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Summary

This study considers the influence of central banks on exchange rates within the realm of discretion assigned to central banks by national governments. Following a review of various central bank measures to influence exchange rates the study concentrates on central bank intervention in exchange markets. We analyze central bank motives for intervention, develop a general model for intervention behavior, and estimate this model for the central banks of Germany and France using ordinary least squares and quarterly data for the years 1975-1983. One result of interest is the tendency of intervention by these central banks to support the movement of the DM/$ and FF/$ exchange rate in the direction of a theoretically hypothesized market equilibrium after allowance for reactions to speculative market behavior and commitment to parities under rules of the European Monetary System.

CENTRAL BANK EXCHANGE RATE POLICY*

Introduction

Interest in central bank exchange rate policy has been stimulated by two questions which have arisen in the context of experience with managed or floating exchange rates since the end of the international fixed parity system in the spring of 1973. The first and broader question is what determines exchange rates when they are managed or floating, including the role of central banks and monetary policy in such determination. The second, narrower question is to what extent discretionary exchange rate policy gives national monetary authorities a policy instrument additional to the instruments employed in implementing control over domestic interest rates or money stocks. This second issue involves the distinction between sterilized and non-sterilized exchange market intervention and the effectiveness of each in influencing exchange rates. Central banks and finance ministries recently have completed a cooperative investigation of this second issue and have published their findings in a "Report of the Working Group on Exchange Market Intervention" (March 1983).[1]

Each of these two themes in the literature involves the behavior of central banks in implementing national exchange rate policy. The present study takes central bank exchange rate policy as its focus. In section one we consider the scope for central bank discretion

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assigned to it within the broader national framework concerning exchange rate policy. Section two surveys a variety of central bank measures to influence exchange rates, comments on their respective roles, and gives our reasons for selecting direct, active intervention in the foreign exchange market as the focus for our empirical work in this paper. Section three presents a general perspective on the role of intervention as a central bank policy instrument. In section four we develop a general model for central bank intervention behavior. Section five discusses problems encountered in the measurement of direct intervention due to the reticence of central banks in making intervention data public. The lack of published data necessitates an indirect approach involving numerous adjustments so as to estimate intervention from other published statistics. In section six we present and discuss econometric estimates of policy reaction functions for intervention behavior for the central banks of the Federal Republic of Germany and France. Section seven contains our conclusions and final comments.

1. Scope for Central Bank Discretion

Central banks are the national institutions normally assigned responsibility for implementing national policy with respect to the foreign exchange value of the national currency. Typically, however, central banks exercise discretion over foreign exchange rate policy only within limits established by official government policy. Central banks do not negotiate a nation's participation in international monetary agreements such as membership in the International Monetary Fund or participation in the European Monetary System. Yet each of these

cooperative international organizations places restrictions in principle on national exchange rate policy. Under the IMF Articles of Agreement nations and thus their banks agree "To promote exchange stability, to maintain orderly exchange arrangements among members, and to avoid competitive exchange depreciation." They agree also to refrain from imposing restrictions on the making of payments and transfers for current international transactions without the permission of the Fund.[2] Thus, under normal conditions, exchange controls are not to be applied to current account transactions.

More stringent limits on central bank discretion over exchange rate policy are imposed by national participation in the European Monetary System (EMS). The parity grid of bilateral exchange rates organized by the participants in the EMS makes intervention mandatory and automatic when defined limits to departures from parity are reached. A second indicator calling for intervention or other corrective action is defined in terms of the divergence between the current ECU market value of a national currency and its ECU parity within the system. When the divergence thus measured reaches a specified limit the national authorities have a presumptive obligation to intervene or take other appropriate measures to counter the divergence. In practice persistent divergence often has resulted in negotiated realignment of parities within the EMS. Central banks may provide technical advice in such negotiations, but decisions are reached by finance ministers or other representatives of national government. Such decisions may be strongly affected by political as well as economic considerations.

For countries operating a managed exchange rate regime outside the EMS the decision to aim at a target exchange rate defined relative to a key reference currency or some weighted average of currencies typically is not made at the sole discretion of the central bank but is made by or in consultation with the upper reaches of government. Under the Reagan administration in the United States, for example, the Federal Reserve System has been required for substantial periods to refrain completely from active intervention in the foreign exchange market.

Thus, the behavior of central banks in implementing exchange rate policy must fit within the range of choice assigned to them by the broader framework of exchange rate policy determined by national governments. This fact has implications for the kinds of questions about exchange rate policy that are in principle answerable by an investigation of central bank activity intended to influence exchange rates. In particular observable central bank actions to influence an exchange rate are unlikely to afford much insight into the timing of a decision to realign a parity, to alter significantly a target rate or range or to borrow massively to assist in defending an exchange rate undergoing heavy market pressure to devalue. Such decisions involve major aspects of national economic and even political policy and are usually taken by the national political authority, albeit with technical advice from the national monetary authorities.

Despite these general limitations central banks do exert substantial influence on exchange rates by a variety of measures and techniques which vary somewhat in different national settings. In the

next section we provide a survey of the kinds of measures central banks have been known to employ to influence exchange rates. This overview is general rather than country-specific.

2. Measures to Influence Exchange Rates

Central banks have an impressive array of measures by which to influence exchange rates. Direct intervention in the foreign exchange market by the purchase or sale of foreign exchange against the domestic currency is the most immediate and flexible of these measures. It may be regarded as the measure of first resort having a prompt effect and thus being especially useful for fine tuning the central bank's influence on the exchange rate. Such direct intervention may be sterilized or non-sterilized. Intervention is considered to be sterilized when it is accomplished in a way that leaves the domestic and foreign countries' monetary bases unchanged while changing the relative supplies available to the private sector of securities denominated in domestic and foreign currencies. Non-sterilized direct intervention changes the monetary liabilities of one or both of the domestic and foreign central banks (i.e., the domestic and/or foreign monetary base). The recent cooperative set of theoretical and empirical studies carried out by central banks and finance ministries of seven countries together with staff members of the European Economic Communities and the Bank for International Settlements concludes that non-sterilized intervention has more powerful effects on exchange rates than does sterilized intervention.[3] In this paper our empirical work concerns direct intervention in the form of purchase or sale of foreign exchange by the central bank. Data available to us do not

permit us to distinguish empirically between sterilized and non-sterilized intervention.

A second set of measures available to central banks at their own discretion is the array of domestic instruments of monetary policy including the central bank lending rate, its control over minimum reserve requirements for bank deposits, open market operations in securities or repurchase agreements, credit ceilings on commercial banks and other measures to influence domestic money supply growth and interest rates. The particular kit bag of such instruments varies from country to country. The effect of changes in these instruments on exchange rates operates in part through their ability to alter money supply and interest rates by changing market conditions, partly through their somewhat slower effect on aggregate demand and on the current account balance via changes in relative prices over time, and partly through expectations about future price levels, interest rates and exchange rates as these may alter current potential or actual capital flows. Sterilized intervention usually, although not always, involves the use of some instruments from this set to offset or neutralize the change in monetary base caused by purchase or sale of foreign exchange during direct intervention.

