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ASSESSING INTERNATIONAL INTERDEPENDENCE WITH A MULTI-COUNTRY MODEL

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Introduction

Policymakers have increasingly emphasized the interdependence of the world's economies. The major purpose of this paper is to support this position with quantitative estimates of the importance of interdependence -- in this case for the effects of the monetary and fiscal policies of Japan, West Germany and the United States. The vehicle used for the simulations presented in this paper is a multi-country econometric model recently developed at the Board of Governors of the Federal Reserve System.[1] The results using this model confirm the quantitative importance of a number of avenues of interdependence: (1) the direct effects of policies in one country on other economies, (2) the feedbacks of a policy change on the initiating country, mediated through changes in foreign variables, and (3) the effect of endogenizing certain variables, such as exchange rates, which are essential for modeling the international influences on a given economy.

*The six authors, members of the Quantitative Studies Section of the International Finance Division, produced jointly the Multi-Country Model and the empirical results on which this paper is based. The paper was written by Howard Howe, Ernesto Hernández-Catá and Guy Stevens. We are very grateful to Joseph Formoso, Ann Mirabito, Sam Parillo, Ken Rubel and Steven Schooler for their contributions to the completion of the model and the preparation of this paper. Helpful discussions with various members of the Board's Division of International Finance are gratefully acknowledged. The views expressed in this paper are those of the authors and do not necessarily represent the views of the Federal Reserve System.

The first section of this paper describes the historical development of the Multi-Country Model to its present general structure. In the second section and the appendix we go into more detail concerning the construction of a typical country model within the overall system. Sections III through VII present the details of typical monetary and fiscal actions in Japan, West Germany and the United States with a view to their effects at home and abroad. To highlight the importance of interdependence for the magnitude of these effects, the results obtained with the Multi-Country Model are compared to the corresponding results derived from the unlinked national models.

I. Development and Present Structure of the Multi-Country Model

In 1974 when the Multi-Country Model (MCM) project was conceived, recent events -- the move to flexible exchange rates, the quadrupling of the price of oil -- had dramatized the importance of the impact of external influences on the U.S. economy. Moreover, it was clear that then-existing quantitative models were incapable of analyzing the effects on the U.S. economy of these and most other internationally-generated influences. At that time, no U.S. models had endogenous exchange rates and few had little more in their foreign sectors than a set of trade equations.

Given this situation, it became clear to researchers inside and outside the U.S. government that a new approach to modeling external influences on the U.S. economy was needed. At the Federal Reserve Board, an effort was undertaken in the Division of International Finance to build an econometric model for the purpose of forecasting and simulation which would:

1. Determine endogenously the international transactions and important exchange rates of the United States.
2. Quantify the effects of international variables on the U.S. economy, particularly trade flows, capital flows, and exchange rates.
3. Analyze the effects of U.S. monetary policy on exchange rates, trade and capital flows.
4. Analyze the effects of exchange market intervention, both by the United States and foreign countries.
5. Quantify the most importance effects of economic

developments in the United States on foreign countries feedbacks of these effects on the United States; and

6. Analyze the impact of changes in foreign monetary policies on the U.S. economy.

This effort eventually led to the Multi-Country Model in its present form.

There are, of course, numerous alternative ways of achieving these objectives. A crucial question was whether the world outside the United States ought to be modeled as a single, undifferentiated region, or whether individual countries should be broken out. As we have discussed at length elsewhere,[2] we found no reasons, either empirical or theoretical, to support the most radical alternative of aggregating all non-U.S. countries into a single, composite "rest of the world." In particular, none of the theoretical reasons required for aggregation across countries were present; moreover, empirical conditions implying aggregability as the near-perfect correlation of important foreign variables such as exchange rates, domestic prices, and incomes had not held in the past decade. Finally, of course, the goals emphasizing the modeling of foreign country detail and policy changes would be furthered by a multi-country, rather than a two-country, approach.

Once the two-country approach had been rejected, the problem became one of deciding on a tractable size for the multi-country system. A particular difficulty with modeling the international influences on the United States economy is that no small set of countries dominates U.S. international transactions. At this stage we have constructed and linked quarterly models for five countries and an abbreviated "rest of the world" (ROW). Besides the United States, foreign countries chosen are Canada, West Germany, Japan and the United Kingdom. As Table I shows, these four countries account for a large percentage of U.S. exports (45% in 1975), imports (41%), the stock of direct investment (44%) and the stock of portfolio claims (42%) and liabilities (35%) on foreigners. Although the percentage is not over-whelming in any of these categories -- thus the difficulty of modeling the international influences on the United States -- these countries account for a larger share than any other four-country set.

Among those favoring disaggregation, no one would dispute the separate modeling of the above four countries. However, despite their size and importance, the rest-of-the-world sector that remains still accounts for more than half of total U.S. trade and capital flows. This fact alone argues for more disaggregation in the future. A perusal of Table I indicates some clear candidates: France, Italy, and Mexico, particularly because of their importance for U.S. trade; Switzerland for capital flows; the Middle East oil exporters and Venezuela for both trade and capital flows.

Even if one were to specify separate models for all of the above countries, the percentage of U.S. trade and capital flows relegated to the rest of the world would still be large. Thus, for the United States, it is virtually impossible to completely ignore the aggregate of the remaining countries not modeled explicitly, the so-called rest of the world (ROW). As the MCM now stands, the treatment of ROW is quite limited. The only endogenous variables in ROW are a set of (bilateral) trade equations between ROW and the five countries modeled individually, the prices of exports and

TABLE I

TRADE AND INVESTMENT BY MAJOR COUNTRIES

(Millions of U.S. Dollars)

	U.S. Trade (1974)		U.S. Direct Investment (1974)		U.S. Total Claims (Non-Direct) on Foreigners (1974)		U.S. Total Liabilities (Non-Direct) to Foreigners (1974)	
	Imports	Exports	Stock	Flow (1974-1973)	Stock	Flow (1974-1973)	Stock	Flow (1974-1973)
W. GERMANY	6428(3)	4986(3)	7998(3)	348(12)	1045(8)	307(7)	10429(4)	-3557(3)
JAPAN	12455(2)	10679(2)	3337(8)	666(6)	14102(1)	6438(1)	14802(1)	1406(5)
FRANCE	2305(9)	2942(9)	4886(4)	591(7)	1347(6)	199(11)	4807(5)	485(9)
UNITED KINGDOM	4021(6)	4574(5)	12461(2)	1421(2)	5116(3)	1676(2)	10455(3)	736(7)
CANADA	22282(1)	19932(1)	28378(1)	2837(1)	5864(2)	1330(3)	4700(7)	-270(11)
ITALY	2593(8)	2752(10)	2769(11)	557(8)	878(9)	206(10)	2869(11)	1097(6)
NETHERLANDS	1453(18)	3976(6)	3209(9)	857(3)	868(10)	463(6)	4086(8)	535(8)
SWITZERLAND	900(24)	1150(19)	4538(6)	724(5)	531	222(9)	10862(2)	5774(1)
MIDDLE EAST OIL EXPORTERS*	4346(5)	3215(7)	2129(12)	-459(9)	714(12)	NA	4727(6)	3981(2)
MEXICO	3386(6)	4855(4)	2825(10)	446(11)	3112(4)	961(5)	1864(12)	483(10)
VENEZUELA	4676(4)	1768(15)	1772(13)	-279(13)	1291(7)	303(8)	3494(9)	19[illegible](4)
BRAZIL	1705(13)	3089(8)	3658(7)	773(4)	2503(5)	966(4)	1160(13)	233(12)
4 Country Total**	45186	40171	52174	5272	26127	9751	40386	-1685
World Total	100965	98524	118613	14938	61548	22577	112884	23504
4 Country % of World Total	44.8%	40.8%	44%	35.3%	42.4%	43.2%	35.8%	7.2%

Source: U.S. Trade, Direction of Trade, Oct. 1975, p.2-4.
U.S. Direct Investment, Survey of Current Business, "U.S. Direct Investment Abroad", Oct. 1975, Tables 12, 13.
Total U.S. Claims on Foreigners, FRB Bulletin, Feb. 1975, A69, T.12, A75, T.23, A68, T.13, and Feb. 1976, A74, T.24, A73, T.23, A67, T.12 also Treasury Bulletin, May 1976, p.97, p.106, p.108.
Total U.S. Liabilities to Foreigners, FRB Bulletin, Feb. 1975, A66, T.8, A68, T.10, A75, T.23, and Feb. 1975, A64-A66, T.8-T.10, A69, T.15-T.16, A73, T.23 also Treasury Bulletin, May 1976, p.92, p.100, p.102, p.111-113.
*Middle East Oil Exporters are defined as in FRB Bulletin; Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates
**Four Country Total comprises W. Germany, Japan, U.K., and Canada.

and imports, and an average industrial production index. Such an abbreviated treatment of ROW could lead to difficulties in forecasting and simulation, as explained in Section III. below. Nevertheless, for the most part, simulations using the system do not seem to have been affected adversely, and the tracking performance of the model, both inside and outside the sample period, has been quite good.[3]

The core of the MCM is a system of five linked national macroeconomic models, at the center of which is a medium-sized model of the U.S. economy. These models explain the main domestic variables and international transactions of each country: real and nominal GNP and its components (consumption, investment, exports and imports of goods and services), deflators for domestic spending, exports and imports, as well as the wage rate, capacity utilization and unemployment.[4] Each country model has a monetary sector which determines short- and long-term interest rates as well as monetary aggregates. The most important instruments of monetary and fiscal policy -- reserve requirements, the discount rate, central bank holdings of a domestic and foreign assets, and real government expenditures -- are integrated into each country model.

The individual country models are linked through trade flows, prices, interest rates and capital flows. For example, the exports of each country are determined by other countries' imports from that country. In this way a change in one country's foreign trade has an immediate impact on the GNP of other countries. Similarly, the price of imported commodities depends on other countries' export prices and on the exchange rates that convert these prices into domestic currency. Movements in foreign price and conditions are transmitted to each country's import price, which in turn directly affects its domestic price level.

The monetary sectors of the various countries in the model are directly linked together through capital flows. A change in monetary conditions in one country will affect its short- and long-term interest rates and funds will move from one country to another insofar as portfolios are readjusted. These international capital movements will directly affect monetary conditions in the receiving countries to the extent that exchange market intervention is allowed to impinge on the monetary base.[5] In addition, interest rate changes in one country may affect exchange rates and therefore have an indirect impact on foreign monetary conditions through changes in foreign trade balances and demand conditions.

A special feature of the Multi-Country Model is that it can operate under a variety of exchange-rate regimes. When fixed exchange rates are assumed, each country's over-all balance of payments determines the change in its stock of international reserve assets. When the model operates under a system of managed floating, the change in a country's international reserves is determined (for countries other than the United States) by the discretionary intervention behavior of the central bank; these official purchases and sales of foreign exchange, together with all the other items in the balance of payments, jointly determine the bilateral dollar exchange rates of these countries.

