I. Introduction*

Experience during the last few years of floating exchange rates shows that increasing instability of exchange rate movements is associated with increasing intervention by central banks in exchange markets. For example, Table 1 below shows the monthly average volume of changes in foreign exchange holdings of eleven countries from 1973 to 1978 and the variability of their dollar exchange rates over the same period.¹

Table 1. Reserve Changes and Exchange Rate Variability, March 1973 - November 1978.

<table>
<thead>
<tr>
<th>Monthly Averages</th>
<th>Reserve Changes *(Bil.$)</th>
<th>Exchange Rate Changes**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>3.82</td>
<td>23.6</td>
</tr>
<tr>
<td>1974</td>
<td>3.30</td>
<td>22.2</td>
</tr>
<tr>
<td>1975</td>
<td>2.58</td>
<td>20.8</td>
</tr>
<tr>
<td>1976</td>
<td>4.39</td>
<td>14.7</td>
</tr>
<tr>
<td>1977</td>
<td>5.11</td>
<td>13.8</td>
</tr>
<tr>
<td>1978</td>
<td>6.28</td>
<td>29.8</td>
</tr>
</tbody>
</table>

*Monthly average absolute changes in end-of-month foreign exchange reserves for Group of Ten countries and Switzerland.

**Monthly average absolute percentage changes in end-of-month dollar exchange rates for same countries.

¹Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States, constituting the "Group of Ten" countries and Switzerland.

*An earlier version of this paper was presented to the Conference on Currency Risk and Exposure—Current Developments in International Financial Management at the Salomon Center of the Graduate School of Business, New York University, New York, February 22, 1979, and to a seminar at the Institute for International Economic Studies on March 26, 1979. Comments of Michael Dooley, Claes Wihlborg, John Hellwell, and members of IIES are appreciated. The support of the Ford Foundation Program in International Economic Order is gratefully acknowledged.
Although changes in foreign exchange reserves are an imperfect measure of intervention, the data show that both intervention and exchange rate movements tended to decrease during the first three years of floating, 1973-1975. During 1973 foreign exchange reserve changes averaged $3.82 billion a month for the eleven countries, or $45.8 billion over the year. Dollar exchange rate changes averaged 23.6% per month for the countries excluding the United States, or 2.36% per month for the average country. As exchange rate variability declined through 1975, so did intervention.

In 1976 and 1977 reserve changes picked up considerably, as several countries preferred to accumulate large holdings of reserves rather than let their exchange rates appreciate (notably the United Kingdom, Italy, and Japan in 1977).

Thus exchange rate variability was substantially reduced while reserve changes increased due to intervention. Then, toward the close of 1977 and throughout much of 1978, both exchange rate instability and central bank intervention increased sharply. The volume of reserve changes in 1978 totaled $75.4 billion, while exchange rate changes averaged almost three percent per month for the ten countries other than the United States.

Central bankers and many economists would argue that unstable private behavior is responsible for the increased instability of exchange rates and that central bank behavior is a response intended to damp down the fluctuations. Other economists would argue that central bank behavior itself, either the intervention activity or domestic monetary (and fiscal) policy, may in fact be the cause of much exchange market instability. These and other views, together with recent experience with central bank intervention, will be discussed below.
Section II of the paper reviews the major issues in the design of intervention policy, while section III discusses the recent experience of several countries in some detail. Section IV derives a policy reaction function for central bank intervention policy, to help describe the factors entering into central bank policy choices. Section V then attempts to test whether central banks have actually behaved as the theory predicts. Section VI provides some concluding observations.

II. Major Issues in Intervention Policy

A. Cause and Effect

As noted in the introduction, perhaps the single most important issue concerning central bank intervention in exchange markets is whether it is a cause or effect of increased instability. For if there is a type of intervention which itself causes instability, it should certainly be immediately proscribed. At first blush, the idea seems a bit absurd, for central banks generally intervene in exchange markets to counter disorderly market conditions or to prevent their exchange rates from moving away from some rate thought of as a "normal" or "equilibrium" exchange rate.

The conventional wisdom that central bank intervention reduces instability in exchange markets is based on the notion that a floating exchange rate fluctuates randomly about some unknown but relatively constant equilibrium rate. From time to time a particularly large random shock or shift in speculative beliefs about the equilibrium rate will set up a cycle of speculative purchases or sales which will push the rate in one direction for an extended period beyond the equilibrium rate. In these conditions central bank intervention can reduce the magnitude of random rate movements and can reduce the extent to which a speculative cycle might "overshoot" the equilibrium rate. Furthermore, by
reducing the variance of exchange rate movements, intervention can reduce the riskiness of stabilizing capital flows, thus making it easier for temporary imbalances in current accounts to be financed privately.

