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COMPARING THE GLOBAL PERFORMANCE OF ALTENATIVE EXCHANGE ARRANGEMENTS

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ABSTRACT

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 critics of the current "non-system" call for tighter international rules of the game in macroeconomic policy making. The proposed systems cover a wide spectrum of measures including maintaining the current flexible exchange rate system but with increased consultations between the major economies; a "target zone " system as advocated by John Williamson; or a full return to a system of fixed exchange rates as advocated by Ronald McKinnon

This paper presents and applies a methodology useful for studying the operating characteristics of a number of alternative monetary arrangements using a large-scale simulation model of the world economy. We consider the performance of the regimes when policymakers do or do not observe the shocks, and when policymakers infer the shocks using an optimal filtering rule. Although the results are model specific and at best illustrative of the issues involved, the approach does have the advantage of providing a richer framework of analysis than is possible in simple models of international interdependence.

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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 critics of the current "non-system" call for tighter international rules of the game in macroeconomic policy making[1]. The proposed systems cover a wide spectrum of measures including maintaining the current flexible exchange rate system but with increased consultations between the major economies; a "target zone " system as advocated by Williamson (1985) and Roosa (1984); or a full return to a system of fixed exchange rates as advocated by McKinnon (1984).

This paper presents and applies a methodology useful for studying the operating characteristics of a number of alternative monetary arrangements using a large-scale simulation model of the world economy. The model developed in Sachs and McKibbin (1985) and McKibbin and Sachs (1986) is attractive for policy analysis because of several desirable features, including rational expectations in the asset markets, and careful specification of stock-flow and long-term growth relations. Using a numerical technique described below, we examine the asymptotic variances of key macroeconomic target variables for a range of stochastic disturbances, and under a variety of exchange regimes. We consider the outcomes when policymakers do or do not observe the shocks, and when policymakers infer the shocks using an optimal filtering rule. Although the results are model specific and at best illustrative of the issues involved, the approach does have the advantage of

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[1]See Corden(1983) for an interesting description of the operating characteristics of this so-called non-system.

providing a richer framework of analysis than is possible in simple models of international interdependence.

The McKibbin-Sachs Global (MSG) model, which provides the framework for the analysis, is summarized in Section II. In Section III we discuss a methodology which is useful for analysing the performance of alternative rules under different assumptions about the observability of shocks hitting the world economy. Section IV contains a discussion of the regimes that we investigate including the practical implementation of these regimes. In Section V the simulation results are examined. Conclusions are contained in Section VI.

II. The MSG Model

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 (1986) and Sachs (1985) for several applications of the model. The MSG model is a general equilibrium macroeconomic model of the world economy. A detailed description of the model can be found in Sachs and McKibbin (1985). Here we briefly summarize some of the main features of the model.

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. The regions are 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 exchange rates and long-term interest rates are conditioned by the expected future path of policy, as governed by alternative policy rules.

The internal macroeconomic structure of the three industrialized regions of the U.S., ROECD and Japan is modelled, 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 basket of each other region, where the consumption of each good depends on income and relative prices. Private absorption depends positively on wealth, disposable income and negatively on long and short term ex ante real interest rates, along conventional lines. Wages are predetermined in each period, with the nominal wage change across periods a function of 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. 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. Money demand is assumed to be determined by transactions motives, so that real balances are a function of real income, nominal interest rates and lagged money balances.

Trade shares and initial asset stocks are based on actual data for 1983. Behavioral parameters are chosen based on our interpretation of the empirical literature. A sensitivity analysis of the selected parameters is not incorporated in this paper although it is under investigation.

We have analyzed both non-linear and linearized versions of the model, and have found that the two versions have very similar properties. In the work presented here, we use the linear version, primarily because our implementation of dynamic game theory requires the linearized model. The model is simulated using numerical techniques which take into account the forward-looking variables in the model. The technique we use is discussed in detail below.

III. Methodology for Analysing Exchange Regimes

There are several ways to analyze the properties of exchange regimes. One way is to analyze the short-run dynamic adjustment to various shocks. An alternative is to follow the approach in Taylor (1985) in which the average operating characteristics of the global economy are analyzed by calculating the stochastic steady state variances of a set of targets given a set of stochastic shocks to the system. The variance measures can then be examined and, given a utility function, the performance of the rules can be analyzed. We follow the second of these approaches in this paper. In addition we provide a summary measure of the performance of each regime using a welfare function. We do not totally avoid the problem of having to select an arbitrary welfare function because in deriving the rules for some regimes we assume that the authorities follow optimizing behavior according to a specific welfare function. This part of the analysis seems to be unavoidable.

This section is divided into two parts. The first explains our procedures for deriving a set of rules in a model with forward-looking agents. The second part discusses the methodology used to analyze the stochastic properties of alternative regimes.

A. Deriving Alternative Rules

The MSG model can be reduced to a minimum state-space representation.

(1) $$X_{t+1} = \alpha_1 X_t + \alpha_2 e_t + \alpha_3 U_t + \alpha_4 E_t + \alpha_5 \epsilon_t$$

(2) $$_t(e_{t+1}) = \beta_1 X_t + \beta_2 e_t + \beta_3 U_t + \beta_4 E_t + \alpha_5 \epsilon_t$$

(3) $$\tau_t = \gamma_1 X_t + \gamma_2 e_t + \gamma_3 U_t + \gamma_4 E_t + \gamma_5 \epsilon_t$$

(4) $$_t(e_{t+1}) = E(e_{t+1} | \Omega_t)$$

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

E_t is a vector of exogenous variables;

U_t is a vector of control variables (monetary or fiscal policy instruments in this model);

e_t is a vector of non-predetermined (or "jumping") variables such as the exchange rates and long term interest rate;

τ_t is a vector of target variables;

ϵ_t is a vector of stochastic shocks;

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

We make several assumptions about the stochastic disturbances. They all enter additively so that certainty equivalence holds. All shocks are temporary although the model dynamics make the effects of the shocks persistent. Where the model dynamics do not add much persistence to particular shocks, as is the case with shocks to portfolio preferences and aggregate demand, we assume that the shocks follow an AR1 process of the following form:

$$\mu_{t+1} = .75\ (\mu_t) + \epsilon_t$$

The autoregressive shocks (μ) are then added to the vector of state variables. Note that shocks to prices and money demand inherently have persistent effects in the model, because the price shocks get built into a wage-price spiral, while the structural money demand relationship is specified with a lagged adjustment process.

The shocks also satisfy the following conditions:

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

$${}_{t-1}(\epsilon_t \epsilon_t') = \Sigma$$

$${}_{t-1}(X_t' \epsilon_t) = 0$$

In addition, we consider three cases about observability of the shocks, relative to the timing of policy choices:

(1) the shocks are observed -- the realization of ϵ_t occurs before U_t is selected;

(2) the shocks are unobserved -- the realization of ϵ_t occurs after U_t is selected;

(3) the shocks are partially unobserved -- the policymakers use their knowledge of the underlying variance-covariance of the shocks and observations on a subset of variables at time t, to infer the underlying shocks from an optimal filtering rule. U_t is then selected after the filtering is performed.

We use three alternative procedures to select possible rules for the policy variables, hereafter referred to as control variables (U). In the first procedure we assume that each country chooses its control variables to maximize an intertemporal utility function, taking as given the reactions of the other countries and given the structure of the model. The second procedure is similar to the first except we assume that a global planner undertakes the optimization, in order to maximize a weighted average of the utility functions of the individual countries. In the third procedure we directly specify an explicit policy rule which is not derived from an explicit optimization problem.

Consider the first procedure in which countries optimize individually. The outcome of this is a familiar Nash equilibrium of a dynamic, linear-quadratic game. The welfare function is specified as:

$$(5) \qquad W = -\sum_{t=0}^{\infty} \beta^t \{\omega_1(\tau_{1t})^2 + \omega_2(\tau_{2t})^2 + \ldots\ldots + \omega_n(\tau_{nt})^2\}$$

$$= -\sum_{t=0}^{\infty} \beta^t \tau'\Omega\tau$$

where W is the level of social welfare;

β is $1/(1+\delta)$ and δ is the social rate of time discount;

ω_i is a weight on target i;

Ω ia a diagonal matrix with each ω on the diagonal;

τ^i is target i.

The targets are assumed to be macroeconomic targets such as the output gap, inflation, current account, budget deficit, nominal income or the nominal exchange rate. The specific targets depend on the regime we are simulating. The rule we find is optimal for the given country (in that it minimizes the dynamic social loss function), taking as given the rules that are being employed in the other regions.

A direct application of optimal control techniques could be used to solve this policy optimization problem. As is well known, under optimal control techniques, the policymaker at time zero is assumed to choose the complete path of policy instruments at the time of the initial optimization. However, as pointed out by Kydland and Prescott (1977), the optimal policy rules will not in general be time consistent. Future governments will not find it optimal to follow the same policies as envisioned by earlier governments. Instead, we look for a <u>time consistent policy rule</u>, that is, a rule that is optimal, taking as given that the same rule will be followed by future governments. The time consistent solution will yield a different path for the policy instruments than does a direct application of optimal control techniques.

The problem that we solve can be written formally as follows. Consider a single controller in the simplest case of no exogenous variables or stochastic shocks (in order to avoid unnecessary complexity). The structure, from (1) - (4) is thus:

$$X_{t+1} = \alpha_1 X_t + \alpha_2 e_t + \alpha_3 U_t \tag{1'}$$

$$e_{t+1} = \beta_1 X_t + \beta_2 e_t + \beta_3 U_t \tag{2'}$$

$$\tau_t = \gamma_1 X_t + \gamma_2 e_t + \gamma_3 U_t \tag{3'}$$

The objective function is:

$$W_t = - \sum_{t=0}^{\infty} \beta^t \tau' \Omega \tau \tag{5'}$$

The policymaker maximizes (5') subject to (1') - (3'), subject to the constraint of time consistency.

We search for a solution of the following form. We are looking for a time-invariant policy rule $U_t = \Gamma X_t$, a quadratic value function $V_t = X_t' S X_t$, and a matrix linking e_t to X_t of the form $e_t = H_1 X_t$, such that Γ, S, H_t have the following properties.

First, $U_t = \Gamma X_t$ solves the problem:

$$\max_{U_t} - \tau_t' \Omega \tau_t + \beta V_{t+1}$$

with $V_{t+1} = X_{t+1}' S X_{t+1}$, τ_t as in (3'), X_{t+1} as in (1), and $e_t = H_1 X_t$. Second,

$$X_t' S X_t = -\tau_t' \Omega \tau_t + \beta X_{t+1}' S X_{t+1}$$

for $U_t = \Gamma X_t$ and $e_t = H_1 X_t$. Third, $e_t = H_1 X_t$ is the stable manifold of the difference equation system (1'), (2') when $U_t = \Gamma X_t$.

In words, we are looking for a time-invariant rule $U_t = \Gamma X_t$ linking the policy instruments to the states. This rule is optimal taking as given that the same rule will be applied in the future. Given this rule, there is a corresponding matrix S such that $X_t' S X_t = - \sum_{t=0}^{\infty} \beta^t \tau' \Omega \tau$. Thus, $X_t' S X_t$ is the value of the objective function following the policy rule $U_t = \Gamma X_t$. Third, given the dynamic model of the economy, and the policy rule $U_t = \Gamma X_t$, the jumping variables must lie on a stable manifold given by $e_t = H_1 X_t$.

For the case of many controllers, the conditions can be rewritten with country subscripts and the additional constraint that each controller takes as given the policy rules of the other controllers. The inclusion of exogenous variables and stochastic shocks is straightforward. With exogenous variables and stochastic shocks included, the solution is a set of rules for the control variables of the form (see (A10) in appendix A):

$$U_t = \Gamma_1 X_t + \Gamma_2 E_t + \Gamma_3 \epsilon_t + C_{1t}$$

and a set of rules for the jumping variables such that the model solution is on the unique stable manifold (see (A12) in appendix A):

$$e_t = H_1 X_t + H_2 E_t + H_3 \epsilon_t + C_{2t}$$

Note that C_{1t} and C_{2t} are intercept terms (shifting over time) that depend on the time path of the exogenous variables.

In general, it is not possible to find closed-form analytical solutions for Γ, S, and H_1 (in the multicontroller game, we look for Γ_i, S_i, and H_{1i} for each of the countries i). In our study we employ the technique of numerical dynamic programming for linear quadratic systems, as in Oudiz and Sachs (1985) and Currie and Levine (1985a). The details of the solution method, which rely basically on a backward recursion procedure, are provided in Appendix A.

Another procedure that we use for calculating policy rules is similar to the first. Instead of assuming that each policymaker maximizes a country-specific objective function, we assume that a single, global planner chooses policy rules for each region to maximize a welfare function that is a weighted sum of the welfare functions of the individual countries. As many authors have shown (e.g. see Sachs and McKibbin (1985)), this cooperative solution may avoid the inefficiencies of the Nash equilibrium found by assuming that each each country chooses its policy rules non-cooperatively.

It is useful to identify "candidates" for policy rules by maximizing an explicit objective function. However, many rules are asserted to be "good" or "robust" without reference to a particular objective function. Thus, in addition to choosing rules through formal dynamic programming procedures, we also directly specify some rules linking U_t and X_t, using suggestions from the policy literature. Thus, we study choices for Γ that: (1) fix exchange rates across countries; (2) stabilize nominal GDP; etc. Even though such rules do not expressly maximize a given objective function, they are often asserted to be desirable, and are therefore worthy of our attention. Note that once we have specified a rule Γ, we must use (1) and (2) to find a stable manifold for the jumping variables e_t.

