PRINCETON STUDIES IN INTERNATIONAL FINANCE NO. 20

An Empirical Study of the Foreign-Exchange Market: Test of a Theory

Fred R. Glahe

INTERNATIONAL FINANCE SECTION
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1. INTRODUCTION TO FORWARD-EXCHANGE THEORY

Prior to the 1920's most economists were not concerned with the workings of the foreign-exchange market and fewer still were even aware of the existence of forward exchange. The reason for this lack of interest was probably the high degree of stability maintained by the major currencies before 1914, under the gold standard. The First World War completely disrupted the international monetary system and it was found impossible at the end of the war to return the leading currencies to their prewar parities. It became the primary goal of central bankers to return the currencies to their prewar parity as soon as possible, without regard to the economic soundness of the policy or its political consequences. Since convertibility could not be immediately restored at the prewar rates of exchange, the major European currencies were "unpegged" with respect to gold and allowed to fluctuate with respect to the dollar. It was hoped that this system of fluctuating exchange rates would be short-lived and it was planned that as soon as a currency attained its prewar value in terms of the dollar, the central bank would return to a system of fixed exchange rates. During this period of fluctuating exchange rates, exporters and importers were exposed to a foreign-exchange risk unless they hedged in the forward market. The same was true for the interest arbitrageur, who prior to the war often participated in uncovered interest arbitrage, but who would not consider it after the war, because fluctuations in the exchange rate could easily wipe out all profit. This increased interest in forward exchange by businessmen and arbitrageurs had the effect of increasing the transactions volume of the forward exchange market and, as will be shown later in this chapter, reducing the effectiveness of interest-rate policy as a means of directing the international flow of short-term capital. These two factors were primarily responsible for the birth of interest by economists in the forward exchange market.

1.1 The Keynesian Theory of Interest Arbitrage

John Maynard Keynes was the first economist to present a fully developed theory of the foreign-exchange market.[1] In his theoretical model he was able to explain the relationship between the forward premium and the difference between short-term interest rates at home and abroad. His theory and conclusions can best be explained with a simple two-country model.[2] The following variables are used:

r_s = spot rate of foreign exchange at time 0 (where exchange rates are defined in terms of units of domestic currency per unit of foreign currency);
r_f = forward rate of exchange for delivery 90 days hence;
i_d = domestic short-term interest rate expressed as the rate of return per 90 days;
i_f = foreign short-term interest rate expressed as the rate of return per 90 days;
R = 90-day forward premium on foreign currency expressed as a per cent per 90 days on the basis of the spot rate of exchange $= \frac{r_f}{r_s} - 1$.

A holder of liquid funds may either keep his money at home or send it abroad. If he keeps it at home, one unit will grow in 90 days to

$$D = (1 + i_d). \tag{1}$$

If capital movements between countries are not restricted, the same unit of domestic currency can be transferred abroad, and the existence of a forward market can make this a riskless venture. This is accomplished in the following manner:

(a) The holder of domestic currency converts this currency into foreign exchange in order that he may, for example, purchase foreign 90-day Treasury Bills. This transaction is conducted in the spot market.
(b) Simultaneously with the purchase of spot foreign exchange, the expected holdings of foreign exchange 90 days hence are sold

[1] John Maynard Keynes, *Tract on Monetary Reform* (London: Macmillan, 1923), pp. 115-139. For information on the precursors of Keynes, see Paul Einzig, *A Dynamic Theory of Forward Exchange* (London: Macmillan, 1961), pp. 132-134.
[2] For a more detailed explanation, see Egon Sohmen, *Flexible Exchange Rates, Theory and Controversy* (Chicago: University of Chicago Press, 1961), pp. 65-69.

in the forward market for domestic currency, that is, the arbitrageur promises to deliver in 90 days a specified amount of foreign exchange in return for a specified amount of domestic currency. The amount of domestic currency received per unit of foreign currency is called the forward exchange rate. If the price of forward exchange is above the spot rate, then it is said to be at a premium and the amount by which it exceeds the spot rate is simply called the forward premium. Should the price of forward exchange be below the spot rate, then it is said to be at a discount. The amount by which the spot rate exceeds the forward rate is called the forward discount.

(c) At the end of the 90-day period, the arbitrageur sells his foreign Treasury Bills and exchanges, as promised, his accumulated foreign exchange for the amount of domestic currency agreed to 90 days earlier.

Thus, one unit of domestic currency converted into $\frac{1}{r_s}$ units of foreign exchange will grow in 90 days to

$$(\frac{1}{r_s})\ (1+i_f). \tag{2}$$

This amount of foreign exchange is then converted into domestic currency by means of the forward contract into

$$F=\frac{r_f}{r_s}\ (1+i_f) \tag{3}$$

units of domestic currency. Now, quite obviously, if

$$D \geqq F, \tag{4}$$

the holder of domestic liquid funds will not consider interest arbitrage and will keep his money at home. However, if

$$D < F, \tag{5}$$

then outward interest arbitrage will take place.

This transfer of funds (assuming a sufficiently large supply of idle balances) will increase the demand for spot foreign exchange and r_s will rise, and increase the supply of forward foreign exchange and r_f will fall. The simultaneous increase of r_s and decline of r_f means that the return from interest arbitrage, F, will fall. When F declines

to the point where it is equal to the return on domestic Treasury Bills, then outward interest arbitrage ceases.

Similarly, if

$$D > F, \tag{6}$$

then inward interest arbitrage will take place, that is, holders of idle foreign-exchange balances will want to purchase domestic Treasury Bills and short-term capital will flow inward into the domestic country. In this case r_s will fall and r_f will rise until once again

$$D = F. \tag{7}$$

An alternative way of expressing this equilibrium condition is to set

$$F = D,$$

or

$$\frac{r_f}{r_s}(1 + i_f) = (1 + i_d), \tag{8}$$

and therefore,

$$\frac{r_f}{r_s} = \frac{1 + i_d}{1 + i_f}. \tag{9}$$

The forward rate can be defined as the 90-day forward premium or discount on foreign currency expressed as a per cent per 90 days on the spot rate of exchange, that is,

$$\frac{r_f}{r_s} = 1 + R. \tag{10}$$

Substituting (10) into (9), the condition for equilibrium can be expressed as,

$$R = \frac{i_d - i_f}{1 + i_f}. \tag{11}$$

If $(R)(i_f)$ is "small," then, as a close approximation to the above exact relationship, it is possible to use the more familiar and convenient relationship

$$R = i_d - i_f. \tag{12}$$

Equation (12) states that the percentage premium or discount on forward exchange over a given period of time tends to equal the interest-rate differential (measured over the same period of time) between the respective countries. Note that the interest rate can be expressed over any time period by simply multiplying both sides of (12) by an appropriate constant. For example, if it is desired to express (12) in terms of interest per annum, then simply multiply both

sides of (12) by $\frac{365}{90} \doteq 4$.

If $R > (i_d - i_f)$, outward interest arbitrage will take place and if $R < (i_d - i_f)$, then inward arbitrage occurs. If interest rates in both countries are the same, then

$$R = 0 \tag{13}$$

and, therefore, the spot and forward rates must be equal.

In the above example it was implicitly assumed that there were no bank or brokerage charges. This will not be the case in the real world and equation (12) in actual practice should be written

$$R = (i_d - i_f) \pm (\text{small percentage}); \tag{14}$$

that is, the difference between the domestic interest rate and the foreign interest rate can deviate by a small percentage before either inward or outward interest arbitrage will take place. During the interwar period, this spread between the forward premium and the interest-rate differential was estimated by Keynes to be about $+\frac{1}{2}$ per cent per annum. This is no longer true, however, and arbitrage operations take place today with a spread as little as $\frac{1}{32}$ per cent per annum.[3]

Keynes observed that on occasion a significant spread between the forward premium and the interest-rate differential could exist for extended periods of time. This condition can only be the result of an insufficient volume of liquid funds for the purpose of interest arbitrage. Furthermore, the measurement of the interest-rate differential is in itself inexact, because there exists not one but many short-term differentials and, therefore, computation based on these will yield varying results.

1.2 Reason for Reduced Efficacy of Bank-Rate Policy

In the beginning of this study it was stated that under the gold-exchange standard, interest arbitrage was very often conducted on an uncovered basis, that is, without hedging in the forward market. This situation existed because of the high level of confidence that arbitrageurs had regarding the permanency of the prevailing spot rates. This confidence was shattered when, at the conclusion of the war, the major European currencies had to adopt fluctuating exchange-rate systems. To avoid exchange risk, therefore, arbitrageurs adopted the

[3] Paul Einzig, *op.cit.*, p. 167.

policy of always hedging in the forward market. This structural change in their behavior greatly reduced the effectiveness of the prewar policy of inducing short-term capital inflow or outflow by small changes in bank rate, because arbitrage profits were now determined not only by the international interest-rate differential, but also by the forward premium, and the normal behavior of arbitrageurs in the spot and forward markets changed the forward premium in a manner which tended to eliminate any arbitrage profits.

Keynes was the first to point out the inherent weakness of pre-1914 international monetary policy when applied to the situation prevailing after World War I. Rather than pursue the traditional policy of varying internal interest rates to attract or discourage short-term capital, Keynes suggested that the central bank intervene in the foreign-exchange market. By varying the forward premium, the monetary authorities "would be able, in effect, to vary the interest offered for *foreign* balances, as a policy distinct from whatever might be their bank-rate policy for the purpose of governing the interest obtainable on *home* balances."[4] This suggestion, which was very radical in 1923 and whose merits are still being debated today, offers the possibility of divorcing, to some extent, domestic and international economic policy.

1.3 Movement in the Spot and Forward Rates

In the theoretical model presented above, it was stated that the behavior of arbitrageurs would change both the spot and forward exchange rates in a manner which would eliminate arbitrage profits. Under fluctuating exchange rates it was Keynes' opinion, however, that the principal effect of arbitrage operations on the foreign-exchange market would be on the forward rate, rather than the spot rate.[5] Sohmen, however, has shown that this conclusion cannot be proved unless information on the shape of the market schedules for both spot and forward exchange is known.[6] He gives two cases where Keynes' view, based on superficial analysis, appears to be justified but, on close examination, is shown to be false.

[4] Keynes, *op.cit.*, p. 135.

[5] Keynes, *op.cit.*, p. 139. A similar conclusion was reached by Charles Kindleberger, "Speculation and Forward Exchange," *Journal of Political Economy*, Vol. 47 (April, 1939), p. 180. Kindleberger was aware, however, that the presence of speculators would alter this result.

[6] Sohmen, *op.cit.*, p. 72.

In the first case, if all sources of demand and supply of forward exchange, other than those of interest arbitrageurs, are exactly matched prior to a change in bank rate, then after the change in bank rate, the excess demand for forward exchange will be perfectly inelastic. Any attempt at covered interest arbitrage will immediately drive the spread between spot and forward to the point where the resulting profits are zero. Thus, the spot rate remains unchanged and the total effect of the interest-rate differential change is felt in the forward market. This result will not be true, however, if uncovered interest arbitrage takes place (an unlikely situation under fluctuating exchange rates), or if speculators are present and their behavior imparts some elasticity to the excess demand for forward exchange. Sohmen has shown that even if uncovered interest arbitrage and speculation are ruled out, Keynes' conclusion is still invalid because he ignored the behavior of importers and exporters who regularly cover in the forward market. These commercial traders base their business decisions, not upon the spot rate, but the forward rate. In the case of outward interest arbitrage, the forward rate will fall, thus imports will be cheaper for the domestic country and more expensive for the foreign country. If the sum of the elasticities of demand for imports exceeds unity in the two countries (the Marshall-Lerner condition), then there will be some elasticity in the demand for forward exchange. Arbitrageurs will now be able to sell their expected foreign exchange forward to importers. Since the sale of forward exchange will have an equal (except for interest accrual) and corresponding purchase in the spot market, the spot rate of exchange must be affected.

The second case arises when the size of the forward market is very small compared to the spot market and there are no speculators present. Take, for example, the situation where a foreign central bank wants to attract short-term capital and attempts to accomplish this by raising its bank rate. When it does this, there will be an incentive for outward interest arbitrage from the domestic country. This will in turn cause an increased demand for spot exchange and an increased supply of forward exchange. If the forward market is thin relative to the spot market, the spot price will not be appreciably affected initially, but the forward rate will rapidly fall and eliminate arbitrage profits. However, if a sufficient number of speculators are present, they will sell forward exchange, which at present they do not have, to arbitrageurs when the forward rate falls below what speculators expect the prevailing spot rate in the future will be. If the speculators are

correct in their forecast, when the forward contracts come due the speculators will be able to take the arbitrageurs' foreign exchange, convert it in the spot market, pay the arbitrageurs the amount of domestic exchange promised, and still have some money left over. If they are wrong, the speculators will not have enough domestic currency left, after converting the arbitrageurs' foreign exchange in the spot market, to meet the forward contract terms, and they will have to make up the difference out of their own pockets. Note, however, that in this situation, if the foreign central bank does not raise its bank rate high enough, the forward exchange rate may not fall far enough to induce speculators to take a short position in forward exchange, and little short-term capital will flow. The foreign central bank can overcome this obstacle by simply continuing to raise its interest rate until it drives down the forward exchange rate to the point where speculators are willing to supply forward exchange. If for some reason speculators are few in number, the central bank can provide the required supply or demand for forward exchange. Furthermore, this operation of the central bank, unlike intervention in the spot market, does not require any foreign-exchange reserves, since the central bank can insure that the spot rates prevailing at the time the forward contracts mature will be of sufficient magnitude to allow costless conversion of the forward exchange. This policy can only succeed, of course, in an atmosphere of confidence in the long-run stability of the currency, which in turn will depend upon appropriate overall monetary and fiscal policy.

