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INTERNATIONALLY DIVERSIFIED BOND PORTFOLIOS: THE MERITS OF ACTIVE CURRENCY RISK MANAGEMENT

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ABSTRACT

A new statistical procedure is used to test for weak form efficiency in the foreign exchange futures markets. Using daily currency futures prices for the 1976-1990 period, we conclude that successive exchange rate changes have not been independent. We examine the implications of this finding for two groups of investors: (1) return seeking investors considering foreign exchange as a separate asset class; (2) international portfolio investors deciding whether or not to currency hedge the foreign exchange rate exposures embedded in their non-dollar investments. Using the currency futures data and monthly data on 10-year dollar and non-dollar bonds, we conclude that active currency risk management, based on a simple application of technical trading signals, can substantially improve the risk-return opportunities for both groups of investors in comparison to passive currency strategies.

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by

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I. Introduction

The issue of how to manage the currency risk associated with a portfolio of international securities has generated considerable interest in recent years. For example, studies by Perold and Schulman (1988) and Thomas (1989) showed that the risk/return tradeoff offered by U.S. government securities could be improved by diversifying into a portfolio of foreign government bonds. Moreover, they showed that a passive strategy of hedging the currency risk embedded in foreign bonds could further enhance the risk-return trade-off from this class of international investments compared to never hedging.[1] In a separate strand of research, various studies have reported that active trading strategies based upon simple technical trading rules often produce profits solely from taking positions in foreign exchange (Dooley and Shafer 1983; Sweeney 1986; Levich 1989). While reports of the profitability of foreign exchange as an asset class have been persistent over the floating rate period, all of these studies have had to rely on severe statistical assumptions that make any inferences somewhat suspect.

In this paper our goal is to draw together these two strands of research.

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[1] See also Gadkari and Demafeliz (1987). For the case of currency hedged equity investments, see Thomas (1988).

First, we update past studies of technical trading rules in the foreign exchange market using a new data base and a new, non-parametric statistical test. Second, we examine the performance of a global bond portfolio that uses technical trading rules as the basis of an active currency hedging strategy. Unlike previous research, which has focused on only two hedging strategies - "always hedge" and "never hedge" - we examine strategies that sometimes hedge, sometimes partially hedge, and even sometimes overhedge.

In brief, our results reveal that persistent positive and statistically significant profits could have been earned in the currency futures market over the 1976 - 1990 period from the application of simple technical trading rules. These results apply to investors who begin trading with a null balance sheet and who are free to take both long and short currency futures positions as guided by the technical rules. As for their impact on investors who initially hold a portfolio of foreign government securities, our results show that selectively hedging can lead to superior results when compared to never hedging or to always hedging. And when an active currency overlay that can take long or short foreign currency positions is adopted, our results show even greater improvements in the Sharpe performance ratio.

Overall, our results show that technical trading rules are most useful to investors with the flexibility to take both long and short currency positions. However, even for the case of a global bond manager whose long bond position constrains the size of his short currency position, our results show that selectively hedging generally dominates the passive hedging strategies we consider.

In the remainder of this paper, we present our tests of the profitability of technical trading rules in Section II. Our analysis of global bond portfolios -- unhedged, passively hedged, and actively hedged -- is presented in Section III. A summary and concluding remarks are in the final section.

II. Testing for Exchange Rate Trends and the Profitability of Technical Trading Rules

Our argument that an active currency risk management strategy may be beneficial rests on the assertion that foreign exchange futures markets can be "beaten" by simple trend following trading rules. This suggests that the foreign exchange markets are inefficient.[2] We do not undertake lightly the task of demonstrating such an improbable assertion. Consequently, we have (1) examined a long time series of exchange rate futures prices; (2) explicitly measured risk and transactions costs; and (3) developed a procedure to test the statistical significance of the profits we observed. To avoid selection bias we report the results for every trading rule we have examined to date.

We collected closing futures prices for five currencies (the German mark, British pound, Swiss franc, Japanese yen, and Canadian dollar) for the period January 1, 1976 through December 31, 1990, yielding approximately 3,800 daily observations

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[2] An alternative hypothesis - that there is a foreign currency risk premium that fluctuates in sympathy with the positions taken by trend following models - is logically possible. The possible economic explanation for such a premium, which would necessarily frequently change its sign over a period of days or weeks, is obscure.

per series.[3] Concatenated series of logarithmic first differences were constructed for each currency by splicing together observations from successive near-term contracts. So, for example, the observations in January and February of 1976 represent daily percentage changes in the March 1976 contract's price; observations in March, April and May of 1976 reflect the June 1976 contract; and so forth.

We have chosen to use futures prices rather than spot prices because the former reflect contemporaneous short-term interest rate differentials, or the "carry" earned by a foreign exchange position. Consequently, changes in futures prices represent the total excess return -- interest income, less the interest expense of funding a foreign currency position, plus capital gain or loss -- accruing to the holder of a foreign currency. Futures prices also capture the total incremental gain or loss resulting from hedging away the foreign currency exposure embedded in a foreign security investment.

Weak-form efficiency of the foreign exchange market is commonly tested by calculating the profitability of mechanical trading rules. We use two kinds of trading rules to generate buy and sell signals, filter rules and moving average crossover rules. We chose filter rules because they have been widely used in academic studies of market efficiency.[4] Moving average crossover rules are more commonly used by foreign exchange market practitioners.

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[3] The data on currency futures are daily settlement prices on the Chicago Mercantile Exchange collected through the I.P. Sharpe Company. The Japanese yen data begin only in 1977.

[4] See for example Alexander (1961) and Fama and Blume (1963).

A filter rule is defined by a single parameter (f), the filter size. If we express exchange rates in American terms (the dollar price per one unit of foreign currency), then the filter rule can be defined as follows: "Buy the currency whenever it rises by f percent above its most recent trough; sell the currency whenever it falls f percent below its most recent peak." We examined seven filter rules with f valued at 0.5%, 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, and 10%.

Specifying a moving average crossover rule requires two parameters: the length (L, in trading days) of the longer moving average (MA_L) and the length (S) of the shorter moving average (MA_S). A L/S moving average rule can be defined as follows: "If $MA_L > MA_S$, then sell the foreign currency. If $MA_L < MA_S$, then buy the foreign currency. If $MA_L = MA_S$, take no position." We examined three moving average crossover rules: 5/1; 20/5; 200/1.

Description of the Test. It is relatively easy to measure the returns that mechanical filter rules earn when they are applied to foreign currency futures. But the observed profits (if any) may have resulted from chance alone. So we need to test to verify that any profits we measure are statistically significant. We could use a conventional t-test if exchange rate volatility had been constant throughout our sample period. Unfortunately, exchange rate volatility has varied substantially.[5] This empirical finding invalidates classical statistical tests that depend on repeated draws from a stationary distribution. Consequently, we have developed a non-parametric test that does not assume the underlying distribution of exchange rates is stationary.

[5] See the evidence presented in Hsieh (1988).

