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MONETARY POLICY UNDER ALTERNATIVE EXCHANGE-RATE REGIMES:
SIMULATIONS WITH A MULTI-COUNTRY MODEL*

by

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Monetary Policy Under Alternative Exchange-Rate Regimes: Simulations
With a Multi-Country Model*

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Introduction

The purpose of this paper is to present some preliminary results on the impact of monetary policy in today's system of managed exchange-rate flexibility. Typical monetary policy actions in the United States, Japan and West Germany will be investigated with an eye both to their effects at home and abroad and to the dependence of these effects on the degree of exchange-rate flexibility and exchange-market intervention.

The emphasis in this paper will be empirical. Although much theoretical work has been done contrasting the effects of policy actions under alternative exchange-market assumptions,¹ little has

* We are very grateful to a number of co-workers for their contributions to the completion of this paper. Joseph Formoso, Ann Mirabito, Sam Parrillo and Steven Schooler bore much of the responsibility and thus deserve much of the credit for the simulations of the Multi-Country Model. 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.

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been done to quantify these effects. The Multi-Country Model which is under development at the Federal Reserve Board provides us with a tool to make such quantitative estimates - - in fact, this was one of the primary purposes for its development. The results presented here are some of the first simulations of monetary and intervention policy run with that model.²

In the first part of this paper we describe the effects of a contractionary monetary policy in the United States implemented by an open market operation. To highlight the differential impact obtained by linking the U.S. model with the rest of the Multi-Country Model, we present results both for the U.S. model alone and for the full Multi-Country Model. We then examine the effects of restrictive monetary policies abroad: 1) an increase in the Bank of Japan's discount rate, and 2) an increase in reserve requirements applicable to German banks. In the third part, we report on the results of experiments dealing with a change in exchange market intervention behavior. We look at what would have happened if the monetary authorities had intervened to moderate exchange rate changes with twice the intensity actually observed over the early floating rate period between 1973 and 1975. Finally, we investigate how the effects of a contractionary monetary policy in the United States are altered when intervention behavior is modified in the manner just described.

The Multi-Country Model (MCM) is a system of linked national macro-economic models, at the center of which is a medium-sized model of the U.S. economy. Linked to it, and to each other, are models for Canada, West Germany, Japan, the United Kingdom, and an abbreviated model representing the rest of the world.

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.³ Each country model has a monetary sector which determines short- and long-term interest rates together with monetary aggregates. The most important instruments of monetary and fiscal policy -- reserve requirements, the discount rate, central bank holdings of 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 converts these prices into domestic currency. Movements in foreign price and cost conditions are transmitted to each country's import price, which in turn

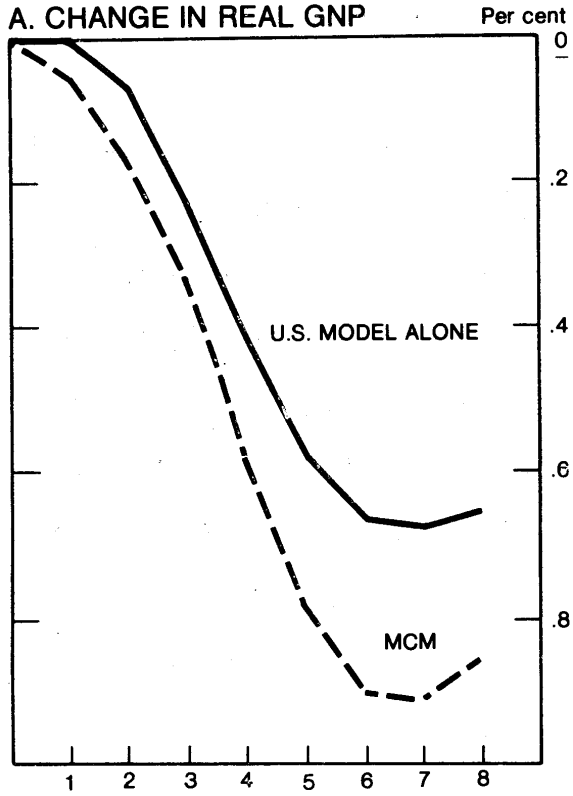
directly affects its domestic price level.

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.⁴ In addition, the 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.

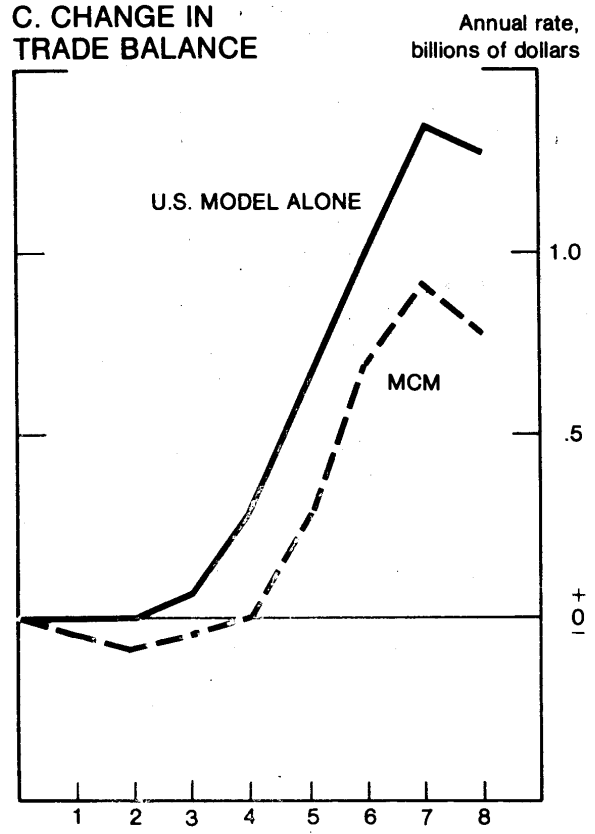
A special feature of the Multi-Country Model is that it can operate under a variety of exchange-rate regimes. When fixed exchange rates are assumed, each country's over-all balance of payments determines the change in its stock of international reserve assets. When the model operates under a system of 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.

