EVALUATING THE PERFORMANCE OF FOREIGN EXCHANGE HEDGES

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Abstract: An evaluation of the performance of foreign exchange hedges shows that, in a mean-variance framework, fully hedging exchange risk does not improve the performance of a portfolio of international equities; however, dynamic strategies which incorporate market information on risk premiums in the forward market are shown to statistically improve performance.

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Introduction

The benefits of international diversification to investors have been known since the early studies of Grubel (1968) and Levy and Sarnat (1970). While those benefits apparently still remain, recent evidence from Eun and Resnick (1988) and Jorion (1989) suggest that further improvements in portfolio performance can be obtained in internationally-diversified portfolios by hedging exchange risk through the use of forward contracts. Their analyses, however, suffer from deficiencies which this paper addresses. First, the hedging strategies that they consider are restricted to the strategy of always fully hedging foreign exchange exposure, as measured on a currency by currency basis. While this strategy may improve performance, alternative strategies could be superior. Second, their measure of performance does not incorporate the distribution of their statistic into the evaluation process so that they are unable to draw inferences in a statistical sense on the ability of hedging to improve performance.

This paper conducts statistical tests of the improvement in performance brought about by hedging foreign exchange risk. In a mean-variance framework one measure of performance is the ratio of excess return and standard deviation, the well known Sharpe measure. All well-diversified portfolios should have equal Sharpe measures. To test for the equivalence of these measures, statistics are employed which have been used for testing mean-variance efficiency in the asset pricing literature.

In addition to the static strategy of always fully hedging a foreign exchange position, alternative strategies are also investigated. For example, theoretical models do not suggest that an investor should be fully hedged against risk.[1] Instead, the position taken in the hedging instrument depends on the covariance between the instrument and the portfolio being held which, in some cases, can imply buying rather than selling foreign currency forward. This paper considers two strategies which adjust the hedge position depending on a contemporaneous measure of the covariance between the returns on forward contracts, the hedging instruments, and the portfolio being hedged.

The fully hedged strategy also does not consider other market information which is publicly available and the role that such information can have in developing a superior hedging strategy. For example, previous research has shown a strong relationship between the premium in the forward market and subsequent exchange rate behavior. This paper includes two strategies which employ information in the forward premium, the difference between the forward and the current spot rate, in a dynamic hedging strategy.

The organization of the paper is as follows. Section I introduces the concept of hedging in a portfolio context. Section II develops the tests of mean variance efficiency which will be used to evaluate performance. Four alternative hedging strategies, two based on a theoretical model and two based on evidence of the

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[1] Anderson and Danthine (1981) develop a theoretical model of hedging which shows that the optimal hedging position can be either positive, negative or zero and will generally differ from the fully-hedged position.

predictive power of available information, are described in Section III. Section IV provides the empirical results of the tests and conclusions are summarized in the final section.

I. The Environment

Consider an investor making a portfolio decision involving 2N+1 assets: N foreign equity portfolios (or individual securities) whose returns involve a foreign exchange component, N forward contracts for foreign exchange and the domestic portfolio. The equities require an initial investment and produce a random return. On the other hand, forward contracts involve a commitment to buy or sell foreign currency and produce a random payoff but require no initial investment. Therefore, it is not possible to define a return on them as such; however, they do produce a payoff and when combined with a portfolio of equities it is possible to compare the return on the portfolio with and without the forward contracts. That is the strategy which will be followed in this paper.

The investor's portfolio problem is defined as follows. Let W_t equal the dollar value of wealth invested at time t and let ω_{it} be the fraction of wealth invested in asset i, with $\Sigma_i \omega_{it} = 1$. The return on the investment in the n+1 equities is given by

$$\sum_{i=1}^{n+1} \omega_{i,t} W_t \frac{P_{i,t+1} S_{i,t+1}}{P_{i,t} S_{i,t}} = \sum_{i=1}^{n+1} \omega_{i,t} W_t R_{i,t+1}.$$

where $P_{i,t}$ is the time t price of security i in its local currency, $S_{i,t}$ is the time t exchange rate for currency i expressed as home currency units ($) per local currency. Now define $\alpha_{it}\omega_{it}W_t/S_{it}$ as the amount of foreign currency i sold forward at time t for delivery at time t+1 at the forward exchange rate $F_{it+1,t}$, which is also expressed in terms of dollars per local currency. Let $h_{i,t} \equiv \alpha_{i,t}\omega_{i,t}$ equal the fraction of wealth sold forward. With these definitions, the payoff on the portfolio is given by

$$\pi_{t+1} \equiv \sum_{i=1}^{n+1} \omega_{i,t} W_t R_{i,t+1} + \sum_{i=1}^{n} h_{i,t} W_t \frac{F_{it+1,t} - S_{i,t+1}}{S_{i,t}}.$$

The return on the hedged portfolio is equal to

$$R^h_{t+1} \equiv \frac{\pi_{t+1}}{W_t} - 1 = \sum_{i=1}^{n+1} \omega_{i,t} R_{i,t+1} + \sum_{i=1}^{n} h_{i,t} f_{i,t+1} - 1$$

where

$$f_{i,t+1} \equiv \frac{F_{it+1,t} - S_{i,t+1}}{S_{i,t}}$$

is the "return" on a forward contract.

Now define

$$R_{t+1} \equiv \sum_{i=1}^{n+1} \omega_{i,t} R_{i,t+1} - 1$$

as the return on an unhedged portfolio and

$$Y_{t+1} \equiv \sum_{i=1}^{n} h_{i,t} f_{i,t+1}$$

as the return on the forward positions taken. The return on the hedged portfolio is then

$$R^h_{t+1} = R_{t+1} + Y_{t+1}.$$

Now that the notation has been defined, it is easy to determine the implications of including forward contracts in the portfolio. In a mean-variance framework, the performance of the hedged and unhedged portfolios can be compared by considering only the first two moments of their distributions. For the expected returns, the difference between the hedged and unhedged portfolios is given by the weighted sum of the mean returns on the forward contracts. The variance, however, is somewhat more complicated and is given by

$$var(R_t^h) = var(R_t) + var(Y_t) + 2cov(R_t, Y_t) .$$

Noting that $F_{it+1,t}$ is not a random variable at time t, the ability of hedging to reduce risk depends on the relationship between the variance of the exchange rate and the covariance of dollar equity returns and the returns on foreign currencies.

The next section describes the method used to evaluate the ability of any particular hedging strategy to improve the performance of a portfolio.

II. Tests of Mean-Variance Efficiency

There are at least two deficiencies with previous research on the effectiveness of hedging foreign exchange risk. First, they were restricted to given portfolio weights on the individual assets. Most commonly, a value-weighted portfolio of international assets is selected and the performance of that portfolio, hedged and unhedged is "compared". It may be, however, that some other set of portfolio weights would have produced different results.