The opposite possibility, that central bank intervention may increase instability, is associated with intervention to peg an exchange rate temporarily at a disequilibrium level. As will be indicated below in section III, this type of behavior has not been infrequent in recent years. Since the true equilibrium exchange rate is always unknown, a central bank which chooses to defend a certain rate may easily choose a disequilibrium rate for either political or mistaken economic reasons. In such a case, speculators are confronted with the "one-way bet" opportunity that used to exist under the adjustable peg regime. When the temporary peg is abandoned, they stand to make large profits. And the central bank will have either lost or gained a large amount of reserves in the process, at taxpayers' expense.

The reserve flow caused by such a speculative run will itself have destabilizing effects on the money supply of the country in question, assuming that sterilization of reserve flows is an imperfect process when large volumes of funds are involved. And the exchange rate movement itself, when it finally comes, will be rapid and sharp, rather than slow and gentle.

Thus the nature of the intervention policy is the key to its causal relationship with instability of exchange rates. A policy that attempts to prevent excessively rapid changes (disorderly markets) or that attempts to smooth out longer swings in exchange rates is unlikely to destabilize, while one that attempts to peg a specific rate that is not an equilibrium rate can have destabilizing effects.
B. Monetary and Fiscal Policies

Another way in which central bank policies have important effects on exchange rate movements is through their control of domestic monetary policy and their indirect influence over fiscal policies through the financing mechanism. In the short run, changes in interest rates which do not merely reflect changes in anticipated future inflation rates have immediate effects on the attractiveness of holding funds in different currencies. Thus a real tightening or easing of monetary policy will often have immediate effects on exchange rates by changing the interest differential between different countries.

Over the longer run, monetary policy has obvious effects on inflation, so that more rapid monetary growth over an extended period will translate into higher inflation and, via the mechanism of purchasing power parity, into a depreciated exchange rate.

Thus the fundamental long-run determinant of the international value of a currency in terms of other currencies is its purchasing power over domestic goods and services. In that sense it is obvious that an inflationary or deflationary domestic monetary policy will result in changes in the equilibrium international value of a currency, and hence instability in the exchange rate as market participants search for the new, unknown equilibrium rate.

C. The External Constraint Under Floating Rates

One major issue concerning floating exchange rates has to do with the effects of floating on the degree of external constraint felt by the makers of domestic monetary and fiscal policy. It has long been argued by economists that a floating exchange rate would liberate domestic monetary policy from the constraint imposed by a pegged rate.\(^2\) In the first instance, this freedom

arises from the absence of intervention to peg the rate. As a result the reserves are no longer threatened by external deficits, and the influx or efflux of reserves no longer affects the domestic money supply. In the longer run, the freedom is attributable to the ability of a floating rate to offset inflation differentials between countries, thus allowing choice of inflationary or deflationary monetary policies by different countries.

In actual fact, floating rates seem to have led to a good deal less "liberation" than economists originally supposed would occur. In the first place, intervention is still quite active, leading to reserve movements. In the second place, there remains an "external constraint" over the total resources available to an economy: any desired excess of domestic spending on traded goods over domestic production must be financed by willing private foreign lending. In an inflationary setting, the required lending may only be forthcoming at very high interest rates or after a very sharp depreciation of the exchange rate, both of which will be costly to the domestic economy.

Nevertheless, it is very clear that a number of countries did realize a substantial additional degree of freedom for their domestic monetary and fiscal policies from floating, most notably the United Kingdom and Germany. As they made use of this additional freedom during the 1973-75 period, inflation rates began to diverge among countries rather more as monetary policies diverged. The result was increased movement of exchange rates merely to offset the differential inflation rates. Thus the introduction of the floating regime itself seems to have induced changes in monetary and fiscal policies that led to increased instability of exchange rates.

D. Rules for Intervention Under Floating Rates

A final major issue concerning central bank intervention is the so-called "guidelines" issue. What sort of rules should the International Monetary Fund promulgate and seek to enforce on central banks with floating rates?

The IMF itself has issued two sets of rules. The 1974 "Guidelines for Floating Exchange Rates" encourage intervention of type (1) "to prevent or moderate sharp and disruptive fluctuations from day to day and from week to week. They permit intervention of type (2) "to moderate movements...when factors recognized to be temporary are at work." And they allow intervention of type (3) to attain a "target zone" for the exchange rate if the Fund agrees that the target zone is a "reasonable" estimate of the equilibrium rate.\(^4\) Aside from possible intervention of type (3), the Guidelines rule out "aggressive" intervention to push down a falling rate or push up a rising rate.