Our test for significance is motivated by the bootstrapping methodology developed by Efron (1979). Briefly, we compare (1) the profits earned by applying a technical trading rule to a historical exchange rate series, to (2) the profits earned by applying the same trading rule to many simulated exchange rate series. By construction, the simulated exchange rate series have the same empirical distribution as the actual series.

We will use German mark data and a 1% filter trading rule to illustrate how our significance test works. Begin by applying the 1% filter to the time series of German mark futures prices. From Table 1 during 1976-90, we see that the 1% filter earned a return of 9.3% per year.[6]

Next apply the simulation technique. The first step is to generate a "pseudo mark" time series by randomly re-shuffling the sequence of price changes in the original sample. Notice that reordering the daily changes does not disturb the starting and ending values of the original series. Also, since the pseudo mark series is constructed by exhaustively sampling the daily price changes in the original sample, the mark and the pseudo mark share the same empirical distribution.

The pseudo mark series can be thought of as one of the many notional paths that the exchange rate might have followed as it evolved from January 1, 1976 to December 31, 1990, holding the original distribution of price changes constant. By construction, first differences of the pseudo mark series are statistically independent. That is, the pseudo mark series is what is usually referred to as a "random walk,"

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[6] All returns in this paper reflect continuous compounding.

whether or not the original mark exchange rate sequence is random.[7]

Repeat this operation until 10,000 pseudo mark time series have been generated, each with the same start point, end point, and distribution as the original mark time series. Then apply the 1% filter rule to each of these 10,000 notional exchange rate paths, generating 10,000 observations which define the empirical distribution of profits.

In this example, the 1% filter rule did not perform well when applied to 10,000 pseudo mark series. The mean return was only -0.06% per year. This result is not surprising, since filter rules will only succeed systematically if the underlying price series is non-random. Of course, the 1% filter rule did get lucky sometimes. Nevertheless, 95% of the pseudo mark series produced a profit of 4.5% per year or less; 99% produced a profit of 6.2% per year or less. You will recall that when the 1% filter rule was applied to the actual German mark series, it yielded a profit of 9.3% per year. This rate of return exceeded that in 99.95% of the 10,000 pseudo mark series. Accordingly, we can reject the hypothesis that the 1% filter rule's observed level of profitability resulted from chance alone, and conclude instead that the original mark exchange rate series must have been non-random.

Empirical Results. We examined seven filter rules and three moving average crossover rules for each of five currencies, yielding fifty profit values reported in

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[7] It would be more accurate to characterize the pseudo mark series as a semi-martingale process, but this term is less widely used. Strictly speaking, the pseudo mark is not a random walk, since the variance of successive changes is not constant.

Table 1. All fifty values were positive. The trading profits were highly statistically significant (at the 1% level as measured by our simulation approach) in thirty-five of fifty cases, significant (at the 5% level) in an additional nine cases, and not statistically significant (but positive) in the remaining cases.[8]

These results demonstrate that simple trend following trading rules have earned statistically significant profits in the foreign exchange futures markets. They do not prove that the profits are economically significant. To do so, we must consider the size of the profits, risk, and transactions costs and compare active currency strategies with a passive "buy-and-hold" strategy.

Regarding transaction costs, in Table 1 we also report the number of transactions entailed by following each trading rule. As expected, small filter sizes and trading rules based on short-term moving averages result in considerably more trading signals than larger filter and rules based on long-term moving averages. For example, the most active filter strategy was the 0.5% rule for the Swiss franc that traded 901 times in 15 years, or about 60 trades per year; the most active moving average strategy was the 1/5 rule for the Canadian dollar that resulted in 987 trades or about 65 trades per year. We calculate that the likely cost of transacting in the currency futures market is about 2.5 basis points (0.025%) per transaction for a large

[8] The results were fairly robust across three, five-year sub-periods. For a more complete description of the test results, see Levich and Thomas (1990).

institution. A more conservative estimate would be roughly 4.0 basis points.[9] At 65 trades per year, a speculator would have his trading profit reduced by 1.62% per year, or 2.60% per year if we take our more conservative measure. Transaction costs of this magnitude would substantially eliminate the 3.3% annual profit for the 1/5 moving average rule for the Canadian dollar, and reduce the profits of the 1/5 rule for other currencies. For the other trading rules we consider, the volume of trading is considerably smaller, and transaction costs do not significantly affect profits.

The returns from buying and holding each foreign currency, and buying and holding an equally-weighted currency portfolio, are reported in Table 2. The rate of return and risk figures in Table 2 are continuously compounded and annualized, but do not account for transaction costs. The returns are in excess of the risk-free rate.[10]

The performance of the buy-and-hold strategy was generally disappointing. The annual (excess) rates of return ranged from 1.9% on the British Pound to -0.2% on the Swiss franc. These modest returns were associated with substantial risks: Canadian dollar volatility was 4.8% but the other currencies' volatility ranged from 12.1% (German Mark) to 13.8% (Swiss Franc). The best Sharpe ratio -- mean excess return divided by volatility -- was recorded by the pound, at 0.16, and the worst

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[9] We consider two elements in the cost of transacting: first, the bid/ask spread which we take as \$0.0002 or \$0.0001 per transaction, and second, the brokerage commission estimated at \$11.00 per round-trip. Since the sizes of currency futures contracts ar fixed and futures prices are variable, the percentage cost of transacting varies somewhat across currencies and over time. Our likely estimate reflects an average of these characteristics.

[10] This is so because margin on account can be in the form of U.S. Treasury bills that earns the risk-free rate for the account holder.

Sharpe ratio was recorded by the Swiss franc, at -0.01. Even though holding a diversified portfolio of foreign currencies resulted in lower volatility, the portfolio's Sharpe ratio (0.10) was disappointing. These results support the view that foreign currencies are not an attractive buy- and-hold investment.[11]

In applying the technical trading rules to hedging currency risk in a global bond investment, it will be convenient to collapse the information in our ten technical rules. To do this we construct a composite trading rule for each currency. The composite rule gives an equal weight to each of the ten technical rules. Each day for each currency, our currency position is $P = (N_L - N_S) \times 10\%$, where N_L is the number of rules recommending a long currency position and N_S is the number of rules recommending a short currency position, and $-1 \leq P \leq +1$. So, for example, if five rules recommend a long position and five rules recommend a short position, we take no currency position at all. If seven rules recommend being long and three recommend being short, our composite position is long 40% of our capital. Similarly, if eight trading rules are short and two are long, our net position is short the foreign currency, in an amount equal to 60% of our capital. Notice that the composite trend following rule is usually only partially invested.

