

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
DEPARTMENT OF ECONOMICS
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AN EMPIRICAL STUDY OF THE FOREIGN-EXCHANGE MARKET: TEST OF A THEORY

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

$$D = (1 + i_d). \quad (1)$$

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

$$\left(\frac{1}{r_s}\right) (1 + i_f). \quad (2)$$

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

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

units of domestic currency. Now, quite obviously, if

$$D \geq F, \quad (4)$$

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

$$D < F, \quad (5)$$

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

$$D > F, \quad (6)$$

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

$$D = F. \quad (7)$$

An alternative way of expressing this equilibrium condition is to set

$$F = D,$$

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

and therefore,
$$\frac{r_f}{r_s} = \frac{1 + i_d}{1 + i_f}. \quad (9)$$

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,

$$\frac{r_f}{r_s} = 1 + R. \quad (10)$$

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

$$R = \frac{i_d - i_f}{1 + i_f}. \quad (11)$$

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

$$R = i_d - i_f. \quad (12)$$

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 $\frac{365}{90} = 4$.

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

$$R = 0 \quad (13)$$

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

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

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 inter-war 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, Spraas 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.

Spraas 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, Spraas 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.