II. The Basic Structure of the Country Models

There are numerous differences among the five country models, largely reflecting differences in institutional detail. There is, however, substantial similarity in their basic structure. The main features of this structure are discussed in this section, and a condensed list of equations is given in the Appendix.[6]

In each country model, prices and quantities are determined by the behavior of four classes of economic agents: the monetary authorities (including the central bank and other holders of official foreign assets), the government, commercial banks, and the private nonbank sector (firms and households). Each country is assumed to produce a different composite consumption-investment commodity, and the domestic and foreign demands for this commodity -- as well as the domestic and export prices -- are determined in the expenditure and pricing sectors of the model. The labor market contains equations explaining the wage rate and the unemployment rate. The short-term interest rate is determined in the monetary sector, which is based on the identity between the sources and uses of the monetary base; and a term structure equation is used to explain the long-term interest rate. Finally, the balance of payments equations are used to determine each country's bilateral dollar exchange rate.

1. Domestic Output and Price Determination

The market for domestic output is described in terms of three sectors: (a) aggregate demand and expenditure, (b) potential output and capacity utilization, and (c) price determination.

(a) Domestic expenditure sector

Aggregate demand (GNP) is broken down into five major components: personal consumption, fixed investment, inventory investment, exports and imports. Consumption depends upon private disposable income[7] and net worth, while gross fixed investment (following the neoclassical approach) is positively related to current and lagged changes in GNP and negatively related to current and lagged changes in the user cost of capital. Since the long-term interest rate is an important determinant of the user cost of capital, the investment function provides a key link between the monetary and real sectors of the model. Inventory investment is assumed to depend upon the gap between expected sales and current production. The change in inventories thus contributes, together with the movement in prices, to the absorption of any discrepancy between final demand and the supply of domestic output.

Imports and exports of goods and services are broken down into merchandise, investment income and other services. Investment income flows are related to lagged stocks of claims and liabilities vis-á-vis foreigners and to the corresponding interest rates. Imports of goods and imports of other services are functions of domestic economic activity, domestic prices and import prices. Since import prices depend upon foreign export prices and exchange rates, the import equations play a key role in the transmission of external influences to a country sub-model. The import equations are also important in that the exports of each country are determined by the imports of the other four countries and those of the rest of the world (ROW).

This feature of the model -- which insures that world imports are equal to world exports at every point in time -- is described in more detail in section II.5.

Private net worth is another important variable determined within the real sector of the model. As mentioned earlier, this variable is included in the consumption function, and it is also used as a scale variable in all the asset demand equations (Section II.3). The change in private net worth is essentially derived as the difference between private disposable income and personal consumption. The stock of private net worth is simply the cumulated sum of private saving and therefore excludes capital gains and losses.

(b) Potential output and capacity utilization

The rate of capacity utilization is defined as the ratio of actual to potential GNP. Potential GNP, in turn, is assumed to be related to the capital stock and to potential employment through a Cobb-Douglas production function. Substituting for potential GNP yields an equation in which capacity utilization is directly related to the output-labor ratio and inversely related to the capital-labor ratio.

(c) Price determination

There are three main price variables in the prototype model: the deflator for domestic absorption expenditures (consumption, investment and government spending), P; the export unit value index, PXG; and the import unit value index, PMG.[8] In each country PMG is determined by the export prices of the other countries in the MCM and ROW, and by the exchange rates which convert these foreign-currency export prices into domestic currency. In turn, each country's export price is determined as a mark-up over wage costs, changes in labor productivity, and the cost of imports (PMG). For certain countries the mark-up depends on domestic and foreign capacity utilization rates as well as competitors' export prices. Thus price and exchange rate developments are transmitted directly among the countries in our model through these import-export price linkages.

The deflator for domestic expenditures -- which includes domestic as well as foreign goods and services -- is also explained as a mark-up over wage rates, labor productivity and import prices, with the mark-up varying in response to the level of domestic capacity utilization.

2. The Labor Market

The important variables determined in this sector are the wage rate in manufacturing and the unemployment rate. The rate of change in nominal wages is a function of the unemployment rate and the expected rate of change in the deflator for aggregate expenditure. Unemployment is viewed as the difference between supply and demand for labor. (It is assumed that because of union contracts and minimum wage laws, wages do not adjust sufficiently to clear the market, so that there may be a disequilibrium in the form of excess labor supply.) Labor demand is determined by lagged adjustment to the desired labor input (the value of output divided by the wage rate), a relation which follows from the equality between the real wage and the marginal physical product of labor. Changes in aggregate demand will thus have an influence on the domestic price not only via changes in capacity utilization but also through demand pressures affecting wages.

Labor supply (the labor force) is a function of population and the real wage rate, or, in certain country models, is treated as exogenous.

3. The Monetary Sector: Asset Demand and Interest Rate Determination

The basic building block in this sector is the balance sheet of the central bank.[9] The balance sheet identity specifies the link between the main sources of the unborrowed monetary base -- net foreign assets (NFA) and the net government position (NGP) -- and its uses: required reserves (RR), free reserves (RF, defined as excess reserves minus borrowed reserves), and currency (CUR)

$$NFA + NGP \equiv RR + RF + CUR$$

Required reserves are calculated by multiplying the (policy determined) reserve requirement ratios by the corresponding deposit stocks. The banks' demand for free reserves depends upon the short-term interest rate and the official discount rate. The demands for deposits, currency, and free reserves are negatively related to the short-term interest rate.[10] Hence, for a given stock of the unborrowed base, the short-term interest rate will adjust so as to equilibrate the existing supply with the direct and indirect demands for base money: RR, RF and CUR. The short-term interest rate is thus determined implicitly by equating the supply and demand for base money.

Except for the model of the United Kingdom, the demand and supply for long-term securities is not explicitly introduced. Instead, it is assumed that these securities are close substitutes for short-term money-market instruments, and the models include term structure equations which express the long-term rate as a weighted average of current and past values of the short-term rate.

The equations explaining the demand for both domestic and foreign assets follow basically the portfolio balance approach and are specified in stock form. (Due to the lack of benchmark data, however, in several instances the capital flow equations have been estimated in first-difference form.) They include private net worth, a transactions variable, and a vector of rates of return as the main explanatory variables.

The equations explaining financial claims and liabilities vis-a-vis foreigners contain not only domestic and foreign interest rates, but also a variable representing the expected change in the exchange rate, since this is part of the rate of return on foreign assets. In several countries the forward rate is used as a proxy for the expected future spot rate.[11] The forward rate or premium is itself explained as a function of the interest rate differential as well as variables designed to reflect expectations concerning future spot rates. The two variables used most often are the ratio of imports to net foreign assets and the country's export price divided by a weighted average of other countries' export prices. The former proxy variable is particularly useful during the fixed rate period, when it serves as an indicator of the ability of the central bank to continue pegging its exchange rate against the dollar. We hypothesize that an increase in these variables generates an expectation of a future depreciation of the currency, which shows up as a larger forward discount (smaller premium).

A key empirical feature of the model is that the net capital account in each country model responds in a stabilizing manner to a change in the current exchange rate. Given the expected future spot rate -- which, as described above, is determined endogenously -- a depreciation of the exchange rate in the current period will generate a net capital inflow that will attenuate the depreciation. In our model, therefore, expectations are basically regressive: a depreciation (appreciation) generates expectations of a future appreciation (depreciation). These regressive expectations prevent exchange rates from fluctuating too sharply in response to shocks to the balance of payments.

Another key feature of the model is that the change in net foreign assets (NFA) in each country model is treated as an endogenous variable. (See section IId.) Hence changes in monetary policy instruments (discount rate, reserve requirements, and control over the central bank's net government position) will have induced effects on the country's NFA component of the monetary base. Changes in NFA may, however, be sterilized by the central bank through changes in its net government position (NGP). We assume that, during the sample period, there was full sterilization in the United States and United Kingdom, and that partial sterilization occurred in Japan.[12]

A number of linkages between the monetary and real sectors should be pointed out. First, a rise in GNP will increase the demand for bank deposits, thereby raising the short-term interest rate which, through the term structure equation, will raise the long-term rate. The higher interest cost will reduce the level of investment, thereby moderating the initial rise in GNP. Second, a change in private net worth will have interest rate effects (assuming a given stock of the monetary base) that will affect investment. Third, when a country does not maintain a pegged exchange rate, a change in monetary policy will have both interest- and exchange-rate effects. For example, expansionary monetary policy will reduce (at least in the short run) the domestic interest rate and depreciate the country's exchange rates vis-a-vis the four other countries. These exchange rate changes will tend to improve its trade balance (expressed in real terms) by raising the price of imports and increasing demand for its exports. Hence, under managed floating, monetary policy affects domestic income and prices not only through its familiar effect on investment expenditure, but also through changes in exchange rates.

4. Exchange Rates and Reserve Changes

Between 1970 and 1973 many countries -- including the five treated separately in the multi-country model -- went through a transition from a system of pegged exchange rates to one of limited exchange rate flexibility, or managed floating. This transition is explicitly introduced in the MCM. Indeed, the structure of each country submodel shifts when that country switches from one exchange regime to the other, notably by changing the way in which the spot exchange rate (E) and the change in official net foreign assets (NFA) are determined.[13] Under both regimes, balance of payments equations play an important role in the determination of these variables.[14]

During the pegged exchange-rate period, each country's spot exchange rate vis-a-vis the U.S. dollar is exogenous[15] and the change in its stock of net foreign assets is endogenously determined by its balance of payments equation. During the period of managed floating, the 4 bilateral exchange rates in the model become endogenous. Explicit exchange rate equations are not used. Rather, with official intervention determined by behavioral equations, exchange rates are determined by balance of payments equations.

During the floating rate period, intervention in the foreign exchange market (the change in NFA) is determined by a reaction function. These reaction functions assume that the monetary authorities "lean against the wind" -- that they intervene to moderate changes in the exchange rate. Currently the form of these equations is quite simple and much work remains to be done in this area. It is encouraging, however, that the introduction of intervention functions improves the dynamic simulation results for exchange rates, presumably by moderating the effect on these variables of errors in the various balance of payments components.

5. Determination of Trade Flows

Trade flows in the MCM are handled on a bilateral basis. For each country model there are 5 bilateral import functions representing the demand for that country's goods on the part of the other 4 countries in the MCM and the ROW sector. Each of these five bilateral equations is incorporated in the model for the corresponding importing country and has the following general form:

$$LOG[X^{v}_{ij}/(PXG_i \cdot E_i)] = A_{oj} + A_{1j} \cdot LOG(GNP_j) + A_{2j} \cdot LOG[P_jE_j/(PXG_i \cdot E_j)]$$

where X^{v}_{ij} = value of merchandise exports from country i to country j (customs clearance basis) in billions of U.S. dollars

GNP_j = gross national product at constant 1972 prices of country j

P_j = price index of country j

E_j = exchange rate index of country j (in U.S. dollars per local currency)

PXG_i = export price (unit value) index for country i, expressed in local currency.

The sum of these 5 bilateral export flows determines total exports on a customs clearance basis. In addition there is a "bridge equation" which serves to make the transition between exports on a customs clearance basis and exports on a balance of payments basis.

Each country model also includes a set of five bilateral import-demand equations. Each equation determines merchandise imports from one of the other five areas in the MCM on the basis of data reported by the exporting country; and a set of five bilateral bridge equations (allowing for shipment lags) determines the corresponding import flows based on the importing country's customs data. Total imports (on customs clearance basis) are then obtained by adding up these five bilateral import flows; and total imports adjusted to balance of payments basis are determined by a bridge equation which includes an adjustment for cif/fob differentials.