The performance of the composite technical trading rules, are summarized

[11] This is the basis of the argument that an international investor's base case should be to currency hedge. See for example, Perold and Schulman (1988), or Thomas (1989). Black (1990) argues that a portion of your foreign equity investments should be permanently unhedged. This is equivalent to taking a buy-and-hold position in foreign exchange with a fraction of your capital.

in Table 3.[12] For each currency, the composite trading rule earned a substantially higher return than the buy-and-hold strategy, even though the trading rule was usually only partially invested. The annual (excess) rate of return in Canadian dollars was 2.1%; the other returns ranged from 8.2% on the Japanese Yen to 6.8% on the German Mark. Moreover, in all but one case the composite trading rule was less risky than the buy-and-hold strategy. The trading rule's volatility was highest for the Swiss franc (8.4%) and lowest for the Canadian dollar (2.8%). The best Sharpe ratio was recorded by the pound, at 1.08, and the worst Sharpe ratio was recorded by the Swiss franc, at 0.84.

The results in Table 3 also show the value of diversification across currency positions. The volatility of the equally weighted currency portfolio (4.7%) was lower than the volatility of all but

one of the single currency positions. Lowering the volatility of currency investing by diversifying resulted in a much improved Sharpe ratio. The diversified currency portfolio's Sharpe ratio, 1.33, is superior to that available in U.S. common stocks during the same sample period.[13] Moreover, the currency portfolio's return was

[12] Again, the returns do not account for transaction costs. In effect, each of the ten trading rules governs how 10% of the portfolio is invested. The transaction costs for the portfolio would then be a weighted average based on the number of transactions for each rule. From Table 1, we see that all DM trading rules resulted in 2,898 total transactions, or less than 20 transactions per rule per year. Thus, transaction costs would reduce profits by between 50 and 80 basis points per year. (see footnote 8 also)

[13] By comparison, the Sharpe ratio achieved by the Standard and Poor's 500 stock index was 0.5 for the same 1976-1990 period.

uncorrelated with the return on equities (sample correlation = -0.08). As a result, foreign currency investment governed by technical trading rules were an attractive diversification instrument for a U.S. equity investor.

III. Global Bond Portfolios and Hedging Strategies.

We now address the issue of global bond portfolios. An investor who buys foreign bonds has two sources of return: (1) the own-currency return, equaling interest income plus capital gain or loss -- reflecting an exposure to interest rate risk, and (2) exchange rate gains or losses -- reflecting an exposure to currency risk. The availability of inexpensive, effective currency risk hedging instruments (forwards and futures) means that an international portfolio manager can be exposed to foreign interest rate risks only (currency-hedged foreign bonds), currency risks only (pure positions in forwards or futures) or to both (unhedged foreign bonds).[14] That is, the decision to hold foreign bonds can be made independently of the decision to bear currency risk. In this paper, we investigate currency hedges executed in only the currency futures markets.[15]

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[14] Foreign interest rate risk could be hedged as well using actual or synthetic interest rate futures contracts. (See Koh and Levich [1993]) We do not consider this case as a foreign currency bond hedged against both exchange rate and interest rate risk effectively becomes a synthetic U.S. dollar bond.

[15] Currency forward contracts differ from currency futures contracts in two important ways: forward trades involve bearing the credit risk of a bank counterparty, and forward positions are usually not marked to market daily. Neither of these differences has a material effect on forward and futures prices, which are ordinarily very close. As a practical matter, forward and futures market hedges produce the same result.

A security is currency exposed if its return (measured in the base currency, say the U.S. dollar) is correlated with foreign exchange rates.[16] Both stocks and bonds can be currency exposed, but in principle we should distinguish between debt and equity investments. Bonds are nominal assets, and so they are naturally denominated in some currency. Because foreign bonds represent claims to fixed amounts of a foreign currency, and the dollar value of those claims fluctuates with the exchange rate, it is not surprising to find that foreign bond investments are currency exposed. In contrast, equity investments represent claims to real assets, which are not naturally denominated in any currency. Nevertheless, in practice foreign equity investments have behaved as though they are currency exposed.[17]

A. Description of the Hedging Strategies

Passive Currency Hedging Strategies. The case for passive currency hedging strategies rests upon several arguments. These strategies are relatively easy to implement and they have low administrative costs. They are easily understood and performance evaluation is simplified. If, by comparison, active (or selective) currency hedging strategies are costly to implement, risky, or often unsuccessful, then passive

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[16] We take a dollar perspective for convenience only. The results are relevant regardless of your base currency. Note that our definition of "currency exposed" does not exclude domestic assets.

[17] See Adler and Simon (1986). We do not treat the question of how to measure currency exposures. Many corporations use the accounting value of their foreign investments as a proxy, but this practice is conceptually flawed. A measure of exposure analogous to beta is justifiable in some cases. See Jorion (1990).

strategies may offer a good alternative.

In this paper we consider two passive currency hedging strategies: "Always Hedge" and "Never Hedge."[18] The always-hedge strategy presumes that currency insurance is inexpensive, so that the costs of always being covered are low. This would be the case if the forward rate used for hedging ($F_{t,1}$) and the expected future spot rate ($E[S_{t+1}]$) were on average equal and if transaction costs are low. The case for always hedging would be enhanced further if the period-to-period discrepancies between $F_{t,1}$ and S_{t+1} were often large. Always hedging would then smooth out period-to-period results without harming long-run returns.

An argument for a passive strategy based on never hedging can also be made. Clearly this case presumes that currency insurance is expensive, so that the cost of hedging is high. Hedging costs could be high because transactions costs are high or because the forward price of foreign currency systematically underpredicts the future spot price. If the discrepancies between $F_{t,1}$ and S_{t+1} are small, or if period-to-period variability in returns is not penalized, then always hedging offers few benefits. Managers could claim that return variability is a normal part of an international portfolio and that some of this volatility is naturally dampened in the context of the larger portfolios that investors hold.

<u>Active Currency Hedging Strategies</u>. The case for active (or selective)

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[18] Many other passive currency risk management rules could be proposed. For example, policies based on (i) maximizing nominal interest earnings, (ii) persistent forward exchange prediction bias, or (iii) a contrarian view based on hedging forward premia but not discounts could be followed in a passive manner. See Aliber (1978) for further discussion of these issues.

currency hedging strategies also relies upon several arguments. First, it presumes the existence of a trading rule that can beat the currency futures market. By this we mean that, on average, the trading rule earns a profit after accounting for transaction costs. And second, since no trading rule will earn a profit in every period, an active strategy presumes that these returns are large relative to the risks.

As was the case with passive strategies, a large number of active strategies could be investigated. This is especially so when a large number of forecasting rules exist, and various composite forecasts could be generated based on these individual forecasts. In this paper we examine only two active strategies similar in spirit to the composite trading rules proposed in section II.

A tactical hedging strategy is one where the percentage of currency futures to sell for currency i ($P_{T,i}$) based on our ten technical rules is determined by the formula:

$$
\begin{aligned}
P_{T,i} &= [10 - (N_{L,i} - N_{S,i})] \times 10\%, && \text{for } N_{L,i} \geq 5 \\
&= 100\% && \text{for } N_{L,i} \leq 4
\end{aligned}
$$

where $N_{L,i}$ and $N_{S,i}$ are the number of technical rules advocating long and short currency positions. When all currency forecasters expect the value of FC to rise ($N_{L,i} = 10$), no hedging is recommended ($P_{T,i} = 0$). But when the trading rules are evenly split ($N_{L,i} = N_{S,i} = 5$), the tactical strategy results in a 100% hedge of the currency risk in a foreign bond portfolio. When most trading rules recommend a short position, the tactical strategy also hedges fully.

