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Until very recently, commodity futures markets were largely ignored by the vast majority of economists. At the same time, markets for foreign currencies were studied by only a relative handful of specialists in international trade and finance. This article describes an area which overlaps the two very arcane areas of commodity futures markets and foreign exchange markets, i.e., the futures market for foreign currencies.

Futures trading in financial instruments began in 1972, when foreign currency futures were listed on the International Monetary Market (IMM) division of the Chicago Mercantile Exchange. Treasury-bill (T-bill) futures began trading in January 1976, and nearly all research in financial futures markets to date has been on interest rate futures. Some impetus for studying financial futures came from the Treasury Department and the Federal Reserve Board, which expressed concern that the financial futures markets might have spillover effects which could cause disruptions of the cash markets (see Treasury/Federal Reserve Staffs, 1979).

Although currency futures are the oldest financial futures markets, it is only recently that they have become popular. The question of how effective they are for hedging is important for two reasons. First, hedgers are necessary to maintain the long-term viability of most futures markets. Second, use of these contracts by importers and exporters may ultimately result in an increase in the volume of international trade.

This article examines the hedging effectiveness of currency futures markets. In particular, the present work demonstrates that the futures markets for British pounds, German marks, and Japanese yen have been as effective as hedging devices as have some of the long-established contracts in agricultural commodity futures.

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I. BACKGROUND

One important issue in commodity futures markets has always been the question of how futures market prices and cash market prices are related. Working (1949, 1958) established that prices of futures contracts on storable commodities are determined largely by their "price of storage." Vignola and Dale (1978, 1980) used the concept of price of storage, or "cost of carry," to explain T-bill futures pricing. More recent studies (Breeden and Cornell, 1980; Kane, 1980; Pomrenze and Jonas, 1980; Capozza and Cornell, 1979; Rendleman and Carabini, 1979) have obtained results that are also consistent with a cost-of-carry hypothesis of futures pricing.

Closely related to the question of the relationship of futures and spot prices is the question of whether or not the futures market may be used to obtain arbitrage profits.[1] Vignola and Dale (1979), Puglisi (1978), and Lang and Rasche (1978) studied the T-bill futures market and determined that when arbitrage possibilities appear, they tend to disappear quickly. This unsurprising result is also true of agricultural commodity futures, but it has not yet been formally tested for foreign currency futures.

Another interesting question is whether trading rules may exist which would enable speculators to profit by buying and selling according to some predetermined formula.[2] Dale and Workman (1979a, 1979b) tested several popular trading rules on the T-bill futures market. They gave a theoretical explanation of why such rules may work in the short run, but they showed that in the long run commission costs resulted in all of them producing losses. This is the same result that is normally obtained with agricultural commodity futures.

Futures contracts on agricultural commodities rarely result in actual deliveries, so another question is whether financial futures contracts will also rarely have deliveries. It turns out that this is one of the key differences between financial futures, particularly T-bill futures, and agricultural commodity futures. Dale (1979) analyzed T-bill futures price movements and correctly predicted that low transportation costs would lead to both increasing deliveries against established contracts and a poor performance for new financial futures contracts that virtually duplicate the terms of established contracts. In contrast, agricultural commodity futures are rarely delivered largely because their transportation costs are so high.

The fact that financial futures contracts may have relatively high percentages of deliveries means that there may be chronic shortages of the deliverable commodity after trading volume increases in a futures contract. This is one case where financial futures have different characteristics among themselves. Treasury futures contracts may face shortages of the deliverable supply of the commodity, because there are normally only a few different maturities that will fulfill the terms of the contract. It is not as easy to envision a shortage of pounds, marks, or yen.

Another important question is whether speculators may destabilize futures markets, in the sense of causing more price volatility than could be justified on

[1] The term arbitrage is used here to mean the holding of a simultaneous spot market and futures market position that guarantees a risk-free profit.