Effects of a Change in U.S. Monetary Policy*

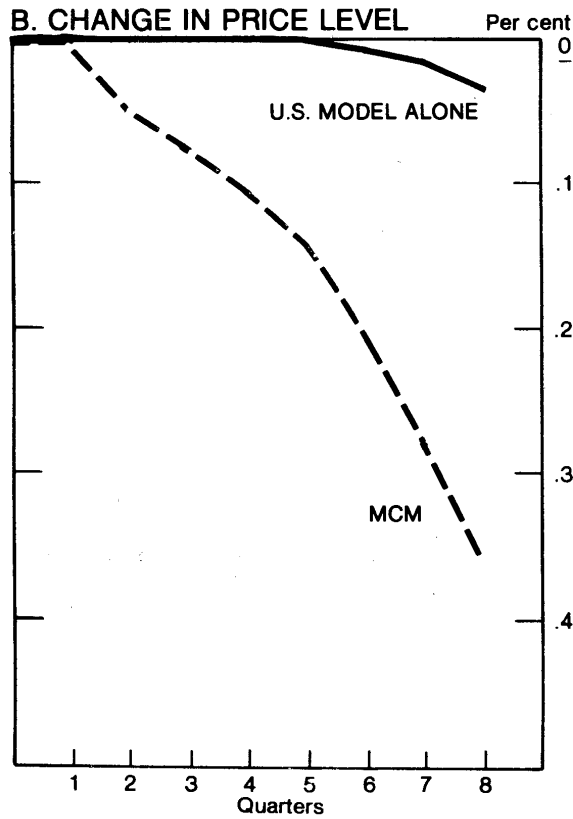
A. CHANGE IN REAL GNP



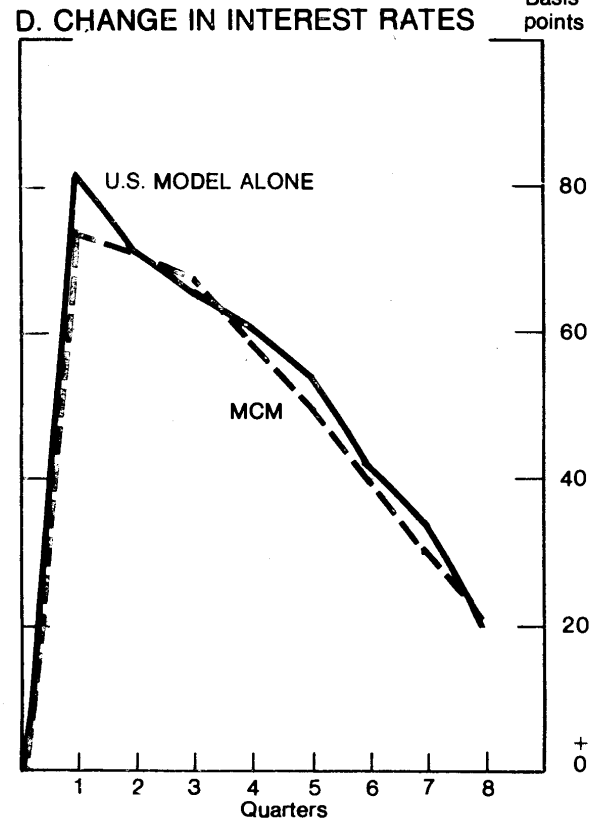
C. CHANGE IN TRADE BALANCE



B. CHANGE IN PRICE LEVEL



D. CHANGE IN INTEREST RATES



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

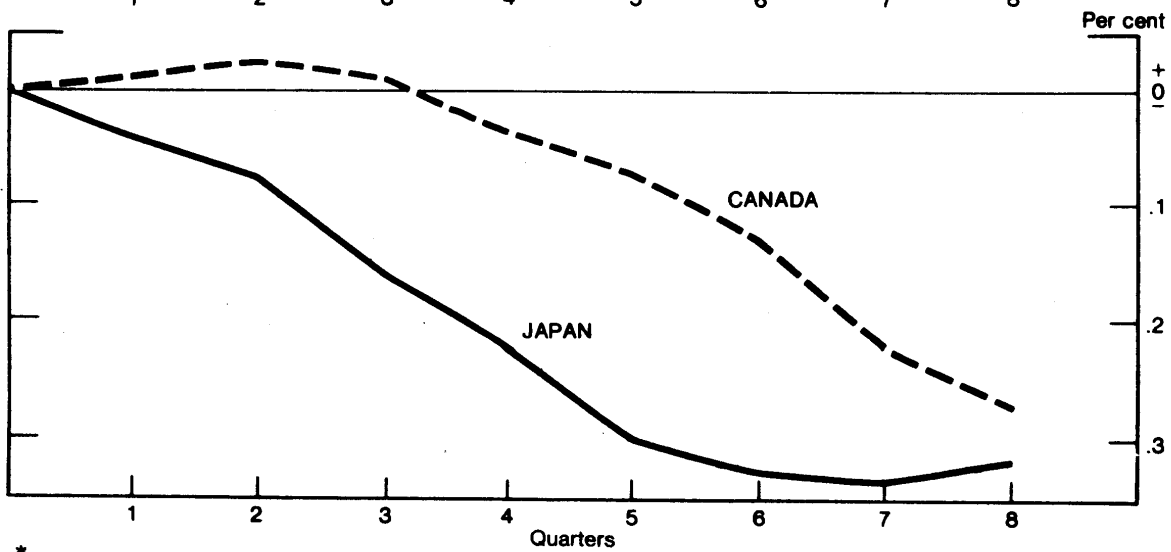
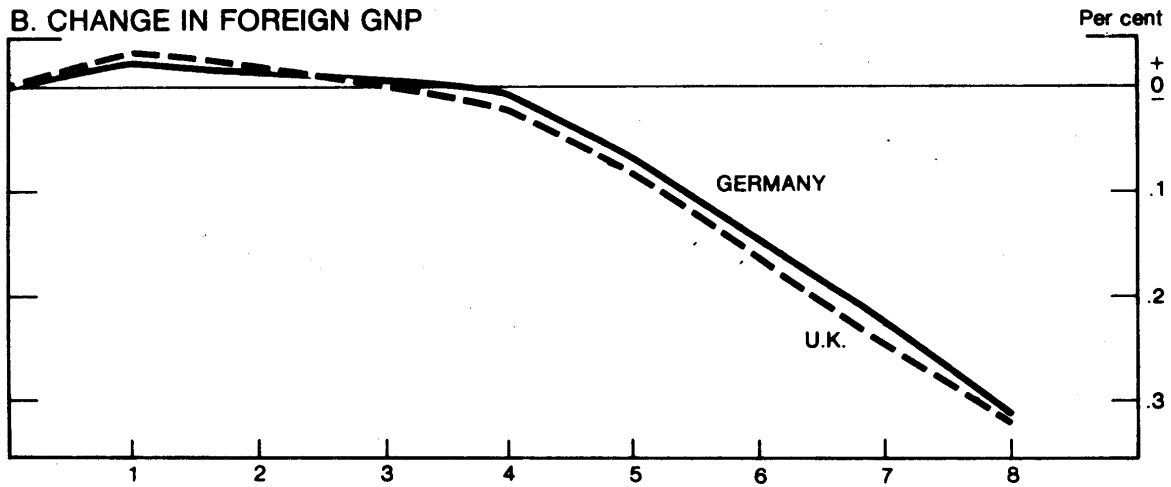
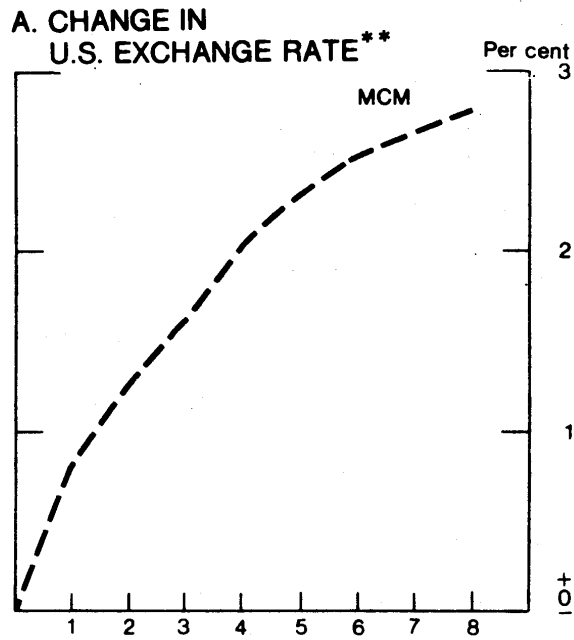
I. The Effects of U.S. Open Market Operations

The first set of simulations relates to a tightening of U.S. monetary policy: an open market sale of \$1 billion in government securities carried out in a period of flexible exchange rates.⁵

In order to illustrate the effects introduced by the MCM, among which are the endogenization of the exchange rate, the results will be presented in two stages. First, we will analyze the effect of the monetary tightening in the context of the model of the U.S. economy taken in isolation, i.e., when it is not linked with the other country models. In this case, the world outside the United States is assumed to be unaffected by the change in U.S. monetary policy, and all bilateral exchange-rates are held exogenous. The results will then be discussed for the same policy change, but when the U.S. model is integrated into the multi-country system; in this case, changes in U.S. variables are allowed to affect exchange rates and economic variables abroad, and these latter changes feed back onto the U.S. economy.

The heavy lines in Chart 1 show the changes in the key variables for the case where the U.S. model is not linked with the other country models. The results are generally consistent with those of most existing models of the U.S. economy, models that, by and large, do not allow foreign variables and exchange rates to vary.

