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CRITICAL DETERMINANTS OF THE EFFECTIVENESS OF MONETARY POLICY
IN THE OPEN ECONOMY

by

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Critical Determinants of the Effectiveness of Monetary Policy
in the Open Economy*

During the 1960's, rapid movements of large amounts of liquid financial capital increasingly frustrated attempts by the authorities in individual countries to conduct monetary policies that diverged to any great extent from those being followed in the world at large. The unwillingness of monetary authorities to reconcile themselves to limited opportunities for pursuing domestic objectives within the constraints imposed by the par value system led to the breakdown of that system and its replacement by a system of managed floating. It is important to identify the features of the monetary policy-making environment which contributed to these developments

In this paper a short-run, two-country model of financial markets is used to isolate some of the factors which influence the effectiveness of monetary policy in national economies which are part of a highly integrated world economy. The authorities in any single economy are constrained in pursuing domestic objectives with monetary policy by the monetary policies pursued abroad, by the practical implications of a reserve currency system, by the extent to which they are committed to an exchange rate target, by the degree to which financial assets issued in their country are regarded by private wealth holders as substitutes for financial assets issued abroad, and by the relative economic size of their country. After the basic model is described, each of these determinants of the effectiveness of monetary policy is discussed in turn.

* This paper was presented at the Conference on Bank Credit, Money, and Inflation in Open Economies held in Leuven, Belgium on September 15 and 16, 1974 and has been published as Girton and Henderson (1976). The results discussed in Section II and some of those discussed in Sections IV and V were first reported in Girton and Henderson (1973).

The authors would like to express their appreciation to their colleagues in the International Finance Division for helpful comments and suggestions. No one but the authors is responsible for the paper's remaining shortcomings. The analysis and conclusions of this paper should not be interpreted as representing the views of the Board of Governors of the Federal Reserve System or anyone else on its staff.

I. The Model

The model developed here is designed to analyze the effects of monetary policy on financial asset markets in the short-run. Monetary policy actions cause instantaneous adjustments in interest rates, the financial asset holdings of both wealth holders and central banks, and, under flexible exchange rates, the exchange rate. However, monetary policy actions are assumed to affect home currency price levels, incomes, and employment levels with a lag, and these variables are regarded as predetermined. In accordance with the short-run nature of the model, the effects of savings on wealth and the effects of investment on the capital stock are ignored.

The model contains two countries, the United States (U.S.) and the United Kingdom (U.K.). The U.S. currency is the dollar; the U.K. currency is the pound. The behavior of four groups is analyzed: wealth holders in the U.S., wealth holders in the U.K., the U.S. central bank (the Federal Reserve, or FR), and the U.K. central bank (the Bank of England, or BOE).

It is assumed that there are only four types of assets: dollar deposits (U.S. money), pound deposits (U.K. money), dollar denominated securities (U.S. securities), and pound denominated securities (U.K. securities).^{1/} All deposits are liabilities of one of the two central banks,^{2/} and each central bank accepts only deposits denominated in its country's currency.^{3/} The nominal interest rate on deposits is fixed at zero. Securities are fixed in nominal value in the currency of the country in which the issuer resides and have variable nominal interest rates.

The exchange rate, S , defined as the dollar price of pounds, may be fixed by the central banks or may be flexible. The expected percentage change in the exchange rate, s , is the same for all wealth holders.^{4/} s is assumed to be a given number, usually zero, under fixed rates and is taken to be a decreasing function of the gap between the current exchange rate and its "normal" level, \bar{S} , under flexible rates:

$$s = s(S - \bar{S}), \quad s_{S - \bar{S}} < 0.$$

This formulation implies that expectations are stabilizing, and it is retained through most of the analysis though occasionally reference is made to the case of destabilizing expectations ($s_{\bar{s}} - \bar{s} > 0$).

Wealth holders in each country hold domestic money and both types of securities. They regard the three assets they hold as imperfect substitutes.^{5/} Wealth holders in the U.S. base their nominal demands in terms of dollars for U.S. securities, B^d , for U.K. securities, SF^d , and for U.S. money, M^d , on their existing dollar denominated nominal wealth, W . It is assumed that the fraction of their nominal wealth which they wish to hold in each of these three assets depends on the interest rate on U.S. securities, r , and the interest rate on U.K. securities adjusted for the expected rate of depreciation of the dollar, $r' + s$, but not on their current savings^{6/} so that

$$B^d = b(r, r' + s)W, \quad (1)$$

$$SF^d = f(r, r' + s)W, \quad (2)$$

$$M^d = m(r, r' + s)W. \quad (3)$$

Similarly, U.K. wealth holders base their pound denominated nominal demands for U.S. securities, $\frac{1}{S}B^{d'}$, for U.K. securities, $F^{d'}$, and for U.K. money, $N^{d'}$, on their existing pound denominated nominal wealth, W' , so that

$$\frac{1}{S}B^{d'} = b'(r-s, r')W', \quad (4)$$

$$F^{d'} = f'(r-s, r')W', \quad (5)$$

$$N^{d'} = n'(r-s, r')W'. \quad (6)$$

W and W' are given by

$$W = M^A + B^A + SF^A,$$

$$W' = N^A + \frac{1}{S}B^A + F^A,$$

where the superscript (A) denotes actual holdings of a given asset.

The balance sheet constraint for U.S. wealth holders requires that the sum of their nominal demands for all assets must be equal to their wealth which is defined to be the sum of the nominal values of the securities and money they currently hold. This constraint implies that b, f, and m must sum to one and that the sum of the partial effects on the three asset demands of a change in either of the two interest rates must be zero.^{7/} U.K. wealth holders face a similar balance sheet constraint. Thus, two of the three asset demand functions are independent in each country. The two securities and home country money are assumed to be strict gross substitutes in the portfolios of wealth holders in each of the two countries. This assumption means that if the interest rate on a given security rises, desired holdings of that security increase while the desired holdings of the other security and money decline.

The liabilities of the FR are the stock of U.S. money held by the U.S. public, M^S , and the stock of dollars held by the BOE, $M^{C'}$; its assets are its holdings of U.S. securities, B^C , and the dollar value of its outside reserve assets, σR .^{8/} R is the FR holding of outside reserve assets, and σ is the dollar price of outside reserve assets. The FR balance sheet is

$$M^S = B^C + \sigma R - M^{C'} + A \quad (7)$$

where A is a balancing item which changes to offset changes in σ .^{9/} For the BOE we have

$$N^{S'} = F^{C'} + \sigma' R' + \frac{1}{S} (B^{C'} + M^{C'}) + A' \quad (8)$$

where $N^{S'}$ is the stock of U.K. money held by the U.K. public, $F^{C'}$ is the BOE holdings of U.K. securities, σ' is the pound price of outside reserve assets, R' is the BOE holdings of outside reserve assets, S is the dollar price of pounds, $B^{C'}$ is the dollar value of BOE holdings of U.S. securities, $M^{C'}$ is the dollar value of BOE holdings of U.S. money, and A' is a balancing item which changes to offset changes in σ' and S . The total world supply of outside reserve assets (\bar{R}) is fixed, that is,

$$\bar{R} = R + R'. \quad (9)$$

Equilibrium in the world market for U.S. securities requires that the supply of U.S. securities available to the public, B^S , given by the total supply of U.S. securities, \bar{B} ,^{10/} minus the holdings of the FR and the BOE, equal the demand for these securities by wealth holders in the two countries:

$$B^S = \bar{B} - B^C - B^{C'} = b(r, r' + s)W + Sb'(r-s, r')W'. \quad (10)$$

Similarly, the supply of U.K. securities available to the public, F^S , given by the total supply of U.K. securities, \bar{F} , minus the holdings of the BOE, must equal the demand for these securities by wealth holders so that, in dollar terms,

$$SF^S = S(\bar{F} - F^{C'}) = f(r, r' + s)W + Sf'(r-s, r')W'. \quad (11)$$

Using the central bank balance sheet identities and the fact that the total supply of outside reserve assets is fixed, the money market equilibrium conditions for the two countries can be written as follows:

$$M^S = B^C + \sigma R - M^{C'} + A = m(r, r' + s)W, \quad (12)$$

$$SN^S = S[F^{C'} + \sigma'(R-R)] + B^{C'} + M^{C'} + SA' = Sn'(r-s, r')W'. \quad (13)$$

Three of the four market equilibrium conditions are independent, so three endogenous variables can be determined.^{11/} Different sets of three variables are taken to be endogenous at different stages in the study depending upon the situation which is being analyzed. In one important case under fixed rates, for example, the two interest rates, r and r' , and the stock of reserves held by the FR, R , are regarded as being endogenously determined, and all the other variables are considered to be given exogenously.

The policy tools of the monetary authorities in the two countries are asset exchanges which alter the composition of the balance sheets of the authorities and the public, while in the first instance at least, leaving the size of these balance sheets

unchanged. The two central banks, taken together, have three independent policy tools with which they can attain three objectives subject to the proviso that the two central banks cannot achieve conflicting values of a single variable such as R or S . Perhaps the easiest way to understand the opportunities open to the authorities is to consider the set of independent equations (10) - (12) and to note that the U.K. central bank can use a different asset exchange to shift each of the three equations while leaving the other two unaffected. All of the other possible asset exchanges available to the two central banks can be shown to be linear combinations of these three exchanges. This observation makes quite clear what it means for the monetary authorities to agree to support a preestablished par value under a fixed exchange rate regime or adopt an exchange rate target under a regime of managed floating. In either case, one policy tool is committed to attaining an exchange rate objective and is not, therefore, available for any other purpose. Whatever the supposed benefits from pegging the exchange rate, they must be weighed against the costs imposed by the loss of a degree of policy making freedom.