[2] See Kaufman (1978) and Powers (1973) for examples.

economic grounds.[3] There are some obvious questions of definition here; however, Dale and Workman (1980) applied a statistical test devised by Working to the T-bill futures market and found no evidence of speculative destabilization. The same test may ultimately be applied to foreign currency futures.

Still another important question, and the one of primary interest in the present work, is that of how well the futures markets perform as hedging devices. Hedgers are important for the long-term viability of most futures contracts, since it is their continued use of futures markets during periods of relative price stability, when many speculators lose interest, that maintains trading volume. Ederington and Plumly (1976) and Ederington (1979) tested the hedging effectiveness of several futures market contracts by examining the stability of the relationship between futures price movements and cash price movements. This method will be discussed further in the next section.[4]

In summary, financial futures and agricultural commodity futures appear to be similar in that (1) they all conform to a cost-of-carry hypothesis of market pricing, (2) risk-free arbitrage profits tend to disappear quickly, (3) speculative mechanical trading rules have poor performance records, and (4) the hedging effectiveness of all types of futures may be measured in the same manner.

Financial futures and agricultural commodity futures differ in that low transportation costs make it much more likely that financial futures may be used as delivery mechanisms. This in turn could potentially cause deliverable supply problems with Treasury futures, but is not as likely to do so with foreign currency futures. Moreover, the virtually limitless supply of foreign currencies makes it far more difficult to try to manipulate foreign currency futures markets.

The author hopes that the discussion above will be helpful in placing financial futures contracts in perspective. There are many important similarities between all types of futures contracts, but financial futures do possess some important unique features.[5] We turn now to a more detailed discussion of foreign currency futures.

II. HEDGING WITH FOREIGN CURRENCY FUTURES

Whenever a business makes a contract to buy or sell goods at some future date, and the contract is denominated in a currency of a country other than the firm's own, the firm faces a risk of exchange rate changes. The firm may simply ignore its exchange rate risk, so that when the contract comes due the price of the goods in its own currency may have either risen or fallen, leaving the firm with a larger or smaller net profit. Most firms, however, are unwilling to specu-

[3] One important work in this area is by Powers (1970), who used a mathematical method developed by Tintner (1940) and Tintner, Rao, and Strecker (1978) to show that futures trading actually reduced cash market price fluctuations. Powers' model, however, only applies to nonstorable commodities.

[4] It should be mentioned that Ederington used inappropriate spot market data and concluded that T-bill futures are much worse as hedging devices than they actually are. Use of the proper data showed T-bill futures to be very useful for hedging (see Cicchetti, Dale, and Vignola, 1979).

[5] As of this writing, commodity exchanges still apply for new financial futures contract listings in a manner almost identical to applying for new agricultural contract listings. Some of the contract specifications, such as describing the types of cartons that may be used for delivery and what adjustments will be made if the delivered products are underweight or blemished, do not seem terribly appropriate to financial futures contracts.

Table I

A POSSIBLE SHORT HEDGE BASED ON ACTUAL PRICES

Cash Market	Futures Market
January 4, 1980	
German firm contracts to buy U.S. machinery for $150,000	Sells 2 September futures contracts at $.6075/DM (=$151,875)
Spot Market: $150,000 = 256,893 DM	
February 1, 1980	
Sells marks in spot market for $150,000	Buys 2 September futures contracts at $.5926/DM (=$148,150)
Spot Market: $150,000 = 261,506 DM	
Results: Loss from delay on spot market	$2646. (=4613/DM)
Gain on futures market	3725. (=6494/DM)
Net gain	$1079. (=1881/DM)

late on the price of foreign exchange. They would prefer to minimize their exchange rate risk, and there are several ways they may do this.

One way a firm can guarantee a price of foreign currency is to use the forward market. A foreign exchange dealer, typically a bank, can enter into a contract to buy or sell a currency at any date in the future. The bank may require the firm to maintain a compensating balance for such a transaction. Moreover, since a forward contract transfers the exchange rate risk to the bank, a bank typically will limit its sales of forward contracts to its most credit-worthy customers.

