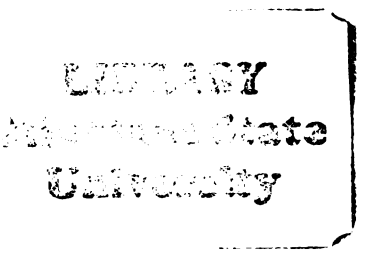

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Carl H. Walther

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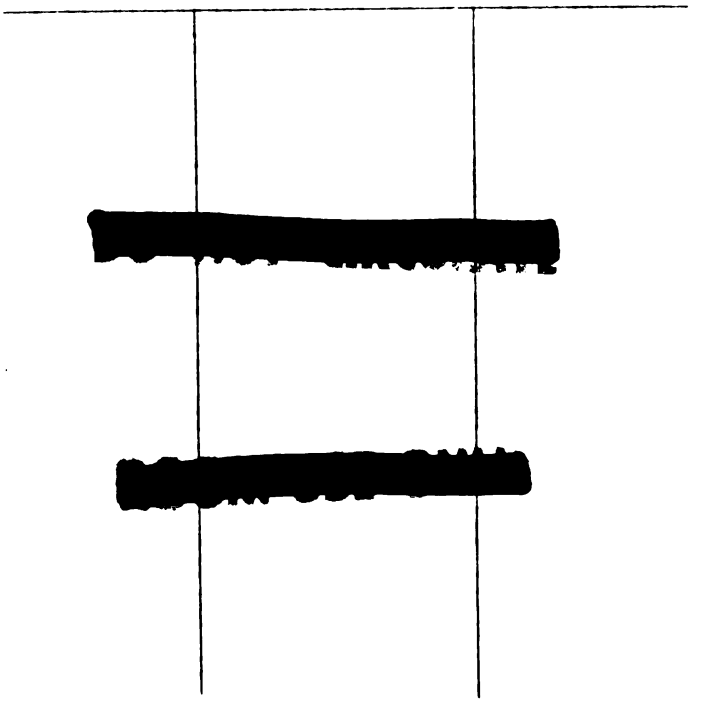

CORPORATE HEDGING STRATEGIES IN THE FOREIGN EXCHANGE FORWARD MARKETS

By

Carl H. Walther

A DISSERTATION

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ABSTRACT

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By

Carl H. Walther

Recent research on strategies to hedge foreign exchange risk in the foreign exchange forward markets has concentrated on the performance of hedges based on portfolio theory. This study extends previous work to examine the hedging effectiveness of portfolio hedges in the foreign exchange forward markets. The relative ability of three non-speculative hedging strategies to reduce foreign exchange risk as the result of holding a foreign currency denominated cash position is examined for British pounds and Deutsche marks for the time period following the introduction of the free-floating currency pricing system for 1974-1982.

To evaluate the performance of each hedging strategy, a returns model was developed with which to measure individual hedging strategy outcomes adjusted for the transaction cost of hedging and a risk premium.

These hedging outcomes were evaluated based on the assumption that the hedger is risk-averse and seeks to minimize the possibility of negative hedging returns. A modified version of the Fishburn alpha-t model was employed to evaluate each hedging strategy.

The results of the study provide evidence for the rejection of the research hypothesis that portfolio-based hedges are more effective than either traditional or naive hedging strategies. Evidence is also provided for the rejection of a minor research hypothesis that traditional hedges are more effective than naive hedges. Portfolio hedges were found to be less effective than traditional hedges, and traditional hedges were found to be less effective than naive hedges in reducing the risk weighted likelihood that hedging returns would fall below a zero return from holding a foreign currency denominated cash position over a period of time.

A direct comparison of the variances of return showed that portfolio based hedges generated greater return variances for both currencies, time periods and hedge durations than did either one of the two competing hedges. The conclusion of such findings is that the hedging methodology implied by portfolio theory, when employed in the foreign exchange forward markets, is not effective in either reducing foreign exchange risk as defined in

this study or in minimizing the variance of return of portfolio hedges.

The implications of the results are twofold. On the microeconomic level, non-speculative corporate hedgers will be able to minimize their foreign exchange risk exposure by employing the naive hedging strategy. Under the assumption that the empirical findings can be generalized to other time periods and currencies, the naive hedging strategy would be the most effective hedging strategy in reducing foreign exchange risk as measured by risk-weighted returns below the return of a perfect hedge.

On the macroeconomic level, the study lends support to the proponents of a fixed currency pricing system who contend that the free floating pricing system creates future price uncertainties and, therefore, hinders the development of international trade. The results of this study show that none of the three non-speculative hedging strategies allows for the complete elimination of foreign currency price risk. The new system also has contributed additional costs to international trade activities in the form of transaction costs and risk premiums which result from implementing hedging programs.

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Finally, to my parents, for their support, kindness, and encouragement, I dedicate this dissertation.

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CHAPTER I

INTRODUCTION

A firm is exposed to foreign exchange risk if it makes or receives payments in a currency different from its own functional currency. This risk is the result of two factors: First, financial decisions and the resulting payment flows are generally separated by a period of time. Second, the price of the underlying foreign currency is likely to change during that time.

During past periods of fixed or pegged exchange rates (such as the Bretton Woods period from 1944-1973), firms faced very little foreign exchange risk. Prices of foreign currencies maintained a fixed relationship to each other. Price changes occurred relatively infrequently and were predictable to a useful degree of accuracy. The environment in which most firms made their decisions featured national governments pledging to maintain exchange rates within small margins around a target rate or par value through agreements within the International Monetary Fund (I.M.F.). This par value could be changed whenever a country's balance of payments moved into disequilibrium and when it became clear that alternative policies (such

as internal deflation and/or controls) were ineffective or politically infeasible.

Such a disequilibrium condition was then defined as being "fundamental" by the I.M.F., and the country was exempted from its obligation to defend its par value. The country, after negotiating with its major trading partners, then revalued or devalued its currency and declared a new par value.

Forecasts of price changes under the fixed parity system were fairly easy and accurate. They were based on a) the pressure on a currency price as a result of balance of payment difficulties; b) the amount of foreign exchange reserves the country held; and, c) the policy (such as exchange controls or devaluation) the country chose to return its currency to equilibrium. The fixed parity system also significantly reduced the downside risk of a price change forecast, since the price either did or did not change in the predicted direction.

With the advent of an exchange rate system of continuously floating rates in 1973, the need for foreign exchange price change forecasts increased significantly. Simultaneously, the ability to forecast price changes was strongly reduced, since the variables used under the Bretton Woods system to forecast price changes had lost their predictive power. Monetary authorities relied more strongly on the equilibrating process, which was facilitated

by freely floating rates. While a devaluation was formerly considered bad, it became a desirable means by which to return to a balanced payment account. The phenomenon of freely floating exchange rates, the movement of which seems characterized by a random walk, has raised such questions as: Can future price changes be forecasted accurately? How should a firm manage its exposure to foreign exchange risk if forecasts are not possible? These questions have led to numerous studies on forecasting foreign exchange prices and foreign exchange risk management, with conflicting results. In general, the results tend to support the view that foreign exchange rates cannot be forecasted accurately. However, market participants often behave as if they possess accurate forecasts. Disagreement also continues to exist regarding the optimal form of risk exposure management.

Objectives of the Study

This research will examine the effectiveness of different strategies of foreign exchange risk management under the assumption that foreign exchange rates cannot be predicted accurately enough to eliminate foreign exchange risk. The effectiveness of non-speculative hedging strategies such as naive or traditional hedging, which are widely practiced by American corporate executives (Rodriguez and Carter, 1978, 1979; Jilling, 1978), is hypothesized to

be higher than for hedges based on portfolio theory. This hypothesis is contrary to the findings of Dale (1981), Naidu and Shin (1981) and Hill and Schneeweis (1982a, 1982b), who found the hedging effectiveness of variance-minimizing portfolio hedges to be superior to naive hedges.

This study, however, will not necessarily present support for or refute earlier findings of hedging effectiveness. In contrast to previous studies, the current study will employ a measure of hedging effectiveness that attempts to incorporate hedger's risk and return preferences as well as the cost of hedging. The reduction of variance of portfolio return was interpreted as hedging effectiveness which, in this study, is seen as minimizing the likelihood that hedging returns will fall below a target return.

Furthermore, this study examines the performance of different non-speculative hedging strategies using the foreign exchange forward market. Dale (1981), Naidu and Shin (1981), and Hill and Schneeweis (1982a, 1982b) tested the hedging performance of different hedging strategies in the foreign exchange futures market. The forward and futures markets differ in two significant practical trading aspects. The futures market is easily accessible to anyone, but unit contract sizes for each foreign currency are relatively large and indivisible. In addition, forward markets are only accessible to trustworthy bank customers, but the unit contract sizes for each currency are negotiable and

may be fit to the needs of the foreign exchange risk manager.

Finally, the current research will contribute information on the risk component introduced with free-floating foreign exchange rates. With the abandonment of the Bretton Woods system in 1973, foreign exchange rates have started to fluctuate widely relative to each other. The loss of stability and forecasting ability has led to successful introduction of the foreign currencies futures markets and increased use of foreign currency forward markets. Both markets are employed frequently by corporate executives in their attempt to hedge the value of foreign currency cash positions. The proponents of the Bretton Woods system contended that the introduction of floating exchange rates, as a new risk component-foreign exchange risk, would represent a major barrier to international trade. A significant increase of both international trade and employment of the forward and futures markets by corporate hedgers has been observed since changing to the new system.

Three non-speculative hedging strategies are identified that are available to risk-averse hedgers. Any evidence that applying such non-speculative hedging strategies does not lead to the elimination of foreign exchange risk will support the arguments of those advocating that a system such as Bretton Woods facilitates international trade.

Chapter II presents a model for measuring hedging returns and the relevant theories and concepts. Specifically, three non-speculative hedging strategies will be discussed and the cost of hedging will be incorporated in the return measure.

Chapter III presents a model for measuring hedging effectiveness under specific assumptions of risk and return preferences of non-speculative hedgers.

Chapter IV outlines the research hypotheses and procedures to be applied in the testing of the hypotheses.

Chapter V discusses and evaluates the results of the tests performed for short- and intermediate-term hedging durations.

Finally, Chapter VI presents the summary of findings, conclusions and implications, and suggestions for future research.

Importance of the Study

The importance of the study is twofold. On the microeconomic level, the non-speculative hedger is interested in identifying the one hedging strategy with the greatest potential for protection against a loss in value of the cash position held. As Kenyon (1981) points out, foreign exchange risk follows a life cycle from conception to birth and finally death. During this life cycle, the business firm is exposed to foreign exchange

risk in that the value of underlying currency of trade will likely change from conception to death.

On the macroeconomic level, the research findings may provide information about the increase in foreign exchange risk since the introduction of the free-floating system. Findings regarding the inability of all non-speculative hedging strategies to reduce or eliminate risk may help to provide information about the adequacy of the current system with respect to trade practices.

The Theory of Hedging and Speculation

According to Ederington (1979), the classic economic rationale of forward or futures markets is to facilitate hedging. The hedger is one whose primary business activity is to receive compensation for the storage of a commodity. Since the hedger is exposed to the risk that the price of the commodity will change during the holding period, he is likely to use the forward or futures market to transfer this risk to speculators. The hedger is generally described as an unsophisticated commodity market participant who, in the words of Hawtrey (1940), "regards the making of price as a wholetime occupation for experts [speculators?] and in general will not pit his fragmented information against the systematic study at the disposal of professional dealers."

The speculator is a person whose primary business

activity is to assume the risk rejected by the hedger, for which he is compensated.

Despite such clear-cut descriptions and definitions of roles, Working (1953) observed that hedgers are part of the time speculators and vice versa. Such a mixed role play apparently seems possible in commodity markets. Traders in such markets are assumed to have gained sufficient understanding of the pricing mechanism from their active market participation such that they are able to predict price changes with above-average success.

Although the literature does not agree as to what hedging is or why it is undertaken (Working 1962), three hedging theories have evolved: the traditional theory, the theories of Holbrook Working, and the portfolio theory. The traditional theory (which predates Working's theory) visualizes the hedger as a primary market commodity dealer who desires insurance against the price risk from holding this commodity. According to this theory, the hedger is assumed to protect himself against price changes by selling a sufficient number of futures/forward contracts to cover his inventory position. At maturity, he simultaneously liquidates both his inventory and futures or forward market position. Any loss (gain) from inventory position would be exactly offset by a gain (loss) realized in the futures market, leaving the hedger with normal compensation for storage of the commodity. The perfect hedge, one in which

gains in one market are exactly offset by losses in the second market, is only possible if the exact price relationship between the spot future prices is maintained over the hedging period. The perfect hedge requires that the change in the basis is zero:

$$\Delta B = \Delta \text{Basis} = 0 \qquad (1)$$

where:

$$B = P_{j,t} - P_{i,t}$$

$$\Delta B = (P_{j,t+1} - P_{i,t+1}) - (P_{j,t} - P_{i,t})$$

$P_{i,t}, P_{j,t}$ = spot, forward rate at period t

$P_{i,t+1}, P_{j,t+1}$ = spot, forward rate at period t+1.

The assumption necessary for (1) to hold true is that the correlation coefficient between the spot price changes and the forward price changes is equal to 1. Working (1953) pointed out, "A major source of mistaken notions of hedging is the conventional practice of illustrating hedging with a hypothetical example in which the price of the future bought or sold as a hedge is supposed to rise or fall by the same amount that the spot price

rises or falls." He challenged the traditional view that hedgers are pure risk minimizers, and envisioned hedgers as being part-time speculators who selectively hedge only those positions which, in their opinion, show a potential loss. Hedgers thus base their decision on the expected value of the change of the basis, and take short or long positions in the futures markets to either hedge or speculate on price changes accordingly. Hedgers do not primarily seek to avoid risk, but make their decision based on expected returns arising from anticipation of favorable relative price movements in the spot and forward markets. As Working (1953) suggested, "The effectiveness of hedging intelligently used with commodity storage, depends on inequalities between the movement of spot and futures prices and on reasonable predictability of such inequalities."