Tax and fiscal policies, although outside the purview of the central bank, are further examples of domestic policy measures that may exert an influence on exchange rates. Examples are the influence of the current and anticipated U.S. federal government budget deficit on current and expected interest rates and exchange rates, the U.S.

Interest Equalization Tax on interest receipts from loans to non-residents in the 1960s, the repeal in 1984 of the U.S. withholding tax on interest and dividends earned by non-residents, and negative interest rates on non-resident bank deposits imposed in Switzerland to deter unwanted capital inflows on certain past occasions.

A third set of measures to influence exchange rates may be broadly characterized as forms of exchange control on capital movements. These arrangements tend to be country-specific. Some, at least, may be fully at the discretion of the central bank authorities while others may require participation of finance ministries or other organs of national government in their application. Control of the net foreign position of commercial banks as practiced in Italy and France is one such measure. Also, in cooperation with government authorities central banks of France, Italy and the United Kingdom have on occasion induced or directed local governments, public corporations and other quasi-public institutions to borrow abroad thus increasing capital inflows in foreign exchange. At times German authorities have imposed special reserve requirements on bank deposits of non-residents and have made certain interest-bearing marketable securities ineligible for purchase by non-residents to reduce speculative capital inflows that were putting upward pressure on the DM. On occasion Italian authorities have required Italian firms to make non-interest-bearing deposits at the central bank in advance of foreign payments. This measure reduces leads in current account payments and also reduces the domestic monetary base; both effects provide support to the foreign exchange value of the lira.

The use of domestic policy instruments and of varieties of exchange controls on capital movements occurs in varying combinations and timing with direct intervention in the form of purchase and sale of foreign exchange. A full discussion and empirical examination of central bank exchange rate policy should integrate this panoply of measures both theoretically and empirically. The direction of effect on exchange rates for each of these instruments taken singly is theoretically clear but analysis of policy choices governing the combinations and timing of their use in concert is an extremely complex task which exceeds both our ambition and ability. Not least of the problems is our inability to quantify satisfactorily the influence of some of these measures. Domestic and international political considerations also may exert an influence on the strategy packages adopted. Accordingly, we pursue the more modest goal of attempting to explain and interpret central bank direct intervention in foreign exchange markets. We omit entirely from our discussion such matters as exchange controls on current account transactions, resort to dual or multiple exchange rate systems and systems of explicit crawling pegs as topics outside the scope of our present inquiry.

3. The Role of Intervention as a Central Bank Policy Instrument: A General Perspective

In this section we set forth a general view of the role of central bank intervention in the foreign exchange market as a basis for a formal regression model to be estimated later in this paper. By "intervention," to repeat, we mean the active purchase or sale of foreign exchange against the domestic currency in the foreign exchange market.

We lack the detailed and privileged information to distinguish empirically between non-sterilized and sterilized intervention and thus will not be concerned to evaluate empirically their relative effectiveness.[4] We have referred earlier to a variety of "other measures" used by central banks to influence exchange rates including their control over the standard instruments of monetary policy and various types of exchange controls or measures to influence capital flows. In addition, we are aware of the existence of types of off-market exchange transactions, so-called "customer transactions," that may occur between a central bank and its own government or agencies of a foreign government and may be regarded as sterilized intervention for the effect they have on an exchange rate. For example, interest earnings in foreign exchange on foreign securities held by a central bank, if retained in foreign exchange by investment in securities denominated in the same foreign currency and purchased in the securities market, will change the relative supplies of domestic and foreign securities available to the private sector. Under portfolio theory and assuming the domestic and foreign securities to be regarded by private investors as not perfect substitutes this action will have interest rate and exchange rate effects equivalent to sterilized intervention.[5] Lack of information prevents us from dealing explicitly with such intervention.

An examination of the motives for active intervention will help us to formulate a central bank's policy reaction function to be estimated empirically. Central banks intervene to achieve an exchange rate different from that which market forces would produce in the absence of

intervention. One obvious motive for intervention is to fulfill an international commitment to maintain a fixed or relatively fixed exchange rate. An example is the obligation to observe the commitment under the EMS to preserve the parity grid. Until the parity implied by the ECU central rate is altered by negotiation, intervention to preserve the parity grid is obligatory and automatic:

> ...[E]ach participating central bank has published buying and selling rates for each other participating currency. During normal business hours the willingness of the central bank to deal at these rates will ensure that market rates do not go beyond the limits, for no commercial bank is going to deal at a rate outside the limits with another bank when it could obtain a better rate from the central bank. The central bank has only to respond to requests to deal initiated by the commercial banks; it need take no initiative itself.
>
> ...When parity grid limit rates are activated, there is no question as to which partner currency will be used for intervention: that is decided by the commercial banks on the basis of which market cross-rates have reached their limits.[6]

The limit implied by the divergence indicator in the EMS leaves more discretion to the central bank and national government as to mode of response when the limit to divergence is approached. Corrective action may involve "other measures" such as domestic monetary policy as well as intervention, but some amount of intervention is likely.

In less structured circumstances more discretionary motives may guide intervention. One is to smooth and steady the market so the market does not generate self-fulfilling short run speculative variability. There is little doubt that intervention for this purpose does occur. A related motive is to resist exchange rate movements

that are expected by the central bank to be transitory and self-reversing. The assumption is that private speculators will not do the job for lack of adequate information or resources and that short run exchange rate variability due to shocks or temporary circumstances such as political disturbances or seasonal factors can have undesirable consequences for firms involved in international trade. The rationale for such intervention is stronger the longer the expected duration of the temporary disturbance, since the adjustments imposed on the real sector's resource allocation increase with the persistence of the disturbance.

Another motive for central bank intervention is to hold an exchange rate steady while gaining time for more fundamental, slower-acting measures to be adopted and have their effect. The strongest theoretical case for such intervention occurs when the central bank and government are preparing new measures such as monetary policy or fiscal policy to influence economic fundamentals with implications for the exchange rate but have not yet announced these measures publicly, possibly because their details have not yet been fully agreed upon.[7]

It is a characteristic of intervention undertaken for the motives described above that it seeks to resist the movement of the exchange rate in the direction determined by market forces. This implies that intervention measured by an increase or decrease in central bank foreign exchange reserves should be inversely related to observed appreciation or depreciation of the exchange rate unless such intervention is perfectly gauged to keep the exchange rate from moving at

all. In that unlikely event no association between intervention and exchange rate movement would be observed.

Other motives for exchange market intervention have been stated by central banks or suggested by students of central bank behavior. Central bankers sometimes speak of intervening to purchase foreign exchange so as to rebuild foreign exchange reserves following a heavy drain on their holdings during a period of sustained downward pressure on the exchange value of the domestic currency or to reduce foreign exchange holdings to more normal levels following a speculative inflow. These occasions usually are associated with events preceding and following a formal change in official parity as in an EMS realignment or a change in an unstated target zone for the exchange rate which the central bank has been defending. Intervention may sometimes occur with the primary purpose of adjusting the domestic monetary base or money supply as a substitute for the use of domestic instruments of monetary policy. This is unsterilized intervention undertaken primarily to influence domestic monetary conditions with effects on the exchange rate ignored or secondary. As an alternative to central bank operations in a domestic securities market this use of intervention is unlikely for countries with well-developed domestic securities markets and established central bank techniques for operating in these markets. Thus, intervention for this purpose is unlikely in the four countries under study. Nevertheless, should it occur, such intervention should have the appearance of resisting the market movement of the exchange rate.

