Effects of Central Bank Intervention in the Foreign Exchange Market

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INTERVENTION IN THE foreign exchange market has been, and continues to be, an important feature of the conduct of economic policy in the present system of widespread floating. Central banks may buy or sell foreign exchange for a number of reasons. They may “lean against the wind” of short-run fluctuations in exchange rates in order to promote “orderly market conditions,” or lean against the wind of longer-term movements in attempts to influence trendlike appreciations or depreciations. Alternatively, they may attempt to speed up adjustments by purchasing or selling foreign exchange when the domestic currency is depreciating or appreciating. Finally, they may buy or sell foreign assets for other reasons than to influence the exchange rate, such as to alter the domestic money supply or to finance government imports or exports. Whatever their intentions, the consequences of central banks’ actions for exchange rate movements will depend critically on what type of domestic asset constitutes the counterpart to the purchases or sales of foreign exchange and on the reactions of the private sector and foreign central banks to these purchases. The purpose of this paper is to review the current state of knowledge about the effectiveness of intervention policy from both theoretical and empirical perspectives. The issue on which attention is focused.

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concerns the extent to which intervention in the foreign exchange market can be considered to be different from general monetary policy—in other words, on the question of whether central banks can use money supply control and intervention policies independently. The answer to this question obviously has important implications for national monetary authorities’ conduct of monetary policy and for the International Monetary Fund’s monitoring of the exchange rate policies of its members.

In order to define the scope of the paper, it is first necessary to select criteria for the classification of different types of intervention policies. The first of these criteria is the time span over which the policy is carried out. One can distinguish between very short-run (i.e., day-to-day) operations in foreign exchange markets and medium- to long-run ones (in this context, those that are pursued for a month or longer). The former would have the goal of preventing disorderly market conditions and of “making a market” on any particular trading day. The latter might, to some extent, have similar objectives but would also be intended to have longer-lasting effects on the exchange rate.

A second criterion for classifying exchange market intervention is the extent to which the intervention is allowed to affect the domestic money supply. At one extreme, the purchase of foreign exchange leads to an increase of exactly the same amount of the domestic money stock. At the other extreme, the intervention policy is accompanied by an open market operation in domestic assets that completely sterilizes the effect of the change in reserves on the domestic money supply. These two types of intervention policy are likely to have substantially different effects, as will be seen later on.

This paper will focus on the effectiveness of medium- to long-run intervention. It will furthermore concentrate on policies that are combined with open market operations in such a way that the domestic money supply is unaffected by them. Effectiveness is finally defined solely in terms of the ability of the policies to influence the exchange rate and not in terms of the broader questions concerning their ultimate effects on other policy targets.

Against this background, the following section of the paper turns to the theoretical aspects of the problem, while Section II reviews the existing empirical evidence on the effectiveness of intervention. The paper ends with a discussion of national and international policy implications of the study.
I. Theoretical Considerations

IMPLICATIONS OF ALTERNATIVE MODELS OF EXCHANGE RATE DETERMINATION

Recent emphasis on asset market equilibrium and the capital account in models of exchange rate determination suggests that the degree of substitutability between assets denominated in different currencies and the degree of capital mobility are crucial for the effectiveness of intervention. The three types of model discussed here rely on different assumptions in this regard. The monetary and the portfolio balance models both assume perfect capital mobility but differ in that the former assumes perfect substitutability between domestic and foreign assets while the latter does not. The balance of payments model does not assume perfect capital mobility but instead assumes that capital movements take place over time in response to interest rate differentials. This model can be consistent with either perfect substitutability between domestic and foreign assets (in the long run) or with imperfect substitutability. The implications for the effectiveness of intervention of each of these three views on exchange rate determination will be discussed in turn.

**Monetary model**

Whether of the variety that relies on instantaneous purchasing power parity or not, the monetary models, by assuming perfect substitutability between domestic and foreign assets and perfect capital mobility, imply that intervention policy not affecting either the domestic or the foreign money supply will have no influence on the exchange rate. This can be shown formally by looking at the equation that Bilson (1979), for instance, derives for the exchange rate. With \( s \) indicating the natural logarithm of the exchange rate (the domestic currency price of foreign exchange), \( m(m^*) \) the natural logarithm of the domestic (foreign) money supply, \( y(y^*) \) the natural logarithm of domestic (foreign) real output, and \( fd \) the forward discount on domestic currency, Bilson derives

\[
s = k + m - m^* - \eta(y - y^*) + \epsilon \cdot fd
\]

(1)

On the distinction between substitutability of assets and capital mobility, see Dornbusch and Krugman (1976).
where \( k \) denotes a constant, \( \eta \) the real income elasticity of demand for money, and \( \epsilon \) the interest semi-elasticity of demand for money. When domestic and foreign interest-bearing assets are perfect substitutes, the intervention policy (combined with complete sterilization) does not alter any of the variables on the right-hand side of (1). This is clearly true for the money stocks and real incomes and can be shown to be true also for the forward discount. When there is perfect substitutability between domestic and foreign assets, the forward discount will equal the expected rate of depreciation of the home currency. This, in turn, is a function of expected future monetary policies and expected growth of real income, provided that economic agents are rational. Formally, with rational expectations based on the model underlying (1), one can derive

\[
s_t = \frac{1}{1 + \epsilon} \sum_{j=0}^{\infty} \left( \frac{\epsilon}{1 + \epsilon} \right)^j E_t \cdot Z_{t+j}
\]

(2)

where \( Z_t = m_t - m^*_t - k - \eta(y_t - y^*_t) \) and where the notation \( E_t X_{t+j} \) indicates the expectation formed at time \( t \) of the value of the variable \( X \) at the time \( t+j \).