The critical assumption of Working's speculative theory of hedging is that inequalities between the movement of spot and futures prices are predictable. This assumption appears to have been satisfied during the Bretton Woods system where directions of foreign currency price changes were reasonably predictable. The change to a floating system of foreign currency prices in 1973 seems to have altered the pricing mechanism of foreign currencies dramatically. The question is to which degree Working's critical assumption-that price changes are predictable-

holds under the new system of floating exchange rates.[1]

A major reformulation of the theory of hedging is offered by Johnson (1960) and Stein (1961). The authors showed that both the risk avoidance approach of traditional hedging theory and the profit maximization approach of Working's theory could be combined in an adjusted form of Markowitz's portfolio theory of holding securities. A hedger could hold a position in the spot market (the primary market) and a certain percentage of his spot market holding in the futures or forward market. Price risk is then seen as the variance of the subjective probability distribution of returns of such a two-assets portfolio from period t to t+1. The minimization of variance of return of such a two-assets portfolio is assumed to be the primary objective of hedging. In mathematical terms, the variance of return of such a portfolio would be minimized by holding z* percent of the spot market position in the futures or forward market where

$$z^* = \frac{Cov_{i,j}}{Var_j} \qquad (2)$$

and

Cov_{ij} = subjective covariance between the future futures or forward market price changes and the spot market price changes and

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[1] See theory and empirical evidence on forecasting foreign exchange prices in the following literature review.

Var_j = subjective variance of the future futures or forward market price changes.

Traditional hedging theory assumed (1):

$$\Delta B = 0 \rightarrow Cov_{i,j} = Var_j \qquad (3)$$

and

$$z^* = \frac{Cov_{i,j}}{Var_j} = 1,$$

whereas portfolio theory allows for a change in the basis from period t to t+1 and assumes

$$\Delta B \neq 0 \rightarrow \frac{Cov_{i,j}}{Var_j} \neq 1, \qquad (4)$$

but is the portfolio variance-minimizing hedge ratio. Thus, traditional hedging theory is a special case of portfolio theory. Therefore, a hedger who naively sets the hedging ratio z = 1 according to traditional hedging theory would, according to portfolio theory, either overhedge (if the variance minimizing ratio $z^* < 1$) or underhedge (if $z^* > 1$), and thus not minimize the variance of return of his two-assets portfolio.

Literature Review

Studies on the management of foreign exchange risk have focused on several related areas. Of foremost importance is the question whether, how, and to what degree of accuracy foreign currency price changes can be forecasted in a managed float system. If it is found that price changes cannot be forecasted accurately, the question arises: how should corporate executives manage the foreign exchange risk to which they are exposed? The remaining parts of this section provide a discussion of the theory and the empirical research undertaken.

Forecasting Foreign Exchange Rates: Theory and Empirical Evidence

Dufey and Mirus (1981) provide an overview of the various forecasting techniques and their underlying models and assumptions. The models are divided according to their assumptions and techniques into informal and formal models.

1. Informal models, generally unspecified, are engrained in the minds of long-term observers of the process that generates price changes. The forecaster develops a "gut feel" for the implications of new economic and political information on the future spot rate. Informal models are very complex and often indescribable to the outsider.
2. Formal models can be further subdivided into

extrinsic and intrinsic models. Extrinsic models are based on causal relationships between two or more exogenous variables, whereas intrinsic models rely on statistical relationships between the variables to be forecast and past values of the same series. Extrinsic models are further subdivided into categories of exogenous variables employed in forecasting exchange rates: models based on the balance of payments analysis, models of the national economy focusing on changes in aggregate demand, and models based on the aggregate supply of money to the economy. One model has gained significant recognition and has been tested extensively according to Morgan (1981). This model depicts the expected rate of change of the spot exchange rate as a result of the expected inflation rate differential between the two countries, the forward exchange premium or discount of the foreign currency, and the difference in interest rates between the two countries. Five theories underly these relationships:

1. The Purchasing Power Parity (PPP) theory states that the rate of change in the exchange rate between two countries tends

over time to equal the differential inflation rate between the two countries' currencies.

2. The Fisher Closed Effect states that nominal interest rates in both countries are equal to the required rate of return to the investor plus the expected rate of inflation in each country.
3. The Fisher Open Proposition postulates that differences in nominal interest rates on similar assets denominated in several currencies reflect the anticipated rates of change in the exchange rates.
4. The Theory of Interest Rate Parity (IRP) relates the forward exchange rate to the nominal interest rate differentials on similar assets denominated in different currencies. The forward exchange rate is at 'interest rate parity' when the interest rate differential is equal to the forward rate discount or premium.
5. The Forward rate as an unbiased predictor of the future spot rate assumes that foreign exchange markets are reasonably

> efficient and all new relevant information is quickly and completely reflected in both forward and spot exchange rates. Further, this theory holds that these rates are always an adequate reflection of the equilibrium position of supply and demand.

All extrinsic models depict the future exchange rate as the dependent variable and a series of exogenous and endogenous variables as the independent variables. These econometric models were very successful in predicting future price changes during the Bretton Woods system, since government action created a predictable lag effect.

Intrinsic models attempt to use information from past price changes to predict future changes. The challenge is to identify the underlying processes that generate new data. These models range in sophistication from charting trend analysis to various time series models (such as moving averages, Box Jenkins forecasting techniques, and momentum models). The problems of intrinsic models lay in the presumption that past relationships will prevail in the future and in the lack of cause and effect understanding.

Morgan (1981) provides an overview of the tests to which various theories have been exposed and summarizes the conclusions drawn. The ability of these theories to explain exchange rate changes is limited in the short run, but tends

to increase with the length of the forecasting horizon. Particularly, the forward rate appears to be a fairly good predictor of spot rates at one to three months ahead but rather a poor predictor thereafter, whereas the forward rate is an unbiased predictor of the future spot rate in the very long run. Thus, in this case, an equal chance exists for the future spot rate to be above or below the forward rate.

Different tests are available for measuring the performance of currency price change forecasts. In assessing forecasting accuracy, a distinction is made between two types of forecasting errors: dimensional and directional. Dimensional forecasting errors (errors in point estimation) miscalculate the magnitude of the deviation between the prediction and the actual spot rate. Directional forecasting errors occur when the directional prediction is on the wrong side of both the forward rate and the actual spot rate. Also, different scales of measurement (such as returns from a buy and hold strategy or the performance of the forward rate) can be adopted when measuring performance.

Levich and Wihlborg (1980) analyzed the accuracy of a wide range of foreign exchange forecasts prepared by thirteen U.S. advisory services. They neglect to describe the theoretical models used by different services. One-, three-, six-, and twelve-month forecasts were analyzed according to accuracy of the forecast, and speculative

profits based on these forecasts were calculated. Based on the analysis of mean squared forecast errors, their results suggest that most forecasts were not as accurate as the forward rate. Their analysis of speculative returns, however, seems to suggest that some advisory services did better than the forward rate. Levich and Wihlborg raise the question of whether these abnormal returns would persist after adjusting them for risk.

King (1978) aggregated forecasts of nine advisory services to form an average "professional" forecast. He found that during the period 1976-I to 1977-III, his professional average was superior to the forward rate forecast only for the Deutsche mark. King suggested that this was a surprising result, since the market for Deutsche mark is considered very active and speculators would be expected to act such that the information in the forecast would quickly be reflected in the forward rate.

Goodman (1979) analyzed six medium-term advisory services that built their forecasts on extrinsic (econometric) models, as well as four short-term technical advisory services that built their forecast on intrinsic (technically oriented decision rules derived from past behavior) models. The ten services were evaluated on the basis of their predictive accuracy for six frequently traded currencies against the dollar for forecasts of three and six months. Goodman found that, while the economically

oriented services appeared no more accurate than the forward rate, the technical services performed remarkably well on the average, although not consistently for all six currencies or different time periods. Goodman neglected to adjust the returns for risk.

Ensor and Clarke (1979) tested the forecasting performances of fourteen major currency advisory services. Point estimates for three major currencies for a twelve-month period (July 1978 - July 1979) were compared. Their findings indicate the general inability of the average service to outperform the forward rate. They conclude, "If adjusted for the cost of information of the various services, only two services would have paid for their keep." Also, no attempt has been made to adjust returns for risk.

Euromoney (1978a, 1978b) conducted a major survey of international treasurers of more than 250 of the world's largest companies in order to evaluate the quality of forecasting services purchased from foreign exchange advisory businesses. In summarizing the results from these surveys, they indicated that most treasurers felt they could not rely to any reasonable degree on the forecasts that were purchased as part of a package of advisory services. Many complained that their in-house forecasts were more reliable than those of the advisory services. The majority indicated that they implemented the forecasts provided about 50 percent of the time, whereas the remaining

minority stated that the provided forecasts were used only 20 percent of the time.

Bilik (1982) compared the relative accuracy of predictions made by a group of foreign exchange services to the forecasts implied by the forward rate from 1974 to 1980. His empirical findings suggest that forward rates do as well as or better than professional forecasters. Paired t-tests showed that only 16 percent of the significant statistics favor directional industry forecasts, while 84 percent favor using forward rates. The analysis also revealed no statistically significant performance differences existed across services. The forecasting performance of dimensional accuracy increased with the forecasting horizon, while directional accuracy decreased.

In summary, the empirical evidence seems to indicate that professionally provided forecasts based on the various theories and models do not seem, and are not perceived by their users, to perform better than simple market-based forecasts such as a buy and hold strategy or the foreign exchange forward rate.

Foreign Exchange Risk Management: Theory and Empirical Evidence

The objective of this research is to explore the effectiveness of different non-speculative hedging strategies in reducing a firm's transaction exposure. Wihlborg (1980) defines transaction exposure as the uncertain

domestic currency value of an open position denominated in a foreign currency with respect to a known transaction; that is, a future foreign currency-denominated cash flow.

The traditional insurance theory of forward exchange argues that the appropriate level to cover such a transaction exposure is the full amount of the exposure. This strategy is generally referred to as "naive" hedging; its usefulness has been challenged on theoretical grounds by several authors.

Folks (1973) suggests that the optimal level of coverage for such a transaction exposure can be found by psotulating a utility function as describing the risk preferences of the decision maker. Each possible level of corporate earnings resulting from different preojected exchange rates and coverage levels is assigned a utility value. The expected utility (the result of multiplying exchange price probabilities and utility values) is used then as the decision rule for the optimal level to cover the exposure.

Wheelwright (1975) discusses the practical transaction exposure problem faced by an occasional large order exporter. Using decision analysis, he suggests establishing a decision tree. The knowledge of the decision maker's personal preference curve allows the conversion of expected outcomes into certainty equivalents, which build the basis for the hedge decision.

A refinement of the decision analysis approach is used by Kohlhagen (1978) and Makin (1978). Kohlhagen assumes that the firm holds a portfolio of foreign currencies transaction exposures. For the management of such a vector of transaction exposures, he develops a decision-theoretic payoff matrix of profits of $N^{i-1} \times N^{i-1}$ outcomes over all sets of possible exchange rates (where each currency can take N different values) and over all strategies (each of which is optimal for one set of future exchange rates). The firm would then use a decision rule (such as a maximax or maximin strategy) in order to select the optimal level of coverage. This approach is based only on reasonable ranges of future exchange rates. Kohlhagen's model appears theoretically inferior since it does not formally treat risk preferences or account for the statistical relationships among different foreign exchange rates. It seems, however, to appeal from a managerial point of view because of the limited information input required.

Similar to Kohlhagen, Makin (1978) sees the firm as holding a portfolio of transaction exposures in the form of accounts receivables and payables denoted in different currencies. He makes the assumption that changes of foreign exchange rates are normally distributed and that the matrix of variances and covariances of all future exchange rates is stable and known at the outset. Using portfolio theory, Makin then derives an efficient frontier of optimal

portfolios of shares of exposures based on the firm's mean profit and variance of profit. Although theoretically strong, the practical application of his model is limited due to the rather constraining assumptions that price changes of foreign exchange rates are normally distributed and that the variances matrix is known ex ante and stable.

Levi (1979) shows that in a world in which the matrix of cross-elasticities between exchange rates is fully known at the outset of the exposure horizon, it is possible to fully cover the entire portfolio of transaction exposures through only one forward contract. Since cross-elasticities between foreign currency movements are stochastic rather than deterministic, the operational value of this approach is limited.

All of the above decision theories designed to determine the optimal coverage level make rather limiting assumptions: that forecasts are available on price ranges, variances of price changes, currency prices, or cross-elasticities; and that investors' preferences are not considered, or their utility functions are quadratic, or exchange price changes are normally distributed. Recent approaches, which do not depend on currency forecasts, have been suggested and empirically tested by Dale (1981), Naidu and Shin (1981) and Hill and Schneeweis (1982a, 1982b). All approaches assume a portfolio consisting of two cash assets, including the actual exposure held in the spot

market and an offsetting transaction held in the forward or futures market. The coverage hedge ratio that minimizes the variance of return of such a two-assets portfolio is considered optimal. Hedging effectiveness of this coverage strategy was measured by comparing the reduction in variance of return of such a portfolio to the variance of return of an unhedged position. All authors found that for different currencies and time periods, a significant reduction in variance could generally be obtained by employing the portfolio-generated coverage ratio.

Although strong from the viewpoint of practical usefulness (since no currency forecasts are necessary), the portfolio approach fails to provide a theoretical framework within which to determine the sample size for the optimal hedge ratio. Furthermore, the reduction in variance of returns is assumed to be the only objective or preference of hedgers. The reduction in variance may or may not be a good measure of hedging effectiveness, since it ignores actual return levels and the cost of hedging. Rather, it assumes that hedgers either have quadratic utility functions or that exchange rates are normally distributed.

Empirical evidence on the risk and return preferences of corporate treasurers and their practices of managing their transaction exposure is rather limited.

