lambda^{J})^{-1.5}$$

$$C^{J}_{L} = \alpha_6(D^{J}+G^{J})(\Lambda^{L}/\Lambda^{J})^{-1.0}$$

$$C^{J}_{P} = \alpha_7(D^{J}+G^{J})(\Lambda^{P}/\Lambda^{J})^{-0.2}$$

$$TB^{J} = \Lambda^{J}(C^{U}_{J}+C^{O}_{J}+C^{L}_{J}+C^{P}_{J}) - (C^{J}_{U}+\Lambda^{O}C^{J}_{O}+\Lambda^{L}C^{J}_{L}+\Lambda^{P}C^{J}_{P})$$

$$A^{J}_{Ut+1} = (A^{J}_{Ut}+CA^{J}_{t})/(1+n) - [(A^{J}_{LJt+1}\Lambda^{J}_{t}+A^{J}_{LUt+1}+B^{J}_{Lt+1}\Lambda^{J}_{t}-A^{P}_{Jt+1}\Lambda^{J}_{t})$$
$$- (A^{J}_{LJt}\Lambda^{J}_{t}+A^{J}_{LUt}+B^{J}_{Lt}\Lambda^{J}_{t}-A^{P}_{Jt}\Lambda^{J}_{t})/(1+n)]$$

$$CA^{J} = TB^{J} + r^{U}(A^{J}_{U}+A^{J}_{LU}) + r^{J}\Lambda^{J}A^{J}_{LJ} + v^{J}\Lambda^{J}B^{J}_{L} - r^{J}\Lambda^{J}A^{P}_{J}$$

$$(A^{J}_{Ut}+A^{J}_{LUt})/\Lambda^{J}_{t} = \sigma^{J}[r^{U}_{t} - r^{J}_{t} - ({}_{t}\Lambda^{J}_{t+1}-\Lambda^{J}_{t})/\Lambda^{J}_{t}] + \theta H^{J}_{t}$$

<u>ROECD Equations</u>

$$Q^{O} = D^{O} + G^{O} + (C^{U}_{O}+C^{L}_{O}+C^{P}_{O}+C^{J}_{O}) - (C^{O}_{U}+C^{O}_{J}\Lambda^{J}+C^{O}_{L}\Lambda^{L}+C^{O}_{P}\Lambda^{P})/\Lambda^{O}$$

$$D^{O} = (1-s)(Q^{O}-T^{O}) - \nu r^{O} + \delta H^{O}$$

$$H^{O} = B^{O} + A^{O}_{U}/\Lambda^{O} + A^{O}_{L} - A^{P}_{O}/\Lambda^{O}$$

$$B^{O}_{t+1} = (B^{O}_{t}+DEF^{O}_{t})/(1+n)$$

$$DEF^{O} = G^{O} + r^{O}B^{O} - v^{O}B^{O}_{L} - T^{O}$$

$$M^{O}_{t}/P^{O}_{t} = \{ Q^{O\phi}_{t}(1+i^{O}_{t})^{-\beta} \}^{.5} \{ M^{O}_{t-1}/P^{O}_{t-1}\}^{.5}$$

$$i^{O}_{t} = r^{O}_{t} + \pi^{O}_{t+1}$$

$$v^{O}_{t} = .13r^{O}_{t} + .82v^{O}_{t-1}$$

$$\pi^{O}_{t+1} = (P^{O}_{t+1}-P^{O}_{t})/P^{O}_{t}$$

$$\pi^{CO}_{t+1} = (P^{CO}_{t+1}-P^{CO}_{t})/P^{CO}_{t}$$

$$\pi^{O}_{t+1} = \pi^{CO}_{t} + \Omega Q^{O}_{t} + \tau(Q^{O}_{t}-Q^{O}_{t-1})$$

$$P^{CO} = (P^{O})^{\gamma_{9}}(P^{U}/E^{O})^{\gamma_{10}}(P^{L}/E^{O})^{\gamma_{11}}(P^{J}E^{J}/E^{O})^{\gamma_{12}}(P^{P}/E^{O})^{(1-\gamma_{9}-\gamma_{10}-\gamma_{11}-\gamma_{12})}$$