Although the 1974 Guidelines had merely hortatory value, the adoption of the Second Amendment to the IMF Articles of Agreement in 1978 has brought into force a revised Article IV including "firm surveillance" over exchange rate policies of members. In setting up its surveillance policies, the IMF has established more limited "Principles for Guidance" of exchange rate policies.\(^5\) These principles again encourage intervention of type (1) but do not mention intervention of types (2) and (3). Rather, the focus shifts to avoiding "manipulation of exchange rates in order to prevent effective balance of payment adjustment or to gain an unfair competitive advantage over other members."

Danger signals include protracted large-scale intervention in one direction,

\(^4\) International Monetary Fund, Annual Report, 1974, pp. 112-16.

high levels of official borrowing or lending, new restrictions over payments
flows, or externally-oriented domestic monetary measures.

The shift from the 1974 Guidelines to the 1977 Principles appears to
reflect a shift from a permissive attitude towards intervention to a restrictive
attitude. That shift reflects the experience reviewed below in section III as
well as growing belief that the "target zone" approach is unworkable. A basic
difficulty of the "target zone" is the impossibility of objectively determining
an equilibrium pattern of exchange rates.\textsuperscript{6} Recent experience also suggests that
countries are quite likely to prefer disequilibrium targets for their inter-
vention, leading to destabilizing speculation of the type discussed earlier.

Since the IMF's 1977 Principles are much less explicit concerning
mechanical rules of intervention than the 1974 Guidelines, it may be wondered
whether they have any greater chance of becoming effective. While this remains
to be seen, it is noteworthy that a regular process of consultation has been
established with all Fund members and that \textit{International Financial Statistics}
has just begun publishing data on "exceptional financing" through officially-
sponsored foreign borrowing -- one of the danger signals alluded to earlier.

Even these data may not suffice, however, since it is possible for the authorities
to induce private foreign borrowing through subtle pressures that will not easily
come to light.\textsuperscript{7}

A recent discussion of the IMF's proposed surveillance technique suggests
that it is intended to apply a case-by-case approach, adapting the "Principles"

\textsuperscript{6}For example, Ethier and Bloomfield's "Reference Rate" proposal suggests
that the IMF should conduct a multilateral negotiation every so often, in which
each country should make known its future monetary and fiscal intentions. The
difficulties of the Smithsonian negotiations pale by comparison. See Wilfred
Ethier and Arthur I. Bloomfield, "The Reference Rate Proposal and Recent

\textsuperscript{7}See the discussion of French policy in Stanley W. Black, \textit{op.cit.},
pp. 154-6.
to fit the specifics of each type of intervention policy examined. Given the many motives for intervention and the many techniques available, this seems quite appropriate. A more difficult question is whether the Fund has chosen the right mix between permissiveness and restrictiveness.

III. Recent Experience with Intervention Policies

The exchange rate policies followed during the 1973-78 period by the Group of Ten countries plus Switzerland fall into three broad categories, with some countries shifting from one category to another: (1) pegged to the Deutschmark through the EEC Snake (Belgium, France intermittently, the Netherlands, Sweden); (2) managed float aiming at a target rate related to trade competitiveness (the United Kingdom, Italy, and frequently Japan); (3) intervention to smooth out excessive swings and avoid disorderly markets (the United States, Germany, Switzerland, and Canada).

These policies, which are only broadly descriptive of the actual policies followed by the countries, have been adopted in an economic environment that was responding to a number of strains. First, the Smithsonian and February 1973 exchange rate realignments improved the U.S. competitive position and worsened the price competitiveness of Germany and Japan and, to a lesser extent, other countries. Second, the advent of floating rates allowed monetary and fiscal policies more room for divergence between countries, with resulting differences between inflation rates in different countries. Third, the 1973-74 worldwide inflationary boom, capped by the oil price increase of January 1974, raised

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inflation and external payments deficits in all OECD countries. Fourth, the worldwide slump of 1975 raised unemployment virtually in all OECD countries.

The central bank intervention policies of those countries that pegged to the Deutschmark through the EEC Snake were by and large automatic. That is, whenever their currencies began to diverge from their cross-parities with other Snake members by 2½ percent above or below, they automatically bought or sold their currency against foreign exchange. In theory, this might have been done by the central bank of the weak-currency country buying its own currency while selling the strongest currency. In actual practice, much intra-Snake intervention seems to have been in dollars, with the weak-currency country selling dollars while buying its own currency. The reasons seem to include wider markets for dollars, wider availability of dollars, and some desire by Snake members to minimize fluctuations in their dollar exchange rates. There is some concern that such policies may have had adverse side-effects on the dollar. An easily-available remedy is for the strong- and weak- currency central banks to coordinate their dollar intervention, with one selling against dollars and the other buying equal amounts against dollars.9