Rodriguez (1978) surveyed risk and return preferences of financial officers of seventy-five U.S.

multinational corporations, and found asymetrical attitudes toward foreign exchange risk. Under varying assumptions about future currency devaluations, managers indicated that their decision would be either not to cover at all or to cover fully their transaction exposure, depending on the likelihood of devaluation. Jilling (1978) interviewed financial officers of 102 U.S. multinational corporations to obtain empirical evidence of foreign exchange risk management practices. His findings showed that 36 percent of the respondents covered their foreign exchange exposure fully all the time, 37 percent covered a portion of the total exposure (various levels), and 12 percent covered more than 100 percent.

Summary

Foreign exchange risk appears to have become a significant additional risk component since the advent of free-floating exchange rates. The forecastability of foreign exchange rates for the purposes of eliminating this new risk component appears to be rather limited, a conclusion that is supported by empirical evidence. Even sophisticated professional forecasting services that use a variety of different forecasting models do not show better forecasting performance than "naive" forecasts such as the forward rate.

On theoretical grounds, a variety of decision-making approaches has been suggested to determine the

optimal coverage level of a firm's transaction exposure. From limited empirical evidence, it seems that corporate treasurers belong to one of two schools of thought: those who believe that foreign exchange forecasts are possible and the coverage decision is a function of the forecast; and those who do not believe that sufficiently reliable forecasts are available and who, therefore, fully cover their transaction exposure to foreign exchange risk.

The current study will make the assumption that foreign exchange rates cannot be forecasted sufficiently accurately to provide useful information for the management of risk exposure. Different hedging strategies are evaluated using a measure of hedging effectiveness that appears to incorporate risk and return preferences of non-speculative hedgers.

CHAPTER II

A MODEL FOR MEASURING HEDGING RETURNS

This study examines the hedging effectiveness of non-speculative hedging strategies. If it is found that the hedging strategies differ in degree of hedging effectiveness, then such information may be used by non-speculative corporate treasurers to develop hedging programs for their foreign exchange risk exposure.

The method of measuring hedging effectiveness employed in this study will differ in two ways from that used by Dale (1981), Naidu and Shin (1981), and Hill and Schneeweis (1982a, 1982b). First, a model for measuring hedging returns will be developed which, contrary to the analysis of the above authors, will explicitly measure the rate of return from a hedging strategy and adjust the rate of return to account for the cost of hedging. In the next chapter, a measure of hedging effectiveness will be derived based on the returns model that will be employed to determine the effectiveness of different non-speculative hedging strategies. This second measure of hedging effectiveness will incorporate hedging returns, transaction costs, and risk and return preferences of corporate non-speculative hedgers.

Factors Relevant to the Study

The term "non-speculative hedging" is employed in this study to refer to the activity of reducing or possibly eliminating the foreign exchange risk resulting from a transaction exposure. Kenyon (1981) identifies the three stages of the life cycle of such a transaction exposure as:

Conception: when the firm commits itself to a currency mismatch, such as through a tender for a contract or a price offer or price list denominated in a foreign currency.

Birth: when the commitment becomes a commercial or contractual reality.

Death: the end of the exposure, when the firm is free to convert the receipt or payment into the other currency and can measure the final cash gain or loss.

Kenyon points out that the firm faces the problem of identifying at what point in the life cycle the coverage or hedge for the transaction exposure should begin. This difficulty is the result of rising hedging costs, which the firm views as the price for being relieved of foreign exchange risk. However, if the firm decides to hedge the exposure at conception, it will incur hedging costs for an expected transaction exposure, which may or

may not materialize. The final hedging cost per actual transaction exposure thus rises above the level that would have resulted from only hedging already existing transaction exposures. If, on the other hand, the firm decides to wait with the hedge until birth of the transaction exposure, it is exposed to a possible currency price change and cash loss. For the purpose of developing a model with which to measure hedging returns, it is assumed either that the time period between conception and birth is small enough to minimize the likelihood of price change, or that prices are quoted conditionally until the birth of the transaction exposure.

Non-Speculative Hedging Strategies Identified

Whenever a firm receives (or has to make) payment in a foreign currency due to international trade activity, it is exposed to foreign exchange risk. A cash position, therefore, is established in period t (the birth of the transaction exposure), which consists of X_{FC} units of foreign currency to be received/paid in period t + 1 (the death of the transaction exposure). The price value of this foreign currency cash position denominated in domestic currency will change from period t to period t + 1 as the result of a price change of the underlying foreign currency during the same period. A non-speculative firm will consider a transaction exposure management program having the

potential to preserve the value of this cash position denominated in domestic currency over the exposure life cycle. Using the foreign exchange forward market, the firm can employ one of the following three alternative hedging strategies, which are not based on speculative price forecasts:

Strategy A: At period t, the amount of the cash position, X_{FC}, is sold/bought forward to period t + 1. At period t + 1, the cash position is liquidated and employed to settle the forward contract.

Strategy B: At period t, the amount of the cash position, X_{FC}, is sold/bought forward to period t + 2. At period t + 1 (the maturity date of the cash position), an equal amount, X_{FC}, is bought/sold forward to period t + 2. A translation gain/loss is realized from holding the cash position in the spot market from period t to period t + 1, which is equal to:

$$\text{translation gain/loss} = X_{FC}[\tilde{sP}_{i,t+1} - sP_{i,t}] \quad (5)$$

where $sP_{i,t}$ = spot sell exchange rate of the foreign currency at period t

$\tilde{sP}_{i,t+1}$ = spot sell exchange rate of the foreign currency at period t + 1.

At the same time, a hedging gain/loss is realized from holding X_{FC} units of foreign currency in the forward marekt from period t to period t + 1, which is equal to

$$\text{hedging gain/loss} = X_{FC}[sP_{j,t} - b\tilde{P}_{j,t+1}] \qquad (6)$$

where $sP_{j,t}$ = forward sell exchange rate of the foreign currency at period t

$b\tilde{P}_{j,t+1}$ = forward buy exchange rate of the foreign currency at period t + 1.

Since the movement of spot and forward exchange rates tends to coincide, the gain/loss from holding the cash position in the spot market tends to offset the loss/gain from simultaneously holding an equal amount in the forward market. If both spot and forward rate were perfectly correlated, strategy B would be ideal in the sense that the value of the cash position denominated in domestic currency would not change from period t to period t + 1.

Strategy C: At period t, a portion, z*, of the amount of the underlying cash position, z^*X_{FC}, is sold/bought forward to period t + 2, where z* is the variance-minimizing hedge ratio of a two-cash-assets portfolio consisting of a spot market and a forward market position.

At period t + 1, an equal amount, z^*X_{FC}, is bought/sold forward to period t + 2. Similar to hedging strategy B, a translation gain/loss is realized from holding the cash position X_{FC} in the spot market, which is equal to

$$\text{translation gain/loss} = X_{FC}[s\tilde{P}_{i,t+1} - sP_{i,t}] \quad (7)$$

At the same time, a hedging gain/loss if realized from holding z^*X_{FC} units of foreign currency in the forward market, which is equal to

$$\text{hedging gain/loss} = X_{FC}[sP_{j,t} - b\tilde{P}_{j,t+1}][z^*]. \quad (8)$$

A Hedging Returns Model

The model for measuring hedging strategy returns is based on the proposition that the objective of non-speculative hedging activity is to preserve the value of the cash position denominated in domestic currency. This research attempts to identify the hedging strategy(s) that, under the stated assumptions, can best accomplish this objective. The variables of the returns model are defined as follows:

Let X_{FC} = Net cash position denominated in a foreign currency established in period t and maturing in period t + 1

z^* = the portion of X_{FC} hedged in the forward market from period t to period t + 1

sP_i = sell spot rates, where all foreign currency prices (spot and forward) are quoted in units of foreign currency per U.S. dollar

sP_j, bP_j = sell, buy forward rates

i,j = subscripts to spot and forward market

t+n = subscripts to time period

$V(X_{FC})_t$ = dollar value of the cash position at period t = $X_{FC}[P_{i,t}]$

$V(X_{FC})_{t+1}$ = dollar value of the cash position at period t+1

Y = change in the dollar value of the cash position X_{FC} from period to to period t+1

$$Y = V(X_{FC})_{t+1} - V(X_{FC})_t$$

Y% = percent change in the dollar value of the cash position X_{FC} from period t to period t+1

$$Y\% = \frac{Y}{V(X_{FC})_t} .$$

With all variables of the returns model thus defined, the returns can now be measured for each hedging strategy.

Return for Hedging Strategy A:

$$V(X_{FC})_{t+1} = V(X_{FC})_{j,t}$$

$$= X_{FC}[sP_{j,t}]$$

$$Y = X_{FC}[sP_{j,t}]-X_{FC}[sP_{i,t}]$$

$$= X_{FC}[sP_{j,t}-sP_{i,t}]$$

$$Y\% = \frac{X_{FC}[sP_{j,t}-sP_{i,t}]}{X_{FC}[sP_{i,t}]}$$

$$Y\% = \frac{sP_{j,t}}{sP_{i,t}} - 1 \qquad (9)$$

Return for Hedging Strategy B:

$$\tilde{V}(X_{FC})_{t+1} = V(X_{FC})_{i,t} + \begin{matrix}\text{Translation}\\ \text{Gain/Loss}\end{matrix} + \begin{matrix}\text{Hedging}\\ \text{Gain/Loss}\end{matrix}$$

$$= X_{FC}[sP_{i,t}] + X_{FC}[s\tilde{P}_{i,t+1}-sP_{i,t}] +[sP_{j,t}$$

$$- b\tilde{P}_{j,t+1}]X_{FC}$$

$$\tilde{V}(X_{FC})_{t+1} = X_{FC}[s\tilde{P}_{i,t+1} + sP_{j,t} - b\tilde{P}_{j,t+1}]$$

$$\tilde{Y} = X_{FC}[s\tilde{P}_{i,t+1} + sP_{j,t} - b\tilde{P}_{j,t+1}] - X_{FC}[sP_{i,t}]$$

$$= X_{FC}[s\tilde{P}_{i,t+1} + sP_{j,t} - b\tilde{P}_{j,t+1} - sP_{i,t}]$$

$$\tilde{Y}\% = \frac{X_{FC}[s\tilde{P}_{i,t+1} + sP_{j,t} - b\tilde{P}_{j,t+1} - sP_{i,t}]}{X_{FC}\ sP_{i,t}}$$

$$\tilde{Y}\% = \frac{s\tilde{P}_{i,t+1} + sP_{j,t} - b\tilde{P}_{j,t+1}}{sP_{i,t}} - 1 \qquad (10)$$

Return for Hedging Strategy C:

$$\tilde{V}(X_{FC})_{t+1} = V(X_{FC})_{i,t} + \begin{matrix}\text{Translation}\\ \text{Gain/Loss}\end{matrix} + (z^*)^1 \begin{matrix}\text{Hedging}\\ \text{Gain/Loss}\end{matrix}$$

$$= X_{FC}[sP_{i,t}] + X_{FC}[s\tilde{P}_{i,t+1} - sP_{i,t}] +$$

$$(z^*)X_{FC}[sP_{j,t} - b\tilde{P}_{j,t+1}]$$

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[1] Where z* is the portfolio variance-minimizing hedge ratio from equation (2).

$$\tilde{V}(X_{FC})_{t+1} = [s\tilde{P}_{i,t+1} + (z^*)sP_{j,t} - (z^*)b\tilde{P}_{j,t+1}][X_{FC}]$$

$$\tilde{Y} = X_{FC}[s\tilde{P}_{i,t+1} + (z^*)sP_{j,t} - (z^*)b\tilde{P}_{j,t+1}] - X_{FC}[sP_{i,t}]$$

$$= X_{FC}[s\tilde{P}_{i,t+1} + (z^*)sP_{j,t} - (z^*)b\tilde{P}_{j,t+1} - sP_{i,t}]$$

$$\tilde{Y}\% = \frac{X_{FC}[s\tilde{P}_{i,t+1} + (z^*)sP_{j,t} - (z^*)b\tilde{P}_{j,t+1} - sP_{i,t}]}{X_{FC}\ sP_{i,t}}$$

$$\tilde{Y}\% = \frac{s\tilde{P}_{i,t+1} + (z^*)sP_{j,t} - (z^*)b\tilde{P}_{j,t+1}}{sP_{i,t}} - 1 \qquad (11)$$

Equations (9), (10), and (11) measure the returns of hedging strategies A, B, and C respectively. The cost of hedging for each hedging strategy is accounted for in the terms P_i and P_j in the above return equations, since they are market quotations and no additional transaction costs will be incurred.

Determination of the Optimal Hedge Ratio

Using the basic assumptions and principles of portfolio theory, Johnson (1960) and Stein (1961) have shown that the optimal hedge ratio, z*, is related to the covariance between the spot and the futures (forward) price changes. A portfolio is established consisting of two cash assets. The cash position is held in the spot market and a portion of the spot market holding is held in the forward market. The portfolio return variance is determined by the variability of returns from the spot market, the variability of returns from the forward market, and the correlation coefficient between the spot market and the forward market. The spot market and forward market variability is determined by the random variables $s\tilde{P}_{i,t+1}$ and $b\tilde{P}_{j,t+1}$ respectively. The variance of return of such a portfolio (H) is

$$V(H) = x_i^2\sigma_i^2 + x_j^2\sigma_j^2 + 2x_ix_jCov_{ij}$$

where

x_i = fixed spot market holding

x_j = portion of x_i that is hedged in the forward market

$\frac{-x_j}{x_i}$ = z, the percentage of the fixed spot market position held in the forward market

σ_i^2 = subjective variance of future spot market sell price changes

σ_j^2 = subjective variance of future forward market buy price changes

Cov_{ij} = subjective covariance between future spot and forward market price changes.

$$\text{Minimize Var (H)} = x_i^2\sigma_i^2 + x_j^2\sigma_j^2 + 2x_ix_jCov_{ij}$$

substitute z for $\frac{-x_j}{x_i}$

$$\text{Var (H)} = x_i^2(\sigma_i^2 + z^2\sigma_j^2 - 2z\sigma_{i,j})$$

differentiate Var (H) with respect to z

$$\frac{d\ V(H)}{d\ z} = x_i^2(2z\sigma_j^2 - 2\sigma_{i,j})$$

set the derivative equal to zero and solve for z

$$0 = x_i^2(2z\sigma_j^2 - 2\sigma_{i,j})$$

$$z^* = \frac{\sigma_{i,j}}{\sigma_j^2}$$

where z* is the variance minimizing hedge ratio for the portion of the cash position held in the forward market.