What is needed is an approach which does not restrict itself to any particular set of portfolio weights. Second, while it is possible to compare the point estimates of any statistic for any two portfolios, comparisons of those point estimates without considering their distributions is not very meaningful in a statistical sense. These two problems are addressed in this section.[2]

Roll (1977) showed that tests of the capital asset pricing model are equivalent to tests of the mean-variance efficiency of a benchmark portfolio. Grinblatt and Titman (1987) extended this idea to cover multiple factor models with the implication that, in a multi-factor framework, some linear combination of the factors must be mean-variance efficient. In a mean-variance framework, efficiency of a set of factors can be determined through the regression

$$(1) \qquad R_t = \alpha + \beta' X_t + e_t$$

where R_t is the excess return on any portfolio, β is a vector of regression parameters, X_t is the set of factors and ϵ_t is the regression residual. The factors are efficient if and only if $\alpha = 0$.

This concept applies to the present context in the following way. In a mean-variance framework, the expected return on an asset will be determined by the riskiness of the asset, where risk is

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[2] Eun and Resnick (1988) look at several strategies for determining the optimal international asset allocation. They do not, however, incorporate any distribution theory into their performance evaluation.

determined by the systematic risk that the asset exhibits. To the extent that a portfolio is well diversified and the risk inherent in forward contracts is systematic, adding forward contracts to the portfolio should not effect its expected performance. If, however, the risk inherent in forward contracts is non-systematic risk so that there is no risk premium required to obtain them, or the portfolio of assets is not sufficiently diversified in terms of currency risk, or forward contracts are priced in a manner different from equities, then their addition may improve the portfolio's performance. In a mean-variance framework, testing whether or not a particular hedging strategy improves performance is purely a matter of testing the mean-variance efficiency of the unhedged portfolio vis-a-vis the hedged portfolio.

The argument that there is no risk premium associated with forward contracts has been accepted in the present context by Eun and Resnick (1988). More generally, however, both theoretical models of asset pricing and empirical work on exchange rates indicate the existence of a risk premium.[3] Of course, what is important empirically is not only the existence of a risk premium, but also whether the magnitude of that premium is similar in the equity and the forward exchange markets. This section will describe the statistics needed to test for this similarity.

Jobson and Korkie (1982), Gibbons, Ross and Shanken (1989), henceforth GRS, and Kandel and Stambaugh (1989) develop statistical

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[3] Hodrick (1987) provides an extensive survey on the literature of risk premiums in forward exchange rates.

tests of mean-variance efficiency in a multivariate setting. One appeal of their analyses for the present study is that they relate tests of mean-variance efficiency to Sharpe measures, defined as the ratio of an asset's mean excess return to its standard deviation, which are common measures of risk-return tradeoff used in investment analysis.[4] Following the notation of Kandel and Stambaugh (1989), consider two portfolios, one consisting of K_1 assets and a second consisting of K_2 assets. In the present context the set of K_1 assets will consist of international equities. The second portfolio will contain the international equities and forward contracts for each of the corresponding foreign currencies. Let the null hypothesis be that the portfolio of K_1 assets is mean variance efficient and let the alternative hypothesis be that the portfolio of K_2 assets is mean-variance efficient. Kandel and Stambaugh consider the statistic

$$Q = \frac{\theta_{K2}^2 - \theta_{K1}^2}{1 + \theta_{K1}^2}$$

where θ_{Ki} is the maximal Sharpe measure obtainable from the set of assets K_i. Under joint normality of the asset returns and the null hypothesis that the set of K_1 assets is mean-variance efficient, Jobson and Korkie (1982) show that [(T-N-1)/N]*Q has an F distribution with degrees of freedom N and (T-N-1), where T is the number of observations and N is the number of forward contracts included in K_2. The statistic is equivalent to a likelihood ratio

[4] Eun and Resnick (1988) employed Sharpe measures for evaluating the performance of hedged and unhedged portfolios.

test that the intercepts are zero in a system of regressions of the returns on the N forward contracts on the set of K_1 factors.

One appealing aspect of this approach to testing mean-variance efficiency is the intuitive geometric interpretation that GRS have given to it. The statistic compares the slopes of the tangent lines to the efficient frontiers of the set of K_2 and K_1 assets. If the set of K_1 assets is efficient then the two slopes should not be statistically different. By definition, the slopes of these tangent lines are given by the Sharpe measures of the set of assets. In this case, however, no restrictions are imposed on the weight of each asset in the portfolio. Instead, the optimal (ex post tangency) portfolios are calculated and their Sharpe measures are compared. Note, however, that the comparison is made between squared Sharpe measures, which implies that the test will identify only the necessary conditions for efficiency.

A possible shortcoming of this likelihood ratio test is that it assumes that all excess returns are multivariate normal and homoskedastic. While this has positive implications in that it produces a known finite sample distribution for the statistic, the assumptions may be somewhat over restrictive and, if violated, result in only asymptotic justification for the test. If the asset returns being tested are not normal, it may be that under the sample distribution this particular statistic is not sufficiently powerful to reject the null even when it is false. One possible source of concern is conditional heteroskedasticity which may manifest itself in excessive kurtosis. Mixing observations from distributions which are normal, but with different variances can produce distributions with high degrees of kurtosis. Fortunately, an alternative statistic is available which is robust under heteroskedasticity.

The consistency of ordinary least squares (OLS) parameter estimates is preserved under heteroskedasticity, however, OLS standard errors are no longer consistent. White (1980) develops a heteroskedasticity-consistent covariance matrix estimator which is useful in situations such as this. To draw inferences, one need only estimate the desired parameters by OLS, and then substitute the corrected variance-covariance matrix using White's estimator. In the current situation, this is accomplished by estimating the intercepts in equation (1), where the returns on the forward contracts are the independent variables and the international equities are the dependent variables. The null hypothesis of efficiency is a joint test that the intercepts for all forward contracts are jointly zero using the heteroskedasticity-consistent covariance matrix. MacKinlay and Richardson (1990) find that this approach is more likely to reject the null hypothesis than the GRS statistic.

This section has developed the statistical methodology needed to evaluate the performance of alternative hedging strategies. The next section outlines the different strategies to be considered for testing in section IV.

III. Hedging Strategies

Having invested some effort in notation makes it easy to explain the different hedging strategies which will be investigated. For example, choosing $\alpha_{i,t} = 0$ for all i and t is the unhedged strategy, which is the benchmark against which all other strategies will be evaluated. An obvious alternative is to choose $\alpha_{i,t} = 1$, which is the naive strategy of always selling forward the original amount invested. While there is little theoretical support for the naive hedging strategy, there are at least two reasons for including it in the analysis. First, it is the strategy which has been most analyzed by previous research in this area.[5] Second, it is easy to implement and, perhaps because of the evidence presented in previous research, may be followed by investors.