B. Analyzing the Stochastic Properties of Alternative Regimes

In this section we explore the implications of the observability of shocks and describe the procedures followed to calculate the variance of target variables in a stochastic steady state. We incorporate stochastic shocks to the equations for aggregate demand, prices, money demand, and portfolio preferences in the U.S., Japan and ROECD. There are 12 shocks in total.

1. Shocks Observed

First consider the procedures used to calculate the variances of the targets when the shocks are observed. A complete derivation is given in Appendix A. The key point is that any rule which is chosen is converted into the form:

$$U_t = \Gamma_1 X_t + \Gamma_2 E_t + \Gamma_3 \epsilon_t + C_{1t} \tag{6}$$

Note that since the shocks are "observed" prior to setting the policies, the control variables depend explicitly on the shocks. We also find the corresponding stable manifold for the jumping variables:

$$e_t = H_1X_t + H_2E_t + H_3\epsilon_t + C_{2t} \tag{7}$$

We can now find the target variables as a function of the states, the exogenous variables, and the stochastic shocks. Using a procedure set out in Appendix A, section 2 we are able to find the variance of the target variables as a function of the variance-covariance matrix of the shocks.

2. Shocks Unobserved When Policy is Selected

When the shocks are unobserved at the time of selecting the control variables, we set Γ_3 in (6) to zero. Note that H_3 will still be non-zero because the shocks will affect the jumping variables despite the lack of any policy response. This can be seen from equation (A11) in Appendix A. In the case of unobserved shocks, equations (6) and (7) would become (using notation from appendix A):

$$U_t = \Gamma_1X_t + \Gamma_2E_t + C_{1t}$$

$$e_t = (J + K\Gamma_1)X_t + (Q)\epsilon_t + (Z+K\Gamma_2)\epsilon_t + C_{2t}$$

We can then use the procedures described in Appendix A for the case of observed shocks, to calculate the variances of the target variables.

3. A Filtering Approach When Shocks are Unobserved

A common prescription for policy setting in a stochastic environment is for policymakers to follow a rule which links policy to a set of contemporaneously observed variables, or intermediate targets in an attempt to reach ultimate objectives. We formalize this approach in this section. Consider the case in which the conditional variance-covariance matrix of a set of shocks is known but in any period the policymaker cannot directly observe the shocks hitting the system. The approach which we develop here is to observe several variables and infer the underlying nature of the shocks by an optimal Kalman filtering rule (see Sargent (1979), p.209 for an illustration of this process).

The procedure we develop here is completely general, though we illustrate it in this paper for a single special case. We assume that the monetary authorities observe the exchange rate and decide on monetary policy based on this observation as well as knowledge of the underlying model and the properties of the underlying shocks. This gives a rule linking monetary policy to the exchange rate which will indicate whether the authorities should optimally "lean with the wind" or "lean against the wind" (i.e. whether a monetary contraction or expansion should follow an observed appreciation of the currency).

To make the procedure a little more transparent, it is worth considering a simple example first. Let M_t be an observed variable related to two underlying shocks in the following way (dropping time subscripts for convenience):

$$M = \alpha_1\epsilon^1 + \alpha_2\epsilon^2 = \alpha\epsilon$$

where $\alpha = [\alpha_1 \; \alpha_2]$

$$\epsilon = [\epsilon^1 \; \epsilon^2]'$$

$$_t(\epsilon_i)^2 = (\sigma_i)^2$$

$$_t(\epsilon^i \epsilon^j) = 0 \qquad \text{for } i \neq j$$

Suppose that M is observed, but that ϵ^1 and ϵ^2 are not. To find the expected values of ϵ^1 and ϵ^2 given M, we want to find the projections of ϵ^1 and ϵ^2 on M:

$$P\{\epsilon^1 \mid \alpha\epsilon\} = \gamma^1 \alpha\epsilon$$

$$P\{\epsilon^2 \mid \alpha\epsilon\} = \gamma^2 \alpha\epsilon$$

where
$$\gamma^1 = \frac{\alpha_1 \sigma_1^2}{\alpha_1 \sigma_1^2 + \alpha_2 \sigma_2^2}$$

and
$$\gamma^2 = \frac{\alpha_2 \sigma_2^2}{\alpha_1 \sigma_1^2 + \alpha_2 \sigma_2^2}$$

We can now find $_t(\epsilon_t | M_t) = \gamma \, M_t = \gamma\alpha\epsilon_t$, where $\gamma = [\gamma^1 \; \gamma^2]'$.

Thus, we can describe the expectations of the shocks conditional on the observation of M. Now let us turn to the multidimensional case. Suppose that at any time t, a set of observed variables M is related to the states, lagged states, jumping variables, control variables, exogenous variables, and the unobserved shocks in the following way:

$$(8) \qquad M_t = \alpha_1 X_{t+1} + \alpha_2 X_t + \alpha_3 e_t + \alpha_4 U_t + \alpha_5 E_t + \alpha_6 \epsilon_t$$

Using the same backward recursion technique as outlined in Section III.A, above, we can find a set of rules for U where, in this case, the rules will be a function not of the actual shocks, but of their expectation (i.e. projection) given M_t:

(9) $$U_t = \Gamma_1 X_t + \Gamma_2 E_t + \Gamma_3 \ {}_t(\epsilon_t | M_t) + C_{1t}$$

There is also a corresponding stable manifold for e_t, of the form:

(10) $$e_t = H_1 X_t + H_2 E_t + H_3 \ {}_t(\epsilon_t | M_t) + H_4 \epsilon_t + C2t$$

Compare (9) with (6). Because of the linearity of the model and the additivity of the disturbances, we can appeal to certainty equivalence to show that the coefficients Γ_1, Γ_2, and Γ_3 are the same whether or not the shocks are observed. We can substitute for X_{t+1} in (8) from equation (1) and for the rules for e_t and U_t from (9) and (10). Simplifying gives:

(11) $$M_t = \beta_1 X_t + \beta_2 \epsilon_t + \beta_3 \ {}_t(\epsilon_t | M_t)$$

We are trying to find ${}_t(\epsilon_t | M_t)$. Equation (11) can be rewritten

$$ {}_t(\epsilon_t | M_t) = \beta_3^{-1}[M_t - \beta_1 X_t - \beta_2 \epsilon_t]$$

This expression has the actual value of the shock on the right hand side. We can appeal to the Law of Iterative Projections to find ${}_t(\epsilon_t | M_t)$.

Formally, we need to fine the projections:

$$P\{\epsilon_t^i | \ \beta_2 \ \epsilon_t\} \qquad \text{for } i = 1,2,3,\ldots,12$$

where $\epsilon_t = [\epsilon_t^1 \ \epsilon_t^2 \ \ldots\ldots \epsilon_t^{12}]'$

Assume the conditional variance-covariance matrix of the shocks is Σ, where:

$$\Sigma_t = {}_t(\epsilon_t \epsilon_t')$$

Each projection will produce a vector of coefficients (γ^i) such that:

$$P(\epsilon_t^i | \beta_2 \epsilon_t) = \gamma^i \beta_2 \epsilon_t$$

By stacking these coefficients we find:

$$\gamma' = [\gamma^1 \gamma^2 \gamma^3 \ldots . \gamma^{12}]' = \{\beta_2 \Sigma \beta_2'\}^{-1} \beta_2 \Sigma$$

Now

(12) $$ {}_t(\epsilon_t | M_t) = \gamma \beta_2 \epsilon_t$$

or

(13) $$ {}_t(\epsilon_t | M_t) = \gamma \{M_t - \beta_1 X_t - \beta_3 \; {}_t(\epsilon_t | M_t)\}$$

Equation (13) now can be solved to give the conditional expectation of the shocks based on observed variables and states

(14) $$ {}_t(\epsilon_t | M_t) = [I + \gamma \beta_3]^{-1} \gamma (M_t - \beta_1 X_t\}$$

The policy rules can be stated in a number of different ways. In (9) we stated the rule for the control variables as a function of the state variables and the expectation of the shock conditional on M. We can also state the rule as a function of the shocks themselves or as a function of the vector of observed variables. Equation (12) can be substituted into (9) and (10) to find new rules for the control and jumping variables as a function of the underlying shocks:

(15) $$U_t = \Gamma_1^* X_t + \Gamma_2^* E_t + \Gamma_3^* \epsilon_t + C_{1t}^*$$

(16) $$e_t = H_1^* X_t + H_2^* E_t + H_3^* \epsilon_t + C_{2t}^*$$

where $\Gamma_1^* = \Gamma_1$ $\qquad$ $H_1^* = H_1;$

$\Gamma_2^* = \Gamma_2;$ $\qquad$ $H_2^* = H_2;$

$\Gamma_3^* = \Gamma_3\gamma\beta_2;$ $\qquad$ $H_3^* = H_4 + H_3\gamma\beta_2;$

The rules for the control variables can also be written as a function of the observed variables by substituting (14) into (9) and simplifying to find:

$$U_t = \Gamma_1^{**}X_t + \Gamma_2^{**}E_t + \Gamma_3^{**}M_t + C_{1t}^{**} \tag{17}$$

where $\Gamma_1^{**} = \Gamma_1 - \Gamma_3[I+\gamma\beta_3]^{-1}\gamma\beta_1$

$\Gamma_3^{**} = \Gamma_3[I+\gamma\beta_3]^{-1}\gamma$

Given these new rules for the control variables and the jumping variables we can proceed to calculate the variance of the targets by using the same procedures outlined above.

IV. Design and Implementation of Monetary Regimes

We can now use the methodology developed in Section III to examine the performance of alternative monetary regimes. Before turning to the specific rules, we make some general observations about alternative monetary regimes.

The large literature that has emerged from the debate about fixed versus flexible exchange rates has produced several helpful insights on choosing a monetary regime. In the simple theoretical models generally used, it is found that the appropriateness of any monetary regime depends on the nature of the shocks impinging on the economy. For example, in a Mundell-Fleming world with capital mobility, if the shocks to the domestic economy are in the money demand equation, then a fixed exchange rate will dissipate the shock to the rest of the world and be beneficial to the domestic economy. If shocks emanate from the real economy, then a flexible exchange rate will generally assist in dampening the effects of the shocks on the domestic economy. If foreign price level shocks are the main source of disturbance, then a flexible exchange rate is better for insulating the domestic economy; and if the foreign shocks are shifts in demand for the home good, a flexible exchange rate is better. A second set of issues involves the incentive effects of any regime. Problems of beggar-thy-neighbor policies can emerge under flexible exchange rates where countries think they can manipulate a bilateral exchange rate to gain some advantage (see Sachs and Oudiz (1985)). A fixed exchange rate regime may provide a constraint on national policymakers to prevent beggar-thy-neighbor policies.

The case for return to more managed exchange rates is examined in more detail in Sachs (1985b) and Obstfeld (1985). The case for exchange rate rules is quite attractive and includes arguments about increased predictability of national authorities and preventing beggar-thy-neighbour behavior. These gains must be balanced, however, against the argument that a set of international rules can lead all participants to make the same mistakes on a global scale.

Our study focuses on regimes for monetary policy rather than regimes for both monetary and fiscal policies. With two policy instruments the analysis of strategic interactions becomes more complex, as shown in McKibbin and Sachs (1986). We consider seven alternative monetary regimes in this paper under various assumptions about the observability of the shocks.

We define a regime as money supply rule for each region in the form

$$U_i = \Gamma_{1i}X_t + \Gamma_{2i}E_t + \Gamma_{3i}\epsilon_t + C_{1it}$$

where U_i is a vector of control variables for country i (in this case containing the money supply).

(1) Pure Float

Our first case, a pure floating exchange rate, is an obvious base case to choose. In this case, the money supplies in the various regions are held fixed, and do not respond to exogenous shocks or changes in the state variables.

(2) Noncooperation

A model such as the MSG model is particularly useful for analyzing the problems of beggar-thy-neighbor policies. This is done in the second regime in which 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 social welfare functions are made intertemporal, by assuming that the level of social welfare depends on the discounted values of the targets in the current and all future periods.
The specific form of the social welfare function that we employ is quadratic, as follows:

$$(18) \qquad W = -\sum_{t=0}^{\infty} \frac{1}{1+\delta}^t [0.5Q_t^2 + \pi_t^2 + 0.5CA_t^2 + 0.1D_t^2]$$

where: W is the level of social welfare,

Q is the GDP gap,

π is the CPI inflation rate,

CA is the current account-GDP ratio,

D is the domestic budget deficit-GDP ratio,

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.

Using the techniques discussed in Section III, we calculate a set of monetary policy rules in the three OECD regions that have the following "equilibrium" property: each set of rules is optimal for the given country (in that it minimizes the dynamic social loss function), taking as given the rules that are being employed in the other regions. We have shown elsewhere (see Sachs and McKibbin (1985)) that 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, Oudiz and Sachs (1985) have shown that the equilibrium rules are likely to produce excessively tight monetary policies and high real interest rates in an inflationary environment.