By explicitly expressing the current value of the exchange rate as a function of future policy variables, equation (2) points to the possibility that intervention might be effective because it alters current expectations about the future course of the economy. Thus, if a current sale of foreign exchange by the central bank signals future monetary contraction, then the home currency will appreciate immediately even if the intervention is fully sterilized so that the money supply did not change in the current period. This constitutes the only possible channel through which intervention-cum-sterilization could be effective within this framework.

**Portfolio balance model**

In contrast to the monetary model, the portfolio balance model \(^3\) does not assume that domestic and foreign interest-bearing assets are perfect substitutes. The reasons for imperfect substitutability may be many, but some of the most quoted

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\(^3\) For recent expositions of this model, including references to the literature and some empirical work, see Dooley and Isard (1979 b) and Frankel (1980).
include exchange risk, differential political and default risks, imperfect information about foreign assets, and government regulation of international capital flows.

In its simplest small-country version, the model can be formalized in terms of equations (3)-(6).

\[ M = m(i,i^* + \lambda) \cdot W \]  
\[ B^H = b(i,i^* + \lambda) \cdot W \]  
\[ S \cdot F = f(i,i^* + \lambda) \cdot W \]  
\[ W = M + B^H + S \cdot F \]

where

- \(M\) = domestic money supply
- \(B^H\) = supply of domestic bonds
- \(F\) = quantity of foreign bonds held in domestic portfolios
- \(W\) = domestic financial wealth
- \(S\) = spot exchange rate
- \(\lambda\) = expected rate of depreciation of domestic currency
  \[ = (E_t S_t + \frac{1}{1 + S_t})/S_t \]
- \(i\) = domestic interest rate
- \(i^*\) = foreign interest rate

As it stands, this model assumes that domestic residents hold foreign securities as well as domestic money and securities. The latter two are assumed to be nontraded. It is also assumed that the foreign rate of interest is taken as a datum by domestic residents (the "small-country assumption"). As pointed out by Dooley and Isard (1979 b), this model is underdetermined in the sense that it can be used to determine the domestic interest rate and either the spot rate \(S\) or the expected rate of depreciation \(\lambda\), but not both unless an additional relationship is introduced. If, for instance, expectations were assumed to be static so that \(\lambda = 0\), then the exchange rate could be determined as a function of the three asset stocks and the foreign rate of interest. A policy of intervention that leaves the domestic stock of money unchanged would then have the effect shown by

\[ \frac{dS}{dF} \bigg|_{dM = 0} = - \frac{m_i}{F \cdot (m \cdot b_i - b \cdot m_i)} < 0 \]  

Thus, a purchase of foreign bonds for domestic bonds would lead to a depreciation of the domestic currency unless the
demand for domestic money was completely interest-inelastic or unless domestic bonds were considered perfect substitutes for foreign bonds. Alternatively, if the current spot rate were determined elsewhere, the portfolio balance model could be solved for the expected rate of depreciation as a function of asset stocks and wealth.

In general, $S$ and $\lambda$ will be determined jointly once some hypothesis concerning the future spot rate is formulated. Given that our knowledge of what determines expectations is fairly limited, it may make a great deal of difference to econometric application of the portfolio balance model whether it is solved for the spot rate or the expected rate of depreciation. This point will be elaborated in the discussion of empirical evidence in Section II.

**Balance of payments model**

The notion that the degree of substitutability between domestic and foreign assets depends on the length of time agents can take to adjust their portfolios may seem plausible if one draws an analogy with conventional consumer demand theory. One way to capture this idea is to specify the reallocation of portfolios in response to changes in interest rates as stock adjustment processes leading to international capital flows in response to interest differentials. These capital flows would, together with the other items in the balance of payments, determine the exchange rate in such a manner that balance of payments equality would be maintained at all times. The resulting model, referred to here as the balance of payments model, thus uses the balance of payments equality as an equilibrium condition in the foreign exchange market.

Letting $CA$ stand for the current account surplus, $NCI$ for the private net capital inflow, and $\Delta RES$ for the purchase of foreign exchange reserves by the domestic monetary authorities (all three of which are dependent on the current spot exchange rate), we can write

$$CA + NCI + \Delta RES = 0 \quad (8)$$

4 Since expectations concerning the future value of the spot rate are likely to depend on expectations concerning future policy actions, the latter will be as important in the portfolio balance framework as they were shown to be in the monetary model. A further discussion of this issue is contained in the subsection entitled "Expectations effects and related issues."

5 For the use of a specification of this type to investigate the importance of the degree of capital mobility for exchange rate overshooting, see Frenkel and Rodriguez (1980).

6 For an early empirical application of this model, see Rhomberg (1964).
as the condition that implicitly determines the spot rate.