Effects of a Change in U.S. Monetary Policy*



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

** Weighted-average of the bilateral exchange rates of the U.S. dollar vis-a-vis the German mark, the Japanese yen, the U.K. pound and the Canadian dollar, respectively.

Panel A shows the expected negative impact on U.S. real GNP; the effect increases gradually, reaching a maximum after 6 quarters, some 7/10 of a per cent below what it otherwise would have been.

This decline is caused in large part by the primary impact of the open-market operation, the rise in the interest rate (Panel D); the interest rate jumps by 80 basis points initially and, as aggregate demand falls off, declines slowly thereafter. In line with the weakening of aggregate demand, there is a small decline in the price level and an improvement in the trade balance.

When the U.S. model is linked to the other five country models, the effects of the same change in U.S. monetary policy are modified significantly. As can be seen from the dashed line in the first panel of Chart 1, the negative impact on GNP is magnified: the maximum effect, seven quarters after the tightening of monetary policy, is some 2/10 of a per cent more than when induced changes in external influences on the U.S. economy are ignored.

The most dramatic difference between the two sets of results is for the price level; it falls by a full 1/3 of a per cent after eight quarters. There is also a significant reduction in the trade balance effect.

The large differences between the results are traceable both to exchange rate changes, which become endogenous in the MCM, and to feedback effects from the foreign economies. The dollar appreciates

with respect to every foreign currency and, consequently, as seen in Chart 2, the weighted-average exchange rate appreciates by almost 3 per cent at the end of two years. Because of this appreciation of the dollar, the price of imports falls by 1-1/2 per cent over the period; this feeds directly and indirectly into the U.S. price level. Moreover, the appreciation reduces U.S. exports and increases imports; this relative reduction in the trade balance adds a second depressing effect on U.S. GNP, in addition to the direct effect of the monetary tightening.

A third negative influence on U.S. GNP is the reduction in foreign economic activity. As shown also in Chart 2, after an initial period,⁶ GNP in each foreign country is affected adversely. This lower level of foreign demand feeds back to the United States, reducing U.S. exports and GNP and diminishing the improvement in the U.S. trade balance.

To summarize, this exercise shows that estimates of the effects of U.S. policy changes on important U.S. variables are altered significantly when international effects are taken into account. The general equilibrium framework of the MCM permits us to capture these international effects and their feedback on the U.S. economy.

Although these estimates do not amount to a conclusive test, their direction corresponds well to the theoretical results presented by Mundell (1963) and others on the comparison of the effects of monetary policy between exchange rate regimes: in particular, a monetary tightening has a more powerful impact on GNP and prices under flexible exchange rates.

II. The Effects of Restrictive Monetary Policies Abroad

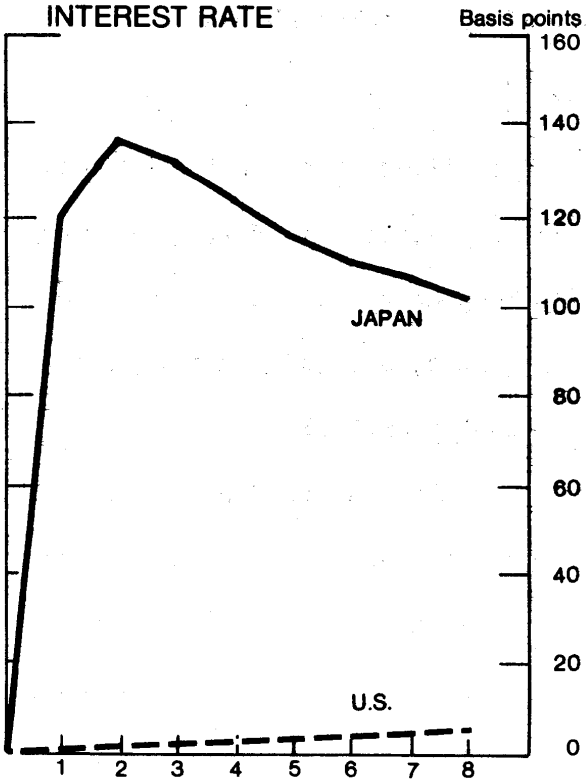
The following two simulations illustrate how the MCM can be used to trace the effects of monetary actions in foreign countries. This capability is illustrated with respect to (i) an increase in the Bank of Japan's official discount rate, and (ii) an increase in the reserve requirements applicable to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

The effects of an increase in the Bank of Japan's discount rate by one percentage point are shown in Chart 3. In panel A, the Japanese short-term interest rate is seen to increase sharply in the first two quarters and to decline gradually thereafter. Although the U.S. short-term rate rises moderately, there is, initially, a substantial increase in the interest-rate differential in favor of Japan. This increase reduces the relative attractiveness of borrowing from the U.S. and Eurodollar markets, thus leading 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. This leads to an improvement in the Japanese trade balance (as seen in panel D) and to additional upward pressure on the Yen. Finally, as indicated in Chart 4, Japanese prices decline under the combined effects of reduced capacity utilization, increased unemployment and exchange rate revaluation; and there is also some upward pressure on U.S. prices stemming from the devaluation of the dollar.