The fact that smaller companies may not have access to the forward market means that many firms may be uninterested in world trade because they lack a means of dealing with foreign exchange risk. One alternative that they now have is to use the new currency futures market. Futures contracts are standardized contracts, as opposed to individually tailored forward contracts. They are also traded at a central exchange place, whereas the forward market really refers to telephones that may be located almost anywhere in the world.

Table I illustrates the use of the futures market by a small German firm. The firm contracts on January 4, 1980, to buy U.S. machinery, for which it will take delivery and pay $150,000 on February 1. For simplicity, assume that the firm's spot market holdings are exogenous, i.e., it maintains a supply of dollars and marks and must only decide how much of this currency to hedge.[6] We will assume for the present that the firm tries to hedge as much of the $150,000 as possible.

[6] This assumption allows us to ignore the complications that would arise if the firm had to borrow currency and would therefore have to decide when and in what country to do so. Inclusion of such complications would only confuse the simple example used here.

As Table I shows, the nearest the firm can come to this is by selling two contracts, worth a total of $151,875. Assume the machinery is delivered and the firm buys back its two contracts on February 1. The value of the mark dropped in January, so if the firm had not hedged it would have had to pay the equivalent of an additional $2646 for the machinery. By hedging in the futures market, however, the firm gained the equivalent of $3725 on its two futures contracts, which in this case more than offset the loss in the cash market.

Several points arise from this. First, the firm has a choice of several futures contract months to use for hedging. Ideally, it would like to own a futures contract that moves up or down in price in step with the spot market. The fact that it is desirable to have cash and futures prices move together provides us with one way of measuring the hedging effectiveness of the futures market, which we will subsequently use.

Besides the desire for parallel spot and futures price movements, a firm also would like to be able to buy or sell futures contracts in amounts that match the size of its position in the spot market. A greater choice of contract sizes would thus be desirable, from the point of view of the firm.

Still another consideration is that of which contract month to use for hedging. In our example, we chose the September 1980 contract. The firm might also have sold March or June 1980 contracts. Before discussing the reasons for the choice of a particular contract month, it is necessary to discuss the demand characteristics of international trading companies.

III. THE SUPPLY AND DEMAND OF TRADED GOODS

The interrelationship of foreign exchange markets, world prices, and international trade flows is a topic of great interest (see Wilson and Takacs, 1979, 1980; Hooper and Kohlhagen, 1978). For example, there has been no empirical evidence that the advent of floating exchange rates has had a negative impact on the volume of international trade. It is an open question, however, whether exchange rate volatility will eventually have an adverse effect on trade flows. To understand the reasons for this, it is necessary to consider the supply and demand functions faced by trading firms.

Following Hooper and Kohlhagen (1978), we will consider the case of a trading company abroad which uses imported inputs in its domestic production function. The term "production function" here is used loosely to imply that the firm may either use the imports as intermediate goods, or it may use the imports as finished goods. In the latter case the "production function" merely means that the firm adds a wholesale or retail distribution service to the finished good.

For simplicity, assume that the importer sells all of its output in its domestic market, and that it requires a fixed ratio of imports to total output. Hooper and Kohlhagen show that the importer's profits are

$$\pi = Q \cdot P - \mathrm{UC} \cdot Q - HP^{*}iQ, \tag{1}$$

where P and Q are the price and quantity of the firm's output, UC is the unit cost, which includes both labor and materials, P^* is the foreign currency price of imports, i is the fixed ratio of imports to total output ($i = q/Q$, where q is the quantity of imports needed to produce Q), and H is the cost of foreign exchange to the importer. This cost depends on the currency in which the import contract is invoiced and the extent to which the contract is hedged in the forward market:

$$H = \beta[\alpha F + (1 - \alpha)R] + (1 - \beta)F, \tag{2}$$

where β is the proportion of imports denominated in the exporter's currency, α is the proportion the importer decides to hedge, F is the forward exchange rate, and R is the (unknown) spot exchange rate on the payment date.