Within this framework, where private capital flows result from a stock adjustment process, it is evident that intervention by the central bank would always succeed in influencing the exchange rate. Whether or not a temporary intervention (corresponding to a permanent exchange of foreign securities for domestic securities by the central bank) would have any lasting effect on the exchange rate would depend on the degree of substitutability between domestic and foreign assets. Under perfect substitutability, once the process of stock adjustment in the demand for foreign assets has run its course, we would be back in the world of the monetary model with no long-run effect on the exchange rate. With imperfect substitutability, the effect derived from the balance of payments model would, over time, approach that of the portfolio balance model with imperfect substitutability between domestic and foreign assets. As far as the effectiveness of intervention is concerned, therefore, a low speed of adjustment in asset markets has the same short-run implications as imperfect substitutability between assets. In the longer run, the only factor that matters is the degree of substitutability.

EXPECTATIONS EFFECTS AND RELATED ISSUES

Expectations effects owing to intervention activity may arise for two distinct reasons. One possibility is that intervention will be interpreted as a signal of future changes in monetary policy (or, more generally, changes in any policy affecting exchange rates). Such changes in policy will, in turn, alter expectations concerning the future equilibrium exchange rate and, through the channels discussed in the previous section, the current spot rate. Another possibility is that, by modifying the net foreign asset position of the economy, intervention will affect the structure of the balance of payments and hence the equilibrium real exchange rate. The current nominal exchange rate will then be affected through the process linking current exchange rate changes with future long-run equilibria. Each of these two possibilities will be discussed in turn.

By intervening in the foreign exchange market, a central bank may be signaling its intentions to pursue policies that will move the exchange rate in the desired direction. An efficient way to do so is to let the intervention be fully reflected in the domestic money supply, thus backing the desired exchange rate adjustment with an appropriate monetary policy. If this is prevented by sterilization operations, the effectiveness of the intervention
is reduced, but to the extent that the commitment to future policy actions ensuring the desired exchange rate movement is believed by the public to be genuine, expectations effects will ensure at least partial success of the intervention policy. This will be the case regardless of the degree of substitutability between domestic and foreign assets. If this substitutability is perfect, the discussion of the monetary model shows that the expectation of future monetary ease or tightening will have the same qualitative effect on the current spot exchange rate as current policy of the same type. The same would be true for the portfolio balance and the balance of payments models, since future policy would affect the expected yield differential between domestic and foreign assets.

It is evident that for the expectations effects to have the influence just described, it is necessary that the motive behind the intervention be credible and that the exchange rate target implied by the intervention not conflict with other policy goals. The latter condition is particularly important in view of the fact that some countries also have targets for money supply growth or for their international reserve position. Insofar as a central bank does allow a purchase, say, of foreign exchange to increase the domestic money supply in the short run but is bound by other constraints to follow a previously announced path of money supply growth in the longer run, the effect of the current intervention on the exchange rate will be largely offset by the implied future reversal of the policy implied by the money growth rule. A similar problem will occur if the central bank has a target for its holdings of international reserves. An intervention purchase of foreign exchange to stabilize the exchange rate will create a divergence from this target and, hence, necessitate a reversal of the policy some time in the future. This reversal will, in turn, offset some of the effect of the intervention in the current period.

An analogy with a situation in which the country is committed to a fixed exchange rate vividly illustrates the point in this paragraph. Such a commitment, if it is always backed by the appropriate policies (and therefore believed by the public), generates private capital movements that perform the function of official intervention. The latter may thus be very small and still have substantial induced effects on the exchange rate.

For an analysis showing that short-run intervention combined with long-run adherence to a growth rate rule for the money supply may lead to increased, rather than decreased, exchange rate volatility, see Genberg and Roth (1979).
The implication of the previous discussion is that for systematic intervention policy to have a maximum impact (in some circumstances, any impact at all) on the exchange rate, the policy must imply, and be followed up with, the appropriate monetary policies. Furthermore, to the extent that the commitment to influence the exchange rate is genuine, there is no reason to be secretive about the fact of intervention, which instead should be made as transparent as possible.

The second way in which intervention policy may be affected by expectations is through its influence on the structure of the balance of payments. When domestic and foreign assets are not perfect substitutes, sterilized intervention will alter the net foreign asset position of the economy as a whole. An intervention purchase of foreign assets for domestic assets will increase the net creditor position of the country and lead to an improved debt service account in the balance of payments. If long-run equilibrium is defined by a balanced current account, the change in debt-service payments implies a change in the long-run equilibrium trade account and hence in the equilibrium real exchange rate (defined as the ratio of the prices of traded goods to nontraded goods). If expectations of relative yields on domestic and foreign assets take this long-run equilibrium into account, the effectiveness of the initial intervention policy will be enhanced. As before, for the mechanism just described to be set in motion, the change in portfolio composition brought about by the intervention must be thought of as permanent and not likely to be reversed within the near future. This, in turn, requires that the public be convinced that the central bank is committed to the exchange rate policy implied by the intervention activity.