While the naive strategy may be a naturally intuitive approach to hedging, economic theory suggests a different solution for arriving at an optimal hedged position. Using the framework developed in Section 1 and imposing the constraint that the sum of the weights, ω_i, must equal one, the return on the hedged portfolio can be written as

$$R_{t+1} = g'_t r_{t+1}$$

where

[5] In addition to Eun and Resnick (1988) and Jorion (1989), investigations into the implications of the naive strategy have been conducted by Perold and Schulman (1988) and Kaplanis and Schaefer (1990) among others.

$$g'_t = (1 - \Sigma_i \omega_{i,t}, \omega_{1,t}, \ldots, \omega_{n,t}, h_{1,t}, \ldots, h_{n,t})$$

$$r'_{t+1} = (R_{1,t+1}, \ldots, R_{n+1,t+1}, f_{1,t+1}, \ldots, f_{n,t+1}) .$$

With this vector notation the variance of the portfolio return can be written as

$$\text{var}(R_{t+1}) = g' \sum g$$

where, for convenience, the time subscripts have been dropped. Now assume that the investor's portfolio problem is

$$\min_{\omega_i, h_i} \quad g' \sum g$$

$$\text{s.t.} \; {}_t r'_{t+1} g = \gamma$$

where ${}_t r_{t+1}$ is the time t expectation of r_{t+1} and γ is an arbitrarily chosen minimum return. By varying the value of γ, the efficient frontier of portfolios can be traced out. The first-order conditions for this problem are given by

$$g' = \frac{\lambda r_{t+1} \Sigma^{-1}}{2}$$

$${}_t r'_{t+1} g = \gamma$$

where λ is the scalar Lagrange multiplier on the single constraint. This represents a system of 2N+2 linear equations in 2N+2 variables which, given knowledge of ${}_t r_{t+1}$ and Σ, can be solved explicitly for g.

Consider the special case where the investor has already made the portfolio decision to invest in foreign securities, i.e. the weights ω_i have been chosen, and the decision now is on the optimal amounts, h_i, of each foreign currency to sell forward. It is easy to show that the solution to this problem is

$$(2) \quad h' = \frac{\lambda_t f_{t+1} \Sigma_{fi,fj}^{-1}}{2} - \omega' \Sigma_{i,fj} \Sigma_{fi,fj}^{-1},$$

where ${}_t f_{t+1}$ is the time t expected return vector for the set of forward contracts, $\Sigma_{i,fj}$ is the off-diagonal submatrix of Σ which contains the covariances between equity and forward contract returns, and $\Sigma_{fi,fj}$ is the submatrix of Σ containing the covariances and variances of the forward contracts. The optimal position thus involves two components, a speculative component involving the expected return on the position and a hedging component which minimizes portfolio risk.[6] Note that the second component consisting of the product of the two matrices is just the multiple regression coefficients from regressions of the N+1 dollar-denominated asset returns on the N forward contract returns. Thus, unlike naive strategies which consider only the effect of exchange rate changes on the returns of assets denominated in that currency, the optimal hedging strategy considers the effect of an exchange rate change on all assets and, given the weight that they represent in the portfolio, chooses the hedge ratio for each currency in order to minimize overall risk. It is also interesting that even in the case where the matrix $\Sigma_{i,fj}$ is diagonal, unless it is the identity matrix it is not optimal to choose a hedge ratio equal to

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[6] This is similar to the result in Danthine and Anderson (1981), except that they assume a specific form for the investor's preferences so that there is a risk parameter instead of a Lagrange multiplier involved.

one due to the correlation between asset returns and exchange rates.

While investments in forward contracts did not produce zero returns over any of the sample periods, the returns that they produced were not statistically different from zero. As a result of this, together with the idea that the main thrust of this study is to look at the hedging motivation for forward contracts, implementation of the optimal hedging strategy will be limited to the hedging component of equation (2). In order to avoid using information unavailable to an investor, the following procedure is employed to obtain the hedge ratios. A multivariate regression is estimated using a sample of sixty monthly returns, with a global foreign equity portfolio as the dependent variable and the N forward contracts as the independent variables. The global equity portfolio is constructed to have fifty percent invested in the US portfolio and the remainder invested in a value-weighted non-US portfolio.[7] The estimated coefficients from this regression are then taken as the hedge ratios in the sixty-first period. This strategy is then repeated, dropping the first observation and using the most recent sixty observations to estimate the regression coefficients which are used for the sixty-second period hedge ratios. The result is a time series of hedge ratios which covers

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[7] Choosing different percentages invested in the two components does change the resulting hedge ratios somewhat; however, this mix is not an unreasonable benchmark since it is fairly close to a value-weighted portfolio. Other mixes which were close to the value-weighted weights did not affect the results.

the period 1979-89.[8] Henceforth, this strategy will be referred to as "Optimal 1". An example of the hedge ratios obtained with this approach is presented in Figure 1, which shows the ratios for the UK £. In the figure, forward sales of the £ are represented by negative values of the hedge ratio. Noteworthy in the figure is the instance of zero and positive values, as well as an absolute value of the ratio well below unity which indicates that fully hedging is not optimal.

One feature of the Optimal 1 strategy is that it can, as illustrated in Figure 1, result in a currency being bought rather than sold forward. Risk averse investors, however, may be reluctant to assume this seemingly additional currency risk. Accordingly, an alternative strategy also based on the regression coefficients is also evaluated. The hedge ratios for strategy "Optimal 2" will be taken to be the minimum of zero and the hedge ratios from strategy Optimal 1. The result is that no currency is ever bought forward, although a zero forward position in any particular currency is possible at any point in time. Both optimal hedging strategies are dynamic strategies which incorporate current information into the hedging decision, unlike the fully-hedged strategy which is a static strategy.

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[8] Kaplanis and Schaefer (1990) also consider a similar strategy, but for a smaller set of currencies and over a shorter sample period. They also choose to ignore the speculative component of the optimal hedge position, which does not appear in their development. Their implementation of the strategy is somewhat different and they consider only the effect of the strategy on risk reduction, not on the first moment of the distribution.

Research has shown that forward rates are biased estimators of future spot rates and that they contain a predictable component. For example, Hansen and Hodrick (1980) find evidence of correlation between past and future returns on forward contracts. To the extent that investors can predict returns, they should be able to develop superior hedging strategies. The next hedging strategies considered incorporate market information available to investors to predict the returns on forward contracts. The specific information used is the forward premium, the difference between the forward exchange rate and the current spot rate. Like the optimal strategies, these are also dynamic hedging strategies.

Empirical evidence supporting the use of the forward premium as a predictor of future returns to forward contracts is given in Table 1 for both US $ and UK £ returns. The table presents the results from a regression of the returns on forward contracts on lagged forward premiums. While the R^2's are not high, tests on the individual coefficients (unreported), as well as the entire set of coefficients, indicate that forward premia have predictive power.[9]

The values of the regression coefficients indicate the nature of the hedging strategies. In nearly all cases, including five-year subperiods, the coefficients on the forward premiums are negative, which indicates that a positive forward premium implies

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[9] Korajczyk and Viallet (1990) find similar results regarding the predictability of forward contract returns using a different set of currencies for the period 1974-1988. They find that the forward premium helps predict returns on forward contracts even when additional evidence from equity markets is incorporated into the regression. Earlier evidence on the ability of the forward premium to predict exchange rate changes is given in Bilson (1981).

a negative return on selling the foreign currency forward. Thus, even though a positive forward premium suggests an appreciating dollar and a loss on open positions in foreign exchange, it also indicates that the forward contract can only be purchased for a value in excess of the expected appreciation and that the result is a loss on the forward sale. In this case the investor is better off by not hedging the open position or by actively buying the currency forward.