Summary

In this chapter, theoretical considerations for the development of a hedging returns model were set forth. The term "non-speculative hedging" is defined as the hedging objective of preserving the value of a foreign currency cash position denominated in domestic currency.

Three non-speculative hedging strategies were identified as being available for corporate hedgers using the foreign exchange forward market. A model was developed for measuring the hedging returns of each strategy. The theory for the derivation of the optimal hedge ratio for portfolio hedges was discussed.

In the following chapter, the returns model will be employed to develop a measure of hedging effectiveness, which will specifically take risk and return preferences of non-speculative hedgers into account. This measure will help determine the effectiveness of the different hedging strategies identified.

CHAPTER III

A MODEL FOR MEASURING HEDGING EFFECTIVENESS

This chapter sets forth a model with which to measure the effectiveness of different hedging strategies. The outcomes of these strategies are evaluated with respect to risk and return preferences of corporate hedgers. The objective of this chapter is twofold: to identify risk and return preferences characteristic to non-speculative foreign exchange risk managers, and to develop a measure of preference that allows for the comparison of outcomes from different hedging strategies.

Risk and Return Preferences of Hedgers

Making decisions regarding hedging appears to be similar to the general framework of investment decision making with respect to the valuation of outcomes. Under conditions of uncertainty, such outcomes take the form of probability distributions of return. The outcomes are evaluated with the help of decision models or rules that attempt to reflect the decision maker's preferences for risk and return as imbedded in his utility function.

In the past, the results of investment decisions often were evaluated based on the mean-variance framework

developed by Markowitz in 1959. Although convenient to apply, the mean-variance rule is generally found to be too restrictive in its assumptions: either the underlying probability distribution must be normal or the decision maker's utility function must be quadratic.

Markowitz discussed the possibility of substituting semivariance of return for variance as a measure of risk. Semivariance depends only on those returns that fall below a target level or mean return.

Mao (1970) provided empirical evidence that, as a measure of risk, semivariance is more consistent with risk (as seen by financial managers) than is variance. Semivariance has the advantage of capturing the financial manager's intuitive notion of risk as the failure to meet some minimum return. Unlike variance, semivariance is influenced only by returns below a target rate.

Bawa (1975) provided the theoretical support for the semivariance measure of risk. He showed the congruence of the mean-semivariance rule with the rules of stochastic dominance. The mean-semivariance rule can be derived from the stochastic dominance selection rules under very general assumptions regarding distributions of returns and utility functions. Bawa concluded, therefore, that on theoretical grounds the mean-semivariance rule is preferred to the more widely used mean-variance rule.

Empirical evidence supporting semivariance as the

appropriate risk measure (particularly for foreign exchange risk) is provided by several authors. Jilling (1978) surveyed corporate executives of 107 U.S. multinational corporations. In most companies, the fear of loss from foreign exchange fluctuations greatly exceeded the hope for gain. Fifty-four percent of the respondents stated that their foreign exchange risk management objective was to have neither an exchange gain nor loss. Thirty-eight percent stated that their objective was plainly the minimization of exchange losses.

Rodriguez (1979) interviewed the financial officers of 70 U.S. multinational firms selected from the Fortune 500 list. She found that management did not appear to analyze the hedging decision in terms of the average expected gain or loss. Instead, management showed a particular aversion to reporting exchange losses.

Similar asymetrical risk and return preferences of corporate treasurers were found during a Euromoney survey (1978b). Managers perceived the pay-off matrix of outcomes from different hedging strategies and currency movements to be as follows: hedged exposure followed by an adverse currency movement was considered "expected performance," a hedged exposure followed by a favorable currency movement was considered tolerable, an unhedged exposure followed by a favorable currency movement (a windfall gain) was considered (undesirable) speculation,

and an unhedged exposure followed by an unfavorable currency movement potentially jeopardized the manager's position.

Such skewed valuation of hedging outcomes seems to indicate possible differences in risk and return objectives and preferences between hedging decisions and investment decisions. Hedgers do not appear to value returns above a target return, and strongly dislike returns below the target returns.

Hedging Effectiveness Defined

Hedging effectiveness in this study is defined to be the potential of a hedging strategy to preserve the domestic currency value of a future foreign currency cash flow over the exposure horizon. The benchmark of performance against which to measure hedging effectiveness is the hedging performance of a perfect hedge. A perfect hedge, by definition, implies the certain preservation of the foreign currency cash flow value.

This definition differs from the one employed by Dale (1981), Naidu and Shin (1981), and Hill and Schneeweis (1982a, 1982b). These authors defined hedging effectiveness as the potential of a hedging strategy to reduce the variance of its returns relative to the variance of return of an unhedged position. Both benchmark measures of performance appear to be equally adequate to

measure the effectiveness of different hedging strategies relative to each other. The measure employed in this study, however, seems to be conceptually more appealing for the analysis of non-speculative hedging strategies. First, in addition to risk aspects, it explicitly incorporates return aspects in the comparative analysis. Second, it allows for a comparison between the non-speculative hedging strategies available to the corporate treasurers and a riskless perfect hedge. Such a comparison may provide information on the magnitude of unavoidable foreign exchange risk present in the current system of floating exchange rates.

A Measure of Hedging Effectiveness

The benchmark measure for hedging effectiveness in this study is the outcome from a perfect hedge. Hedging strategies generating returns below those of a perfect hedge are considered less effective than the perfect hedge. The return deviations of different non-speculative hedging strategies from the return of the perfect hedge are evaluated from the viewpoint of the hedger's risk preferences.

Fishburn (1977) suggested a two-parameter model to establish preference rules for investment return distributions. His model is a generalized version of the mean-semivariance rule. It measures the semi-alpha moment below a target return

$$F_{\alpha}(t) = \int_{-\infty}^{t} (t-Y)^{\alpha} dF(Y) \qquad \alpha > 0, \qquad (12)$$

where

$F_{\alpha}(t)$ = risk-weighted probability that returns will fall below t

Y = return observation where b goes from zero to n and n is the total number of return observations below t

t = target return

α = measure of risk aversion for returns below t

$0 < \alpha < 1$ = risk-seeking attitude

$\alpha = 1$ = risk-neutral attitude

$\alpha > 1$ = risk-averse attitude, where

small α = high concern for not meeting the target return, but little concern about the absolute value of the return below t

large α = little concern about small deviations below t, but high concern about large deviations below t

F(Y) = probability distribution function of Y.

Under the assumption that the perfect hedge is the appropriate benchmark measure of performance, hedging strategy F is preferred to hedging strategy G if

$$F_{\alpha}(t) < G_{\alpha}(t), \tag{13}$$

where

$F_{\alpha}(t), G_{\alpha}(t)$ = subjective, risk-weighted probabilities, as a result of employing hedging strategies F, G, that the future dollar value of the current foreign currency cash position is less than the current dollar value of the current cash position

Y = hedging return Y% from hedging strategy A, B, or C

t = target return of a perfect hedge

α = measure of hedger's risk aversion toward returns below the return of a perfect hedge

$F(Y)$ = probability distribution function of Y% from equations (9), (10), and (11).

Fishburn (1977) demonstrated that the alpha-t model has a fair degree of compatibility with the primary concerns expressed by investment managers, with the

von Neumann-Morgenstern utility functions for investment decisions and with stochastic dominance relationships. Thus, it maintains its validity under less contraining assumptions about return distributions and hedgers' utility functions than does the mean-semivariance decision rule.

The alpha-t model also appears to be reasonably consistent with observed risk and return preferences of corporate hedgers. Only returns below a target return are valued, according to hedgers' degree of risk aversion toward such returns.

Summary

In this chapter, the study of risk and return preferences of corporate hedgers was set forth. Knowledge of such preferences, gained from theory and empirical observation, was incorporated in a measure of hedging effectiveness.

Hedging effectiveness was defined as the potential of a hedging strategy to perform as well as a perfect hedge, which has a return and a variance of return of zero. A zero return was interpreted as no change in the value of a foreign currency-denominated cash flow during its holding period. The perfect hedge is the benchmark measure of performance in this study to determine the relative effectiveness of the three non-speculative hedging strategies A, B, and C.

The hedging effectiveness of each hedging strategy was determined by evaluating the return deviation below the target return of the perfect hedge. These return deviations were evaluated using Fishburn's alpha-t model. This model appears to incorporate satisfactorily return and risk preferences of non-speculative corporate hedgers.

CHAPTER IV

RESEARCH HYPOTHESES AND DESIGN

This section sets forth the hypotheses that will be tested together with the procedures to be applied to the sample data. Particularly, a description of the hedge building and implementation will be provided, as well as procedures for testing the hedging effectiveness. Finally, the methodology employed in the analysis of the sample and test of hypotheses will be considered.

Research Hypotheses

The objective of the research can be embodied in one major hypothesis: that the effectiveness of portfolio-based hedges exceeds the effectiveness of naive or traditional hedges when analyzed from the viewpoint of a non-speculative hedger. The null hypothesis is that the portfolio-based hedges are no more effective than naive or traditional hedges.

That is, if risk preferences of non-speculative hedgers are reflected in the α term of the measure of hedging effectiveness, portfolio-based hedges are expected to be more effective in eliminating foreign exchange risk than naive or traditional hedges. This research hypothesis

applies to different foreign currencies, hedge durations, and time periods.

The nonrejection of the null hypothesis implies that the variance-minimizing portfolio hedge ratio does not allow the construction of more effective hedges than naive or traditional hedges. The nonrejection of the null hypothesis may occur for two reasons. First, the optimal portfolio hedge ratio is equal to the ex ante regression slope coefficient between the foreign exchange spot and forward rates. In order to implement the portfolio approach, it is necessary to estimate this slope coefficient. The method chosen to do this was to employ the most recent sample regression slope coefficient as the best estimate of the ex ante population coefficient. This forecast may not be sufficiently accurate to allow for the formation of risk-minimizing portfolio hedge ratios.

Second, the objective of portfolio hedges is to minimize the variance of return. In this study, hedging effectiveness is measured with respect to a target return and risk as measured by the semi-alpha moment around the target return. Therefore, the proposed test of hedging effectiveness is a joint test of the effectiveness of portfolio hedges to minimize foreign exchange risk as defined in this study, the stability of the population coefficient, and the accuracy of its estimate.

If the empirical results lead to the nonrejection

of the null hypothesis, then the return variance will be calculated for each hedging strategy. If the variance of return of portfolio hedges is found to be smaller than that of the competing hedges, then this supports the fact that the methodology for constructing the hedge ratios was effective and will support the conclusion that portfolio hedges are not statistically more effective from the viewpoint of a non-speculative hedger.

The rejection of the null hypothesis suggests that the variance-minimizing hedge ratio allows for the formation of more effective hedges than do naive or traditional hedges. If the hedging effectiveness of portfolio hedges is greater than that of competing hedges, then this implies that the estimation procedure for, and the stability of, the population coefficient is sufficient to allow for the formation of more effective portfolio hedges. The test of the main hypothesis, therefore, is also an indirect test of the stability of the population coefficient,[1] as reflected in its degree of usefulness in forming more effective hedges than naive or traditional hedges.

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[1] Direct tests of the stability of the regression slope coefficient are proposed by Bartlett, Cox and Steward, Gujarati, Theil, Odeh-Olds, and Cochran.

Research Design

Sample and Data Source

The sample for this study consists of foreign exchange spot and forward rates of the British pound and Deutsche mark. Forward rates include one-, two-, three-, six-, and twelve-month buy and sell rates.[2] Weekly rates (Wednesday closing) were obtained from Data Resources Incorporated.

Time Period

The time period of the study is from January 1974 to December 1982, divided into two subperiods of January 1974- June 1978 and July 1978-December 1982. This division is done to examine the hedging effectiveness during two periods apparently of significant difference with respect to the behavior of foreign exchange prices.

The first period, 1974-1978, was the period immediately following the Smithonian Agreement, which marked the end of the fixed exchange rates. In March 1973, the currencies of several industrial nations were place on a hybrid of fixed and floating exchange rates. The Canadian

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[2]Bowers (1977) points out that the analysis is sensitive to which currency of an exchange rate one chooses to make the numeraire. Time series of dollars per unit of foreign currency are not mathematically the same as time series of units of foreign currency per dollar. The numeraire to be used in this study will be units of foreign currency per dollar.

dollar, Japanese yen, Italian lira, Swiss franc, French franc, Austrian schilling, and British pound were allowed to float on the market, with their relative prices largely determined by supply and demand conditions. Thus, this period marks an era of adjustment to the new economic reality for international trade. Two further major events in this time period were the OPEC oil price increases and a transition from the U.S. dollar as the primary currency of payment for oil purchases by all industrialized nations to the concept of currency baskets. The intent of these currency baskets was the diversification of foreign exchange risk for OPEC, since these baskets consisted of up to fifteen currencies from developed countries. The increased use of these currency baskets generated significant supply/demand disequilibria for the currencies included in the baskets and, therefore, widely fluctuating currency prices.

The second period, 1978-1982, was characterized by relatively more stable economic conditions and exchange rates and the completion of the adjustment process to the new regime. In January 1978, the International Monetary Fund met to formalize the present system of floating exchange rates.

Methodology

This study aims to provide evidence to either support or refute the contention that portfolio hedges are no more effective than naive or traditional hedges. This issue is examined by forming weekly hedges over the time period 1974-1982 and measuring their returns using equations 9, 10, and 11. Short-term hedges of 30-, 60-, and 90-day duration and a longer-term hedge of 180-day duration will be formed to reflect corporate hedging needs.[3] The empirical distributions of return generated by each hedging strategy will be evaluated, using the alpha-t model, to measure the relative effectiveness of each hedging strategy.