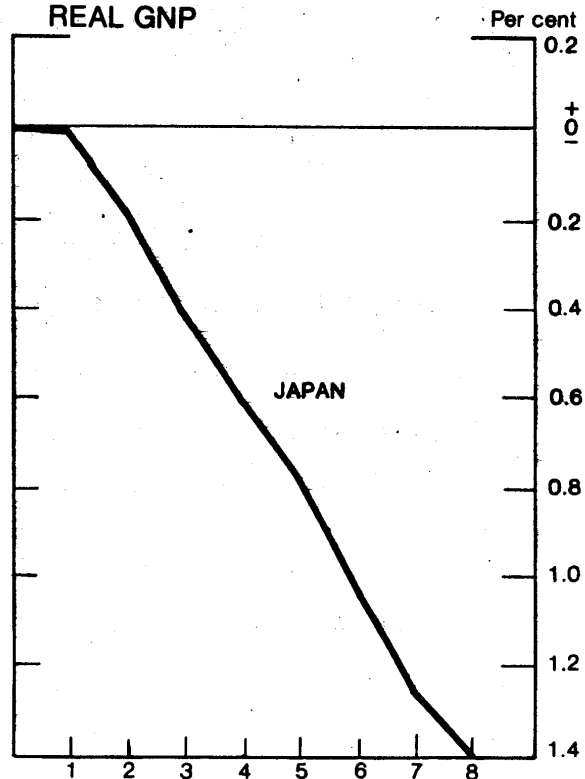
Chart 3

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

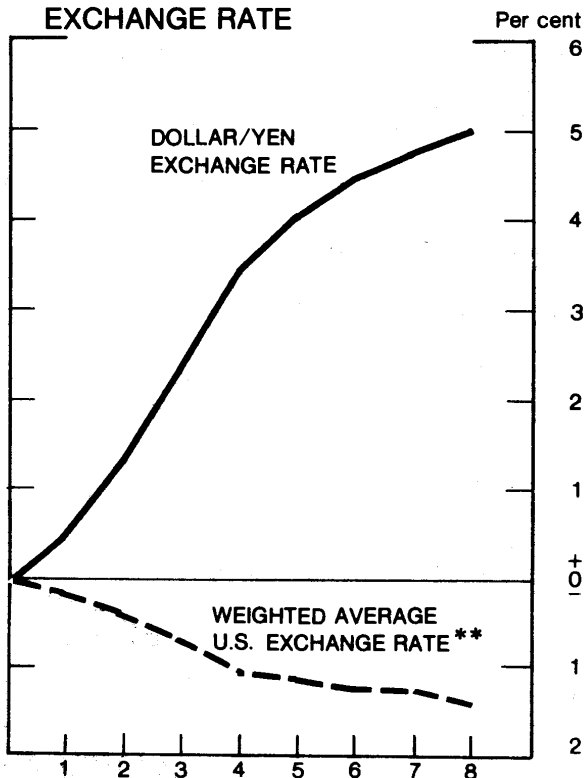
A. CHANGE IN SHORT-TERM INTEREST RATE



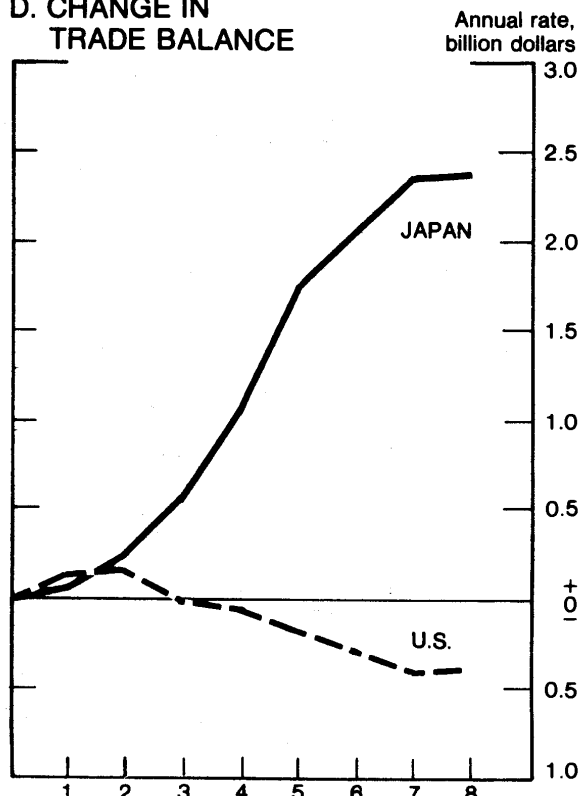
C. CHANGE IN REAL GNP



B. CHANGE IN EXCHANGE RATE



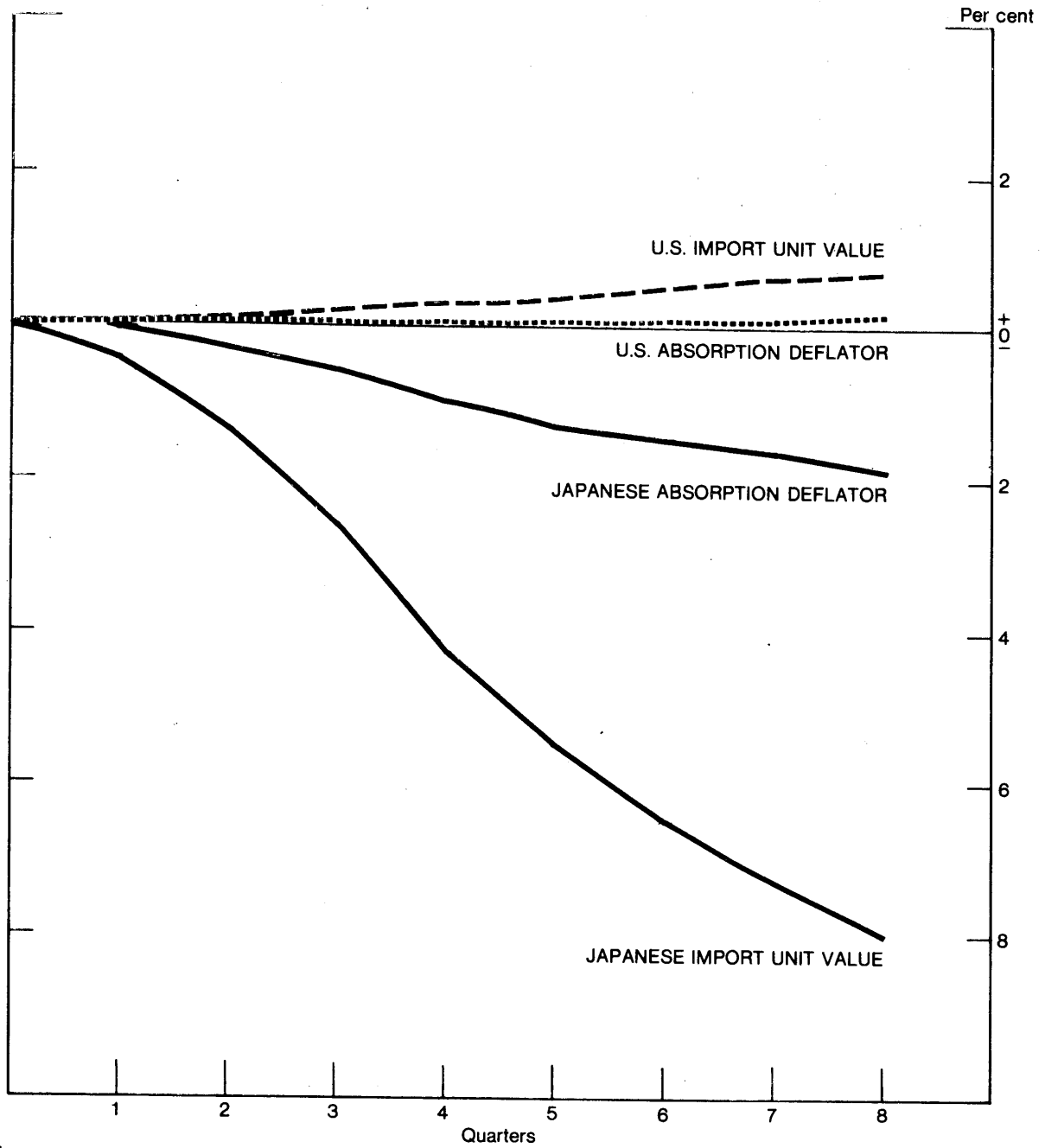
D. CHANGE IN TRADE BALANCE



* All changes are measured relative to conditions that would prevail in the absence of policy actions.
 ** Units of foreign currency per dollar

Chart 4

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

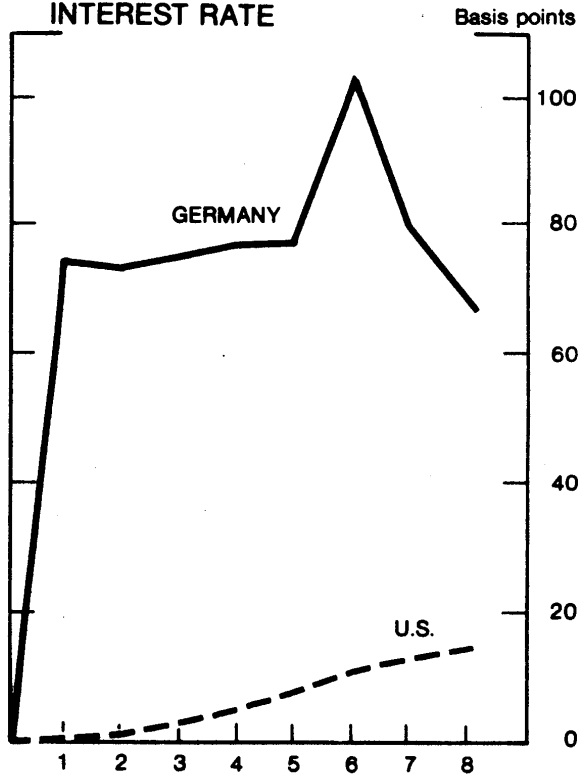


* All changes are measured relative to conditions that would prevail in the absence of policy actions.