A single contract is rarely divided into payments in two different currencies. Equation (2) may be considered to be the average behavior of a firm over several contracts. Also, we have assumed temporarily that the firm hedges in the forward market, rather than the futures market, so that any quantity desired may be hedged.

Given the exchange risk, the variance in the importer's profits is

$$V(\pi) = [P^{*}iQ\beta(1 - \alpha)]^2 \cdot \sigma_R^2, \tag{3}$$

where σ_R^2 is the variance of the spot exchange rate. Note that the importer would know his expected profits with certainty ($V = 0$) if he either could have all contracts denominated in his own currency ($\beta = 0$), if he could hedge all his foreign exchange risk ($\alpha = 1$), or if exchange rates were fixed ($\sigma_R^2 = 0$). The last case may help explain why many businessmen prefer fixed exchange rates in spite of the fact that the majority of economists favor flexible exchange rates.

To determine the output and import demand for the firm, it is necessary to posit some form of utility function. We will assume a quadratic utility function, which is an increasing function of expected profits and a decreasing function of the variance of those profits.[7]

To calculate the utility maximization conditions requires taking the partial derivatives of the utility function with respect to the control variables output (Q) and proportion hedged (α), and setting the resulting equations equal to zero. The resulting rather lengthy expressions will not be reproduced here. Suffice it to note that both first-order conditions have maximum values for Q when $\alpha = 1$, i.e., when all exchange rate risk can be removed.

Of greater interest to us here is the frequently ignored second-order condition for a maximum. A first-order condition is a maximum if the second-order condition is less than zero, i.e., if

$$(F - ER)^2 - \gamma\sigma_R^2 < 0. \tag{4}$$

Equation (4) has some very interesting properties. If a risk-averse firm[8] ($0 < \gamma$) expects the forward rate to equal the future spot rate ($F = ER$), then the first term vanishes and the remaining term is clearly less than zero. This means that the firm thinks the forward market is efficient, and it will maximize its output and hedge away all of its foreign exchange risk.

There is an ambiguity when the forward rate differs from the expected future spot rate. We will loosely consider two cases, that of a small difference between the two rates and that of a large difference.

[7] We leave the Hooper and Kohlhagen formulation at this point. They used a linear utility function, which was useful for their purposes but which does not have an existing solution for our purposes. Our function has indifference curves that are not linear, which makes more economic sense.

[8] γ varies from -1 to $+1$, with risk-averse firms having positive values.

If the forward rate and expected spot rate are almost equal and the firm is very risk averse (γ almost $+1$), then the second term will be greater, the expression will be negative, and the conditions for maximum utility will still hold. The firm will hedge its exchange risk.

If the forward rate and expected spot rate are almost equal and the firm is almost risk neutral (γ almost 0), then the sign of the term depends on the size of the expected exchange rate volatility. If the expected volatility is small (σ_R^2 almost 0), the expression will be positive and the firm will not bother to hedge. If the expected volatility is large, however, the expression will be negative, which means the firm will want to hedge away the large foreign exchange risk.

Now consider the case in which the forward rate differs greatly from the expected spot rate. If this is the case and the expected exchange rate volatility is small, then the expression is positive, the forward market is perceived to be inefficient, and the firm will not want either to maximize its output or to hedge.

Finally, consider the case in which the forward rate differs greatly from the expected spot rate, and the expected exchange rate volatility is large. This would be the case if the firm thought that the reason that the forward and spot rates differ is because of chronic turbulence in foreign exchange markets. The second-order condition would then be negative, and the firm would conclude that in those circumstances a lousy hedge is better than no hedge, and it would attempt to minimize its risk by using the forward exchange market.

Too much should not be concluded from the very simple model described above. Nonetheless it is fascinating that the results obtained seem to be very consistent with the real world. It is very unusual for mechanical maximization techniques to produce such interesting behavioral results.