Estimation Procedure for the Portfolio Hedge Ratio

The portfolio variance-minimizing hedge ratio, z*, is the ratio of the ex ante (subjective) covariance between the spot and forward rate price changes and the variance of the forward rate price changes. This study will employ the most recent estimate of the population coefficient as the best estimate of the ex ante population coefficient, a method which does not require the rather limiting assumption that the population coefficient is

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[3]Since data for the buy and sell 60-day forward rate are not available prior to 1978, the analysis of 30- and 60- day short-term hedges will be limited to the time period from 1978-1982.

stable over time. Rather, it assumes a fair degree of instability in that for every new hedge a new estimate of the hedge ratio is made based only on the most recent observed price relationship. The only assumption made about the stability of the coefficient is that the most recent price relationship will be a sufficiently accurate prediction of the future price relationship to allow for an increase in hedging effectiveness relative to the hedging effectiveness of traditional hedges.

Next, the number of weekly sample observations to be employed for the initialization of the portfolio hedge ratio has to be determined. As Fama (1976) points out, the variance of a sample estimate of the true regression slope coefficient and, therefore, the error-in-the-variables problem can be reduced by computing the sample coefficient from a large sample. This approach, however, leans too heavily on the assumption that the value of the true slope coefficient is stationary through time.

A positive relationship is hypothesized to exist between the length of the initialization period (the number of sample observations) and the duration of the hedge period. This hypothesis is based on the assumption that the estimation of a future price relationship during a certain period would improve if such an estimate was based on the observed price relationship in the most recent period of similar length. In other words, the

prediction of a longer-term price relationship would improve if based on a longer-term past price relationship, and vice versa for shorter periods. A simple procedure is employed to test this relationship and to allow for the determination of the optimal sample size. Each time period, 1974-1978 and 1978-1982, is divided into two subperiods. In the first subperiod of each period (January 1974 to June 1975, and July 1978 to December 1979), hedge ratios are formed based on 16, 22, and 28 weekly sample observations (representing short-term and longer-term durations) and are compared to the observed ratio in the subsequent hedge period. The difference is measured by the random variable

$$X_D = X_{ep} - X_{ep} ,$$

where

X_D = difference between the ex post sample hedge ratio and the ex ante sample hedge ratio

X_{ea} = (ex ante) sample hedge ratio observed in the hedge period

X_{ep} = (ex post) sample hedge ratio observed in the initialization period and calculated based on the most recent 16, 22, and 28 weekly observations.

This procedure is repeated for 30-, 60-, 90-, and 180-day hedges during both subperiods for both currencies. The variance of X_D for each case is calculated and the number of sample observations which minimize the variance of X_D is then employed as the optimal lengths of the initialization period.

Estimation Procedure for Hedging Effectiveness

For a given value of alpha and a target return, hedging strategy A with return distribution F^A is said to be more effective then hedging strategy B with return distribution F^B if

$$e_{A/B} = \frac{F_\alpha^A(t)}{F_\alpha^B(t)} \leq 1 , \qquad (14)$$

where $F_\alpha(t)$ is the Fishburn alpha-t measure of hedging effectiveness, as defined in Chapter 3.

The null hypothesis can now be restated as

$$e_{A/C} \leq 1 \quad , \quad e_{B/C} \leq 1.$$

Statistical estimates of the relative hedging effectiveness are

$$\hat{e}_{A/C} = \frac{F_{n\alpha}^A(t)}{F_{n\alpha}^C(t)} \quad , \quad \hat{e}_{B/C} = \frac{F_{n\alpha}^B(t)}{F_{n\alpha}^C(t)} \quad ,$$

where the empirical estimate of the Fishburn alpha-t measure of hedging effectiveness is

$$F_{n\alpha}(t) = \frac{1}{N} \Sigma(t-Y_k)^{\alpha} \qquad (15)$$

and the summation is over all k such that $Y_k < t$.

Large values of $\hat{e}_{A/C}$ and $\hat{e}_{B/C}$ support the research hypothesis for a given specification of α and target level t (for the evaluation, t is taken to be 0 throughout). The measure of effectiveness, $\hat{e}$, will be calculated for different time periods, currencies, hedge durations, and levels of risk aversion.

Summary

The null hypothesis of the study states that the hedging effectiveness of portfolio hedges is no greater than that of naive or traditional hedging strategies.

To test this proposition, weekly hedges are formed for a hypothetical transaction exposure in British pounds and Deutsche marks over the period 1974-1982. The return distributions of short-term hedges of 30, 60, and 90 days and an intermediate-term hedge of 180 days are examined.

The hedging effectiveness of different hedging strategies is measured using the two parameters alpha-t model. Several alpha values reflecting different

degrees of hedgers risk aversion are assumed. The relative hedging effectiveness of each hedging strategy for different risk assumptions, time periods, foreign currencies, and hedge durations is evaluated.

CHAPTER V

FORWARD MARKET HEDGING EFFECTIVENESS

The main research hypothesis of the study is that portfolio hedges in the foreign exchange forward markets are more effective in eliminating foreign exchange risk than either naive or traditional hedges. This hypothesis implies that negative weekly hedging returns, evaluated by the Fishburn alpha-t model, are less risky for portfolio hedges than for other hedging strategies. The first section of this chapter will discuss the hedging effectiveness for British pound hedges and Deutsche mark hedges formed in the first period from 1975-1978, while the second section continues this analysis for the period from 1979-1982. In the third section, the relative effectiveness of different hedging strategies is examined during hedging periods of different lengths. The fourth section compares variances of return of different hedging strategies. Finally, a summary of the findings is contained in the last section of this chapter.

As set forth in Chapter IV, the first step in the analysis is the determination of the statistical estimates for the effectiveness measure e. The return deviations of

the three hedging strategies, which are below zero, are evaluated for alpha values ranging from .25 to 5.0 in increments of .25. This range of values includes risk-seeking, risk-neutral, and various degrees of risk-averse attitudes of hedgers. (See Chapter III for the interpretation of alpha values.) The analysis will focus on alpha values greater than one, which present risk attitudes of non-speculative corporate hedgers.

Period I Hedging Effectiveness

The test period covers the entire period during which currencies floated freely since the abandonment of the fixed parity system. The early period, which immediately followed the changeover, can be characterized as a period of limited free float. Frequent government intervention to "create" more economically favorable exchange prices, the oil crisis, and the practice of currency baskets might have prevented an undisturbed pricing process based on market forces and, therefore, possibly affected the performance of hedging strategies.

Estimates of the e values in this period for British pound and Deutsche mark hedges are shown in Tables 1 and 2, respectively. Both 90- and 180-day British pound portfolio hedges can be described in this period as non-effective over the range of all alpha values. For alpha values greater than one (risk

TABLE 1.--Estimates of e ratios for period I British pound forward market hedges (A, B, and C refer to naive, traditional, and portfolio hedges, respectively).

HEDGING EFFECTIVENESS
BRITISH POUND
750618 - 780628

	90-DAY			180-DAY		
ALP	A/B	A/C	B/C	A/B	A/C	B/C
.25	.9020	.6346	.7036	.7877	.6353	.8066
.50	.7613	.3798	.4989	.5795	.4052	.6993
.75	.6438	.2186	.3396	.4348	.2590	.5957
1.00	.5479	.1231	.2246	.3318	.1656	.4989
1.25	.4699	.0685	.1457	.2565	.1056	.4115
1.50	.4061	.0379	.0933	.2002	.0671	.3350
1.75	.3533	.0209	.0592	.1572	.0424	.2699
2.00	.3090	.0115	.0373	.1240	.0267	.2157
2.25	.2714	.0064	.0235	.0980	.0168	.1713
2.50	.2391	.0035	.0147	.0776	.0105	.1355
2.75	.2111	.0019	.0092	.0614	.0066	.1068
3.00	.1867	.0011	.0057	.0487	.0041	.0840
3.25	.1652	.0006	.0036	.0385	.0025	.0660
3.50	.1463	.0003	.0022	.0305	.0016	.0518
3.75	.1296	.0002	.0014	.0241	.0010	.0407
4.00	.1147	.0001	.0009	.0191	.0006	.0319
4.25	.1016	.0001	.0005	.0151	.0004	.0251
4.50	.0899	.0000	.0003	.0119	.0002	.0197
4.75	.0796	.0000	.0002	.0094	.0001	.0155
5.00	.0704	.0000	.0001	.0074	.0001	.0122

TABLE 2.--Estimates of e ratios for period I Deutsche mark forward market hedges (A, B, and C refer to naive, traditional, and portfolio hedges, respectively).

HEDGING EFFECTIVENESS
DEUTSCHE MARK
750618 - 780628

	90-DAY			180-DAY		
ALP	A/B	A/C	B/C	A/B	A/C	B/C
.25	1.0682	1.0540	.9867	1.2796	1.3251	1.0356
.50	1.0249	.9950	.9708	1.2587	1.3001	1.0329
.75	.9819	.9340	.9512	1.2283	1.2611	1.0267
1.00	.9403	.8748	.9304	1.1944	1.2172	1.0191
1.25	.9000	.8187	.9097	1.1603	1.1724	1.0105
1.50	.8610	.7661	.8897	1.1272	1.1287	1.0013
1.75	.8231	.7168	.8709	1.0958	1.0868	.9918
2.00	.7863	.6709	.8533	1.0661	1.0472	.9822
2.25	.7505	.6282	.8370	1.0384	1.0098	.9725
2.50	.7158	.5884	.8220	1.0125	.9747	.9627
2.75	.6821	.5513	.8083	.9883	.9418	.9530
3.00	.6495	.5168	.7957	.9658	.9110	.9433
3.25	.6180	.4847	.7843	.9449	.8822	.9336
3.50	.5876	.4548	.7740	.9256	.8552	.9240
3.75	.5583	.4268	.7646	.9078	.8300	.9143
4.00	.5300	.4008	.7561	.8915	.8065	.9047
4.25	.5028	.3764	.7485	.8766	.7846	.8951
4.50	.4767	.3536	.7417	.8630	.7642	.8854
4.75	.4516	.3322	.7356	.8508	.7451	.8758
5.00	.4275	.3121	.7301	.8399	.7275	.8661

aversion), portfolio hedges have been significantly less effective in reducing foreign exchange risk than either naive or traditional hedges. At higher alpha values, decreasing $\hat{e}$ values seem to indicate the rapidly diminishing effectiveness of portfolio hedges.

The 90-day German mark portfolio hedges can be described as non-effective for all alpha values representing risk aversion, whereas the 180-day Deutsche mark portfolio hedges were more effective than naive or traditional hedges for alpha values of 2.25 and below and 1.5 and below, respectively. The effectiveness of portfolio hedges diminished in favor of naive and traditional hedges for higher alpha values.

Traditional hedges, which are based on the theory that a loss resulting from a position held in the spot market will be offset by a simultaneous gain from a position held in the forward market, did not appear to show the expected performance improvement over naive hedges in this period. Ninety- and 180-day traditional British pound hedges as well as 90-day traditional Deutsche mark hedges were less effective than naive hedges at all alpha values representing risk aversion. In contrast, 180-day traditional Deutsche mark hedges were more effective for alpha values of 2.5 and below, and less effective for higher alpha values only.

To summarize the first period results, it was

found that portfolio hedges were not more effective in reducing foreign exchange risk than either naive or traditional hedges. The one exception to this conclusion was 180-day Deutsche mark portfolio hedges, which were more effective than naive or traditional hedges for alpha values of 2.25 and below, and 1.5 and below, respectively. Traditional British pound and Deutsche mark hedges were less effective than naive hedges for all alpha values representing risk aversion, with the exception of 180-day Deutsche mark hedges. These were, once again, more effective than naive hedges for alpha values of 2.5 and below.

Period II Hedging Effectiveness

The second hedge-building period (December 1979-December 1982) was characterized by relatively more stable economic conditions and an adjustment to the free-float exchange rate system. The IMF formalized the new currency pricing system in January 1978. Any significant differences in the performance of the hedging strategies between both time periods may be the result of different political and economic circumstances in each period. In the second period, such differences may have led to a more unobstructed pricing process.

Estimates of the e values for this period are shown in Tables 3 and 4 for British pound and Deutsche mark hedges, respectively. All British pound portfolio

TABLE 3.--Estimates of e ratios for period II British pound forward market hedges (A, B, and C refer to naive, traditional, and portfolio hedges, respectively).

HEDGING EFFECTIVENESS
BRITISH POUND
791226 - 821215

	30-DAY			60-DAY			90-DAY			180-DAY		
ALP	A/B	A/C	B/C	A/B	A/C	B/C	A/B	A/C	B/C	A/B	A/C	B/C
.25	1.1613	1.0801	.9301	1.0280	.9868	.9599	1.1233	.9563	.8514	1.2962	1.0664	.8227
.50	1.0197	.9163	.8986	.9744	.9079	.9318	1.0345	.8411	.8131	1.2236	.9471	.7740
.75	.8995	.7792	.8662	.9253	.8415	.9094	.9399	.7348	.7818	1.1305	.8334	.7372
1.00	.7939	.6644	.8368	.8810	.7837	.8896	.8458	.6394	.7560	1.0292	.7278	.7071
1.25	.7000	.5679	.8113	.8415	.7326	.8705	.7562	.5553	.7344	.9273	.6312	.6806
1.50	.6160	.4865	.7898	.8066	.6867	.8514	.6731	.4818	.7158	.8297	.5441	.6558
1.75	.5411	.4175	.7716	.7757	.6452	.8318	.5972	.4178	.6995	.7387	.4665	.6315
2.00	.4745	.3589	.7564	.7484	.6076	.8119	.5288	.3621	.6848	.6556	.3980	.6071
2.25	.4154	.3089	.7435	.7242	.5732	.7915	.4676	.3138	.6711	.5806	.3381	.5824
2.50	.3632	.2661	.7326	.7027	.5417	.7709	.4131	.2719	.6581	.5132	.2860	.5573
2.75	.3171	.2294	.7233	.6835	.5127	.7502	.3647	.2354	.6455	.4531	.2410	.5319
3.00	.2766	.1978	.7152	.6663	.4860	.7294	.3219	.2038	.6330	.3996	.2024	.5065
3.25	.2410	.1707	.7081	.6508	.4612	.7087	.2842	.1763	.6206	.3521	.1694	.4811
3.50	.2099	.1473	.7019	.6368	.4382	.6882	.2508	.1525	.6081	.3100	.1413	.4560
3.75	.1826	.1271	.6963	.6241	.4168	.6679	.2215	.1319	.5955	.2726	.1176	.4313
4.00	.1587	.1097	.6913	.6124	.3968	.6479	.1956	.1140	.5828	.2396	.0976	.4073
4.25	.1379	.0947	.6868	.6017	.3780	.6283	.1729	.0985	.5700	.2104	.0808	.3841
4.50	.1197	.0817	.6826	.5917	.3603	.6090	.1528	.0851	.5571	.1847	.0668	.3617
4.75	.1039	.0705	.6787	.5823	.3437	.5902	.1352	.0736	.5442	.1620	.0551	.3403
5.00	.0901	.0608	.6751	.5736	.3279	.5718	.1197	.0636	.5312	.1421	.0454	.3198

TABLE 4.--Estimates of e ratios for period II Deutsche mark forward market hedges (A, B, and C refer to naive, traditional and portfolio hedges, respectively.)