The return on the tactically hedged portfolio (R_T) is simply

$$R_T = R_U (1-P_T) + R_H (P_T) \qquad (1)$$

where R_U is the return on the unhedged bond and R_H is the return on the currency-hedged bond. Note also that R_U and R_H are related by $R_H = R_U + R_{FH}$ where R_{FH} is the return on the futures hedge, i.e. the return from selling currency futures [-ln (F_{t+1}/F_t]. Equation (1) can then be re-written as

$$\begin{aligned} R_T &= R_U (1-P_T) + (R_U + R_H) (P_T) \\ &= R_U \qquad + R_F \; P_T \qquad (2) \end{aligned}$$

with $0 \leq P_T \leq 1$. We use equation (2) to compute R_T, taking R_U from the monthly series of bond prices and taking R_F P_T from the daily series of trading signals and futures prices accumulating these to a monthly series.

The currency overlay strategy is actually a combination of two separate investments: (1) a foreign currency bond position that is always hedged against currency risk, and (2) a currency position governed by the composite currency trading rule [$P = (N_L - N_S)$x10%] as described in section II. At one extreme, if all trading rules recommend a long position the currency overlay strategy will be 100% in foreign currency similar to the tactical hedge. But at the other extreme, if all trading rules recommend a short position, the currency overlay strategy will "overhedge" to become net 100% short in the foreign currency. Recall that in this case, the tactical hedge resulted in a full hedge, yielding no net currency exposure. As the range of currency positions is wider with the currency overlay strategy, it should be riskier than the tactical hedge strategy.

The return on the currency overlay strategy (R_{CO}) is given by

$$R_{CO} = R_H + R_A \tag{3}$$

where R_A is the return on the active composite trading rule, or $R_A = \Sigma_t P_t * \ln(F_{t+1}/F_t)$, and P_t, the percentage of futures contracts to buy, satisfies $-1.0 \leq P_t \leq +1.0$. We use equation (3) to compute R_{CO} taking R_H from the monthly series of bond prices and taking R_A from the daily series of trading signals and futures prices and accumulating these to a monthly series.

B. Empirical Results

Our bond data reflect the monthly returns (interest income plus capital gain or loss in local currency) on foreign government bonds with approximately 10-year maturities.[19] Most of the data are available for the 1975-1990 period but because of limitations on Japanese yen currency futures data, the effective sample period is

[19] For the period 1975-1985, data are for individual bonds and are from Goldman Sachs. For the 1986-1990 period, data are for liquid bond indices and are from J.P Morgan Securities.

1977-1990. The returns are converted into U.S. dollars by using end-of-period spot rates (for unhedged returns) and the one-month Euro-currency rate differential (for hedged returns).[20]

For calculating the returns associated with the "always hedge" strategy, the currency hedge is repeated (or rolled-over) each month. Since the maturity of the foreign currency bonds far exceeds the maturity of the currency hedge, the bond portfolio continues to reflect essentially all of its initial foreign currency interest rate risk.

The results for the two passive strategies are reported in Tables 4 and 5. As a benchmark, we also computed the returns for a U.S. dollar government bond portfolio with similar maturity. The mean return for the dollar portfolio over the entire 14 year period was 9.00% with standard deviation 8.91%. The mean excess return, over and above the risk-free rate, was 1.06%, producing a Sharpe ratio of 0.12.[21] For the unhedged portfolios (Table 4), we see that mean returns were higher for three of the four currencies (BP, DM and JY) and for an equally-weighted portfolio than for the U.S. dollar portfolio. However, volatility measures for these foreign currency bonds were all considerably higher than the U.S. dollar portfolio. Nevertheless, the Sharpe ratios for the BP, DM and JY portfolios and the global

[20] Equating the interest differential to the cost of a forward hedge relies on the covered interest rate parity principle, which is robust in the Eurocurrency market. We use these data rather than futures to establish an exact one-month hedge.

[21] The sequence of one-month U.S. Treasury Bill yields from the Center for Research in Security Prices (University of Chicago) is used as a risk-free return. The Sharpe ratio is calculated as $(R_i-R_F)/\sigma(R_i)$

portfolio all equal or exceed the U.S. dollar bond benchmark.[22]

The unhedged global portfolio, however, is imperfectly correlated with the U.S. dollar portfolio, so opportunities for diversification gains were present. In Figure 1, we see that a mixture of roughly 40% global portfolio and 60% U.S. dollar bonds would have improved the total returns to risk measure. The Sharpe ratio, however, is maximized with a full investment in the global unhedged portfolio.

The results for the portfolios with 100% currency hedging are shown in Table 5. The effect on mean return is mixed with two currencies (BP and JY) showing 2-3% lower returns, and two currencies (DM and CD) showing little change.[23] The effect on the reduction of volatility in each foreign currency bond portfolio is unambiguous. The trade-off between risk and return is reflected in the Sharpe ratios, which are little changed (compared to Table 4) for two currencies (BP and CD) but much improved for two others (DM and JY). The Sharpe ratio is 0.41 for the equally-weighted global portfolio, higher than for the unhedged portfolio and higher than for the U.S. dollar benchmark. The opportunities for diversification with the fully-hedged global portfolio are shown in Figure 2. Here it is clear that the fully-

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[22] Had we measured performance on the basis of mean return relative to volatility, the U.S. dollar portfolio would come out ahead of the other portfolios in Table 4. Even based on the $R_i/\sigma(R_i)$ measure, the foreign portfolios presented in later table will be superior to the U.S. dollar portfolio. See Thomas (1989) for an analysis using the total returns to volatility measure.

[23] The results in Table 5 do not include the incremental transaction costs associated with hedging. Always hedging our monthly returns implies 12 hedging transactions per year at a cost of 2.5-4.0 basis points each (see footnote 8) or 30-38 basis points per year.

hedged global portfolio completely dominates the U.S. dollar portfolio. Ex-post, a 100% weight on the fully-hedged global bond portfolio would have maximized either a Sharpe ratio or the total return/risk trade-off.[24]

The results for the two active currency hedging strategies are summarized in Tables 6 and 7.[25] The more conservative, tactical hedging strategy shows some measure of success relative to the two passive approaches. In Table 6, all mean returns are higher the either of the two passive foreign currency strategies. And all volatilities are bounded within the two measures reported in Tables 4 and 5. The trade-off appears to be worthwhile as the Sharpe ratios for the tactical currency hedging strategy are all greater than those reported for either passive strategy. The Sharpe ratio for the tactically managed global portfolio is 0.75, nearly twice that of the fully hedged global portfolio and more than six times that of the U.S. dollar portfolio.