More significant than the mechanics of intra-Snake intervention have been the monetary and fiscal policies pursued by the Snake members to keep their exchange rates aligned with the Deutschmark. Since the DM has appreciated steadily, especially since 1975, these countries have had to try to match German very favorable price and wage behavior in order to avoid having their competitive positions deteriorate seriously. While some have succeeded, others have failed, with the results being a series of DM appreciations within the Snake, other

currencies' depreciations within the Snake, with France and Sweden dropping out of the Snake in March 1976 and August 1977, respectively. Most of these countries made serious efforts to orient their monetary and fiscal policies towards the external constraint, i.e., matching German inflation. The French failed sooner, the Swedes later.

Turning to the second group of countries, which aimed at target exchange rates much of the time, the United Kingdom and Italy have both suffered from excessive inflation during this period. As a result, both allowed their exchange rates to float downward gradually during 1973-75, with heavy management, to offset the effects of inflation on their external competitiveness. A substantial part of British management involved some $14 billion of officially-sponsored foreign borrowing for domestic purposes over the period 1973-77 by nationalized industries and other public bodies. Since the funds were to be used domestically, their conversion to sterling gave the authorities an additional source of foreign exchange for intervention. The U.K. Treasury assumed the exchange risk under a forward cover scheme, so the whole process amounted to forward purchases of sterling by the Treasury over the life of the bonds issued, usually five years or more.

In 1976, however, capital outflows overwhelmed the intervention policies of both countries and led to sharp declines in their exchange rates, running beyond domestic inflation. In both cases, tight monetary and fiscal policies in conjunction with IMF standby agreements reversed the situation in 1977. As their current balances shifted into surplus, their exchange rates began to appreciate, and both countries began to intervene heavily to avoid appreciating against the dollar for competitive reasons.
What is more significant, both the United Kingdom and Italy intervened by rigidly pegging their currencies to the dollar in 1977, thus setting up a "one-way bet" on appreciation. Huge quantities of speculative capital flowed into both countries, with the British picking up $17 billion in additional reserves and the Italians $5 billion in 1977. The result was to undermine the control of domestic monetary growth, which was important for keeping domestic inflation under control. And eventually the authorities were forced to allow their exchange rates to appreciate by the huge capital flows invited by their policies. At the same time, considerable leverage over the domestic inflation process was lost.

In behalf of these policies, it may be argued that both countries needed to build up their reserves for precautionary reasons and to provide funds for some debt repayments. Also, both sought to protect their competitive positions from the effects of appreciation. Nevertheless, it seems very likely that rigid pegging was an inefficient means to those ends, involving unwanted side-effects.

Japan has also managed her exchange rate rather heavily since 1974, as indicated by the fact that the effective rate of the yen changed little between 1974 and 1976, while the Japanese current account improved sharply and international reserves rose $3 billion. Relatively favorable price behavior since the beginning of 1974 enabled Japan to improve her competitive position through mid-1977 and the current account surplus soared to $20 billion in 1978. In the face of large surpluses, the yen appreciated at first slowly in 1977 and then rapidly in 1978.

Central bank intervention took the form of repeated unsuccessful efforts to defend specific levels for the yen/dollar rate. The level was lowered from 294 in stages all the way down to 220 before the central bank gave up its tactics of trying to defend specific rates. In the process, huge speculative
capital inflows were induced to come into Japan, and the reserves rose $6.7 billion in 1977 and a further $6.3 billion in the first quarter of 1978. After the first quarter of 1978, the authorities seemed to adopt a more flexible intervention policy and the rate appreciated further to a low of 176 before rebounding.

The last four countries, the United States, Canada, Switzerland, and Germany, have neither pegged nor attempted to defend specific rates, with the exception of Germany's participation in the Snake. On the other hand, each country has used intervention to moderate sustained swings in its exchange rate, as well as to counter disorderly markets. These policies have not been sufficiently effective to avoid occasional disorderly periods, in which speculative capital has flowed rapidly into or out of a specific currency, accompanied by large rate movements.

In these cases, the primary difficulty appears to have been the failure of domestic monetary and fiscal policies in the different countries to provide adequate support to exchange rate movements to assist in the adjustment of external payments imbalances. To be specific, both Germany and Switzerland have followed relatively restrictive monetary and fiscal policies during the period 1973-77, with a pause for considerable stimulus during the 1974-75 recession. Since both countries had surpluses in their external accounts, on both current account and official settlements, they should have been trying to adjust their external surpluses by means of exchange rate appreciation and/or other policies. It is well known that successful adjustment through an exchange rate appreciation requires stimulative macroeconomic policy to ensure that there is adequate domestic demand to utilize the resources freed from production for the external sector. Otherwise, the appreciation is likely to have a deflationary
impact on the economy that will offset in part the factors tending to reduce
the current account surplus. In such a case, expectations for continuing exchange
depreciation may well outweigh the effects of low interest rates, leading to
another capital inflow which again frustrates the adjustment process. This problem
has also afflicted Japan.