1.4 Recent Contributions to Forward-Exchange Theory

Since the resumption of general convertibility in 1951, many academic economists have shown renewed interest in the forward exchange market and its interaction with the spot market. These economists realized that the traditional Keynesian emphasis on covered interest arbitrage was insufficient to fully explain the equilibrium rate of forward exchange and that other operations in the forward exchange market were equally important in determining the equilibrium rate. These additional operations, which, along with covered interest arbitrage, constitute the source of demand for and supply of forward exchange, can be broadly defined as commercial hedging and speculation. The addition of these components to the Keynesian theory has resulted in the challenging of the major conclusion of the prewar

theory, that is, the new theory contends that the equilibrium forward premium rate can be considerably different from the interest-differential rate.[7]

J. SPRAOS

J. Spraos made the first major contribution after the war.[8] Writing in 1953, Spraos' work was primarily concerned with and shaped by conditions existing at that time in the London foreign-exchange market. The London market was reopened in December 1951 and forward sterling was unpegged. However, there were still in existence foreign-exchange controls imposed on British residents. Limitations on outward interest arbitrage virtually eliminated this form of short-term capital movement (inward arbitrage was still possible, however) and the accumulation of speculative foreign-exchange balances (other than unhedged commercial-trading obligations) was illegal. Despite these limitations Spraos made an important contribution. He was the first to investigate the implications of triangular arbitrage on Keynes' suggestion that intervention by the monetary authorities in the forward market would allow a nation to pursue an interest-rate policy independently of her trading partners. Spraos showed that consistency of cross spot rates resulting from spot arbitrage implied consistency of cross forward rates regardless of the existing interest rates in the various countries and, therefore, an independent interest-rate policy was feasible.

Under the assumption that there are no short-term capital flows between centers, Spraos pointed out that the relationship between the spot and forward rates was not completely divorced and independent of the short-term interest differential between the centers. The reason that this is true is found in the behavior of commercial traders. If, for example, an American importer has contracted to pay a British exporter a certain amount of pounds 60 days after delivery of the merchandise, the importer will usually be offered a cash discount by the exporter if his bill is paid on delivery of the merchandise. This offered

[7] The surveys given here of contemporary forward-exchange theory are at best, like most economic surveys, poor substitutes for the original source material and they are most profitably used as guides in the reading of the original works. The arguments and conclusions that I have singled out to be of primary importance from each contribution should be weighed in the light of the entire work and judged accordingly.

[8] J. Spraos, "The Theory of Forward Exchange and Recent Practice," *Manchester School of Economics and Social Studies*, Vol. 21 (1953), pp. 87-117.

discount, of course, is determined by the London short-term interest rate. Whether the American importer decides to accept the cash-discount offer and pay on "sight" or to wait 60 days, depends upon the short-term New York interest rate and the premium on the forward pound. Seeking to maximize his profits, the behavior of the importer will have the same effect on the spot and forward sterling rates as that of an interest arbitrageur. Taking the simplest possible case, it is easily shown why this is so. Suppose that the London interest rate (which will determine the cash discount) is higher than the New York rate and that the forward premium on sterling is zero. It would pay the American importer (if the interest-rate differential were sufficiently large) to borrow from a bank in New York the dollars needed to purchase pounds spot in order to take advantage of the cash discount, because the savings realized through the cash discount would be greater than the cost of borrowing the dollars for 60 days. This behavior would increase the demand for spot pounds and raise the spot rate. The forward pound would then go to a discount and the equilibrium condition of equation (12) would be approached. As long as such profits continued to exist the spot price of sterling would continue to rise until the conditions for equilibrium were met. If the initial conditions were somewhat more complicated, the same profit-seeking behavior of importers or exporters would result in decisions to either borrow (from oneself or a bank) and pay on "sight" or to purchase forward exchange and pay sometime in the future. The net effect will be for the forward-premium rate to approach the interest-rate differential. In actual practice, however, Spraos pointed out that equilibrating mechanism will not work as efficiently as "pure" interest arbitrage and that the relationship between spot and forward rates will become somewhat blurred, but nonetheless, divergence from equality between the forward premium and the interest-rate differential will not be great, unless there are some persistent obstructionist forces present.

Spraos described how these persistent obstructionist forces could come about through speculation or by government intervention in the forward markets. Since he was primarily concerned with the institutional framework as it existed in 1952, Spraos concentrated his attention on speculation, because in his opinion there was "no evidence of overt official intervention in the forward exchange market having taken place."[9]

[9] *Ibid.*, p. 97.

Spraos developed a theory of speculation based on the subjective marginal valuations of speculators with regard to the risk involved in supporting or going against a given currency. The behavior of these speculators was shown to be influenced by the institutional framework under which they operated. For purposes of analysis, Spraos compared speculation under a fully pegged spot rate with that under a floating spot rate. It was further assumed that the aggregate subjective probability of speculators, with regard to an upward revaluation of the currency in question, was virtually zero. Under these circumstances the behavior of speculators under a system of fixed spot rates would be different from that of speculators under a system of floating spot rates. Spraos listed and explained the following three differences:

(1) Speculation under a pegged spot rate would be based on much longer expectations than that under a floating-rate system.

(2) Under a system of pegged spot rates, a case can be made for the *a priori* assumption that the speculative excess demand for the currency under pressure, related to its forward rate, will have higher elasticity than under a floating-rate system.

(3) Under a system of pegged spot rates, where the only conceivable movement of the rate is downward, the number of decision variables faced by speculators is reduced and the maximum gains of speculators taking net long positions if they are correct, and the maximum losses of speculators taking net short positions if they are wrong, can be calculated in advance from the forward discount at which the forward contracts are made. Under the system of floating spot rates a greater amount of uncertainty prevails, since the spot rate can rise or fall. Spraos argues that the lower the degree of uncertainty in speculation, the larger will be the number of speculators present in the market and, therefore, the more elastic the speculative demand or supply.

A major consequence of these differences, in Spraos' opinion, was that the higher elasticity of speculators' excess-demand schedules under a system of fixed spot rates (given that this schedule was not prone to violent shifts) "should impart a considerable degree of stability to the forward rate, in spite of any day-to-day instability in the balance between commercial demand for and supply of forward exchange."[10]

[10] *Ibid.*, p. 104.

S. C. TSIANG

S. C. Tsiang was the first economist to publish a systematic theory of forward exchange which explained how the interplay of the operations of interest arbitrage, commercial hedging, and speculation jointly determine the forward exchange rate and how the forward exchange market and the spot exchange market are linked together.[11] While these three operations are normally performed by three different institutional groups (banks, merchants, and speculators), it is not unusual for one of these institutions to be performing two or more of these operations at the same time. Banks are primarily engaged in interest arbitrage, but in a special sense (as defined by Tsiang) merchants and speculators may also engage in interest arbitrage. Speculation is the major activity of speculators, but banks that take open speculative positions and merchants who leave all or part of their foreign-exchange commitments unhedged can also be considered to be engaged in speculation. Tsiang's theory is based on a detailed description of the determinants of the demand for and supply of forward and spot exchange necessitated by each of these three operations.

In developing his theory of the demand for and supply of foreign exchange, Tsiang first presents the traditional Keynesian approach that was described in Section 1.1 of this chapter. Tsiang diverges from this theory, however, when analyzing what he calls the major shortcoming of the theory, namely the notion that the theory is only applicable up to the point where arbitrage funds abruptly run out. In reality, what transpires is that arbitrageurs become increasingly reluctant to reduce their spot liquid resources in either the domestic or foreign money market as the magnitude of their arbitrage operations (either outward or inward) increases. This results from the fact that banks and other financial institutions need spot liquid funds to carry on their day-to-day business operations and forward claims will not suffice. "That is to say, spot liquid assets yield some intangible returns of convenience or liquidity in addition to their interest yields. Banks (and other financial institutions) would normally be expected to distribute their command over spot liquid assets in various financial centers in such a way that the marginal yields of interest *cum* liquidity

[11] S. C. Tsiang "The Theory of Forward Exchange and Effects of Government Intervention on the Forward Exchange Market," International Monetary Fund *Staff Papers*, Vol. 7 (1959), pp. 75-106.

(convenience) net of exchange risks of liquid assets would be approximately equal between different financial centers."[12]

Therefore, in terms of a revised equation (12), the equilibrium condition for each individual arbitrageur will be

$$R = (i_d + \rho_{d_i}) - (i_f + \rho_{f_i}), \tag{15}$$

where ρ_{d_i} is the subjective marginal-convenience yield to individual arbitrageur i of his net short-term liquid assets in the domestic center, and ρ_{f_i} that of his net short-term liquid assets in the foreign center. These subjective marginal-convenience yields are decreasing functions of the net short-term liquid assets in each center. Based upon this theory of behavior of the individual arbitrageur, Tsiang derives the current net demand for forward foreign exchange for the i^{th} individual. If it is assumed that the spot exchange rate and the interest-rate differential are given, Tsiang's net demand function for the individual arbitrageur is a decreasing function of the current forward exchange rate.

The aggregate excess demand of arbitrageurs for forward foreign exchange is obtained by summing all the individual net demand functions. The aggregate function differs from the individual function in that it is a decreasing function of the forward premium rate, the domestic interest rate, and the foreign interest rate and not merely the forward exchange rate. Symbolically,

$$A_t = A(R, i_d, i_f), \tag{16}$$

where A_t is the aggregate excess-demand function for forward exchange by interest arbitrageurs. This difference results from the assumption that, while for individual arbitrageurs the spot-rate and the interest-rate differential can be taken as given, for aggregate interest arbitrage this no longer applies, but instead they may be functions of aggregate demand. In the situation of outward interest arbitrage, the spot rate of foreign exchange and the domestic interest rate will tend to be pushed up unless they are rigidly pegged, while the foreign interest rate will tend to be lowered. The greater the effect interest arbitrage has on the domestic and foreign interest rates, the lower will be the aggregate elasticity of excess demand for forward foreign exchange.

[12] *Ibid.*, p. 81.

The traditional theory that the operations of interest arbitrageurs in the forward market would determine the forward exchange rate had within it the implicit assumption that the excess demand for forward exchange by arbitrageurs was infinitely elastic over a very wide range. Tsiang disproved this assumption by showing that this demand was a downward sloping function of the divergence of the forward premium from the interest-rate differential and, therefore, of less than infinite elasticity.

Tsiang's theory of speculation is based on the assumption that all speculation is in forward exchange and none is in spot exchange. While this is an essentially correct institutional statement, a small amount of speculation does take place in the spot market, but Tsiang shows that speculation in the spot market can always be analyzed as a combination of the operations of interest arbitrage and speculation in forward exchange.

If a speculator considers that the future spot rate will probably be higher (lower) than the current forward rate, he would purchase (sell) forward exchange until the marginal risk of extending (reducing) his speculative position by an additional unit of foreign exchange is just equal to the amount by which the expected future spot rate exceeds (is less than) the current forward rate. Symbolically, this can be expressed as

$$E(r_{st}) - r_{ft} = \beta_t, \tag{17}$$

where $E(r_{st})$ is the expected value of the future spot rate t days hence, r_{ft} is the current forward rate for delivery in t days, and β_t is the marginal risk of extending his position in foreign exchange. As the speculator buys (sells) forward exchange, thus extending his position, the marginal risk of extending his position will rise (fall).

The net speculative position of the speculator will have a very important effect in determining the value of his marginal risk prior to any purchase or sale of forward exchange in any given time period. "If he has already accumulated a large long position from his previous purchases of forward exchange, the excess of his current expected rate over the current forward rate has to be quite considerable to induce him to make any further purchase of forward exchange. Indeed, he may become a seller of forward exchange to cover his pre-existing long position, when the excess of his expected rate over the forward rate is reduced even though it is still positive."[13]

[13] *Ibid.*, p. 88.

The net position of a speculator is an aggregation of all his previous forward-purchase and sales contracts which have not as yet matured. Tsiang assumes that, if the effect of past forward commitments upon the speculator's current risk position are assumed to diminish exponentially and his current marginal risk is a linear homogeneous function of his current and past commitments, then his marginal risk can be shown to be

$$\beta_t = \gamma s_t + \lambda \beta_{t-1}, \tag{18}$$

where γ is a positive coefficient, λ a positive fraction measuring the diminishing influence of past commitments, s_t is the net purchase of forward exchange on the day in question, and β_{t-1} is the marginal risk, based on his net position, from the day before.

Substituting (18) into (17) and rearranging, Tsiang gets

$$s_t = \frac{1}{\gamma}\left[E(r_{st}) - r_{ft}\right] - \frac{\lambda}{\gamma}\beta_{t-1}, \tag{19}$$

which is a linear approximation of an individual speculator's net demand function on day t.