The results for the currency overlay strategy (Table 7) are still more encouraging. Without exception, mean returns are higher than for the tactical hedging program, and volatility measures are about the same. The effect on the Sharpe ratio is unambiguous. For three currencies (DM, BP, JY) the return/risk ratios are substantially higher than for the pure U.S. dollar bond portfolio. For the global

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[24] These results correspond generally with those reported earlier in Thomas (1989).

[25] Again, the returns are measured before transaction costs. With the most active hedging strategy producing an average of 20 transactions per currency per year (see footnote 8), the impact on returns would be 50-80 basis points per annum.

portfolio, the Sharpe ratio is 1.23, more than ten times that for the U.S. dollar bond portfolio. Another image of these two active strategies is shown in Figure 3.

The results presented above are evidence that active hedging strategies would have been very beneficial to international bond portfolio managers. However, with the wide swings in currencies over the sample period, it is possible that our results might have been largely determined by events in a single year or two. To investigate this possibility, we examined the sensitivity of our results to the sample period by breaking the sample into three sub-periods and into five sub-periods. Only the results for the five sub-periods are presented as summarized in Figures 4 and 5.

In Figure 4, we present the total returns from investing in U.S. dollar bonds and our global bond portfolio managed according to the four different currency risk strategies we proposed. Over the entire sample period, any global bond strategy earned higher returns than the U.S. dollar bond portfolio. Foreign bond portfolios earned higher returns in all cases in 1977-78, a period of substantial U.S. dollar weakness. All foreign portfolios (with the exception of the unhedged strategy) earned higher returns than the U.S. dollar portfolio during the strong dollar years of 1979-81 and 1982-84. The return of a weak dollar in 1985 made the returns on the unhedged foreign portfolio far outdistance dollar bonds, but actively managed foreign bonds also earned higher returns than U.S. bonds. The final period (1988-90) saw exchange rates moving within narrower bands. U.S. dollar bond portfolios earned higher returns than foreign bonds, with the exception of those with an active currency overlay. The active overlay strategy had the highest total return in four of the five subperiods.

In Figure 5, we present a similar analysis for Sharpe ratios for the alternative portfolios in various sub-periods. From the first four sub-periods, we could conclude that foreign portfolios, either passively (100%) hedged or actively hedged, produced Sharpe ratios very near to or superior than the U.S. dollar portfolio. In the final sub-period, however, this regularity breaks down. We can also examine the dominance of active versus passive hedging strategies. In the first, second and fifth sub-periods, both active strategies produced higher Sharpe ratios. But in 1982-84, always hedging outperformed the tactical strategy, and in 1985-87, the never hedge strategy performed on a par with both active strategies. The regularity that remains is that in every sub-period, the currency overlay strategy produced a positive Sharpe ratio and a Sharpe ratio greater than the U.S. dollar portfolio. Moreover, the currency overlay strategy produced the highest Sharpe ratio in four of the five subperiods. Thus, a foreign bond portfolio that includes an active currency risk management strategy based on a currency overlay approach seems to dominate the performance of a passively held U.S. dollar bond portfolio.

IV. Summary and Conclusions

In this paper we described a new test for weak-form market efficiency, applied it to foreign currencies, and decisively rejected the hypothesis that exchange rates have evolved randomly. While foreign exchange has not been attractive as a buy-and-hold investment, we found that simple trend-following trading rules historically earned economically and statistically significant profits.

Should international investors, then, routinely currency hedge all of their foreign investments? To date, most contributors to the currency hedging debate have either implicitly or explicitly assumed that foreign currency positions do not promise abnormal, risk-adjusted returns. But if foreign exchange markets offer unusual profit opportunities, the arguments for always hedging are weakened. Our results in Section III suggest that selective hedging may produce superior investment performance. However, it appears that the greatest opportunities are present if investors are not restricted in their ability to overhedge in currencies where they hold long positions in bonds. This finding was supported by an examination of performance over shorter time periods where the currency overlay strategy consistently produced a positive Sharpe ratio, and one exceeding the that for a U.S. bond portfolio. Our results in Section II suggest further that foreign exchange may be an attractive asset class for return-seeking investors, even if they do not own foreign securities.

In light of these findings international investors may wish to reconsider the advice to always hedge all, or always hedge a set percentage, of their portfolio's currency exposures. Using simple tactical hedge/no hedge rules based on signals from technical currency trading models would have increased the risks of foreign investing compared to a strategy of always currency hedging. But tactical hedging rules would have increased returns too. A more aggressive strategy using an active currency overlay earned the highest returns (both gross returns and excess returns relative to volatility) of any strategy we examined, yet was less risky than not hedging at all.

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TABLE 1: Profits of Technical Trading Rules in Currency Futures Markets, 1976-1990

	Currency				
Strategy	SF	DM	CD	BP	JY
Filter 0.5	8.1[a] 901	2.2 825	3.3[a] 305	9.9[a] 791	7.5[a] 784
1.0	6.8[b] 533	9.3[a] 409	3.4[a] 121	7.5[a] 424	8.3[a] 410
2.0	3.7 253	5.5[b] 195	1.7[b] 51	7.4[a] 188	7.0[a] 174
3.0	7.2[b] 127	7.9[a] 97	0.9 28	8.4[a] 106	7.1[a] 98
4.0	10.1[a] 78	8.1[a] 62	1.6[b] 15	8.0[a] 65	10.1[a] 60
5.0	6.7[b] 62	8.2[a] 41	1.1 11	4.3[c] 55	8.4[a] 44
10.0	6.0[a] 15	3.5[b] 15	1.8[a] 2	4.5[a] 14	4.8[a] 15
MA 5/1	5.2[b] 980	6.4[a] 964	3.3[a] 987	7.4[a] 943	7.3[a] 929
20/5	8.9[c] 211	11.2[a] 215	2.7[a] 196	10.5[a] 187	10.6[a] 191
200/1	6.9[a] 81	8.1[a] 75	2.3[b] 81	8.7[a] 60	9.2[a] 85

Notes: Profits in percent per annum, U.S. dollar returns
Second line is number of trades in full sample
a Significant at the 1% level in a bootstrap test
b Significant at the 5% level in a bootstrap test
c Significant at the 10% level in a bootstrap test

Japanese yen data are for 1977-1990.