These empirical findings suggest the following two strategies. The first strategy, "Strategy 1", looks at the forward premium and hedges the full value of the foreign exchange exposure when the premium is negative, but buys an equal amount of the currency forward when the premium is positive. Using the notation from Section 2, $\alpha_{it} = \pm 1$ depending on the forward premium. This is related to the fully-hedged strategy in the sense that if a currency is always selling at a discount, then the two strategies are equivalent. Except for the DM, however, all of the currencies considered had periods of both positive and negative forward premia. Some might not consider this to be a true hedging strategy since it actively assumes risk, much like the Optimal 1 strategy described above. On the other hand, if the premia were always negative, then the strategy would produce identical results to the fully-hedged strategy.

The second strategy, "Strategy 2", is somewhat more cautious and sells the currencies forward when the premium is negative, $\alpha_{it} = 1$, but takes no position, $\alpha_{it} = 0$, when the premium is positive.

This is, of course, similar in spirit to the strategy Optimal 2.

This section has defined the hedging strategies which will be evaluated. The next section describes the data and compares the performance of the various strategies.

IV. Empirical Results

Before proceeding to an evaluation of hedging strategies, it is instructive to examine the performance of the underlying equities and forward contracts. Throughout this section the empirical analysis will be conducted using a set of value-weighted country stock market indices. The data appendix contains a detailed description of the data. The choice of value-weighted indices and portfolios is a natural one since most asset pricing theories predict that such portfolios should be mean-variance efficient. Also, buy-and-hold strategies minimize transaction costs and are easily implemented by individual investors. Alternative strategies which require portfolio rebalancing each period were analyzed in a related context by Eun and Resnick (1988). They found little difference between the ex post behavior of equally-weighted portfolios and portfolios formed through more complicated mean-variance optimizing strategies.

Summary statistics for the US $-denominated returns for the country indices and the forward contracts are presented in Table 2. Means and standard deviations are reported on an annualized monthly dollar return basis, with statistics for the stock indices reported in excess of the U.S. treasury bill rate. For the fully-hedged strategy all of the forward contracts produced negative average returns, which is the first evidence indicating a cost involved with hedging exchange risk. For the individual assets there is little evidence that the fully-hedged strategy improved performance. The Sharpe measure of the hedged portfolio is greater than the unhedged portfolio in only two out of six cases.

Conversely, in every case Strategy 1 and Strategy 2 produced increases in the Sharpe measure. These increases were obtained through a combination of substantially higher mean returns, which were only partially offset by increases in the variance. The results of strategies Optimal 1 and Optimal 2 are somewhat mixed, with some reduction in variance apparent, but these are accompanied by offsetting reductions in the mean returns.

In order to explore the possibility that the behavior of the domestic currency over the sample period was an important determinant in the results, all analyses are also conducted for UK £-denominated returns. Sample statistics for the £-denominated returns are presented in Table 3. In this case the returns to three of the six forward contracts were positive, although not statistically significant. Once again the fully-hedged strategy reduced the variance of the portfolios. Unlike the $-denominated returns, however, in five out of six cases the Sharpe measure actually increases as a result of employing that strategy. Even larger gains are observed, however, using Strategy 1 and Strategy 2, whereas mixed results are again produced by employing the two optimal strategies.

In order to assess the importance of the assumption of normality on the tests for mean-variance efficiency, tests for normality of the time series are represented by the Studentized Range Statistics presented in Table 4. Generally, the data exhibit sufficient kurtosis that normality can be rejected.[10] One potential source of this rejection is evident in the statistic present in the second column of the table, which tests for heteroskedasticity following the procedure developed by Breusch and Pagan (1979). Given the strong evidence against homoskedasticity, the heteroskedasticity-consistent tests described in section II will be useful.

Another aspect of the overall environment which is worthwhile investigating is the general behavior of the exchange rate during the sample period. Figure 2 presents the U.S. dollar effective exchange rate over the sample period. The effective exchange rate is calculated by the International Monetary Fund and weights the value of the dollar against all of its major trading partners on the basis of the value of trade conducted. What the graph shows is that the sample period has been largely dominated by the rise in the value of the dollar during the early eighties, followed by its subsequent fall in value back to its original level. This behavior could be important. If, for example, the period of rapid appreciation of the dollar was generally unexpected appreciation, where unexpected is taken to mean in excess of the interest rate

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[10] Eliminating the observation for October, 1987 does reduce these statistics considerably.

differential between the two countries, then this will manifest itself in unusually high (positive) returns on forward contracts. Conversely, to the extent that the depreciation of the dollar that occurred in the mid-1980's was largely unexpected, forward contracts will produce large negative returns during that period. Given these implications of the behavior of the dollar, it is important to be careful not to draw conclusions about the value of hedging by looking at a single short sample period, especially if that period was 1980-85 or 1985-89.[11] For comparison, the UK £ effective exchange rate is presented in Figure 3. Here the behavior is much different than that of the dollar, with less evidence of a single dominating episode of appreciation/depreciation.

Theory tells us that whenever assets are less than perfectly correlated it is better to hold diversified portfolios. Table 5 provides evidence on this by presenting the correlation matrix of foreign currency stock returns and changes in the value of the foreign currencies for the sample countries. For ease of discussion, the matrix has been decomposed into its three constituent components: the correlations between local-currency equity returns, the correlations between the returns on foreign currencies, and the cross correlations between the two.

One source of risk reduction is readily apparent in the generally low correlations between foreign currency stock returns.

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[11] Jorion (1989) shows that the effect of hedging is influenced by periods of currency appreciation and depreciation.

Similar findings have been reported by Solnik (1988) and others. Over the sample period, for example, the correlation between the Japanese market and the US market was only 0.34. The largest correlation was 0.71 between the US and Canadian markets. As an overall measure, the (equally weighted) average correlation over this group of stocks for this period was 0.44.

Panel B of Table 5 presents the correlations between foreign currency changes. Here there is much more variation in the correlations than there is for the stock returns, with the numbers ranging from a low of 0.13 between the Canadian dollar and the Japanese yen and a high of 0.90 between the DM and the Swiss franc and French franc. However, the overall average correlation was 0.53, not too much higher than that of the stocks themselves.

Perhaps the most interesting part of the table is Panel C, which presents the cross-correlations between the foreign currency stock returns and the various foreign currency changes. A total of 12 of the entries are reported as negative; however, these are mostly small in absolute value and statistically insignificant. Note, however, that most of the positive entries are also insignificant, with only the Canadian $ producing several significant correlations. Generally, these low and sometimes negative correlations imply that the currency component of a foreign equity return provides additional variance reduction for the portfolio.[12]

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[12] These numbers are substantially at odds with the significantly positive correlations that Eun and Resnick (1988) found for (essentially) all of the stocks and currencies in their

Table 6 presents the values of the adjusted F statistics and the heteroskedasticity-consistent χ^2 statistics and their corresponding probability values for the five hedging strategies for the entire sample period, as well as three subperiods. In each case the null hypothesis consists of holding only the set of possible equities (both foreign and U.S.), whereas the alternative hypothesis allows the hedging instruments to be added to this set in the manner discussed in section III. Similar statistics for the £-denominated returns are presented in Table 7.

For the fully-hedged strategy, the null hypothesis is rejected in only one case, £ returns for the period 1984-89. The implication is that even though in some cases differences between the Sharpe measures of the hedged and unhedged portfolios occurred, these differences are not sufficiently large that the hypothesis that they are the same can be rejected.