Yet another purpose for central bank direct intervention in the foreign exchange market is to achieve a defined target rate. Such a target rate may represent the central bank's view of an equilibrium exchange rate consistent with fundamental economic forces as yet imperfectly reflected in the actual market rate or may represent a change in policy. The concept of an equilibrium exchange rate evoked here is that of modern asset theory with rational expectations. The intervention may signal the authorities' intention to do what is necessary, including altering basic monetary policy, to achieve market acceptance of the target rate. If the market regards the signal as credible and thus alters its expectations appropriately, intervention on a relatively modest scale may bring the market to accept the target rate as its equilibrium exchange rate. By contrast a central bank may sometimes intervene in an effort to establish or sustain a market rate which is overvalued or undervalued relative to the market's view of its equilibrium rate. For example the authorities may seek an undervalued exchange rate for the purpose of protecting export and import-competing industries from foreign competition, stimulating aggregate demand for domestic output and contributing to a surplus or reduced deficit in the balance of payments. Or they make seek an overvalued exchange rate so as to cheapen imports and thus exert a downward or restraining pressure on domestic price inflation. Under modern conditions of high capital mobility (absent capital controls) even very large scale intervention is unlikely to succeed for very long in maintaining an overvalued or undervalued exchange rate. The trading flows unleashed in the exchange market in response to asset stock disequilibria

sensed by private sector portfolio managers can become too massive to be resisted by central bank intervention when intervention policy lacks credible support from monetary and fiscal policy, productivity trends and other basic economic forces.

Attempts to create or maintain an overvalued or undervalued exchange rate will appear as intervention to resist the market movement of the exchange rate as the market seeks to establish an equilibrium rate consistent with its expectations about economic fundamentals. However, both practices violate rules of good behavior stipulated by the IMF and EMS. They also are unlikely to succeed in the absence of stringent and effective capital controls. Thus, intervention to resist the market movement of the exchange rate normally should not represent a persistent effort to preserve a disequilibrium rate.

Thus far this discussion of central bank purposes that guide intervention suggests that the prevailing observable pattern characterizing intervention should be one of resisting the direction of movement of the market exchange rate. "Leaning against the wind" will be characteristic of intervention undertaken to fulfill international commitments to fixed exchange rates, to smooth and steady the market, to resist exchange rate movements expected by the authorities to be transitory and self-reversing, to gain time for other measures to become effective, and to support an overvalued or undervalued exchange rate. We contend, however, that the pattern of "leaning against the wind" is primarily a short-run pattern most likely to be observed in studies based on daily, weekly or even monthly data. As the period of

observation lengthens the influence on the exchange rate of more persistent and systematic economic forces becomes more evident relative to that of short-run random and transitory influences. So far as official intervention supports a target exchange rate consistent with a market rate whose trend is unidirectional based on expectations about economic fundamentals, the observed pattern of intervention may be one of "leaning with the wind." This is the pattern we find in our regression estimates based on quarterly data. We comment further on this issue in section 6 in presenting our regression results.

We conclude this discussion of the role of intervention as a central bank policy instrument by quoting a statement of the Deutsche Bundesbank which expresses both the aims and the limitations of official intervention in exchange markets:

> In its intervention policy the Bundesbank's guiding principle is that interventions should be made only for the purpose of maintaining "orderly market conditions," and that fundamental trends in the market should not (and cannot) be counteracted. However, interventions have not only served to maintain orderly market conditions and avoid hectic exchange rate fluctuations from day to day, rather, the attempt has been made to moderate excessive fluctuations in the Deutsche Mark rate vis-a-vis the U.S. dollar over extended periods of time. This has been done not least also in the interest, and with the full consent of the other members of the European currency bloc.[8]

4. A General Model for Intervention Behavior

In this discussion we have set forth motives for central bank intervention and concluded that in most cases intervention will be undertaken to resist rather than to reinforce the market movement of the exchange rate. However, intervention should not resist and may

even reinforce a change in market rate judged to be consistent with a change in economic fundamentals. We have also noted that intervention is either obligatory or part of a broader discretionary response when intervention points defined under rules of the EMS are reached or approached. These considerations suggest that a general model for intervention by central banks whose countries participate in the EMS should include as explanatory variables the percentage rate of change in the observed market exchange rate and appropriately designed indicators of limits defined under EMS rules for the parity grid and the divergence indicator. Thus,

$$(1) \qquad V_t = a_0 + a_1 DER_t + a_2 EMSBi_t + a_3 ECU_t$$

is an initial version of an intervention model, where

V = a measure of exchange market intervention

DER = percentage change in the exchange rate = Log [ER(t)/ER(t-1)] and ER = domestic per foreign currency

EMSBi = EMS bilateral parity grid indicator

ECU = EMS divergence indicator

Theories of exchange rate determination contained in the literature are a source for other variables that might enter a general model for intervention behavior. There is a rich and expanding literature in this area. For convenience we refer to the particular model formulated by Peter Hooper and John Morton "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination."[9] This model, building on work of Rudiger Dornbusch and Jeffrey Frankel, expresses the current nominal spot exchange rate as a function of the expected change in the long run equilibrium exchange rate (decomposed

into long run equilibrium price levels and real terms of trade components) and terms deriving from the uncovered interest parity condition including expected long run equilibrium rates of inflation and domestic and foreign interest rates for the relevant period over which a change in the spot rate is considered. One version of this model expressed in logarithmic form is as follows:

$$(2) \qquad e = \bar{p} - \bar{p}^* + q - \frac{1}{\theta}[(r-\bar{\pi}) - (r^*-\bar{\pi}^*)]$$

where e = ln of the spot exchange rate (domestic/foreign)

$\bar{p}$ = ln of the long run equilibrium price level

q = ln of the real exchange rate ($= e - p + p^*$)

θ = a speed of adjustment parameter

r = interest rate (3-month rate at quarterly rate)

$\bar{\pi}$ = inflation rate (at quarterly rate)

$*$ = denotes foreign variable

$-$ = denotes long run equilibrium rate

We note that Hooper and Morton expand this model into its more detailed elements including monetarist versions of determinants of equilibrium prices and the influence of current account trends on the anticipated equilibrium real exchange rate as well as incorporating a measure of risk premium before subjecting the model to econometric tests. Our intentions are less ambitious.

We seek guidance from theory as to some manageable variables that may be added to our model of intervention behavior. We have noted various motives for active intervention to resist an exchange rate change in the direction market forces are moving it. However, such

resistance need not occur when the market movement is consistent with a recent change in underlying economic forces such as monetary conditions reflected in interest rates and inflation rates.