The aggregate excess demand function, S_t, is obtained by simply summing the functions for each individual speculator. The essential characteristics of the aggregate function remain the same as that of the individual function. Specifically,

$$S_t = \sum_i \frac{1}{\gamma_i}\left[\overline{E(r_{st})} - r_{ft}\right] - \sum_i \left[\frac{\lambda_i}{\gamma_i}\beta_{t-1,\,i}\right] \tag{20}$$

where $\overline{E(r_{st})}$ is the weighted-average expected future spot rate of all speculators.

The aggregate behavior of speculators will be, to a large extent, influenced by $\overline{E(r_{st})}$, the weighted average expected rate, and Tsiang shows that if the current forward rate, r_{ft}, has little influence on $\overline{E(r_{st})}$, then aggregate speculative excess demand will be a decreasing function of the current forward rate.

All foreign-trade transactions which call for future payments are assumed to generate either demand for or supply of forward exchange. Import contracts create a demand for forward exchange and exports a supply of forward exchange. This occurs as commercial traders seek to avoid any exchange risk. As was pointed out above (page 9), however, some importers or exporters may buy or sell spot exchange in order to take advantage of "cash discounts" for early payment. These

transactions are shown by Tsiang to be the equivalent of the combined operations of hedging in the forward market and implicit interest arbitrage. Thus, it is assumed that the demand for and supply of forward exchange for commercial hedging operations is determined by the volume of import and export contracts entered into by commercial traders.[14] The volume of these contracts is primarily the function of the forward exchange rate, since this rate will determine how much importers will have to pay and exporters will receive; symbolically,

$$M_t = M(r_{ft}) \text{ and} \tag{21}$$

$$X_t = X(r_{ft}). \tag{22}$$

Assuming no government intervention, the equilibrium forward rate of exchange will be determined at the level where total excess demand is zero; namely,

$$A_t + S_t + (M_t - X_t) = 0. \tag{23}$$

If the spot rate is pegged, then equations (16), (19), (21), (22), and (23) will be sufficient to determine the forward rate and the total demand for forward exchange.

Determination of the equilibrium rate is shown in Figure 1. Arbitrageurs' excess demand, A_t, is drawn with a relatively elastic downward sloping line, and with reference to the pegged spot rate, r_s. Speculators' excess demand is also drawn with a relatively elastic downward sloping line. The demand for forward exchange, M_t, and the supply of forward exchange, X_t, are drawn as relatively inelastic.

The equilibrium rate is graphically determined by first horizontally adding S_t to M_t, forming the $(S_t + M_t)$ curve. The equilibrium rate is that rate at which the excess demand of importers and speculators over the supply of exporters, *cd*, is just equal to arbitrageurs' excess supply (negative excess demand), *ab*.

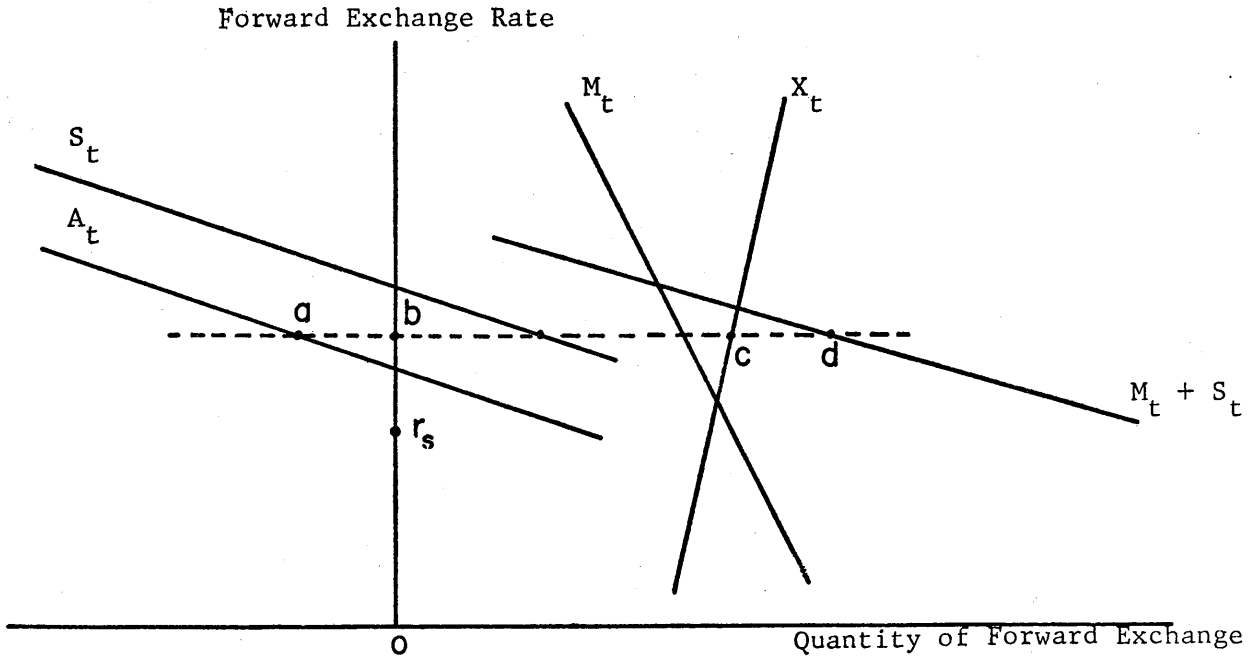
If the spot exchange rate is not fixed, then the spot and forward rates must be simultaneously determined. Tsiang makes the simplifying assumption that all forward contracts and all import and export contracts are for exactly 90 days. Equilibrium in the spot market is given by the following equation:

$$(M_{t-90} - X_{t-90}) = (A_t - A_{t-90}) + G_t, \tag{24}$$

[14] In order to simplify the exposition of Tsiang's theory, I have excluded the possibility of current import and export contracts financed by long-term capital investment. This does not significantly alter the theory or its conclusions.

FIGURE 1

Determination of the Equilibrium Rate of Exchange



where $(M_{t-90} - X_{t-90})$ is the excess supply of spot exchange from import and export contracts that are currently due for payment, $(A_t - A_{t-90})$ are arbitrageurs' net sales (purchases when negative) of spot exchange to cover the net increases (decreases when negative) in their forward positions, and G_t represents the net sale (purchase when negative) of spot exchange by the exchange-stabilization authorities. In this relationship, only A_t and G_t are functions of the spot rate, with A_t being particularly important since it is also a function of the forward rate and therefore joins the spot and forward markets together. By writing equations (23) and (24) as functions of A_t, we get

$$A_t = (X_t - M_t) - S_t = (M_{t-90} - X_{t-90}) + A_{t-90} - G_t, \qquad (25)$$

which specifies the condition of equilibrium in the spot and forward markets. Equation (25) "means that the forward and spot rates will be jointly determined in such a way that, at the joint equilibrium of both markets, the excess supply (or demand if negative) of forward exchange (excluding arbitrageurs' demand for foreign exchange) on the forward market and the excess demand (or supply if negative) for spot exchange (again excluding arbitrageurs' supply of spot exchange in order to cover their current purchases of forward exchange) on the spot market would both be equal to the demand for forward exchange on the part of arbitrageurs under the equilibrium forward and spot rates (i.e., under the equilibrium forward premium or discount)."[15]

This simultaneous determination of the spot and forward rates is shown in Figure 2. In the spot market, the excess supply of spot exchange, excluding arbitrageurs' demand for spot exchange is *fh* at the equilibrium spot rate *oe*. At the equilibrium forward rate, *ob*, the excess demand for forward exchange (less arbitrageurs' excess demand, which is in this illustration negative) is *cd*. The joint equilibrium condition as specified in equation (25) means that $fh = ab = cd$, where *ab* is arbitrageurs' excess supply of forward exchange, given the forward premium $\frac{ob - oe}{oe}$.

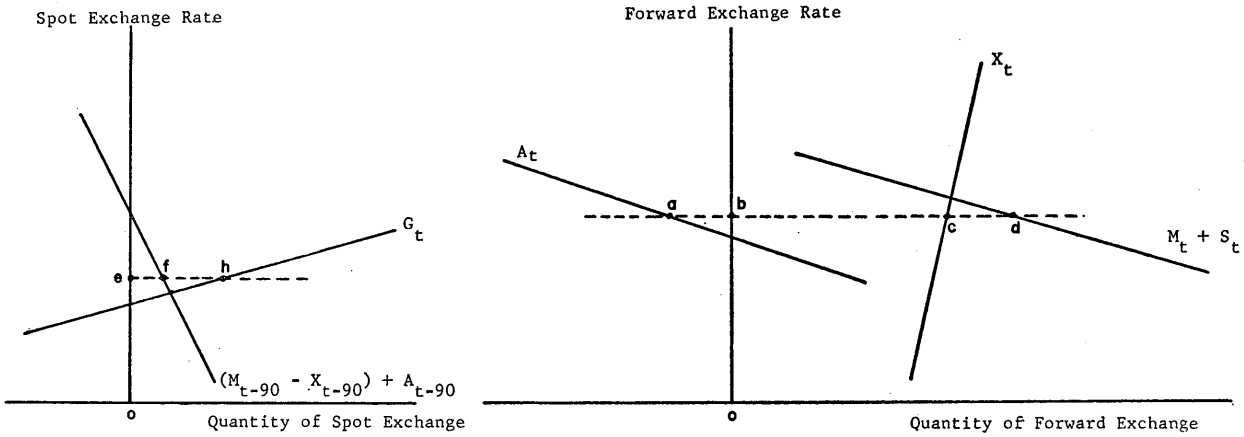
After presenting his theory, Tsiang utilized it to analyze the implications of intervention in the forward market by the monetary authorities.

The condition of equilibrium in the forward market, with intervention taking place, is given by

[15] *Ibid.*, p. 98. Note that Tsiang has ignored the interest accrual to arbitrageurs.

FIGURE 2

Determination of Spot and Forward Exchange Rates



$$A_t = (X_t - M_t) - S_t + I_t, \tag{26}$$

where I_t is the net sale of forward exchange by the monetary authorities. The condition for equilibrium in the spot market remains as before, so that the condition for joint equilibrium may now be stated as,

$$A_t = (X_t - M_t) - S_t + I_t = (M_{t-90} - X_{t-90}) + A_{t-90} - G_t. \tag{27}$$

Consider the case where the foreign currency is under speculative pressure to devalue. Then the main question, about which the contemporary debate on the advisability of forward intervention revolves, is what effect will an intervention policy supporting the forward rate have upon the sales of spot exchange out of reserves in support of the spot rate. As Tsiang views this question, it should be broken down into two sub-questions, which are (1) What will happen to spot sales immediately after intervention? and (2) What will happen when the forward contracts sold by the monetary authorities mature?

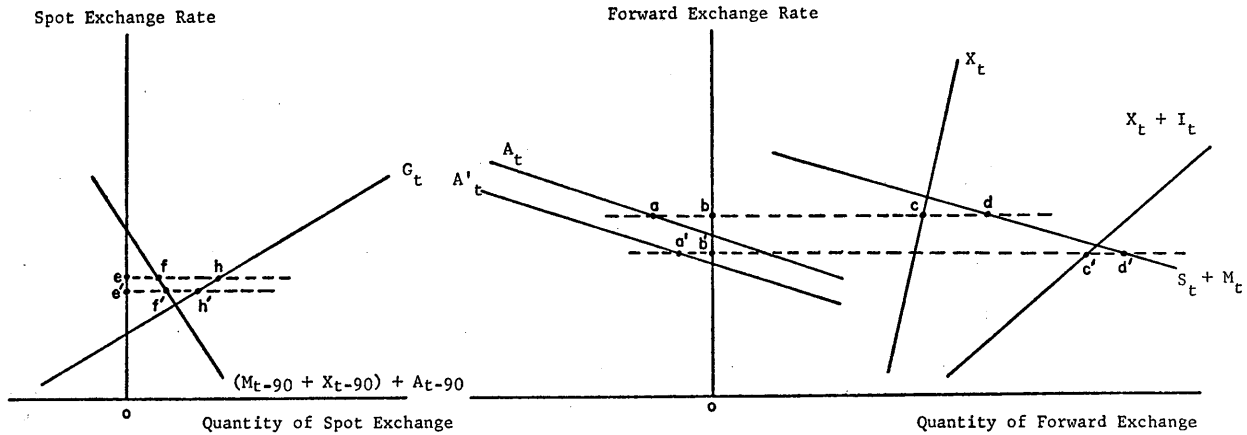
The immediate effect of intervention depends upon whether the act itself will have any psychological effect on expectations in the spot and forward markets. Assuming initially that there are no psychological effects, then the new equilibrium conditions can be shown in Figure 3.

The amount of government sales of forward exchange is shown by the distance of the horizontal shift in the X_t curve to the right, forming the $X_t + I_t$ curve. This reduces the amount of forward exchange that has to be supplied by arbitrageurs to meet the positive excess demand of exporters and importers. Simultaneously, the spot rate will tend to fall, since arbitrageurs will now be buying less spot exchange. If the spot rate was fixed, then this would mean a reduction in the loss of reserves by the monetary authorities. If the spot rate was supported, but not fixed, then there would be both a reduction in reserve loss and a fall in the spot rate. A fall in the spot rate, however, would cause a downward shift in arbitrageurs' excess demand for forward exchange, A_t. This downward shift from A_t to A'_t would mean a further fall in the forward rate, and a decrease in arbitrageurs' excess demand for forward exchange and a decrease in their excess supply of spot. Simultaneous equilibrium will be achieved when $a'b' = c'd' = f'h'$. At this new equilibrium both the spot and forward rates are lower, supply of forward exchange and demand for spot exchange by arbitrageurs is lowered, and the depletion of foreign-exchange reserves is reduced.