Both Strategy 1 and Strategy 2 produced substantially different results. For the \$-denominated returns, both strategies reject the null hypothesis for the overall period and for the second and third subperiods. The £-denominated returns also reject the null for the overall period, but do not reject for any subperiod for Strategy 1. Strategy 2 rejects the null in the second and third subperiods using the heteroskedasticity-consistent test, but not the likelihood ratio test. Also important, nearly

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sample. The reason for this is that they used a short sample period, 1980-85, which was a period over which both the dollar and the stock market appreciated significantly. Adler and Simon (1986) use an earlier period, 1976-79, with weekly data and also find generally low correlations between stocks and exchange rates.

all of the estimated intercepts were positive in value, an indication of superior performance.

Neither of the optimal hedging strategies was very successful in rejecting the null hypothesis. Marginal rejections are obtained for the £-denominated returns in the first subperiod for both strategies using the heteroskedasticity-consistent statistic. It should be noted, however, that three out of the six estimated intercepts were negative for Strategy 1 and three out of five were negative for Strategy 2.[13] Since a negative intercept indicates inferior, not superior, performance, these rejections are suspect. The Optimal 2 strategy for $-denominated returns is significant at the 8% level. Once again, however, three of the six estimated intercepts have negative values.

IV. Conclusions

The value of hedging exchange risk is that it reduces the variance of a portfolio's return. This was generally true for every strategy in every sample period for both dollar and pound denominated returns. However, if this insurance is priced by the market in a manner similar to that for other types of risk, then the risk reduction will also be offset by a reduction in return. This paper compared the tradeoff between these two factors in a mean-variance framework. The conclusion is that when sufficiently long periods of time are considered there is no improvement in the

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[13] Only five currencies were tested for Strategy 2 for the £-denominated returns because the estimated US $ hedge ratios were zero for all periods.

risk-adjusted performance of a fully-hedged portfolio over an unhedged portfolio. The fully-hedged portfolio does have lower risk, but it also has a lower return which exactly offsets the risk reduction.

Alternative hedging strategies sometimes did better. The two strategies which employed the information contained in the forward premium significantly improved performance in most cases. On the other hand, the two strategies which calculated optimal hedge ratios almost never improved performance.

Much work remains to be done. First, consideration of alternative hedging strategies which include the use of additional market information would seem appropriate. One such strategy might incorporate the forward premium or other market information in order to generate an expected return on forward contracts. This could then be included as the speculative component of the optimal hedging strategies. Second, inclusion of foreign currency bonds may have important consequences for the results. Given that the returns on holding bonds move inversely to interest rates, holding foreign currency denominated bonds in a portfolio may provide a natural hedge against (at least short term) exchange rate changes. Unfortunately, data on foreign bonds is not as readily available as are returns on foreign market indices.

Data Appendix

Equity returns used throughout are country index returns, including dividend yields, taken form Morgan Stanley's Capital International Perspective. Each country index is a value-weighted index representing approximately 60% of its respective market.

Exchange rates come from multiple sources. Dollar forward exchange rates for the period 1974-83 were obtained from Data Resources Incorporated, while those for the period 1984-89 were calculated from one month eurodeposit rates obtained from Morgan Guarantee Trust's World Financial Markets. Dollar spot rates come from the International Monetary Fund's International Financial Statistics. Sterling exchange rates, both spot and forward were calculated as the crossrates from the dollar exchange rates.

References

Adler, Michael and D. Simon, 1986,"Exchange Risk Surprises in International Portfolios," Journal of Portfolio Management, Winter, 44-53.

Anderson, R. and J.P. Danthine, 1981,"Cross Hedging," Journal of Political Economy, 89, pp. 1182-1196.

Bilson, John, 1981,"The Speculative Efficiency Hypothesis," Journal of Business, 54, 435-452.

Breusch, T. and A. Pagan, 1979,"A Simple Test for Heteroscedasticity and Random Coefficient Variation," Econometrica, 47, pp.1287-1294.

Eun, C. and B. Resnick, 1988,"Exchange Rate Uncertainty, Forward Contracts and International Portfolio Selection," Journal of Finance, 43, pp. 197-216.

Gibbons, M., S. Ross and J. Shanken, 1989,"A Test of the Efficiency of a Given Portfolio," Econometrica.

Grinblatt, M. and S. Titman, 1987,"The Relation Between Mean-Variance Efficiency and Arbitrage Pricing," Journal of Business, 60, pp. 97-112.

Grubel, H., 1968,"Internationally Diversified Portfolios: Welfare Gains and Capital Flows," American Economic Review, 58, pp. 1299-1314.

Hansen, Lars and R. Hodrick, 1980,"Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis," Journal of Political Economy, 88, 829-853.

Hodrick, R., 1987,"The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets," Harwood Academic Publishers, New York.

Jobson, J.D. and Bob Korkie, 1982,"Potential Performance and Tests of Portfolio Efficiency," Journal of Financial Economics, 10, pp. 433-466.

Jorion, Phillippe, 1989,"Asset Allocation with Hedged and Unhedged Foreign Stocks and Bonds," Journal of Portfolio Management, Summer, 49-54.

Kandel, S. and R. Stambaugh, 1989,"A Mean-Variance Framework for Tests of Asset Pricing Models," Review of Financial Studies, 2, pp. 125-156.

Kaplanis, Evi and S. Scheafer, 1990,"Exchange Risk and

International Diversification in Bond and Equity Portfolios," London Business School.

Korajczyk, Robert and C. Viallet, 1990,"Equity Risk and the Pricing of Foreign Exchange Risk," Northwestern University.

Levy, H. and M. Sarnat, 1970,"International Diversification of Investment Portfolios," American Economic Review, 60 , pp. 668-675.

MacKinlay, Craig and M. Richardson, 1989,"A Generalized Methods of Moments Test of Mean-Variance Efficiency," working paper, University of PA.

Perold, Andre and E. Schulman, 1988,"The Free Lunch in Currency Hedging: Implications for Investment Policy and Performance Standards," Financial Analysts Journal, May-June, 45-50.

Roll, R., 1977,"A Critique of the Asset Pricing Theory's Tests, Part I: On Past and Potential Testability of the Theory," Journal of Financial Economics, 4, pp. 129-176.

White, H.,1980,"A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity," Econometrica 48, pp. 817-838.