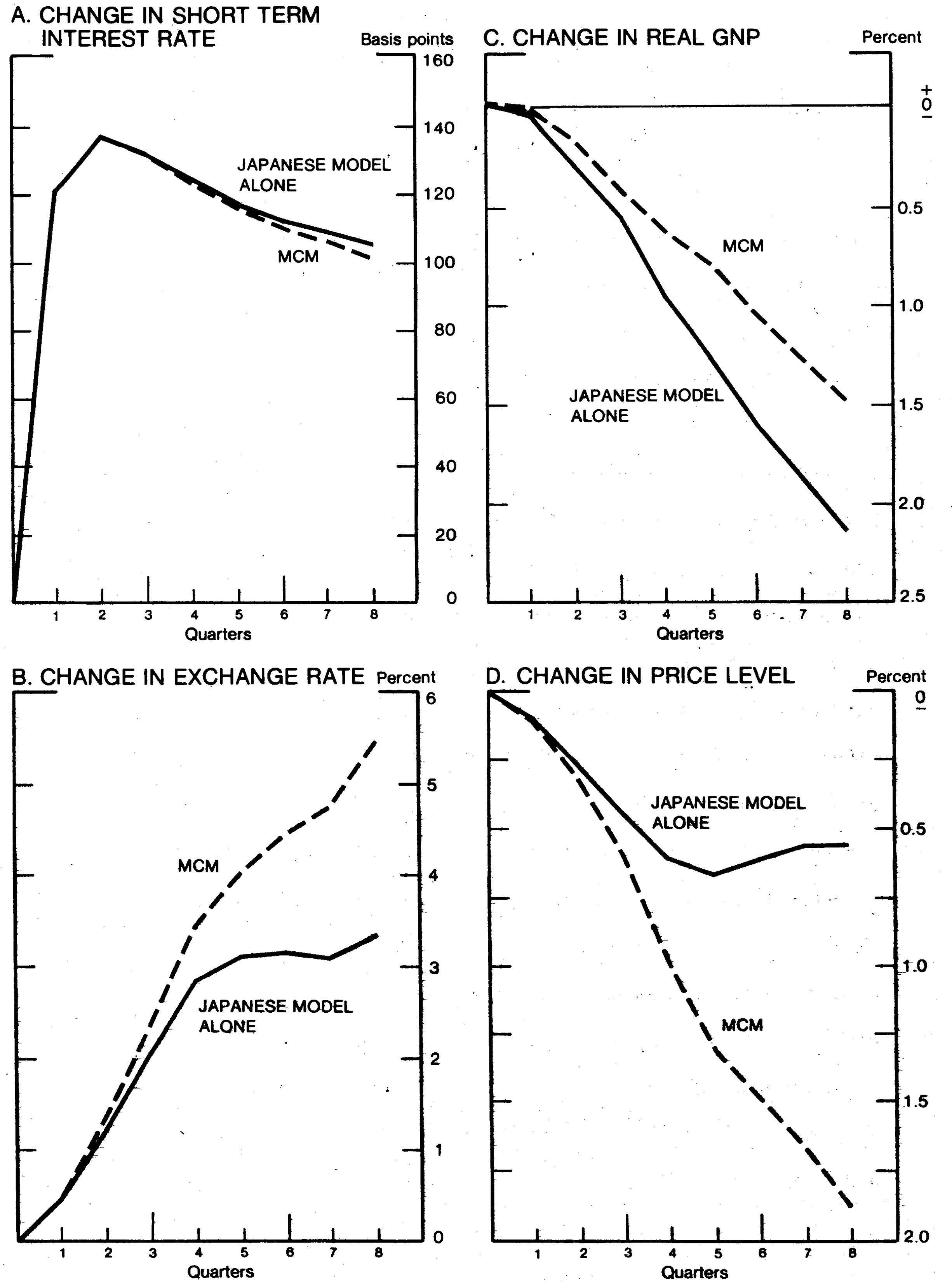
III. The Effects of Restrictive Monetary Policies Outside the United States

The following two simulations illustrate how the MCM can be used to trace the effects of monetary actions in foreign countries. This capability is illustrated with respect to (i) an increase in the Bank of Japan's official discount rate, and (ii) an increase in the reserve requirements applicable to German banks.

The effects of an increase in the Bank of Japan's discount rate by one percentage point are shown in Chart 1. These effects will first be discussed in general terms. In a second stage the simulation results for the unlinked Japanese model will be compared to those obtained when the Japanese model is integrated into the MCM. In panel A, the Japanese short-term interest rate is seen to increase sharply in the first two quarters and to decline gradually thereafter. This leads, initially, to a substantial increase in the interest-rate differential in favor of Japan which reduces the relative attractiveness of borrowing from the U.S. and Eurodollar markets. This incipient capital inflow leads to an appreciation of the Yen against the dollar, as shown in panel B. The rise in domestic interest rates also has an adverse impact on fixed investment in Japan, resulting in a contraction of aggregate demand (panel C). As indicated in panel D, Japanese prices decline under the combined effects of reduced capacity utilization, increased unemployment and exchange rate appreciation. There is also some downward pressure on wages as unemployment increases, and eventually the lower wages will further accentuate the decline in prices. Finally, as shown in panel A of Chart 2,

Chart 1

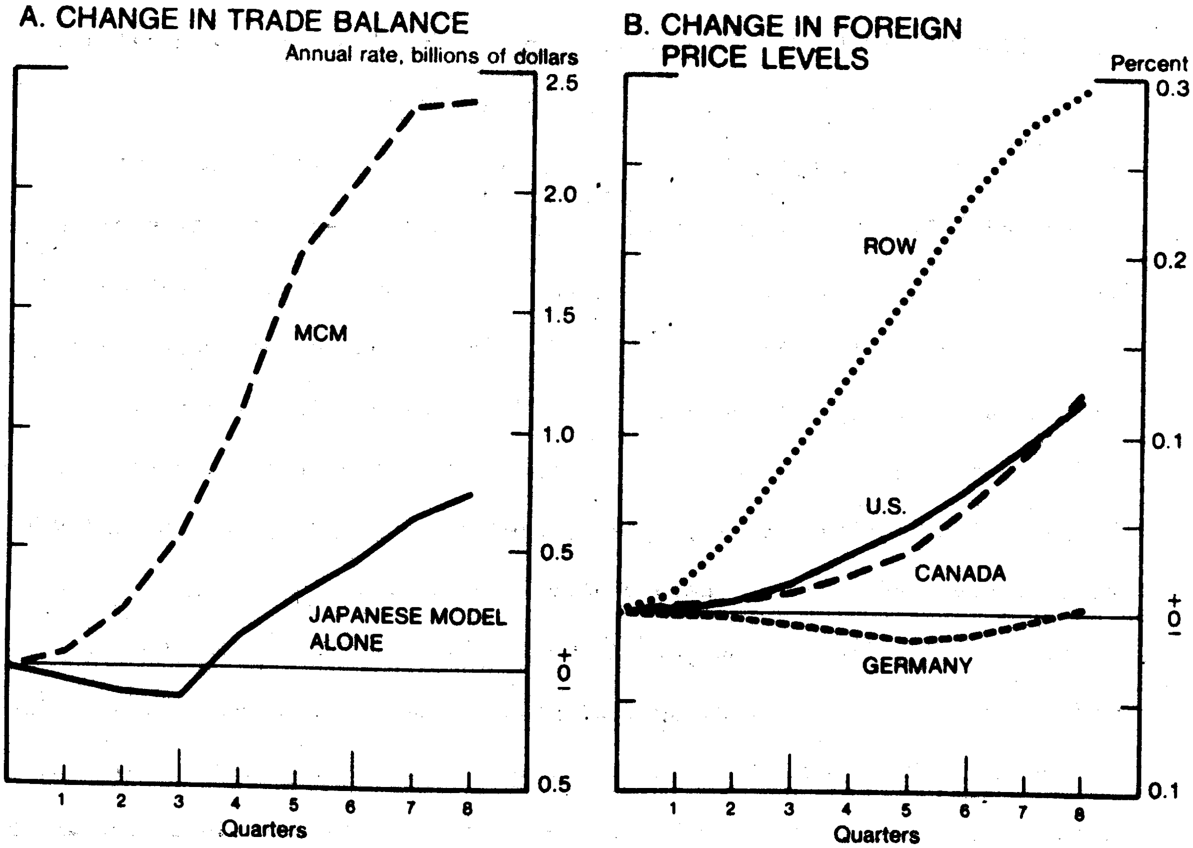
Effects of a One Percentage Point Increase in Japan's Discount Rate*



* All changes are measured relative to conditions that would prevail in the absence of policy actions.

Chart 2

Effects of a One Percentage Point Increase in Japan's Discount Rate*



*All changes are measured relative to conditions that would prevail in the absence of policy actions.

the decline in GNP leads to an improvement in the Japanese trade balance, and hence to additional upward pressure on the Yen.

To a large extent, the differences between simulations using the linked and unlinked versions of the Japanese model stem from differences in the way merchandise exports are determined. In the unlinked Japanese model, exports are determined by an aggregative equation which represents total world demand for Japanese goods. In the MCM, however, there are five bilateral export equations representing demand functions for Japanese goods on the part of the United States, Canada, the United Kingdom, Germany and ROW, respectively; and total Japanese exports are obtained by adding up these 5 bilateral export flows. The method used within the MCM has the obvious merit of allowing for country-specific income and price elasticities of import demand. Moreover, this method provides a consistent way in which imports and exports can be jointly determined within the MCM since, for example, Japanese exports to the U.S. are equal to U.S. imports from Japan.[16]

One implication of these differences in the method of export determination between the linked and the unlinked versions of each country model is that there is no assurance that the demand elasticities resulting from the two procedures will be the same. In the case of Japanese exports, for example, there is a substantial difference between the estimated elasticities with respect to the Japanese export price, as indicated in the following table.

Elasticity of foreign demand for Japanese goods with respect to the Japanese export price

Importing area	Unlinked model	MCM
United States	---	-1.24
Canada	---	-1.25
Germany	---	-2.62
United Kingdom	---	-2.45
R.O.W.	---	-1.39
	-0.47	-1.47 1/

1/ Trade-weighted average

This difference in elasticities has important implications for the relative magnitude of the multipliers. In the example of a restrictive monetary action in Japan, there is a depressive impact on Japanese GNP and hence on capacity utilization and prices, including in particular export prices. But the decline in the export price will stimulate Japanese exports 3 times as much in the MCM as it will in the unlinked version of the Japanese model. Therefore the improvement in the Japanese trade and current account balances will be much larger under the MCM simulation, and the decline in GNP will be correspondingely reduced.

There are, of course, other differences between the two sets of simulations which stem from the fact that foreign variables become endogenous in the MCM. Hence, while foreign prices (expressed in foreign currency) do not change in simulating the unlinked Japanese model, they tend to increase in the MCM simulation (Chart 2, panel B) because the monetary contraction in Japan leads to a devaluation of these foreign currencies vis-a-vis the Yen. (Movements in bilateral yen exchange rates parrallel the change in the dollar/

yen rate shown in Chart 1B.) In turn, this increase in partner-country prices will tend to stimulate Japanese exports and depress Japanese imports, thus making the trade surplus even larger in the MCM simulation. Countervailing the relative-price effect is a decline in foreign GNPs over the long run in the linked simulation. This has a depressive impact on Japanese exports which is absent in the unlinked model.