Canada and the United States have in a sense been polar opposites of
Switzerland and Germany, since both have been trying to adjust external deficits
by means of exchange rate depreciation, at least during 1977-78. In each case, a
major question in the minds of participants in the exchange markets has been
whether the domestic policies adopted, together with the change in the competitive
position, would be adequate to improve the external imbalance.

Between December of 1977 and November of 1978, the United States
gradually edged towards a more and more committed policy of intervening in the
exchange markets to counter declines in the dollar, without attempting to defend
a specific rate. The U.S. Treasury opened a swap line with the Deutsche
Bundesbank on January 4, 1978 to augment the Fed's swap, following a statement
of concern over the dollar by President Carter on December 21, 1977. On March
13, 1978, the Fed swap line was doubled to $4 billion in addition to a purchase
of DM from Germany in exchange for SDRs. Finally, on November 1, 1978, following
a run on the dollar caused by his October 24 announcement of an anti-inflationary
program with no reference to monetary policy, President Carter was forced to
shore up the dollar by announcing a one percentage point increase in the Federal
Reserve discount rate, new reserve requirements on bank certificates of deposit,
and the mobilization of up to $30 billion in foreign exchange for more active
intervention.
Two major new departures from previous U.S. intervention policy were included in this package: activation of the swap agreement with the Bank of Japan and issuance of up to $10 billion worth of foreign currency denominated, medium-term securities. The first of these actions for the first time established a cooperative, working, joint intervention policy in yen between the United States and Japan, similar to the previous arrangement with Germany. The second action indicated that the United States government was willing to undertake a substantial medium-term exchange risk to obtain funds for intervention in support of the dollar. This indicated a belief that "Fundamental economic conditions and growth trends...are moving toward a better international balance." Thus the risk was regarded as worth taking.

IV. A Model of Central Bank Reactions

In order to formalize some of the ideas expressed in section II and to test them empirically utilizing the experience discussed in section III, the following simple model of central bank intervention policy has been formulated. It is assumed that intervention is a continuous process, unfolding simultaneously on a daily, even hourly, basis with the movements of the market variables that it is designed to influence. Given that only monthly data are available, the conceptual framework must relate current intervention to current values of targeted variables.

The theory of optimal control, with a multi-period criterion such as the expected present value of future welfare, provides an appropriate conceptual framework for the derivation of reaction functions. Relying on this framework,

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we can expect to find closed loop form reaction functions expressing the control variables of the analysis as functions of the current values of the state variables. The behavioral relationships of the economy, together with the settings of the control variables and future disturbances will guide the evolution of the state variables over time.

The instantaneous, or one-period, welfare function which enters into the multiperiod criterion is assumed to be a quadratic in the change in the logarithm of the exchange rate $\Delta e_t$, the deviation of end-of-period reserves from a target level $x_t-\hat{x}$, the deviation of the exchange rate from purchasing-power parity $p_t/e_t p^*_t$, the rate of inflation $\Delta p_t$, and the deviation of the unemployment rate from a target level $u_t-\hat{u}$.

\[ W = W(\Delta e_t, x_t-\hat{x}, p_t/e_t p^*_t, \Delta p_t, u_t-\hat{u}). \]

The welfare function includes price and exchange rate stability, as well as target levels of reserves, unemployment, and the exchange rate, based on purchasing-power parity.

The constraints facing the authorities are given by the balance of payments, which directly or indirectly involves all of the variables entering the welfare function, together with the equations determining the domestic structure of the economy. The current account balance in terms of foreign currency (2) is assumed to depend upon lagged values of relative price competitiveness as measured by the deviation from PPP and real income levels at home and abroad.

\[ c_t = c( (p/e p^*_t)_{t-1}, y_t, y^*_t) \]

Capital flows, on the other hand, are assumed to respond much faster to changes in exchange rates and interest rates than the current account. The desired and actual change in the stock of net foreign assets during period $t$ is assumed to depend on the change in the expected rate of return on foreign assets (neglect wealth effects, for simplicity) and a random disturbance term.
(3) \[ \Delta k_t = k(\Delta r^*_t + \Delta E_{t+1} e_{t+1} - \Delta e_t - \Delta r_t) + v_t, \]

where \( r_t \) and \( r^*_t \) are the domestic and foreign short-term interest rates and \( E_{t+1} e_{t+1} \) is the expected value of next period's exchange rate, given information available in period \( t \). Substituting equation (2) and (3) into (4),

(4) \[ c_t = \Delta k_t + \Delta x_t, \]

we have an equation relating the current change in the exchange rate to intervention policy, the current balance, exchange rate expectations, and interest rates.