These conclusions are, of course, dependent upon the previous assumption that there were no psychological effects as a result of

FIGURE 3

Equilibrium under Intervention in the Forward Exchange Market



intervention. If intervention has a positive psychological effect (that is, restores confidence in the currency), then the excess-demand curve of speculators will be shifted downward, the above conclusions would still be correct, and the rate of drawing upon official reserves would be further reduced. Suppose, however, that intervention causes a weakening of confidence, and speculators' excess demand shifts upwards. If this upward shift is sufficiently large, the spot and forward rates would rise and the rate of drawing upon foreign-exchange reserves would be increased.

Tsiang believes that occasional intervention will be unlikely to have a negative effect on speculators' confidence and that it will probably have a positive effect. Protracted intervention, however, will most likely have a greater effect on destroying confidence than the greater reduction in foreign-exchange reserves that would have resulted from nonintervention.

The deferred effects of forward intervention, that is, the resulting conditions in the spot and forward markets when the forward contracts sold by the monetary authorities mature, will tend to offset the immediate gains of intervention. This occurs for two reasons. First, if the initial intervention was successful in reducing arbitrageurs' supply of forward contracts, then when these contracts mature, the amount of spot exchange released, would be lower than it would have been otherwise. Secondly, since imports and exports are a function of the forward rate, a fall in this rate will increase imports and reduce exports; therefore, when these forward contracts mature, there will be a greater demand for spot exchange with the accompanying increased reduction of official reserves.

Tsiang concludes that the effect of intervention "can be expected to relieve the current pressure on the spot exchange market (and hence to cut the current drain on official reserves if the spot rate is officially supported) merely by shifting the current pressure to a later period and at the cost of worsening, to some extent, the current balance of trade. Unless the current pressure on the balance of payments is expected to be reversed shortly, or is expected to be curtailed by the increase in confidence inspired by the very act of intervention, there does not seem to be a strong case for intervention."[16]

EGON SOHMEN

Egon Sohmen, in his doctoral dissertation, developed a theoretical model of the forward exchange market which was essentially the same

[16] *Ibid.*, p. 105.

as Tsiang's.[17] Sohmen later extended his dissertation and published a monograph in 1961 which incorporated this model. Some of the theoretical observations made in this monograph, with respect to forward exchange, were discussed in Section 1.3 of this study.[18] Sohmen's most recent contribution extends his theory further by considering not only one spot and one forward market, but any number of forward markets, and sheds additional light on some neglected aspects of forward-exchange theory.[19]

Sohmen is probably the most outstanding theoretical apologist for flexible-exchange-rate systems and much of his recent contribution should be read with this in mind. For example, in *The Theory of Forward Exchange*, Sohmen dispels the folklore that forward hedging on the part of commercial traders involves an intrinsic risk premium and shows that this is not the case if full convertibility is maintained by the monetary authorities. He does this to counter the argument that flexible-exchange-rate systems increase the cost of world trade and thus reduce its volume. This conclusion rests upon his belief (as opposed to Tsiang's) that the subjective marginal-convenience yields [ρ_f and ρ_d in equation (15)] are not significant factors and, therefore, interest arbitrage would prevent excessive divergence between interest differentials and forward premia. Suppose that the interest rates in two countries are identical, then the forward rate would be approximately equal to the spot rate and the cost of hedging would obviously be zero. Should the interest rates differ, the cost of forward exchange for the traders of one country will be higher than spot, while the cost to traders in the other country will be less than spot, and for commercial trade as a whole these losses and gains will tend to cancel out over time.

Sohmen blames the present international monetary system for the large divergencies between interest differentials and forward premia which have been observed from time to time since the resumption of general convertibility. These divergencies have been characteristically associated with periods of expected depreciation of "weak" currencies and appreciation of "strong" currencies and have usually resulted from, in Sohmen's opinion, the reluctance of central banks to allow interest arbitrage to take place. When arbitrage is thus impaired, the currency

[17] Egon Sohmen, *Economics of Flexible Exchanges* (Cambridge: Massachusetts Institute of Technology, 1958).

[18] Egon Sohmen, *Flexible Exchange Rates, Theory and Controversy* (Chicago: University of Chicago Press, 1961).

[19] Egon Sohmen, *The Theory of Forward Exchange*, Princeton Studies in International Finance No. 17 (Princeton, N.J.: International Finance Section, 1966).

under speculative attack is driven to a sizable discount, thereby making the cost of hedging against devaluation quite costly. Sohmen concludes that "It is most remarkable that the appearance of large forward discounts and the occasional breakdown of forward markets—both phenomena being so intimately and characteristically associated with the present system of (adjustably) *pegged* exchange rates—are so often pointed out as evidence of the prohibitive cost (or actual impossibility) of forward coverage for traders in a system of *flexible* exchange rates."[20]

Not only does Sohmen's recent modification approach, that is, allowing for the existence of any number of forward markets, more closely the real world, but it also illuminates certain implications of monetary policy. Suppose that the domestic central bank follows an expansionary monetary policy and lowers domestic interest rates. The foreign interest rate will rise relative to the domestic rate, outward interest arbitrage will take place, the spot rate of domestic currency will tend to fall, and the forward rate of domestic currency will rise. If the spot rate is flexible, then depreciation of spot will encourage some exports and discourage some imports, thus increasing the expansionary effect of domestic monetary policy via the foreign-trade multiplier. If the spot rate is pegged, there will simply be a reduction in the foreign-exchange reserves of the central bank. Since the domestic forward exchange rate rises and if most commercial traders deal in the forward market, then it appears that perhaps the foreign-trade effect of an expansionary domestic monetary policy under a flexible exchange-rate system could very well work in a contrary manner. By expanding forward-exchange theory to include any number of forward exchange markets, Sohmen shows that this would not immediately happen. To understand Sohmen's conclusion, consider the following very simplified example. Assume that domestic and foreign interest rates are equal initially, speculation is not present, excess demand of commercial traders is zero on both spot and forward markets, and the spot and forward exchange rates for all forward maturities are equal at $2.80 per pound. Further assume that the excess-demand functions of commercial traders are not affected by changes in domestic interest rates.

Suppose that there are only four forward markets, of 3, 6, 9, and 12 months, and the domestic interest rate declines relative to the foreign interest rate by 4 per cent per annum. The new equilibrium condition (given the excess-demand function of commercial traders) with respect

[20] *Ibid.*, p. 30.

to the forward market with the longest maturity (12 months) is specified by equations (10) and (12),

$$R = (i_d - i_f) = -.04,$$

and

$$R = \frac{r_f}{r_s} - 1 = \frac{2.78}{2.90} - 1 = -.04,$$

where the equilibrium forward foreign exchange rate, r_f, is \$2.78 and the equilibrium spot foreign exchange rate, r_s, is \$2.90. If these were the only transactions taken by arbitrageurs, the 3, 6, and 9-month forward rates would remain unchanged, but this is impossible because the term structure of interest rates will determine within narrow limits the term structure of forward rates. For example, the equilibrium 3-month forward premium would be minus one per cent. Therefore, given the new spot rate of \$2.90, the 3-month forward rate is

$$r_f = r_s(R+1) = \$2.90\ (.99) = \$2.87.$$

The shorter-term forward exchange rates rise, which means that the corresponding domestic forward rates fall, thus stimulating exports and discouraging imports for this period. In terms of arbitrage operations, arbitrageurs in the closer forward markets, where the existing forward rate is below the equilibrium rate, have bought forward exchange of that maturity and sold it spot. This tends to depress the spot price (which, for simplicity in this example, was ignored) and raise the short forward rates. For these maturities, arbitrage funds flow "uphill" to the country with the lower interest rate, but for the longer maturities, the funds flow in their normal direction.

Dropping the assumption that commercial traders are unaffected by monetary policy, Sohmen shows that their behavior will tend to reinforce the term-structure effects on closer forward rates. In conclusion, Sohmen is very optimistic (perhaps overly so) about the effectiveness of monetary policy under flexible exchange rates. He believes that the foreign-trade effect will reinforce domestic policy almost instantaneously and that this effect will not be reversed too quickly. By the time the foreign-trade effect is reversed, the lagged domestic reaction to lower interest rates should be assuming a dominant role in increasing national income.

Sohmen's position on official intervention in the forward market to stabilize the forward rate depends upon the attitudes of the central bank. If the central bank is not willing to place maintenance of the

exchange rate high on the list of its policy objectives, then forward intervention will only put off the final day of judgment and increase the cost. If, however, the spot exchange rate is earnestly maintained by the central bank, he feels that in order for the bank to show its good intentions it should intervene in the forward market to maintain the equilibrium alignment between the spot and forward rates. What is wrong with this conclusion is that, if the participants in the market believe the expressed convictions of the central bank regarding the spot rate, then intervention is unnecessary in the forward market to maintain the proper relation between the spot and forward rates. It appears that the conclusion of Tsiang mentioned above is still the most appropriate, namely that intervention by the central bank can only be justified for short-term periods to offset very temporary discrepancies between the two rates.

PETER B. KENEN

In his contribution to forward-exchange theory, Peter Kenen has departed from the traditional aggregate approach based upon the functional classification of forward transactions and has instead sought new insight into the forward market by analyzing the operations of an export-import firm.[21] Kenen shows that an individual firm will engage in the operations of speculation, hedging, and interest arbitrage, and claims that this microeconomic approach reveals certain interrelationships between these operations which the aggregate approach does not.

With his model, Kenen reproduces many of the propositions which have been previously derived by the traditional approach and explores conditions necessary for stability in the foreign-exchange market. With regard to the implications of official forward intervention by the monetary authorities, Kenen states that his analysis supplies a strong basis for believing that forward intervention should be used to offset speculative pressure. While agreeing with Tsiang that the immediate effect of intervention will reduce the loss of current reserves, he disagrees with him about the deferred loss of reserves. Kenen believes that these deferred losses will not occur because the monetary authorities will be able to match their net commitments of forward exchange with those of speculators. In Kenen's opinion, the magnitude of profit or loss incurred by the monetary authorities from their forward opera-

[21] Peter B. Kenen, "Trade, Speculation, and the Forward Exchange Rate," in Robert E. Baldwin *et al.*, *Trade, Growth, and the Balance of Payments*, Essays in Honor of Gottfried Haberler (Chicago: Rand McNally and Co., 1965), pp. 143-169.

tions depends exclusively upon the forward premium at which they choose to stabilize the forward exchange rate.

JEROME L. STEIN

Jerome Stein's approach to forward-exchange theory, when compared with the previously mentioned economists, is unique.[22] Stein appears to be the only one who has a first hand, intimate knowledge of the actual behavior of foreign-exchange traders in the New York market. This factor has resulted in a highly institutionalized approach to forward exchange theory where specific institutions are delegated specific operations in the market. Probably the most important example of this approach is Stein's analysis of speculative operations in the forward market. According to Stein, the only parties that speculate in the forward market are the large banks, and all other parties in the foreign-exchange market are restricted by bank practice to the spot market. In other words, while it may be theoretically possible for non-bank individuals to speculate in forward exchange, in actual practice they are prevented from doing so.

Stein combined these institutional observations with a mathematical model which he had previously developed for commodity markets[23] and produced a most interesting theory of forward exchange. Stein's theory is interesting on two counts. First, it purports to be able to estimate, over a given period of time, in what direction (long or short) the banks, as a group, are speculating in forward exchange. Second, since this estimation is made by simply observing the relative movements in the spot rate, the forward premium and the interest-rate differential, it is possible to test his theory empirically if the actual net forward positions of banks are known.

The remainder of this study is devoted to the task of empirically testing Stein's theory. In the next chapter, Stein's theory is developed in some detail. The following chapter describes an empirical test over a period of time when needed data are available. Finally, the last chapter presents some observations on empirical research in forward-exchange theory.

[22] Jerome L. Stein, *The Nature and Efficiency of the Foreign Exchange Market*, Essays in International Finance No. 40 (Princeton, N.J.: International Finance Section, 1962).

[23] Jerome L. Stein, "The Simultaneous Determination of Spot and Future Prices," *American Economic Review*, Vol. 51 (December 1961), pp. 1012-1025.

2. JEROME STEIN'S THEORY OF FOREIGN-EXCHANGE-MARKET EQUILIBRIUM

According to Jerome Stein,[24] any time period in the foreign-exchange market can be classified as normal or speculative. A period is defined as normal if there exists confidence in the stability of the current set of spot and forward rates. Should the current set of prices diverge from what the market considers to be normal, then it is expected that this divergence will be eliminated within a short period of time. A speculative period is defined as one in which the market expects a change to occur in the normal set of prices within a short period of time.

A normal period exists when the balance-of-payments surplus or deficit is considered by the market to be temporary at the existing set of exchange rates. In a speculative period, however, the balance-of-payments surplus or deficit is not expected to be short-lived at the existing set of exchange rates.