Our procedure is to difference (2) to obtain:

$$(3) \qquad de = d\bar{p} - d\bar{p}^* + dq - \frac{1}{\theta} d[(r-\bar{\pi})-(r^*-\bar{\pi}^*)].$$

From (3) we discard $d\bar{p}$, $d\bar{p}^*$ and dq for our purposes offering two reasons. First, we doubt the feasibility of calculating anticipated changes in long run equilibrium prices and in real terms of trade. Second, we are primarily interested in factors that dominate quarterly changes in the exchange rate; we think changes in anticipated short run real interest rates expressed in $d[(r-\bar{\pi}) - (r^*-\bar{\pi}^*)]$ have a stronger claim to this role than do the discarded variables.

With this addition our model becomes:

$$(4) \qquad V_t = a_0 + a_1 DER_t + a_2 \text{ RelDifRealR} + a_3 ECU + a_4 \text{ EMSBi}_t,$$

where the term including a_2 represents the last term of equation (3).

We note that de ≡ DER so that this percentage rate of change in the exchange rate is a function of the change in the real interest rate differential also included on the right hand side of (4). This suggests some redundancy in the two variables which may pose some problem in interpretation of the econometric estimates. Nevertheless, there are some reasons for testing the model containing both variables. First, we expect intervention to react to market changes in the exchange rate and we believe there are forces influencing

market behavior, other than changes in the real interest rate differential, that are reflected in DER. The relatively poor forecasting record of models designed to explain the market exchange rate lends credence to the view that the market rate contains information not included in the explanatory variables of the models. Thus DER may reflect influences otherwise missing from our model of intervention behavior such as political events and other forms of "news" or, perhaps, a change in expectations about the equilibrium real exchange rate. Second, the observed value of DER is influenced by the intervention which takes place during the time interval of observation. Thus, there is a problem of multiple causation between intervention and the percentage rate of change in the exchange rate used as an explanatory variable for intervention. However, suppose in a particular calendar quarter intervention exactly offsets the market impetus to change the exchange rate arising from a change in the real interest rate differential and that the changing differential is the sole influence acting to change the exchange rate. Then DER = 0 and if we omit the change in the real interest rate differential from the model, we have no explanation for observed intervention behavior. With the inclusion of the change in the real interest rate differential we continue to explain intervention behavior under these circumstances. Thus, the two explanatory variables supplement each other in the regression model. In presenting our empirical results below we discuss further the issue of inverse or joint causation and present the results of statistical tests which support the causal direction expressed in our regression model.

We have mentioned in our foregoing discussion various "other measures" used by central banks to influence exchange rates. Principal among these are changes in basic monetary policy and various non-market measures to control capital flows. We make no attempt to deal specifically with such measures in this paper. However, they should be reflected at least partially in the observed percentage change in the exchange rate and in changes in interest rate and inflation rate differentials.

Decisions to agree to a negotiated realignment of exchange rates within the EMS or to alter a target rate under a managed exchange rate regime involve broader economic and political issues and processes than lie within the discretion of central banks or are encompassed by our model of intervention as developed thus far. Yet anticipated and realized changes in such policy-chosen parities have consequences for intervention behavior that should be reflected in an intervention model even though the choices are not explained by the model. A change in official parity or central rate within the EMS typically is anticipated by the market from an appraisal of economic fundamentals. Such market anticipation may cause speculative capital flows prior to the change in central rate and reverse flows after the change. In resisting the pressure of these speculative flows on the exchange rate a central bank will intervene in the market. This aspect of intervention is allowed for in this model by carefully considering the timing of changes and the definition of variables for those changes. In particular we include three different variables to represent EMSBi, the bilateral parity grid indicator. EMSBi0 relates the current market

exchange rate and the central bilateral rate defined as of the last day of the quarter. This variable should influence intervention behavior in line with the general theory outlined above. Second, we include EMSBil where the central bilateral rate is that in effect one month before the end of the quarter. This variable is intended to detect the reverse flows of speculation, and therefore also observed intervention, when there has been a change in the central bilateral rate during the last month of the quarter. Last, we include EMSBilCube which identifies nonlinearities in the reaction due to large changes in the central bilateral rate.

There were also econometric problems, explained in section 5 below, for the first quarter of 1979. Hence we include a dummy variable, IQ79 for this quarter.

The resulting final form for our general model for intervention is as follows:

$$(5) \qquad V_t = a_0 + a_1\, DER_t + a_2\, RelDifRealR_t + a_3\, ECU_t + a_4\, EMSBi0_t + a_5\, EMSBil_t + a_6\, EMSBilCube_t + a_7\, IQ79 + u_t$$

where u is a random error term.

Expected signs of the coefficients are uncertain for a_0, a_1, a_6, and a_7; minus for a_2, a_3, a_4; and plus for a_5.

5. Measurement of Direct Intervention

To accomplish a quantitative study of central bank intervention policy it is necessary to have a statistical time series for central bank intervention in the foreign exchange market. Data on central bank direct or active intervention in the foreign exchange market are not made public by central banks. An alternative is to infer the

amount of a central bank's net intervention by using changes in the value in dollars of its foreign exchange reserves from one observation date to the next. The IMF's publication, International Financial Statistics is a standard source for the dollar value of national foreign exchange reserves on a quarter-year basis.

Unfortunately for the purpose at hand simple differences between quarterly levels of the dollar value of national foreign exchange reserves do not provide a reliable measure of central bank net intervention in foreign exchange markets. This is because changes may occur in the dollar value of a nation's foreign exchange reserves for reasons other than the purchase or sale of foreign exchange by the nation's central bank or other institution charged with responsibility for foreign exchange dealing. Among the principal sources of such changes other than intervention are interest receipts on official foreign exchange assets, borrowing of foreign currencies by central banks and governments to fortify exchange reserves during periods of pressure on the exchange rate and repayments during periods of ease, and changes in the dollar value of gold and of exchange reserves held in non-dollar currencies. We adjust the IFS series for foreign exchange for each of these undesired influences so far as published data permit to obtain our measure of net purchase or sale of foreign exchange.

Our first adjustment is to remove from the IFS series on foreign exchange the dollar value of certain gold holdings that EMS member nations have pledged to the European Monetary Cooperation Fund (EMCF) as a condition of membership in the European Monetary System (EMS).

This adjustment involves both a quantity and a price adjustment. The gold inclusion and valuation problems date from March 1979 when the EMS began its operation. Since that date (with a minor timing exception for the United Kingdom) central banks of EMS member states have been required to deposit (actually to earmark while retaining physical possession) 20 percent of their individual gold and dollar foreign exchange reserves with the EMCF in exchange for European Currency Units (ECUs). These dollars and the dollar value of gold so deposited as ECU counterparts are included in the IMF's measure of the dollar value of foreign exchange (otherwise excluding gold) for EMS member countries. Thus, this special treatment of gold involved in the EMS introduces a jump in the IMF's dollar valued exchange reserves series for EMS members beginning in 1979.1. Moreover, arrangements between the EMCF and central banks of member states are such that the gold temporarily transferred to the EMCF is revalued at a market related dollar price at the beginning of each calendar quarter.[10] The dollar value of pledged gold should be removed from the foreign exchange series for two reasons. First, valuation changes in pledged gold do not represent purchase and sale of foreign exchange during intervention and should be excluded. Second, we wish to make a separate adjustment for interest receipts on foreign exchange assets and gold should not be viewed as foreign exchange for this purpose.