In Figure 1, four schedules are plotted which show the pairs of r and r' which are compatible with equilibrium in each of the four financial asset markets. The curve labeled B_0B_0 gives the combinations of r and r' for which the private demand for securities issued in the U.S. is equal to the fixed supply of securities issued in the U.S. minus the holdings of U.S. securities by the FR and the BOE. The curve slopes upward; an increase in r causes an excess demand for U.S. securities so that r' must rise in order to cut demand back until it matches the fixed supply of U.S. securities available to wealth holders. Minus (plus) signs in a region near the schedule for a given market indicate that the interest rate pairs in that region imply excess supply (demand) in that market; vertical (horizontal) arrows represent the direction of pressure on r (r') in each of the regions. The curve labeled F_0F_0 represents the combinations of r and r' which insure that wealth holders' demands for securities issued in the U.K. are equal to the available supply. The F_0F_0 curve is

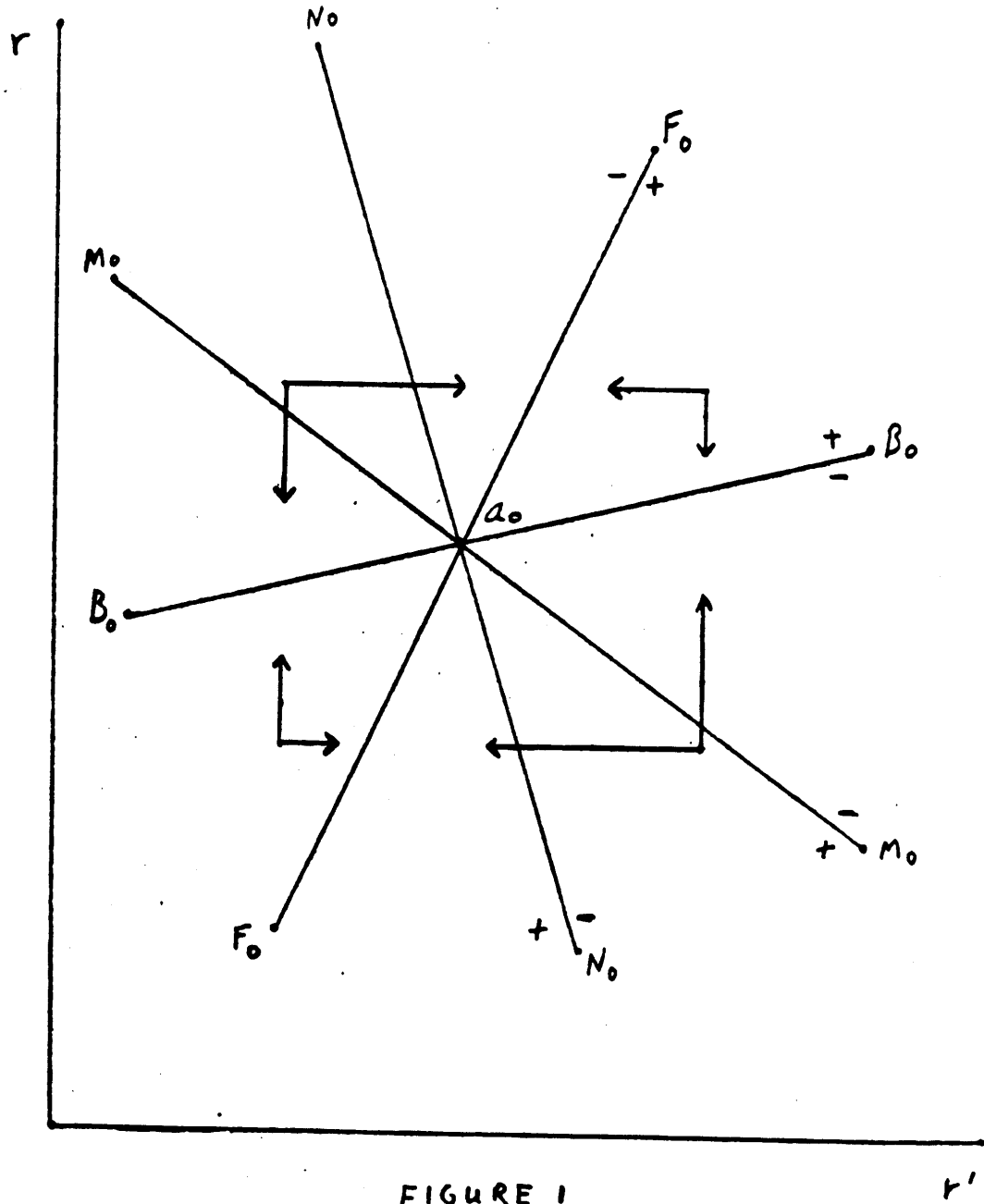


FIGURE 1

positively sloped; an increase in r is required to offset the excess demand caused by an increase in r' if private wealth holders are to continue to be satisfied holding the available supply of U.K. securities. Combinations of r and r' that equate the demand for and supply of U.S. money, given a fixed U.S. money supply available for the public to hold, are plotted as the M_0M_0 curve. The M_0M_0 curve is negatively sloped since an increase in either r or r' reduces the demand for U.S. money. Combinations of r and r' that equate the demand for the fixed supply of U.K. money are plotted as the N_0N_0 curve. The N_0N_0 curve is negatively sloped since an increase in either r or r' reduces the demand for U.K. money.

The assumption that the three assets held by wealth holders in each of the two countries are strict gross substitutes, insures that the slope of the F_0F_0 curve must be greater than the slope of the B_0B_0 curve. Suppose that all four markets are in equilibrium as at a_0 . At every point in the quadrant northeast of a_0 , there are excess supplies of the two kinds of money. The balance sheet constraints for wealth holders imply that the sum of the excess supplies for all assets must be zero, so at no point in the quadrant can there be excess supplies of both of the two securities. This possibility is ruled out only if F_0F_0 is steeper than B_0B_0 .

It is assumed that wealth holders in each country regard their currency as a better substitute for the security denominated in that currency than for the security denominated in the other currency. This plausible assumption is sufficient to insure that the N_0N_0 curve has a steeper (more negative) slope than the M_0M_0 curve.

Interest rate changes alone are not sufficient to insure that three independent schedules will have a common intersection point. A third variable not shown explicitly on the graph, for example, the stock of reserves held by the FR, must be free to vary in order to insure that a common intersection exists. If three of the four schedules intersect at a common point, the fourth schedule must also pass through that point. It is useful to retain all four schedules even though in a given situation three schedules are sufficient to determine the equilibrium values of the endogenous variab

II. The Effectiveness of Monetary Policy Under Fixed Exchange Rates and Alternative Reserve Regimes

The discussion of instruments and targets above makes it clear that, even when central banks have agreed to keep the exchange rate fixed, the two central banks, taken together, still have available two policy instruments. Each central bank can, in general, use open market operations in the security denominated in its country's currency to achieve a monetary policy objective. Exactly what size open market operation is required to attain a specified objective and exactly what effects on other variables are associated with that open market operation depend both on the monetary policy response of the other central bank and on the form in which changes in international reserves are held. If the FR undertakes an open market operation, the BOE may respond by remaining passive, stabilizing the U.K. interest rate, or stabilizing the U.K. money supply. Institutional arrangements and BOE preferences may make it possible and desirable for the BOE to take all of its reserve changes in the form of outside reserve assets such as gold or SDR's. Proposals for full asset settlement considered by the Committee of Twenty envisioned such an "outside reserve regime". Alternatively, the BOE may desire or consider itself constrained to hold changes in its reserves in the form of claims denominated in the "key currency", U.S. dollars.

In Figure 2 we trace the implications of an expansionary open market operation by the FR for a variety of BOE policy responses under the assumption that all reserve changes are held in the form of outside reserves. The initial equilibrium position is given by the intersection of the curves with the $(_0)$ subscript. If the U.S. authorities increase their holdings of U.S. securities by a given amount and then allow no further change in these holdings, the BB curve shifts down, say from B_0B_0 to B_1B_1 since, for a given value of r' , the public will hold a reduced supply of U.S. securities only if r is lower. The new equilibrium must be on the new BB curve.

Consider the case in which the BOE remains passive, neither buying nor selling U.K. securities. In order to increase its holdings of U.S. securities by a given

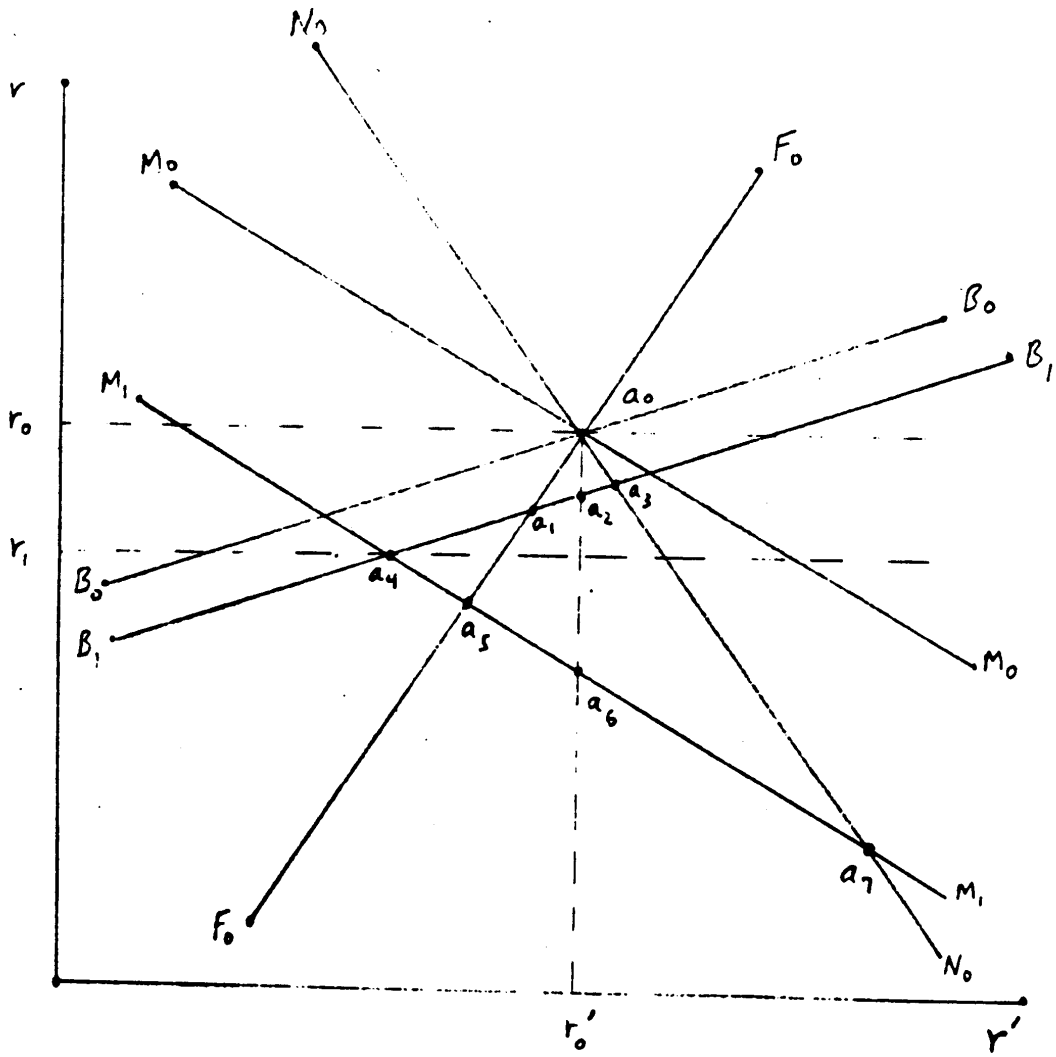


FIGURE 2

amount, the FR offers to supply dollar deposits in exchange for U.S. securities. At the initial interest rate pair there is excess demand for U.S. securities and an excess supply of U.S. money. FR bidding for U.S. securities leads to a downward movement in r , an increase in private demand in the U.S. and U.K. for U.K. securities, and a downward movement in r' . As interest rates are bid down, an excess demand for U.K. money appears; this development coupled with the remaining excess supply of U.S. money results in upward pressure on S . In order to keep S from rising, the BOE must buy dollars for pounds, an action which reduces the U.S. money supply and raises the U.K. money supply by equal amounts measured in dollars. Thus, the initial excess supply of money in the U.S. is removed partly by increases in the U.S. demand for money and partly by decreases in the U.S. money supply matched by increases in the supply of and demand for U.K. money. Money demands increase, and U.S. security demands fall in both countries because of interest rate declines. The FR loses reserves because the BOE converts the proceeds of its exchange rate stabilization operations into reserve assets.