$$C^{O}_{U} = \alpha_{8}(D^{O}+G^{O})(\Lambda^{O})^{1.5}$$

$$C^{O}_{J} = \alpha_{9}(D^{O}+G^{O})(\Lambda^{J}/\Lambda^{O})^{-1.5}$$

$$C^{O}_{L} = \alpha_{10}(D^{O}+G^{O})(\Lambda^{L}/\Lambda^{O})^{-1.0}$$

$$C^{O}_{P} = \alpha_{11}(D^{O}+G^{O})(\Lambda^{P}/\Lambda^{O})^{-0.2}$$

$$TB^{O} = (C^{U}_{O}+C^{L}_{O}+C^{P}_{O}+C^{J}_{O}) - (C^{O}_{U}+C^{O}_{J}\Lambda^{J}+C^{O}_{L}\Lambda^{L}+C^{O}_{P}\Lambda^{P})/\Lambda^{O}$$

$$A^{O}_{Ut+1} = (A^{O}_{Ut}+CA^{O}_{t})/(1+n) - [(A^{O}_{L}+B^{O}_{L})_{t+1}\Lambda^{O}_{t} - (A^{O}_{L}+B^{O}_{L})_{t}\Lambda^{O}/(1+n) - A^{P}_{Ot+1} + A^{P}_{Ot}/(1+n)]$$

$$CA^{O} = (A^{O}_{U}-A^{P}_{O})r^{U} + (A^{O}_{L}\Lambda^{O})r^{O} + (B^{O}_{L}\Lambda^{O})v^{O} + TB^{O}\Lambda^{O}$$

$$(A^{O}_{U}-A^{P}_{O})_{t}/\Lambda^{O}_{t} = \sigma[r^{U}_{t} - r^{O}_{t} - ({}_{t}\Lambda^{O}_{t+1}-\Lambda^{O}_{t})/\Lambda^{O}_{t}] + \Theta H^{O}_{t}$$

LDC Equations

$$P^L = (P^U)^{\eta_1}(P^O E^O)^{\eta_2}(P^J E^J)^{-\eta_3}(P^P)^{(1-\eta_1-\eta_2-\eta_3)}(C_L^U+C_L^O+C_L^P+C_L^J)^{\gamma_L}$$

$$C_U^L = \eta_1(C_U^L+\Lambda^O C_O^L+\Lambda^P C_P^L+\Lambda^J C_J^L)$$

$$C_O^L = \eta_2(C_U^L+\Lambda^O C_O^L+\Lambda^P C_P^L+\Lambda^J C_J^L)/\Lambda^O$$

$$C_J^L = \eta_3(C_U^L+\Lambda^O C_O^L+\Lambda^P C_P^L+\Lambda^J C_J^L)/\Lambda^J$$

$$C_P^L = (1-\eta_1-\eta_2-\eta_3)(C_U^L+\Lambda^O C_O^L+\Lambda^P C_P^L+\Lambda^J C_J^L)/\Lambda^P$$

$$TB^L = \Lambda^L(C_L^U+C_L^O+C_L^P+C_L^J) - C_U^L - \Lambda^O C_O^L - \Lambda^P C_P^L - \Lambda^J C_J^L$$

$$CA_t^L = \omega CA_{t-1}^L + \epsilon\{DEBT_t - \xi\Lambda_t^L(C_{Lt}^O+C_{Lt}^U+C_{Lt}^P+C_{Lt}^J)[1 + n(1-\omega)/\epsilon]\}$$

$$DEBT_t = A_L^U + (A_L^O\Lambda^O) + A_L^P + B_L^U + (B_L^O\Lambda^O) + A_{LU}^J + A_{LJ}^J\Lambda^J + B_L^J\Lambda^J$$

$$B_{Lt+1}^U = B_{Lt}^U + .1[A_{Lt+1}^U(1+n) - A_{Lt}^U]$$

$$B_{Lt+1}^O = B_{Lt}^O + .1[A_{Lt+1}^O(1+n) - A_{Lt}^O]$$

$$\Lambda_t^J B_{Lt+1}^J = \Lambda_t^J B_{Lt}^J + .1[(A_{LJt+1}^J\Lambda_t^J+A_{LUt+1}^J)(1+n) - (A_{LJt}^J\Lambda_t^J+A_{LUt}^J)]$$