In the German monetary experiment, the reserve requirements on demand, time, savings and foreign deposits were all increased by one percentage point over their historical values. The results of this contraction largely follow those of the Japanese monetary contraction. Initially, the short-term interest rate increases sharply by about 80 basis points. This increase results in a widening of the interest rate differential in favor of Germany, which in turn leads to a private capital inflow in the first period of about DM 2 billion. Since the interest rate differential does not increase in the next four periods, there is no incentive for additional portfolio inflows. Moreover, since the mark appreciates in the first period, the regressive exchange rate expectations incorporated in the capital flow equations lead to capital outflows in subsequent periods. The mark continues to appreciate to about 9 percent over what it would have been otherwise, however, because of the continued improvement in the current account.

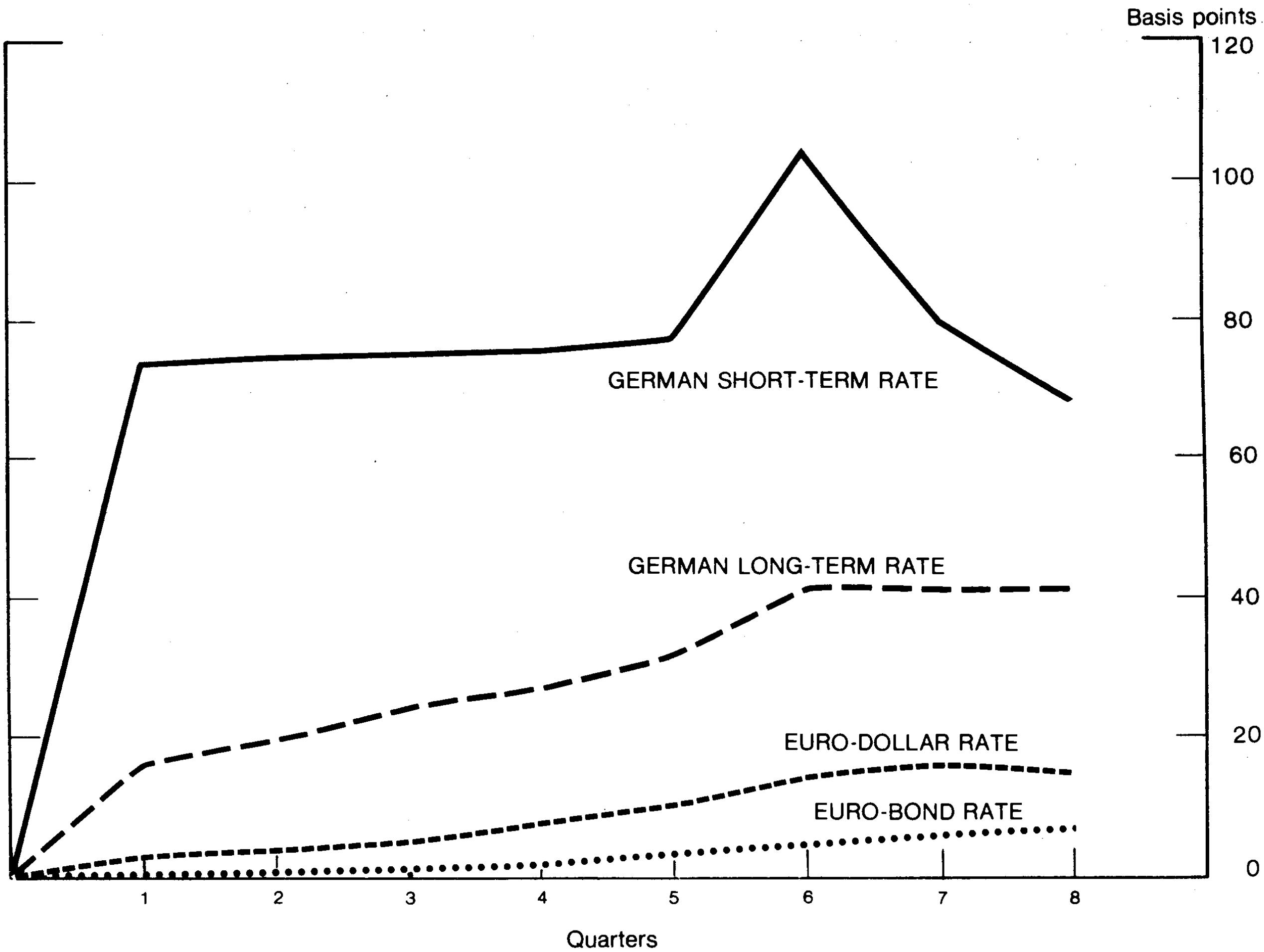
The rise in interest rates impacts negatively on investment, leading to a decline in GNP of about 0.5 per cent at its peak. The decline in GNP leads to a reduction in imports and an improvement in the trade balance which reinforces the upward pressure on the mark. In response to the domestic contraction and the exchange rate appreciation, the German domestic price level declines by about one percent after 8 periods.

The mark appreciates by as much as 9 percent against the yen, the dollar, and the Canadian dollar as a result of the monetary contraction. These exchange-rate changes lead to higher import prices in the United States, Canada and Japan. The increases in the domestic price levels are not as uniform among countries as the exchange rate changes due to differing import compositions. The domestic price increases range from about 1/2 of a percent in Japan to approximately one-tenth of a percent in Canada.

Chart 3 illustrates the transmission of monetary effects in the MCM. The increase in the German short-term interest rate has lagged effects on the German long-term interest rate, which increases by about 40 basis points after 8 quarters. The tightening of monetary conditions in Germany also affects Eurodollar interest rates. The MCM includes an equation for the 3-month Eurodollar deposit rate which is a reduced form of the supply and demand for Eurodollars. The German short-term rate is one of the explanatory variables in this equation, reflecting German participation in the Eurodollar market. Through this channel the short-term Eurodollar rate in-increases (by about 15 basis points) in response to the increase in the German short-term rate. Reflecting its term structure, the yield on dollar-denominated Euro-bonds is influenced by the rise in the Eurodollar rate, and eventually increases by about 8 basis points.

Chart 3

Change in German and Foreign Interest Rates Resulting from an Increase in German Reserve Requirements*



*All changes are measured relative to conditions that would prevail in the absence of policy actions.

IV. The Effect of a Restrictive U.S. Open Market Operation

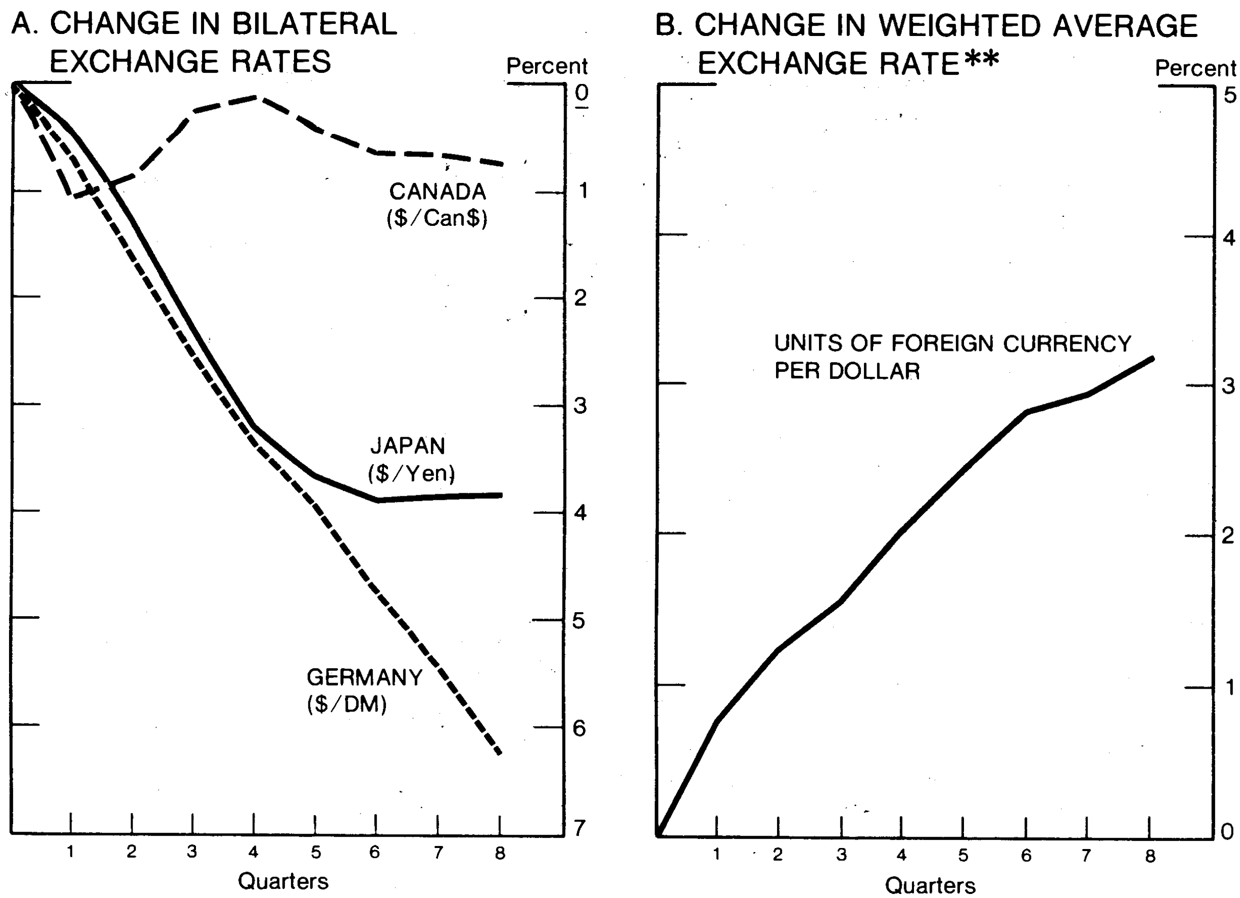
The experiment chosen to demonstrate the effect of U.S. monetary policy is an open market sale of $1 billion in government securities carried out in the second quarter of 1973.

Most of the effects noted above for the Japanese and German cases are present in the two U.S. simulations. However, in comparing the impact of the United States monetary tightening in the MCM with that for the U.S. model taken alone, the difference in exchange-rate effects dominates the picture. For the U.S. model simulated in isolation, all exchange rates remain fixed, because the U.S. balance-of-payments condition is not used to determine an exchange rate.[17] On the other hand, when the MCM is simulated for the period in question, all bilateral exchange rates appreciate substantially (Chart 4, panel A). As shown in panel B, the dollar appreciates in the MCM by over 4 per cent on a weighted average basis. This difference in the degree of appreciation as between linked and unlinked simulations, is much stronger for the United States than for the German and Japanese simulations, and adds a powerful negative effect on U.S. GNP and prices. The effect of the exchange-rate appreciation, along with the negative impact on foreign GNP's similar to the Japanese case described above, combine to <u>magnify</u> the reduction in U.S. GNP observed for the U.S. model taken in isolation. This is shown in panel A of Chart 5. The maximum effect, seven quarters after the initial tightening, is some 2/10 of a per cent more than when external influences on the U.S. economy are ignored.