The domestic side of the model can be sketched in roughly as follows. A Phillips' curve together with IS and LM curves and Okun's law suffice to determine the rate of inflation, domestic demand, the interest rate, and the unemployment rate as functions of the policy variables relating to exchange rate intervention, the domestic component of the monetary base, and fiscal policy, as well as foreign prices and income.

Maximization of the intertemporal welfare function subject to these constraints will yield policy reaction functions for monetary and fiscal policy as well as exchange rate intervention policy. In general, these policy reaction functions will depend on currently observed values of the state variables of the model. The exchange market intervention reaction function in particular will include the rate of inflation, the level of unemployment, the level of reserves, the current account balance, the deviation of the exchange rate from purchasing-power-parity, and the expected rate of change of the exchange rate, as in (5):

(5) \[ \Delta x_t = f(\Delta E_{t+1} e_{t+1}, p_t e_t p^*_t, c_t, \bar{x} - \bar{x}_{t-1}, \Delta p_t, u_t - \bar{u}). \]

The assumed signs are shown in (5) above the individual variables. The signs for inflation and unemployment follow from policy-makers' desire to avoid depreciation or appreciation as the first or second of these variables increases.
It is worth noting that the form of the intervention equation includes terms for both so-called "leaning against the wind" intervention (types (1) and (2) referred to in section II above) and "target" intervention (type (3)). It appears that "target" intervention would be most closely associated with attempts to maintain a competitive position in the current account, while "leaning against the wind" would be most closely associated with counteracting disturbances in the capital account and factors affecting expectations.

V. An Empirical Test of the Intervention Model

As a test of the intervention model proposed in section IV, ordinary least squares regressions in the form of equation (5) were run on monthly data for the Group of Ten countries from April 1973 to May 1979. Specific sources of the data and definitions of the variables are given in the Appendix. The dependent variable is measured as the monthly change in foreign exchange reserves, less changes in liabilities incurred as "exceptional balance of payments financing" and changes in liabilities to foreign monetary authorities, as reported in the balance of payments lines of International Financial Statistics. One or both of the latter two variables furnished an important source of funds for exchange market intervention at various times during this period for Belgium, Canada, France, Sweden, and the United Kingdom.

The rate of change of the expected future exchange rate was proxied by the change in the current end-of-month dollar exchange rate, which is equivalent to assuming that for forecasting purposes the exchange rate follows a random walk. Alternatively, for some countries the monthly rate of change of the IMF's MERM-weighted exchange rate was used instead of the dollar rate. In addition, for

\[ e_{t+1}^t = \hat{E}_t e_{t+1} + w_{t+1}, \]

where \( w_{t+1} \) is a random variable with mean zero and given variance, it follows that \( \hat{E}_t e_{t+1} = e_t \) implies \( e_{t+1} - e_t = w_{t+1} \).
countries which have been members of the European Community Snake, an index of the relative deviation above or below the mid-point of the Snake has been constructed, with weights varying with the distance from the mid-point.\textsuperscript{13}

The deviation of the exchange rate from purchasing-power-parity is measured by the IMF's quarterly indices of relative wholesale prices or relative normalized unit labor costs, adjusted for exchange rate changes, using a three-month centered moving average to smooth the quarterly data. In addition, the deviations of these indices from their means (as target values) were weighted by the squared distance from the mean to reflect increasing weight on larger deviations.\textsuperscript{14}

The current balance is proxied as the monthly trade balance, converted to U.S. dollars using the monthly average dollar exchange rate. Inflation is measured by the rate of change in consumer prices. The deviation of unemployment from its target value is proxied by the gap of industrial production below a trend line through its peak values.

Lagged values of the trade balance, reserves, the rate of inflation, and the gap were all utilized, as well as a lagged dependent variable in some cases. Where autocorrelated residuals appear, a Cochrane-Orcutt procedure has been adopted. Dummy variables were added to the EMS member countries to allow for the jump in their foreign exchange reserves due to allocation of ECU's in March 1979. In addition, dummy variables were added to the equations for Canada for the period since the Quebec Separatist election victory, for Italy and the

\textsuperscript{13}The specific form of the index is \( s = (e - \bar{e})/0.045(\bar{e} - |e - \bar{e}|) \), where \( e \) is the dollar exchange rate adjusted for intra-Snake parity changes and \( \bar{e} \) is the mid-point between the highest and lowest Snake currency.