FOREIGN REACTIONS TO DOMESTIC INTERVENTIONS

Since an exchange rate reflects the relationship between two currencies, it is inappropriate to consider intervention policy from the point of view of only one country. Not only may the foreign country be carrying out intervention policy in its own

9 For a model incorporating the features described in this sentence, see Genberg and Kierzkowski (1979).
10 See Hooper and Morton (1980) and Isard (1980) for models that implement this idea both theoretically and empirically.
11 See Marston (1980) for a detailed analysis of some of the issues discussed in this section.
right but, in attempting to influence other targets such as interest rates or the money supply, it may unintentionally reinforce or weaken the effects of domestic intervention. This is so because, by pursuing these other objectives, the foreign authorities may affect the changes made in the domestic or foreign asset stocks upon which the effect of the domestic intervention depends. The most obvious instance in which the reaction of the foreign central bank matters occurs when the United States is one of the partners. As an empirical observation, it appears that non-U. S. central banks tend to hold a significant portion of their international reserves in U. S. Treasury bills. As has been shown in a number of studies, this practice implies that the U. S. money supply will be essentially immune to foreign interventions in the foreign exchange market. Suppose, for example, that an increase in the U. S. money supply leads to downward pressure on the dollar that is resisted by purchases of dollars in the foreign exchange market by non-U. S. central banks. These purchases tend to reduce the initial expansion of the U. S. money stock and to increase foreign exchange reserves of the intervening central banks. But the practice of converting these foreign exchange gains into U. S. Treasury bills returns the U. S. money supply to what it was before the intervention. Foreign central banks thus, in effect, perform sterilization policies for the United States. The end result, as far as asset stocks in the hands of the public are concerned, of a fully sterilized non-U. S. intervention is that neither money supply will be affected but the supply of U. S. Treasury bills will be reduced and the supply of non-U. S. securities will be increased. A sterilized intervention by the United States, on the other hand, would lead to an increase in the non-U. S. money supply, while the supply of foreign securities would be left unchanged.

Consider alternatively a situation in which the non-U. S. authorities pursue an interest rate policy. In this case, an intervention purchase of dollars for foreign exchange by the U. S. Federal Reserve System—by putting downward pressure on U. S. interest rates and hence, with unchanged expectations

12 See, for instance, Balbach (1978), Girton and Henderson (1977), and Swoboda (1978).
13 The relevant money supply measure here is the stock of money held by the private sector. Prior to the redefinitions adopted by the Federal Reserve System in January 1979, published U. S. money supply figures included U. S. dollar deposits held by foreign official institutions.
of exchange rate changes, on interest rates abroad—would elicit contractionary monetary policies in the foreign country. The sterilized intervention in the United States has therefore caused a reduction in the money supply abroad, and it is conceivable that, for this reason, the effect on the exchange rate will be the opposite from that intended by the U. S. authorities.

The foregoing discussion makes it clear that, in order to assess empirically the ultimate impact of foreign exchange market intervention, it would be necessary to study the behavior of both countries whose exchange rate was being managed even if it were known a priori that only one of them was intervening actively. With integrated asset markets, intervention works through changes in asset stocks, and these changes occur for many reasons other than intervention. Explicit account of them must therefore be taken in empirical work.

II. Empirical Evidence

The theoretical considerations in the previous section showed that the effectiveness of intervention depends essentially on the degree of substitutability between domestic and foreign assets, the degree of capital mobility, and the determinants of expectations of future policy actions. Some of the existing empirical evidence on these issues will be reviewed in this section.

REVIEW OF EXISTING EMPIRICAL STUDIES

The empirical tests having a bearing on the effectiveness of intervention can be divided into those that look directly at exchange rate equations, those that look at the effect of intervention on interest rate differentials, and those that search for evidence of foreign exchange risk in the relationship between spot and forward exchange rates. Although the underlying null hypothesis is the same in each case (i.e., the absence of risk differentials between assets denominated in different currencies), the different methodologies employed makes it useful to divide the discussion of the results into these three categories.

Evidence from exchange rate equations

Monetary models. Even though sterilized intervention should
not influence the exchange rate in the monetary model because of the perfect substitutability assumption, two recent empirical studies have included intervention measures in estimated exchange rate equations based on this approach. In Tullio (1979), the difference between the Swiss franc-lira exchange rate quoted for bank notes in Zurich and the rate quoted for cable transfers was related to the relative supplies of money in the two countries and to the relative levels of income and expected prices, as in the monetary model. The null hypothesis was that the exchange rate on bank notes, being less subject to official intervention, would react faster to the underlying determinants than the rate on cable transfers. This conjecture did receive support from the results. The amount of intervention by the Bank of Italy was also included in the equation, and the estimation indicated that a purchase of foreign exchange had a significant positive effect on the spread between the exchange rates on bank notes and cable transfers. Tullio interpreted this result as showing the ability of the Bank of Italy to slow down a required depreciation of the lira by sterilized sales of foreign exchange. Another interpretation of this result is, however, that such sales are viewed as temporary and likely to be reversed, leading to an expansion of the money supply in the future. The expectation of an expansionary monetary policy then results in depreciation of the value of bank notes in anticipation of the actual change in policy.