HEDGING EFFECTIVENESS
DEUTSCHE MARK
791226 - 821215

	30-DAY			60-DAY			90-DAY			180-DAY		
ALP	A/B	A/C	B/C	A/B	A/C	B/C	A/B	A/C	B/C	A/B	A/C	B/C
.25	1.2235	1.1359	.9284	1.0961	1.0288	.9386	1.2447	1.0111	.8123	1.2443	1.0663	.8569
.50	1.1468	1.0424	.9090	1.0774	1.0048	.9326	1.1821	.9642	.8157	1.2366	1.0009	.8094
.75	1.0566	.9449	.8944	1.0455	.9712	.9289	1.1051	.9055	.8194	1.2224	.9280	.7592
1.00	.9564	.8467	.8853	1.0044	.9316	.9275	1.0201	.8382	.8217	1.2042	.8510	.7067
1.25	.8511	.7501	.8813	.9571	.8883	.9281	.9320	.7661	.8220	1.1827	.7726	.6532
1.50	.7452	.6573	.8820	.9055	.8427	.9306	.8443	.6925	.8203	1.1585	.6952	.6001
1.75	.6429	.5700	.8866	.8515	.7958	.9347	.7593	.6202	.8167	1.1320	.6206	.5482
2.00	.5475	.4897	.8944	.7962	.7484	.9400	.6788	.5511	.8118	1.1034	.5500	.4984
2.25	.4610	.4172	.9048	.7410	.7012	.9463	.6036	.4865	.8060	1.0734	.4842	.4511
2.50	.3846	.3529	.9174	.6866	.6547	.9535	.5342	.4273	.7998	1.0421	.4237	.4065
2.75	.3185	.2967	.9316	.6341	.6094	.9611	.4710	.3737	.7934	1.0102	.3687	.3649
3.00	.2622	.2483	.9472	.5838	.5658	.9692	.4139	.3258	.7872	.9780	.3192	.3264
3.25	.2148	.2070	.9638	.5362	.5240	.9773	.3628	.2834	.7814	.9458	.2752	.2909
3.50	.1755	.1722	.9811	.4916	.4845	.9855	.3172	.2462	.7760	.9138	.2362	.2585
3.75	.1430	.1429	.9990	.4502	.4473	.9935	.2770	.2136	.7712	.8825	.2020	.2289
4.00	.1164	.1184	1.0174	.4119	.4125	1.0013	.2415	.1853	.7671	.8518	.1722	.2022
4.25	.0947	.0981	1.0361	.3768	.3801	1.0088	.2104	.1607	.7635	.8221	.1464	.1781
4.50	.0770	.0813	1.0550	.3446	.3501	1.0159	.1833	.1394	.7606	.7933	.1242	.1565
4.75	.0627	.0673	1.0742	.3152	.3224	1.0226	.1596	.1210	.7582	.7656	.1051	.1372
5.00	.0510	.0558	1.0935	.2885	.2968	1.0288	.1390	.1052	.7564	.7391	.0888	.1201

hedges can be described in this period as non-effective from the viewpoint of a risk-averse hedger. For alpha values greater than one, 30-, 60-, 90-, and 180-day portfolio hedges were less effective than both other hedges, as indicated by the $\hat{e}$ values of less than one in Table 3. In all instances, the hedging effectiveness of portfolio hedges decreased with rising alpha values.

Although British pound portfolio hedges in both periods were less effective than either naive or traditional hedges, the performance of the portfolio hedges increased in the second period when compared to the first period. Second period values for $\hat{e}_{A/C}$ and $\hat{e}_{B/C}$ for alpha values greater than one were often several times higher than corresponding $\hat{e}$ values in the first period, thus indicating an increase in the effectiveness of portfolio hedges in the second period relative to naive or traditional hedges.

The traditional British pound hedges for all hedge durations were less effective than naive hedges and more effective than portfolio hedges for all alpha values greater than one. However, like portfolio hedges, their performance increased significantly in the second period relative to the first period when compared to naive hedges (as indicated by $\hat{e}_{A/B}$ values in the second period). Both portfolio hedges and traditional hedges showed a greater

hedging effectiveness than naive hedges for a few alpha levels representing risk-seeking attitudes.

The second period 30-, 60-, 90- and 180-day Deutsche mark portfolio hedges can be described as non-effective relative to naive hedges for all alpha values greater than one. The 30-, 60-, and 90-day traditional Deutsche mark hedges also appear to have been less effective than naive hedges, whereas the 180-day traditional hedges could be considered more effective in eliminating foreign exchange risk for alpha values of 2.75 and below and less effective for higher alpha values.

The hedging effectiveness for 90- and 180-day Deutsche mark portfolio hedges was lower than that of traditional hedges for all alpha values. On the other hand, 30- and 60-day portfolio hedges showed improving hedging effectiveness with increasing alpha values, and can be considered more effective than traditional hedges in eliminating foreign exchange risk for alpha levels of 4.0 and greater.

Contrary to the findings for British pound hedges, the performance of 90- and 180-day Deutsche mark hedges did not improve from period I to period II, but remained generally constant. However, relative to naive or traditional hedges, the performance of Deutsche mark portfolio hedges was higher than that of British pound portfolio hedgers in both periods.

Similar to the first period, second period portfolio hedges were not more effective in reducing exchange risk than either of the two remaining hedges. The only exception to this conclusion was 30- and 60-day Deutsche mark portfolio hedges, which were both more effective than traditional hedges in reducing risk for alpha values of 3.75 and higher. Traditional British pound and Deutsche mark hedges were again less effective than naive hedges for all alpha values representing risk aversion, with the exception of 180-day Deutsche mark hedges, which were more effective than naive hedges for alpha levels of 2.75 and below.

Effectiveness of Different Hedge Durations

The hedging durations chosen in this study appear to be representative of the hedging needs of corporate managers. Short-term hedges of one-, two-, and three-month duration and longer-term hedges of six-month duration were examined for their propensity to reduce foreign exchange risk using the foreign exchange forward market. Although not formally stated as a research hypothesis, the hedging duration may or may not have an impact on the relative performance of naive, traditional, and portfolio hedges. It was found that no noticeable persistent relationship exists between the hedging effectiveness of portfolio hedges and the hedging period length. On

average, British pound portfolio short-term hedges were not significantly more or less effective than longer-term hedges in either period, although the relative hedging effectiveness increased from period I to period II. Longer-term Deutsche mark portfolio hedges were significantly more effective in the first period relative to naive or traditional hedges than were 90-day hedges. This relationship, however, persisted in the second period only for traditional hedges, which were more effective for longer-term hedges than for short-term hedges. In the second period, no noticeable difference in hedging effectiveness was found between the performance of short- and longer-term Deutsche mark portfolio hedges for all alpha levels below four. For higher alpha values, short-term Deutsche mark portfolio hedges were found to be more effective than longer-term portfolio hedges relative to traditional hedges.

Direct Test of Portfolio Theory of Hedging

The objective of portfolio theory of hedging is to minimize the variance of return. Hedging effectiveness in this study, however, was measured with respect to two parameters - a target return and a risk, as measured by the semi-alpha moment below the target return. The tests performed thus far are, therefore, indirect tests of the portfolio theory of hedging.

As pointed out in Chapter IV, a direct test of the adequacy of the methodology suggested by portfolio theory to construct hedge ratios is the comparison of the variances of different hedging strategies. Table 5 lists the standard deviations of return of naive hedges, traditional hedges, and portfolio hedges for the four hedge durations as well as the two time periods for British pound Deutsche mark forward market hedges. With the exception of first-period British pound hedges, the variances of return of portfolio hedges were higher than those of naive or traditional hedges for both currencies and time periods and all hedge durations as indicated by the higher standard deviations of return.

Summary

The major research hypothesis of this study is that portfolio hedges are more effective in reducing foreign exchange risk than either naive or traditional hedges. To test the null hypothesis as presented in Chapter IV, estimates for e (the ratio of the Fishburn alpha-t model) were made for Deutsche mark and British pound forward market hedges. A range of alpha values from .25 to 5.0 was employed to represent risk-seeking, risk-neutral, and risk-averse attitudes of corporate hedgers. The analysis of the degree of relative hedging effectiveness of the three non-speculative hedging strategies was based on the

TABLE 5.--Standard Deviations of Return for British Pound and Deutsche Mark Non-speculative Forward Market Hedges in Periods I and II

Period	Currency	Hedge Duration Days	Hedging Strategy A[1]	B[2]	C[3]
I	Bp	90	.0193	.0200	.0189
I	Bp	180	.0382	.0447	.0392
I	Dm	90	.0080	.0088	.0095
I	Dm	180	.0160	.0143	.0143
II	Bp	30	.0035	.0050	.0053
II	Bp	60	.0064	.0075	.0080
II	Bp	90	.0092	.0133	.0149
II	Bp	180	.0155	.0267	.0289
II	Dm	30	.0056	.0068	.0074
II	Dm	60	.0118	.0125	.0132
II	Dm	90	.0181	.0197	.0230
II	Dm	180	.0346	.0306	.0433

[1]Naive hedging strategy

[2]Traditional hedging strategy

[3]Portfolio hedging strategy

comparison of the ê ratios.

The findings of the study, as discussed in this chapter, seem to provide evidence for the non-rejection of the null hypothesis. The hedging effectiveness of the portfolio hedges appears to be lower during both time periods than for either naive or traditional hedges. Although some findings seem to lend support to the research hypothesis over certain ranges of alpha values and hedge durations, their frequency and magnitude were not sufficient to reject the null hypothesis. These findings are limited to the 180-day Deutsche mark hedges in the first time period, and 30- and 60-day Deutsche mark hedges in the second time period. The 180-day Deutsche mark portfolio hedges were more effective than either naive or traditional hedges for alpha values of 2.25 and below, and 1.5 and below, respectively. The 30- and 60-day Deutsche mark portfolio hedges were more effective than traditional hedges for alpha values of 4.0 and higher in both periods.

While the hedging effectiveness of British pound portfolio hedges was lower than that of either naive or traditional hedges, it improved significantly from period I to period II. Although the hedging effectiveness of Deutsche mark portfolio hedges was significantly higher than that of British pound portfolio hedges in both periods (vis a vis naive and traditional hedges), it did

not improve from period I to period II but remained unchanged on average.

Although not explicitly stated as a research hypothesis, this study simultaneously tested the hedging effectiveness of traditional hedges relative to naive hedges. The analysis of the estimates of $e_{A/B}$ values indicates the relative ineffectiveness of traditional hedges compared to naive hedges in eliminating risk. With few exceptions, all $\hat{e}_{A/B}$ values were less than one for both time periods.

Furthermore, no significant relationship appears to exist between the hedging effectiveness of different hedging strategies and the duration of the hedge for all British pound hedges in both periods. The evidence for the Deutsche mark is conflicting in both periods. While longer-term traditional hedges were more effective than short-term hedges relative to naive hedges, no noticeable difference in hedging effectiveness was found between short- and longer-term Deutsche mark portfolio hedges relative to naive hedges. Short-term portfolio hedges appeared to be more effective relative to traditional hedges than did longer-term portfolio hedges.

Finally, based on the relative ineffectiveness of portfolio hedges to reduce foreign exchange risk as measured in this study, a direct test of portfolio hedging theory was performed through comparison of the return

variances of the three hedging strategies. The variance of return of portfolio hedges was found to be larger than that of both naive and traditional hedges, with one exception. This leads to the conclusion that the hedging methodology implied by portfolio theory was not effective in the foreign exchange forward markets either in reducing foreign exchange risk as defined in this study or in minimizing the variance of hedging returns.

CHAPTER VI

CONCLUSIONS

The effectiveness of several non-speculative foreign exchange risk hedging strategies was examined in this study, which differed significantly from previous studies in several aspects. First, the present study explicitly incorporated actual hedging returns in the analysis. These returns were adjusted to include the transaction cost of hedging and a risk premium. Although current literature disagrees as to the correct definition and measurement of the transaction cost and the risk premium, the model developed incorporates both costs without suffering from the difficulty of definition or measurement.

Second, the hedging decision-making process was modeled to include realistic relevant criteria of corporate treasurers facing the problem of managing foreign exchange risk. The future outcomes of hedging decisions were seen to be similar to those of investment decisions and to consist of an expected return and a probability distribution around the expected return. The Fishburn two parameter alpha-t model was employed to measure foreign

exchange risk or the weighted likelihood that hedging returns from any one hedging strategy would fall below the zero return of a perfect hedge. This likelihood was evaluated based on various levels of risk preferences ranging from risk averse to risk seeking.