Table 1

$\frac{S_t - F_{t-1,t}}{S_{t-1}} = \alpha_i + \beta_i \frac{F_{t-1,t} - S_{t-1}}{S_{t-1}} + \epsilon_t$		
1974:01-1989:12	US $	UK £
H_o: $\alpha_i = 0 \;\; \forall i$	22.79 (<.001)	25.64 (<.001)
H_o: $\beta_i = 0 \;\; \forall i$	48.39 (<.001)	60.82 (<.001)
H_o: $\alpha_i = \beta_i = 0 \;\; \forall i$	51.56 (<.001)	63.96 (<.001)

Table 2 - Sample Statistics - $ Returns 1974:01 - 1989:12

	Canada	France	Germany	Japan	Switz.	U.K.	C$	FF	DM	¥	SF	£
Mean												
Unhedged	5.75	10.92	10.75	14.47	6.94	11.92						
Full Hedge	5.22	8.37	10.25	11.84	6.19	10.55	-0.54	-2.54	-0.49	-2.62	-0.76	-1.36
Strategy 1	6.90	13.99	11.25	13.37	7.42	14.79	1.15	3.07	0.50	-1.09	0.48	2.88
Strategy 2	8.58	19.61	12.24	14.90	8.66	19.04	2.83	8.69	1.50	0.43	1.72	7.12
Optimal 1	6.23	13.74	6.85	13.87	6.87	12.18	-1.52	0.94	-2.11	-1.66	1.97	0.01
Optimal 2	6.23	13.95	9.57	13.92	6.18	12.29	-1.52	1.16	0.61	-1.61	1.29	0.12
Standard Deviation												
Unhedged	21.61	26.47	21.85	20.80	20.40	29.15						
Full Hedge	19.71	23.08	18.77	15.47	16.88	26.05	4.64	11.62	12.08	11.99	13.58	11.69
Strategy 1	21.17	25.03	18.94	16.14	16.77	28.79	1.63	6.14	11.80	11.57	13.34	4.93
Strategy 2	23.35	30.15	19.46	17.37	17.04	34.64	4.57	11.36	12.08	12.01	13.58	11.52
Optimal 1	20.59	24.14	26.95	20.16	19.79	22.63	4.22	8.30	7.62	3.19	2.54	1.63
Optimal 2	20.59	23.92	23.31	20.15	19.25	22.48	4.22	8.21	2.25	3.19	1.82	1.46
Sharpe												
Unhedged	0.08	0.12	0.14	0.20	0.10	0.12						
Full Hedge	0.08	0.10	0.16	0.22	0.11	0.12	-0.03	-0.06	-0.01	-0.06	-0.02	-0.03
Strategy 1	0.09	0.16	0.17	0.24	0.13	0.15	0.20	0.14	0.01	-0.03	0.01	0.17
Strategy 2	0.11	0.19	0.18	0.25	0.15	0.16	0.18	0.22	0.04	0.01	0.04	0.18
Optimal 1	0.09	0.16	0.07	0.20	0.10	0.16	-0.10	0.03	-0.08	-0.15	0.22	0.00
Optimal 2	0.09	0.17	0.12	0.20	0.09	0.16	-0.10	0.04	0.08	-0.15	0.20	0.02

Table 3 - Sample Statistics - £ Returns 1974:01 - 1989:12

	Canada	France	Germany	Japan	Switz.	U.S.	C$	FF	DM	¥	SF	$
Mean												
Unhedged	4.03	8.81	8.38	12.49	4.61	4.20						
Full Hedge	3.86	6.81	8.79	10.60	4.91	4.39	-0.16	-2.00	0.42	-1.89	0.30	0.19
Strategy 1	8.55	10.74	9.14	10.68	4.91	7.53	4.52	1.92	0.77	-1.81	0.30	3.33
Strategy 2	13.24	14.66	9.49	10.77	4.91	10.66	9.21	5.84	1.12	-1.72	0.30	6.47
Optimal 1	2.86	12.25	5.74	13.50	3.89	9.78	-3.83	1.06	-1.89	-0.70	0.35	2.00
Optimal 2	2.86	12.02	7.76	13.38	4.00	7.77	-3.83	0.84	0.12	-0.82	0.46	0.00
Standard Deviation												
Unhedged	22.89	25.31	20.84	20.15	19.25	20.26						
Full Hedge	19.71	23.17	18.65	15.54	16.82	16.62	11.37	9.71	9.92	11.28	11.34	11.60
Strategy 1	20.63	24.29	18.74	15.50	16.82	17.42	9.50	7.09	9.86	11.26	11.34	10.34
Strategy 2	23.09	26.99	18.89	15.48	16.82	19.57	11.06	9.57	9.92	11.28	11.34	11.45
Optimal 1	20.51	23.17	26.86	20.32	19.33	24.89	11.58	8.30	7.73	2.64	2.42	7.88
Optimal 2	20.51	23.04	22.92	20.22	18.81	19.79	11.58	8.24	0.78	2.58	1.59	0.00
Sharpe												
Unhedged	0.05	0.10	0.12	0.18	0.07	0.06						
Full Hedge	0.06	0.08	0.14	0.20	0.08	0.08	-0.00	-0.06	0.01	-0.05	0.01	0.00
Strategy 1	0.12	0.13	0.14	0.20	0.08	0.12	0.14	0.08	0.02	-0.05	0.01	0.09
Strategy 2	0.17	0.16	0.15	0.20	0.08	0.16	0.24	0.18	0.03	-0.04	0.01	0.16
Optimal 1	0.04	0.15	0.06	0.19	0.06	0.11	-0.10	0.04	-0.07	-0.08	0.04	0.07
Optimal2	0.04	0.15	0.10	0.19	0.06	0.11	-0.10	0.03	0.04	-0.09	0.08	-

Table 4 - 1974:01-1989:12				
	£ Returns		$ Returns	
	SR	BP	SR	BP
Canada $	6.36	5.86 (0.56)	6.52	12.87 (0.08)
France F	6.29	26.94 (0.00)	5.81	21.52 (0.00)
German M	5.54	10.27 (0.17)	6.41	49.19 (0.00)
Japan ¥	7.37	19.79 (0.01)	6.31	24.01 (0.00)
Switz. F	5.94	12.41 (0.09)	7.05	41.18 (0.00)
U.K. £			6.57	40.11 (0.00)
U.S. $	6.01	5.69 (0.58)		

Critical Value for the Studentized-Range at the 5% level is approximately 6.00.

The BP statistic is distributed as $\chi^2(7)$. P-values are in parentheses.

Table 5 - Correlation Matrix - 1974-89

Panel A

	FRAN	GERM	JAP	SWIT	UK	US
CAN	0.44	0.24	0.26	0.45	0.51	0.71
FRAN		0.48	0.34	0.51	0.48	0.50
GERM			0.28	0.61	0.36	0.39
JAP				0.29	0.30	0.34
SWIT					0.52	0.56
UK						0.56

Panel B

	FF	DM	YN	SF	UKP	
CD	0.22	0.24	0.13	0.20	0.26	
FF		0.90	0.64	0.82	0.66	
DM			0.62	0.90	0.66	
YN				0.64	0.54	
SF					0.62	

Panel C

	CD	FF	DM	YN	SF	UKP
CAN	0.32	0.10	0.03	-0.01	0.05	0.10
FRAN	0.12	0.06	0.01	0.05	0.01	0.05
JAP	0.19	0.01	0.02	0.11	0.01	0.04
SWIT	0.15	-0.04	-0.07	-0.07	-0.12	-0.03
UK	0.16	0.03	-0.04	-0.03	-0.05	0.04
US	0.24	0.05	0.02	-0.02	-0.01	-0.01