In Suss (1980), a three-equation model of exchange rate, interest rate, and intervention behavior was estimated for four industrial countries—France, the Federal Republic of Germany, Japan, and the United Kingdom—relative to the United States. The level of the exchange rate was explained by the amount of central bank intervention in addition to the variables in the monetary model—relative money supplies, income levels, and interest rates. Intervention was assumed to depend in part on changes in the exchange rate and in part on the desire to maintain a fixed relationship between international reserves and imports. For all countries, the results indicated statistically significant "leaning against the wind" policies of reserve management. But, paradoxically, the coefficient of the intervention variable in the exchange rate equation indicated in each case that a purchase of foreign exchange by the domestic central bank would lead to appreciation of the home currency. For three of the four countries, this coefficient was statistically significant.
As in the previous case, a possible interpretation of this result is that intervention systematically gives information about future monetary policy, so that a purchase of foreign exchange for domestic currency is interpreted as a temporary easing of monetary conditions and, hence, generates expectations of future contraction. The expected future contraction then leads to an immediate appreciation of the home currency.

**Portfolio balance models.** The portfolio balance model suggests that the exchange rate should depend not only on the supplies of domestic and foreign monies but also on domestic and foreign nonmonetary assets. The latter assets matter because their relative supplies modify yield premiums owing to exchange risk and political or default risk. The exchange rate will then be affected for the reasons explained in Section I. In estimated exchange rate equations based on the portfolio approach, the relative size of the coefficients on domestic assets and foreign assets will show the quantitative effects of an open market purchase of foreign assets for domestic assets—that is, of a sterilized intervention in the foreign exchange market.

Recent attempts at implementing the portfolio model empirically include Artus (1976, 1981), Branson and others (1977, 1979), Dooley and Isard (1979 a), Frankel (1980), Hooper and Morton (1980), Isard (1980), and Martin and Masson (1979). Of these nine studies, only the first five find any support for the portfolio balance model and, hence, for the proposition that sterilized intervention has a significant effect on the exchange rate. In Branson and others (1977), the level of the dollar/deutsche mark rate over the period August 1971 to December 1976 was explained by the money supplies in the two countries as well as their respective net foreign asset positions. The signs of the estimated coefficients of all four variables were those predicted by the theory. Although the level of significance was too low to warrant strong conclusions, using the point estimates as a guide, the results suggest that sterilized intervention is effective. According to Table 7 in the Branson and others (1977) paper, a $1 billion purchase of foreign assets by the Bundesbank, leaving the German money supply unchanged, would lead to a

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14 It should be noted that Suss did not put this interpretation on her results. Instead, she explained them in terms of a partial adjustment process of the exchange rate and reserve flows.

15 For a formalization of this argument, see Genberg (1981 a).
depreciation of 0.185 cent per deutsche mark. The low significance level of the estimates and the high serial correlation of the residuals do, however, raise some doubts as to the robustness of these conclusions. These doubts are confirmed in the authors' 1979 update of their original study. When the estimation period was extended to March 1978, two of the four coefficients changed signs, and the only variable with the expected sign and high statistical significance was the U. S. money supply.

Like Branson and others (1977), Artus (1976) studied the dollar/deutsche mark rate and estimated simultaneously an exchange rate equation and a reaction function of the authorities in order to avoid simultaneity biases. His sample period was April 1973 to July 1975, and as a consequence of using the rate of change of the exchange rate as the dependent variable, the net foreign asset position was replaced by the current account as the variable capturing relative asset supplies. This variable was highly significant in the estimations, and the estimated coefficients of the model implied that a once-and-for-all DM 1 billion purchase of foreign assets by the Bundesbank would depreciate the mark by 1.13 per cent in the first month if it were completely neutralized by a corresponding open market sale of domestic assets. Subsequent feedbacks would lead to a further 0.48 per cent depreciation for a permanent effect of 1.61 per cent. 16 In Artus (1981), the current account and the interest rate differential between the United States and the Federal Republic of Germany were again significant explanatory variables in an exchange rate equation covering the period extending from the fourth quarter of 1973 to the fourth quarter of 1979, suggesting that German and U. S. assets are not perfect substitutes. 17

Dooley and Isard (1979 a) also investigated movements in the deutsche mark/dollar rate. The sample period was May 1973 to June 1977, and the results supported the existence of a risk premium and imperfect substitutability, in that the estimated model outperformed the forward rate as a predictor of the future spot rate. However, the estimates of the parameters of the model took on plausible values only by imposing prior information on the size of these coefficients.

16 These figures can be compared with those of Branson and others (1977), which imply a 0.071 per cent depreciation for an equal-sized intervention. (The average exchange rate for 1974 of 2.59 deutsche mark per dollar was used to convert the intervention expressed in dollars into deutsche mark.)

17 The information presented in the 1981 paper is not sufficient to determine the quantitative effect of intervention on the exchange rate.
In contrast to the studies mentioned previously, the other empirical applications of the portfolio approach found virtually no support for the underlying theoretical models. Frankel (1980) and Isard (1980) both attempted to explain the dollar/deutsche mark rate. In each case, the crucial variable measuring relative asset supplies was either not significant or took the unexpected sign. The same negative results emerged from equations in Martin and Masson (1979) explaining the U. S. dollar/Canadian dollar rate and the U. S. dollar/yen rate, as well as from equations explaining the value of the dollar in terms of a West European basket (Martin and Masson) or in terms of a basket of the industrialized countries' currencies (Hooper and Morton (1980)).