Precise information on the magnitude of changes in pledged gold and its valuation is available only at the EEC and is not made public. Accordingly, we make an adjustment for this effect for each quarter

beginning in 1979.1 by deducting the current dollar value of 20 percent of each nation's gold stock in troy ounces as of 1978.4 valued each subsequent quarter at the London gold price in dollars per ounce [series c for the United Kingdom in the IFS]. This adjustment removes gold and changes in its valuation from the IFS series for foreign exchange.

A rough adjustment for interest receipts on foreign exchange assets can be made by applying the U.S. Treasury bill average rate for the calendar quarter in question to the level of foreign exchange assets. We are unable to estimate separately interest receipts on assets denominated in non-dollar currencies so we ignore the distinction and treat all foreign exchange assets as earning the same interest rate as do dollar denominated assets. These estimated earnings in dollars are then subtracted from the next quarter's dollar value of foreign exchange holdings to net out interest receipts.

Part of the foreign exchange reserves of countries in our study is held in non-dollar denominated assets. The dollar value of such reserves changes when the exchange rate between the relevant non-dollar currency and the dollar changes. Such changes do not represent purchase or sale of foreign exchange and should be excluded from the foreign exchange series for our purpose. We accomplish this correction by deducting from our foreign exchange series the IFS series entitled "Counterpart to Valuation Change" [78d.d] which has been prepared by the IMF to reflect such changes.

A further adjustment is desirable to remove from the foreign exchange series official borrowings and repayments of foreign exchange

which do not pass through the foreign exchange market and thus do not represent direct intervention in that market. The more sizeable official borrowings (and repayments) take the form of inter-central bank swaps and claims arising from foreign central bank intervention to support the domestic country's exchange rate. We measure active, direct intervention in the foreign exchange market by first differences in the adjusted series for the level of foreign exchange reserves. Any net borrowing of foreign exchange during a quarter will overstate intervention in the form of a purchase of foreign exchange while any net repayment will overstate the sale of foreign exchange. Thus we wish to subtract official borrowing and add official repayment.

To adjust our first difference on foreign exchange for official borrowing and repayment we use three series provided in the IFS. The first is entitled "Reserve Position in the Fund" [1c.d.]. We add the quarterly first difference in this series to our basic series for intervention. If the first difference in "Reserve Position in the Fund" has a negative sign this signifies borrowing and vice versa. Thus addition of the first difference keeping the appropriate sign corrects for official borrowing or repayment involving a country's reserve position in the Fund. A similar adjustment is needed for first differences in the series entitled "Use of Fund Credit" [2e.s] but with sign reversal since an increase in level and thus a positive first difference signifies borrowing.

A final adjustment for official borrowing is made by subtracting from our series representing intervention the IFS series entitled "Liabilities Constituting Foreign Authorities Reserves" [79x.d]. No

first difference is needed for this series which is a flow series taken from balance of payments statistics. This item represents changes in claims of foreign banks on the domestic central bank. It includes normal operating balances of foreign central banks at the domestic central bank. This may be important for "reserve center" banks such as the Bank of England and the Deutsche Bundesbank. These normal operating balances should be omitted from our adjustment but our data do not permit this. More importantly for our purpose this item includes "swap" borrowings by the domestic central bank and foreign central bank claims arising from foreign central bank intervention to support the domestic central bank's exchange rate. Both are forms of borrowing (or repayment) of foreign exchange reserves which must be netted out of our series for changes in foreign exchange in order for the latter to represent more accurately intervention in the form of active purchase and sale of foreign exchange in the market.

Our measure of active direct intervention in the foreign exchange market is first differences in the IFS series entitled "foreign exchange" [1d.d] modified by the adjustments just discussed. We are aware of other forms of official borrowing and repayment that may distort our desired measure of intervention but for which we lack published data to make desirable adjustments. We discuss three such cases for the information of the reader. First, borrowing by central banks and governments in the eurodollar market may add to official foreign exchange reserves in dollars without passing through the foreign exchange market if the authorities retain loan proceeds in

dollar denominated assets. In principle differences in foreign exchange reserves on successive dates should be adjusted to exclude such borrowings and repayments before changes in foreign exchange reserves can be taken to represent net intervention in the foreign exchange market. We are not able to make this adjustment.

Another important category of borrowing to increase national foreign exchange reserves has been referred to as "induced or directed borrowing" undertaken at the direction of government or national monetary authorities by local governments, public utilities and other public or quasi-public firms and institutions. When proceeds from such borrowing are converted into domestic currency by the borrower, the conversion occurs via the foreign exchange market and thus increases official exchange reserves only if the central bank intervenes. Thus, in this circumstance, there is no need to net out such borrowing from changes in foreign exchange reserves in calculating the amount of central bank intervention. However, if the foreign exchange proceeds of such borrowing are retained in foreign currency denominated assets and placed on deposit with the central bank without conversion to domestic currency, they will increase official foreign exchange reserves without the occurrence of direct intervention by the central bank. In such cases these loans and repayments should be netted out from changes in official foreign exchange reserves when such changes are used to estimate net intervention by the central bank. One identifiable instance of this kind is the use of "compensatory loans" by the Italian monetary authorities. Other instances of this practice may occur in other countries without being identified in

published statistics. In principle directed borrowing of this second kind should be netted out from the statistics on official foreign exchange reserves in estimating central bank intervention in the foreign exchange market. In this paper we have not attempted such an adjustment.

Central banks sometimes borrow foreign exchange from domestic commercial banks by means of "swaps" in which the commercial banks transfer foreign exchange assets to the central bank in return for a deposit claim on the liability side of the central bank's balance sheet. Once again, such transactions should be netted out from the foreign exchange series for the purpose of estimating direct intervention by the central bank. Since such swaps are undertaken to "window dress" the central bank's balance sheet, their accounting entry both in the central bank's balance sheet and that of commercial banks usually is buried in some undecipherable category. Moreover, dates of published balance sheets of the central bank and commercial banks may be deliberately chosen not to coincide so as to prevent direct comparisons of counterpart entries. For these reasons it is not possible to adjust published foreign exchange series to net out the effect of such swaps with commercial banks.

Quarterly first differences in the IFS statistical series entitled "Foreign Exchange" [1d.d] adjusted as has been described serve as our measure of net direct active intervention in the foreign exchange market by the central banks included in this study. In the statistical appendix we present a precise symbolic definition of the intervention measure together with general descriptions and sources for all data used in this study.

6. Central Bank Exchange Market Intervention Behavior: Econometric Results for Germany and France

Table I presents our estimated intervention equation for the Deutsche Bundesbank. The table contains variable names and definitions, coefficients and their t-ratios, the value of R square, the Durbin-Watson statistic and a test statistic to be discussed below. Data are quarterly observations for the period 1975-1 to 1983-3. Estimation is by ordinary least squares.

DER is the percentage rate of change in the DM/$ exchange rate over a calendar quarter. By itself, it expresses the influence of all forces that cause an exchange rate to change measured over this period. It does not express shorter-run variability within a quarter.