The size of the FR reserve loss can be represented graphically. If the U.S. public increased its money holdings by an amount exactly equal to the quantity of securities the FR purchases, the MM curve would be shifted from M_0M_0 to M_1M_1 which must lie below the intersection of B_1B_1 and F_0F_0 . However, the U.S. public actually increases its money holdings by an amount corresponding to the distance between M_0M_0 and the MM curve (not shown) which passes through a_1 . The part of the initial excess supply of money which is removed by a decline in the U.S. money supply and a matching loss of reserves by the FR is represented by the distance between M_1M_1 and the MM curve which passes through a_1 .

If the BOE stabilizes r' , the new equilibrium is at a_2 , and if it stabilizes the U.K. money stock, the new equilibrium is at a_3 . Successively larger sales of U.K. securities which shift FF until it passes through a_2 or a_3 are required by these two responses. Successively less of the initial excess supply of U.S. money is removed by interest rate declines which raise the U.S. demand for money, and successively more

of the initial excess supply is removed by decreases in the U.S. money supply matched by losses of reserves by the U.S. The reserve losses can be represented by the distances between M_1M_1 and MM curves which pass through a_2 and a_3 respectively. The actions of the BOE when it sterilizes present a sharp contrast to its actions when it is passive. Instead of being content to trade U.K. money for U.S. money, the BOE takes measures which are tantamount to replacing that part of the U.S. money stock which it receives through the exchange market with U.K. securities.

The BOE can pursue a fourth kind of policy response; it can stabilize its stock of international reserves. In order to keep from gaining reserves, the BOE must see to it that interest rates move so as to make U.S. residents content with an increase in their money holdings exactly equal to the amount of securities the FR wants to buy. To achieve its desired result, the BOE must buy enough securities to shift FF from F_0F_0 until it passes through the intersection of B_1B_1 and M_1M_1 at point a_4 . Since the supplies of both securities are reduced, both interest rates must end up lower than in the original position. At these lower rates, U.K. residents are content to increase their money holdings by an amount equal to the open market purchases of the BOE.

The discussion above of FR open market operations provides all the information necessary for analyzing FR actions designed to increase the U.S. money supply (say from the level represented by M_0M_0 to that represented by M_1M_1), or to lower the U.S. interest rate (say from r_0 to r_1), given various BOE policy responses under the outside reserve regime. In order to obtain either of these two objectives, larger and larger open market operations must be undertaken and larger and larger reserve losses incurred as the BOE policy response moves from passiveness, to interest rate stabilization, to money stock stabilization. The effectiveness of FR monetary policy in terms of "bang per buck" and the costs associated with using it depend upon the reactions of the BOE.

It is interesting to ask how the policymaking environment for the FR is changed if the BOE takes changes in its international reserves in the form of assets denominated

in dollars since the international monetary system conformed more and more closely to this "key currency reserve regime" during the final decade of the Bretton Woods system.^{12/} The first point to note is that if the BOE holds its reserve changes in the form of U.S. money, no change is required in the preceding analysis, since whether or not the BOE converts the proceeds of its support operation into outside reserves has no effect on the position of the four schedules. However, virtually all changes in international reserves are taken in the form of interest bearing assets, so the most interesting case arises when the BOE takes its reserve changes in the form of U.S. securities. In this case, an open market operation by the FR, which shifts the BB curve from B_0B_0 to B_1B_1 in Figure 2, raises the U.S. money supply from the level associated with M_0M_0 to the level associated with M_1M_1 no matter what the monetary policy response of the BOE. Suppose, for example, that the BOE follows a passive monetary policy. The FR offer to supply dollar deposits in exchange for U.S. securities creates downward pressure on r and r' and upward pressure on S . There is a tendency for the U.S. money stock to decline as the FR makes net purchases of securities from U.K. residents. However, the dollars acquired by the BOE in its support operation are neither held as deposits nor converted into outside reserves, but rather are used to purchase U.S. securities in the market, so the U.S. money supply remains constant.^{13/} When the non key currency country holds changes in reserves in the form of key currency securities, they, in effect, sterilize the key currency country's money supply. The reserve accumulations by the BOE cause BB to shift from B_1B_1 until it passes through a_5 and cause further downward movements in r and r' , movements which are required for equilibrium to be attained given that the U.S. money stock is kept constant.

While the effect of an open market operation by the FR on the U.S. money supply is independent of the monetary policy response of the BOE under the key currency reserve regime, the effect on the U.S. interest rate is not. If the BOE stabilizes r' instead of remaining passive, the equilibrium is at a_6 , and if the BOE stabilizes N^S , the equilibrium is at a_7 . Thus, in contrast to the result obtained under the outside

reserve regime, the effectiveness of an open market operation by the FR in lowering r is greater the smaller the change which the BOE permits in its money supply. This result arises because sales of U.K. securities by the BOE reduce (increase) the downward (upward) pressure on r' so that r must fall farther to make U.S. residents willing to hold the U.S. money stock corresponding to $M_1 M_1$.

Two conclusions can be drawn regarding U.S. reserve losses (increases in U.S. liabilities to the BOE) associated with an expansionary open market operation by the FR under the key currency reserve regime. First, just as in the case of the outside reserve regime, U.S. reserve losses become greater as the BOE policy response progresses from passiveness to interest rate stabilization to money stock stabilization. To see this, compare the shifts in BB which are required to move it from $B_1 B_1$ to a_5 , a_6 , and a_7 respectively. Second, for any specified policy response by the BOE, the FR loses more reserves as a result of an open market operation of a given size under the key currency regime than under the outside reserve regime. For a passive response by the BOE, reserve gains are reflected in the NN schedule which must shift farther to reach a_5 than to reach a_1 ; for a money stock stabilization response by the BOE, reserve gains are reflected in the FF schedule which must shift farther to reach a_7 than to reach a_3 . Both of these conclusions and the conclusions regarding reserve changes under the outside reserve regime are special cases of a more general result. This result, which is proved elsewhere, is that for any given shock to portfolio equilibrium, the less reserve changes are allowed to affect money supplies, the larger the total reserve change required to reestablish equilibrium.^{14/}

Up to this point, the effectiveness of monetary policy has been measured in terms of the change in a specified target variable associated with an open market operation of a given size. Using this criterion, FR monetary policy is more effective under the key currency reserve regime. However, it has higher costs in terms of reserve losses. An alternative way of measuring the effectiveness of monetary policy is in terms of the change in a specified target variable associated with a change in reserv

holdings of a given size. Using this criterion, FR monetary policy is equally effective under both reserve regimes. To see this, simply observe that in order for the FR to achieve a specified objective, such as the money supply represented by M_1M_1 or the interest rate r_1 in Figure 2, with a given monetary policy response by the BOE it must experience the same reserve loss under both reserve regimes.

It is important to remember, however, that the FR may face a less binding reserve constraint under the key currency reserve regime. An open market purchase involves a loss of outside reserves under the outside reserve regime and an increase in U.S. liabilities to foreign official holders under the key currency regime, and the FR may feel or actually may be more constrained from undertaking an expansionary open market operation by the former than by the latter.

For the U.K., the situation is somewhat different. Figure 3 shows the effect of an expansionary open market operation by the BOE which shifts FF from F_0F_0 to F_1F_1 . With passive behavior by the FR, the new equilibrium is at a_3 under the key currency reserve regime, while under the outside reserve regime it is at a_1 . The open market operation leads to smaller changes in N^S and r' and involves larger reserve losses under the key currency reserve regime, so U.K. monetary policy is less effective in terms of both of the measures considered above. Of course, if the FR stabilizes r , a_2 is reached under both regimes, and, if the FR stabilizes M^S under the outside reserve regime, a_3 is attained under both regimes. The monetary policy environment for the BOE is at best left unchanged if a key currency reserve regime is substituted for full asset settlement, and it may be made more unfavorable.

III. The Effectiveness of Monetary Policy and Intervention Policy

Under the current regime of managed floating, central banks need not intervene to support predetermined par values. If exchange rates are allowed to vary, given sized monetary policy actions have larger impacts on target variables under many circumstances.