Before discussing some possible explanations for the differences in findings between the studies just reviewed, the results of the study by Quirk (1977) should be mentioned in the present context. Quirk set out to study the reaction of the Bank of Japan to exchange rate changes. The main purpose of this article was to see to what extent interventions by the Japanese authorities could be explained by exchange rate movements. In order to take account of the possibility of simultaneity between intervention and the exchange rate, however, Quirk also estimated an equation in which the exchange rate was made a function of the amount of intervention. After reviewing various models of exchange rate determination, Quirk adopted an eclectic formulation that allowed for effects of, inter alia, intervention, changes in interest rate differentials, relative growth rates of money supplies, and changes in Japan's current account position. The dependent variable was the monthly change in the dollar/yen rate for the period March 1973 to October 1976. The regression results failed to show any effect of intervention on the exchange rate once the influences of interest rates, money supplies, and the current account were taken out. These results can thus be taken to imply that intervention with full sterilization is ineffective. Some caution is warranted, however, as either the interest rate differential or the current account balance may respond to asset supplies and, therefore, transmit the influence of intervention indirectly.

The contrast between the results of Artus and Branson and others, on the one hand, and Quirk, on the other, is interesting and puzzling in view of the a priori expectation that substitutability between dollar assets and deutsche mark assets would be higher than that between dollar assets and yen assets. On this
view, intervention should have been less effective in the Federal Republic of Germany than in Japan.

There are two major explanations for the differences in conclusions between the various studies reviewed previously. One is the very difficult problem of specifying exchange rate expectations correctly. The various papers differed in this respect, and the results may have been correspondingly affected. The importance of treating this issue properly is illustrated clearly in the paper by Dooley and Isard (1979 a), where it is suggested that most of the actual fluctuations of exchange rates have been unexpected.

The second source of difference between the studies is the measurement of relative asset supplies denominated in different currencies. Data on these are not readily available, and the constructed series may differ between studies. Resulting disparities are due to different treatments of valuation changes in official holdings of foreign assets and to differences in the treatment of central bank intervention in the construction of the stock of foreign assets owned by the private sector.

While every empirical implementation of the portfolio balance model is going to be hampered by the problem of data availability, the importance of correctly specifying exchange rate expectations may be reduced if, instead of trying to explain exchange rate movements, attention is turned toward the determinants of interest rate differentials and risk premiums. Studies that follow this route are reviewed next.

Evidence pertaining to the existence and determinants of foreign exchange risk

A major reason for imperfect substitutability between domestic and foreign assets could be the existence of nondiversifiable foreign exchange risk. An indication of such risk is a deviation of the forward exchange rate from the expected future spot rate that constitutes a risk premium. A number of recent studies have attempted to identify this premium. The procedure most commonly followed starts with the definition of the *ex ante* risk premium given in

\[ p^e_{t} = E_t S_{t+1} - F_t \]  \hspace{1cm} (9)

where \( F_t \) stands for the one-period forward rate observed at time \( t \). By invoking the assumptions of rational expectations and
an efficient foreign exchange market, the actual spot rate at \( t + 1 \) is equal to the expected spot rate plus a random error \( u \) as in

\[
S_{t+1} = E_t S_{t+1} + u_{t+1}
\]

(10)

where \( u_t \) is "white noise."  Using equations (9) and (10), the \textit{ex post} risk premium \( p \) can be written

\[
p_t = S_{t+1} - F_t = E_t S_{t+1} - F_t + u_{t+1} = p_t^{\text{ex ante}} + u_{t+1}
\]

(11)

Equation (11) implies that tests of hypotheses about the unobservable \textit{ex ante} risk premium can be carried out using the observable \textit{ex post} risk premium. Under the null hypothesis of a zero \textit{ex ante} risk premium, the \textit{ex post} premium should follow a white noise process. In particular, it should have a zero mean and be serially uncorrelated. Early tests for these properties failed to reject the hypothesis of a zero \textit{ex ante} risk premium or, in other words, failed to reject the hypothesis that the forward rate is an unbiased forecast of the future spot rate and that the forecast error is serially uncorrelated. These studies took as the alternative hypothesis the existence of a \textit{constant} risk premium and looked only at a single forward rate maturity. More recent studies by Hansen and Hodrick (1980) and Meese and Singleton (1980) that consider the possibility of a risk premium that varies over time reject the hypothesis that the \textit{ex ante} risk premium is zero.

Taking the results of the last two studies as the current state of the art, the question remains, of course, what the determinants of the risk premium are. The portfolio balance model implies (see, for instance, Dooley and Isard (1979 b)) that the outstanding stocks of "outside" assets denominated in each currency as well as the distribution of wealth between, and the portfolio preferences of, the residents of the two countries should be important explanatory variables. Frankel (1979) tested this hypothesis for the dollar/deutsche mark case for the sample period extending from the first quarter of 1973 to the fourth quarter of 1978 and failed to find any statistically significant relationship of the hypothesized type. Dooley and Isard (1979 b) obtained

\[18\] A random variable is said to be a "white noise" process if it has a zero mean, constant variance, and if it is serially uncorrelated.


\[20\] Stockman did allow for differences between periods by splitting his sample into two subperiods.
essentially similar results, although they did not test directly for the existence of a risk premium. They found that relative asset stocks can explain very little of the difference between the future spot exchange rate and the current forward rate, suggesting, on the one hand, that variations in risk premiums cannot explain a very large proportion of the variation of exchange rates and, on the other hand, that most of the movements in spot rates have been unexpected.