The information conveyed by DER is altered, however, when changes in the nominal interest rate and inflation rate differentials (as in RelDifRealR) are included in our regression equation, since their influence on intervention may act both directly as they condition central bank views of an equilibrium exchange rate and indirectly via the market exchange rate itself. To investigate these separate effects we first regressed DER on RelDifR and RelDifInf. Then the residual of this regression was used in our intervention equation in place of DER. Since this revised equation also includes changes in the interest rate and inflation rate differentials, the coefficients of RelDifR and RelDifInf correctly show both the direct and indirect effects of these variables, while DER expresses the effect on intervention of all other forces acting through the exchange rate. Very little of the variation in DER was explained by changes in the interest rate or inflation rate differentials. This result is similar

TABLE I

GERMANY
INTERVENTION EQUATION

	Coefficient	t-ratio
Constant	-45.37	-0.12
DER	-0.13	-1.46
RelDifRealR	-718.36	-3.21
ECU	-766.49	-1.91
EMSBi0	-825.88	-1.63
EMSBi1	2033.37	4.74
EMSBi1Cube	-36.26	-4.23
IQ79	-6720.69	-3.34
R square		0.688
DW		1.75
Test on b(RelDifInf) = 0		t = 1.13

Time is measured in quarters.
Data Set 1975-1 to 1983-3.

DEPENDENT VARIABLE
Intervention (Millions of US Dollars)

INDEPENDENT VARIABLES

In the following descriptions, f(x) means log first difference, i.e., f(x) = 100 * log[x(t)/x(t-1)].

For these variables, coefficients are all measured as millions of dollars per one percent change in the underlying independent variable.

DER = f(ER)
ER = DM per $ (end of period)
RelDifRealR = f(rGer/rUS * Gerinfl/USinfl)
rGER is one plus the German day-to-day money rate, period average.
rUS is one plus the US treasury bill rate, period average.
Gerinfl = GerCPI(t)/GerCPI(t-1)
USinfl = USCPI9t)/USCPI(t-1)
EMSBi0 = 100*[log Ger/Fr ER - log EMS Central Rate]
or 0 before the Central Rate was established.
Both rates are those in effect the last day of the quarter.
EMSBi1 = EMSBi0 except the Central Rate is dated one month before the end of the quarter.
EMSBi1Cube = cube of EMSBi1.
ECU = 100*[log DM/ECU ER - log DM/ECU Central Rate] (end of quarter)
or 0 before the Central Rate was established.
IQ79 = 1 for first quarter of 1979 and 0 elsewhere.
Coefficient is millions of dollars in the period.

to the general lack of success by economists in their attempts to explain exchange rate changes econometrically. As a result, the equation employing the residual form of DER is almost the same as that employing DER. Since these results do not differ greatly, we report only the equation estimated with DER.

While the variable DER may include some of the effects just discussed, its primary contribution is to reflect "news" as discussed in section 4. By definition news is unexpected. Whether the authorities choose to intervene to resist or support news-induced changes in the market exchange rate may well depend on the nature of the news in each instance. For this reason we have no prior view as to the sign expected on DER and indeed a coefficient of zero would not be unreasonable. This latter interpretation is confirmed by the lack of significance for the coefficient on DER in our econometric results in Table I.

RelDifRealR measures the percentage rate of change in the real interest rate differential between Germany and the United States. It includes the effects of the nominal interest rate differential, RelDifR, and the inflation differential, RelDifInf. The significant negative coefficient on RealDifRealR implies that the Bundesbank's intervention policy supports an exchange rate change in response to a change in economic forces as expressed in real interest rate differentials. Thus, intervention policy supports a movement in the exchange rate in the direction of equilibrium as analyzed in contemporary theories of exchange rate determination. In other words, the authorities "lean with the wind" over periods of a calendar quarter.

Logically such support can take the form of intervention to resist a temporary movement of the spot rate away from the equilibrium direction indicated by the change in the real interest rate differential or alternatively to accelerate the movement of the spot rate in the direction of a changing equilibrium. Studies of intervention behavior based on daily, weekly, or monthly data typically have found that central banks intervene to resist the direction of movement of the market exchange rate, that is, they "lean against the wind."[11] Our study, however, uses quarterly data for net cumulative intervention and for changes in the real interest rate differential. The quarterly time period opens the possibility that the prevailing movement in the equilibrium exchange rate as assessed by the central bank is unidirectional during the calendar quarter and that intervention occurs only or predominantly to oppose short run market movements away from such an equilibrium direction. The degree of uncertainty involved in analyzing equilibrium exchange rate paths clearly admits of the possibility that market sentiment may differ from central bank views in the short run. Our regression results cannot distinguish between intervention to resist market movement away from equilibrium and intervention to accelerate market movement toward equilibrium. The former interpretation is more consistent with central bankers' undertakings under international agreements and their stated policy not to engage in "aggressive" intervention behavior.

Another possible explanation for the significant negative coefficient on RelDifRealR might appear to be that both the interest rate and intervention are responding jointly to some other force acting on

the exchange rate and not included in the regression equation or that causation is reverse running from a change in the exchange rate to a change in the interest rate differential. For example, non-sterilized intervention to resist a depreciation of the domestic currency might raise the domestic interest rate by reducing the money supply. Or, the authorities might both intervene and raise the domestic interest rate to resist depreciation. The theory underlying our intervention equation implies that intervention responds to a change in the real interest rate differential whereas the reverse or joint causation hypotheses stress the link between intervention and the nominal interest rate. Therefore, a test of the competing hypotheses can be made by estimating the model as we present it with the real interest rate. Then the difference between the real and nominal interest rate is added to the model as a separate variable. (In this case this difference variable is the percentage change in the difference in the inflation rates in Germany and the United States.) If this latter variable has a coefficient significantly different from zero, then the reverse or joint causation hypothesis is supported. If the coefficient is not significantly different from zero, then the direct theory that we propose is supported. The results of this test are reported in the last line of Table I (and later Table II for France) in the form of the t-ratio for the estimated coefficient on RelDifInf. The indicated non-significance of the coefficient supports the real interest rate theory underlying our equation.

The variable ECU represents the divergence of the DM/ECU market rate from its central rate established by the EMS. When this

divergence indicator approaches a specified limit the appropriate national authority is expected to undertake corrective action which may take the form of exchange market intervention or other measures such as changes in domestic monetary or fiscal policy. Thus, intervention is not mandatory in response to warnings from the divergence indicator so it is possible that little effect will be observed. Nevertheless, we have a significant negative coefficient.

The variable EMSBi0 or "bilateral parity grid indicator" represents the Deutsche mark/French franc market exchange rate in relation to its central rate under EMS rules. The design of the variable is given in notes to the table. Both the market exchange rate and the central rate are observed as of the last day of the quarter. EMS rules establish a specific limit to movement of this variable. Intervention is automatic when the limit to the bilateral parity is reached and may be discretionary prior to that limit. An increase in the DM/FF exchange rate moves the rate toward the limit and calls for German or French intervention to prevent the limit from being surpassed. Such intervention causes a decrease in the level of German foreign exchange holdings as measured in this paper whether the actual intervention is carried out by the Deutsche Bundesbank or the Banque de France. As expected, the coefficient has a negative sign. It is significant at the 6 percent one tail level.