$$A_{Lt+1}^O\Lambda_t^O = \{a_1[(A_{Lt+1}^U+A_{Lt+1}^O\Lambda_t^O+A_{Lt+1}^P +A_{LJt+1}^J\Lambda_t^J+A_{LUt+1}^J)(1+n)$$

$$- (A_{Lt}^U+A_{Lt}^O\Lambda_t^O+A_{Lt}^P+A_{LJt}^J\Lambda_t^J+A_{LUt}^J)] + A_{Lt}^O\Lambda_t^O\}/(1+n)$$

$$A_{Lt+1}^P = \{a_2[(A_{Lt+1}^U+A_{Lt+1}^O\Lambda_t^O+A_{Lt+1}^P+A_{LJt+1}^J\Lambda_t^J+A_{LUt+1}^J))(1+n)$$

$$- (A_{Lt}^U+A_{Lt}^O\Lambda_t^O+A_{Lt}^P+A_{LJt}^J\Lambda_t^J+A_{LUt}^J)] + A_{Lt}^P\}/(1+n)$$

$$A^J_{LJt+1}\Lambda^J_t = \{a_3[(A^U_{Lt+1}+A^J_{LJt+1}\Lambda^J_t+A^J_{LUt+1}+A^O_{Lt+1}\Lambda^O_t+A^P_{Lt+1})(1+n)$$
$$- (A^U_{Lt}+A^J_{LJt}\Lambda^J_t+A^J_{LUt}+A^O_{Lt}\Lambda^O_t+A^P_{Lt})] + A^J_{LJt}\Lambda^J_t\}/(1+n)$$

$$A^J_{LUt+1} = \{a_4[(A^U_{Lt+1}+A^J_{LJt+1}\Lambda^J_t+A^J_{LUt+1}+A^O_{Lt+1}\Lambda^O_t+A^P_{Lt+1})(1+n)$$
$$- (A^U_{Lt}+A^J_{LJt}\Lambda^J_t+A^J_{LUt}+A^O_{Lt}\Lambda^O_t+A^P_{Lt})] + A^J_{LUt}\}/(1+n)$$

$$A^U_{Lt+1} = (A^U_{Lt}+CA^L_t)/(1+n) - [(A^J_{LJt+1}\Lambda^J_t+A^J_{LUt+1}+A^O_{Lt+1}\Lambda^O_t+A^P_{Lt+1}+B^U_{Lt+1}+B^J_{Lt+1}\Lambda^J_t+B^O_{Lt+1}\Lambda^O_t)$$
$$- (A^J_{LJt}\Lambda^J_t+A^J_{LUt}+A^O_{Lt}\Lambda^O_t+A^P_{Lt}+B^U_{Lt}+B^J_{Lt}\Lambda^J_t+B^O_{Lt}\Lambda^O_t)/(1+n)]$$

OPEC Equations

$$P^P = (P^U)^{\eta_4}(P^OE^O)^{\eta_5}(P^JE^J)^{\eta_6}(P^L)^{(1-\eta_4-\eta_5-\eta_6)}(C^U_P+C^O_P+C^L_P+C^J_P)^{\gamma_P}$$

$$C^P_U = \eta_4(C^P_U+\Lambda^OC^P_O+\Lambda^LC^P_L+\Lambda^JC^P_J)$$

$$C^P_O = \eta_5(C^P_U+\Lambda^OC^P_O+\Lambda^LC^P_L+\Lambda^JC^P_J)/\Lambda^O$$

$$C^P_J = \eta_6(C^P_U+\Lambda^OC^P_O+\Lambda^LC^P_L+\Lambda^JC^P_J)/\Lambda^J$$

$$C^P_L = (1-\eta_4-\eta_5-\eta_6)(C^P_U+\Lambda^OC^P_O+\Lambda^LC^P_L+\Lambda^JC^P_J)/\Lambda^L$$