Interest rate determination in domestic and Eurocurrency markets

Even if exchange risk is not present, substitutability between domestic and foreign assets may be imperfect because of political risk differentials (as a result, for example, of the possibility of future controls on international capital movements). Dooley and Isard (1980) tested this proposition by investigating the determinants of the differential between Euromark interest rates and comparable rates within the Federal Republic of Germany. Their hypothesis was that in the absence of actual capital controls and political risk, this differential would be zero. By adjusting for the effects of capital controls by means of dummy variables, they were able to isolate statistically significant influences of German and non-German wealth variables on the interest rate differential. These effects were consistent with their portfolio balance theory of the determinants of this differential. Their measure of the supply of outside assets denominated in deutsche mark failed to be significant in the regression, however, a fact that could be rationalized by the opposite influences of political and foreign exchange risks. The implication of this lack of significance for the effects of intervention is that sterilized operations in the foreign exchange market do not influence the differential between Euromark interest rates and domestic rates and therefore, presumably, are also incapable of affecting the exchange rate.

In another recent study of the behavior of differentials between domestic and Euromarket interest rates, Giddy and others (1979) studied the rates on dollar-denominated deposits and loans. They hypothesized that, owing to temporary market imperfections, U.S. rates would react less quickly than Euromarket rates to changes in credit conditions. These market

21 In their framework, this variable captures the effect of sterilized exchange market intervention.
imperfections were ascribed to regulatory restraints, institutional and perceptual factors, and oligopolistic market conditions prevailing in the United States but absent in the Euromarkets. The empirical evidence was consistent with the underlying hypothesis and suggests that tight credit policies in the United States (as a result, for example, of interventions in the foreign exchange market) would temporarily raise Euromarket rates relative to domestic U.S. rates and might through this channel succeed in affecting the foreign exchange value of the dollar. According to the hypothesis advanced by Giddy and others (1979), this influence would only be temporary and would disappear as soon as the market imperfections in the United States became nonbinding.

**Determinants of covered interest rate differentials**

If foreign exchange risk is either absent or not influenced by intervention policy, the portfolio balance model implies that a necessary condition for fully sterilized intervention to have some effect on the exchange rate is that it influence the covered relative yield on domestic and foreign assets. It is possible to derive a well-defined relationship between the covered interest differential and variables like the outstanding stocks of "outside" assets denominated in each currency, their distribution between countries, and the distribution of wealth between countries. In this framework, intervention would modify the supplies of assets available to the public and, hence, would affect the covered interest differential unless the assets used in the intervention operations were essentially perfect substitutes. Genberg (1981 a) tested this latter prediction by regressing the covered interest differential between the United States and the Federal Republic of Germany, and between the United States and Japan, on asset stocks, wealth, and intervention variables for the period extending from the third quarter of 1974 to the first quarter of 1980. On balance, the evidence from these regressions gave very little support for the prediction of the portfolio balance

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22 The qualification is necessary, since models of exchange rate determination have not yet incorporated market imperfections of the type considered in the Giddy and others (1979) paper. Their influence on exchange rate movements is thus uncertain.

23 This statement abstracts from the expectational consideration discussed in the previous subsection entitled "Expectation, effects and related issues."

24 See, for instance, Dooley and Isard (1979 b, 1980) and Kouri (1976).
model concerning movements in covered interest differentials. This was particularly true for the Federal Republic of Germany. Applied to the intervention issue, these results indicate that the German authorities can expect to see very minimal effects of any intervention in the foreign exchange market as long as intervention is prevented from influencing the money supply. The effect of intervention on the exchange rate may be somewhat more pronounced in Japan, but comparing the estimates obtained from dividing the entire sample into two subperiods, the relationships involved seem to be unstable over time and may therefore not be useful to policymakers.

OVERALL EVALUATION

The empirical evidence on the influence of intervention policy on exchange rate movements is mixed. As was shown previously, when variables measuring intervention activity are included directly in estimated exchange rate equations, they almost always fail to show an influence of the predicted type. On occasion, intervention seems even to lead to exchange rate movements in the “wrong” direction. Supplies of nonmonetary assets also often fail to be significant explanatory variables in these equations, contrary to what one would expect if intervention were effective. Current account developments, though, have had significant influence on exchange rates, which, in the portfolio balance framework, may be an indication of potential for sterilized intervention to alter spot rates. The significance of current account balances is, however, also consistent with other models of exchange rate determination in which sterilized intervention is ineffective.

As noted previously, the inconclusive nature of these results may be due to difficulties in taking appropriate account of exchange rate expectations in empirical tests and to the inadequacy of data on intervention and, more generally, on international capital flows and the international distribution of financial wealth by currency composition.