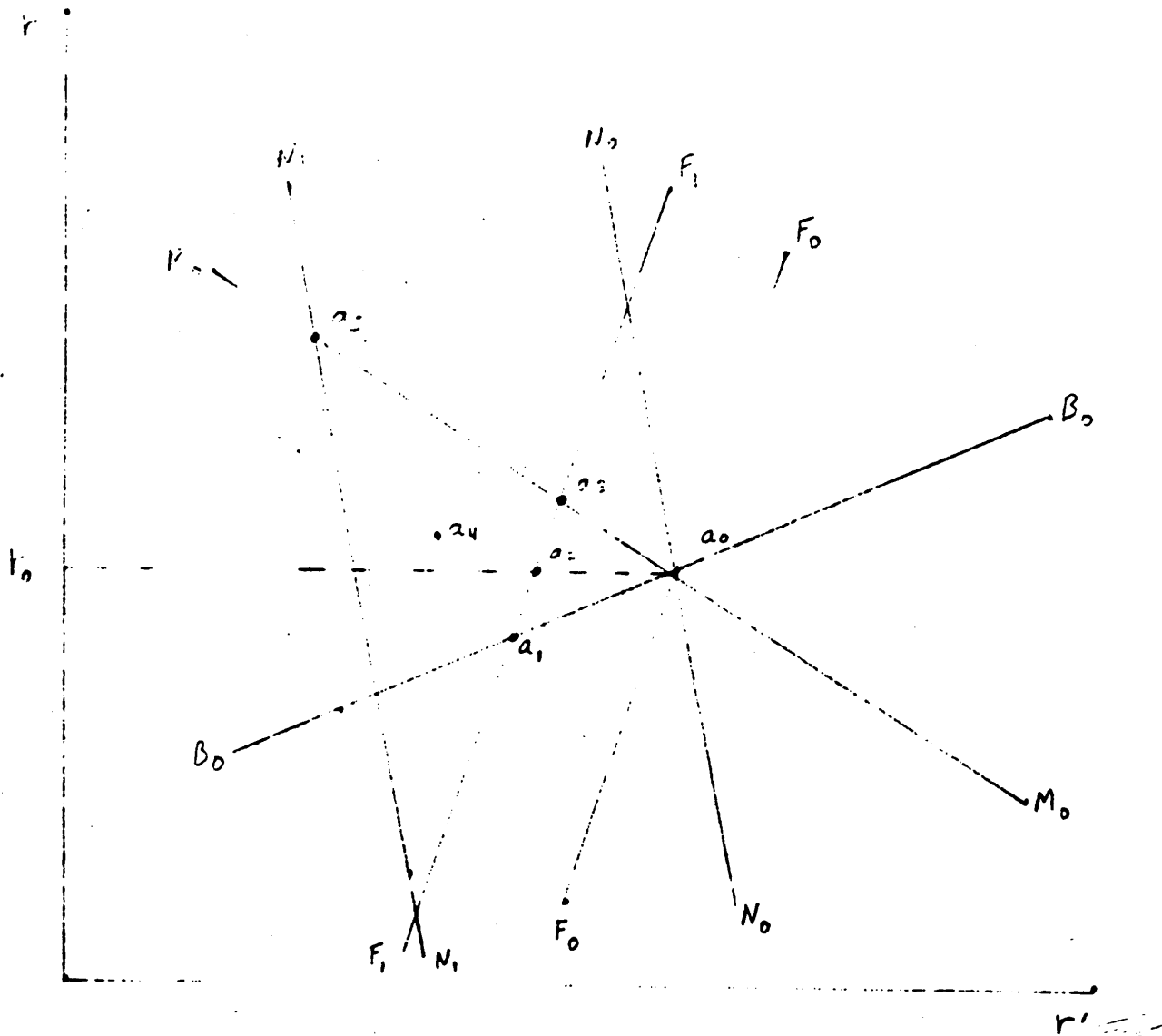


FIGURE 3

A first step in analyzing the impact of different types and degrees of intervention on the effectiveness of monetary policy is to consider the effect of an open market operation under freely floating exchange rates. Suppose the BOE undertakes an expansionary open market operation and the FR remains passive. The original equilibrium is given by the intersection of the schedules with the $(_0)$ subscript at a_0 in Figure 3, and the BOE open market purchase shifts FF and NN to F_1F_1 and N_1N_1 respectively. At unchanged values of r , r' , and S , there is an excess supply of U.K. money and an excess demand for U.K. securities. The excess demand for U.K. securities puts downward pressure on r' which tends to create excess demand for U.S. securities with resulting downward pressure on r ; the excess supply of U.K. money puts downward pressure on S , the dollar price of pounds. The depreciation of the pound stimulates demand for pound assets shifting N_1N_1 and F_1F_1 upward for two reasons. First, the dollar value of U.S. wealth falls, and the pound value of U.K. wealth rises.^{15/} But these changes accrue completely in the form of reduced values of pound holdings in the U.S. and increased pound values of dollar holdings in the U.K., so that both groups want more pound assets. Both groups also want fewer dollar assets, so M_0M_0 shifts down, and B_0B_0 shifts up. Second, given our assumption of stabilizing expectations, a decline in S causes s to rise, a movement which stimulates demand for pound assets and reduces demand for dollar assets. Even if expectations are destabilizing, the schedules will shift in the directions described above if the wealth effects are strong enough.^{16/} The new equilibrium pair of r and r' must lie within the kite-shaped area bounded by the M_0M_0 , N_1N_1 , B_0B_0 , and F_1F_1 schedules, say at a_4 . Thus, the expansionary open market purchase by the BOE with the FR passive lowers r' and S , but the net effect on r is indeterminate. The U.S. interest rate will fall (rise) if the leftward shift in the M_0M_0 schedule due to a decrease in S is greater (less) than the leftward shift in the B_0B_0 schedule resulting from a decrease in S . An interesting special case of the model arises when money demands do not depend on wealth and when the expected

change in the exchange rate does not depend on its level so that money demands in both countries are independent of S .^{17/} In this case, the equilibrium is at a_5 , and r definitely rises.

Comparing the results of a U.K. open market purchase under flexible rates with the results under fixed rates, it is clear that monetary policy is more effective in most cases. As is well known, with a freely floating exchange rate an open market purchase increases the money supply by the full amount of the purchase, whereas under fixed rates, the same operation by a non key currency country which does not sterilize increases the money supply by only a fraction of the amount of the operation. Less obviously, an open market purchase must lower r' by more with flexible rates than it would with fixed rates and a constant U.S. money supply; a_4 must lie to the left of a_3 . This result is important, since when rates are fixed, it is quite likely that the FR would remain passive under a key currency regime or would sterilize under an outside reserve regime. In these situations the M_0M_0 schedule represents the opportunity set for the BOE, and, by letting the exchange rate vary, the BOE can cause this opportunity locus to shift in a favorable way.^{18/} An open market purchase lowers r' by more under flexible rates than it would under either fixed rate regime given an interest rate stabilization policy by the FR; a_4 must lie to the left of a_2 on the dashed line, indicating a constant r . An open market purchase may lower r' by more or less with flexible rates than it would with fixed rates and a passive response by the FR under an outside reserve regime. r' is lowered by more (less) with flexible rates if the upward shift in the F_1F_1 schedule due to a decrease in S is greater (less) than the upward shift in the B_0B_0 schedule resulting from a decrease in S .

Perhaps more interesting from a policy-making point of view is the regime of managed floating under which the authorities are willing to let the exchange rate move to some extent for some purposes, but intervene to keep it from moving freely. Suppose the BOE performs an open market operation which shifts FF and NN from F_0F_0 and N_0N_0 to F_1F_1 and N_1N_1 in Figure 4, and decides to allow the exchange rate to depreciate

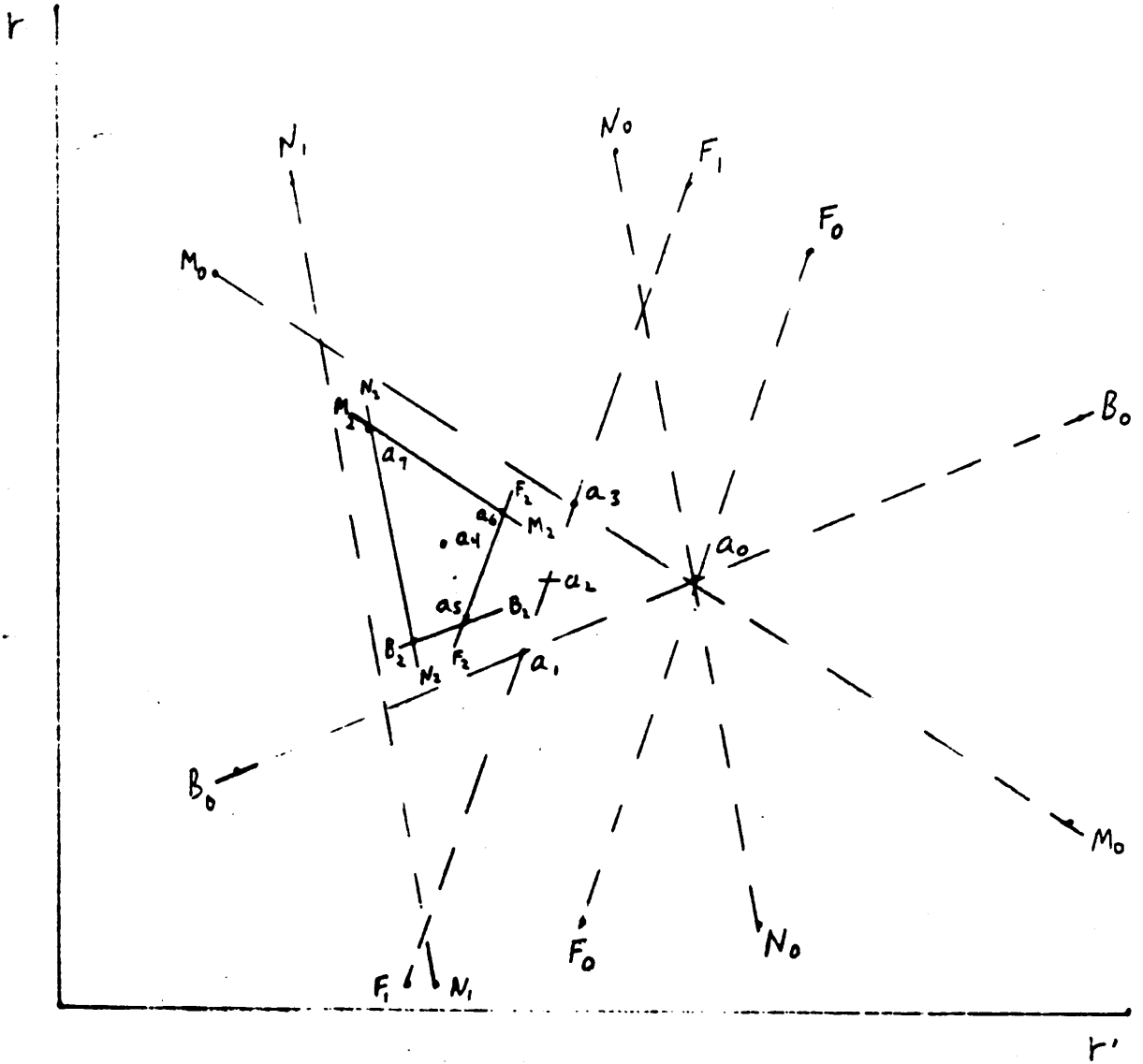


FIGURE 4

enough to shift M_0M_0 , B_0B_0 , F_1F_1 , and N_1N_1 to M_2M_2 , B_2B_2 , F_2F_2 , and N_2N_2 . Exactly where the new equilibrium point is located depends upon the intervention policy used by the BOE to keep S from declining further. If the BOE buys U.K. money with U.S. money, the MM and NN curves are shifted until they pass through a_5 which lies to the left (right) of a_1 if a_4 (the equilibrium under freely floating rates) lies to the left (right) of a_1 . The U.K. money supply increases by more than it would under fixed exchange rates and by less than it would under freely floating exchange rates. If the FR sterilizes the effect of the purchase of pounds for dollars by the BOE on its money supply, or if the BOE sells off dollar securities and uses the proceeds to purchase U.K. money, the NN and BB curves are shifted until they pass through a_6 which must lie to the left of a_3 . This type of intervention reduces the effectiveness of an open market purchase from what it would be under floating rates but increases the effectiveness of an open market purchase over what it would be with no exchange rate change at all, both in terms of the increase in the U.K. money supply and of the decrease in r' . It results in a smaller net increase in the U.K. money supply than intervention accomplished by an exchange of moneys with the FR passive. If the BOE sells dollar securities and uses the proceeds to buy pound securities additional to those purchased in the open market operation, or if they use dollar deposits to buy pound securities over the exchanges and the FR sterilizes the U.S. money supply, the BB and FF curves are shifted until they pass through a_7 which must be to the left of a_4 , the equilibrium under freely floating rates. In this case, the U.K. money supply rises by the full amount of the open market operation just as under freely floating rates, and r' is decreased even more than it would be under floating rates. The latter result arises primarily because additional U.K. securities are purchased as part of the exchange market intervention.