(3) <u>Cooperation</u>

It is very likely the case that the social welfare of all of the countries can be enhanced by a different set of policies, that provides for cooperatively selected rules of the game. We can find such a set of 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. With some arbitrariness, we select these weights to be GNP shares. The result of this global optimization is a new set of rules that avoids the problem of beggar-thy-neighbor policies.

(4) Nominal GDP Targeting

An alternative regime that is frequently proposed is to target a measure of nominal GDP. We implement this rule by assuming that each of the OECD regions choose monetary policy non-cooperatively to minimize the variance of its own nominal GDP, taking as given the rules of the other countries. Exchange rates are left free to fluctuate. This is the fourth and final of the floating exchange rate regimes that we consider.

(5) McKinnon Rule

We now come to the regimes of fixed exchange rates. Of course, saying that a regime has fixed exchange rates does not completely specify the monetary arrangements of the regime because there are many ways of allocating the responsibility across the countries for keeping the exchange rates constant. The first case we consider is that proposed by Ronald McKinnon (1984). Under the McKinnon rule, exchange rates within the OECD region are held fixed with an additional constraint that a weighted average of the OECD nominal money stocks remains fixed (or has a fixed, low rate of growth).

(6) Global Nominal GDP Targeting

The second fixed exchange rate regime is the global nominal GDP targeting regime. In this regime we find a set of money supply rules for each of the three regions which: (a) fixes the cross-exchange rates; and (b) fixes the expected nominal GDP of the world economy. The operational difference of this rule and the McKinnon rule can be best understood with respect to particular shocks. Suppose a pure velocity shock occurs in the U.S., which reduces the demand for U.S. money for several periods. In the McKinnon plan, the world stock of money would remain constant, but the U.S.

money stock would decline while the money supplies in the rest of the OECD would increase (these shifts would be necessary to keep the exchange rate fixed). On balance, an excess supply of money, at initial interest rates and prices, would develop in the world economy. The result would be an increase in world output and eventually in prices. Under the nominal GDP targetting plan, however, the fall in U.S. money demand will be fully compensated by a fall in the U.S. money supply. There will be no need for a sustained period of higher output or prices. The key distinction is that the GDP targetting rule does not require that the global money stock remains fixed.

(7) Leaning With or Against the Wind

Neither the cooperative rules nor the non-cooperative rules are likely to produce purely fixed exchange rates as the first best optimum. However, the rules that do emerge are likely to be too complex for actual implementation. An alternative set of rules may be easy to implement, although they do not perform as well as the optimum rules. One such set of proposals has been called "leaning with the wind" or "leaning against the wind." This is implemented in this paper as the third technique outlined in Section III. We assume that policymakers know the variance-covariance matrix of a range of shocks, although the specific realization of the shocks in any period is not observed. The authorities in each region maximize a welfare function of the form given in equation (5') and are assumed to infer the realization of any shocks by observing movements in the exchange rate. They then apply an optimal rule to determine the expected value of each shock and adjust policy accordingly. The rules which arise from this regime depend crucially on the variance-covariance matrix of the shocks.

An exhaustive analysis of the seven different rules would require the study of many types of shocks, with alternative assumptions about their variances and covariances. In this preliminary study, we consider twelve temporary shocks in all: shocks to money demand in the U.S., Japan, and ROECD; shocks to aggregate demand in each region; shocks to prices in each region including OPEC prices; and shocks to portfolio preferences. We primarily restrict our attention to stochastically independent shocks. However, we do consider one case of negatively correlated velocity shocks.

V. Simulation Results

Impulse responses to 7 of the shocks (of unit size) are illustrated in figures 1 to 7 in appendix B. The reader is referred to this appendix for more discussion of the results. These figures contain the responses of U.S. output, inflation, the current account, exchange rate and short interest rates for shocks in the case of a flexible exchange rate with no policy response. To save space, only the results for shocks to U.S. and ROECD aggregate demand, prices and money demand are presented. These figures illustrate the dynamics of the model and the nature of the various shocks under the alternative regimes.

A. Shocks Observed or Unobserved

Using the procedures outlined in Section III, we calculate the standard deviations of a set of targets given the set of stochastic shocks under the first six exchange regimes (the case of leaning with/against the wind is discussed in the next section). Tables 1 to 12 contain the results for each of the shocks where the shocks are assumed to be independent. Table 13 illustrates the results for a negatively correlated monetary shock. Within each table are the results for the standard deviations of output, inflation, and the current account, and the budget deficit, for both the U.S. and ROECD, in the case of observed and unobserved shocks. In order to save space, we do not include the results for Japan, as they are qualitatively similar to the ROECD and U.S. results. To read these tables note that each column corresponds to a rule being followed by the major regions and each row corresponds to the standard errors of the target variables. Therefore in Table 1, with a stochastic portfolio shock (with unit variance) in a flexible exchange rate regime with no policy reaction, the standard deviation of U.S. output is 0.323. In the noncooperative regime the standard deviation of U.S. output is .265 if the shock is unobserved by policymakers and .050 if the shock is observed. Table 14 contains a calculation of welfare loss for each region using the intertemporal utility function shown in equation (27).

Before examining the consequences of each shock in detail, there are several general points to note about the implications of the observability of any shock. First, whether or not a shock is observed does not affect the results for the flexible exchange rate regime or the fixed exchange rate regimes since monetary policy is set to maintain the fixed exchange rate independently of the shocks. There is no policy response under the floating exchange rate case and so observing or not observing the shock makes no difference. Second, observing a shock generally reduces the variances of the targets. This is not a general proposition because for a range of welfare functions, it is possible that when shocks are observed, policymakers could use that information to choose a rule that raises the variance of some targets while lowering the variance of other targets. For example, if a policymaker cares about targets other than output or inflation, it is possible that in minimizing the variance of some other target, the variance of output and inflation may increase if the shock is observed and the policymaker acts quickly to offset the effect of the shock on his target variable.

Tables 1 and 2 contain the results for a shock that shifts the demand by private portfolio holders for dollar assets relative to ECU- or Yen-dominated assets, respectively. The cooperative rule dominates the other regimes in terms of minimizing the variance of the target variables presented. Note that the difference between the cooperative and noncooperative rules are very small. This is the case for each of the shocks considered below, and suggests that the gains to coordination are small in this empirical model. In Sachs and McKibbin (1985) we also found that policy coordination yielded rather small gains for the industrialized countries, but that the gains to the developing countries from coordination of the industrialized countries were potentially quite large. We do not consider this aspect of policy coordination here.

Depending on the weight one places on the various targets, the nominal GNP targetting performs about as well as the flexible exchange rate system if the portfolio shocks are unobserved and better if the policymakers can observe the shocks and act quickly to offset them. The two fixed exchange rate regimes perform poorly for this type of shock.

The results for aggregate demand shocks in the U.S., Japan and ROECD are presented in Tables 3 to 5. In the case of the U.S. demand shock, cooperation dominates for the country that does not directly experience the demand shock, but is worse for the U.S. In the case of the ROECD and Japanese shocks, cooperation benefits each region. This result depends on the weights each region receives in the global planner's objective function. We assume GNP weights in this analysis. Presumably a set of weights can be found for the U.S. shock in which cooperation benefits each country.

Nominal GNP targeting now performs marginally better than a flexible exchange rate in the case of unobserved demand shocks and much better if the shocks are observed. The McKinnon rule is again dominated by the other regimes. The added flexibility of the global GNP targeting shows to be beneficial. It reduces the variance of targets relative to the McKinnon rule and reduces the variance of targets relative to the other regimes for the ROECD. This property is the result of the weights placed on each country in creating the average measure of world GNP. No weighting will make every country better off relative to the cooperative regime.

Results for an OPEC oil price shock are shown in Table 6. Cooperation is again the dominant regime. The McKinnon rule now performs well and dominates the country-specific and global GNP targeting regimes. This occurs because the world money supply does not accommodate the price shock and there is little need for exchange rate adjustment between the U.S. and ROECD. Although the results are not shown, this is not the case for Japan. This can be seen in the summary welfare calculations in Table 14. Japan requires a depreciation relative to the other major regions when oil prices rise (and an appreciation when oil prices fall) and is hurt by the nonadjustment on nominal exchange rates.

Tables 7 to 9 contain the results for uncorrelated price shocks in each region. The small difference between cooperation and noncooperation is again seen here. The McKinnon rule and global GNP targeting again stand out as accentuating the variance of the targets.

To this point the fixed exchange rate regimes have performed poorly relative to the other regimes. This is not altogether surprising because the shocks have been from the real economy and real exchange rate adjustment is required. In our model with sticky prices, no initial adjustment of the real exchange rate can occur when the nominal exchange rate is also fixed.
Tables 10 to 12 illustrate the results for an uncorrelated shock to money demand in each region. Compared to the regimes with unobserved shocks, the McKinnon rule works well for the country in which the shock occurs because the shock is dissipated to the rest of the world. The other countries suffer from greater variance of targets relative to the other regimes. This is a familiar result in which a domestic monetary shock is best handled by a fixed exchange rate because it dissipates the shock throughout the world economy. Other countries would prefer a flexible exchange rate to aid in insulating their own economies against the shock. However, when compared to the case of the observed shocks the McKinnon rule performs less well because in other regimes the authorities can directly offset the shock in the money market. Under the McKinnon rule the constraint on global money supplies necessitates the transmission of the shock to other money markets. This highlights a problem with the McKinnon rule even in the case of money demand shocks for which it was designed. For the shock to be totally offset it would require a rise in the world money stock with the only change to national money stocks being in the region where the money demand shock occurs. If the shocks are negatively correlated across countries (i.e. money demand rises in one country while it

falls in another) then the McKinnon rule would totally offset the shocks. There would not be any need for a change in the global money stock. This is illustrated in Table 13 which shows the consequences of a negatively correlated money demand shock in the U.S. and ROECD. This shock assumes that the unit shocks to the demand for money are perfectly negatively correlated in the two regions. The McKinnon rule performs very well compared to the other regimes when the shocks are unobserved. The small deviations result because the weights on each country in calculating the global money stock are not equal, yet the shock is the same size in each country. With observed shocks the other regimes can again completely offset the shock in the money markets and so the McKinnon rule is marginally outperformed.

In Table 14 we apply the welfare function given in equation (27) to calculate a summary measure of welfare <u>loss</u> for the U.S., ROECD and Japan under each regime. The results conform with the discussion on individual variances above.

In summary, the cooperative and noncooperative regimes under a floating exchange rate perform better than any of the fixed exchange rate regimes except in the case of an unobserved negatively correlated velocity shock. This shows the main advantage of the McKinnon rule. In general, the global nominal GDP targetting regime outperforms the McKinnon rule because it allows some flexibility in adjusting the world stock of money when required. This additional flexibility is not enough to offset a problem with the fixed exchange rate regimes. With sticky prices, a fixed exchange rate initially prohibits the adjustment of the real exchange rate when it is required. The reader is referred to Roubini (1986) for a discussion of the conditions under which a fixed exchange rate can lead to the optimal cooperative outcome in a theoretical three country model.

The analysis so far may be unfair to the McKinnon proposal. There are many issues which we have not addressed and circumstances which would favor a rule such as the McKinnon proposal. We have ignored the problems with uncertain parameter values that would hinder the implementation of any of the "optimal" rules. One of the appealing features of the McKinnon proposal is the ease of implementation of the rule. The other rules we investigate are very complicated functions linking the control variables to the conditions of the economy and would be difficult to implement.

B. Leaning With the Wind or Leaning Against the Wind and Optimal Filtering

Many economists have advocated the use of intermediate targets and indicators to set policy. One such application is the prescription to set monetary policy by observing movements in the nominal exchange rate. This has been called "leaning with the wind" if the policy is to relax monetary policy when the exchange rate is depreciating and "leaning against the wind" if the policy is to relax monetary policy when the exchange rate is appreciating. In the former policy the objective is to push the exchange rate in the direction that it is already moving and in the latter case it is to dampen any movement. In this section we formalize the policy using the third technique outlined in Section III above. We assume that policymakers observe the exchange rate and apply an optimal filtering rule to find an appropriate feedback rule linking monetary policy to the exchange rate. To illustrate the key point of this section we make different assumptions about the underlying nature of the shocks and derive the best rule linking the control variables (monetary supplies) to the observed variable (the effective nominal exchange rate).

Consider the problem faced by the U.S. when the underlying shocks are known to be either aggregate demand or money demand shocks. Consider how the policymakers should act if they know which of the two shocks has occurred. In the case of a known positive aggregate demand shock, without a policy response, the exchange rate would appreciate and output and inflation would rise above the desired levels. The appropriate response is to contract monetary policy to offset the demand shock. In the case of a rise in money demand, with no policy response, there would be falling output and an appreciating exchange rate as the result of rising interest rates. The policymaker can completely offset the effect of the money demand shock by a money supply expansion. There would then be no spillover effects from the money market to the rest of the economy. Now suppose that the shocks themselves are unobserved, but that the the exchange rate is observed to be appreciating. Given a conditional variance-covariance matrix, the authorities apply the filtering rule to determine the best rules to link policy to the exchange rates. As an illustration suppose that shocks have zero covariance. Table 15 shows the optimizing rule linking the monetary policy to the exchange rate for a range of variances of the shocks. The calculation of expected value is based on actual shocks of unit value.