The evidence drawn from studies concerned more directly with the substitutability between domestic and foreign assets is similarly inconclusive. On the one hand, evidence appears to indicate that nondiversifiable exchange risk or political risk, or both, may exist in international financial markets, suggesting that portfolio preferences might be exploited by intervention
policy to influence spot rate movements. But studies attempting to link fluctuations in risk premiums to such policies have been singularly incapable of detecting any systematic and statistically significant effects. As before, the conflict between these findings may result from the unreliability of the data on international holdings of assets by currency denomination. Another possibility is that many of the tests performed to date—being joint tests of the hypotheses of rational expectations, market efficiency, and the existence of risk premiums—are not powerful enough to be able to pinpoint the size and causes of risk premiums in foreign exchange markets.

In view of the very weak evidence of the effectiveness of intervention policy, one may legitimately ask why intervention in foreign exchange markets is so common. Two considerations show that there is not necessarily any conflict between empirical evidence and practice.

First, it may be that the time horizon of central banks for intervention policy is typically much shorter than the one adopted in this paper and the studies reviewed here. Intervention may be carried out mainly in order to influence day-to-day, or even shorter-term, swings in exchange rates and therefore may be reversed over periods as long as a month or a quarter. In this case, studies that are based on these longer time horizons may fail to detect any effects of intervention even though, from the point of view of the objective of the intervening authorities, the policies did have the desired effects.

Second, it should be remembered that, in this paper, "intervention" refers to foreign exchange market operations that are prevented by sterilization policies from influencing the domestic money supply. Countries may not always sterilize completely, although there is considerable evidence that they regularly sterilize to some degree. Incompletely sterilized intervention, by altering the money supply, is likely to be effective, even with high substitutability of international assets. There is thus no conflict between the fact of substantial actual intervention activity and the observation that sterilized intervention is ineffective.

25 See Black (1980) for a recent analysis and a description of intervention policies during the 1973–78 period that show central bank operations in the foreign exchange market have been quite prevalent.
III. Implications for Conduct of Policy

If the empirical evidence just reviewed is taken, as it probably should be, to indicate that the effect of sterilized intervention in the foreign exchange market on the exchange rate is negligible or so uncertain that it cannot be employed with the required degree of accuracy, then intervention policy and money supply policy become inextricably linked. The choice of a strategy for the management of the money supply becomes dependent on the choice of intervention strategy, and vice versa. This interdependence, in turn, suggests a number of considerations that must be kept in mind when monetary policy is formulated.

First of all, it should be emphasized that the results do not imply that intervention policy should not be pursued or that monetary policy should not use the exchange rate as an indicator or not be conducted with the aim of achieving a specific exchange rate target. The theory of optimum currency areas and the theory of optimal intervention policy (see, for instance, Boyer (1978)) suggest that, in some circumstances, domestic monetary policy should be aimed at keeping the exchange rate fixed relative to some foreign currency or group of currencies, or that movements in the exchange rate may convey information that should be incorporated in monetary policy decisions. What the results do suggest is that money supply and intervention policies should not be pursued independently.

The theoretical discussion indicates that by attempting to conduct intervention policy independently of monetary policy, the monetary authorities may unintentionally generate unintended and destabilizing movements in the exchange rate. This is because the two policies, unless they are coordinated, may convey different signals to the market, which, in turn, will lead to expectations causing instability and surprising movements in the exchange rate. It follows, therefore, that the central bank should be clear and explicit about the objective of monetary policy and should manage both the money supply and operations in the foreign exchange market with this single objective in mind. Since expectations with respect to objectives of monetary policy have large effects on exchange rate movements, there is little to be gained from being secretive about the objective of intervention policy and from attempting to pursue such policy and money supply policy independently. This is true not only for medium- and longer-run intervention policy but also for short-
run interventions. Unless the objective of such policy and its relation to medium-term management of the money supply are clearly understood, short-run operations in the foreign exchange market may, through their effect on recorded money supply figures, lead to unintended changes in expectations about the future stance of policy.

The theoretical discussion also shows that intervention policy of one country will influence monetary and credit conditions in other countries. The ultimate effect on the exchange rate will therefore depend on how these other countries react to such influences. It follows that intervention policy, in order to have the intended effect, must be carried out with explicit account being taken of foreign policy responses. 26 This may be most easily done if operations in the foreign exchange markets are coordinated internationally. A minimum requirement in this respect is that explicit or implicit exchange rate targets be consistent across countries.

The previous paragraph suggests a clear-cut role for international organizations charged with monitoring the international monetary system. The empirical evidence on the effectiveness of sterilized intervention as well as the theoretical models emphasizing the role of the supplies of nonmonetary assets furthermore imply that in monitoring exchange rate policies, account must be taken not only of intervention policy per se but also of the equally important policies affecting the supply of, and the demand for, other assets, be they internationally traded or not.

REFERENCES


26 Note that not only intervention policy but also open market operations in domestic assets will, in general, have repercussions on conditions in foreign financial markets. For small countries in particular, feedbacks from such repercussions ought to be taken into account in formulating domestic policy.


CENTRAL BANK INTERVENTION IN FOREIGN EXCHANGE MARKET