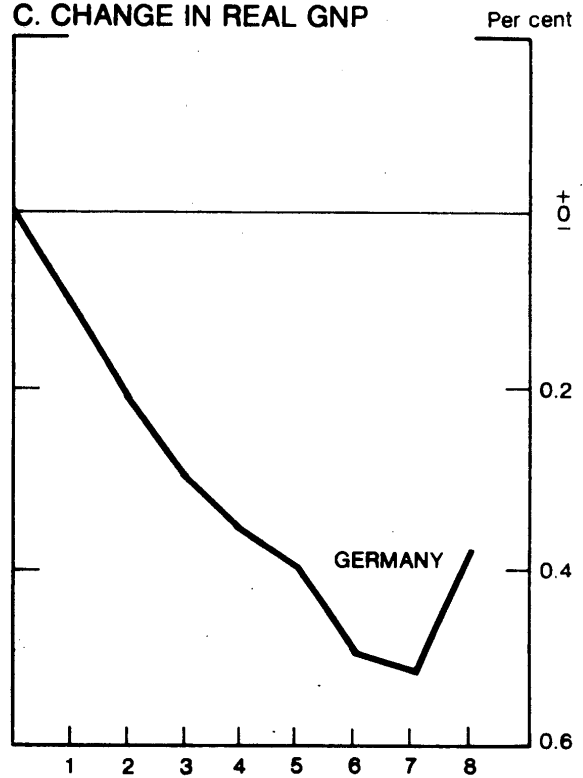
Charts 5 and 6 show the effects of increasing by 1 percentage point the reserve requirements applicable to four types of deposit liabilities issued by German banks. The results are generally similar to those reported in the Japanese experiment. It may be noted, however, that the U.S. trade balance improves in response to the monetary contraction in Germany, because U.S. exports are stimulated by the sharp depreciation of the dollar. In the Japanese stimulation this exchange rate effect is also present, but it is more than offset by the depressing impact on U.S. exports of a large reduction in Japanese GNP.

Effects of a One Percentage Point Increase in German Reserve Requirements*

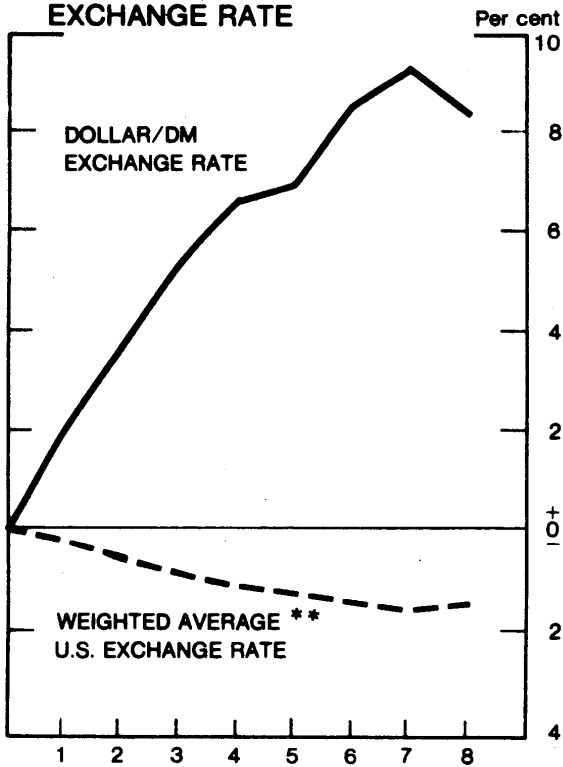
A. CHANGE IN SHORT-TERM INTEREST RATE



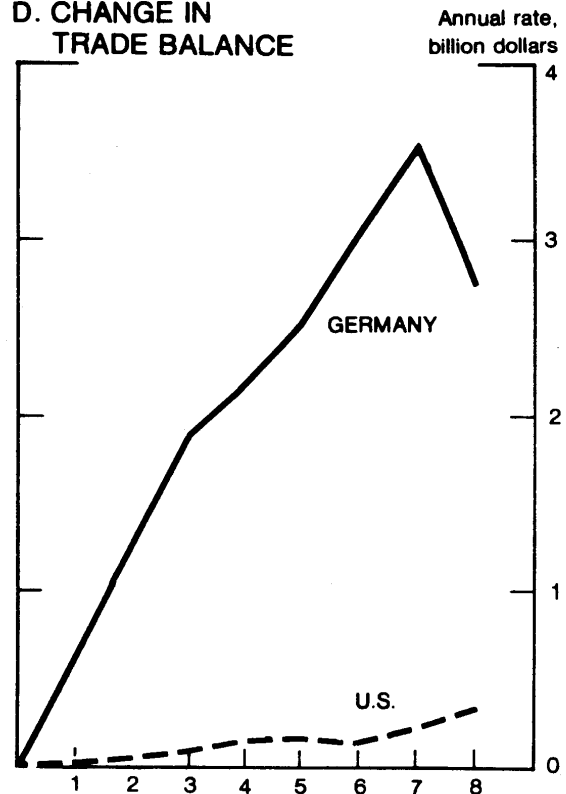
C. CHANGE IN REAL GNP



B. CHANGE IN EXCHANGE RATE



D. CHANGE IN TRADE BALANCE

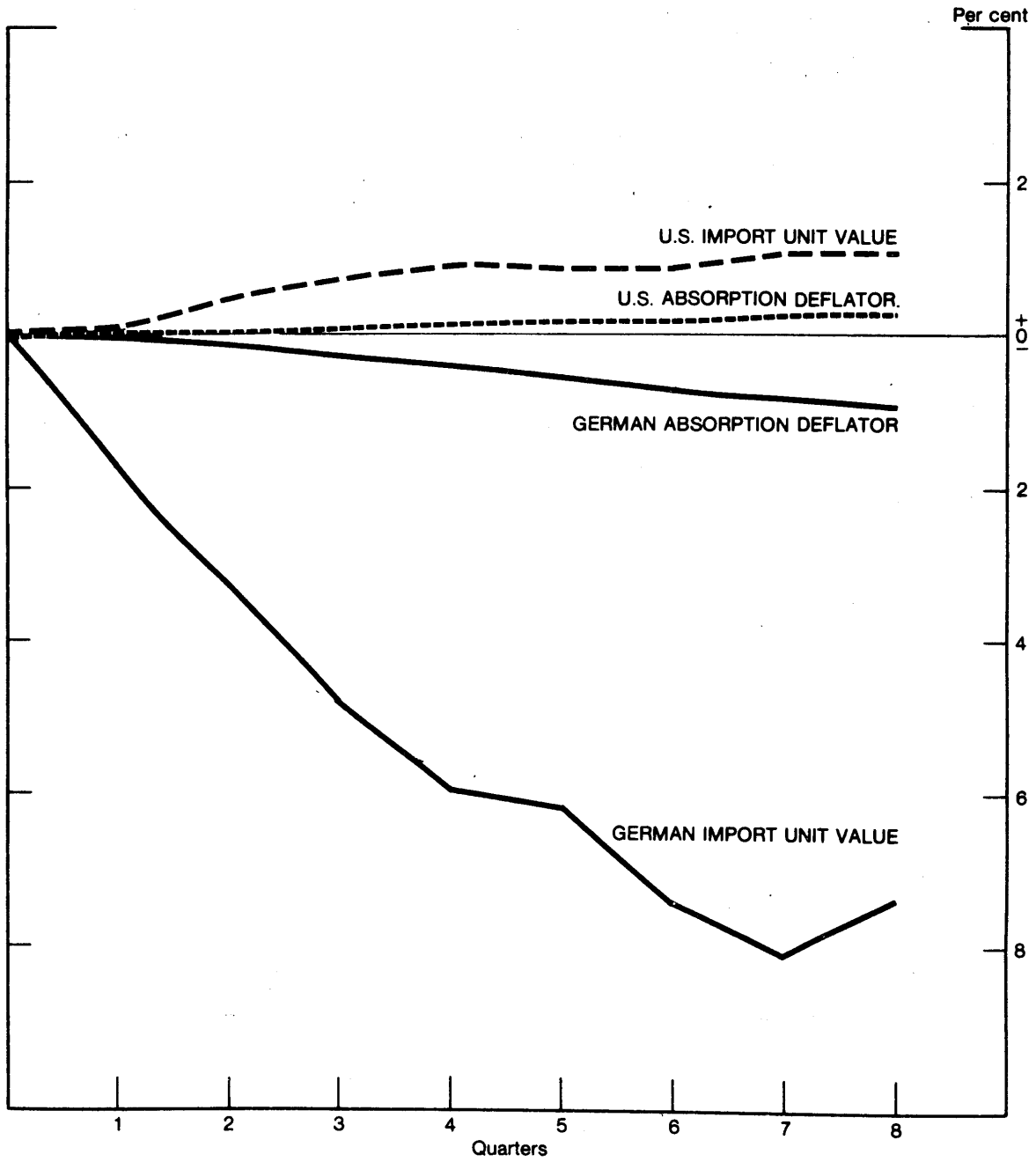


* All changes are measured relative to conditions that would prevail in the absence of policy actions.