As far as other key U.S. variables are concerned, there is a dramatic difference in the effect of the monetary tightening on the price

Chart 4

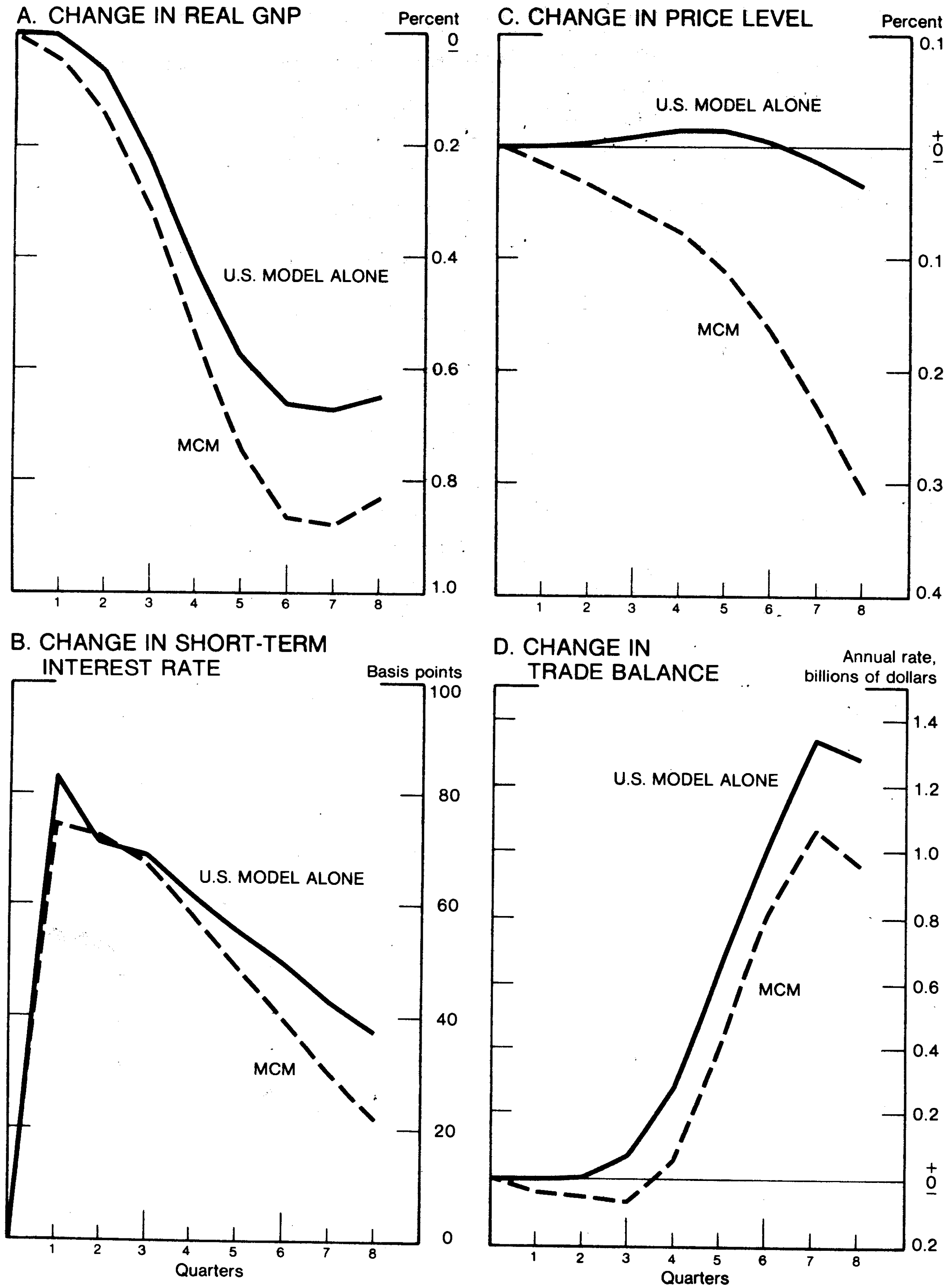
Effects of a Restrictive U.S. Open Market Operation*



* All changes are measured relative to conditions that would prevail in the absence of policy actions.
** Weighted average of the bilateral exchange rate of the U.S. dollar vis-a-vis the German mark, the Japanese yen, and the Canadian dollar, respectively.

Chart 5

Effects of a Restrictive U.S. Open Market Operation*



*All changes are measured relative to conditions that would prevail in the absence of policy actions.

level in the two U.S. simualtions (panel C) and a significant reduction in the trade balance effect (panel D). While the primary cause of both is again the large exchange rate appreciation, other factors also contribute to the effects -- as discussed above for Japan and Germany: reduced capacity utilization, increased unemployment, and lower wages. The effect of the monetary tightening in the MCM on foreign variables -- particularly foreign GNP's and prices -- is very similar to that discussed earlier for the German and Japanese experiments.

V. The Effects of Stimulative Fiscal Policies Abroad

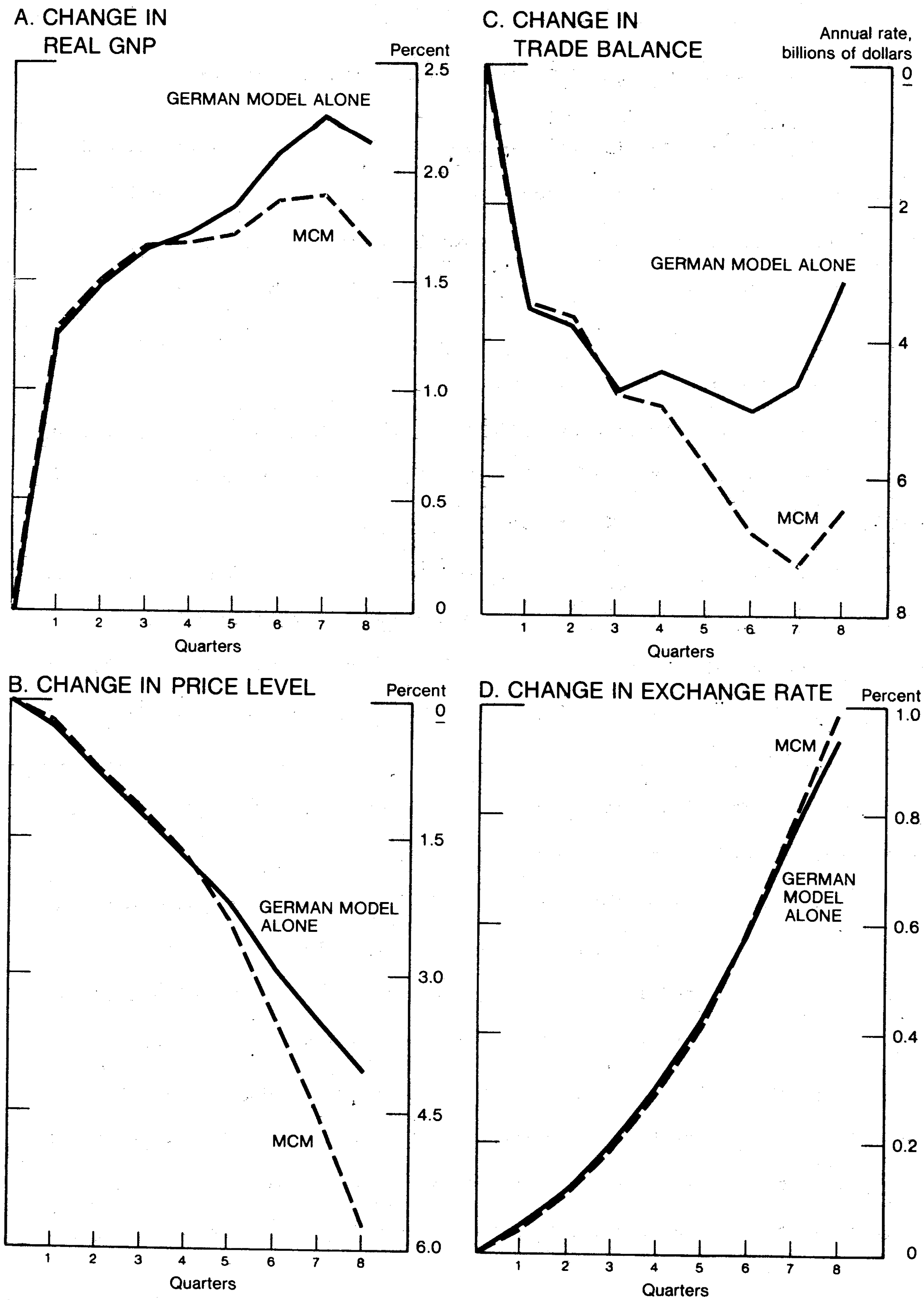
This set of simulations describes the domestic and international effects of German and Japanese fiscal policy actions. The results will first be analyzed in the context of the multi-country model. Later, these multi-country simulation results will be compared with results obtained by applying the same fiscal shocks to the unlinked German and Japanese models (i.e., holding incomes and prices abroad constant.)

In the first experiment, (Charts 6 and 7) it is assumed that Germany increases real government spending by DM 10 billion (or by roughly 6 per cent in terms of 1975 levels). This increase leads to an expansion of aggregate demand in Germany (panel A in Chart 6) which generates additional demand for foreign goods. As a result, the Deutschemark depreciates with respect to the dollar (panel B) and the German trade balance deteriorates (panel C). The expansion of demand in Germany also exerts upward pressure on domestic prices (panel D) and these inflationary pressures are accentuated by the devaluation of the mark. German interest rates also increase in response to the increase in aggregate demand, as shown in panel A of Chart 7.

The foreign effects of the German fiscal stimulus are presented in panels B through D of Chart 7. For the first four periods the U.S. and Canadian economies are stimulated in about the same degree by German growth (panel B). Japanese income is most affected by the German stimulus. After 8 periods, Japanese GNP is one fifth of a percentage point higher than it would otherwise have been. The strength of stimulus to the Japanese economy comes about largely through third-country effects. As the German expansion stimulates countries in the rest-of-the-world sector of the MCM, import demand in these