Stein's thesis is that there exists a different pattern of market reactions during normal periods and speculative periods, and by examining changes in the spot rate, the forward premium, and the interest-rate differential between two centers it is possible to determine the speculative behavior of foreign-exchange traders. These traders, who will henceforth be referred to as professional speculators, buy and sell foreign exchange and deliberately take speculative positions.[25]

2.1 Price Movements During a Normal Period

During a normal period there will be an inverse relationship between movements in the spot price of a foreign currency and its forward premium. When the spot rate rises, the forward premium will fall (a discount is a negative premium; therefore, a negative premium will become smaller algebraically while increasing in absolute value). When the spot rate falls, the forward premium will rise (if the forward rate was at a discount, it would increase algebraically).

During a normal period variations are always occurring in the rela-

[24] Jerome L. Stein, *The Nature and Efficiency of the Foreign Exchange Market*, Essays in International Finance No. 40 (Princeton, N.J.: International Finance Section, 1962), pp. 28-38.

[25] In Jerome Stein's terminology they are called professional risk-bearers.

tive interest rates between countries, the current-account balance, the long-term capital-account balance, and the volume of unilateral transfers. The foreign-exchange market adjusts to these variations. The market adjustments to these variations must be such as to equate the demand and supply for spot exchange and equate the demand and supply for forward exchange. These two parts of the foreign-exchange market are so interdependent that if one part of the market is in disequilibrium, the other part cannot remain in equilibrium.

There are two types of normal periods when the spot and forward rates move in opposite directions. The first type is produced by autonomous changes in the balance on current account, plus long-term capital account, plus unilateral transfer account, and is called the basic-balance normal. The second type of normal period is produced by autonomous changes in interest rates at home or abroad and is called the interest-differential normal.

THE BASIC-BALANCE NORMAL PERIOD

The Supply and Demand for Spot Exchange. Suppose that there is a deficit in the balance of payments. This deficit could have been produced by an increase in unilateral transfers, a fall in the long-term capital account, or a decline in the current-account balance. Regardless of the way in which it was produced, the result is an excess demand for spot exchange and is considered by the market to be temporary. (This is shown by item 1, Table 1.)

As a result of this deficit, the spot price rises. As the market buys exchange from the banks, bank traders ask higher prices in order to prevent depletion of and to even out their spot positions.

As the spot price rises, relative to a set of normal prices, leads and lags in payments develop. Exporters accelerate their sales of foreign exchange to take advantage of the higher exchange rate, which is believed to be temporary. Importers lag their payments in foreign exchange, hoping that the exchange rate will fall to its normal level before they must make payment. This reduces some of the excess demand for foreign exchange and a net supply of spot exchange is produced by the leads and lags (item 2, Table 1).

Interest arbitrageurs also provide a supply of spot exchange. As the spot price rises relative to the forward price, the forward premium falls. Given the money-market rates of interest between two countries, the profitability of outward interest arbitrage decreases with a fall in the forward premium. Interest arbitrageurs then sell spot foreign

TABLE 1

SPOT PURCHASES AND SALES DURING A NORMAL PERIOD: DEFICIT IN THE BALANCE OF PAYMENTS

Purchases	*Sales*
(1) Deficit in the balance of payments (produces a rise in the spot price).	(2) Leads and lags: exporters accelerate their sales of exchange and importers lag their purchases of exchange in anticipation of a fall in the spot rate. (3) Interest arbitrageurs sell spot as forward premium falls. (4) Domestic firms borrow abroad and sell foreign exchange for domestic currency. They cover the exchange risk in the forward market. (5) Some institutions may reduce spot holdings of foreign currency. (6) The rise in the spot price can affect balance of payments.

exchange for domestic exchange, which they invest. Interest arbitrageurs who do not reside in the domestic country will simultaneously sell spot foreign exchange for domestic currency and buy foreign exchange forward to avoid any foreign-exchange risk.

As the forward premium on the foreign currency falls, the forward premium on the domestic currency rises. It becomes less costly for domestic firms to borrow in foreign money markets with the exchange risk covered. Domestic firms borrow abroad, sell the foreign exchange for domestic currency and simultaneously repurchase forward foreign exchange. Likewise, foreign firms will find it more expensive to borrow in the domestic money markets with the exchange risk covered.

The net effect of interest arbitrage and foreign borrowing is to increase the supply of spot foreign exchange (items 3 and 4, Table 1).

Some banks and other institutions which have spot balances of foreign exchange will sell some of their holdings to take advantage of the higher price (item 5, Table 1).

The rise in the price of foreign exchange can affect the balance of payments in the very short run. Some import orders might be cancelled and additional export orders might result. The net effect of this would be to increase the supply of foreign exchange (item 6, Table 1). This has the effect of offsetting item 1.

The Supply and Demand for Forward Exchange. Transactions 3 and 4 in Table 1 have associated transactions in the forward market. Interest arbitrageurs who invest their funds in the domestic money market, or firms which switch their borrowing to foreign money markets not

only sell spot exchange, but simultaneously buy forward exchange from the same party. (These are items 7 and 8 in Table 2.) As interest arbitrageurs and borrowers in foreign money markets buy forward exchange, the price of forward exchange rises. The large banks, which are the professional speculators in the foreign-exchange market, "seldom take positions mainly by augmenting their foreign-exchange balances. When they take a position, it is in the futures market."[26] An investment is made in forward contracts without tying up reserves. In this example of a basic-balance normal period, the professional speculators expect the spot price of foreign exchange to be lower in the future than it is in the present; therefore, they are willing to sell more forward contracts for foreign exchange than they desire to buy, that is, they take a short position in forward exchange (item 9, Table 2). A long position is taken in forward contracts if the price of spot exchange is expected to be higher in the future. If the professional speculator guesses correctly, he makes a profit; if not, a loss is incurred.

Equilibrium in both the spot and forward markets results when the spot rate has risen and the forward premium has fallen. The price of forward exchange has risen to induce the professional speculators to assume the risks of serving the interest arbitrageurs and other hedgers, but the forward premium has fallen; hence, the price of forward exchange has risen by less than the spot price of foreign exchange.

TABLE 2

FORWARD PURCHASES AND SALES DURING A NORMAL PERIOD: DEFICIT IN THE BALANCE OF PAYMENTS

Purchases	*Sales*
(7) Interest arbitrageurs.	(9) Professional speculators.
(8) Firms that borrowed in foreign money markets.	

THE INTEREST-DIFFERENTIAL NORMAL PERIOD

"A change in the interest-rate differential may be viewed by the market in several ways. First, it may not be accompanied by any strong expectations that there will be a change in the normal set of exchange rates. In this case, the change in the interest differential is a normal disturbance. That is, it occurs during a normal period. Second, the change in the interest differential may be heralded as a decision to alter the exchange rates, relative to its current levels. In such a case,

[26] Stein, *op.cit.*, p. 32.

the disturbance is speculative: it occurs during a speculative period. There are many situations when both views are held by different components of the market. Then the resulting price reactions will be the weighted sum of the reactions of the various components."[27]

Market reactions to a change in international interest rates during a normal period are presented here.

The Supply and Demand for Spot Exchange. Assume that interest rates abroad fall relative to domestic interest rates, but the market does not expect significant changes in the normal rates of exchange.

An inflow of funds results as foreign interest rates fall. Owners of foreign treasury bills and time deposits will switch their funds to domestic bills and time deposits. Likewise, borrowing will switch to foreign money markets and spot foreign exchange will be sold (item 1, Table 3). Both arbitrageurs and borrowers will avoid exchange risk. The attempts to sell foreign exchange will drive the price down, be-

TABLE 3

SPOT PURCHASES AND SALES DURING A NORMAL PERIOD: DECLINE IN FOREIGN INTEREST RATES

Purchases	*Sales*
(2) Leads and lags: importers accelerate their foreign-exchange purchases and exporters lag their foreign-exchange sales.	(1) Interest arbitrageurs sell foreign exchange for domestic exchange in order to invest in the domestic money market. Some borrowing shifts abroad, and this foreign exchange is also sold in the domestic market. Price tends to fall.
(3) Current-account or long-term capital-account surplus may fall.	
(4) Long positions may be taken by some institutions.	

cause foreign-exchange traders will lower their asking prices to prevent covering these purchases at a loss. As the spot price falls, the forward premium rises, thus profitability of inward interest arbitrage decreases and the net increase in supply of foreign exchange is reduced.

As the price of foreign exchange falls, relative to the expected normal price, the leads and lags of international payment once again develop (item 2, Table 3). Importers accelerate their purchases of foreign exchange to take advantage of the reduction in price. Similarly, exporters lag their sales of foreign-exchange receipts in anticipation of a price rise. The net effect is to reduce the quantity of foreign exchange offered for sale in the market.

A fall in the price of foreign exchange may decrease the domestic

[27] *Ibid.*, p. 32.

country's current-account balance in the very short run. If the fall in the exchange rate is great enough, it may induce foreign importers who do not have forward cover to cancel their purchases. This would decrease the net supply of foreign exchange. The long-term capital account or the invisible current account may also be affected by foreign-exchange-rate movements. A domestic firm about to make long-term investment abroad may accelerate payment to take advantage of a fall in the exchange rate. Similarly, the payment of corporate dividends by domestic branches of foreign concerns may be delayed. Thus, the invisible current-account balance may also be influenced by a decline in exchange rates. This phase of the equilibrium adjustment is represented by item 3, Table 3.

Some institutions may take long uncovered positions in spot foreign exchange, as a result of the decline in price. They plan to sell the foreign exchange when the price returns to its normal level (item 4, Table 3).

The price of foreign exchange will fall until item 1 is offset by items 2-4. In the final equilibrium the price of spot foreign exchange will be lower than initially.

The Supply and Demand for Forward Exchange. Transaction 1, Table 3, has an associated transaction in the forward market. Interest arbitrageurs simultaneously buy forward when spot is sold. "In this manner they attempt to shift the risks of exchange-rate fluctuations onto the institutions which purchase futures. The major risk-bearing institutions in the futures market are the large banks which make the markets in all maturities."[28] The price of futures must rise above the normal expected price of spot, in order to induce the banks to sell these forward contracts and take a short position. The equilibrium in this market is shown in Table 4.

Equilibrium in the spot and forward markets results when the spot rate has fallen and the forward premium has risen. Thus, the rate of capital inflow is reduced, the demand for forward exchange is reduced, and some institutions decrease their sales of spot exchange.

2.2 Price Movements During a Speculative Period

"The market consists of a variety of institutions with different price expectations or aversions to risk. During a speculative period, several important segments of the market expect prices to change and react

[28] *Ibid.*, p. 35.

accordingly. It is shown that, during a speculative period, the spot price moves in the same direction as the forward premium. . . ."[29]

TABLE 4

FORWARD PURCHASES AND SALES DURING A NORMAL PERIOD: DECLINE IN FOREIGN INTEREST RATES

Purchases	*Sales*
(6) Interest arbitrageurs and domestic borrowers who borrow abroad buy forward exchange to cover spot sales.	(5) Large banks which take positions in forward exchange and thus raise bid prices.

Assume that traders in the large banks expect large-scale buying of a foreign currency by their customers and foreign banks, who are motivated by expectations of a rise in the normal set of exchange rates. The foreign-exchange traders who make the market will take long positions in the forward and spot markets to avoid short positions or market losses when the buying orders materialize. This is shown in item 1, Table 5 and item 4, Table 6, when they buy forward and spot respectively. Their long position is in the forward market, predominantly for the reasons explained above.

It is in the forward market that major pressure is initially felt, and the premium on the foreign forward currency rises. This implies that the premium on the forward dollar falls, and as a result outward interest arbitrage is encouraged. Interest arbitrageurs buy spot foreign exchange to invest abroad (item 5, Table 6) and simultaneously sell forward foreign exchange to the large banks. Likewise, foreign firms are encouraged to borrow in the domestic money market with the exchange risk covered in the forward market (item 2, Table 5 and item 5, Table 6).

Some institutions may take advantage of the situation to make profits by swapping. They buy foreign exchange spot and sell foreign exchange forward when the forward premium on the foreign currency exceeds the cost of carrying larger foreign balances. These institutions are listed in item 3, Table 5 and item 6, Table 6.

The pressure in the forward market is transmitted by interest arbitrageurs, foreign borrowers, and some institutions to the spot market. Another source, initially, is via the leads and lags of international payments. With spot price rising and expected to rise further, exporters lag cashing their exchange receipts and importers accelerate their

[29] *Ibid.*

TABLE 5

FORWARD PURCHASES AND SALES DURING A SPECULATIVE PERIOD: EXPECT PRICE OF FOREIGN CURRENCY TO RISE

Purchases	*Sales*
(1) Large banks buy in anticipation of the state of the market or of customers' requirements. Price tends to rise.	(2) Interest arbitrageurs and foreign borrowers sell forward exchange as premium rises. (3) Some institutions buy spot foreign currency and sell it forward to profit from the price differential.

TABLE 6

SPOT PURCHASES AND SALES DURING A SPECULATIVE PERIOD: EXPECT PRICE OF FOREIGN CURRENCY TO RISE

Purchases	*Sales*
(4) Foreign-exchange traders in anticipation of market requirements. (5) Interest arbitrageurs buy spot foreign exchange and invest abroad. Foreigners borrow in the domestic market and convert domestic currency for uses at home. (6) The institutions which buy spot foreign exchange and simultaneously sell it forward. (7) Initial leads and lags of exporters and importers.	(8) Leads and lags by those who think that the price rise has gone far enough. (9) The current and long-term capital account will increase as a result of the rise in the spot price of foreign exchange.

purchase of foreign exchange. The net effect is to increase the purchasing pressure in the spot market (item 7, Table 6).