$$H^P = A^P_U + A^P_O + A^P_L+A^P_J\Lambda^J$$

$$TB^P = \Lambda^P(C^U_P+C^O_P+C^L_P+C^J_P) - C^P_U - \Lambda^OC^P_O - \Lambda^LC^P_L - \Lambda^JC^P_J$$

$$CA^P_t = \zeta[\psi(C^U_P+C^O_P+C^L_P+C^J_P)_t(P^P/P^U)_t - H^P_{t-1}] + nH^P_{t-1}$$

$$A^P_{Ut+1} = (A^P_{Ut}+CA^P_t)/(1+n) - [(A^P_O+A^P_L)_{t+1}+A^P_{Jt+1}\Lambda^J_t- (A^P_O+A^P_L+A^P_J\Lambda^J)_t/(1+n)]$$

$$A^P_{Ot+1} = \{b_1[(A^P_U+A^P_O+A^P_L+A^P_J\Lambda^J_t)_{t+1}(1+n) - (A^P_U+A^P_O+A^P_L+A^P_J\Lambda^P)_t] + A^P_{Ot}\}/(1+n)$$

$$A^P_{Jt+1}\Lambda^J_t = \{b_2[(A^P_U+A^P_O+A^P_L+A^P_J\Lambda^J_t)_{t+1}(1+n) - (A^P_U+A^P_O+A^P_L+A^P_J\Lambda^J)_t] + A^P_{Jt}\Lambda^J_t\}/(1+n)$$

Definitions

A_j^i	Claims on country j held by private creditors in country i
B_j^i	Claims on country j held by official creditors in country i
B^i	Government debt of country i
C_j^i	Consumption by country i of the output of country j
CA	Current account
D	Domestic absorption
DEBT	Developing country debt
DEF	Government deficit
E^0	Exchange rate ($/ECU)
E^J	Exchange rate ($/yen)
G	Government Expenditure
H	Real Financial Wealth
i	Nominal interest rate
M	Nominal money supply
n	Growth rate
P^i	Price level of country i goods
P^C	Consumer price index
π_t	Domestic price inflation
π_t^C	Consumer price inflation

Q	Gross domestic product
r	Real short interest rate
R	Real long interest rate
T	Taxes
TB	Trade Balance
v	Concessional real interest rate
Λ	Real exchange rate
${}_tX_{t+1}$	Expectation of X_{t+1} based on period t information

Parameter Values

$S = 0.3$

$S^J = 0.5$

$\nu = 0.2$

$\delta = 0.1$

$n = 0.03$

$\phi = 0.8$

$\beta = 0.9$

$\Omega = 0.2$

$\tau = 0.2$

$\gamma_1 = 0.922$

$\gamma_2 = 0.034$

$\gamma_3 = 0.024$

$\gamma_4 = 0.013$

$\gamma_5 = 0.893$

$\gamma_6 = 0.022$

$\gamma_7 = 0.020$

$\gamma_8 = 0.026$

$\gamma_9 = 0.911$

$\gamma_{10} = 0.032$

$\gamma_{11} = 0.028$

$\gamma_{12} = 0.010$

$\alpha_0 = 0.034$

$\alpha_1 = 0.024$

$\alpha_2 = 0.008$

$\alpha_3 = 0.013$

$\alpha_4 = 0.022$

$\alpha_5 = 0.020$

$\alpha_6 = 0.026$

$\alpha_7 = 0.039$

$\alpha_8 = 0.032$

$\alpha_9 = 0.010$

$\alpha_{10} = 0.028$

$\alpha_{11} = 0.019$

$\sigma = 4$

$\sigma^J = 1$

$\theta = 0.5$

$\eta_1 = 0.195$

$\eta_2 = 0.353$

$\eta_3 = 0.145$

$\eta_4 = 0.092$

$\eta_5 = 0.323$

$\eta_6 = 0.109$

$\gamma_L = 0.5$

$\gamma_P = 0.5$

$a_1 = 0.110$

$a_2 = 0.230$

$a_3 = 0.010$

$a_4 = 0.130$

$b_1 = 0.226$

$b_2 = 0.070$

$\omega = 0.9$

$\epsilon = 0.3$

$\xi = 1.985$

$\psi = 1.65$

$\zeta = 0.29$