This table illustrates the proposition that if the shock causing the appreciation is more likely to be an increase in aggregate demand, the policymaker should contract monetary policy. In this case a rise in aggregate demand is accompanied by an appreciating currency. The contractionary monetary policy will reinforce the appreciating currency and so will be a policy of "leaning with the wind." If the shock is more likely to be a rise in the demand for money, the policymaker should accommodate the shock by expanding monetary policy. In this case, a rise in money demand is also accompanied by an appreciating currency. The appropriate policy response is to "lean against the wind" and adopt an expansionary monetary policy which will offset the appreciating currency. The reason for the large offset coefficient when the shock is a monetary shock comes from the property that a monetary shock can be completely offset in the money market. The exchange rate will be independent of the shock in this case.

The example illustrates a proposition that is central to this paper. The appropriate policy rule depends crucially on the nature and observability of the shocks hitting the world economy. This general principal clearly needs further detailed investigation.

VI. Conclusion

This paper has presented techniques for examining the operating characteristics of alternative rules for the world monetary system. We have shown that the performance of each regime depends crucially on the nature of the shocks impinging on the economy using a dynamic general equilibrium simulation model of the world economy. For the country-specific shocks considered above, the fixed exchange rate regimes perform poorly in the sense of leading to a large variance of a set of macroeconomic target variables. When a shock requires adjustment of the real exchange rate, a regime of fixed nominal exchange rates in a sticky price world, leads to short term nonadjustment of the real exchange rate which results in increased variance of target variables. For global shocks, such as a change in OPEC prices, the fixed exchange rate regime performs tolerably well. For other shocks, such a negatively correlated monetary shocks, the fixed exchange rate regime proposed by McKinnon performs quite well.

Although the results are model specific, the techniques we have developed allow us to more fully explore the implications of any proposal for reforming the world monetary system than is possible in simple theoretical models of international interdependence. We are now continuing this work in a more complete empirical model.

Table 1: Increase in the Demand for Ecu Assets

(standard deviation of targets)

			Unobserved Shocks					Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.323	0.265	0.263	0.347	1.240	0.838	0.050	0.044	0.148
	inflation	0.182	0.159	0.158	0.157	0.535	0.379	0.068	0.065	0.092
	CA	0.085	0.094	0.095	0.079	0.258	0.153	0.087	0.087	0.078
	budget	0.005	0.005	0.005	0.004	0.013	0.007	0.006	0.006	0.005
ROECD	output	0.419	0.360	0.360	0.442	2.178	0.327	0.059	0.040	0.155
	inflation	0.192	0.204	0.204	0.189	1.119	0.119	0.079	0.076	0.096
	CA	0.115	0.132	0.129	0.119	0.368	0.171	0.128	0.123	0.120
	budget	0.001	0.001	0.001	0.001	0.003	0.002	0.001	0.001	0.001

Table 2: Increase in the Demand for Yen Dominated Assets

(standard deviation of targets)

			Unobserved Shocks					Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.105	0.087	0.084	0.106	0.264	0.245	0.032	0.017	0.055
	inflation	0.056	0.055	0.053	0.047	0.151	0.113	0.028	0.023	0.031
	CA	0.025	0.031	0.028	0.021	0.072	0.043	0.028	0.024	0.020
	budget	0.001	0.002	0.002	0.001	0.003	0.002	0.002	0.002	0.001
ROECD	output	0.108	0.089	0.083	0.113	0.372	0.032	0.048	0.019	0.060
	inflation	0.058	0.056	0.053	0.054	0.194	0.031	0.035	0.025	0.035
	CA	0.036	0.049	0.045	0.046	0.104	0.061	0.057	0.051	0.048
	budget	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000

Table 3: U.S. Aggregate Demand Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	2.163	1.442	1.446	1.574	6.654	3.668	0.182	0.214	0.638
	inflation	0.929	0.483	0.497	0.455	3.256	1.667	0.280	0.274	0.381
	CA	0.672	0.666	0.667	0.690	1.437	0.935	0.709	0.706	0.675
	budget	0.010	0.008	0.008	0.011	0.044	0.024	0.008	0.008	0.006
ROECD	output	1.053	0.805	0.803	1.280	4.896	1.086	0.093	0.096	0.397
	inflation	0.627	0.486	0.486	0.617	2.508	0.429	0.192	0.191	0.259
	CA	0.550	0.547	0.546	0.568	1.088	0.687	0.595	0.592	0.576
	budget	0.002	0.002	0.002	0.002	0.009	0.005	0.002	0.002	0.001

Table 4: ROECD Aggregate Demand Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	1.054	0.646	0.643	1.062	2.774	2.388	0.130	0.120	0.387
	inflation	0.655	0.420	0.420	0.517	1.091	1.087	0.184	0.178	0.242
	CA	0.248	0.243	0.240	0.223	0.666	0.419	0.196	0.196	0.175
	budget	0.017	0.013	0.013	0.011	0.034	0.016	0.011	0.011	0.008
ROECD	output	2.126	1.366	1.364	1.509	7.423	1.001	0.167	0.135	0.516
	inflation	0.936	0.448	0.447	0.456	3.730	0.350	0.251	0.247	0.318
	CA	0.304	0.342	0.330	0.321	0.963	0.423	0.283	0.272	0.261
	budget	0.004	0.003	0.003	0.002	0.007	0.003	0.002	0.002	0.002

Table 5: Japanese Aggregate Demand Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.323	0.228	0.210	0.368	0.551	0.875	0.097	0.054	0.180
	inflation	0.210	0.162	0.155	0.184	0.285	0.409	0.091	0.078	0.103
	CA	0.072	0.095	0.083	0.069	0.192	0.148	0.083	0.071	0.058
	budget	0.006	0.006	0.006	0.005	0.007	0.006	0.006	0.006	0.004
ROECD	output	0.344	0.257	0.217	0.393	0.781	0.117	0.141	0.059	0.191
	inflation	0.217	0.174	0.158	0.203	0.428	0.101	0.106	0.082	0.113
	CA	0.149	0.178	0.159	0.159	0.355	0.200	0.177	0.160	0.147
	budget	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001

Table 6: OPEC Oil Price Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.029	0.010	0.008	0.050	0.030	0.048	0.011	0.009	0.044
	inflation	0.025	0.017	0.017	0.030	0.024	0.024	0.015	0.015	0.027
	CA	0.002	0.003	0.003	0.003	0.004	0.003	0.004	0.004	0.003
	budget	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
ROECD	output	0.049	0.019	0.017	0.078	0.063	0.069	0.020	0.017	0.069
	inflation	0.038	0.033	0.033	0.048	0.042	0.045	0.027	0.027	0.044
	CA	0.011	0.010	0.011	0.011	0.012	0.010	0.009	0.010	0.010
	budget	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7: U.S. Price Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	2.769	1.819	1.813	3.144	4.783	3.717	1.630	1.626	2.946
	inflation	1.257	1.441	1.447	1.353	2.594	1.848	0.954	0.960	1.249
	CA	0.390	0.232	0.233	0.479	0.946	0.642	0.216	0.217	0.458
	budget	0.014	0.008	0.008	0.019	0.035	0.025	0.007	0.007	0.019
ROECD	output	0.630	0.162	0.160	0.691	3.419	0.453	0.041	0.057	0.484
	inflation	0.422	0.140	0.141	0.374	1.697	0.083	0.073	0.068	0.276
	CA	0.319	0.191	0.190	0.352	0.727	0.443	0.178	0.178	0.337
	budget	0.003	0.002	0.002	0.004	0.007	0.005	0.001	0.002	0.004

Table 8: ROECD Price Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.734	0.199	0.202	0.699	1.734	1.222	0.065	0.074	0.449
	inflation	0.474	0.158	0.159	0.372	0.626	0.455	0.077	0.064	0.257
	CA	0.147	0.100	0.082	0.123	0.422	0.210	0.069	0.055	0.111
	budget	0.010	0.004	0.004	0.010	0.021	0.009	0.001	0.001	0.009
ROECD	output	3.087	1.941	1.952	3.398	5.627	3.222	1.629	1.630	2.980
	inflation	1.380	1.522	1.528	1.536	2.992	1.478	0.936	0.934	1.324
	CA	0.169	0.139	0.121	0.187	0.584	0.247	0.097	0.082	0.168
	budget	0.002	0.001	0.001	0.002	0.004	0.002	0.000	0.000	0.002

Table 9: Japanese Price Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.321	0.126	0.092	0.350	0.434	0.935	0.083	0.047	0.224
	inflation	0.227	0.095	0.082	0.198	0.186	0.415	0.063	0.045	0.143
	CA	0.064	0.065	0.048	0.059	0.157	0.128	0.056	0.042	0.055
	budget	0.005	0.003	0.003	0.004	0.007	0.004	0.002	0.002	0.004
ROECD	output	0.339	0.172	0.107	0.369	0.810	0.262	0.125	0.058	0.234
	inflation	0.232	0.113	0.087	0.214	0.406	0.190	0.080	0.050	0.153
	CA	0.143	0.128	0.103	0.153	0.347	0.200	0.112	0.092	0.153
	budget	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Table 10: U.S. Money Demand Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	1.681	1.574	1.573	1.729	0.706	0.001	0.000	0.000	0.000
	inflation	0.518	0.621	0.624	0.565	0.277	0.000	0.000	0.000	0.000
	CA	0.166	0.165	0.165	0.190	0.079	0.000	0.000	0.000	0.000
	budget	0.002	0.001	0.001	0.004	0.003	0.000	0.000	0.000	0.000
ROECD	output	0.315	0.143	0.145	0.155	1.075	0.000	0.000	0.000	0.000
	inflation	0.133	0.056	0.057	0.089	0.386	0.000	0.000	0.000	0.000
	CA	0.159	0.162	0.162	0.176	0.095	0.000	0.000	0.000	0.000
	budget	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000

Table 11: ROECD Money Demand Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.260	0.043	0.023	0.241	0.734	0.000	0.000	0.000	0.000
	inflation	0.151	0.052	0.053	0.141	0.290	0.000	0.000	0.000	0.000
	CA	0.061	0.037	0.027	0.057	0.083	0.000	0.000	0.000	0.000
	budget	0.004	0.004	0.004	0.005	0.003	0.000	0.000	0.000	0.000
ROECD	output	2.259	1.995	2.002	2.254	1.121	0.000	0.000	0.000	0.000
	inflation	0.705	0.799	0.803	0.773	0.404	0.000	0.000	0.000	0.000
	CA	0.069	0.056	0.047	0.070	0.099	0.000	0.000	0.000	0.000
	budget	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000

Table 12: Japanese Money Demand Shock

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	0.082	0.072	0.043	0.033	0.243	0.000	0.000	0.000	0.000
	inflation	0.052	0.040	0.021	0.033	0.084	0.000	0.000	0.000	0.000
	CA	0.018	0.034	0.017	0.014	0.025	0.000	0.000	0.000	0.000
	budget	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
ROECD	output	0.073	0.101	0.040	0.034	0.367	0.000	0.000	0.000	0.000
	inflation	0.057	0.054	0.019	0.033	0.121	0.000	0.000	0.000	0.000
	CA	0.022	0.066	0.026	0.027	0.032	0.000	0.000	0.000	0.000
	budget	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 13: Negatively Correlated Money Demand Shocks in the U.S. and ROECD

(standard deviation of targets)

		Unobserved Shocks						Observed Shocks		
		float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
US	output	1.587	1.564	1.557	1.580	0.024	0.000	0.000	0.000	0.000
	inflation	0.426	0.598	0.593	0.461	0.009	0.000	0.000	0.000	0.000
	CA	0.163	0.170	0.166	0.196	0.003	0.000	0.000	0.000	0.000
	budget	0.000	0.005	0.004	0.008	0.000	0.000	0.000	0.000	0.000
ROECD	output	2.409	2.139	2.146	2.304	0.037	0.000	0.000	0.000	0.000
	inflation	0.694	0.836	0.839	0.742	0.014	0.000	0.000	0.000	0.000
	CA	0.122	0.160	0.155	0.169	0.035	0.000	0.000	0.000	0.000
	budget	0.001	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000

Table 14: Welfare Calculation

Portfolio Shift towards Ecu Assets

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	0.977	0.712	0.702	0.965	11.965	5.572	0.107	0.099	0.248
ROECD	1.442	1.267	1.261	1.547	40.629	0.903	0.177	0.155	0.313
Japan	0.656	0.687	0.478	0.823	5.146	1.095	0.562	0.240	0.396

Portfolio Shift Towards Yen Assets

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	0.098	0.080	0.075	0.089	0.663	0.481	0.011	0.011	0.029
ROECD	0.108	0.091	0.080	0.113	1.235	0.037	0.023	0.023	0.046
Japan	1.737	1.801	1.597	2.740	20.638	0.874	0.384	0.384	0.775

U.S. Aggregate Demand Shock

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	37.714	16.436	16.656	18.519	371.487	109.380	3.804	3.820	6.336
ROECD	12.079	7.808	7.791	14.978	207.562	11.100	2.398	2.374	3.433
Japan	7.503	4.408	4.517	8.722	41.692	33.315	1.526	1.540	2.371

ROECD Aggregate Demand Shock

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	11.172	4.559	4.528	9.413	57.865	45.323	0.678	0.639	1.638
ROECD	34.993	13.122	13.038	15.381	461.234	7.844	1.290	1.178	2.946
Japan	8.547	5.488	3.691	7.753	28.083	7.960	3.093	1.347	2.457

Table 14: Welfare Calculation (contd.)