Leaving aside the details and qualifications of the preceding analysis, the main point is that the effects of monetary policy depend crucially on the exchange market policy being followed. Indeed, it is instructive to recognize that open market

operations and exchange market intervention of various types are all simply asset exchanges and that it is the net result of all the asset exchanges which determine the ultimate equilibrium values of the exchange rate, the interest rates, and the money supplies.

IV. The Effectiveness of Monetary Policy and the Degree of Substitutability Between Securities

Investigating the impact of changes in the degree of substitutability between home and foreign securities is interesting for two reasons. During the final years of the Bretton-Woods system it was argued that increased capital market integration made it more difficult for monetary authorities, primarily those in non key currency countries, to achieve their objectives. One aspect of increased capital market integration is increased substitutability. Also, it has been argued that allowing exchange rates to float makes the task of the monetary authorities easier because exchange rate flexibility reduces the degree of substitutability between assets.

Other analysts have considered the effects of monetary policy in models in which wealth holders in a given country regard securities issued in that country as being either perfectly substitutable or completely non-substitutable for securities issued abroad.^{19/} Often these analysts have restricted their attention to the case of a single open economy which is small in economic size when compared to the rest of the world. While familiar polar assumptions yield familiar results in our model, it can also be used to explore the effects of changes in the degree of substitutability in the intermediate range in which U.S. and U.K. securities are substitutes but not perfect substitutes for one another. In order to separate the effects of changes in the degree of asset substitutability from the effects of relative economic size, the assumption that the two countries are of roughly equal economic size is retained.

As before, the basic monetary policy action considered is an open market operation by the BOE with a passive response by the FR. Whenever fixed rates are assumed, full asset settlement is also assumed unless otherwise indicated.

Consider first the case in which U.S. and U.K. securities are perfect substitutes. Perfect substitutability implies that the returns on the two securities differ only by the expected rate of change in the exchange rate, no matter what the composition of the world supply of securities. A sufficient condition for the two securities to be perfect substitutes under both fixed and flexible exchange rates is that wealth holders be risk neutral, but weaker conditions may insure that the two securities are regarded as perfect substitutes, especially under fixed exchange rates. In the case of perfect substitutes, the model can be reduced to the following three equations:

$$M^S = B^C + \sigma R - M^{C'} + A = m(r)W \quad (14)$$

$$SN^S = S[F^{C'} + \sigma'(\bar{R}-R)] + B^{C'} + M^{C'} + SA' = Sn'(r')W' \quad (15)$$

$$r = r' + s(\bar{S}-S) \quad (16)$$

where W and W' are defined as before and where the single world securities market has been omitted because it is redundant by Walras' Law. After substitution for r' using (16), equations (14) and (15) can be used to determine r and S .

The $m_0 m_0$ ($n_0 n_0$) schedule in Figure 5 shows the pairs of r and S which clear the U.S. (U.K.) money market given that (16) holds. Consider an open market purchase by the BOE which would shift nn from $n_0 n_0$ to $n_1 n_1$ if the U.K. money supply expanded by the full amount of the purchase. Under fixed rates with full asset settlement and a passive response by the FR, the new equilibrium lies at a point such as a_1 which lies between $n_0 n_0$ and $n_1 n_1$ on the dashed line which represents a constant exchange rate. The U.S. and U.K. interest rates fall by the same amount since they are locked together in the fixed rate case. The U.K. money supply increases by less than the amount of the open market purchase, and the U.S. money supply rises. If the U.S. sterilizes, or if the U.K. sells off U.S. securities to finance its intervention, the equilibrium is at a_0 and the open market purchase achieves nothing except a reduction in U.K. reserves. In these cases, if the BOE keeps trying to lower world interest rates and raise its money supply, it continues to lose reserves and no new equilibrium is reached.

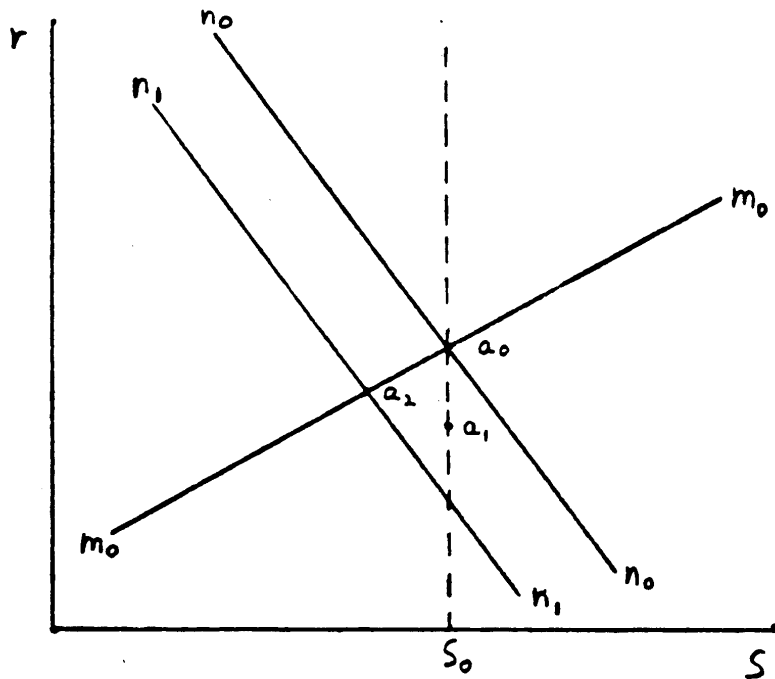


FIGURE 5

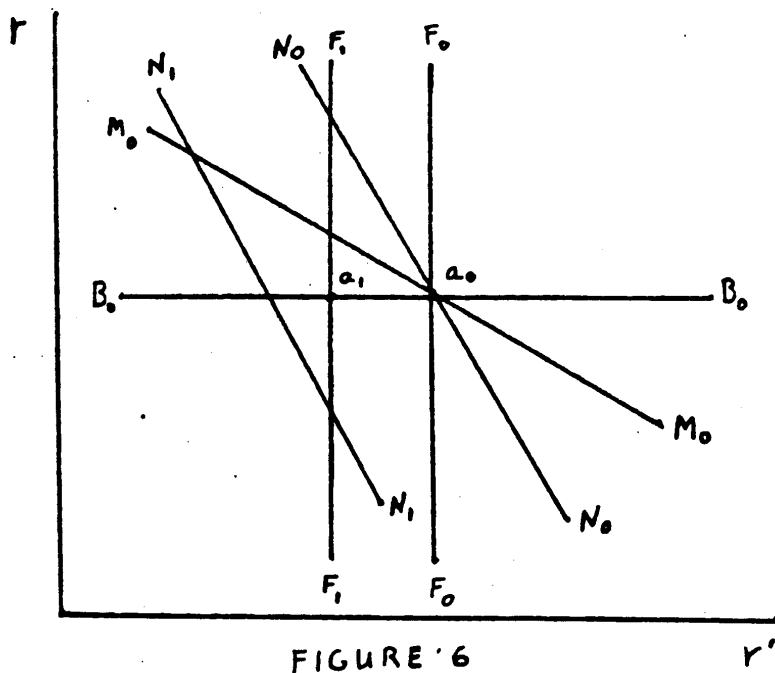


FIGURE 6

Under flexible exchange rates the new equilibrium is at a_2 . The U.K. money supply rises by the full amount of the open market purchase, and r' is lowered more than r because the pound depreciates.

In terms of the graphical framework used earlier in the paper, the slopes of the BB and FF curves approach positive one as the degree of asset substitutability increases without limit. As the two securities become virtually identical, any increase in r' must be offset by an almost identical increase in r in order for either of the two securities markets to remain in equilibrium. The slopes of the MM and NN schedules approach negative one as the two securities become indistinguishable.^{20/}

The other limiting case in which U.S. and U.K. residents view the two types of securities as being completely non substitutable for one another even though both groups of residents view both types of securities as substitutes for domestic money is portrayed in Figure 6.^{21/} Under fixed rates with full asset settlement and the FR passive, equilibrium following an open market purchase by the BOE is at a_1 . The rate on U.K. securities falls by enough to make both U.K. and U.S. residents willing to reduce their holdings of U.K. securities and increase their holdings of money by the amount of the open market purchase. The interest differential changes by the amount of the decline in the U.K. rate, and the BOE loses reserves. Under flexible rates, the new equilibrium point lies in the kite-shaped area bounded by M_0M_0 , N_1N_1 , B_0B_0 , and F_1F_1 .

Determining the impact of increases in the degree of substitutability between securities on the effects of monetary policy when securities are neither completely non substitutable nor virtually perfect substitutes is somewhat more difficult. In order to make the problem more tractable, some stronger assumptions are made. It is assumed that "own rate effects" are greater than "cross rate effects" on the demands for securities by both U.S. and U.K. wealth holders.^{22/} Throughout the paper it has been assumed that in each country the absolute value of the response of money demand to a one percentage point increase in the rate on securities issued abroad is less than the absolute value of the response of money demand to a one percentage point increase in the rate on securities issued at home. These assumptions imply that the BB (FF)

curve has a positive slope which is less (greater) than one and that the MM (NN) curve has a negative slope which is less (more) negative than negative one.

If the demand functions of wealth holders in the two countries are not "too different", increases in the degree of substitutability cause the slope of the BB (FF) schedule to increase (decrease) continuously toward positive one.^{23/} Since wealth holders in the U.S. (U.K.) come to view the two securities as being more and more alike, the responses of their money demand to the two interest rates become more similar and the slope of the MM (NN) schedule falls (rises) continuously toward negative one as the two securities become better substitutes.