Chart 6

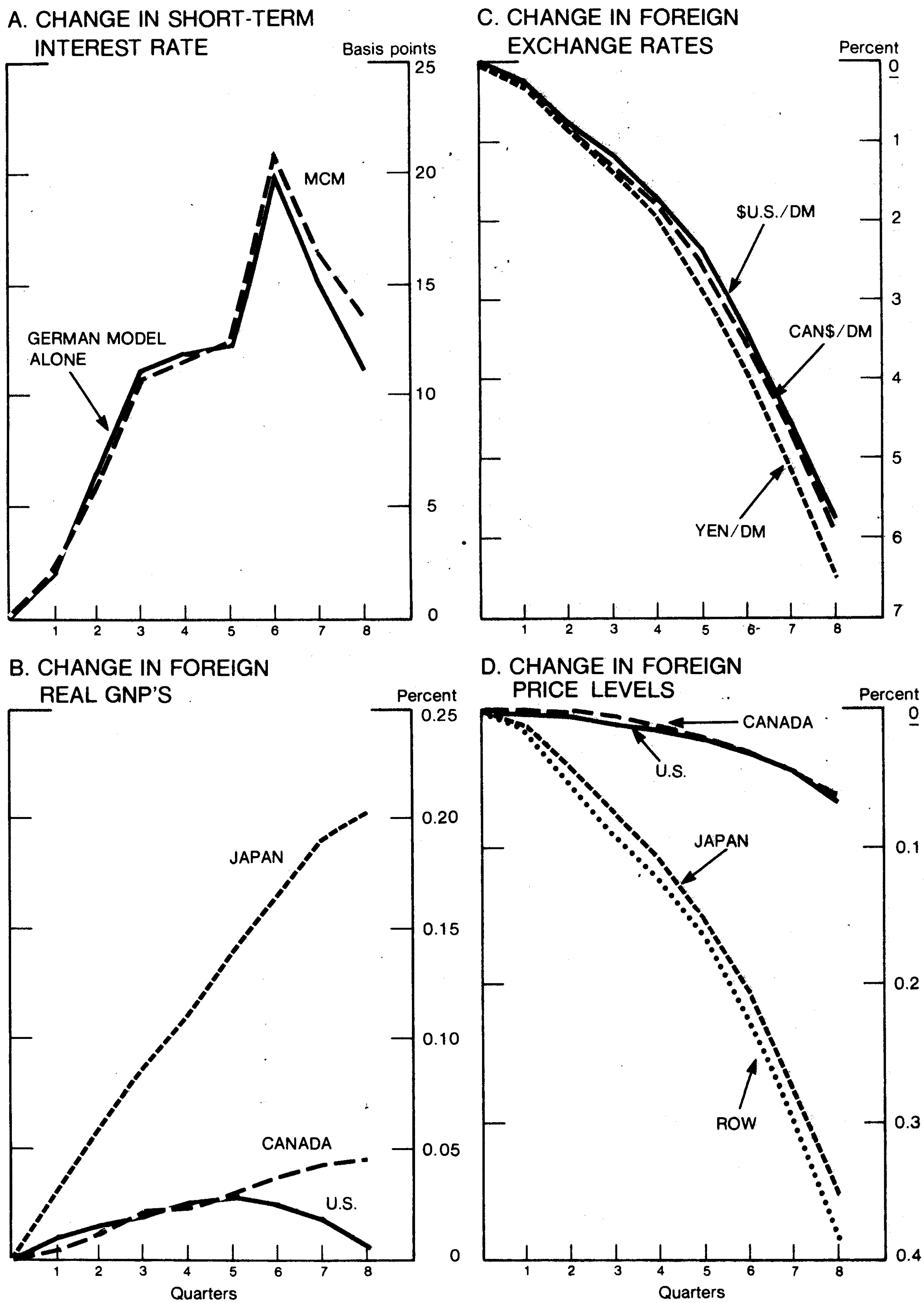
Effects of a DM 10 Billion Increase in German Government Spending*



*All changes are measured relative to conditions that would prevail in the absence of policy actions.

Chart 7

Effects of a DM 10 Billion Increase in German Government Spending*



* All changes are measured relative to conditions that would prevail in the absence of policy actions.

countries increases. Since the rest-of-the-world sector is treated in the MCM as a single aggregate, the model cannot distinguish between the Eurodpean expansion that would result from a German fiscal stimulus, and expansion in Asia where Japan has a very large trade share. Thus, the response of Japanese GNP to the German fiscal stimulus is probably over-estimated. As a result of this improvement in the Japanese trade balance, the DM depreciates with respect to the yen by about 6.5 per cent after 8 periods, more than with respect to the dollar, as seen in panel C. The exchange rate of the mark with respect to the Canadian dollar essentially follows the DM/dollar rate.

Changes in foreign price levels mirror the changes in exchange rates. As shown in Chart 7, the price level in Japan is eventually about 0.4 per cent lower than it would have been otherwise. The effect of the German stimulus on the U.S. and Canadian price levels is much smaller than for Japan; both price levels are about 0.05 per cent lower at the end of 8 periods, mainly a result of the depreciation of the Deutschemark.

The structural difference in export specification described in the case of the Japanese monetary policy exercise also applies when comparing the results of the linked and unlinked versions of the German model. In the export equation for the unlinked German model, the long-run elasticity of exports with respect to the DM exchange rate is unitary. By contrast, the bilateral import demand equations that jointly determine German exports in the MCM imply an average exchange-rate elasticity that is significantly lower than one in absolute value (the estimated elasticities are -0.7 in the U.K. equation, and -0.4 in the equation for the rest-of-the-world sector). Thus, for a given depreciation of the DM, German exports increase more in the unlinked German model than in the MCM. This added export stimulus reinforces the government spending stimulus in the unlinked version of the German model and leads to a large GNP multiplier than in the MCM: after 8 periods the GNP multiplier is at least half a percentage point higher in the unlinked model than it is in the MCM (Chart 6A).[18]

The larger export effect in the unlinked model shows up clearly in the German trade balance. In panel C of Chart 6 the balance deteriorates signficantly less in the case of the unlinked version than with the MCM. Consequently, the exchange rate of the mark with respect to the dollar is seen to depreciate less in the case of the MCM (panel B). The smaller increase in the German price level (panel D) for the unlinked version is consistent with the smaller depreciation in the DM. The difference between the unlinked and the MCM results, however, is less for prices than for exchange rates.[19]

The effect of the government spending increase on interest rates comes about largely through the rise in demand for cash and bank deposits in response to the increase in income. The supply of the monetary base also affects the level of interest rates, which, in turn, is affected by intervention in foreign exchange markets to moderate changes in the exchange rate. Since the mark depreciates in this experiment, the sale of foreign exchange by the Bundesbank contracts the monetary base and this leads to an increase in the interest rate. Since the depreciation is less in the unlinked version than in the MCM, there is less intervention and a smaller increase in short-term interest rates. (Chart 7A). This occurs despite a larger income effect (see Chart 6A) in the unlinked version.

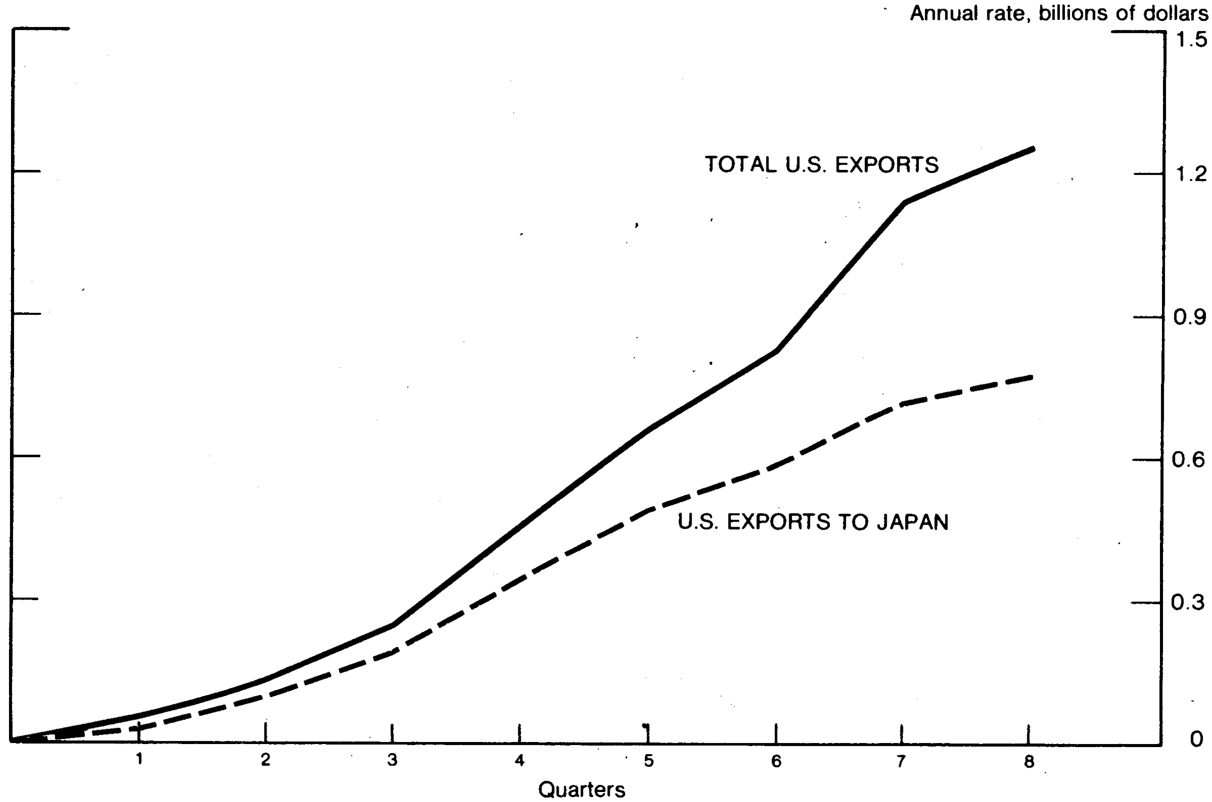
The effects of a ¥ 1 trillion increase in Japanese government expenditures are qualitatively similar to those discussed above in the context of the German fiscal experiment. After 8 quarters, Japanese GNP increases by about 1 - 3/4 per cent, the trade balance deteriorates by about 4 billion dollars, the yen depreciates by a little over 4 per cent and the short-term interest rate increases by 20 basis points.

Japanese domestic prices increase by about 3 per cent in the MCM simulation. A major quantitative difference between the German and Japanese experiments is the degree to which the price effect in the MCM simulation exceeds the price effect in the unlinked simulation. This gap is much wider in the Japanese experiment (about 2 percentage points) than in the German experiment (about one-half of a percentage point), because the Japanese price variable is much more sensitive than its German counterpart to changes in import prices and, hence, in exchange rates.

The Japanese expansion has a stimulative effect on foreign economies. GNP in Canada and the United States increases by about 1/4 of a per cent; Germany GNP increase by about 3 tenths of a per cent. Chart 8 illustrates how third-country effects can be captured by the model. Here, the rise in U.S. exports is seen to result not only from an increase in Japanese imports, but also from an increase in third-country imports from the U. S. Thus the expansion in Japanese GNP has a positive indirect effect on the U.S. trade balance by having an expansionary impact on the rest of the world.

Chart 8

Change in U.S. Exports Resulting from a Yen 1 Trillion Increase in Japanese Government Spending*



* All changes are measured relative to conditions that would prevail in the absence of policy actions.

VI. The Effects of Increased Government Expenditures in the United States

In the U.S. experiment, a sustained fiscal stimulus of $10 billion in real government expenditures was applied as of the second quarter of 1973. Qualitatively, the effects on most domestic U.S. variables are similar to those discussed in the German and Japanese experiments. Characteristically, U.S. GNP expands (by 2 per cent), interest rates and prices increase (by 100 basis points and 6 per cent, respectively) and the trade balance weakens (by $4 billion). Unlike the two previous simulations, and despite the greater degree of national interdependence in the MCM, the magnitudes of the impact of the U.S. fiscal expansion on the above key variables are remarkably similar for the MCM and the U.S. model taken in isolation. This result contrasts with the effects of a restrictive U.S. monetary policy described in Section IV above: the impact of the policy change is considerably different in the MCM than in the U.S. model by itself.

An interesting phenomenon found in the U.S. simulations that is absent in the others, is the "crowding-out" effect observed as the stimulus to U.S. GNP gradually dies out after peaking in the fourth quarter. The cause seems to be the greater sensitivity of components of U.S. demand -- especially investment and consumption -- to variations in the interest rate.

VII. Conclusions

The experiments presented in this paper illustrate in a number of ways the interdependence among the world's economies. In one set of simulation exercises, monetary and fiscal policies in Japan and Germany were changed. In all cases the policy changes had significant impacts on the U.S. economy. Moreover, these policy actions had significant feedback effects on the initiating economy. The importance of the feedbacks is confirmed by comparing the results for a given policy change in the MCM with those for the unlinked country model where "foreign" variables are held exogenous.