TABLE 2: Profits Using a Buy-and-Hold Trading Rule in Currency Futures Markets, 1977-1990

	SF	DM	CD	BP	JY	Port-folio
Mean Excess Return	-0.17%	0.31%	0.48%	1.48%	1.82%	0.86%
Volatility	13.75%	12.07%	4.78%	12.28%	13.06%	9.04%
Sharpe Ratio	-0.01	0.03	0.10	0.12	0.14	0.10

Note: Profits in percent per annum, U.S. dollar returns

TABLE 3: Profits Using a Composite Trading Rule in Currency Futures Markets, 1977-1990

	SF	DM	CD	BP	JY	Port-folio
Mean Excess Return	7.00%	6.84%	2.06%	7.60%	8.18%	6.26%
Volatility	8.38%	7.47%	2.76%	7.02%	8.05%	4.69%
Sharpe Ratio	0.84	0.92	0.75	1.08	1.02	1.33

Note: Profits in percent per annum, U.S. dollar returns

TABLE 4: U.S. Dollar Returns from Unhedged Ten-Year Bonds, 1977-1990

	DM	CD	BP	JY	Global Portfolio	US $
Mean Return	9.75%	8.59%	14.07%	12.90%	11.33%	9.00%
Mean Excess Return (a)	1.81%	0.65%	6.13%	4.96%	3.39%	1.06%
Volatility	15.53%	11.17%	17.42%	16.89%	11.68%	8.91%
Sharpe Ratio	0.12	0.06	0.35	0.29	0.29	0.12

Note: Calculations based on N=168 monthly observations. (a) The risk-free return for the period was 7.94% per annum. The global portfolio is an equally weighted portfolio of the four non-dollar bonds.

TABLE 5: U.S. Dollar Returns from Fully Hedged Ten-Year Bonds, 1977-1990

	DM	CD	BP	JY	Global Portfolio	US $
Mean Return	10.05%	8.57%	11.30%	11.04%	10.24%	9.00%
Mean Excess Return (a)	2.11%	0.63%	3.36%	3.10%	2.30%	1.06%
Volatility	6.06%	9.04%	10.11%	6.38%	5.68%	8.91%
Sharpe Ratio	0.35	0.07	0.33	0.49	0.41	0.12

Note: Calculations based on N=168 monthly observations. (a) The risk-free return for the period was 7.94% per annum. The global portfolio is an equally weighted portfolio of the four non-dollar bonds.

TABLE 6: U.S. Dollar Returns from Tactically Hedged Ten-Year Bonds, 1977-1990

	DM	CD	BP	JY	Global Portfolio	US $
Mean Return	12.63%	9.04%	16.80%	15.57%	13.51%	9.00%
Mean Excess Return (a)	4.69%	1.10%	8.86%	7.63%	5.57%	1.06%
Volatility	9.29%	9.50%	13.24%	11.10%	7.47%	8.91%
Sharpe Ratio	0.50	0.12	0.67	0.69	0.75	0.12

Note: Calculations based on N=168 monthly observations. (a) The risk-free return for the period was 7.94% per annum. The global portfolio is an equally weighted portfolio of the four non-dollar bonds.

TABLE 7: U.S. Dollar Returns from Hedged Ten-Year Bonds Combined with Active Currency Overlay, 1977-1990

	DM	CD	BP	JY	Global Portfolio	US $
Mean Return	17.68%	10.78%	19.74%	19.55%	16.44%	9.00%
Mean Excess Return (a)	9.74%	2.84%	11.80%	11.61%	9.00%	1.06%
Volatility	9.14%	9.20%	13.75%	10.44%	7.32%	8.91%
Sharpe Ratio	1.06	0.31	0.86	1.11	1.23	0.12

Note: Calculations based on N=168 monthly observations. (a) The risk-free return for the period was 7.94% per annum. The global portfolio is an equally weighted portfolio of the four non-dollar bonds.

TABLE 8: Sharpe Ratios for International Portfolios with Alternative Currency Hedging Strategies, 1977-1990

Strategy	DM	CD	BP	JY	Global Portfolio
No Hedge	0.12	0.06	0.35	0.29	0.29
Always Hedge	0.35	0.07	0.33	0.49	0.41
Tactical Hedge	0.50	0.12	0.67	0.69	0.75
Currency Overlay	1.06	0.31	0.86	1.11	1.23

Note: Sharpe Ratio for U.S. dollar portfolio is 0.12 .

FIGURE 1

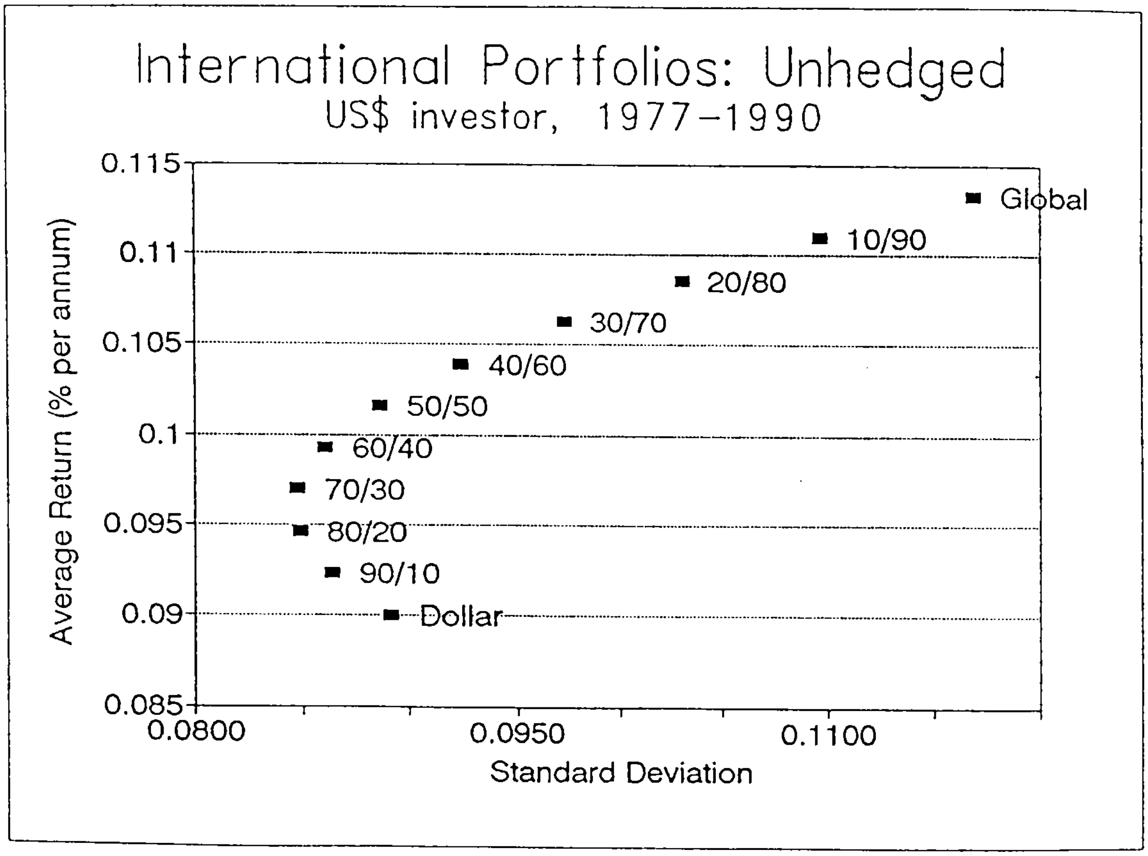

International Portfolios: Unhedged
US$ investor, 1977-1990
Average Return (% per annum)
0.115
0.11
0.105
0.1
0.095
0.09
0.085
0.0800
0.0950
0.1100
Standard Deviation
Global
10/90
20/80
30/70
40/60
50/50
60/40
70/30
80/20
90/10
Dollar