The impact of an increase in the degree of asset substitutability on the effectiveness of monetary policy can be assessed using Figure 7. The unprimed schedules refer to the original degree of substitutability while the primed schedules refer to a higher degree of substitutability. An open market operation by the BOE with the original degree of substitutability leads to equilibrium at a_1 , a_2 , or a_3 under fixed rates, depending upon the FR policy response. An open market operation with increased substitutability shifts FF from $F'_0F'_0$ to $F'_1F'_1$ (not shown) which intersects the horizontal dashed line somewhere between a_0 and a_2 , because one of the effects of increasing the degree of substitutability is to reduce the change in r' required to offset a given disturbance in the market for U.K. securities. It is assumed that the interest rate responses of money demands become more similar in such a way that an equal change in both interest rates in the same direction causes money demand to rise or fall by the same amount no matter what the degree of substitutability between the two securities. This assumption implies that a given movement of the NN schedule along the dashed line with a slope of positive one is associated with the same change in money demand no matter what the slope of the NN schedule, so N_1N_1 and $N'_1N'_1$ intersect on this line following the open market operation. Under fixed rates, with full asset convertibility, the new equilibrium must lie on $B'_0B'_0$, somewhere between a_0 and the point of intersection with a line parallel to $F'_0F'_0$ through a_2 . As one would expect, an increase in substitutability implies that an open market purchase of a given size

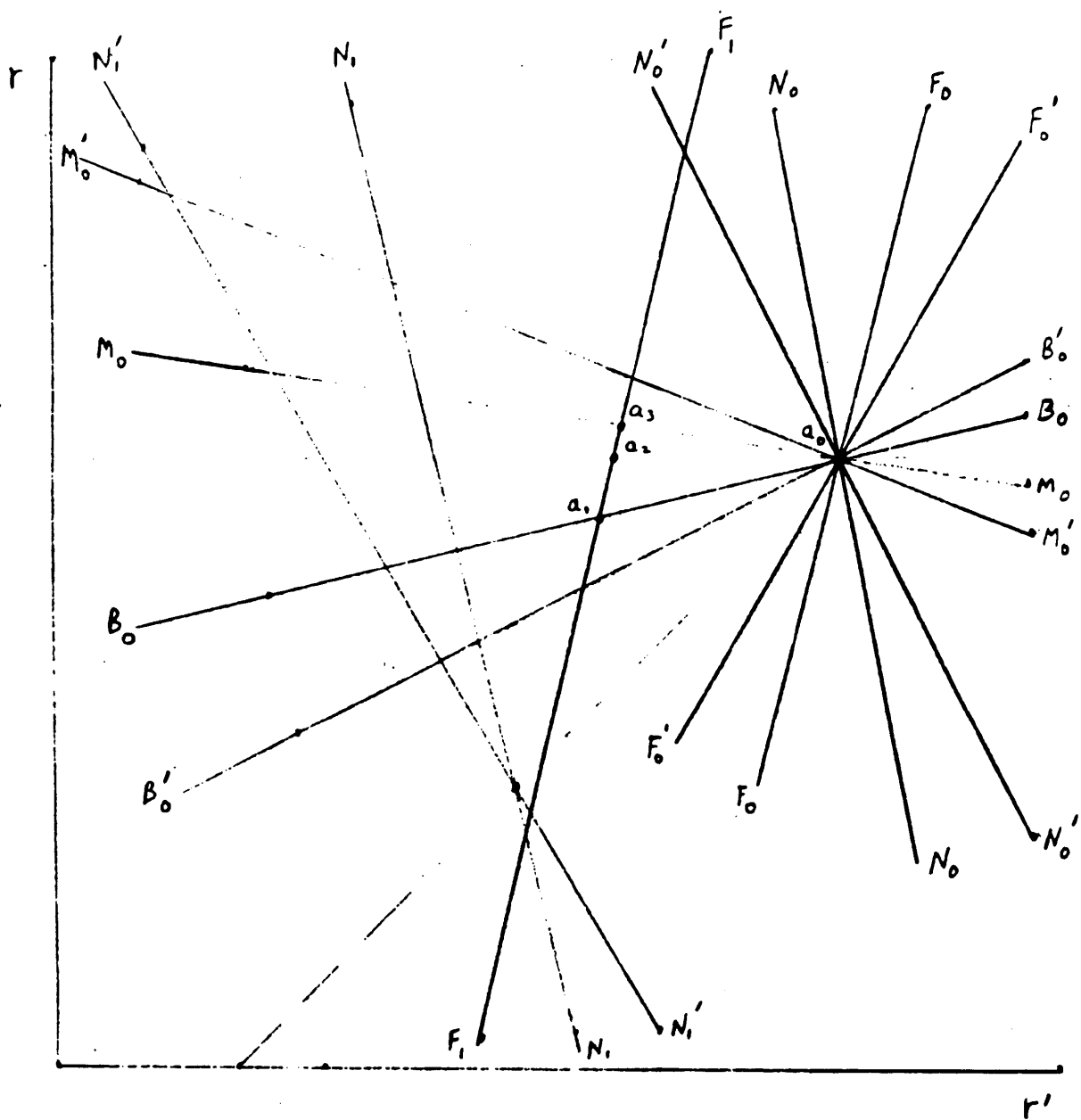


FIGURE 7

causes less of a change in the differential between the U.S. and U.K. rates. This result follows simply from the fact that $B'_0B'_0$ is flatter than B_0B_0 . However, the impact of increased substitutability on the decline in r' is ambiguous. The increased direct effect (reduced leftward shift in FF) of a decline in r' on the demand for U.K. securities tends to reduce the required decrease in r' following the open market purchase while the increased induced effect (rotation of the FF and BB schedules) tends to raise the required decrease in r' following the open market purchase. We have not been able to determine whether or not one of these tendencies dominates the other except in one special case.^{24/} Experimentation with the graph reveals that for a given leftward shift in the FF schedule, the smaller the amount of rotation of either the BB or FF schedules, the more likely it is that an increase in substitutability leads to a reduction in the amount by which r' falls after an open market purchase. Given the range of possibilities for the location of the new equilibrium point, it is not possible to determine whether the U.K. reserve loss is larger or smaller with increased substitutability.

If the U.S. sterilizes with full asset convertibility, or if the U.K. takes its reserve losses in the form of U.S. securities, results are more definite. The equilibrium with increased substitutability lies on $M'_0M'_0$, between a_0 and the point of intersection with a line drawn parallel to $F'_0F'_0$ through a_2 . With increased substitutability, r' definitely falls less, the interest differential is changed by less, and the U.K. loses more reserves. The last of these results is established by noting that $N'_1N'_1$ must move farther along the dashed line with a slope of positive one to reach the new equilibrium point, than N_1N_1 must move to reach a_3 .

If the introduction of flexible rates reduces the degree of asset substitutability, the primed schedules can be taken to represent the fixed rates situation and the unprimed schedules the flexible rates situation. The flexible rates equilibrium then lies in the kite-shaped area bounded by N_1N_1 , F_1F_1 , B_0B_0 , and M_0M_0 . An open market

operation by the U.K. will clearly be more effective in changing the U.K. money supply and r' when compared to the fixed rates case, either with FR sterilization or under a key currency reserve regime, but whether or not it will be more effective in moving r' when compared to the fixed rates case with passive behavior by the FR and full asset settlement is indeterminate here as in previous cases.

V. The Effectiveness of Monetary Policy and Relative Economic Size

In this section, we explore the implications of the assumption that the U.K. is a "small country" in the sense that its economic size as measured by nominal wealth in dollar terms is negligible when compared with the economic size of the U.S. measured in the same way. First, assume that U.S. and U.K. securities are perfect substitutes. Consider an open market purchase by the BOE which would lower the nn schedule to n_1n_1 in Figure 5 if the U.K. money supply expanded by the full amount of the purchase. When the U.K. is small relative to the U.S., the mm schedule does not move from m_0m_0 , so under fixed rates, the equilibrium point remains at a_0 . In the limit, U.S. residents are willing to reduce their holdings of securities by the relatively small amount of a plausible-sized BOE open market purchase and increase their holdings of money by the same amount with a negligible decrease in the rigidly linked interest rates.^{25/} U.K. reserves decrease by the amount of the open market purchase.

Under flexible exchange rates, the mm curve remains fixed at m_0m_0 if, as seems reasonable, the net pound position of U.S. residents goes to zero as W' goes to zero. The pound depreciates by enough to shift n_1n_1 until it passes through a_0 , r remains unchanged, and r' is driven down by an amount equal to the increase in the expected rate of appreciation of the pound.

Now consider the case in which the U.K. is small but in which U.S. and U.K. securities are neither completely non substitutable nor perfectly substitutable for one another in the portfolios of wealth holders. This case is shown in Figure 8. In contrast to the case in which the two countries are of roughly equal economic size, the open market operation leaves the F_0F_0 schedule unaffected when the U.K. is a small

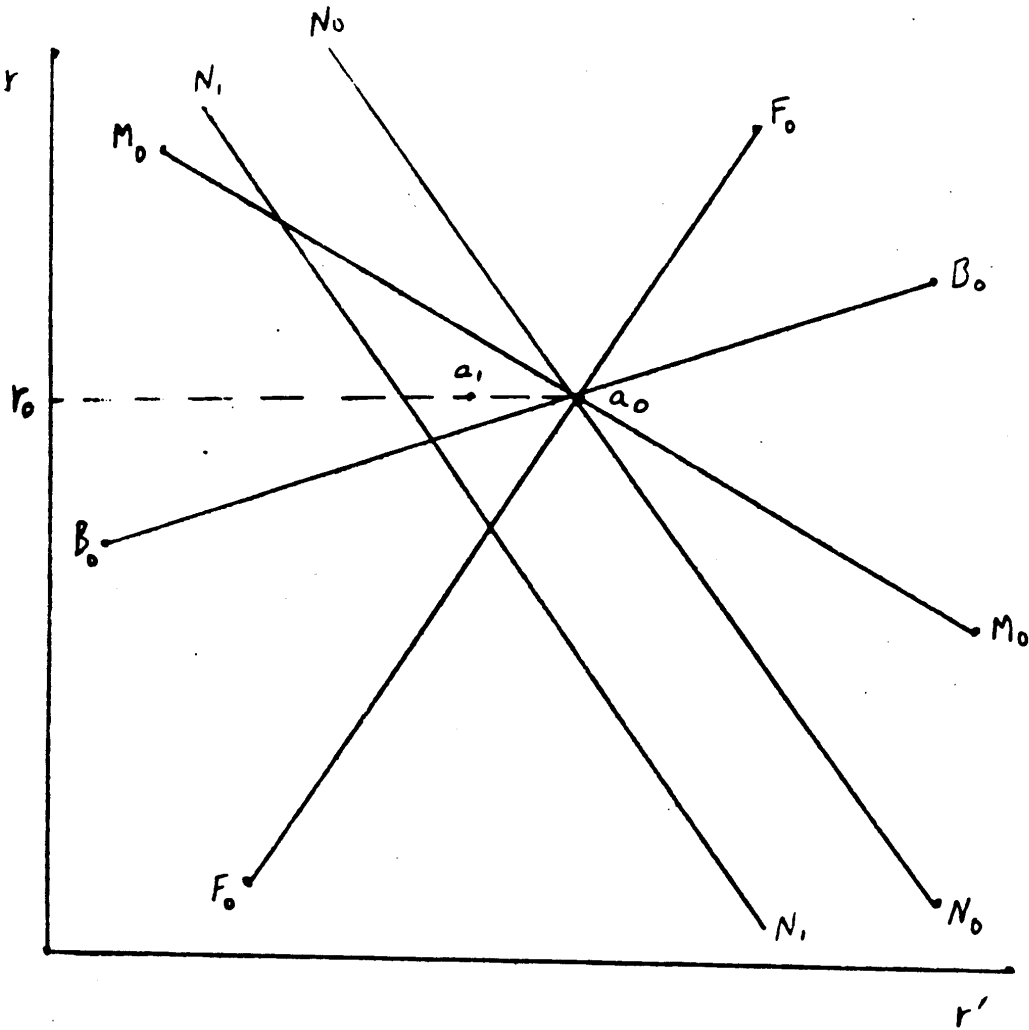


FIGURE 8

country. In the limit, it takes a negligible decrease in r' to induce the fall in the demand for U.K. securities necessary to offset the relatively small decrease in the supply of U.K. securities resulting from a plausible-sized U.K. open market purchase unless U.K. securities are "indispensable assets" in the portfolios of U.S. wealth holders.^{26/} Since the FF schedule is unaffected by the open market purchase, the equilibrium values of the two interest rates are unchanged. The U.K. money supply remains at its initial level, and the U.K. loses reserves equal to the full amount of the open market purchase. This reserve loss can be measured by the distance between N_1N_1 , the position the NN schedule would occupy if the U.K. money supply were increased by the full amount of the open market purchase, and N_0N_0 . Thus, the central bank in a small country is able to affect neither the interest rate on securities issued in its country nor its country's money supply by an open market purchase, even if its securities are not perfect substitutes for those issued in the rest of the world, provided that its securities are not regarded as indispensable assets by the world's wealth holders.