Japanese Aggregate Demand Shock

	Unobserved Shocks						Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	1.091	0.625	0.544	1.145	2.767	6.171	0.181	0.110	0.313
ROECD	1.291	0.869	0.670	1.438	6.064	0.410	0.407	0.233	0.460
Japan	14.720	9.240	6.101	6.805	259.563	10.222	6.664	3.878	8.689

Opec Price Shock

	Unobserved Shocks						Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	0.011	0.004	0.004	0.023	0.011	0.019	0.003	0.003	0.019
ROECD	0.029	0.014	0.014	0.059	0.042	0.049	0.011	0.010	0.048
Japan	0.068	0.054	0.047	0.122	0.125	0.087	0.048	0.037	0.137

U.S. Price Shock

	Unobserved Shocks						Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	60.393	41.338	41.404	75.769	204.731	115.848	24.884	24.922	66.040
ROECD	4.697	0.559	0.557	4.843	98.887	2.286	0.240	0.245	2.754
Japan	2.855	0.333	0.365	2.045	17.770	7.558	0.147	0.169	1.206

ROECD Price Shock

	Unobserved Shocks						Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	5.547	0.546	0.540	4.292	21.827	10.722	0.114	0.092	1.902
ROECD	73.520	46.301	46.721	89.639	274.489	81.481	24.273	24.242	68.302
Japan	4.161	1.368	0.668	3.305	11.151	5.502	0.666	0.217	1.754

Table 14: Welfare Calculation (Contd.)

Japanese Price Shock

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	1.155	0.210	0.133	1.122	1.550	6.799	0.098	0.044	0.518
ROECD	1.334	0.393	0.204	1.384	6.078	0.996	0.225	0.093	0.688
Japan	43.170	36.367	33.698	45.555	228.572	36.295	25.924		
24.004	50.688								

U.S. Money Demand Shock

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	18.641	18.014	18.043	20.136	3.626	0.000	0.000	0.000	0.000
ROECD	0.880	0.291	0.294	0.391	8.046	0.000	0.000	0.000	0.000
Japan	0.432	0.174	0.171	0.333	1.889	0.000	0.000	0.000	0.000

ROECD Money Demand Shock

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	0.642	0.047	0.038	0.555	3.921	0.000	0.000	0.000	0.000
ROECD	33.575	28.930	29.146	34.525	8.755	0.000	0.000	0.000	0.000
Japan	0.458	0.554	0.095	0.490	2.046	0.000	0.000	0.000	0.000

Japanese Money Demand Shock

				Unobserved Shocks			Observed Shocks		
	float	noncoop	coop	nominal y	McKinnon	Global y	noncoop	coop	nominal y
U.S.	0.068	0.052	0.017	0.019	0.405	0.000	0.000	0.000	0.000
ROECD	0.068	0.113	0.017	0.022	0.908	0.000	0.000	0.000	0.000
Japan	11.325	13.441	12.309	17.489	0.212	0.000	0.000	0.000	0.000

Table 15: Rules for Monetary Policy Given an Observed Exchange Rate

σ_y^2	σ_m^2	$_t(\epsilon_t^y \mid M_t)$	$_t(\epsilon_t^m \mid M_t)$	γ
1.00	0.00	1.33	0.00	0.240
0.90	0.10	1.32	0.05	0.230
0.75	0.25	1.29	0.14	0.209
0.50	0.50	1.20	0.40	0.145
0.25	0.75	1.00	1.00	-0.047
0.10	0.90	2.00	1.08	-0.620
0.00	1.00	4.00	3.00	large-

note: σ_y^2 = variance of aggregate demand shock

σ_m^2 = variance of money demand shock

$_t(\epsilon_t^y \mid M_t)$ = conditional expectation of the aggregate demand shock.

$_t(\epsilon_t^m \mid M_t)$ = conditional expectation of the money demand shock.

γ = coefficient linking monetary policy to the exchange rate. A positive value implies a contractionary monetary policy in response to an appreciating currency or "leaning with the wind".

Appendix A: Technical Derivations

1. Solution of Dynamic Programming Problem

This section presents the solution algorithm for the following problem:

(A5) Max $\quad W_i = -\sum_{t=0}^{\infty} \beta^t \quad \tau_i^{'} \Omega_i \tau_i$

Subject to:

(A1) $\qquad X_{t+1} = \alpha_1 X_t + \alpha_2 e_t + \alpha_3 U_{it} + \alpha_4 E_t + \alpha_5 \epsilon_t$

(A2) $\qquad e_{t+1} = \beta_1 X_t + \beta_2 e_t + \beta_3 U_{it} + \beta_4 E_t + \beta_5 \epsilon_t$

(A3) $\qquad \tau_t = \gamma_1 X_t + \gamma_2 e_t + \gamma_3 U_{it} + \gamma_4 E_t + \gamma_5 \epsilon_t$

(A4) $\qquad {}_t(e_{t+1}) = E \, [\, e_{t+1} \mid \Omega_t \,]$

where the subscript i refers to country i.

The trick to solving the infinite horizon case is to assume that the problem is really of finite-time, with a horizon T. As is usual with dynamic programming, we use a process of backward recursion. We first solve the maximization problem in period T, assuming that period T is the final period. Assuming $e_{T+1} = e_T$ and using (A2) gives the jumping variables as a function of the state, control and exogenous variables. This can be substituted into (A3) to give targets as a function of state, control and exogenous variables as well as the stochastic shocks. The problem becomes:

Max $\quad W_T = - \tau_{iT}^{'} \Omega_i \tau_{iT}$

s.t. $\qquad \tau_T = \mu_1 X_T + \mu_{2i} U_{iT} + \mu_3 E_T + \mu_4 \epsilon_t$

where Ω_i is a diagonal matrix containing the utility weights. The solution gives a rule for the control variables and jumping variables of the following form:

(A6) $$U_{iT} = \Gamma_{1iT}X_T + \Gamma_{2iT}E_T + \Gamma_{3iT}\epsilon_T$$

(A7) $$e_T = H_{1T}X_T + H_{2T}E_T + H_{3T}\epsilon_T$$

These rules can be substituted into the equation for the targets given in (A3), to find the value of the welfare function in period T as a function of the state and exogenous variables and the shocks in period T.

$$W_{iT} = V_T(X_T, E_T, \epsilon_T)$$

To clarify the procedure, consider period t. The problem becomes:

(A8) $$\text{Max } {}_tW_t = - \tau_{it}\Omega_i\tau_{it} \quad + \beta \quad {}_tV_{it+1}(X_{t+1}, C3_{t+1})$$

$$\text{s.t.} \qquad \tau_t = \mu_1 X_t + \mu_{2i}U_{it} + \mu_3 E_t + \mu_4\epsilon_t$$

where C_{3t+1} is a constant depending on the path of all future exogenous variables. We can use (A1) to solve out for X_{t+1} and to write the problem in terms of period t variables and constants. The problem can then be solved as we did for period T. In terms of the recursion steps we have:

$$e_{t+1} = H_{1t+1}X_{t+1} + H_{2t+1}E_{t+1} + H_{3t+1}\epsilon_t + C_{2t+1}$$

Taking expectations of both sides gives:

$$e_{t+1} = H_{1t+1}X_{t+1} + H_{2t+1}E_{t+1} + C_{2t+1}$$

where C_{2t+1} is a constant containing the accumulation of all future exogenous variables. Substituting for e_{t+1} from (A2) and X_{t+1} from (A1) gives:

$$\beta_1 X_t + \beta_2 e_t + \beta_3 U_{it} + \beta_4 E_t + \beta_5 \epsilon_t = H_{1t+1}(\alpha_1 X_t + \alpha_2 e_t + \alpha_3 U_{it} + \alpha_4 E_t + \alpha_5 \epsilon_t) + H_{2t+1} E_{t+1} + C_{2t+1}$$

which can be solved for e_t:

(A9) $$e_t = JX_t + KU_t + ZE_t + Q\epsilon_t + C_{4t};$$

where $J = (\beta_2 - H_{1t+1}\alpha_2)^{-1}(H_{1t+1}\alpha_1 - \beta_1)$

$K = (\beta_2 - H_{1t+1}\alpha_2)^{-1}(H_{1t+1}\alpha_3 - \beta_3)$.

$Z = (\beta_2 - H_{1t+1}\alpha_2)^{-1}(H_{1t+1}\alpha_4 - \beta_4)$

$Q = (\beta_2 - H_{1t+1}\alpha_2)^{-1}(H_{1t+1}\alpha_5 - \beta_5)$.

This rule for e given in (A9) is substituted into the equation for the target variables given in (A3) to find:

$$\tau_t = \mu_1 X_t + \mu_2 U_t + \mu_3 \epsilon_t + C_{5t}.$$

Substituting into the welfare function given in (A8) and differentiating with respect to the control variables (U) gives a set of first order conditions which can be solved to find:

(A10) $$U_t = \Gamma_{1t} X_t + \Gamma_{2t} E_t + \Gamma_{3t} e_t + C_{1t}$$

Now we can substitute this rule for the control variables into (A9) to find a rule for the jumping variables as a function of the state variables and exogenous variables as given in (A12).

(A11) $$e_t = (J + K\Gamma_1)X_t + (Z+K\Gamma_2)E_t + (Q + K\Gamma_3)\epsilon_t + C_{4t} + KC_{1t}$$

(A12) $$e_t = H_{1t} X_t + H_{2t}E_t + C_{2t}$$

This procedure is then repeated until a stable rule for the Γ and H matrices is found. We then let $T \to \infty$.

2. Derivation of the Target Variance

Given the rules for the jumping variables and the control variables, we substitute these into (A1) to find:

(A13) $$X_{t+1} = \bar{A}X_t + \bar{Z}\epsilon_t + \bar{B}E_t$$

where $\bar{A} = \alpha_1 + \alpha_2 H_1 + \alpha_3\Gamma_1$

$\bar{B} = \alpha_4 + \alpha_2 H_2 + \alpha_3\Gamma_2$

and $\bar{Z} = \alpha_5 + \alpha_2 H_3 + \alpha_3\Gamma_3$

We next decompose $\bar{A}$ into its eigenvalue matrix and eigenvector matrix:

$$\bar{A}P = P\Lambda$$

or

$$\bar{A} = P\Lambda P^{-1}$$

where Λ is a diagonal matrix with characteristic roots along the diagonal Note that P, Λ, P^{-1} are complex matrices. Then, (A11) may be rewritten as:

(A14) $$Y_{t+1} = \Lambda Y_t + P^{-1}\bar{Z}\epsilon_t + P^{-1}\bar{B}E_t$$

where $Y_t = P^{-1}X_t$

Several of the eigenvalues will have unit values because we do not constrain the level of prices or level of debt in the steady state but only their rate of change. The Y's corresponding to these unit roots have infinite variances. Thus, we take the subset of Y's that have finite variance in the

their rate of change. The Y's corresponding to these unit roots have infinite variances. Thus, we take the subset of Y's that have finite variance in the

next steps. Call this reduced vector y. Λ and $P^{-1}Z$ are adjusted to conform with y.

Define $\Omega = {}_t(y_t y_t^{'})$, where $y^{'}$ signifies the complex conjugate of y. Since y is a stationary process, ${}_{t-1}(y_t y_t^{'}) = {}_{t-1}(y_{t+s} y_{t+s}^{'})$ for all s. Then from (A14) and assuming constant exogenous variables:

(A15) $$\Omega = \Lambda \Omega \tilde{\Lambda}^{'} + P^{-1}\bar{Z}\Sigma\bar{Z}^{'}(\tilde{P}^{-1})^{'}$$

Equation (A15) implicitly defines Ω which is the unconditional variance of y. This equation is solved by an iterative procedure to find Ω. The target vector τ_t is given in (A3). Given the rules for e_t and U_t in (A10) and (A12) we find:

(A16) $$\tau = \bar{M}X_t + \bar{O}\epsilon_t$$

where $$\bar{M} = \gamma_1 + \gamma_3\Gamma_1 + \gamma_2 H_1$$

$$\bar{O} = \gamma_4 + \gamma_3\Gamma_3 + \gamma_2 H_3$$

Since $Y_t = P^{-1}X_t$, this implies

(A17) $$\tau_t = (\bar{M}P)Y_t + \bar{O}\epsilon_t$$

<u>Very</u> <u>importantly</u>, all Y's having unit roots have no effect on τ_t. For m unit roots, the first m columns of $(\bar{M}P)$ are zero. Thus, by eliminating the first m columns of $\bar{M}P$, equation (A17) may be rewritten as:

(A18) $$\tau_t = (\bar{M}P)_{-m} y_t + \bar{O}\epsilon_t$$

(the -m is now dropped for notational convenience).

The variance covariance matrix of τ can then be written as:

(A19) $$_t(\tau\tilde{\tau}') = \bar{M}P\Omega\tilde{P}'\bar{M}' + \bar{O}\Sigma\bar{O}'$$

We can also calculate the expected utility loss given some arbitrary welfare function.