\textsuperscript{14}These variables, referred to as \( tz \) where \( z \) is the appropriate index of relative costs or prices, are constructed as \( tz = 1000(z - \bar{z}) \).
United Kingdom for the period since their IMF standby agreements, and for the
United States since the November 1, 1978 change in intervention policy.

The results of these regressions are shown in Table 2. Viewed as
a test of the hypotheses of section IV, the results are supportive and interesting.
Nevertheless, they are still preliminary in several respects. Firstly, the Snake
variable needs to be redefined in terms of monthly average exchange rates rather
than end-of-month data. Secondly, several of the equations appear to be unstable
in terms of a Chow test which splits the sample into two parts. Thirdly, and
related to the second point, further work needs to be done to incorporate important
political and economic changes into the reaction functions. Some preliminary work
along this line has already been done, as reflected in the dummy variables for
Canada, Italy, and the United Kingdom.

The best equations, in terms of the largest number of correct, significant
signs (at the 5 percent level for a one-tailed test) are for Germany and Japan,
with six each. The Canadian equation has four signs correct, with the trade
balance showing up perversely. The remainder have between two and three significant
coefficients, while the trade balance has the wrong sign for Belgium, the
competitiveness index \( z = p/ep^* \) has the wrong sign for Italy and Sweden, and the
change in the exchange rate also has the wrong sign for Sweden.

Major interest centers on the importance of "leaning against the wind"
and "target" exchange rate variables, given in the first four columns of Table 2.
The largest dollar amount of leaning against the wind, relative to exchange rate
charges, has apparently been done by the United Kingdom, Germany, and Canada,
with Italy, France, and Japan coming in somewhat lower. The anomalous result
for Sweden may be due to that country's foreign borrowing and buildup of reserves
during 1975, when its currency was declining against the dollar. The two most
dedicated Snake members, Belgium and the Netherlands, did not intervene to
stabilize their exchange rates against non-Snake currencies, as France and Germany
apparently did. U. S. intervention during this period was only weakly related to movements in the dollar rate of the D mark, at least using the available monthly data.

The coefficient of intervention for Germany is exactly the same as estimated by Artus, while the Japanese coefficient is significantly less than estimated by Quirk.\textsuperscript{15} On the other hand, other variables appear to explain Japanese intervention. Other magnitudes, except for the Swedish, appear quite reasonable. For example, the ratio of the U.S. and German coefficients, roughly one to thirty, is not far from the rates of intervention reported by the two countries. The Snake intervention coefficients also look quite acceptable, with the high degree of openness easily explaining the strength of Benelux intervention.

Target intervention variables related to competitiveness are significant with the right sign for five of the ten countries, with the largest magnitude interestingly shown by Japan. Nor is the importance of competitiveness for Canada, Belgium, and the Netherlands surprising, given their highly competitive neighbors. What is remarkable is the apparent relationship of U.S. intervention to competitiveness considerations. A moment’s reflection suggests that the United States has generally only become concerned about the dollar when its value has “gone beyond what is implied by the fundamentals,” as the November 1 statement for example indicated. The anomalous result for Italy may be a result of conscious efforts to undervalue the lira, while the Swedish wrong sign seems closely related to the crown being dragged up by the Snake.

The trade balance is highly significant for Japan and also Germany, probably indicating that stabilizing capital flows have not been adequate to finance their surpluses during significant parts of this period. The same effect appears to a lesser extent for the United Kingdom, which had difficulty financing

deficits in 1973-76 and surpluses in 1977-78.

Domestic inflation appears as a quite significant influence on German, Japanese, and to some extent French and Belgian intervention. At least one aspect of the "virtuous" or "vicious circle" appears to be operative here, as divergent inflation rates induce capital flows. The gap, or ratio of industrial production to its trend level, appears to be significant for both Germany and Italy, suggesting that high unemployment increases reserve accumulation, either by making appreciation less desirable or more probable or both.

The lagged stock of reserves, which implies desire to maintain a target level of reserves, is surprisingly significant for the United States, Canada, Japan, and to a lesser extent the Netherlands. The lagged dependent variable is significant for Germany and Sweden.

The EMS dummy variables are all highly significant, as is the British exchange rate pegging of 1977. Otherwise, only the Quebec Separatists and the U.S. policy change of November 1, 1978 appear marginally significant as dummy variables.