FIGURE 2

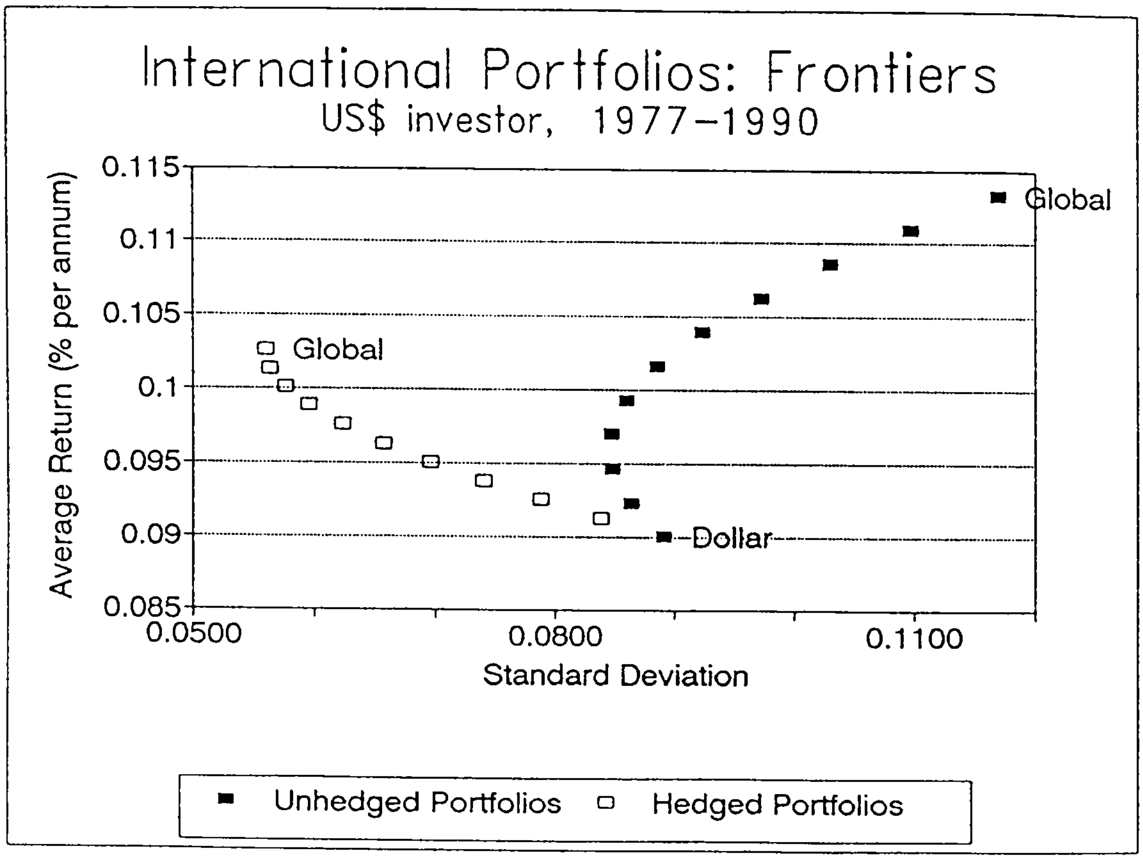
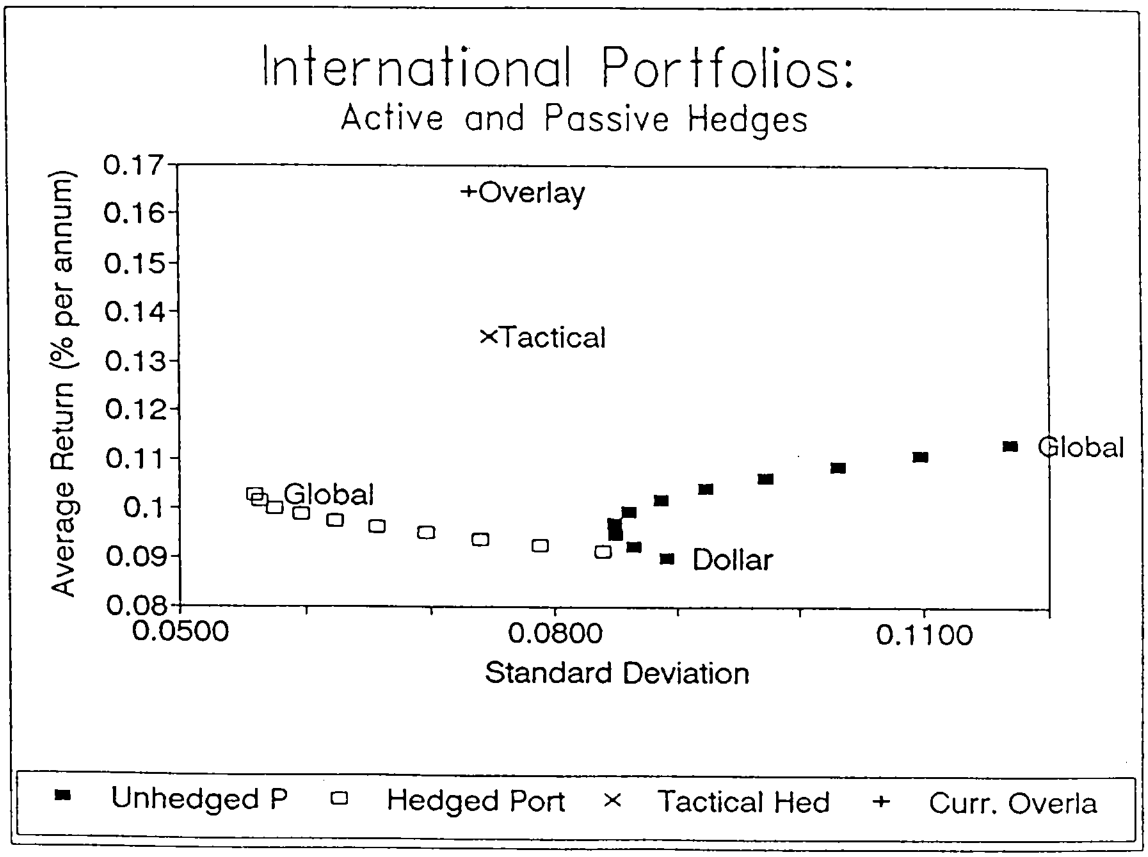

International Portfolios: Frontiers
US$ investor, 1977–1990
Average Return (% per annum)
0.115
0.11
0.105
0.1
0.095
0.09
0.085
0.0500
0.0800
0.1100
Standard Deviation
Global
Global
Dollar
Unhedged Portfolios
Hedged Portfolios