The significant point for our purposes is that a foreign firm will maximize its output (and hence its demand for imports from the U.S.) if it perceives the existence of a financial market in which it can virtually eliminate its foreign exchange risk. In the next section we will see why foreign currency futures markets may eventually be such an ideal market.

IV. MEASURING HEDGING EFFECTIVENESS

Consider once again the foreign firm which has exogenous holdings of currencies that it wishes to hedge. The discussion in Section III, using the forward market, showed that the firm will maximize its output if it has available a market which it perceives can minimize its risk. The derivation used forward markets, which we noted are not available for use by small firms. Small firms may use futures markets, however, which give similar results, so we will continue our discussion by assuming that the firm chooses between spot and futures market holdings.[9]

Following Ederington (1979) we assume the firm wants to maximize the expected return $E(R)$ of its currency portfolio:

$$E(R) = X_s E(P_s^2 - P_s^1) + X_f E(P_f^2 - P_f^1) + K_1(D_s) - K_2(X_f), \qquad (5)$$

[9]The first- and second-order conditions for maximizing utility with futures markets rather than forward markets will not be shown here for the usual reasons: (1) the complications arising from the inexact match of futures contract sizes and quantity of funds to be hedged would add nothing significant to the discussion; (2) the model is very simplified to begin with; and (3) the author did not want to repeat 20 pages of algebra.

where X_s and X_f represent spot and futures market holdings, $E(P_s^2 - P_s^1)$ is the expected change in the spot price, $E(P_f^2 - P_f^1)$ is the expected change in the futures price, $K_1(D_s)$ represents exogenous holdings of domestic currency, and $K_2(X_f)$ represents brokerage fees and margin costs of the futures contracts.

As in the preceding section, let α represent the proportion of spot holdings to be hedged. The hedging proportion that minimizes risk is given by

$$\alpha^* = \sigma_{sf}/\sigma_f^2. \tag{6}$$

Note that if spot and futures prices move together, the covariance between the two will equal the variance of the futures price. Thus $\alpha^* = 1$, and the firm will hedge all of its exchange risk and maximize its output, as in the preceding section.

Besides the risk-minimizing proportion given by equation (6), we also wish to measure the overall hedging effectiveness of the futures market. To do this, we wish to measure the percent risk reduction that the futures market has over an unhedged portfolio. A straightforward calculation shows that the reduction in variance due to futures, or hedging effectiveness e, is given by

$$e = \sigma_{sf}^2/\sigma_s^2\sigma_f^2. \tag{7}$$

Note here that if spot and futures prices move together then $e = 1$ and the futures market provides a complete reduction in exchange rate risk.

Finally, recall in our example in Table I that the importer had a choice of futures contract months to sell. September was picked arbitrarily, but the firm would prefer to use the contract which minimizes its risk. For example, in some agricultural commodities a contract in a distant month may be traded more heavily than a nearby contract if the distant contract corresponds more closely with harvest time. The distant contract could then conceivably be a better hedging device.

To test the hedging effectiveness of financial futures, α^* from equation (6) and e from equation (7) were calculated for a series of two-week and four-week hedges in British pounds, German marks, and Japanese yen. The period covered was mid-1974 through mid-1980, although not all contracts were traded enough to provide usable data over the entire time period. The results showed that foreign currency futures have been surprisingly good devices for hedging, as will be described in the next section.

V. RESULTS

Tables II and III show the results for two- and four-week hedges. What is particularly striking about these tables is that all three types of currencies showed better than a 97 percent rating of hedging effectiveness. For comparison purposes consider that Ederington (1979, pp. 165, 166) obtained a range of effectiveness ratings of 84 to 92 percent for the long-established wheat market and 45 to 72 percent for the corn market.

The excellent hedging performance of foreign currency futures seems even more remarkable in light of the extremely low volume that characterized the early trading months of these contracts. At one time it was not unusual for less than ten contracts to trade on many consecutive days.