Let $\Pi = {}_t(T\tilde{T}')$, and utility $U = \sum_{t=0}^{\infty} \beta^t \tau' W\tau$

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

Then,

$$_t(\tau' W\tau) = \mathrm{Tr}_t(W\tau\tilde{\tau}') = \mathrm{Tr}(W\Pi).$$

Thus we find

(A20) $$_t(U) = \mathrm{Tr}(W\Pi)/(1-\beta)$$

Appendix B: Impulse Response to Shocks

To assist the reader in understanding the nature of the shocks facing the policymakers, we present results for shocks under a floating exchange rate regime with no policy response. Figures 1 to 7 contain the impulse responses of U.S. output, inflation, current account, interest rate and exchange rate to each of the shocks. The shocks examined are a 1% increase in the demand for ECU denominated assets, a 1% increase in U.S. and ROECD aggregate demand, a 1% rise in U.S. and ROCED prices and a 1% fall in U.S. and ROECD money demand. The results for Japanese shocks are not shown but are similiar (apart from scaling) to the ROECD shocks. To read the figures note that the results are presented as: percentage deviation of output and exchange rate from base; change in inflation and interest rates from base; and deviation of the current account from base as a percent of potential U.S. GNP.

Figures 1a and 1b contain the results for a temporary increase in the demand for ECU denominated assets. The shock is imposed as an exogenous risk premium in the portfolio balance equation which is sufficient to lead to a 1.3% impact depreciation of the nominal dollar/ecu exchange rate. The depreciation improves the U.S. current account immediately by 0.08% of U.S. GNP and leads to a rise in output of .22%. The output stimulus is quickly crowded out by rising interest rates and an initial inflation rise, resulting from the depreciation.

The results for exogenous shifts in aggregate demand in the U.S. is given in figures 2a and 2b. The 1% shock in the U.S. is sufficient to raise output by 1.5% in the first period due to multiplier effects. Interest rates rise by 1.25 percentage points in the first year. Inflation actually declines in the first year due to our assumption of sticky domestic prices. The exchange rate appreciation of 2.7% leads to an initial decline in consumer price inflation which quickly rebounds as excess demand pushes up the domestic price component in subsequent years. The current account deteriorates by 0.37% of GNP in the first year due the the strong domestic demand and an appreciated currency.

Figures 3a and 3b give the effects on U.S. variables of a corresponding shock to aggregate demand in the ROECD. The foreign demand shock equal to 1% of ROECD GNP improves the U.S. current account by .19% of U.S. GNP. The dollar depreciates 2.6% on impact. The U.S. is faced with rising interest rates, strong demand and rising inflation. The major difference (apart from scale effects) between the foreign and the U.S. demand shocks are that a deteriorating current account and strong dollar accompanies the U.S. shock and improved current account and depreciated dollar accompanies the ROECD shock.

The results for a U.S. price shock are given in figure 4a and 4b and for the ROECD price shock in figure 5a and 5b. The shock is implemented by adding an exogenous term to the Phillips curve in each country. Note that the shock affects prices in the second period although the presence of forward looking asset prices causes some adjustment in the first period. U.S. output falls by 1.3% when the U.S. price shock is realized, and the current account deteriorates for several years following the shock. Global inflation and higher world interest rates follow each price shock. The nominal exchange rate appreciates initially and depreciates over time. The jump appreciation follows from the anticipated nature of the shock. Since nominal U.S. interest rates exceed foreign interest rates in the first year, by the interest arbitrage condition, the U.S. dollar must be expected to depreciate. A similar line of reasoning applies to the jump depreciation following the ROECD price shock.

Figures 6a, 6b, 7a and 7b contain the response to an exogenous reduction in money demand in the U.S. and ROECD respectively. For the U.S shock, the initial excess supply of money causes a fall in nominal and real interest rates and a rise in output. The exchange rate depreciates in the period of the shock due to the low interest rate. The strong first period output effect feeds into inflation in the second period. The rise in prices swings the money market into an excess demand for real money balances in the second period by which time the exogenous demand for money has dropped. This leads to a sharp rise in interest rates and a fall of output. The role of sticky prices in our model is apparent once again. The ROECD shock is transmitted very slightly. In this case the positive effect of strong initial ROECD demand is offset by an exchange rate depreciation which results in very slight improvement of the U.S. current account.