VI. Conclusion

This paper has examined some of the major issues concerning exchange market intervention, recent experience of the Group of Ten countries plus Switzerland, and some tests of a model of central bank intervention behavior for the Group of Ten countries. Intervention has been shown to be significantly related to exchange rate changes or, where relevant, EC Snake targets for nine out of the ten countries. Exchange rate targets related to competitiveness have been shown to be significant in five of the countries. Reserve targets appeared to be of some importance in four of the countries. Domestic targets also appeared significant in five of the countries.
The stability of these results over time is still open to question, however, and further work needs to be done to improve their stability. Some of the equations, however, appear quite robust. Further work will concentrate on this issue and on relating intervention policy choices to the structure of the economies in question as well as their other macro-economic policy choices.
Table 2. Intervention Policy Reaction Functions, April 1973-May 1979^1/

<table>
<thead>
<tr>
<th>Country</th>
<th>( \Delta c^2 )/</th>
<th>s</th>
<th>( z^3 )/</th>
<th>( t^2 )/</th>
<th>( t^3 )/</th>
<th>( b )</th>
<th>( b_{-1} )</th>
<th>( \Delta p^4 )/</th>
<th>( y/y^4 )/</th>
<th>( x_{-1} )</th>
<th>( \Delta x_{-1} )</th>
<th>dums</th>
<th>dum</th>
<th>( R^2(\text{ae}) )</th>
<th>d(0)</th>
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<td>-481.5*</td>
<td>-0.07*</td>
<td>-0.23*</td>
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<td>1980*</td>
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<td>1.8</td>
<td>(11.1)</td>
<td>(183)</td>
<td>(.32)</td>
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<td>24.1*</td>
<td>-87.3*</td>
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<td>.27</td>
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<td>-178</td>
<td>.70</td>
<td>(1.6)</td>
<td>(218)</td>
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<tr>
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<td>-73.4</td>
<td>0.20</td>
<td>.06</td>
<td>-269.4*</td>
<td>-2.7</td>
<td>4700*</td>
<td>.81</td>
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<td>(324)</td>
<td>(.55)</td>
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<td>4.1</td>
<td>340.9</td>
<td>.61*</td>
<td>.02</td>
<td>-1037.7*</td>
<td>-5.4*</td>
<td>.26*</td>
<td>5760*</td>
<td>.66</td>
<td>(6.4)</td>
<td>(777)</td>
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<td>-.35</td>
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<td>.50*</td>
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<td>2.2</td>
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<td>.23</td>
<td>(1.6)</td>
<td>(154)</td>
<td></td>
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<tr>
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<td>(1.1)</td>
<td>15.6*</td>
<td>488.4*</td>
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<td>-.24*</td>
<td>149</td>
<td>.23</td>
<td>(1.6)</td>
<td>(154)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Constant terms omitted to save space. * indicates significance at the 5 percent level on a one-tailed test.

2. MEER-weighted price of foreign exchange; except for Belgium, Canada, Germany, Japan: price of U.S. dollar; and U.S.: price of D mark.

3. Relative wholesale prices, corrected for exchange rates; except for Canada and Italy: relative normalized unit labor costs.
Data Appendix

$Ax$ Change in end-of-month foreign exchange reserves, in millions of U.S. dollars, less monthly average of quarterly balance of payments data on liabilities incurred for "exceptional balance of payments financing" and "liabilities constituting the reserves of foreign monetary authorities."

$Ae$ 100 times the change in the logarithm of the inverse of the MERM-weighted effective exchange rate index (France, Italy, Netherlands, Sweden, U.K.) or 100 times the change in the logarithm of the end-of-month price of the dollar (Belgium, Canada, Germany, Japan) or the dollar price of D-mark (U.S.).

$s = (e-\bar{e})/(.045\bar{e} - |e - \bar{e}|)$, where $e$ is the end-of-the-month dollar exchange rate corrected for intra-Snake parity changes and $\bar{e}$ is the mid-point between the highest and lowest Snake currencies.

$z$ three-month centered moving average of quarterly observations (recorded monthly) on relative wholesale prices, calculated by converting domestic prices into dollars and comparing with a weighted average of other industrial country prices converted to dollars; except for Canada and Italy where relative normalized unit labor costs, calculated similarly, were used.

$tz$ 1000 times $(z-\bar{z})^3$

$tb$ trade balance in millions of U.S. dollars.

$Ap$ 100 times the change in the logarithm of the consumer price index

$y/y$ 100 times the logarithm of the ratio of industrial production to the trend line passing through its peaks.

$de_{ms}$ 1 in March 1979, 0 otherwise
Canada: 1 after November 1978 for Quebec Separatist election victory, 0 otherwise.

Italy: 1 after IMF standby agreement in April 1977, 0 otherwise.

U.K.: 1 for peg from March 1977 to October 1977, 0 otherwise.

U.S.: 1 after November 1, 1978, 0 otherwise.

SOURCE: International Financial Statistics