The author does not know why foreign currency futures contracts should have

Table II
TWO-WEEK HEDGES

The Futures Contract	Number of Observations	Estimated e	Estimated α^*
British pounds			
The nearby contract	155	0.9971	0.9967
3–6-month contract	155	0.9904	0.9943
6–9-month contract	155	0.9785	0.9885
German marks			
The nearby contract	155	0.9990	0.9807
3–6-month contract	155	0.9911	0.9330
6–9-month contract	155	0.9951	0.9169
Japanese yen			
The nearby contract	155	0.9990	0.9710
3–6-month contract	104	0.9958	0.9197
6–9-month contract	86	0.9909	0.8744

Table III
FOUR-WEEK HEDGES

The Futures Contract	Number of Observations	Estimated e	Estimated α^*
British pounds			
The nearby contract	78	0.9977	0.9988
3–6-month contract	78	0.9905	0.9938
6–9-month contract	78	0.9817	0.9865
German marks			
The nearby contract	78	0.9990	0.9822
3–6-month contract	78	0.9975	0.9491
6–9-month contract	78	0.9954	0.9190
Japanese yen			
The nearby contract	69	0.9987	0.9694
3–6-month contract	52	0.9935	0.9162
6–9-month contract	43	0.9895	0.8708

shown such an exceptionally good potential for hedging. One possibility is that spot and forward foreign exchange markets are normally among the most efficient types of financial markets. Perhaps the early futures contracts were dominated by a few sharp-eyed arbitragers who acted quickly whenever a futures market price got out of line with either spot prices or other futures prices. This is pure conjecture, of course, but historically even thinly traded futures contracts have been influenced by spot market conditions, regardless of how few contracts were being traded.

Regardless of the reasons, the performance of foreign currency futures since their inception may ultimately result in more and more hedgers being attracted to these markets. As the very simple model given in this article shows, use of futures markets by firms abroad serves to reduce exchange rate risk and increase the demand for imports from the U.S.

Also, foreign currency futures seem less likely to be plagued by some of the difficulties that have occurred in other futures markets. For one thing, the deliverable supplies of the commodities are virtually unlimited. Also, speculators in foreign currencies tend to be among the most sophisticated, a factor which helps to maintain efficient markets (Stone, 1980). Also, not only have hedgers recently appeared to have begun using the currency futures market (Hobson, 1978), the fact that most international trade takes place with payment lags of several weeks (Magee, 1974) means that the contracts have an economic justification.

Finally, even a proliferation of financial futures contracts would not appear to be harmful. As Dale (1979) has shown, essentially duplicative financial futures contracts have a high failure rate. Thus, the only new contracts that would survive are those that have appeal to hedgers, who are necessary to maintain viable markets. Thus, the only new foreign currency futures contracts that are likely to survive are precisely those that have the most economic justification.

There are two areas of future research that are suggested here. First, it would be interesting to determine if there is a bias in forward quotes relative to futures quotes. This has a bearing on whether forward rates or futures rates are unbiased predictors of future spot rates.

Second, given the remarkable hedging effectiveness of currency futures, why are they not used more? Is it really just a matter of educating potential hedgers? Also, the Hobson (1978) and Jaffe and Hobson (1979) surveys show that the largest single class of hedges in currency futures is "IMM arbitragers." It would be interesting to determine their role in all of this.

VI. CONCLUSIONS

This article has used simplified models for both international trade demand and futures market hedging effectiveness to reach the following conclusions:

(1) The futures markets for British pounds, German marks, and Japanese yen are at least as effective as hedging devices as are the much older and more heavily traded futures markets for agricultural commodities.

(2) Because of their effectiveness in reducing risk, more and more rational hedgers can be expected to use foreign currency futures markets.

(3) The greater the risk reduction available from futures markets, the greater the potential demand for tradable goods.

(4) Proliferation of new types of foreign currency futures is not to be feared, not only because the deliverable supplies of the commodities are virtually limitless, but also because contracts with different specifications would offer an increasing number of ways to minimize foreign exchange risk and this in turn would help to increase the volume of international trade.

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