The simulation experiments for changes in U.S. monetary policy confirm the above points and, in addition, show the importance of endogenizing exchange rates. In comparing the impact of the U.S. monetary tightening in the MCM with that for the U.S. model taken alone, the difference in exchange rate effects dominates the picture. For the U.S. model simulated in isolation all exchange rates are assumed fixed -- an approach similar to the "old" way of modeling the United States as a closed economy. When the MCM is stimulated, all bilateral exchange rates show a substantial appreciation of the dollar; on a weighted-average basis this amounts to over 3 per cent. This appreciation adds a powerful negative effect on U.S. GNP and prices. The effects of the exchange rate appreciation, along with feedback effects from the negative impact of the U.S. contraction on foreign GNPs, combine to magnify the reduction in U.S. GNP observed for the U.S. model taken in isolation.

Footnotes

[1]Needless to say, therefore, the estimates presented here are preliminary in nature and are in no way official estimates of the Board of Governors or the Division of International Finance.

[2]See Stevens (1976).

[3]Preliminary results for the sample period are reported in Berner _et. al._ (1977); final results for the sample period and for ex post forecasts will be presented in our forthcoming book.

[4]Trade flows of all other countries other than the five mentioned above are explained in the abbreviated rest-of-the-world model.

[5]In the model describing the U.S. economy it is assumed that the monetary base is insulated from changes in international reserve assets by offsetting open market operations, whereas for other countries a change in international reserves will have some impact on the monetary base.

[6]For a more detailed description the reader may consult a longer summary paper (Berner, et. al. 1976) and the much more extensive papers devoted to individual sectors (Howe on prices, Berner on the goods and labor markets, Clark and Kwack on asset markets and Stevens on the balance of payments and the rest of the world).

[7]The disposable income variable used in the model is a proxy obtained by adding total government transfers to GNP, and subtracting taxes and capital consumption allowances.

[8]Some country models also include variables for wholesale or producer's prices.

[9]The U.K. financial sector does not use the sources and uses of the monetary base as an equilibrium condition. Rather, the supplies and demands for short- and long-term securities are modeled. The Bank of England is assumed to determine the supply of long-term securities and the rate paid on treasury bills.

[10]For estimation purposes, the equation for free reserves was normalized so as to make the short-term rate the left-hand variable.

[11] In the original specification of the model, the expected future spot rate was assumed to equal the actual spot rate observed one quarter ahead plus a random error. Except for Canada, this assumption did not provide good estimation results; therefore the forward rate and the other expectational variables discussed below were used for Germany, Japan, the U.K. and the U.S. In the Canadian model, the specification in terms of next period's value of the spot rate was retained. In simulation, this actual value is replaced by an estimated value obtained from a regression using past exchange rates and changes in NFA as explanatory variables.

[12] Partial sterilization was specified for Canada during the fixed exchange rate period.

[13] NFA is a proxy for exchange market intervention. It is defined as the change in net foreign assets held by the monetary authorities net of SDR allocations and valuation changes.

[14] In previous papers we have discussed how (and proved that) a country's balance of payments equation can be substituted for any of the other equilibrium conditions in the model (See Stevens (1976). For reasons discussed in these papers, we have taken the course of substituting the balance-of-payments equation for the market-clearing condition in the short-term securities market.

[15] The four bilateral exchange rates considered in the model are the rates for the DM, the Canadian dollar, the U.K. pound, and the Japanese yen, respectively, in terms of the U.S. dollar. The model also includes an "effective" exchange rate for the U.S. dollar which is simply a weighted average of the four bilateral rates previously mentioned. Cross-exchange rates (e.g. between the Pound and the DM) are obtained by assuming perfect triangular arbitrage.

[16] Strictly speaking, we must allow for shipment lags and statistical discrepancies which are handled in the MCM by introducing a set of "bridge equations". Each of these equations relates M_{ij} to current and lagged values of X_{ji}.

[17] In principle the U.S. balance of payments equation could be used to solve for "the exchange rate" or net change in international reserves for the "rest of the world." However, since the structure of that region is so rudimentary, we felt it would be useless to calculate or use such endogenous variables.

[18]If there were no difference in export elasticites, the international income and price feedbacks would operate to make the MCM multiplier larger than the unlinked multiplier.

[19]This is mainly the result of the insensitivity of the German absorption deflator in the model to changes in foreign prices. In terms of the German price of industrial products, the difference would be more striking. After 11 periods, the price of industrial products increases by 5% in the MCM version and by 3.6% in the unlinked version.

References

Berner, Richard, Peter Clark, Howard Howe, Sung Kwack and Guy Stevens, "Modeling The International Influences on the U.S. Economy: A Multi-Country Approach," International Finance Discussion Paper No. 93, Board of Governors of the Federal Reserve System, November 1976.

Berner, Richard, "The Goods Market and the Labor Market of the Multi-Country Model," International Finance Discussion Paper No. 97, Board of Governors of the Federal Reserve System, December 1976.

Berner, Richard, Peter Clark, Ernesto Hernández-Catá, Howard Howe, Sung Kwack and Guy Stevens, "A Multi-Country Model of the International Influences on the U.S. Economy: Preliminary Results," International Finance Discussion Paper No. 115, Board of Governors of the Federal Reserve System, December 1977.

Clark, Peter and Sung Kwack, "Asset Markets and Interest Rate Determination in the Multi-Country Model," International Finance Discussion Paper No. 94, Board of Governors of the Federal Reserve System, December 1976.

Howe, Howard, "Price Determination in the Multi-Country Model," International Finance Discussion Paper No. 98, Board of Governors of the Federal Reserve System, December 1976.

Stevens, Guy, "Balance of Payments Equations and Exchange Rate Determination," International Finance Discussion Paper No. 95, Board of Governors of the Federal Reserve System, December 1976.

Stevens, Guy "Alternatives for Modeling the World Outside the United States," International Finance Discussion Paper No. 96, Board of Governors of the Federal Reserve System, December 1976.

Appendix

Structure of the Country Models

The letter "V" appended to a variable name indicates measurement in the current value : the national currency. When the V is absent, the variable is generally expressed in 1972 ırrency units. Exceptions to this rule are financial variables, such as capital account items ıd the components of the monetary sector, which are all in nominal terms. The subscript "ni" ıdicates a variable defined on national income accounts' basis. An asterisk indicates that ırrent and lagged values of the starred variable are used as explanatory variables. An "F" in :ont of a variable name denotes a weighted average of foreign variables of the indicated type. ; indicates percentage change. Variable names are given at the end of the Appendix.

All equations were estimated by ordinary least squares, with first-order adjustment ›r autocorrelation when needed. Distributed lag structures were estimated using both Almon ıd Shiller techniques.

BEHAVIORAL EQUATIONS

Domestic expenditure sector

1. Consumption function	$C = C(Y, NW, C_{-1})$
2. Private fixed investment	$IFP = IFP[\Delta(GNP \cdot P/UC)^*, KP_{-1}]$
3. Private inventory investment	$II = II[(C + IFP + XG - MG), (C + IFP + XG - MG)^*, \Delta\%P]$
4. Capital consumption allowance	$CCAV = CCAV[P \cdot KP_{-1}, (GNPV - TV - CV)]$

Government sector

5. Government transfers	$TRANV = TRANV(GNPV, RL \cdot GD_{-1}, UL)$
6. Tax function	$TV = TV(GNPV - CCAV)$

Current account

7. Exports of goods	$XG = XG[FGNP, ROWIP, PXG^*, (FP/E)^*]$	
8. Imports of goods: link from customs to BOP basis	$MGV\$ = g(\sum_j M_{ij})$	$j = 1,\ldots 5$
9. Imports of goods: bilateral bridge equations	$M_{ij} = M_{ij}(X^*_{ji})$	$j = 1,\ldots 5$
10. Bilateral import demand functions	$X_{ji}/(PXG \cdot E_j) = X_{ji}\ [GNP, WPI^*, (PXG_j \cdot E_j/E)^*]$	
11. Investment income, receipts	$XSYV = XSYV[\theta(R \cdot FC_{-1}) + (1 - \theta)(FR \cdot FC_{-1})(FRL \cdot LTDC_{-1})^*]$	
12. Investment income, payments	$MSYV = MSYV[\Psi(R \cdot FL_{-1}) + (1 - \Psi)(FR \cdot FL_{-1}), (FRL \cdot LTDL_{-1})^*]$	
14. Imports of other services	$MSOP = MSOP(YD, PMS, P)$	

14.	Exports of other services	XSOP = XSOP(FGNP, PXS · FE, FP)
15.	Import of goods and services: link from BOP to NI basis	$MGSV_{ni}$ = M(MGSV)
16.	Export of goods and services: link from BOP to NI basis	$XGSV_{ni}$ = X(XGSV)
17.	Transfer payments	MTRANV = MTR(YDV)
18.	Transfer receipts	XTRANV = XTR(FGNP, ROWIP · ROWPXG)

Price determination and capacity utilization

19.	Domestic Price (absorbtion deflator)	P = P[W*, (GNP/LE/H)*, PMGS, CU]
20.	Wholesale price index	WPI = WPI[W*, (GNP/LE/H)*, PMG, CU]
21.	Export unit value	PXG = PXG[W*, (GNP/LE/H)*, PMG, CU, FCU,(FPXG/FE)*]
22.	Import unit value	PMG · E = PMG(FPXGT*, FE*)
23.	Services deflator, imports	PMS · E = PMS[(FP*)]
24.	Services deflator, exports	PXS = PXS [W*, (GNP/LE/H)*, CU]
25.	Capacity utilization	CU = F[GNP/(LF · H), KP/(LF · H), t]

Labor market

26.	Wage rate in manufacturing	Δ% W = W(LU*, Δ%P)
27.	Average weekly hours worked	H = H[(GNPV/(W · LE)), CU, t]
28.	Employment	LE = LE[GNPV/(W · H)), t]

Domestic asset demand and interest rate determination

29.	Currency held by banks	CURB = CURB(DT)
30.	Currency held by the nonbank public	CUR/NW = CUR (GNPV/NWV, RS)
31.	Demand deposits	DD/NW = DD(GNPV/NWV, RS, RTD)
32.	Time deposits	TD/NW = TD[GNPV/NWV, RS, RTD, FRS, (EE-E)/E]
33.	Net free reserves	RF/DT = RF(RS, RD, ΔUB/DT)
34.	Long term interest rate	RL = RL(RS*)
35.	Required reserves	RR = RR(a·DD + b·TD)

Capital movements, official reserves and forward exchange rate

36.	Financial claims on foreigners	$FC = FC[RS^*, FRS^*, RL^*, FRL^*, (EE-E)/E, NWV, FNWV, XGV^*)$
37.	Financial liabilities	$FL = FL[RS^*, FRS^*, RL^*, FRL^*, (EE-E/E)/E, NWV, FNWV, MGV^*]$
38.	Direct investment claims	$DLTDC = LTDC(\Delta FGNPV^*)$
39.	Direct investment liabilities	$DLTDL = LTDL(\Delta FGNP^*)$
40.	Forward premium on the dollar	$FPR\$ = FPR\$[(EE-E)/E, FLOAT]$
41.	Expected exchange rate change	a. $(EE-E)/E = \Phi[(FPXG/PXG - E), (NFA/MGSV)_{-1}, FLOAT]$ b. $(EE-E)/E = (E_{+1} - E)/E + \eta$
42.	Intervention function	$DNFAFL = h(E/E_{-1}, NFA_{-1})$