	Table 6 - Tests of Mean-Variance Efficiency - $ Returns			
	1974-89[1]	1974-78	1979-83	1984-89
Full Hedge				
F(6,T-7)	0.86 (0.524)	0.85 (0.536)	1.63 (0.160)	1.83 (0.109)
$\chi^2(6)$	5.05 (0.537)	8.00 (0.238)	11.34 (0.078)	12.34 (0.055)
Strategy 1				
F(6,T-7)	3.89 (0.001)	1.16 (0.342)	3.44 (0.007)	2.60 (0.027)
$\chi^2(6)$	21.72 (0.001)	12.66 (0.049)	23.86 (0.000)	25.16 (0.000)
Strategy 2				
F(6,T-7)	4.22 (0.001)	1.13 (0.358)	3.43 (0.007)	3.18 (0.009)
$\chi^2(6)$	25.65 (0.000)	10.31 (0.112)	26.83 (0.000)	25.87 (0.000)
Optimal 1				
F(6,T-7)	1.45 (0.201)		1.38 (0.243)	0.34 (0.915)
$\chi^2(6)$	9.59 (0.143)		9.99 (0.125)	3.46 (0.749)
Optimal 2				
F(6,T-7)	1.96 (0.077)		1.07 (0.394)	1.09 (0.382)
$\chi^2(6)$	11.55 (0.073)		7.69 (0.262)	10.76 (0.096)

1. The sample period for Optimal 1 & 2 strategies is 1979:01-1989:12

Table 7 - Tests of Mean-Variance Efficiency - £ Returns				
	1974-89	1974-78	1979-83	1984-89
Full Hedge				
F(6,T-7)	0.86 (0.52)	0.98 (0.45)	1.18 (0.33)	2.01 (0.08)
$\chi^2(6)$	5.21 (0.52)	8.06 (0.23)	8.27 (0.22)	13.65 (0.03)
Strategy 1				
F(6,T-7)	1.13 (0.35)	0.60 (0.73)	1.37 (0.25)	1.41 (0.23)
$\chi^2(6)$	6.92 (0.33)	4.67 (0.59)	10.83 (0.09)	10.94 (0.09)
Strategy 2				
F(6,T-7)	2.27 (0.04)	0.67 (0.68)	1.86 (0.11)	2.02 (0.08)
$\chi^2(6)$	14.12 (0.03)	5.55 (0.47)	13.92 (0.03)	15.01 (0.02)
Optimal 1				
F(6,T-7)	0.35 (0.91)		1.57 (0.18)	0.97 (0.45)
$\chi^2(6)$	2.38 (0.88)		11.88 (0.06)	7.12 (0.31)
Optimal 2				
F(5,T-6)	1.28 (0.28)		1.63 (0.17)	0.56 (0.73)
$\chi^2(5)$	2.93 (0.71)		11.16 (0.05)	8.61 (0.13)

1. The sample period for Optimal 1 & 2 strategies is 1979:01-1989:12

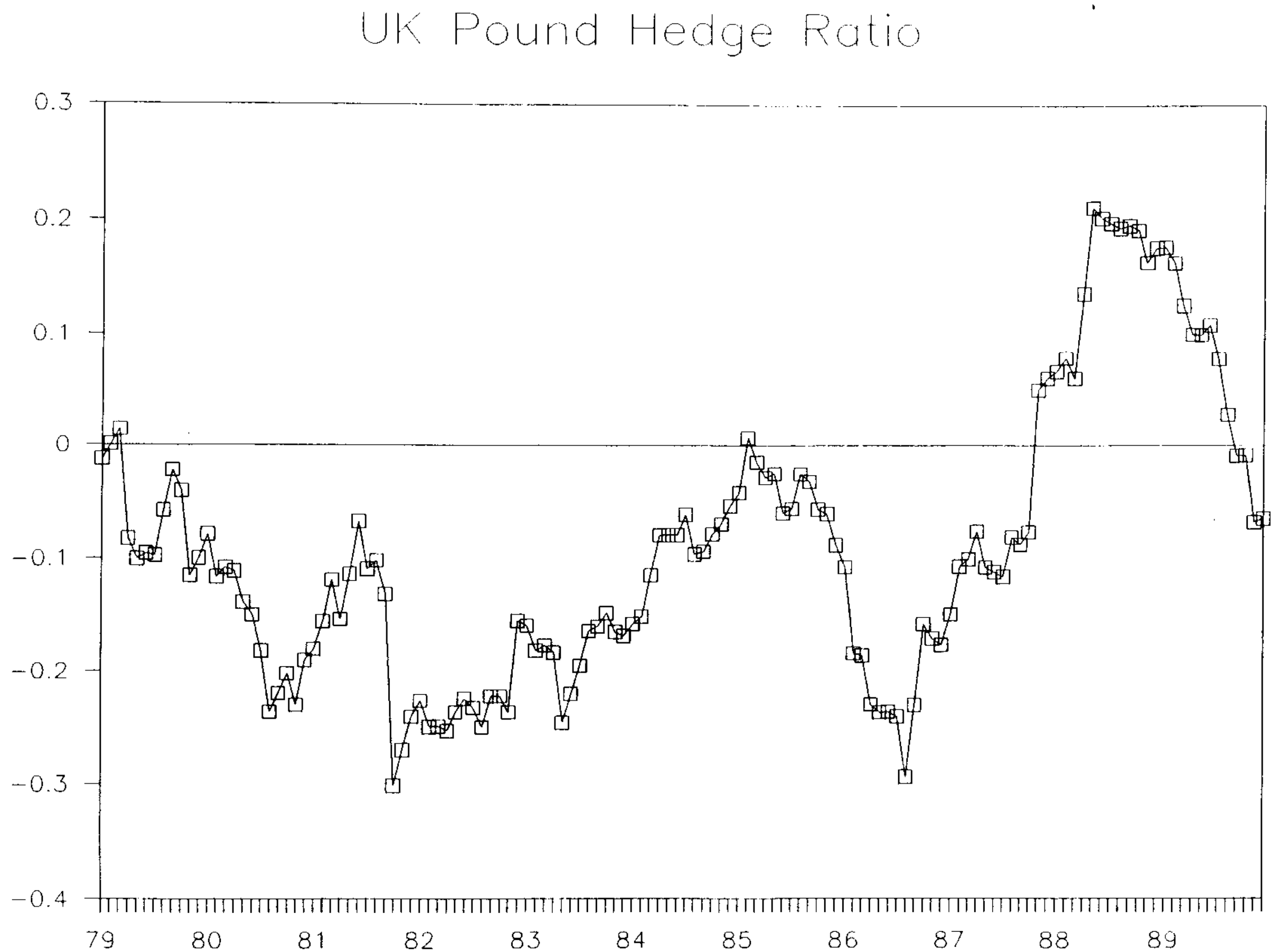

UK Pound Hedge Ratio
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
79
80
81
82
83
84
85
86
87
88
89