The next variable is EMSBi1. It represents the same bilateral parity grid indicator as EMSBi0, but the central rate to which the market rate is compared is that in effect one month before the end of the quarter. When the central rate does not change in that month, the

variable is identical to EMSBi0, but when it changes, the variable is likely to be large, indicating the large change in the current rate from the old central rate. Its coefficient will then represent the speculative flows and related intervention behavior that are reversed right after a change in the central rate. Its coefficient is expected to be positive. This coefficient is very significant reflecting the importance to intervention behavior of this unwinding of speculative positions.

Next consider the variable EMSBilcube. It allows large values of EMSBil to have effects that are moderated or increased from those indicated by a linear model. In this case the coefficient is negative indicating a moderating influence on the positive coefficient of EMSBil. This variable is particularly important for the devaluations that France undertook in 1981 and early 1982. We interpret this result to mean that the flow back into France of speculative funds that would typically be expected following official validation of market expectations was reduced or did not occur at these times because the devaluations were not sufficient to reassure speculators against the franc.

In the intervention regression for Germany we enter a dummy variable for the first quarter of 1979, IQ79. This quarter poses special analytical and measurement problems. The EMS began operation on March 13, 1979, at which time EMS member nations agreed to deposit 20 percent of their existing gold and dollar reserves with the European Monetary Cooperation Fund. As explained in section 5 this change requires substantial adjustments in our measure of intervention in

this quarter. These adjustments eliminated a large unexplained residual for this quarter in earlier regressions estimated for France and Italy performed on an unadjusted measure of intervention. Staff of the IMF with whom we have had discussions believe that the unadjusted IFS series for "foreign exchange" for Germany is conceptually comparable to those for France and Italy despite the fact that published sources from the Deutsche Bundesbank show that the Bundesbank enters an offsetting liability in its balance sheet for the dollar value of gold transferred to the EMCF.[12] When we accept the IMF interpretation and make adjustments to the German foreign exchange series (used in calculating our measure of intervention) comparable to adjustments applied to the French and Italian series, we obtain a very large unexplained residual in the German intervention regression for 1979.1. For this reason we use a dummy variable for this quarter which is significant. In the French regression a dummy variable for 1979.1 was significant in our earlier regression with the unadjusted measure of intervention but not for the adjusted measure--a directly contrary result.

Finally, we call attention to the R square of .688 for our German intervention equation which we regard as highly satisfactory as a measure of explanatory power for a phenomenon as difficult to explain as central bank intervention behavior.

Table II presents our estimated intervention equation for the Banque de France. Again, data are quarterly. Intervention, measured as before, is explained principally by changes in the real interest rate differential between France and the United States. DER again

TABLE II

FRANCE
INTERVENTION EQUATION

	Coefficient	t-ratio
Constant	-268.66	-0.99
DER	-4.18	-0.09
RelDifRealR	-667.25	-4.27
EMSBil	537.52	2.08
EMSBilCube	-10.13	-2.08
R square		0.475
DW		2.19
Test on b(RelDifInf) = 0		t = 0.88

Time is measured in quarters.
Data Set 1975-1 to 1983-2.

DEPENDENT VARIABLES

Intervention (Millions of US Dollars)

INDEPENDENT VARIABLES

In the following descriptions, f(x) means log first difference, i.e., f(x) = 100 * log [x(t)/x(t-1].
For these variables, coefficients are all measured as millions of dollars per one percent change in the underlying independent variable.

DER = f(ER)
ER = ffr per $ (end of period)

RelDifRealR = f(rEr/rUS * Frinfl/Usinfl)
rFr is one plus the French call money rate, period average.
rUS is one plus the US treasury bill rate, period average.
Frinfl = FrCPI(t)/FrCPI(t-1)
USinfl = USCPI(t)/USCPI(t-1)

EMSBil = 100*[log FrGer ER - log EMS Central Rate]
or 0 before the Central Rate was established.
The ER is dated the end of the quarter and the central rate is dated one month before the end of quarter.
This variable is the log of the reciprocal of the similar variable employed in the German regression.

EMSBilCube = cube of EMSBil.

measures the effect of "news" as expressed in the percentage change in the FF/US exchange rate. The coefficient here is very small indeed with a t-ratio of .09. As with Germany the variable RelDifRealR explains a great deal and the test for joint or reverse causation has the same non-significant result as for Germany.

The variable representing the bilateral parity constraint between the French franc and the Deutsche mark (EMSBi0), and that representing the divergence of the FF/ECU market rate from its central rate established by the EMS, (ECU), were not significant with the correct signs and have been dropped from this regression. This result suggests that France did not respond to these limits systematically throughout the period under study: 1975.1-1983.2. This conjecture is strengthened by the fact that the franc was subject to a managed float from June 1976 to November 1979 and was devalued three times in the period October 1981 to March 1983.

EMSBi1 represents the unwinding of speculative positions following a devaluation as does EMSBicube. Their coefficients are significant and similar to those for Germany. The dummy variable for the first quarter of 1979 was not significant indicating that the data transformations (discussed in Section 5) appear to do their job for France. Again, as with Germany, we regard the R square of .475 as quite satisfactory.

7. Conclusions and Final Comments

Central bank exchange rate policy is a subject considerably broader and more complex than central bank intervention policy. In our quantitative empirical work we have concentrated on intervention

policy because of its comparative feasibility. Even here there are difficulties. We have defined intervention as the purchase and sale of foreign exchange. Since central banks do not publish intervention data we have sought to develop a proxy measure for intervention by making a number of adjustments to the series on "foreign exchange" published by the IMF in International Financial Statistics. We are aware of further adjustments that should be made in principle but for which we lack adequate data. Nevertheless, we believe our adjusted measure of intervention is sufficiently like the true series to merit the use to which we have put it. We would welcome access to a true series to test this belief.

Our theoretical model for intervention behavior contains as explanatory variables the percentage change in a key exchange rate, changes in real interest rate differentials between the relevant domestic and foreign countries, and variables to represent bounds to parity zones specified by rules of the EMS. Our econometric results imply intervention to support changes in the equilibrium exchange rate as this is influenced by changes in the real interest rate differential. As expected, intervention also occurs to conform to EMS intervention rules except when the underlying economic forces make EMS parity zones untenable resulting in a realignment of central rates within the relatively fixed-rate EMS system. Anticipated or realized parity changes cause capital flows to which intervention reacts so that some appropriate representation of parity changes in the intervention model is highly desirable. The variables EMSBil and EMSBilCube represent this effect in our present model. Our intervention model is incapable

of explaining a decision to realign parities within the EMS or to reset an implicit target exchange rate to be defended by intervention policy. Such decisions are aspects of central bank or national exchange rate policy that require a much broader analytical framework than that needed for intervention policy.

In Sections 1 and 2 we have characterized the scope and role of central bank exchange rate policy within the framework of national economic policy and have described measures other than direct, active intervention available to various central banks to influence exchange rates. Policy decisions regarding these matters involve relatively complex economic and even political issues which are not readily amenable to analysis by rigorous quantitative methods. They certainly lie outside the scope of this paper. However, considerable insight into both sets of issues may be achievable by detailed study of actual historical episodes, particularly those when large changes in market exchange rates and in explicit or implied parity targets have occurred.[13]

STATISTICAL APPENDIX

Data Sources

Data for EMS bilateral central rates and EMS ECU central rates are from IMF Occasional Paper 19, The European Monetary System: The Experience, 1979-82, by Horst Ungerer, with Owen Evans and Peter Nyberg (May 1983), Appendix I, Tables 2 and 4.