** Units of foreign currency per dollar.

Chart 6

Effects on Prices of a One Percentage Point Increase in German Reserve Requirements *



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

III. Changes in Central Bank intervention and monetary policy

The structure of the Multi-Country Model makes it possible to analyze central bank intervention in foreign exchange markets and the effects of such intervention on exchange rates and other variables. The strategies of central banks in foreign exchange markets are too complex to be fully captured by any model and, in fact, have varied over recent years. Nevertheless, in estimating the equations of the MCM, it was found that the monetary authorities of Canada, Germany and Japan have attempted, with some regularity, to moderate movements in exchange rates by exchange market intervention. To investigate the sensitivity of the model to changes in intervention behavior, two simulations are analyzed in this section.

First, monetary authorities abroad were assumed to have intervened to resist exchange rate changes with twice the intensity actually observed over the early floating rate period. This increased exchange market activity is found to reduce noticeably exchange rate fluctuations.

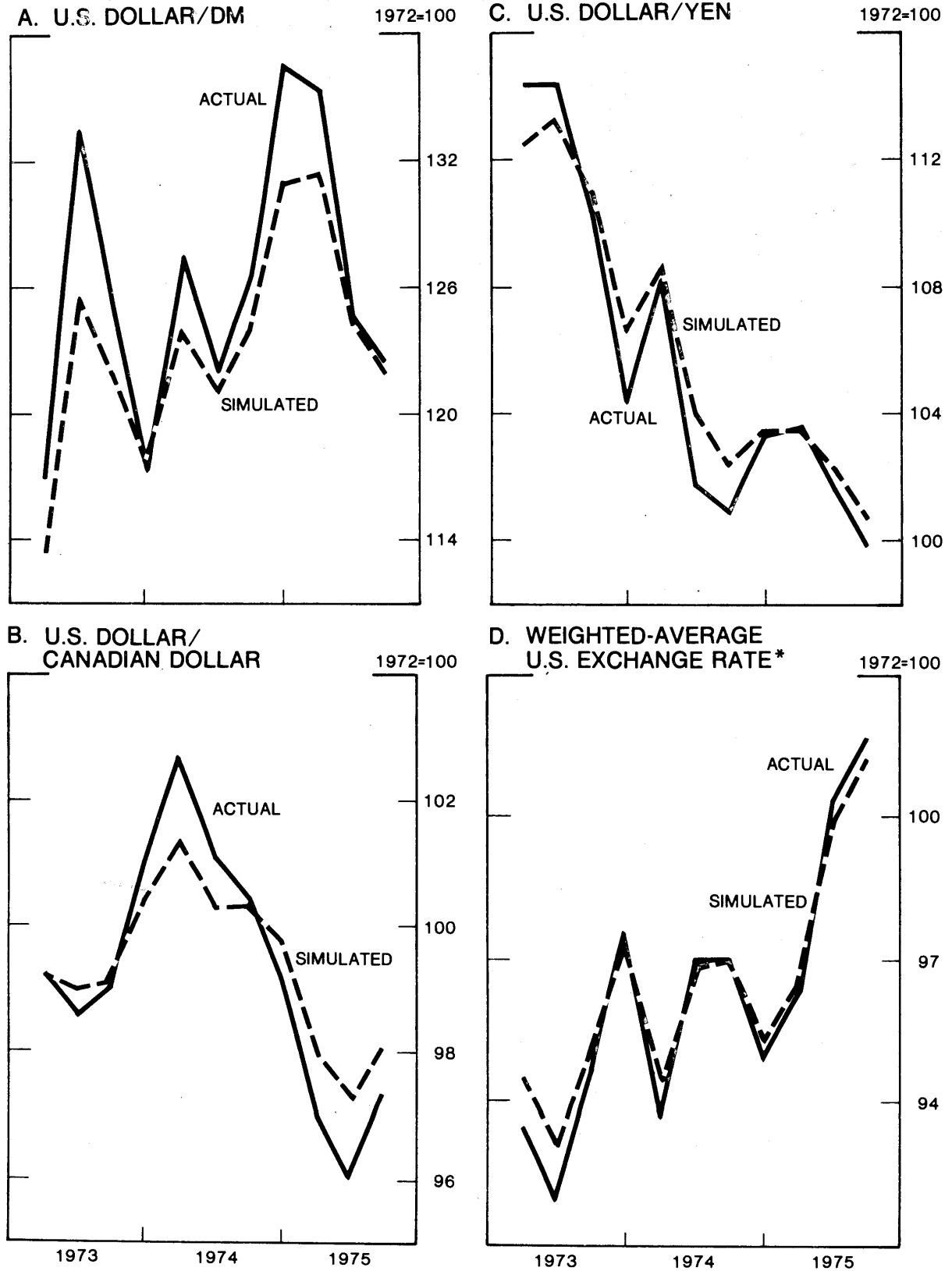
The second simulation investigates how the effects of a monetary contraction in the U.S. are altered when the tendency of the central banks to resist exchange rate changes is doubled. In other words, the assumptions concerning central bank intervention underlying the first simulation of this section are superimposed

on the U.S. monetary contraction reported in Section II. The results of this experiment indicate that "leaning against the wind" with greater intensity does not necessarily reduce the impact of a monetary tightening on GNP and prices.

The first simulation investigates the extent to which the amplitude of exchange rate movements during the early period of floating exchange rates would have been reduced if the authorities of Canada, Germany and Japan had all intervened with twice the resistance to exchange rate changes as actually observed during that period. For example, it was estimated that from 1970:3 to 1975:4 the Bank of Canada sold, on average, about Can\$110 million for each percentage point rise in the dollar value of the Canadian dollar and purchased the same amount for each percentage point fall in the Canadian dollar. For the purpose of this exercise, the amount was doubled to some Can\$220 million per percentage point. Analogous changes were made for Germany and Japan.⁷

Chart 7 shows the actual and hypothetical paths of the dollar exchange rates for the Deutschmark, the yen and the Canadian dollar, as well as for the weighted average exchange rate of the U.S. dollar over this period. For each of the three currencies, the amplitude of exchange rate movements would have