Figure 1a Increase in Demand for ECU assets

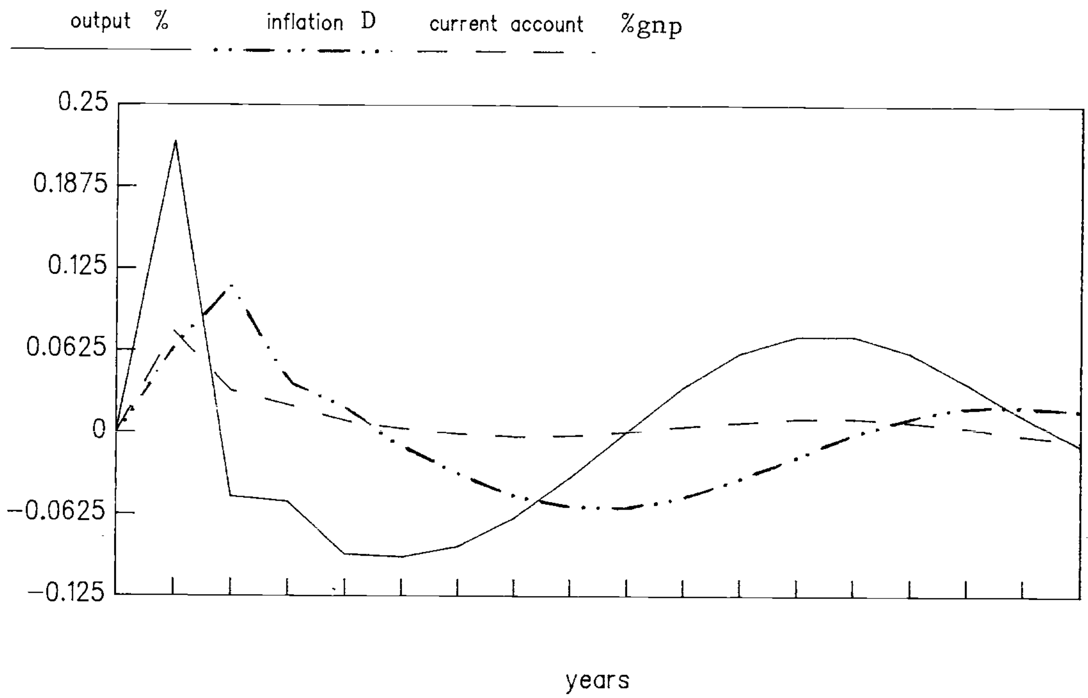


Figure 1b Increase in Demand for ECU assets

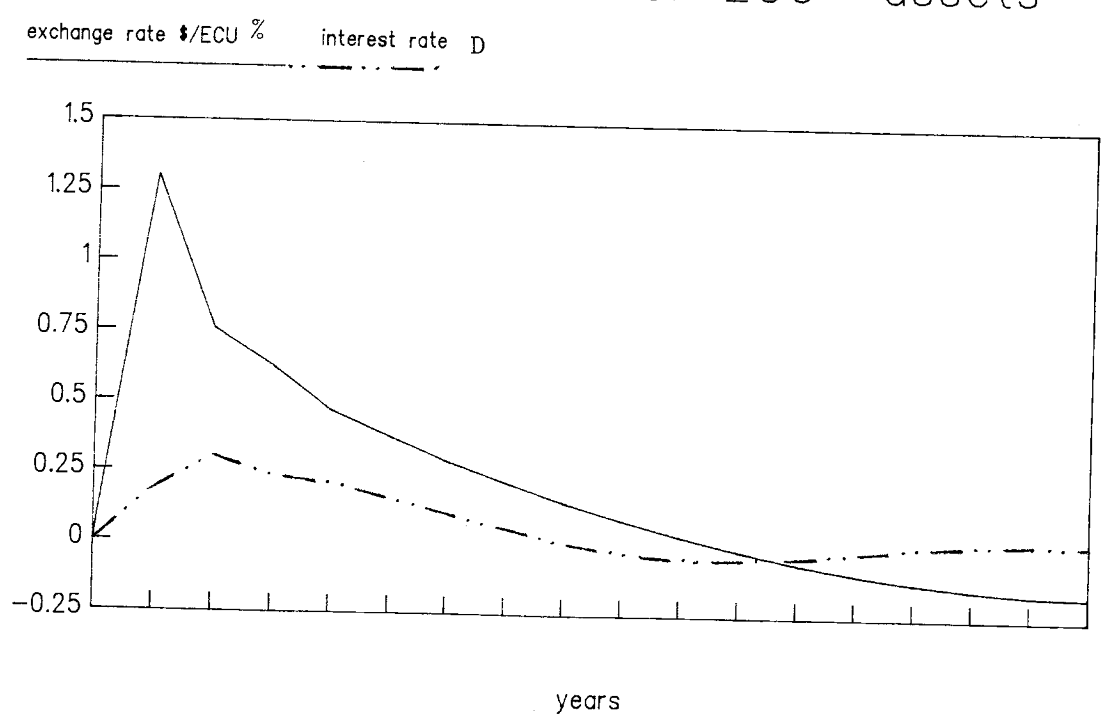


Figure 3a Increase in ROECD Aggregate Demand

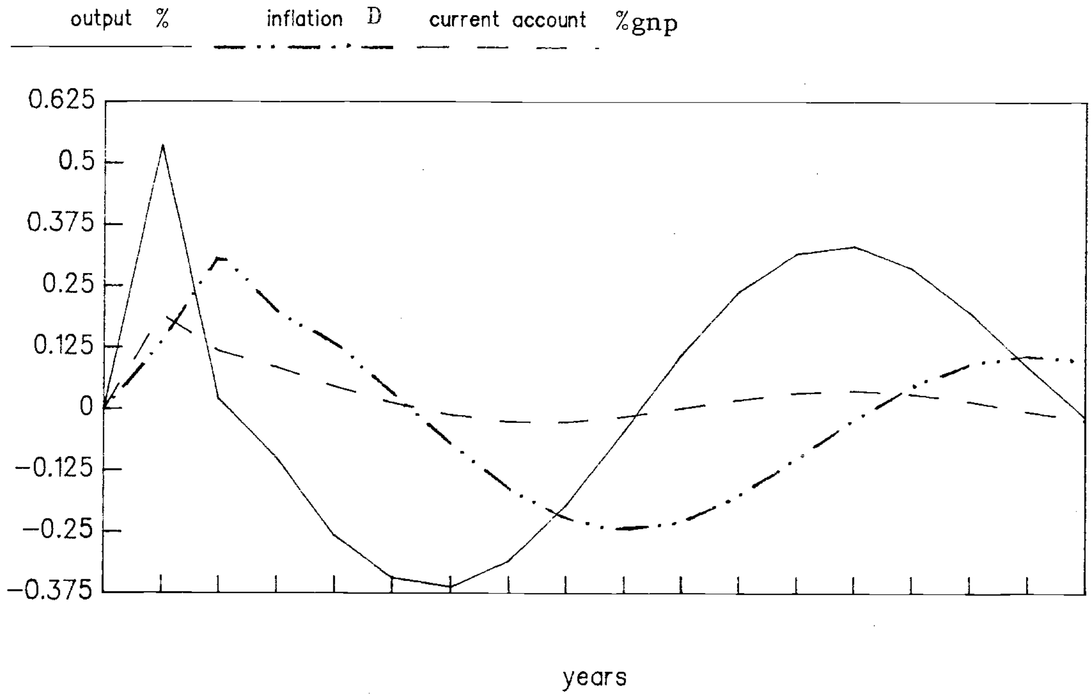


Figure 3b Increase in ROECD Aggregate Demand

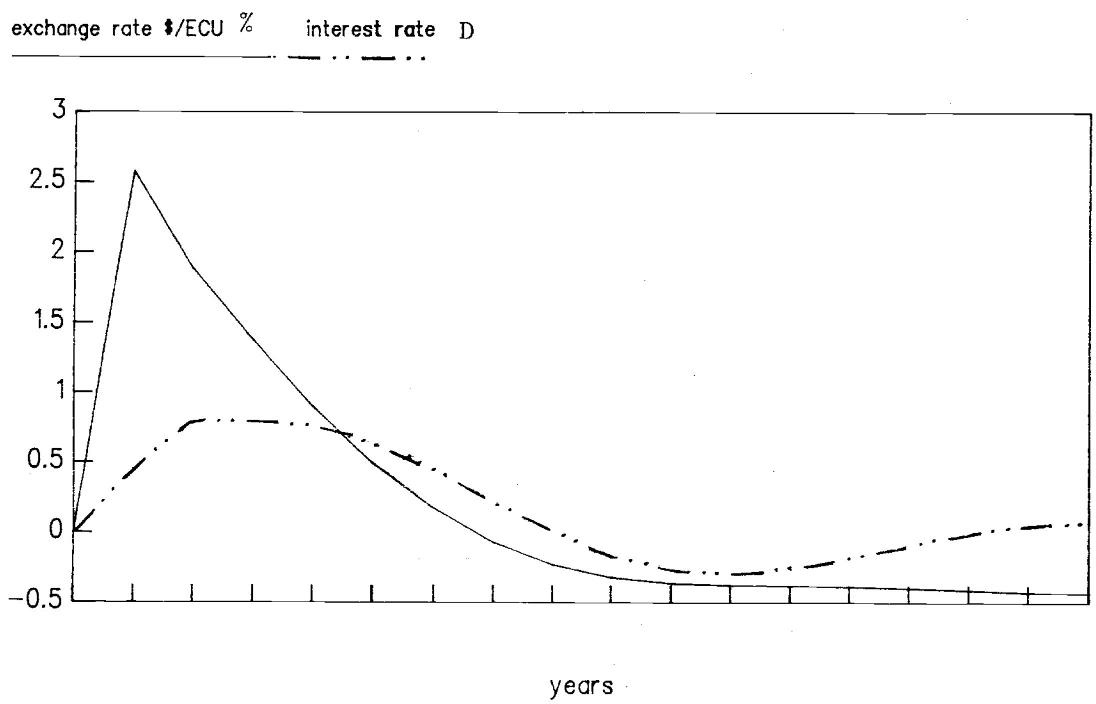


Figure 2a Increase in U.S. Aggregate Demand

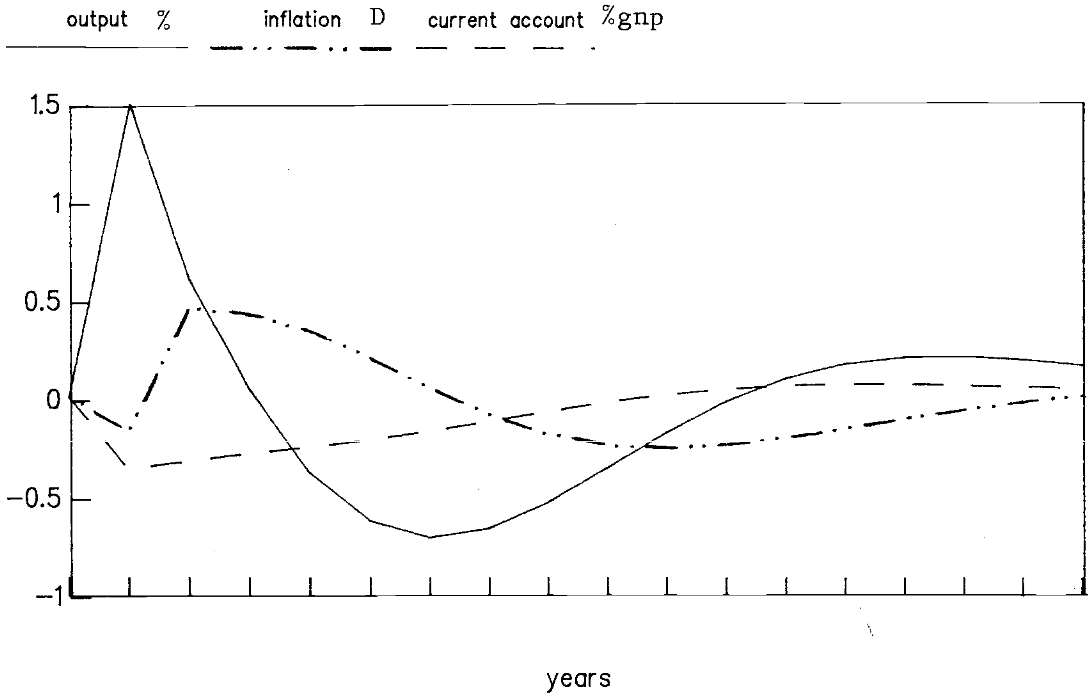


Figure 2b Increase in U.S. Aggregate Demand

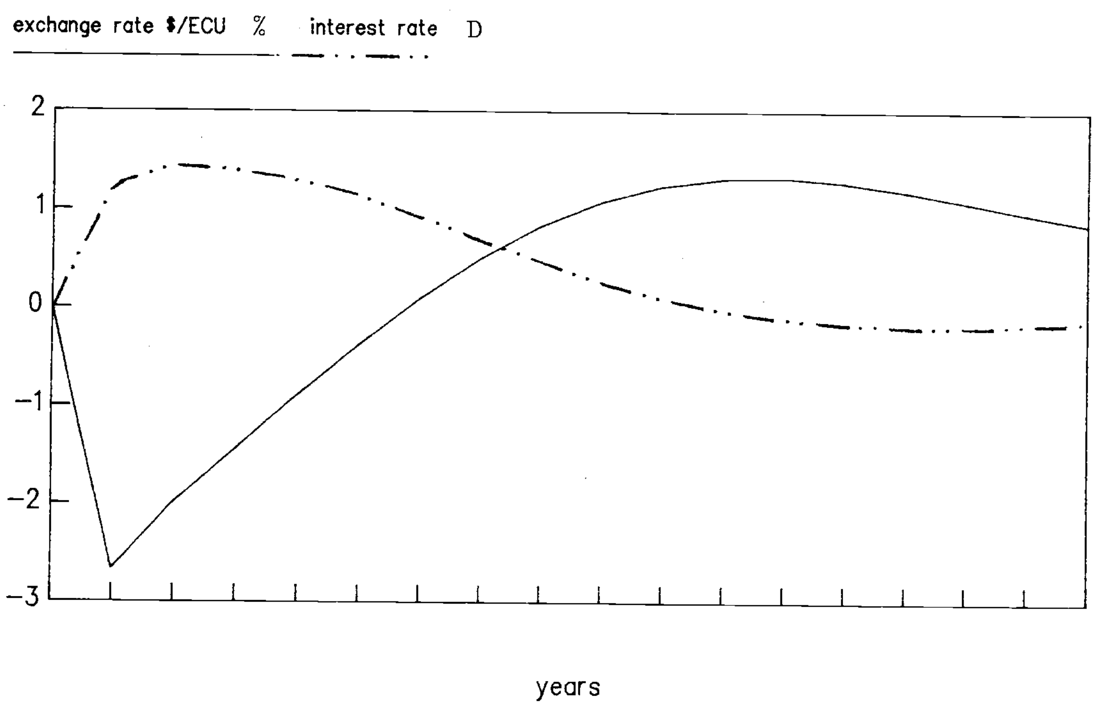


Figure 4a

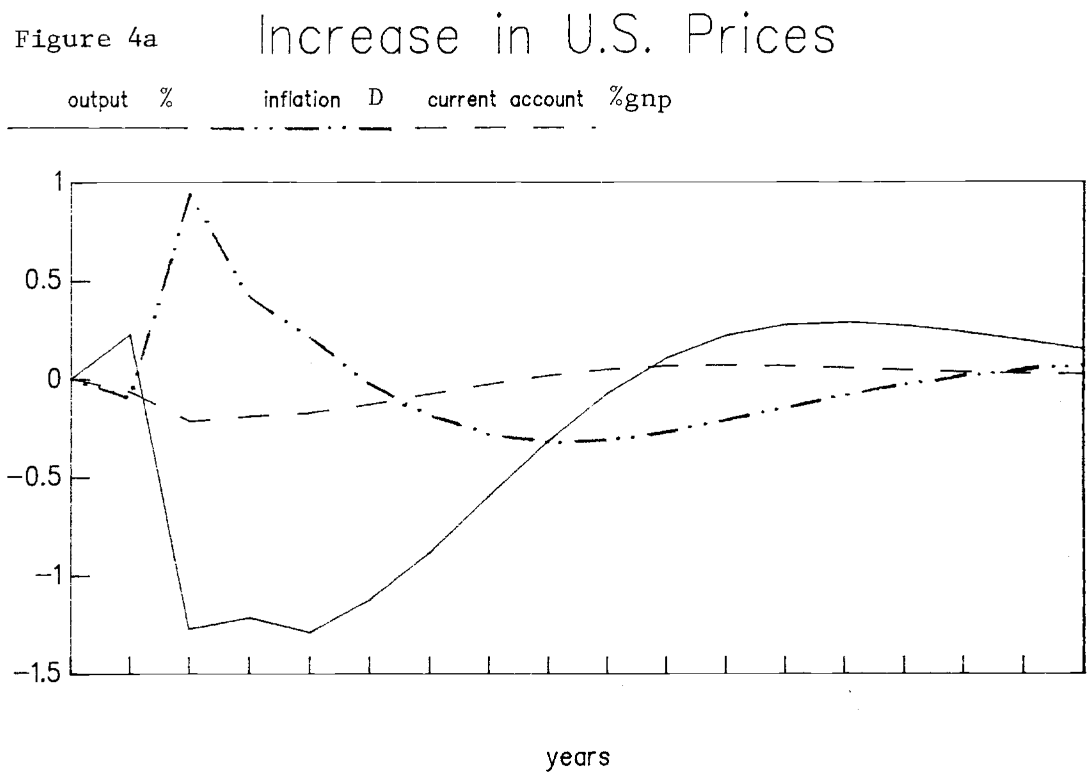


Figure 4b