Figure 1

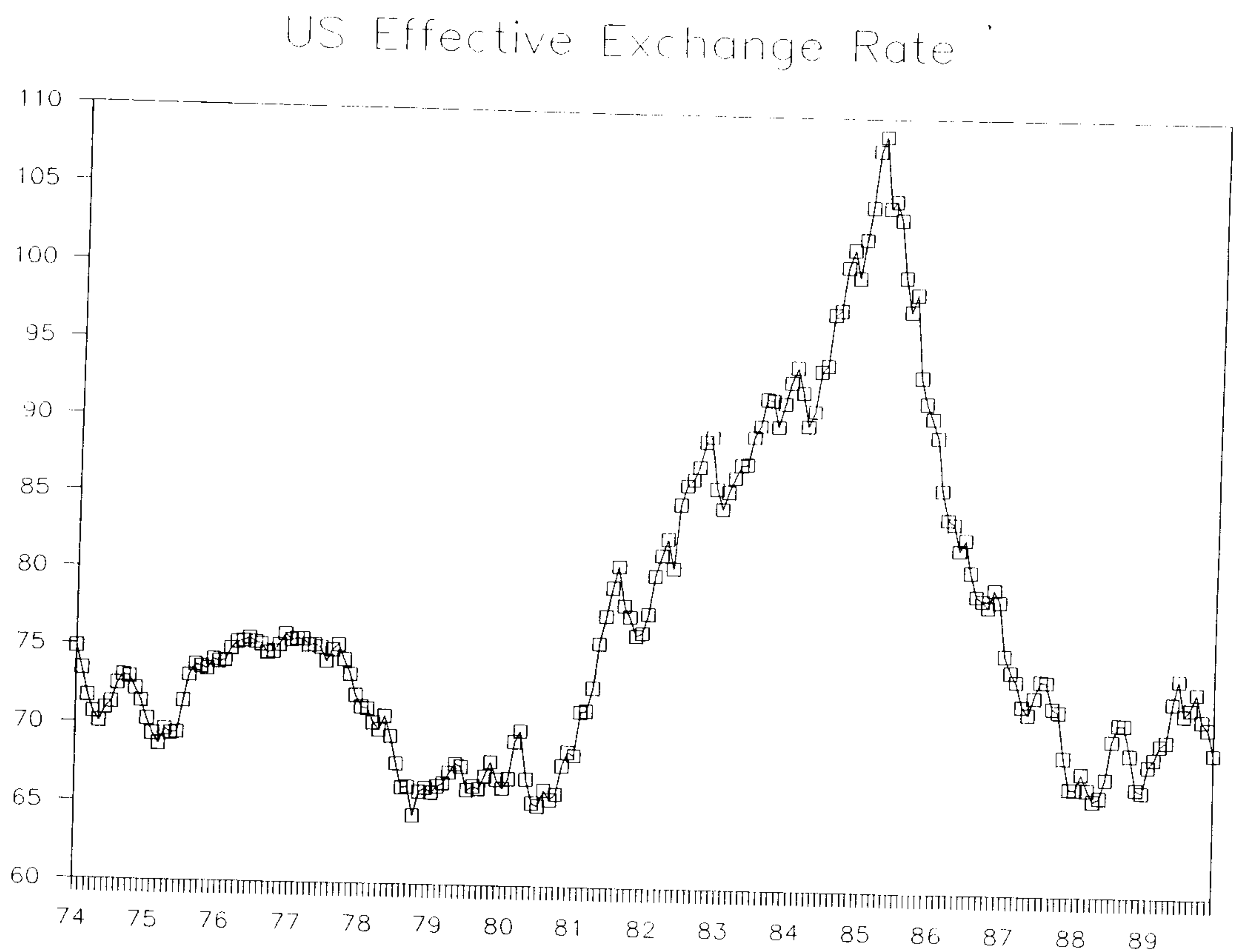
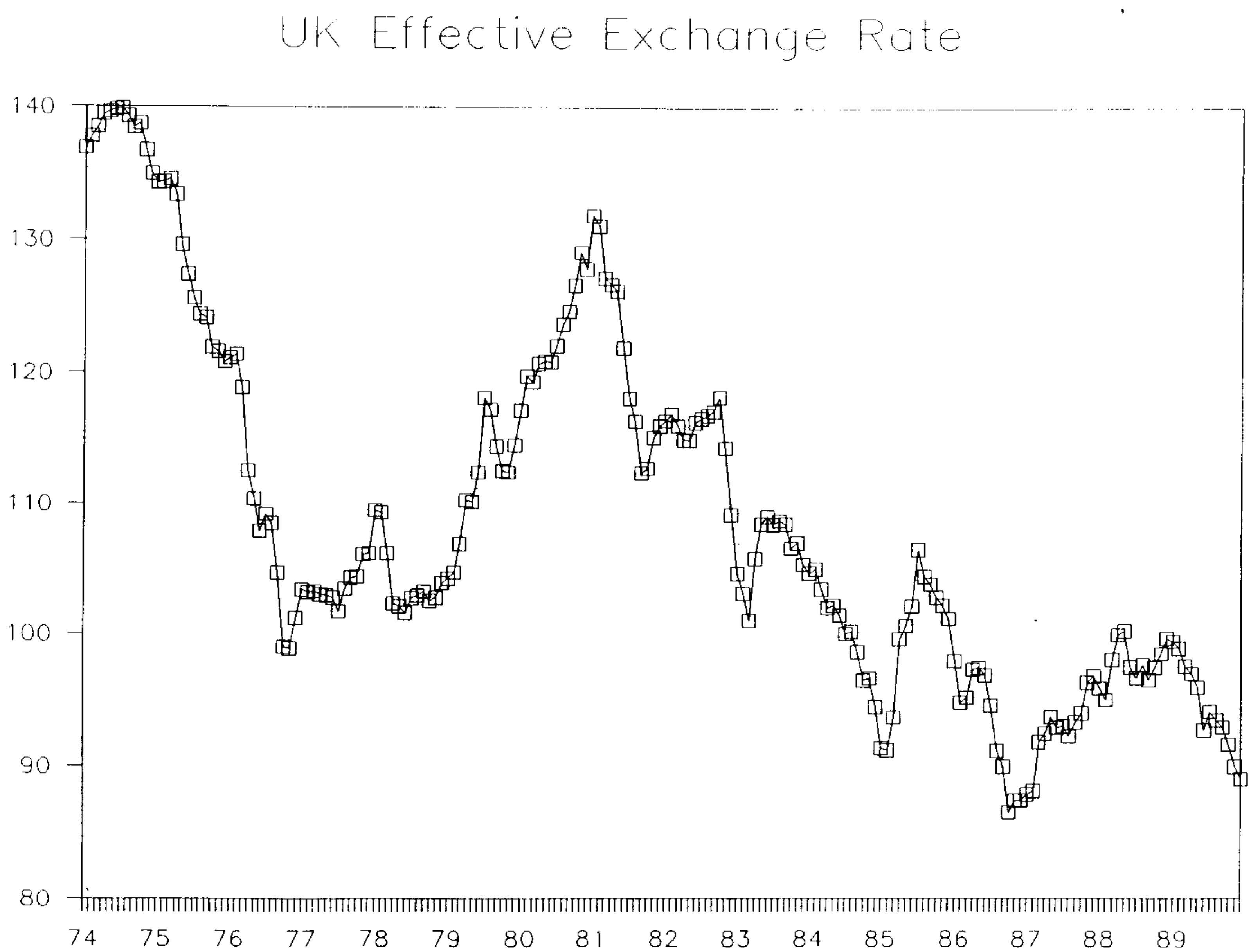

US Effective Exchange Rate
110
105
100
95
90
85
80
75
70
65
60
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89

Figure 2


UK Effective Exchange Rate
140
130
120
110
100
90
80
74
75
76
77
78
79
80
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82
83
84
85
86
87
88
89

Figure 3