All other data are from the IMF tape for International Financial Statistics updated where necessary using various issues of the IMF's International Financial Statistics.

Intervention Definition

The measure of "intervention" used as the dependent variable in our regression models for Germany and France has been discussed in Section 5 of our paper. A precise symbolic definition of this variable is as follows:

INTERVENTION DEFINITION

V = intervention
FE = Foreign Exchange (asset) $millions
RPF = Reserve Position in the Fund (asset) $millions
UFC = Use of Fund Credit (liability) SDR millions
SDR = SDR per domestic currency times domestic currency per $
= SDR per $
GQ = Gold Reserve in ounces
GP = London Gold Price ($ per ounce) from IMF UK series c
LCFAR = Liability Constituting Foreign Authorities Reserves (flow) $millions
CVC = Counterpart to Valuation changes (flow) $million
R = US Treasury Bill Rate for 1 quarter investment.
$= (1. + USTB)^{.25} - 1.$

$$Assets = [FE + RPF - UFC * SDR]$$

$$VA = Assets(t) - Assets(t-1) - LCFAR - CVC - R(t-1) * FE(t-1)$$

For the period before 1979-1 when EMS formed:

$$V = VA$$

In 1979-1, 20 percent of the gold reserve was moved to EMS reserves. For this one quarter:

$$V = VA - GQ(78-4 * .2 * GP(t-1)$$

For the succeeding quarters we adjust for gold price changes and interest earnings as appropriate.
For 79-2 and beyond:

$$V = VA + [R(t-1)*GQ(t-1) + GP(t-1) - GP(t)] * .2*GQ(78-4)$$

NOTES

1. Report of the Working Group on Exchange Market Intervention" by the Working Group on Exchange Market Intervention established at the Versailles Summit of the Heads of State and Government, June 4, 5 and 6, 1982 (March 1983), 36 pp. mimeo. In addition to the summary report a number of supporting studies, though not all, have been published as follows:

   Bank of Canada, A Study of the Efficiency of Foreign Exchange Markets, by David Longworth, Paul Boothe and Kevin Clinton, October 1983, 92 pp. mimeo.

   Bank of England, "Intervention, Stabilization and Profits," Quarterly Bulletin, Vol. 23, No. 3, Sept. 1983, pp. 384-391.

   Banca d'Italia, "A Case Study of the Effectiveness of Foreign Exchange Market Intervention: The Italian Lira (September 1975-March 1977), by Stefano Micossi and Salvatore Rebecchini, Research Department, Discussion Papers on International Economics and Finance, No. 4, December 1983, 44 pp.

   Board of Governors of the Federal Reserve System, Staff Studies, as follows:

   126. Definition and Measurement of Exchange Market Intervention, by Donald B. Adams and Dale W. Henderson, August 1983, 5 pp.

   130. Effects of Exchange Rate Variability on International Trade and Other Economic Variables: A Review of the Literature, by Victoria S. Farrell with Dean A. DeRosa and T. Ashby McCowan, January 1984, 21 pp.

   131. Calculations of Profitability for U.S. Dollar Deutsche Mark Intervention, by Laurence R. Jacobson. October 1983, 8 pp.

   132. Time Series Studies of the Relationship Between Exchange Rates and Intervention: A Review of the Techniques and Literature, by Kenneth Rogoff. October 1983, 15 pp.

   133. Relationships Among Exchange Rates, Intervention and Interest Rates: An Empirical Investigation, by Bonnie E. Loopesko. November 1983, 20 pp.

   134. Small Empirical Models of Exchange Market Intervention: A Review of the Literature, by Ralph W. Tryon, October 1983, 14 pp.

Several other studies in the Board of Governors' Series are promised as "forthcoming." See Board of Governors of the Federal Reserve System, Federal Reserve Bulletin, January 1984, pp. A73-A74.

2. International Monetary Fund, Articles of Agreement of the International Monetary Fund, Article I, Section (iii) and Article VIII, Section 2(a).

3. "Report of the Working Group on Exchange Market Intervention," pp. 17 and ff.

4. For such an evaluation see "Report of the Working Group on Exchange Market Intervention," and related studies listed in footnote 1.

5. For a rewarding discussion of types of central banks transactions that may constitute "intervention" see especially Federal Reserve Board of Governors, Staff Studies No. 126, "Definition and Measurement of Exchange Market Intervention," by Donald B. Adams and Dale W. Henderson.

6. Bank of England, "Intervention Arrangements in the European Monetary System," in Quarterly Bulletin, Vol. 19, No. 2, June 1979, p. 194.

7. For a brief account of intervention by the Federal Reserve System to steady the market prior to the announcement of a new support package for the U.S. dollar in October 1979 see Federal Reserve Bank of New York, Quarterly Review, Winter 1979-80, Vol. 4, No. 4, pp. 58-61.

8. Report of the Deutsche Bundesbank for the Year 1974, p. 60.

9. Hooper, Peter and John Morton, "Fluctuations in the Dollar: A Model of Nominal and Real Exchange Rate Determination," Journal of International Money and Finance (1982), 1, pp. 39-56.

10. "At the beginning of each quarter adjustments are made to the revolving swaps between the central banks and the EMCF in order to ensure that each central bank's contribution to the EMCF continues to represent at least 20 percent of its gold and dollar reserves, valued in accordance with the ruling dollar rates or the price of gold. As in the case of the initial contribution, this value is based for gold on the average price, converted into ECUs, of the last six months (but not more than the price on the penultimate working day of the period), and for the dollar on the market rate two working days before the value date." Deutsche Bundesbank, "The European Monetary System: Structure and Operation," in Monthly Report of the Deutsche Bundesbank, Vol. 31, No. 3, March 1979, p. 16.

11. See Donald V. Coes, "Exchange Market Intervention in Four European Countries," in Donald R. Hodgman (editor), Federal Reserve Bank of Boston Conference Series No. 26, The Political Economy of Monetary Policy: National and International Aspects, 1984, pp. 206-22 and items cited in Coes' bibliography.

12. See Report of the Deutsche Bundesbank for the Year 1979, pp. 57-58 where there appears this statement: "By valuing the gold transferred to the EMCF (through swap agreements) at market-oriented prices that are brought into line with the actual market developments at quarterly intervals a "liquidity gain" results which can easily lead to the financing potential of these resources being overstated. (This gain is offset in the Bundesbank's balance sheet by a contra-entry on the liabilities side.)" An example of such a contra-entry in calculating the monetary reserves entering the net external position of the Bundesbank may be seen in Table IX.6, "External Position of the Deutsche Bundesbank" in Monthly Report of the Deutsche Bundesbank, Vol. 31, No. 5, May 1979, p. 74*.

13. For example, see Forrest Capie and Geoffrey Wood, "Devaluation in Historical Perspective: The United Kingdom Case" in this volume.