Effects of Increased Exchange Market Intervention on Exchange Rates



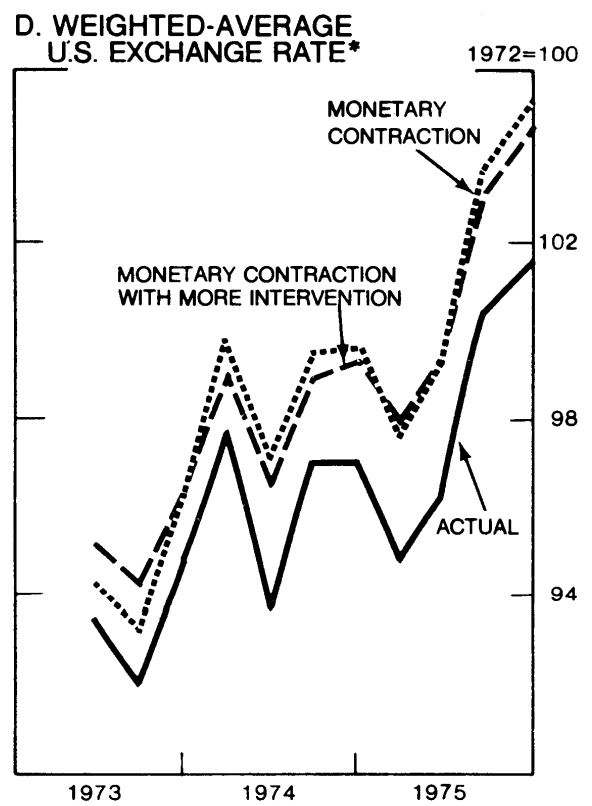
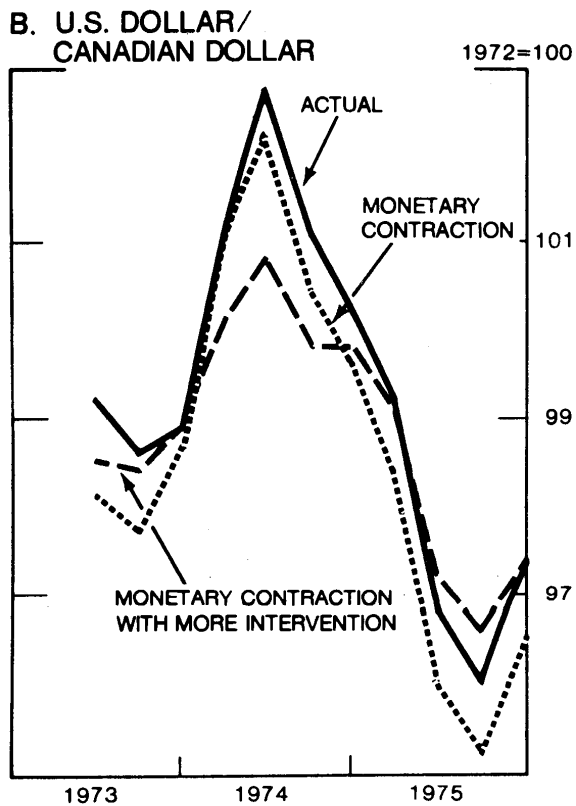
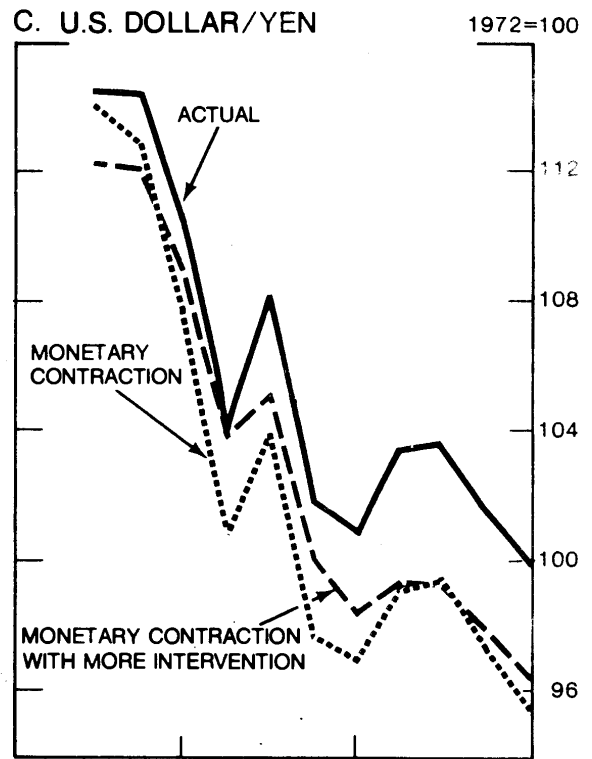
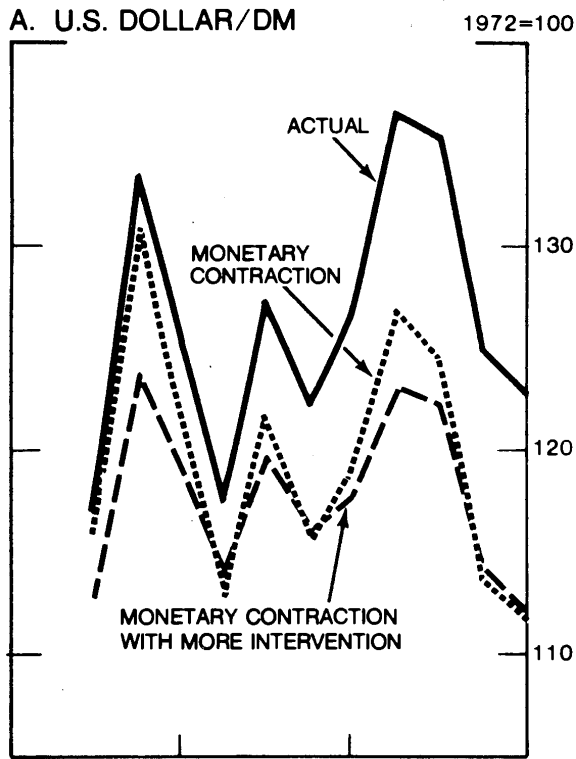
*Units of foreign currencies per dollar.

been reduced if central banks had "leaned against the wind" with greater intensity, although large fluctuations would not have been eliminated. Reductions in the variability of the Deutsche-mark, the yen, and the average U.S. dollar exchange rate would have been on the order of about 20 per cent; the reduction for the Canadian dollar would have been about 40 per cent.⁸

The effects of the increased exchange rate smoothing on output would have been small -- GNPs would have deviated by no more than two-tenths of one per cent from their historical levels. Prices and trade flows would have differed more noticeably from their actual values although the changes would have been largely transitory. The increased exchange market intervention would have led to substantial interest rate variability in all countries, primarily because of the impact of the larger reserve changes on the monetary bases of these countries.

In the second simulation, the doubled intervention coefficients were combined with the \$1 billion open market sale by the Federal Reserve. The joint effects of increased smoothing and the monetary contraction can be seen in chart 8. Monetary restraint has led to an appreciation of the U.S. dollar and, in addition, the increased intervention has smoothed the paths of the three bilateral exchange rates. As compared to the case of the U.S. monetary contraction alone, the variabilities of the exchange rate paths with the contraction and increased smoothing

**Effects of a Contraction in U.S. Monetary Policy
Coupled With an Increase in Exchange Market Intervention**



* Units of foreign currencies per dollar.