Counterbalancing the above buying pressure in the spot market are two factors. As the price of foreign exchange rises, expectations begin to be revised. Importers and exporters initially expect the price to rise to a certain level. When the current price of foreign exchange rises above this level, exporters will accelerate cashing exchange receipts and importers will lag payments in foreign exchange. The initial leads and lags become gradually reversed as the price rises (item 8, Table 6).

The other factor that offsets the buying pressure in the spot market is the balance of payments (item 9, Table 6). With a rise in the spot price of foreign exchange, some importers will cancel orders and some exporters will have orders increased. Similarly, domestic firms planning long-term capital investments abroad may decide to wait until the spot rate declines, while foreign investors may accelerate payments to take advantage of the increased value of their currencies. The net

effect will be to increase the sales of foreign exchange in the spot market.

The spot price will rise, in a free market, until items 8 and 9 offset items 4, 5, 6, and 7. At the final equilibrium, the spot price and forward premium will be higher than they were before the onset of speculative pressure. A higher forward premium is necessary to equilibrate the forward market and a higher spot rate is necessary to equilibrate the spot market.

Necessary changes having been made, the above analyses for the basic-balance normal, interest-differential normal, and speculative periods apply for opposite initial conditions than those used in the examples.

2.3 Summary of Jerome Stein's Conclusions

During a speculative period the spot price of a foreign currency and its forward premium rise or fall concurrently. When both the spot and forward premium fall, Stein infers that professional risk-bearers have taken a short position in the forward market, that is, they have sold more foreign currency forward than they have bought forward. When both the spot and forward premium rise, it is concluded that the professional risk-bearers have purchased more foreign currency forward than they have sold; they have taken a long position.

A normal period is said to have occurred if the spot price and forward premium move inversely. There are two types of normal periods and the position taken by professional risk-bearers will depend upon which type occurs. These two normal periods are classified according to the exogenous disturbance which brings about the deviations in the spot and forward rates. They are referred to as the basic-balance and the interest-differential type of normal periods.

The basic-balance normal period results from autonomous changes in the basic balance of payments: the balance on current account plus the long-term capital account plus the unilateral-transfer account. When the spot price declines and the forward premium rises, professional risk-bearers take long positions in the forward market, and they take short positions when the opposite occurs. The interest-differential normal period occurs when autonomous changes in interest rates take place internally or externally. During interest-differential normal periods, when the spot price declines and the forward premium rises, risk-bearers take short positions, and they take long positions when the

spot price rises and the forward premium falls. In other words, professional speculators, for the same given movement in the spot and forward rates, take opposite positions in the basic-balance and interest-differential periods.

To determine the position taken during normal periods, it is necessary to classify the period into one or the other of the two types. Stein accomplishes this by placing two more restrictions on the interest-differential period. These restrictions are that (1) the interest-rate parity (the foreign prime interest rate minus the domestic prime rate) and the spot rate move in the same direction, and (2) the interest-rate parity changes by more than 10 points per month (a point being 1/100 of one per cent).[30] The conclusions of Stein's theory are summarized in Table 7.

TABLE 7

POSITION TAKEN BY PROFESSIONAL RISK-BEARERS

	Position	
Type of Period	*Short*	*Long*
Speculative	Spot Rate Falls Forward Premium Falls	Spot Rate Rises Forward Premium Rises
Basic-Balance Normal	Spot Rate Rises Forward Premium Falls	Spot Rate Falls Forward Premium Rises
Interest-Differential Normal	Spot Rate Falls Forward Premium Rises Interest-rate parity falls by 10 points per month	Spot Rate Rises Forward Premium Falls Interest-rate parity rises by 10 points per month

[30] The choice of a interest-rate parity change of 10 points per month was not specified in that portion of Stein's paper explaining the theory, but later, on page 51 in another section, where he used the theory in empirical analysis. This choice is somewhat arbitrary.

3. EMPIRICAL TESTING OF STEIN'S THEORY

3.1 Data and Methodology

Stein's theory lends itself very well to empirical testing because of the clear set of rules, which allow one to predict the positions taken by the risk-bearers in the forward market. By simply comparing the predicted position with the actual position, the predictive capability of the theory can be ascertained. A major problem in testing the theory, however, is the difficulty of obtaining the required data on the aggregate operations of professional risk-bearers. Fortunately, one such set of data exist for the period extending from January 1935 to the end of convertibility in 1939.[31] The market for British pounds was chosen for analysis, because this currency was the most heavily traded in the United States and flexibility of its exchange rate made for large variations during this period.

Daily data on the spot and 90-day forward rates between the pound and the dollar were obtained from the historical records of the First National City Bank of New York. The weekly average spot rate and 90-day forward premium for the week ending on Wednesday were then computed. The weekly time series is given in Appendix I. Weekly average rates were needed because the forward positions of professional risk-bearers, as collected by the U.S. Treasury, were given weekly and not daily. The average rates should give a clearer picture of change throughout the week in the foreign-exchange market than would a change in the rates from one Wednesday to the next.

The weekly position, as of the Wednesday of each week, taken by professional risk-bearers in the forward market from January 8, 1936 to August 31, 1939 is given in Appendix II.[32] Also given in Appendix II is the 90-day Treasury-bill rate prevailing on the Wednesday of each week in London and New York. The interest-rate parity (London rate minus New York rate) was computed for each week and averaged to

[31] U.S. Department of the Treasury, *Capital Movements Between the United States and Foreign Countries and Purchases and Sales of Foreign Exchange in the United States*, Reports 1-9 (Washington: U.S. Government Printing Office, 1936-38).

U.S. Department of the Treasury, *Bulletin of the Treasury Department*, Volume 1 (Washington: U.S. Government Printing Office, 1939).

[32] The Treasury data actually begin January 9, 1935, but the information for 1935 could not be used because forward rates were not systematically recorded by the First National City Bank in 1935.

give the monthly rate shown in Appendix I. While the Treasury-bill-rate differential may not have been the actual interest parity which induced interest arbitrage, it was a sensitive indicator of interest-rate changes and is therefore used.[33]

Examples drawn from the data for the three types of periods are given to best explain how the data were analyzed.

SPECULATIVE PERIODS

A period is speculative when the spot price of a currency and its forward premium move in the same direction. Such a period existed from July 8 to 22, 1936. Data from this period are taken from Appendix

TABLE 8

DATA FROM A SPECULATIVE PERIOD, 1936

Date	*July 1*	*July 8*	*July 15*	*July 22*
Spot price of pound	502.25	502.263	502.563	502.813
Premium on forward pound	—1.5	—1.225	—1.0729	—1.0208
Predicted position of professional risk-bearers		long	long	long
Actual position of professional risk-bearers		$279,000 short	$9,564,000 short	$1,095,000 short

I and presented in Table 8. From July 8 through July 22 both the spot rate and forward premium rose.[34] According to Stein's theory, during speculative periods if the spot rate and forward premium are rising, professional risk-bearers are assumed to be taking long positions in the forward market. As shown in Table 8, professional risk-bearers during this period actually took short positions. In this example, therefore, predictions based on Stein's theory were wrong in every instance.

BASIC-BALANCE NORMAL PERIOD

A basic-balance normal period is one in which the spot rate and forward premium move in opposite directions; either the interest-rate parity does not change by more than 10 points per month or, if the

[33] Paul Einzig, "Deposit Hunting," *The Banker* (November 1937), pp. 93-97.

[34] During the period studied, the forward pound was continually at a discount; therefore, considering the forward discount as a negative forward premium, algebraic changes in the forward rate must be considered rather than absolute changes.

interest-rate parity does change by more than 10 points per month, then the spot rate moves in the opposite direction from the interest-rate-parity change. An example of this period existed from June 3 to June 17, 1936. Data for this period are given in Table 9. The spot rate rose and the forward premium fell, and the interest-rate parity increased by less than 10 points. According to Stein's theory, the risk-bearers are supposed to take short positions. Professional risk-bearers in this example actually took short positions; thus, predictions based on Stein's theory were correct.

INTEREST-DIFFERENTIAL NORMAL PERIOD

In this type of normal period the spot rate and forward premium move in opposite directions; the interest-rate parity changes by at least 10 points per month, and the spot price moves in the same direction as the interest-rate parity. As shown in Table 10, these conditions pre-

TABLE 9

DATA FROM A BASIC-BALANCE NORMAL PERIOD, 1936

Date	*May 27*	*June 3*	*June 10*	*June 17*
Spot price of pound	497.833	499.888	501.281	503.052
Premium on forward pound	—0.7917	—1.0563	—1.1979	—1.401
Interest-rate parity	0.3351 average in May and 0.4119 average in June			
Predicted position of professional risk-bearers		short	short	short
Actual position of professional risk-bearers		$4,950,000 short	$3,397,000 short	$9,127,000 short

vailed from October 6 to October 20, 1937. The interest-rate parity rose by more than 10 points from September to October and the spot price and forward premium moved in opposite directions, with the spot rate rising. Applying Stein's theory to these data, one would predict that professional risk-bearers were taking long positions in the forward market. Comparing these predictions with the actual behavior of risk-bearers, it is found that the predictions are true for the weeks ending October 6 and 20, but false for the week ending October 13.

During the period of time investigated in this analysis, there were 190 weekly observations and, with the use of Stein's theory, it was

TABLE 10

DATA FROM AN INTEREST-DIFFERENTIAL NORMAL PERIOD, 1937

Date	*Sept. 29*	*Oct. 6*	*Oct. 13*	*Oct. 20*
Spot price of pound	494.938	495.302	495.513	495.883
Premium on forward pound	—0.6771	—0.7135	—0.7250	—0.8021
Interest-rate parity	0.2265 Average in September and 0.3405 Average in October			
Predicted position of professional risk-bearers		long	long	long
Actual position of professional risk-bearers		$2,657,000 long	$1,765,000 short	$5,323,000 long

possible to determine the forward positions taken by professional risk-bearers in 95 of these weeks. As defined by Stein's theory, there were 104 speculative periods, 65 basic-balance periods, and 21 interest-differential periods. During speculative periods, the predictions were correct 55 times and incorrect 49 times. In the basic-balance periods, the predictions were correct 29 times and incorrect 36 times. During interest-differential periods, the predictions were correct 11 out of 21 times. These results are summarized in Table 11.

If these separate observations are considered as Bernoulli trials, each with a probability p of correctly predicting the forward position taken by professional risk-bearers during the week, then the expected number of correct predictions would be equal to np. Using the binomial approximation to the normal distribution, where the mean $\mu = np$ and the standard deviation $\sigma = \sqrt{npq}$, the hypothesis that Stein's theory is able to predict forward positions, over the period of time in question, can be statistically tested.

TABLE 11

SUMMARY OF RESULTS

Type of period	*Number of observations*	*Number of correctly predicted positions*	*Number of incorrectly predicted positions*
Speculative	104	55	49
Basic-Balance	65	29	36
Interest-Differential	21	11	10
Total	190	95	95

3.2 Test Results and Conclusions

The overall predictive power of Stein's theory is statistically tested by adopting as our null hypothesis that the theory has a probability $p = 0.5$ of correctly predicting the forward position taken during any given week. The alternative hypothesis is that $p > 0.5$. If the null hypothesis, H_0, is rejected and the alternative hypothesis, H_1, is accepted, this is equivalent to saying that the theory has better than a random chance of correctly predicting behavior. For H_0, the null hypothesis, $p = 0.5$ and for H_1, the alternative hypothesis, $p > 0.5$. Let n equal the total number of observations and the mean $\mu = np = (190)\ (0.5) = 95$. The standard deviation

$$\sigma = \sqrt{npq} = \sqrt{(190)(0.5)(0.5)} = 6.89,$$

where $q = (1 - p)$. Let S_n equal the number of weekly positions correctly predicted. In this case, $S_n = 95$.

The test statistic is:

$$Z = \frac{S_n - np}{\sqrt{npq}}.$$

Setting α, the probability that H_0 will be rejected when in fact H_0 is true, equal to 0.5 and using the normal distribution, the null hypothesis will be rejected if $Z > 1.645$. Since

$$Z = \frac{95 - 95}{6.89} = 0$$

the null hypothesis H_0 is accepted. It is concluded that Stein's theory, in general, was not able to predict the positions of professional risk-bearers during the period studied.

Carrying out the same test described above for the speculative, basic-balance, and interest-differential periods, yields values for Z of 0.589, —0.869, and 0.218, respectively. It is concluded, therefore, that Stein's theory lacked any predictive capability in each of the three types of periods during the time period studied.

The empirical "evidence" cited by Stein in *The Nature and Efficiency of the Foreign Exchange Market*[35] consisted of observing the spot and forward rates during a period of time when accurate guesses as to the positions of professional speculators could be made: for example, the

[35] Jerome Stein, *The Nature and Efficiency of the Foreign Exchange Market*, Essays in International Finance No. 40 (Princeton, N.J.: International Finance Section, 1962), pp. 38-44.

period just after the German revaluation of March 1961 when speculators believed that the revaluation had not gone far enough and more revaluation was to occur or that the pound would be devalued. In this situation speculators would quite obviously take long positions in forward Marks and short positions in forward pounds. Stein examined the movements of the spot rate and forward premium, found that they moved in a manner consistent with the theory and, therefore, concluded that the theory had predictive ability. Examination of the sterling crisis in the summer of 1961 yielded similar results.