Turning to the case of flexible rates, it is useful to consider two sub cases. As before, the FF schedule is unaffected by the open market purchase, but the NN schedule is shifted from N_0N_0 to N_1N_1 . First, assume that the expected change in the exchange rate is not sensitive to the level of the spot rate so that $s_{S-\bar{S}} = 0$. If, as seems reasonable, the net pound position of U.S. residents goes to zero as W' goes to zero, depreciation of the pound leaves the BB, FF, and MM curves unaffected, but the NN curve shifts up from N_1N_1 until it passes through a_0 . In this case, the only effect of the open market operation is to depreciate the pound. Second, assume again that $s_{S-\bar{S}} < 0$. If decreases in the level of the spot rate lead to increases in the expected rate of change of the spot rate, the new equilibrium is at a point like a_1 which lies between a_0 and N_1N_1 on the dashed line, indicating a constant r . Decreases in S shift the BB, FF, and MM schedules to the left by the same distance. r and $r' + s$ must remain constant, but r' can fall because s rises. Just as in the perfect substitutes case, the central bank in a small country can change its interest rate under flexible exchange rates if exchange rate expectations depend on the spot rate.

APPENDIX A

The purpose of this Appendix is to specify some conditions under which increases in the degree of substitutability between securities affect the equilibrium schedules in the way described in the text.

Let x be a variable which takes on the value zero when the two securities are completely non substitutable and which rises continuously and without limit as substitutability increases. All of the demand responses to interest rate changes are functions of x and can be written as, for example, $b_r(x)$, but to conserve space, the explicit functional notation is often suppressed. It is convenient to define the following five vectors:

$$\alpha = \begin{bmatrix} b_r \\ f_{r'} \\ b'_{r'} \\ f'_{r'} \end{bmatrix}, \quad \beta = \begin{bmatrix} f_r \\ b_{r'} \\ f'_{r'} \\ b'_{r'} \end{bmatrix}, \quad \gamma = \begin{bmatrix} m_r \\ m_{r'} \\ n'_{r'} \\ n'_{r'} \end{bmatrix}, \quad \delta = \begin{bmatrix} b_{r'} \\ f_r \\ b'_{r'} \\ f'_{r'} \end{bmatrix}, \quad \mu = \begin{bmatrix} \hat{m} \\ \hat{m} \\ \hat{n}' \\ \hat{n}' \end{bmatrix},$$

where α is a vector of own rate effects; β and δ are vectors of cross rate effects; γ is a vector of money demand responses; and μ is a vector of constants, the elements of which satisfy $m_r(0) \leq \hat{m} \leq m_{r'}(0)$, and $n'_{r'}(0) \leq \hat{n}' \leq n'_{r'}(0)$. The two balance sheet constraints imply that $\alpha(x) + \beta(x) + \gamma(x) \equiv \underline{0}$. The assumption that own rate effects are greater than cross rate effects implies that $\alpha(x) + \delta(x) > \underline{0}$ for all x . When the two securities are perfectly non substitutable for one another, $\alpha(0) = -\gamma(0)$ and $\beta(0) = \underline{0}$.

As the degree of asset substitutability increases, the asset demand responses are assumed to change as follows: (1) the values of the own rate effects rise continuously without limit and the values of the cross rate effects decrease continuously without limit,

$$\alpha_x > \underline{0},$$

$$\lim_{x \rightarrow \infty} \alpha = \underline{\infty},$$

$$\beta_x < \underline{0},$$

$$\lim_{x \rightarrow \infty} \beta = -\underline{\infty};$$

(2) own rate effects and cross rate effects on the same demand function become continuously more alike,

$$\alpha_x + \delta_x < \underline{0};$$

and (3) the responses U.S. (U.K.) money demand to the two interest rates approach one another continuously and tend toward a common value which lies between them as a limit,

$$m_{rx} \geq 0, m_{r'x} \leq 0, n'_{r'x} \geq 0, n'_{rx} \leq 0, \lim_{x \rightarrow \infty} \gamma = \mu.$$

These assumptions and the two balance sheet constraints imply

$$b_{r'x} - f_{rx} \begin{cases} < 0 \text{ if } b_{r'} - f_r > 0 \\ > 0 \text{ if } b_{r'} - f_r < 0 \end{cases}, \quad b'_{r'x} - f'_{rx} \begin{cases} < 0 \text{ if } b'_{r'} - f'_r > 0 \\ > 0 \text{ if } b'_{r'} - f'_r < 0 \end{cases},$$

$$\lim_{x \rightarrow \infty} (\beta - \delta) = 0, \quad \lim_{x \rightarrow \infty} (\alpha + \delta) = \lim_{x \rightarrow \infty} (\alpha + \beta) = \mu.$$

The assumptions regarding the interest rate responses of money demands are sufficient to insure that the slope of the MM (NN) curve becomes continuously more (less) negative and approaches negative one as a limit as the degree of substitutability increases. The slopes of the MM and NN curves never actually take on the value of negative one for, if the two securities were exactly identical in every respect, a decline in r would lead residents in both countries to try to move completely out of U.S. securities into U.K. securities, but there seems to be no reason why wealth holders should want to change their money holdings. When the two securities are exactly alike, the MM and NN schedules reduce to single points which must lie on the line with a slope of positive one which represents the BB and FF schedules.

The analysis of what happens to the BB and FF curves as substitutability increases is somewhat more complicated. The slope of the BB curve is given by,

$$\frac{dr}{dr'} \Big|_{BB} = \omega \left(-\frac{b_{r'}}{b_r} \right) + (1-\omega) \left(-\frac{b'_{r'}}{b'_r} \right),$$

where

$$\omega = \frac{b_r W}{b_r W + b'_{r'} W'}.$$

Since the numerators and denominators of $-\frac{b_{r'}}{b_r}$ and $-\frac{b'_{r'}}{b'_r}$ are either increasing or decreasing without limit and since the sum of the numerator and denominator of each ratio approaches a constant, both ratios approach positive one as x approaches infinity, so

$$\lim_{x \rightarrow \infty} \left[\frac{dr}{dr'} \Big|_{BB} \right] = 1.$$

Differentiating the expression for the slope of the BB curve we have,

$$\frac{d \left[\frac{dr}{dr'} \Big|_{BB} \right]}{dx} = \omega \frac{d \left[-\frac{b_{r'}}{b_r} \right]}{dx} + (1-\omega) \frac{d \left[-\frac{b'_{r'}}{b'_r} \right]}{dx} + \left(\frac{b'_{r'}}{b'_r} - \frac{b_{r'}}{b_r} \right) \omega_x,$$

$$\omega_x = \frac{b'_r b_r W W'}{(b_r W + b'_{r'} W')^2} \left[\frac{b_{rx}}{b_r} - \frac{b'_{rx}}{b'_r} \right].$$

The assumption that own rate effects and cross rate effects on the demand for U.S. securities become more alike in both countries is sufficient to insure that the first two terms on the right hand side are positive; that is, with the weights held constant, the weighted average definitely rises. The weighted average rises (falls) if the weight on the larger of the two terms $-\frac{b_{r'}}{b_r}$ and $-\frac{b'_{r'}}{b'_r}$ rises (falls).

w rises (falls) if the per cent increase in b_r is greater (less) than the per cent increase in b'_r . While the sign of the third term cannot be determined, it is smaller in absolute value the more alike are the two countries either in terms of the ratios of cross effects to own effects or in terms of per cent changes in own effects and is zero if the two countries are exactly alike in either or both respects. Thus, the possibility of a "perverse" movement in the slope of the BB curve arises because of differences in the two countries.^{27/} In the text we assume that the two countries are "similar enough" that the slope of the BB curve rises continuously as x increases. It can be shown that the assumptions above are sufficient to insure that the slope of the FF curve approaches positive one as x approaches infinity and that the slope of the FF curve decreases continuously as x increases if the two countries are "similar" enough.

It is assumed in the text that equal changes in the two interest rates in the same direction causes the same change in money demands no matter what the degree of substitutability between the two securities,

$$m_r(x) + m_{r'}(x) \equiv 2 \hat{m}$$

$$n'_r(x) + n'_{r'}(x) \equiv 2 \hat{n}'$$

This assumption is plausible and greatly facilitates the derivation of conclusions in the graphical framework, but the conclusions of the paper continue to hold under weaker assumptions.

For a further discussion of the impact of increases in the degree of substitutability on the effectiveness of monetary policy, see Girton and Henderson (1973).

APPENDIX B

The purpose of this Appendix is to provide a formal representation of the arguments used in the text to derive results for the case in which the U.K. is small.

Let \bar{W} represent the nominal value of world wealth in dollars which is assumed to remain constant, so $\bar{W} - SW'$ is equal to W , the nominal value of U.S. wealth. Assume that in both countries the ratio of central bank held securities to wealth is independent of wealth, so

$$B^C = \epsilon W, \quad F^{C'} = \epsilon' W'.$$

An open market purchase by the BOE is represented by an increase in ϵ' .

First, it is shown that the mm schedule used in the perfect substitutes case does not shift following an open market purchase by the U.K. Suppose the U.S. reserves rise (U.K. reserves decline) by the full amount of the U.K. open market purchase:

$$\sigma dR = SW' d\epsilon'.$$

The U.S. money market equilibrium condition is

$$M^S = B^C + \sigma R - M^{C'} + A = m(r)(\bar{W} - SW').$$

Differentiating this condition, substituting in the expression above for σdR , and solving for the change in r required to offset an increase in ϵ' yields

$$\left. \frac{dr}{d\epsilon'} \right|_{S=\bar{S}}^{mm} = \frac{SW'}{m_r(\bar{W} - SW')}.$$

The size of the shift in the mm schedule resulting from an increase in U.S. reserves which is equal to the full amount of the U.K. open market purchase approaches zero continuously as W' approaches zero.

FOOTNOTES

1/ Forward contracts are added to the model in Girton and Henderson (1977). See footnote 5.

2/ The implications of adding a fractional reserve banking system for each country to the model are explored in Girton and Henderson (1976).

3/ The model can be modified to allow both central banks to accept deposits denominated in both currencies so long as some assumptions are made which determine the desired liability composition for each central bank.

4/ The assumption that all wealth holders expect the same percentage change in the exchange rate makes possible considerable simplification in the exposition of the model, but this assumption can be dropped without affecting any of the conclusions.