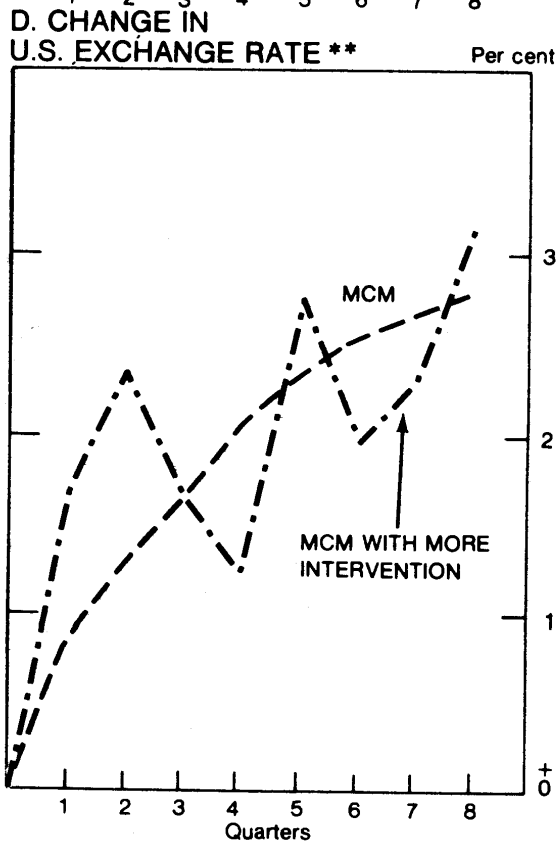
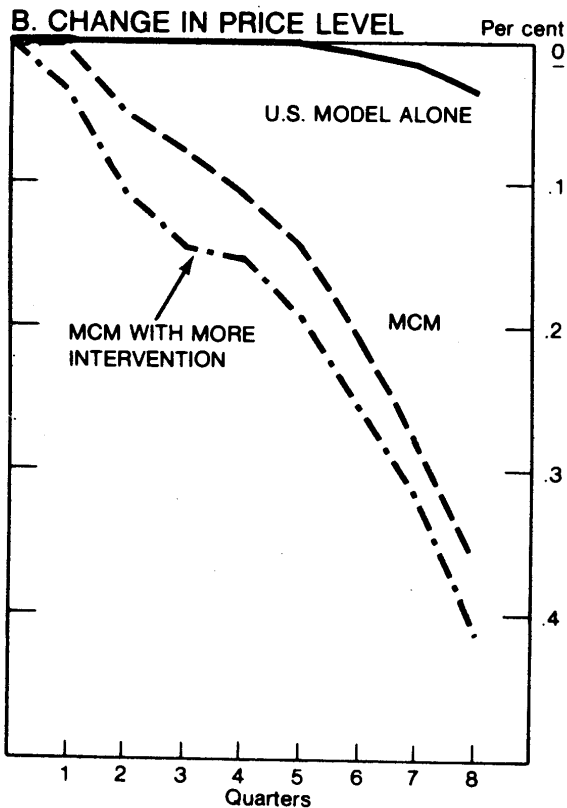
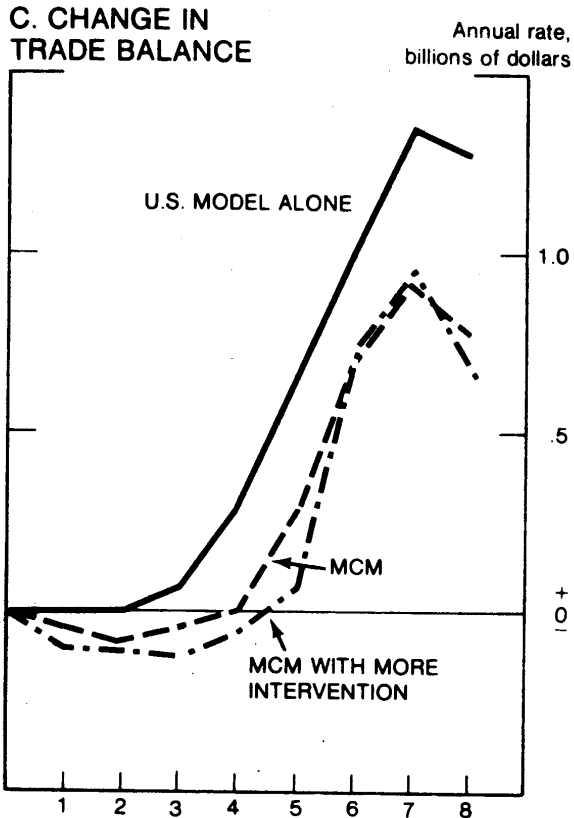
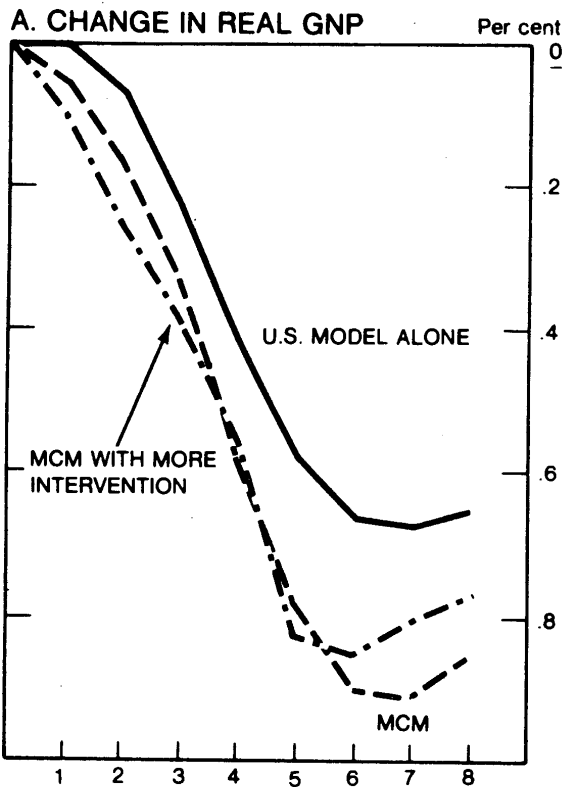
were lower by about 40% for the Canadian dollar, about 35% for the Deutschemark, about 10% for the yen, and approximately 15% for the U.S. weighted average exchange rate.⁹

The effects of the increased intervention on the U.S. monetary policy multipliers are mixed. In chart 9, the effects of the compound experiment on GNP, the trade balance, and the price level in the U.S. are compared with those of the simple monetary contraction. Panel A indicates that the GNP multiplier is slightly greater over the early part of the period for the simulation with more intervention. However, after the fifth quarter, the increased intervention reduces the GNP multiplier by about 1/10 of a percentage point. This seems to be a result of the reduced price level and consequent relative improvement in the real trade balance in the sixth quarter.

As shown in panel C, the initial effect of greater intervention is to increase the effect of the monetary contraction on the trade balance. The trade balance is the channel through which the effects of increased intervention are transmitted to GNP. The much larger initial appreciation of the U.S. weighted average exchange rate (panel D) acts to enhance the reduction in the U.S. trade balance and thereby to reduce GNP further than in the case of the simple monetary contraction.

Panel B indicates the effects of increased intervention on the price level. Reflecting the greater impact on GNP in the earlier period, the price multiplier is greater under increased intervention than under "normal" intervention. In the early part of the period, this is a direct result of the greater contractionary effect on GNP. Later

Effects of a Change in U.S. Monetary Policy*



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** Weighted-average of the bilateral exchange rates of the U.S. dollar vis-a-vis the German mark, the Japanese yen, the U.K. pound and the Canadian dollar, respectively.

in the period, when increased intervention diminished the GNP effect, the price level remains below that for the normal intervention case. This is most likely a result of the dependency of price and wage changes in the model on past price changes.

Finally, as seen in panel D, the schedule showing the response of the average U.S. exchange rate exhibits greater variability in the case where the contraction is coupled with greater intervention than in the case of the simple monetary contraction. This is a result of the functioning of the intervention rules in the model which assumes that foreign monetary authorities intervene in such a way as to moderate exchange rate changes. Given these rules, increasing the intensity of exchange market intervention will result in smoothing the path of exchange rates and will therefore introduce deviations between the simulated and historical paths of these exchange rates.

Footnotes

- 1/ For example, Fleming (1962) , Mundell (1968) and Girton and Henderson (1976) .
- 2/ 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.
- 3/ Trade flows of all other countries other than the five mentioned above are explained in the abbreviated rest-of-the-world model.
- 4/ 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.
- 5/ The simulations reported in this paper were done for the period 1973:2 through 1975:1; in some cases the simulations have been repeated for other time periods and, to date, the conclusions have been largely unaltered by the period of simulation.
- 6/ The GNP's of Germany, the U.K., and Canada experience slight increases in the first three periods in response to the U.S. monetary contraction. The appreciation of the dollar vis-a-vis other currencies, by itself, would tend to improve foreign trade balances and stimulate foreign GNP's. Offsetting this exchange rate effect, and dominating it in the later periods, is the reduction in U.S. imports due to the decline in U.S. GNP.
- 7/ The intervention coefficients for Japan and Germany implied purchases of about \$250 million and \$140 million, respectively, per percentage point increase in the dollar value of the yen and the Deutschemark.
- 8/ These reductions were calculated as the percentage difference between the standard deviations of the historical and the simulated exchange rate paths.
- 9/ There was no change in the variability of the dollar/pound rate because no change in intervention was assumed in the case of the U.K. monetary authorities.

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