Third, the test of hedging effectiveness was performed on three different non-speculative hedging strategies: the naive, the traditional, and the portfolio strategy. While the naive strategy has been practiced extensively in the past by corporate treasurers in the foreign exchange forward markets, the application of the traditional strategy has primarily been limited to commodities for which futures markets exist. The portfolio strategy, as a derivative of the Modern Portfolio Theory, only recently found theoretical consideration for application to the area of foreign exchange risk management in both the foreign exchange forward and futures markets.

Finally, no previous research has been done to examine the actual outcomes from different hedging strategies in the foreign exchange forward market. The foreign exchange forward market is similar to the foreign exchange futures market, a major tool for hedging foreign exchange risk. Both markets differ, however, in several practical trading aspects. The hedging needs and characteristics of the business firm determine the market most suitable for present hedging needs.

The major research hypothesis stated that portfolio hedges would be more effective in reducing foreign exchange risk than would either naive or traditional hedges. Minor research hypotheses were concerned with the relative hedging effectiveness of naive and traditional hedges and the hedging effectiveness during different time periods.

Due to the change in the monetary system in 1973 to a free supply and demand pricing framework for foreign currencies, the hypotheses were applied to two separate time periods: an adjustment period from 1974-1978 and a more stabilized period from 1978 to 1982. Some of the early modeling had been done using the Italian lira and the Japanese yen. The actual tests of hedging effectiveness in this study were performed for the British pound and Deutsche mark, two major trading currencies with significant depth of market.

Summary of Findings - Portfolio Hedges

The relative effectiveness of portfolio hedges as compared to naive or traditional hedges was determined by the values $\hat{e}_{A/C}$ and $\hat{e}_{B/C}$. These values are estimates of the ratio of the risk-weighted probabilities that the return of a particular hedging strategy will fall below the zero return of a perfect hedge. During the early study period, which immediately followed the conversion to

the new system, both British pound and Deutsche mark 90- and 180-day portfolio hedges were found to be less effective than either naive or traditional hedges. For all levels of risk aversion, British pound portfolio hedges were significantly less effective during this period than Deutsche mark portfolio hedges. One exception to these findings were 180-day Deutsche mark portfolio hedges, which were more effective in reducing foreign exchange risk for lower alpha values (representing risk aversion) than either naive or traditional hedges.

In the second period of relative stable economic conditions, the empirical evidence indicated a performance of portfolio hedges similar to that of the first period. Both British pound and Deutsche mark short- and longer-term portfolio hedges were less effective for all levels of risk preference than either naive or traditional hedges. The exception to the general findings in this period were short-term Deutsche mark portfolio hedges which were more effective than traditional hedges at higher levels of risk aversion.

While both British pound and Deutsche mark portfolio hedges were generally less effective than naive or traditional hedges in both periods, the relative hedging effectiveness of second period British pound portfolio hedges improved significantly when compared to first and second period Deutsche mark portfolio hedges, first and

second period British pound naive and traditional hedges and first period British pound portfolio hedges.

Such empirical findings of the relative hedging ineffectiveness of portfolio hedges vis-a-vis competing hedges, however, do not represent conclusive evidence for the relative ineffectiveness of hedges based on portfolio theory. Portfolio theory predicts the minimization of variance of return, whereas hedging effectiveness in this study was measured using a 2 parameter risk-return model. The comparison of return variances from different hedging strategies showed that portfolio hedges generated larger return variances in both time periods and for all hedging durations than did either traditional or naive hedges. This leads to the conclusion that the methodology implied by portfolio theory, when employed in the foreign exchange forward markets, did not minimize the variance of return of portfolio hedges relative to competing hedges.

Summary of Findings - Traditional Hedges

The hedging effectiveness of traditional hedges as compared with naive hedges is reflected in the $\hat{e}_{A/B}$ ratios in Tables 1, 2, 3, and 4. Assuming a zero change in the basis (the difference between today's spot and forward rate and the spot and forward rate at a future point in time), the traditional hedge predicts the complete elimination of foreign exchange risk and becomes a

perfect hedge.

In the first period, both the British pound and Deutsche mark traditional hedges were less effective than naive hedges. Only 180-day Deutsche mark traditional hedges were more effective than naive hedges in eliminating foreign exchange risk for risk-averse alpha levels of up to 2.5. Deutsche mark traditional hedges were generally more effective when compared to British pound hedges.

The findings of second period traditional hedges were similar to those of the first period. With the exception of longer-term Deutsche mark hedges, short- and longer-term British pound and Deutsche mark traditional hedges were again less effective than naive hedges in eliminating foreign exchange risk for alpha levels of greater than one. Also, similar to the first period, Deutsche mark long-term traditional hedges were more effective than naive hedges for alpha levels of up to 2.75. For alpha levels below one (representing risk-seeking attitudes), all Deutsche mark traditional hedges were more effective than naive hedges.

The magnitude of the $\hat{e}_{A/B}$ ratios during both periods indicates that, similar to portfolio hedges, a significant increase in hedging effectiveness did take place from first period to second period for both currencies. This increase may have been the result of a

more stable currency pricing relationship caused by such factors as limited protective governmental price support, reduced use of OPEC currency baskets, or stabilizing economic conditions of the country.

A relationship was expected to exist between the length of the hedge period and hedging effectiveness, since both portfolio and traditional hedges depend on the co-movement between spot and forward exchange prices and on the relative stability of this movement pattern over time. The probability of such a price relationship prevailing into the future may diminish with increased length of hedging period. The relative hedging effectiveness of both portfolio and traditional hedges vis-a-vis naive hedges, however, was with few exceptions not significantly greater for shorter-term hedges than for longer-term hedges.

Results of the Study

The findings of the study, as summarized in the previous sections, provide evidence for the rejection of the hypothesis that portfolio hedges are more effective in eliminating foreign exchange risk than either naive or traditional hedges. With few exceptions, it was found that portfolio hedges were less effective than traditional hedges, and traditional hedges were less effective than naive hedges in reducing foreign exchange risk in the

foreign exchange forward markets.

The hedging effectiveness of portfolio hedges increased from period I to period II for both currencies, which suggests that the pricing relationship between spot and forward rates has become more stable over time. This stability allows for improvement in the prediction of future price changes based on past price changes.

The study adds new evidence to previous research on the hedging potential of portfolio hedges without necessarily refuting or supporting previous studies. It extends previous work by analyzing the hedging effectiveness of the foreign exchange forward markets, incorporating hedging returns adjusted for a risk premium and the transaction cost of hedging, and modeling the hedging decision-making process based on a theoretical framework and observed hedging behavior of corporate executives.

Implications of the Results

The implications of the study are twofold. Under the assumption that the research findings can be generalized to other time periods and currencies, on the micro-economic level the findings suggest an optimal hedging procedure for risk-averse hedgers. Firms having hedging needs that best fit the features of the foreign exchange forward market would minimize foreign exchange risk by hedging a foreign cash position at birth using the naive

hedging strategy.

On the macroeconomic level, the results of the study seem to lend support to proponents of monetary systems such as the Bretton Woods system. The introduction of floating exchange rates (and the resulting loss of forecasting ability) represents an additional risk component to international trade. Under the assumption that most international business firms consider uncertainty about a future foreign currency price to be an undesirable feature, floating rates have introduced additional costs of doing business (transaction costs and insurance costs) to eliminate such pricing uncertainty.

Suggestions for Future Research

This research suggests several possibilities for future studies. The current study employed the foreign exchange forward market to test the effectiveness of three non-speculative hedging strategies. An extension to the foreign exchange futures market may show increased performance of portfolio hedges because government price intervention or other macroeconomic influences are less likely to directly affect the performance of this market and a less disturbed price relationship between spot and futures rates may exist.

The time period studied was from 1974 to 1982. A significant improvement in the performance of portfolio

hedges was observed from the first subperiod (1974-1978) to the second subperiod (1978-1982). An extension of this research to include future time periods may show further improvements in the performance of portfolio hedges.

The firm in this study was assumed to hold only one foreign currency cash position. In the case where a firm holds two or more foreign currency cash positions, the hedging strategy of the firm may change based on the interrelationship of foreign currencies. An extension of the two-asset portfolio to a multiple-asset portfolio may significantly improve the performance of portfolio hedges relative to other non-speculative hedges.

APPENDIX A

AN ANALYSIS OF THE HEDGING EFFECTIVENESS OF TRADITIONAL HEDGES

APPENDIX A

AN ANALYSIS OF THE HEDGING EFFECTIVENESS OF TRADITIONAL HEDGES

According to traditional hedging theory, a hedger can protect against an adverse price change of a commodity held (such as a foreign exchange cash position X_{FC}) by assuming an offsetting position in the commodity's forward or futures market. Thus, the hedger places a bet in the forward market against his or her own position in the spot market for the duration of the holding period. At maturity, the hedger liquidates both positions and any loss derived from holding one position will be offset by a simultaneous gain in the second position. As shown in Chapter I, a perfect hedge (i.e., the complete elimination of price risk) is possible only if the change in the basis is zero. Under this condition, the translation gain or loss is exactly equal to the transaction loss or gain.

This study tested the hedging effectiveness of traditional hedges relative to naive hedges. The analysis of the estimates of $e_{A/B}$ values as a measure of hedging effectiveness indicated the relative ineffectiveness of traditional hedges compared to naive hedges in eliminating foreign exchange risk. With few exceptions, all $\hat{e}_{A/B}$

values were less than one.

The returns necessary for the comparison of the relative hedging effectiveness of naive and traditional hedges are measured by equations (9) and (10), respectively. For a 180-day hedge, for example, the naive hedge is defined as being more effective than the traditional hedge if:

$$\frac{{}_{s}P_{j,t,180}}{{}_{s}P_{i,t}} - 1 > \frac{{}_{s}\tilde{P}_{i,t+1} + {}_{s}P_{j,t,360} - {}_{b}\tilde{P}_{j,t+1,180}}{{}_{s}P_{i,t}} - 1, \quad (20)$$

where

${}_{s}P_{j,t,180}$ = 180-day bid forward rate at period t

${}_{s}P_{j,t,360}$ = 360-day bid forward rate at period t (to open the hedge)

${}_{b}\tilde{P}_{j,t+1,180}$ = 180-day ask forward rate at period t+1 (to close the hedge position).

From equation (20) it follows that whenever

$$({}_{}P_{j,t,180} - {}_{}P_{j,t,360}) > (\tilde{P}_{i,t+1} - \tilde{P}_{j,t+1,180})^{1}, \quad (21)$$

---

[1] The subscripts s and b (indicating bid and ask quotations) were eliminated for the purpose of this analysis.

then the inequality indicated in equation (20) holds and the naive hedge is more effective than the traditional hedge. Since forward exchange rates are the market consensus of the future spot rate value, the left-hand expression of inequality (21) at period t is equal to the expected change of the exchange rate from period t+1 to period t+2. The right-hand expression of inequality (21) at period t+1 is equal to the expected change of the exchange rate, also from period t+1 to period t+2. The right-hand expression, therefore, is the short-term expectation of the price change from period t+1 to period t+2, whereas the left-hand expression is the long-term expectation of the price change during the same period. The empirical evidence seems to support the statement that the short-term expectation of the future price change (as defined by the right-hand term of inequality in equation 21) was on the average smaller than the longer-term expectation of the future price change (as defined by the left-hand term of inequality in equation 21) during the test period from 1974-1982.

Since the Fishburn alpha-t model employed in this study measures only return deviations below a target return of zero, the tests of hedging effectiveness performed provide evidence only for a bias in the pricing process of foreign exchange in the case where the foreign currency sold at a discount. The interpretation of such

findings appears to be that whenever a foreign currency sold at a discount, the long-term predictions of future price changes of British pounds and Deutsche marks (as expressed by the differences in the forward rates) were on average lower (more pessimistic) than the short-term predictions for the same period. Such findings of bias in the pricing process of foreign exchange rates are, however, not necessarily contradictory to the widely held view that foreign exchange rates behave as if generated by a random-walk process. Since the advent of floating exchange rates, the currency pricing process is based on supply and demand equilibria similar to the pricing process of other commodities. The classic economic rationale for the existence of foreign exchange forward markets is that they facilitate hedging. That is, they allow those who deal in a foreign currency to transfer the risk of price changes of this foreign currency to speculators who are more willing to assume such risk. Speculators, however, expect to be compensated for their risk exposure and may, in the case of a discount, bid foreign exchange forward prices low enough to assure adequate compensation. The fact that uncertainty and the corresponding risk involved in a future currency spot price increase with time might represent an explanation for the inequalities observed on average in equations (20) and (21) and the more pessimistic pricing of longer-term forward contracts than shorter-term forward contracts.