5/ Wealth holders in each country might regard the two securities as imperfect substitutes for two sets of reasons. First, the two securities are issued in different countries and wealth holders might believe that the returns on the two securities are uncertain and that these returns are not perfectly correlated either because they perceive that fluctuations in economic activity are not perfectly correlated across countries, or because they view governments as having different degrees of "responsibility"; that is, business and political risks might be different in the two countries. Second, the two securities are denominated in different currencies so actual or potential exchange rate movements or exchange controls add exchange risk to the other risks associated with holding "foreign" assets. Either set of reasons is sufficient to insure that wealth holders in both countries would, in general, want to hold well defined amounts of both securities.

Adding forward contracts to the model so that a security denominated in one currency can be converted into a security denominated in the other currency does not change this conclusion. In Girton and Henderson (1977) it is shown that if securities denominated in different currencies are regarded as imperfect substitutes only because of exchange risk and if capital markets are perfect, forward contracts are redundant assets. Black (1973) imposes somewhat less stringent assumptions on a model which includes forward contracts.

6/ The demand functions used in the text can be arrived at from more general demand functions by ignoring interest payments, assuming first degree homogeneity in wealth, and subsuming variables held constant into the functional form.

7/ See Tobin (1969). The U.S. balance sheet constraint is

$$W = B^A + SF^A + M^A \equiv B^d + SF^d + M^d,$$

where B^A , F^A , and M^A are predetermined actual holdings. This identity and equations (1) through (3) imply

$$M^d = m(r, r' + s) \equiv [1 - b(r, r' + s) - f(r, r' + s)]W,$$

so

$$b_r + f_r + m_r \equiv b_{r'+s} + f_{r'+s} + m_{r'+s} \equiv 0,$$

where b_r is the partial derivative of $b(r, r' + s)$ with respect to r , etc. Similar relationships hold for the U.K.

8/ We assume that the FR does not hold U.K. securities or U.K. money.

9/ A change in the exchange rate may be reflected in a change in σ , the dollar price of outside reserve assets; in σ' , the pound price of outside reserve assets; or in both. Of course, at least one currency price of reserve assets must change. The relationship between dS , $d\sigma$, and $d\sigma'$ is given by

$$dS = \frac{1}{\sigma'} d\sigma - \frac{\sigma}{\sigma'^2} d\sigma'.$$

Changes in S , σ , and σ' alter the domestic currency value of initial reserve holdings of at least one central bank. However, these changes themselves have no effect on the money supply of either country. We assume that in order to balance their balance sheets, the two central banks simply change A and A' so as to offset the effects of changes in σ , σ' , and S on the domestic currency value of their assets,

$$dA = -R d\sigma$$

$$dA' = -(\bar{R} - R) d\sigma' + \frac{1}{S^2} (B^{c'} + M^{c'}) dS.$$

10/ The total supply of U.S. securities (\bar{B}) is equal to the sum of cumulated U.S. government deficits and the value of net claims to the income of the capital stock of the U.S. non-financial corporate sector. \bar{B} might also include consumer debt, but we assume that obligations of ultimate wealth holders to one another are netted out. \bar{F} has a similar interpretation.

Instead of including in \bar{B} and \bar{F} all securities issued in the two countries, it may be useful to restrict attention to some subset of securities. A significant part of short-run financial capital movements seems to be made up of changes in holdings of short-term (liquid) assets. If people quickly balance money and short-term security holdings according to rates of return independently of their holdings of long-term (illiquid) securities, then, for some purposes, defining W and W' to include only short-run securities and money may be useful. The treatment here is theoretical, and no attempt is made to prejudge the question of what is the best empirical definition of allocatable wealth in any particular application.

11/ Adding the left-hand sides of (10), (11), (12) and (13) yields the total dollar value of all assets available to wealth holders, which can be expressed as $\bar{B} + \bar{S}F + \sigma\bar{R}$ since $S = \sigma/\sigma'$. Adding the right hand sides of (10), (11), (12), and (13), taking account of the fact that $b + f + m \equiv b' + f' + n' \equiv 1$, yields world wealth in dollar terms, $W + SW'$. $\bar{B} + \bar{S}F + \sigma\bar{R}$ is identically equal to $W + SW'$, so only three of the four market equilibrium conditions are independent.

12/ International economists have focused considerable attention on some aspects of the key currency reserve regime. It has been argued that the pressure to take corrective measures in the face of persistent payments imbalances and the burden of adjustment when it takes place are distributed asymmetrically under such a regime. In a two country, flexible price version of the income-expenditure model, Don Roper (1973) has shown that if adjustment is actually to take place, the adjustment burden will usually be distributed asymmetrically in favor of the key currency country. Although securities and, therefore, the sterilization process are not given explicit treatment in Roper's model, he has emphasized that the key currency country is relieved of the task of sterilization since the non-center countries sterilize for the center country.

13/ From time to time, some of the increases in dollar denominated, interest bearing assets acquired by foreign official institutions with the dollars accumulated in their support operations have been in the form of special non-marketable securities issued by the U.S. Treasury. When reserve changes are taken in this form, there is no reduction in the supply of U.S. securities available to the public. The decrease in U.S. money in the hands of the public is matched by an increase in U.S. money held by the Treasury.

If the Treasury decides to get rid of its new cash balances immediately, it retires debt, and the money supply in the hands of the public is restored to its previous level. However, if the Treasury does not run down its new cash balances, then the Federal Reserve must actively pursue open market operations if it wants to keep the U.S. money supply in the hands of the public constant.

It is unlikely that the Treasury will want to add to its cash balances just because foreign central banks have accumulated dollar balances. It will generally run down its cash balances over a relatively short period by reducing its offerings of new debt below the gap between its expenditures and its tax receipts. However, when a significant portion of large and rapid dollar accumulations abroad are converted into so called "specials", as was the case in the spring of 1973, the Federal Reserve may have to deal with a non negligible, but temporary, disturbance when attempting to achieve money supply management goals.

14/ This result is proved in Girton and Henderson (1976).

15/ Throughout this paper, we assume that F^A and B^A are positive; that is, we assume that residents of both the U.S. and the U.K. have positive net holdings of foreign securities. If either F^A or B^A , or both are negative, the description of how the schedules shift when the exchange rate changes must be modified somewhat, and some of the results may be changed.

16/ That is, letting $s_{S-\bar{S}} = s' < 0$, if

$$(b_{r,W} - b'_{r,W'})s' + bF^A + b'(N^A + F^A) > 0,$$

$$(f_{r,W} - f'_{r,W'})s' - f(N^A + B^A) - f'B^A < 0,$$

$$m_{r,Ws'} + mF^A > 0, \quad -n'_{r,W's'} - n'B^A < 0.$$

If these conditions are met, a necessary condition for stability under plausible adjustment assumptions is definitely satisfied. However, even if some of these conditions are not met, the same necessary condition for stability may be satisfied. Whether or not these conditions are met, necessary and sufficient conditions for stability may not be satisfied unless some restrictions are placed on the relative speeds of adjustment in the various markets. A more detailed analysis of stability conditions does not yield many additional insights.

While the model may be stable if some of the conditions above are violated, some of the comparative statics results may be changed.

17/ In this case the U.S. asset demands, for example, are given by

$$\begin{aligned}M^d &= \tilde{M}(r, r' + s), \\B^d &= \tilde{B}(r, r' + s, W), \\SF^d &= \tilde{F}(r, r' + s, W),\end{aligned}$$

where s is a parameter, the signs of the interest rate effects are the same as before and

$$\tilde{B}_W + \tilde{F}_W \equiv 1.$$

18/ The $M_0 M_0$ schedule is analogous to the foreign offer curve in optimum tariff analysis.

19/ For models in which it is assumed that wealth holders regard securities issued at home and abroad as perfect substitutes, see Mundell (1968, Chapter 18) and McKinnon and Oates (1966). For a model in which it is assumed that wealth holders regard securities issued abroad as completely non-substitutable for both securities issued at home and domestic money, see McKinnon (1969).

20/ For a more detailed discussion of the effects of increases in the degree of substitutability on the four schedules of the model, see Appendix A.

21/ If U.S. (U.K.) citizens do not consider U.K. (U.S.) securities to be substitutes for either U.S. (U.K.) securities or U.S. (U.K.) money so that, as far as financial asset holding is concerned, the U.S. (U.K.) is a "closed" economy, the MM and BB schedules (NN and FF schedules) coincide. Since, in each country, money and securities issued at home are the only assets considered suitable for wealth holding, the same value of the interest rate on securities issued at home must clear both the money market and the market for securities issued at home. In this case, an open market purchase by the BOE causes the rate on U. K. securities to fall by more than the case described in the text, since this rate must decline by enough to make U. K. residents willing to reduce their holdings of U. K. securities and increase their holdings of money by the amount of the open market purchase. Of course, the differential between the U.S. and U.K. rates changes by the full amount of the decline in the U.K. rate.

22/ The restrictions on the interest rate responses of the asset demand functions implied by these assumptions are spelled out in detail in Appendix A.

23/ The exact conditions are discussed in more detail in Appendix A.

24/ When the two countries are exactly identical in terms of the responses of asset demands to interest rate changes, a rise in substitutability causes dr' to become less negative. The assumption that the responses of asset demands to interest rate changes are identical in the two countries is not compatible with our earlier assumption regarding the responses of money demands in the two countries to interest rate changes. Two restrictions required by our interpretation of what it means for countries to be identical are that $m_r = n'_r$ and $m_{r'} = n'_{r'}$. We have assumed above that $|m_r| > |m_{r'}|$, and this assumption in conjunction with our new restrictions implies $|n'_r| > |n'_{r'}|$, which violates our earlier assumptions. If we are to assume that countries are identical, in the sense described here, and to retain as much of the spirit of our earlier arguments regarding the interest rate responses of money demand functions as possible, we must also assume $m_r = m_{r'}$.

25/ This result is derived formally in Appendix B.

26/ This result is derived formally in Appendix B.

27/ A similar problem would arise in the analysis of a closed economy with two well defined groups of wealth holders with different demand schedules for two types of securities and money. In closed-economy macro economics, problems like this are said to be due to "distribution effects" which are usually assumed away. It seems somewhat less natural to assume that such distribution effects are unimportant in a two country world.

Second, it is shown that when U.S. and U.K. securities are imperfect substitutes, the FF schedule does not shift following an open market purchase by the U.K. The expression for the shift in the FF schedule caused by an increase in ϵ' is

$$\left. \frac{dr'}{d\epsilon'} \right|_{r=\bar{r}}^{\text{FF}} = - \frac{W'}{\frac{1}{S} f_{r'+s} (\bar{W} - SW') + f'_{r'} W'}$$

The size of the shift in the FF schedule caused by an open market purchase by the BOE approaches zero as W' approaches zero unless U.K. securities are indispensable assets in the portfolios of U.S. wealth holders, that is, unless the interest sensitivity of U.S. demand for U.K. securities approaches zero as W' approaches zero.

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