One possible reason for this apparent conflict between the results of this study and those of Stein's study might be due to the fact that Stein only looked at periods of crisis. During these periods the operating forces of his theory of the market were decidedly dominant, while in noncrisis periods random forces may have been of sufficient magnitude to generate a level of "noise" sufficient to prevent detection of the movement of the dominant factor.

This idea can be tested for the period covered in this study by combining the data from two periods of crisis in order to obtain a sufficiently large sample. The two periods chosen extend from August 31 to October 5, 1938—the Sudetenland Crisis—and from August 2 to August 30, 1939—the outbreak of World War II. During both these periods there was primarily bear speculation on the pound. Stein's theory correctly forecast the position of professional risk-bearers 10 out of 11 times. Applying the same statistical test described above,

$$Z = \frac{10 - (11)\,(.5)}{\sqrt{11(.5)\,(.5)}} = 2.69,$$

and it is concluded that for this subsample of the data, p is greater than one half. Thus, Stein's theory appears to have predictive power during periods of crisis, but not in the everyday workings of the foreign-exchange market, insofar as the time period considered in this study is concerned.

Another possible reason for the poor empirical showing in this study could be the result of structural changes in the foreign-exchange market. Stein based his theory on the post-1951 foreign-exchange market, but the data used were all prewar. Einzig has listed eighteen major changes in the forward market that occurred in the London foreign-exchange market between 1939 and 1961.[36] Similar changes

[36] Paul Einzig, *A Dynamic Theory of Forward Exchange* (London: Macmillan, 1961), pp. 33 and 34.

probably occurred in New York. These changes could possibly render Stein's theory inappropriate for analysis in the time period considered in this study. If this is indeed the case, however, there appears to be little justification for Stein to apply his theory to the foreign-exchange market of 1921-25.[37] Furthermore, Stein's conclusion that professional speculators were able to forecast price *and make profits* during this period is unwarranted.

[37] Stein, *op.cit.*, pp. 45-55.

4. THE NEED FOR STATISTICAL DATA

Since the 1920's economists have not been negligent in the attention they have paid to the foreign-exchange market. The work of Keynes and his prewar contemporaries focused attention on the relation between the foreign-exchange market and short-term capital flow. As a result of this research, central bankers and their governments became aware of the necessity of collecting information about the amount of foreign balances and the flow of short-term liabilities and assets. While these statistics are important, they are insufficient to understand completely the workings of the foreign-exchange market. They give the end results, but do little to explain the manner in which these results come about.

To my knowledge, there has been only one attempt to collect and publish systematically data on the volume and types of transactions in the foreign-exchange market. This was done by the United States Treasury Department acting under the authority of an Executive Order from President Franklin Roosevelt. These data were collected and published (with decreasing detail as time went on) from January 1936 until March 1950. Collection and publication of these data were discontinued in 1950 because they showed very small changes during the sterling crisis of 1949, and it was concluded that they had little power in explaining what was happening or predicting what was going to happen.[38] The behavior of the market in 1949, as viewed from New York, is not surprising. The London foreign-exchange market at that time was very tightly regulated, the pound was not convertible in London, and the forward exchange market was still closed. Under these conditions, it is not the least bit surprising that the New York market showed little change, since the run on the pound was accomplished primarily by the leads and lags of international payments.

If central banks are to use the monetary policy tools at their disposal with a high degree of efficiency, they must base their decisions on appropriate data as well as the most relevant economic theory. The development of relevant economic theory depends, to a large extent, upon the availability of proper data for testing and verification. If this study does nothing more than point out the serious problem of relying

[38] Paul Einzig, *A Dynamic Theory of Forward Exchange* (London: Macmillan, 1961), p. 80.

on data from the 1930's to test economic theories of the 1960's, it will have served a useful purpose. The Federal Reserve System and the United States Treasury should recommence the collection and publication of foreign-exchange-market data. This new series need not necessarily be exactly the same as those in the past, but should be based in part on the suggestions of economists involved in this area of research. With data of this type available, economists should be able to develop a more realistic and applicable theory of the foreign-exchange market and speak with perhaps a more unified voice with regard to the appropriate international monetary policy to be pursued under various conditions.

APPENDIX I

DATA REQUIRED FOR ANALYSIS IN STEIN'S THEORY, TYPE OF PERIOD, PREDICTED POSITION, AND ACTUAL POSITION

Week Ending	Average Weekly Spot Rate[a]	Average Weekly Forward Premium[a]	Interest Parity[b] (monthly avg.)	Type of Period			Predicted* Position	Actual* Position[b]
				Speculative	Basic-Balance	Interest-Differential		
Dec. 1935			0.5187					
Jan. 8, 1936	493.208	−1.0000	0.3195					
15	496.354	−0.6771		X			+	−
22	495.604	−0.6354				X	−	−
29	499.917	−0.4167		X			+	−
Feb. 5	501.583	−0.4844	0.3156		X		−	+
12	501.625	−0.5250			X		−	+
19	499.083	−0.6823		X			−	+
26	499.425	−0.7500			X		−	+
Mar. 4	499.208	−0.7500	0.3351	X			−	−
11	498.521	−0.8229		X			−	−
18	497.354	−0.6979			X		+	−
25	496.417	−0.7448		X			−	−
Apr. 1	495.354	−0.6094	0.3312		X		+	+
8	495.313	−0.6615		X			−	−
15	494.219	−0.4583			X		+	+
22	494.073	−0.4167			X		+	−
29	493.771	−0.5000		X			−	−
May 6	495.063	−0.5313	0.3351		X		−	+
13	497.521	−0.7396			X		−	+
20	496.825	−0.8063		X			−	−
27	497.833	−0.7917		X			+	−

* A positive sign means that a long position was taken and a negative sign means that a short position was taken.

[a] SOURCE: Historical records of the First National City Bank of New York.

[b] SOURCE: See Appendix II.

Week Ending	Average Weekly Spot Rate[a]	Average Weekly Forward Premium[a]	Interest Parity[b] (monthly avg.)	Type of Period			Predicted* Position	Actual* Position[b]
				Speculative	Basic-Balance	Interest-Differential		
June 3	499.888	—1.0563	0.4119		X		—	—
10	501.281	—1.1979			X		—	—
17	503.052	—1.4010			X		—	—
24	502.188	—1.4583		X			—	—
July 1	502.250	—1.5000	0.3942		X		—	—
8	502.263	—1.2250		X			+	—
15	502.563	—1.0729		X			+	—
22	502.813	—1.0208		X			+	—
29	501.938	—0.9531			X		+	+
Aug. 5	501.698	—0.9115	0.3437		X		+	+
12	502.479	—0.7135		X			+	+
19	502.906	—0.7135		X			+	—
26	503.135	—0.7292			X		—	+
Sept. 2	503.208	—0.7448	0.3632		X		—	—
9	504.438	—0.6875		X			+	+
16	506.188	—0.7969			X		—	—
23	506.552	—0.8542			X		—	—
30	497.979	—1.0313		X			—	—
Oct. 7	491.875	—1.0313	0.3901	X			—	—
14	490.150	—0.8500			X		+	—
21	489.125	—0.7604			X		+	+
28	489.031	—0.8958		X			—	+
Nov. 4	488.975	—0.8250	0.4394		X		+	+
11	487.888	—0.7500			X		+	—
18	488.656	—0.6563		X			+	—
25	489.458	—0.5625		X			+	—
Dec. 2	490.400	—0.4688	0.6723	X			+	—
9	490.292	—0.5365		X			—	—
16	490.656	—0.7084				X	+	—
23	491.260	—0.7292				X	+	+
30	491.288	—0.8313				X	+	—

Jan. 6, 1937	491.175	−0.5781	0.3861			X	−	−
13	491.172	−0.5625				X	−	−
20	491.010	−0.6250		X			−	−
27	490.344	−0.6563		X			−	−
Feb. 3	489.865	−0.7292	0.3840	X			−	+
10	489.479	−0.6875			X		+	−
17	489.563	−0.6125		X			+	+
24	489.313	−0.6250		X			−	+
Mar. 3	488.917	−0.7292	0.2676	X			−	−
10	488.219	−0.7917		X			−	−
17	488.583	−0.7656		X			+	−
24	488.510	−0.6875				X	−	−
31	488.802	−0.6770		X			+	−
Apr. 7	489.917	−0.7344	−0.0306		X		−	+
14	490.177	−0.9219			X		−	+
21	492.001	−1.1458			X		−	−
28	493.667	−1.3646			X		−	−
May 5	494.042	−1.3802	0.1051			X	+	−
12	493.906	−1.5000		X			−	−
19	494.219	−1.4583		X			+	−
26	494.240	−1.4375		X			+	−
June 2	493.425	−1.4375	0.2731		X		+	−
9	493.292	−1.3177			X		+	−
16	493.688	−1.2943		X			+	−
23	494.198	−1.2240		X			+	−
30	493.563	−1.3385		X			−	−
July 7	494.963	−1.2438	0.2444	X			+	−
14	496.365	−1.0938		X			+	−
21	497.594	−1.2917			X		−	−
28	497.448	−1.4063		X			−	+

* A positive sign means that a long position was taken and a negative sign means that a short position was taken.

[a] SOURCE: Historical records of the First National City Bank of New York.

[b] SOURCE: See Appendix II.

Week Ending	Average Weekly Spot Rate[a]	Average Weekly Forward Premium[a]	Interest Parity[b] (monthly avg.)	Type of Period			Predicted* Position	Actual* Position[b]
				Speculative	Basic-Balance	Interest-Differential		
Aug. 4	498.115	—1.5000	0.2787		X		—	—
11	498.771	—1.4814		X			+	—
18	498.625	—1.4010			X		+	—
25	498.719	—1.3438		X			+	—
Sept. 1	497.135	—1.3625	0.2265	X			—	—
8	495.725	—1.6938		X			—	—
15	494.854	—1.1666			X		+	—
22	495.688	—0.7917		X			+	—
29	494.938	—0.6771			X		+	—
Oct. 6	495.302	—0.7135	0.3405			X	+	+
13	495.513	—0.7250				X	+	—
20	495.883	—0.8021				X	+	+
27	495.283	—0.7396			X		+	—
Nov. 3	496.250	—0.7375	0.4251	X			+	+
10	500.013	—0.6615		X			+	—
17	498.650	—0.7063		X			—	+
24	500.385	—0.7396				X	+	—
Dec. 1	499.337	—0.7063	0.6272		X		+	—
8	499.615	—0.7917				X	+	—
15	499.815	—0.7813		X			+	—
22	499.781	—0.8229		X			—	—
29	499.763	—0.8938		X			—	—
Jan. 5, 1938	500.100	—0.7250	0.4262	X			+	—
12	500.063	—0.7083				X	—	—
19	499.656	—0.7188		X			—	—
26	499.833	—0.7344			X		—	—
Feb. 2	500.813	—0.7552	0.4331		X		—	—
9	501.146	—0.7292		X			+	—
16	502.575	—0.6750		X			+	—
23	502.125	—0.6688			X		+	—

Mar.	2	501.958	−0.7188	0.4396	X		−	−
	9	501.333	−0.7500		X		−	−
	16	499.115	−0.7969		X		−	−
	23	496.344	−0.8073		X		−	−
	30	496.521	−0.7031		X		+	−
Apr.	6	496.469	−0.6302	0.4081		X	+	−
	13	496.958	−0.5938		X		+	−
	20	499.969	−0.5313		X		+	−
	27	498.885	−0.5313			X	+	−
May	4	498.698	−0.5417	0.4631	X		−	−
	11	498.083	−0.6146		X		−	−
	18	496.927	−0.6354		X		−	−
	25	495.354	−0.5750			X	+	−
June	1	494.638	−0.5729	0.5384		X	+	−
	8	494.781	−0.4427		X		+	−
	15	496.666	−0.4844			X	−	−
	22	496.479	−0.4688			X	+	−
	29	495.875	−0.5729		X		−	−
July	6	495.088	−0.5063	0.4816		X	+	−
	13	493.406	−0.4167			X	+	−
	20	492.500	−0.6771		X		−	−
	27	492.219	−0.6667			X	+	−
Aug.	3	490.979	−0.6875	0.4487	X		−	−
	10	488.865	−0.6719			X	+	−
	17	487.610	−0.6250			X	+	−
	24	488.094	−0.6771			X	−	−
	31	486.875	−0.6979		X		−	−
Sept.	7	484.063	−1.2500	0.8337	X		−	−
	14	481.240	−1.2917		X		−	−
	21	480.958	−1.5000		X		−	−
	28	476.448	−2.0000		X		−	+

* A positive sign means that a long position was taken and a negative sign means that a short position was taken.

[a] SOURCE: Historical records of the First National City Bank of New York.

[b] SOURCE: See Appendix II.