FIGURE 3



International Portfolios:
Active and Passive Hedges
Average Return (% per annum)
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.0500
0.0800
0.1100
Standard Deviation
+Overlay
×Tactical
Global
Global
Dollar
Unhedged P
Hedged Port
Tactical Hed
Curr. Overla

FIGURE 4

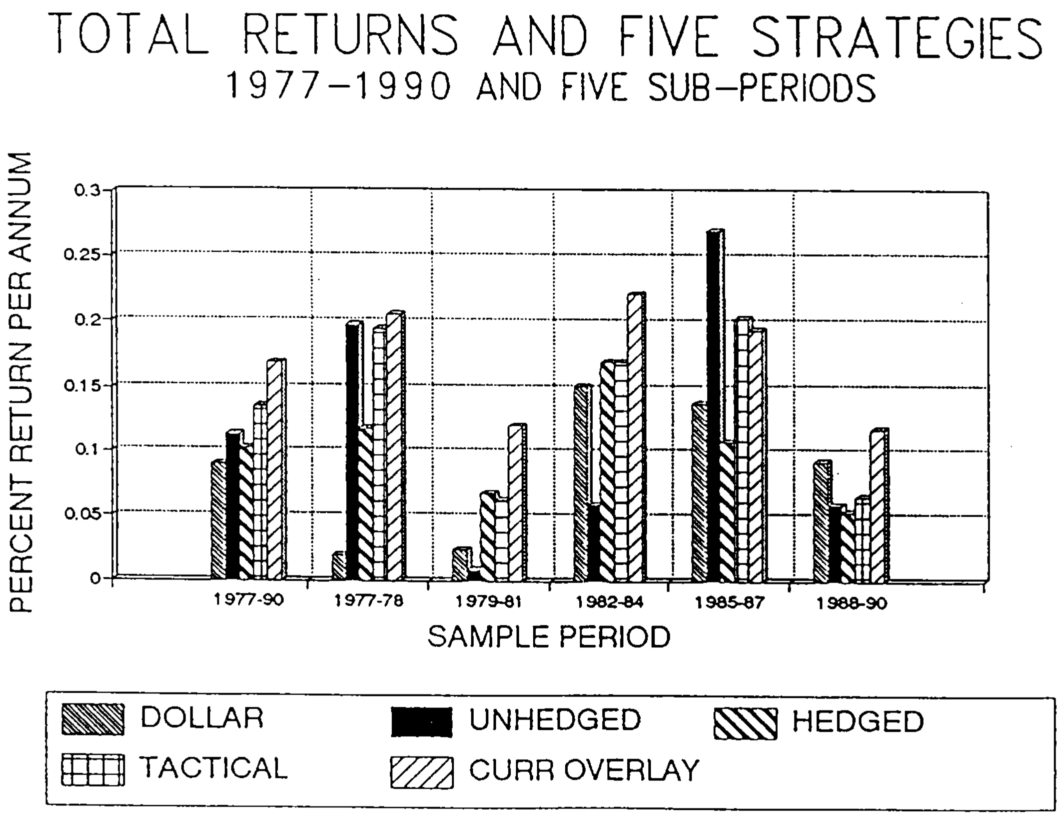
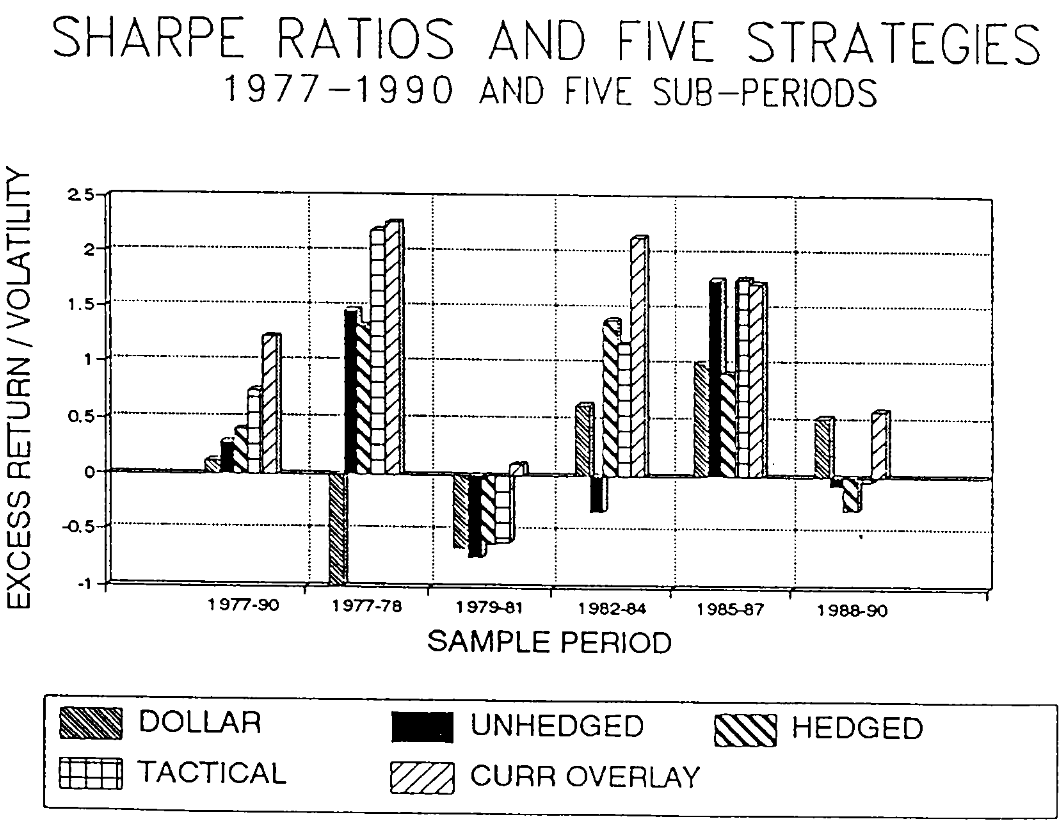

TOTAL RETURNS AND FIVE STRATEGIES
1977-1990 AND FIVE SUB-PERIODS
PERCENT RETURN PER ANNUM
0.3
0.25
0.2
0.15
0.1
0.05
0
1977-90
1977-78
1979-81
1982-84
1985-87
1988-90
SAMPLE PERIOD
DOLLAR
UNHEDGED
HEDGED
TACTICAL
CURR OVERLAY

FIGURE 5


SHARPE RATIOS AND FIVE STRATEGIES
1977-1990 AND FIVE SUB-PERIODS
EXCESS RETURN / VOLATILITY
2.5
2
1.5
1
0.5
0
-0.5
-1
1977-90
1977-78
1979-81
1982-84
1985-87
1988-90
SAMPLE PERIOD
DOLLAR
UNHEDGED
HEDGED
TACTICAL
CURR OVERLAY