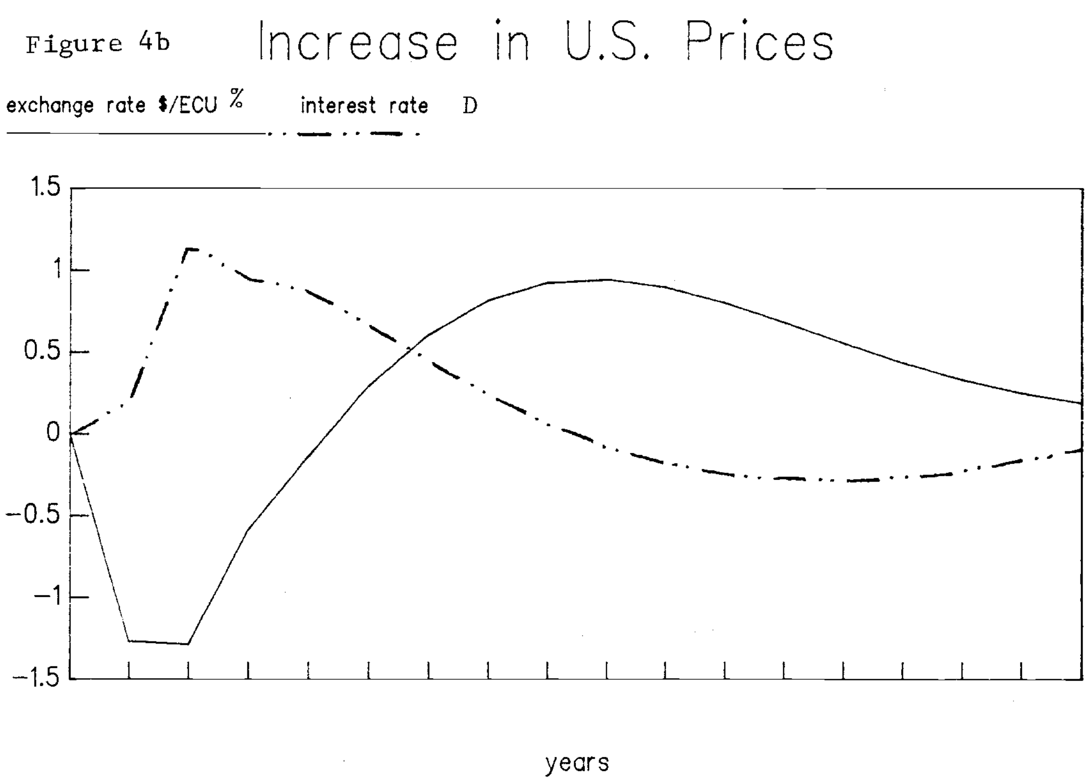


Figure 5a

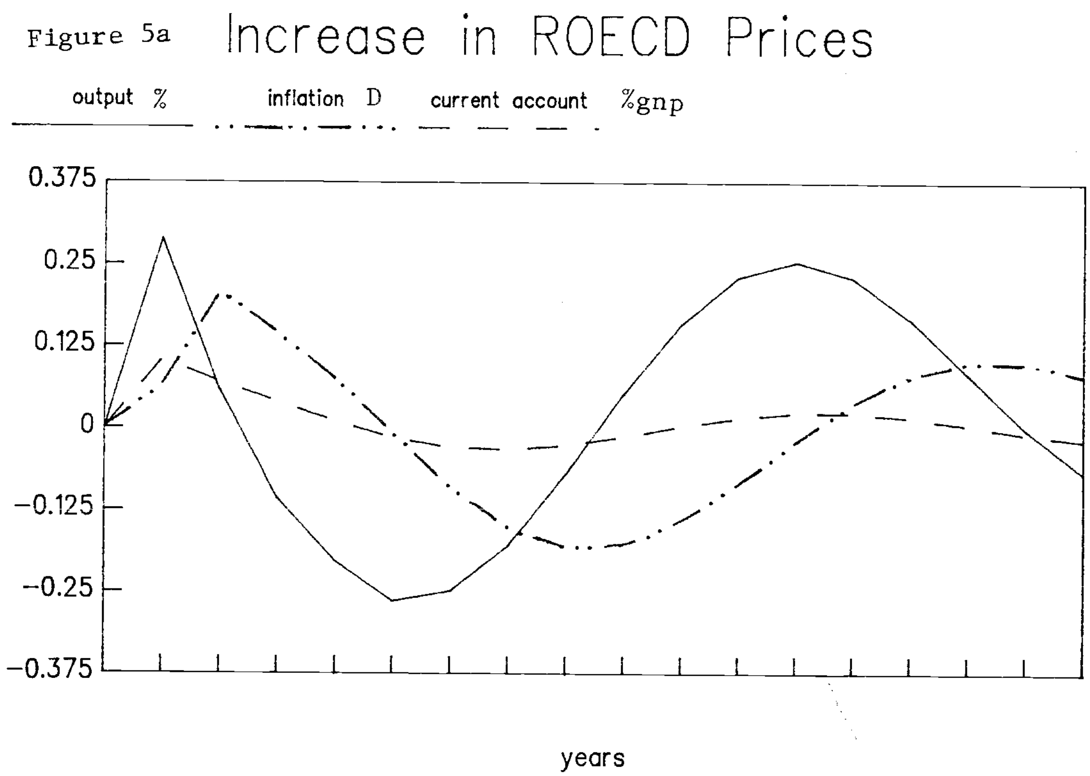


Figure 5b

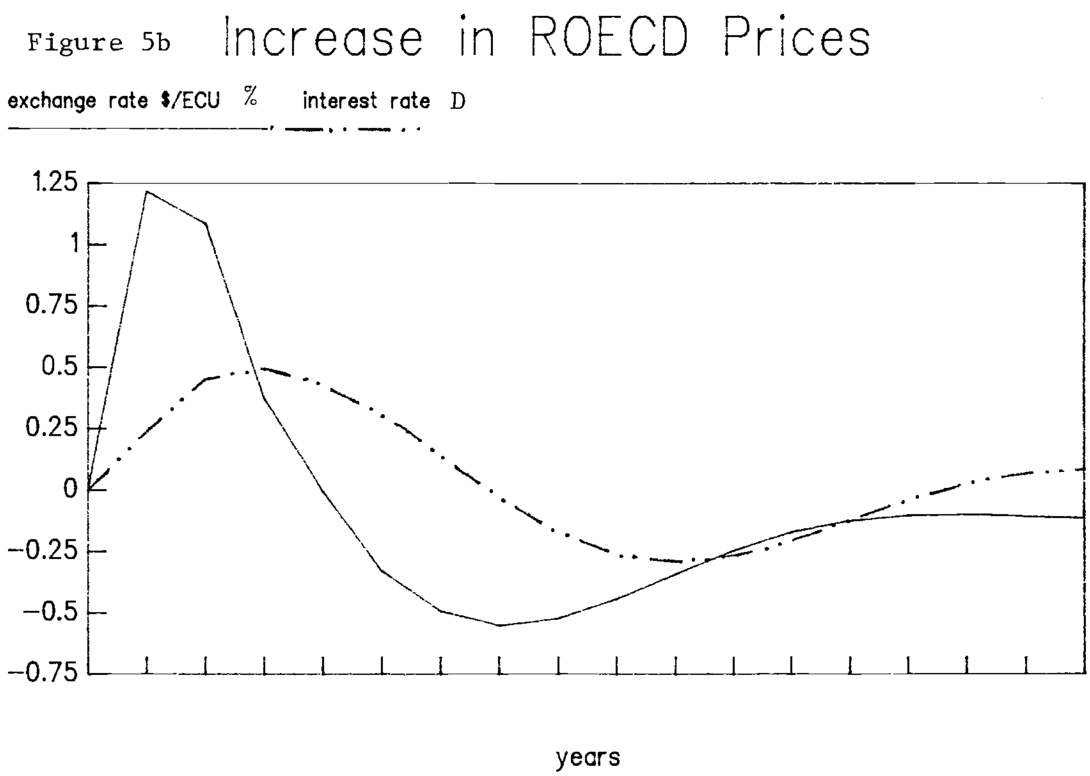


Figure 6a Reduction in U.S. Money Demand

output % inflation D current account %gnp

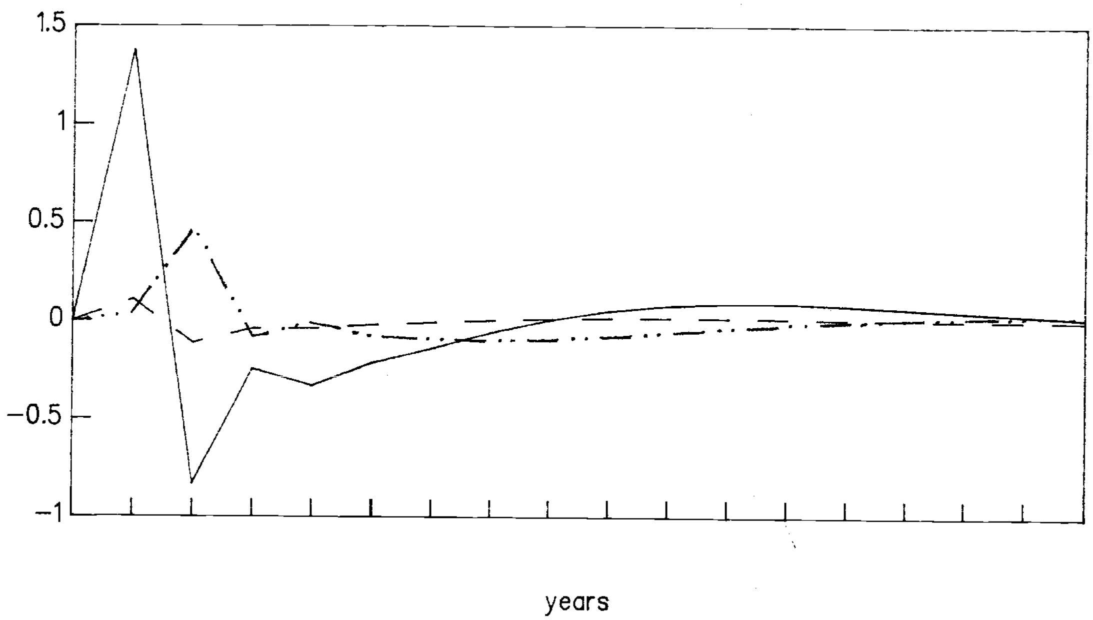


Figure 6b Reduction in U.S. Money Demand

exchange rate $/ECU % interest rate D

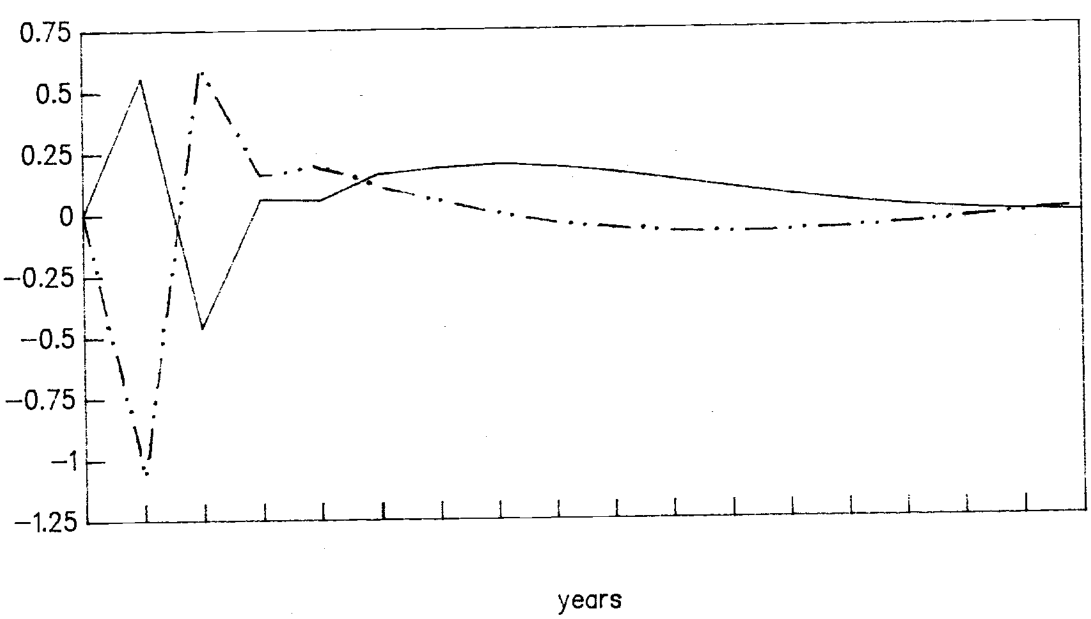


Figure 7a Reduction in ROECD Money Demand

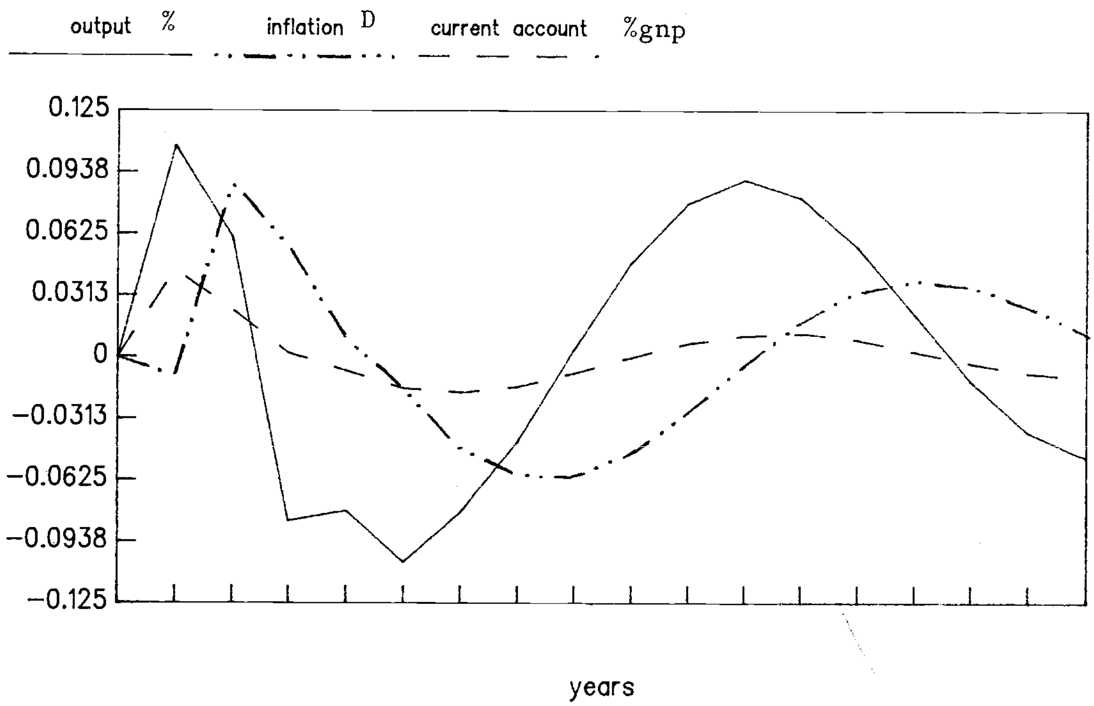
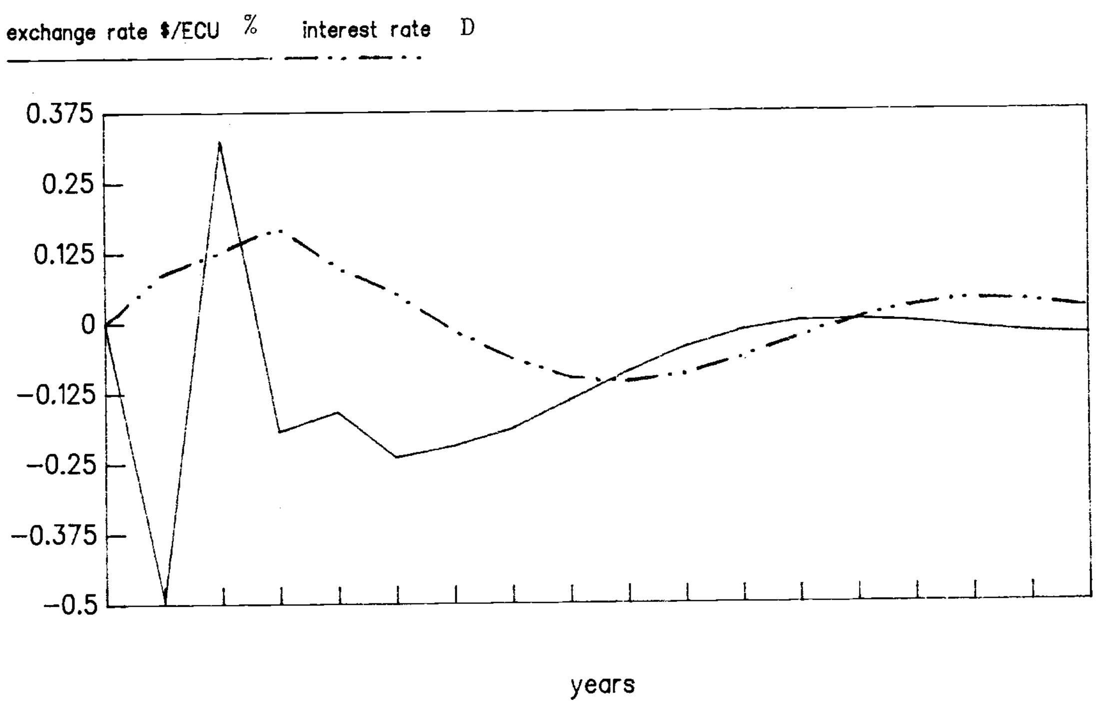


Figure 7b Reduction in ROECD Money Demand



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