Week Ending	Average Weekly Spot Rate[a]	Average Weekly Forward Premium[a]	Interest Parity[b] (monthly avg.)	Type of Period			Predicted* Position	Actual* Position[b]
				Speculative	Basic-Balance	Interest-Differential		
Oct. 5	480.458	—1.3125	0.6386	X			+	+
12	477.663	—1.1688				X	—	+
19	474.923	—1.7135		X			—	—
26	476.333	—1.5417		X			+	—
Nov. 2	476.031	—1.3646	0.6069		X		+	+
9	475.913	—1.1313			X		+	—
16	470.160	—1.4500		X			—	—
23	468.802	—1.6094		X			—	—
30	465.213	—1.6875		X			—	+
Dec. 7	468.771	—1.8750	—1.1553			X	+	—
14	466.917	—2.1250		X			—	—
21	467.208	—2.1771				X		
28	466.550	—2.4000		X			—	—
Jan. 4, 1939	464.188	—2.2109	0.5233			X	—	—
11	466.865	—1.8333		X			+	—
18	467.635	—1.6875		X			+	—
25	467.688	—1.4938		X			+	—
Feb. 1	467.781	—1.5938	0.5012		X		—	+
8	468.208	—1.2292		X			+	—
15	468.700	—1.2813			X		—	—
22	468.700	—1.4125			X		—	—
Mar. 1	469.031	—1.3594	0.5450	X			+	—
8	468.969	—1.2500			X		+	—
15	469.031	—1.2917			X		—	—
22	468.250	—1.9115		X			—	—
29	468.281	—1.9375			X		—	0
Apr. 5	468.177	—2.2917	1.3294	X			—	—

	12	468.094	−2.5417		X		−	−
	19	468.115	−2.7448			X	+	−
	26	468.125	−2.6354		X		+	−
May	3	468.166	−2.4583	0.6825	X		+	−
	10	468.146	−1.6198			X	−	−
	17	468.146	−1.3333			X	−	−
	24	468.177	−1.3854		X		−	−
	31	468.238	−1.4375		X		−	−
June	7	468.500	−1.4010	0.7044	X		+	−
	14	468.438	−1.3490		X		+	−
	21	468.219	−1.6042		X		−	−
	28	468.156	−1.5000		X		+	+
July	5	468.125	−1.8906	0.7385	X		−	−
	12	468.175	−1.8625		X		+	−
	19	468.288	−1.6688		X		+	−
	26	468.198	−1.5938		X		+	+
Aug.	2	468.125	−1.6688	1.1926	X		−	−
	9	468.113	−1.8750		X		−	−
	16	468.113	−2.2000		X		−	−
	23	468.063	−2.4500		X		−	−
	30	451.635	−2.9250		X		−	−

* A positive sign means that a long position was taken and a negative sign means that a short position was taken.

[a] SOURCE: Historical records of the First National City Bank of New York.

[b] SOURCE: See Appendix II.

APPENDIX II

WEEKLY FORWARD POSITION OF PROFESSIONAL SPECULATORS
(in thousands of dollars)
AND
WEEKLY INTEREST-RATE PARITY BETWEEN NEW YORK AND LONDON

Date	*Forward Position*[a] *(thousands of dollars)*	*London 3-Mo. Treasury-Bill Rate*[b]	*New York 3-Mo. Treasury-Bill Rate*[c]
Dec. 31, 1935	— 3,323	0.6875	0.15
Jan. 8, 1936	—10,618	0.5312	0.20
15	— 299	0.5156	0.20
22	— 2,109	0.5156	0.20
29	— 7,457	0.5156	0.20
Feb. 5	+ 3,080	0.5156	0.20
12	+ 2,881	0.5156	0.20
19	+ 902	0.5156	0.20
26	+ 1,561	0.5156	0.20
Mar. 4	— 2,499	0.5469	0.20
11	— 5,603	0.5312	0.20
18	— 930	0.5312	0.20
25	— 4,368	0.5312	0.20
Apr. 1	+ 148	0.5312	0.20
8	— 3,091	0.5312	0.20
15	+ 2,987	0.5312	0.20
22	— 1,659	0.5312	0.20
29	— 566	0.5312	0.20
May 6	+ 7,521	0.5312	0.20
13	+ 2,160	0.5312	0.20
20	— 4,477	0.5312	0.20
27	— 5,310	0.5469	0.20
June 3	— 4,950	0.5625	0.20
10	— 3,397	0.7187	0.20
17	— 9,172	0.8906	0.20
24	— 8,752	0.6875	0.20
July 1	— 7,634	0.5625	0.20
8	— 279	0.5625	0.16
15	— 9,564	0.5625	0.15
22	— 1,095	0.5625	0.15
29	+ 3,555	0.5312	0.15

[a] SOURCE: From January 1935 to September 1938: *Capital Movements Between the United States and Foreign Countries and Purchases and Sales of Foreign Exchange in the United States*, U.S. Treasury Dept. From September 1938 to August 1939: *Bulletin of the Treasury Department* (computed from Weekly Forward Sales Table 44—and Weekly Forward Purchases—Table 41).

[b] SOURCE: Weekly issues of *The Economist*, London.

[c] SOURCE: Board of Governors of the Federal Reserve System, *Banking and Monetary Statistics* (Washington: The National Capital Press, 1943), pp. 461-462.

Date	*Forward Position*[a] *(thousands of dollars)*	*London 3-Mo. Treasury-Bill Rate*[b]	*New York 3-Mo. Treasury-Bill Rate*[c]
Aug. 5	+ 1,099	0.5312	0.15
12	+ 393	0.5312	0.20
19	− 1,381	0.5312	0.20
26	+ 902	0.5312	0.20
Sept. 2	− 7,282	0.5312	0.20
9	+ 3,428	0.5312	0.16
16	− 4,986	0.5312	0.16
23	− 1,405	0.5312	0.16
30	− 4,646	0.5312	0.16
Oct. 7	− 6,473	0.5312	0.18
14	− 6,318	0.5312	0.16
21	+ 5,391	0.5312	0.12
28	+ 2,876	0.5469	0.12
Nov. 4	+ 6,292	0.5469	0.10
11	−12,312	0.5469	0.11
18	− 7,773	0.5469	0.11
25	−10,600	0.5469	0.11
Dec. 2	− 804	0.6094	0.11
9	− 3,602	0.8125	0.10
16	− 1,373	1.0156	0.10
23	+ 4,469	0.8125	0.10
30	− 518	0.6719	0.15
Jan. 6, 1937	− 1,003	0.6094	0.18
13	− 6,741	0.5625	0.18
20	− 708	0.5312	0.18
27	− 1,757	0.5312	0.15
Feb. 3	+ 645	0.5312	0.15
10	− 2,827	0.5312	0.16
17	+ 4,719	0.5312	0.15
24	+ 913	0.5625	0.15
Mar. 3	− 46	0.5312	0.15
10	− 2,019	0.5469	0.25
17	− 832	0.5312	0.25
24	− 1,137	0.5156	0.37
31	− 1,863	0.5156	0.55
Apr. 7	+ 236	0.5469	0.58
14	+ 250	0.5469	0.65
21	− 7,645	0.5469	0.60
28	− 3,228	0.5469	0.48
May 5	− 4,951	0.5469	0.45
12	−10,088	0.5312	0.47
19	−13,099	0.5312	0.42
26	− 5,535	0.5312	0.38
June 2	−11,338	0.5312	0.35
9	− 4,422	0.7031	0.35
16	− 6,358	0.7500	0.36
23	− 8,010	0.6873	0.39
30	−16,713	0.5937	0.35

Date	Forward Position[a] (thousands of dollars)	London 3-Mo. Treasury-Bill Rate[b]	New York 3-Mo. Treasury-Bill Rate[c]
July 7	−12,131	0.5625	0.34
14	− 9,603	0.5625	0.30
21	− 3,756	0.5312	0.30
28	+ 6,195	0.5312	0.27
Aug. 4	− 9,782	0.5312	0.24
11	− 8,963	0.5312	0.26
18	− 452	0.5312	0.25
25	− 2,086	0.5312	0.26
Sept. 1	− 8,949	0.5312	0.34
8	− 7,975	0.5312	0.45
15	−10,878	0.5312	0.45
22	− 6,342	0.5312	0.29
29	− 6,996	0.5312	0.22
Oct. 6	+ 2,657	0.5469	0.19
13	− 1,765	0.5469	0.20
20	+ 5,323	0.5469	0.20
27	− 2,714	0.5312	0.22
Nov. 3	+ 797	0.5156	0.17
10	− 1,685	0.5156	0.11
17	+ 4,956	0.5156	0.08
24	− 4,697	0.5937	0.08
Dec. 1	− 1,124	0.7187	0.09
8	− 9,474	0.8750	0.11
15	− 2,196	0.7187	0.12
22	− 4,829	0.6875	0.11
29	− 2,165	0.6562	0.09
Jan. 5, 1938	− 3,745	0.5625	0.11
12	− 6,990	0.5312	0.10
19	− 5,522	0.5156	0.11
26	− 4,740	0.5156	0.10
Feb. 2	− 1,026	0.5156	0.10
9	− 4,068	0.5156	0.07
16	− 3,332	0.5156	0.08
23	− 2,579	0.5156	0.08
Mar. 2	− 9,303	0.5156	0.09
9	− 8,544	0.5156	0.07
16	− 8,179	0.5156	0.07
23	− 8,753	0.5156	0.07
30	−10,297	0.5156	0.08
Apr. 6	− 807	0.5156	0.11
13	− 7,562	0.5156	0.14
20	− 1,481	0.5156	0.13
27	− 5,378	0.5156	0.05
May 4	− 4,764	0.5156	0.04
11	− 5,730	0.5156	0.06
18	−12,059	0.5156	0.06
25	−10,271	0.5156	0.05

Date	Forward Position[a] (Thousands of dollars)	London 3-Mo. Treasury-Bill Rate[b]	New York 3-Mo. Treasury-Bill Rate[c]
June 1	−15,204	0.5469	0.04
8	− 6,184	0.6094	0.05
15	− 9,274	0.6250	0.05
22	−13,827	0.5937	0.05
29	− 6,631	0.5469	0.04
July 6	− 3,200	0.5469	0.04
13	− 9,134	0.5469	0.06
20	− 6,916	0.5312	0.06
27	−11,180	0.5312	0.07
Aug. 3	− 7,872	0.5312	0.07
10	− 9,587	0.5156	0.07
17	− 5,875	0.5156	0.06
24	−10,139	0.5156	0.06
31	− 2,956	0.5156	0.06
Sept. 7	− 1,601	0.5312	0.06
14	− 904	0.7187	0.06
21	− 7,396	0.8750	0.09
28	+ 140	1.5000	0.08
Oct. 5	+ 284	0.7187	0.10
12	+ 1,439	0.6875	0.05
19	− 3,264	0.7656	0.05
26	− 385	0.6250	0.04
Nov. 2	+ 16	0.5469	0.04
9	− 1,368	0.5312	0.04
16	− 2,304	0.5312	0.04
23	−11,480	0.7500	0.04
30	+ 2,570	0.8750	0.04
Dec. 7	− 3,695	0.8750	0.04
14	− 4,822	0.9375	0.03
21	− 3,970	1.0000	0.03
28	− 3,888	1.0937	0.02
Jan. 4, 1939	− 2,155	0.5625	0.02
11	− 3,175	0.5625	0.03
18	−13,820	0.5469	0.03
25	−13,483	0.5312	0.03
Feb. 1	+ 5,548	0.5312	0.03
8	−15,088	0.5312	0.03
15	− 4,901	0.5312	0.03
22	− 662	0.5312	0.03
Mar. 1	− 5,892	0.5312	0.03
8	− 1,568	0.5312	0.03
15	− 2,281	0.5312	0.03
22	− 7,899	0.5625	0.03
29	0	0.7187	0.03
Apr. 5	− 1,951	1.1250	0.03
12	− 3,553	1.4375	0.03
19	−10,680	1.5625	0.03
26	−10,530	1.3125	0.03

Date	*Forward Position*[a] (*Thousands of dollars*)	*London 3-Mo. Treasury-Bill Rate*[b]	*New York 3-Mo. Treasury-Bill Rate*[c]
May 3	−10,458	1.0625	0.03
10	− 3,337	0.6250	0.03
17	− 236	0.6250	0.03
24	− 7,673	0.6250	0.03
31	− 2,041	0.6250	0.03
June 7	− 6,254	0.6406	0.03
14	− 1,986	0.7344	0.03
21	− 6,048	0.8125	0.03
28	+ 3,004	0.7500	0.03
July 5	− 1,538	0.7500	0.03
12	−13,019	0.8125	0.03
19	−11,090	0.7969	0.04
26	+ 3,107	0.7344	0.04
Aug. 2	− 3,046	0.6875	0.04
9	− 6,697	0.6406	0.04
16	− 2,357	0.7187	0.04
23	− 5,215	0.9375	0.04
30	−10,533	3.2187	0.06

[a] SOURCE: From January 1935 to September 1938: *Capital Movements Between the United States and Foreign Countries and Purchases and Sales of Foreign Exchange in the United States*, U.S. Treasury Dept. From September 1938 to August 1939: *Bulletin of the Treasury Department* (computed from Weekly Forward Sales Table 44—and Weekly Forward Purchases—Table 41).

[b] SOURCE: Weekly issues of *The Economist*, London.

[c] SOURCE: Board of Governors of the Federal Reserve System, *Banking and Monetary Statistics* (Washington: The National Capital Press, 1943), pp. 461-462.

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