IDENTITIES

1.	GNP identities	$GNP = (CV + IFPV + IIV + GV)/P + XGS_{ni} - MGS_{ni}$
2.		$GNPV = CV + IFPV + IIV + GV + XGSV_{ni} - MGSV_{ni}$
3.	Components of GNP (value)	$CV = C \cdot P$
4.		$GV = G \cdot P$
5.		$IFPV = IFP \cdot P$
6.		$IIV = II \cdot P$
7.	Disposable income proxy	$YDV = GNPV - TV + TRANV - CCAV$
8.	Private capital stock (gross)	$KP = KP_{-1} + (IFP - SR)/4$
9.	User cost of capital	$UC = P[RL + \delta]$
10.	Private net worth proxy	$\Delta NWV = YDV - CV$
11.		$NWV = \Delta NWV + NWV(-1)$
12.		$NW = NWV/P$
13.	Government debt proxy	$GD = GD_{-1} + (GV + TRANV - TV)/4$
14.	Exports of goods and services	$XGS = XG + (XGSV - XGV)/PXS$
15.		$XGS_{ni} = XGS$
16.		$XGSV = XGV + XSOV + XSYV$

17.	Imports of goods and services	$MGS = MG + (MGSV - MGV)/PMS$
18.		$MGS_{ni} = MGS$
19.		$MGSV = MGV + MSOV + MSYV$
20.	Merchandise imports, BOP basis	$MGV = MGV\$ \cdot E$
21.		$MG = MGV/PMG$
22.	Merchandise exports	$XGV = XG \cdot PXG$
23.	Other services, debits	$MSOV = MSO \cdot PMS$
24.	Other services, credits	$XSOV = XSO \cdot PXS$
25.	GNP deflator	$PGNP = GNPV/GNP$
26.	Deflators for exports and imports of goods and services	$PXGS_{ni} = XGSV_{ni}/XGS_{ni}$
27.		$PMGS_{ni} = MGSV_{ni}/MGS_{ni}$
28.	Unemployment	$UE = LF - LE$
29.	Unemployment rate	$UN = UE/LF \cdot 100$
30.	Balance sheet of the monetary authorities	$NFA + NGP + OTH = RR + RF + CUR + CURB$
31.	Unborrowed base	$UB = RR + RF + CUR + CURB$
32.	Net foreign assets, stock	$NFA = NFA_{-1} + DNFA/4$
33.	Total bank deposits	$DT = DD + TD$
34.	Direct investment claims	$LTDC = DLTDC/4 + LTDC_{-1}$
35.	Direct investment liabilities	$LTDL = DLTDL/4 + LTDL_{-1}$
36.	Change in financial claims on foreigners	$DFC = \Delta FC \cdot 4$
37.	Change in financial liabilities to foreigners	$DFL = \Delta FL \cdot 4$
38.	Balance of payments	$DNFA = (XGSV - MGSV) + XTRANV - MTRANV + (DFL - DFC) + (DLTDL - DLTDC) + NGK + EO$
39.	Official reserve changes	$DNFA = DNFAFX + DNFAFL$
40.	Exchange rate	$E = EFX + EFL$
41.		$EFL(1 - FLOAT) + DNFAFX \cdot FLOAT = 0$
42.	Forward exchange rate	$EFR = E \cdot E_{1972}(1 + FPR\$/400)$

EQUATIONS OF THE REST OF THE WORLD SECTOR

havioral equations

1. Imports of goods: bilateral bridge equations	$M_{Rj} = M_{Rj}(X_{jR})$	$j = 1,...5$
2. Imports of goods: intra-ROW trade	$M_{RR}/ROWPXG = M_{RR}(ROWIP,\ ROWPXG^{*},\ \overline{PXG\$}*)$	
3. Bilateral import demand functions	$X_{jR}/(PXG \cdot E_j) = X_{jR}[(ROWIP,\ ROWPXG*,\ (PXG_j \cdot E_j)^{*}]$	$j = 1,...5$
4. Export price	$ROWPXG = ROWPXG(\overline{PXG\$}, PPO*)$	
5. Average Industrial production index	$ROWIP = ROWIP(ROWXG,\ ROWIP_{-1})$	
6. Eurodollar rate	$RED = RED(RUS,\ \overline{RS},\ \overline{FPR\$})$	
7. Eurobond rate	$REB = REB(RED*)$	

entities

8. Imports of goods: ROW total ($value)	$M_R = \sum_j M_{Rj} + M_{RR}$	$j = 1,...5$
9. Exports of goods: World total ($value)	$XGV_w = \sum_j M_j + M_R + Z$	$j = 1,...5$
10. Exports of goods: ROW total ($value)	$X_R = XGV_w - \sum_j X_j$	$j = 1,...5$
11. Exports of goods: ROW total (volume)	$ROWXG = X_R/ROWPXG$	

DEFINITIONS AND SOURCES OF VARIABLES[1/]

C = private consumption expenditure

CCAV = capital consumption allowances

CU = capacity utilization index

CUR = currency in the hands of the non-bank public

CURB = currency in the hands of banks

DD = demand deposit component of M1

DLTDC = change in long-term direct claims on foreigners

DLTDL = change in long-term direct liabilities to foreigners

DFC = change in total financial claims on foreigners

DFL = change in total financial liabilities to foreigners

DNFAFX = DNFA · (1-FLOAT)

DNFA = change in net foreign assets of the monetary authorities

DNFAFL = DNFA · FLOAT

DT = total bank deposits (DT = DD + TD)

E = spot exchange rate, U.S. dollars/local currency

EE = expected future spot exchange rate, U.S. dollars/local currency

EO = errors and omissions item in the balance of payments

EFX = E · (1-FLOAT)

EFL = E · FLOAT

EFR = 3-months forward exchange rate, U.S. dollars/local currency

FC = total financial claims on foreigners (short- and long-term nondirect claims)

FL = total financial liabilities to foreigners (short- and long-term nondirect liabilities)

FCU = weighted average[1/] of foreign capacity utilization indexes

FE = trade-weighted average[1/] of foreign spot exchange rates

1/The symbol "x" indicates an exogenous variable. The symbol "#" indicates a variable that is endogenously determined within the Multicountry Model, but is exogenous (or not included) in the unlinked country model.

FGNP = weighted average[1/] of foreign GNP variables

FLOAT = switch variable for floating rate period

$\overline{\text{FPR\$}}$ = forward premium on the U.S. dollar (per cent per annum)

FPR$ = weighted average[2/] of FPR$ variables

FP = weighted average[1/] of foreign absorption deflators

FPXG = weighted average[1/] of foreign export prices

FPXGT = weighted average of foreign export prices (including ROWPXG)

FRS = weighted average of foreign short-term interest rates

FRL = weighted average of foreign long-term interest rates

FR = weighted average of FRS and FRL

G = government expenditures

GD = proxy for the stock of government debt

GNP = gross national product

H = average monthly hours worked

IFP = private fixed investment

II = private inventory investment

KP = gross private capital stock

LE = total employment

LF = labor force

LTDL = long-term direct liabilities to foreigners

LTDC = long-term direct claims on foreigners

M_j = merchandise imports of country j, customs basis (in U.S. dollars)

M_{ij} = merchandise imports of country i from country j, customs basis (in U.S. dollars)

M_R = merchandise imports of the rest-of-the world (in U.S. dollars)

1/Average for the remaining four countries of the multi-country model.

2/Average for Canada, Germany, Japan and the United Kingdom

M_{Rj} = merchandise imports of the rest of the world from country j (in U.S. dollars)

M_{RR} = intra-ROW trade

MG = merchandise imports, balance of payments basis (volume)

MGS = imports of goods and services, balance of payments basis (volume)

MGS_{ni} = imports of goods and services, national income accounts basis

MGV = merchandise imports, balance of payments basis (in local currency)

MSOV = services account payments other than investment income.

MSYV = investment income payments

MTRANV = Transfers payments in the balance of payments

NFA = net foreign assets of the monetary authorities (cumulated value of DNFA/4)

NGK = net government capital account

NGP = net government position of the monetary authorities (claims on government minus government deposits)

NW = private net worth proxy (cumulated value of private savings)

OTH = other assets of the monetary authorities, net

P = deflator for aggregate expenditure; P = (GNPV-XGSNIV+MGSNIV)/(GNP-XGSNI+MGSNI)

PGNP = GNP deflator

$PMGS_{ni}$ = deflator for imports of goods and services

PMG = unit value of merchandise imports (local currency)

PMS = price of imported services (local currency)

PPO = world price of primary products other than cereals, expressed in U.S. dollars

$PXGS_{ni}$ = deflator for exports of goods and services

PXG = unit value of merchandise exports (local currency)

$\overline{PXG\$}$ = weighted average 1/ of export unit value indexes, expressed in U.S. dollars

PXS = price of exported services (local currency)

R = weighted average of short- and long-term interest rates

RD = official discount rate

1/Average for Canada, Germany, Japan, the United Kingdom and the United States.

REB = Eurobond rate

RED = 3-months Eurodollar deposit rate

RF = Bank's net free reserves (excess reserves minus borrowings from the Central Bank).

RL = long term interest rate

ROWIP = average of industrial production indexes for 9 rest-of-the-world (ROW) countries 1/

ROWPXG = Export price index of the rest-of-the-world

ROWXG = ROW merchandise exports (volume)

RR = Banks' required reserves

RS = short-term interest rate

$\overline{RS}$ = weighted average 2/ of short-term interest rates

RTD = interest rate on time deposits

RUS = U.S. 3-months commercial paper rate

SR = removal and scrappage of fixed capital

TD = time deposit component of M2

t = linear time trend

TRANV = total government transfers

TV = total government tax receipts

UB = unborrowed monetary base

UC = user cost of capital

UE = number of unemployed

UN = unemployment rate

W = compensation per man-hour in manufacturing

WPI = wholesale price index

X_{ij} = merchandise exports to country j, customs basis (in U.S. dollars)

1/Belgium, France, Italy, Korea, Mexico, the Netherlands, Norway, Switzerland and Taiwan.

2/Average for Canada, Germany, Japan and the U.K.

X_j = merchandise exports of country j customs basis (in U.S. dollars)

X_{ij} = merchandise exports to country j customs basis (in U.S. dollars)

X_{jR} = merchandise exports of country j to the rest of the world

XG = merchandise exports, balance of payments basis (volume)

XGV = merchandise exports, balance of payments basis (in local currency)

XGV_w = merchandise exports, world total (U.S. dollars)

XGS = exports of goods and services, balance of payments basis

XGS_{ni} = exports of goods and services, national income accounts basis

X_R = ROW merchandise exports, total (in U.S. dollars)

XSO = services account receipts other than investment income

XSYV = investment income receipts

XTRANV = transfer receipts in the balance of payments

YD = disposable income proxy

Z = discrepancy between world imports and exports (including CIF/FOB differentials)

a, b, = reserve requirement ratios on demand and time deposits, respectively.

δ = depreciation rate

η = random error term

θ = fraction of total financial claims on foreigners denominated in local currency

ψ = fraction of total financial liabilities to foreigners denominated in local currency