APPENDIX B

LISTING OF PROGRAM TO DETERMINE THE OPTIMAL SAMPLE SIZE FOR THE INITIALIZATION OF z*

APPENDIX B

Listing of Program to Determine the Optimal Sample Size for the Initialization of z*

```
   PROGRAM NPRDTST     74/176  OPT=1,ROUND=A/ S/ M/-D,-DS      FTN 5.1+564          06/01/83
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS=*USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=50000
FTN8,I=SETFILE,ET,E=ERRORS.

      1            PROGRAM NPRDTST                                                    100
      2      *****************************************************************        110
      3      *                                                               *        120
      4      *     PURPOSE:  EMPIRICALLY TEST ALTERNATIVE INITIALIZATION     *        130
      5      *               PERIODS FOR Z-STAR.                             *        140
      6      *                                                               *        150
      7      *****************************************************************        160
      8                                                                               170
      9            CHARACTER*14 CURRNCY(2)                                            180
     10            CHARACTER*8  SRSNME(5)                                             190
     11            CHARACTER*7  BDATE,EDATE,ODATE,DATE(500)                           200
     12            CHARACTER*3  ACTION(2)                                             210
     13                                                                               220
     14            INTEGER      OBS,TOBS,NOBS,FOBS,STRY,FWRD,FC,C,ACT,                230
     15           +             POS,MPOS,N,NT                                         240
     16            INTEGER      NRET(4),SRSTIME(2,5),MEDGE(4,2),OPEN(4,2),CLOSE(4,2),250
     17           +             NPRD(3)                                               260
     18                                                                               270
     19            REAL         RATES(2,0:5,2),DEL(2,0:5,2)                           280
     20            REAL         DEXRATE(2,0:5,500),EXRATES(2,0:5,500),RET(3,4)        290
     21            REAL         ASUMX(3),ASUMY(3),ASUMXY(3),ASUMY2(3),AZSTAR(3)       300
     22            REAL         BSUMX,BSUMY,BSUMXY,BSUMY2,BZSTAR,XDEL(3)              310
     23            REAL         FPRD,FNPRD                                            320
     24                                                                               330
     25      *****************************************************************        340
     26      *                                                               *        350
     27      *   OPEN FILES AND INITIALIZE VARIABLES                         *        360
     28      *                                                               *        370
     29      *****************************************************************        380
     30                                                                               390
     31            OPEN(5,FILE='INPUT')                                               400
     32            OPEN(6,FILE='OUTPUT')                                              410
     33            OPEN(98,FILE='EXFILE',STATUS='OLD',FORM='UNFORMATTED')             420
     34                                                                               430
     35            REWIND 98                                                          440
     36                                                                               450
     37      ****INITIALIZE CONSTANTS                                                 460
     38                                                                               470
     39            CURRNCY(1)='BRITISH POUND'                                         480
     40            CURRNCY(2)='DEUTSCHE MARK'                                         490
     41                                                                               500
     42            ACTION(1)='ASK'                                                    510
     43            ACTION(2)='BID'                                                    520
     44                                                                               530
     45            SRSNME(1)='  30-DAY'                                              540
     46            SRSNME(2)='  60-DAY'                                              550
     47            SRSNME(3)='  90-DAY'                                              560
     48            SRSNME(4)=' 180-DAY'                                              570
     49            SRSNME(5)=' 360-DAY'                                              580
     50                                                                               590
     51            NPRD(1)=16                                                         600
     52            NPRD(2)=22                                                         610
     53            NPRD(3)=28                                                         620
     54                                                                               630
     55            SRSTIME(1,1)=30                                                    640
     56            SRSTIME(2,1)=4                                                     650
     57            SRSTIME(1,2)=60                                                    660
     58            SRSTIME(2,2)=9                                                     670
     59            SRSTIME(1,3)=90                                                    680
     60            SRSTIME(2,3)=13                                                    690
     61            SRSTIME(1,4)=180                                                   700
     62            SRSTIME(2,4)=26                                                    710
     63            SRSTIME(1,5)=360                                                   720
     64            SRSTIME(2,5)=52                                                    730
     65                                                                               740
     66      ****USER SELECT CURRENCY DATE RANGE                                      750
     67                                                                               760
     68            WRITE(6,6010) (C,CURRNCY(C),C=1,2)                                 770
     69      100   READ(5,*) FC                                                       780
     70            IF(FC.NE.1.AND.FC.NE.2) THEN                                       790
     71              WRITE(6,6020)                                                    800
     72              GO TO 100                                                        810
     73            ENDIF                                                              820
     74            WRITE(6,6030)                                                      830
     75            READ(5,*) BDATE,EDATE                                              840
     76                                                                               850
     77      ********READ IN EXCHANGE DATA FOR DESIRED CURRENCY                      860
     78                                                                               870
     79            READ(98) TOBS                                                      880
     80            NOBS=0                                                             890
     81            DO 230 OBS=2,TOBS                                                  900
     82              READ(98) NOBS,ODATE,(((RATES(ACT,FWRD,C),DEL(ACT,FWRD,C),       910
     83           +                                          ACT=1,2),FWRD=0,5),C=1,2)920
     84              IF(ODATE.GE.BDATE.AND.ODATE.LE.EDATE) THEN                       930
     85                NOBS=NOBS + 1                                                  940
     86                DATE(NOBS)=ODATE                                               950
```

APPENDIX B--Continued

```
                DO 220 FWRD=0,5                                                 960
                  DO 210 ACT=1,2                                                970
                    EXRATES(ACT,FWRD,MOBS)=RATES(ACT,FWRD,FC)                   980
                    DEXRATE(ACT,FWRD,MOBS)=DEL(ACT,FWRD,FC)                     990
210               CONTINUE                                                      1000
220             CONTINUE                                                        1010
              ENDIF                                                             1020
230         CONTINUE                                                          1030
            WRITE(6,6040) MOBS                                                1040
                                                                              1050
****USER SELECT PERIOD USED TO FORM HEDGE                                      1060
                                                                              1070
300         WRITE(6,6050)                                                     1080
            READ(5,*) TPOS                                                    1090
            IF(TPOS.GT.4) THEN                                                1100
              WRITE(6,6060)                                                   1110
              GO TO 300                                                       1120
            ENDIF                                                             1130
            WRITE(6,6070)                                                     1140
            DO 310 POS=1,TPOS                                                 1150
305           OPEN(POS,1)=0                                                   1160
              CLOSE(POS,1)=0                                                  1170
              WRITE(6,6000)                                                   1180
              READ(5,*) ODAY,CDAY                                             1190
              IF(ODAY.EQ.30) THEN                                             1200
                OPEN(POS,1)=30                                                1210
                OPEN(POS,2)=1                                                 1220
              ELSE IF(ODAY.EQ.60) THEN                                        1230
                OPEN(POS,1)=60                                                1240
                OPEN(POS,2)=2                                                 1250
              ELSE IF(ODAY.EQ.90) THEN                                        1260
                OPEN(POS,1)=90                                                1270
                OPEN(POS,2)=3                                                 1280
              ELSE IF(ODAY.EQ.180) THEN                                       1290
                OPEN(POS,1)=180                                               1300
                OPEN(POS,2)=4                                                 1310
              ELSE IF(ODAY.EQ.360) THEN                                       1320
                OPEN(POS,1)=360                                               1330
                OPEN(POS,2)=5                                                 1340
              ELSE                                                            1350
                WRITE(6,6080)                                                 1360
                GO TO 305                                                     1370
              ENDIF                                                           1380
              IF(CDAY.EQ.30) THEN                                             1390
                CLOSE(POS,1)=30                                               1400
                CLOSE(POS,2)=1                                                1410
              ELSE IF(CDAY.EQ.60) THEN                                        1420
                CLOSE(POS,1)=60                                               1430
                CLOSE(POS,2)=2                                                1440
              ELSE IF(CDAY.EQ.90) THEN                                        1450
                CLOSE(POS,1)=90                                               1460
                CLOSE(POS,2)=3                                                1470
              ELSE IF(CDAY.EQ.180) THEN                                       1480
                CLOSE(POS,1)=180                                              1490
                CLOSE(POS,2)=4                                                1500
              ELSE                                                            1510
                WRITE(6,6090)                                                 1520
                GO TO 305                                                     1530
              ENDIF                                                           1540
              IF(CLOSE(POS,1).EQ.0.OR.OPEN(POS,1).EQ.0) GO TO 305             1550
              HEDGE(POS,1)=ODAY - CDAY                                        1560
              HEDGE(POS,2)=SRSTIME(2,OPEN(POS,2)) - SRSTIME(2,CLOSE(POS,2))   1570
              IF(HEDGE(POS,1).LE.0) THEN                                      1580
                WRITE(6,6100)                                                 1590
                GO TO 305                                                     1600
              ENDIF                                                           1610
310         CONTINUE                                                          1620
                                                                              1630
*****************************************************************************1640
*                                                                           *  1650
*   CALCULATE X FOR EACH POSITION                                           *  1660
*                                                                           *  1670
*****************************************************************************1680
                                                                              1690
            DO 590 POS=1,TPOS                                                 1700
              WRITE(6,6200) CURRNCY(FC),HEDGE(POS,1)                          1710
                                                                              1720
***INITIALIZE STAT REGS                                                       1730
                                                                              1740
*****EXPOST                                                                   1750
              DO 510 N=1,3                                                    1760
                ASUMX(N)=0.                                                   1770
                ASUMY(N)=0.                                                   1780
                ASUMY2(N)=0.                                                  1790
                ASUMXY(N)=0.                                                  1800
510           CONTINUE                                                        1810
              DO 530 N=1,3                                                    1820
                LPBEG=MOBS-HEDGE(POS,2)                                       1830
                LPEND=MOBS-HEDGE(POS,2)-NPRD(N)                               1840
                DO 520 OBS=LPBEG,LPEND,-1                                     1850
                  ASUMX(N)=ASUMX(N)+DEXRATE(1,0,OBS)                          1860
                  ASUMY(N)=ASUMY(N) +                                         1870
     +                                DEXRATE(2,CLOSE(POS,2),OBS)             1880
     +            ASUMY2(N)=ASUMY2(N) +                                       1890
     +                                DEXRATE(2,CLOSE(POS,2),OBS)**2.         1900
     +            ASUMXY(N)=ASUMXY(N) + DEXRATE(1,0,OBS)*                     1910
     +                                  DEXRATE(2,CLOSE(POS,2),OBS)           1920
520             CONTINUE                                                      1930
530           CONTINUE                                                        1940
                                                                              1950
*****EXANTE                                                                  1960
              BSUMX=0.                                                        1970
              BSUMY=0.                                                        1980
              BSUMY2=0.                                                       1990
              BSUMXY=0.                                                       2000
              LPBEG=MOBS                                                      2010
              LPEND=MOBS-(HEDGE(POS,2)-1)                                     2020
              DO 540 OBS=LPBEG,LPEND,-1                                       2030
                BSUMX=BSUMX+DEXRATE(1,0,OBS)                                  2040
                BSUMY=BSUMY +                                                 2050
     +                      DEXRATE(2,CLOSE(POS,2),OBS)                      2060
     +          BSUMY2=BSUMY2 +                                             2070
     +                            DEXRATE(2,CLOSE(POS,2),OBS)**2.           2080
                BSUMXY=BSUMXY + DEXRATE(1,0,OBS)*                             2090
```

APPENDIX B--Continued

```
     +                                  DEXRATE(2,CLOSE(POS,2),OBS)
540      CONTINUE

***CALULATE ZSTAR

         KNT=0
*****EXPOST
550      CONTINUE
           KNT=KNT+1
           NT=0
           DO 560  N=1,3
           IF(ASUMX(N).EQ.0) GO TO 560
             NT=NT+1
             FNPRD=FLOAT(NPRD(N))
             COV=ASUMXY(N)/FNPRD-(ASUMX(N)/FNPRD*ASUMY(N)/FNPRD)
             VAR=ASUMY2(N)/FNPRD-(ASUMY(N)/FNPRD)**2.
             AZSTAR(N)=COV/VAR
560        CONTINUE
*****EXANTE
           FPRD=FLOAT(HEDGE(POS,2))
           COV=BSUMXY/FPRD-(BSUMX/FPRD*BSUMY/FPRD)
           VAR=BSUMY2/FPRD-(BSUMY/FPRD)**2.
           BZSTAR=COV/VAR

***PRINT DIFFERENCE
           DO 570 N=1,NT
             XDEL(N)=AZSTAR(N)-BZSTAR
570        CONTINUE
           WRITE(6,6210) KNT,BZSTAR,(AZSTAR(N),XDEL(N),N=1,NT)

***UPDATE STAT REGS

*****EXPOST
           DO 580 N=1,NT
             DOBS=MOBS-HEDGE(POS,2)-(KNT-1)
             AOBS=DOBS-(NPRD(N)+1)
             IF(AOBS.GT.0) THEN
               ASUMX(N)=ASUMX(N)-DEXRATE(1,0,DOBS)
     +                               +DEXRATE(1,0,AOBS)
               ASUMY(N)=ASUMY(N)-DEXRATE(2,CLOSE(POS,2),DOBS)
     +                               +DEXRATE(2,CLOSE(POS,2),AOBS)
               ASUMY2(N)=ASUMY2(N)-DEXRATE(2,CLOSE(POS,2),DOBS)**2.
     +                                 +DEXRATE(2,CLOSE(POS,2),AOBS)**2.
               ASUMXY(N)=ASUMXY(N)-DEXRATE(1,0,DOBS)
     +                                 *DEXRATE(2,CLOSE(POS,2),DOBS)
     +                                 +DEXRATE(1,0,AOBS)
     +                                 *DEXRATE(2,CLOSE(POS,2),AOBS)
             ELSE
*****EXAUNTE
               ASUMX(N)=0.
               ASUMY(N)=0.
               ASUMY2(N)=0.
               ASUMXY(N)=0.
             ENDIF
580        CONTINUE
           DOBS=MOBS-(KNT-1)
           AOBS=DOBS-HEDGE(POS,2)
           BSUMX=BSUMX-DEXRATE(1,0,DOBS)
     +                   +DEXRATE(1,0,AOBS)
           BSUMY=BSUMY-DEXRATE(2,CLOSE(POS,2),DOBS)
     +                   +DEXRATE(2,CLOSE(POS,2),AOBS)
           BSUMY2=BSUMY2-DEXRATE(2,CLOSE(POS,2),DOBS)**2.
     +                     +DEXRATE(2,CLOSE(POS,2),AOBS)**2.
           BSUMXY=BSUMXY-DEXRATE(1,0,DOBS)
     +                   *DEXRATE(2,CLOSE(POS,2),DOBS)
     +                   +DEXRATE(1,0,AOBS)
     +                   *DEXRATE(2,CLOSE(POS,2),AOBS)
       IF(KNT.LT.20) GO TO 550
590    CONTINUE

6000   FORMAT(' ?')
6010   FORMAT(' ENTER THE NUMBER OF THE CURRENCY YOU WOULD LIKE',
     +/,       ' TO CALCULATE RETURNS FOR:'.
     +//,1OX,I3,3X,A14,
     +/,1OX,I3,3X,A14,
     +//,       ' ?')
6020   FORMAT(' YOU MUST ENTER EITHER A "1" OR A "2"',/,' ?')
6030   FORMAT(' ENTER THE DATE RANGE TO BE USED IN CALCULATING'./.
     +,              RETURNS(YYMMDD YYMMDD)',/,' ?')
6040   FORMAT('-NUMBER OF OBSERVATIONS READ IN:',I4)
6050   FORMAT('-ENTER NUMBER OF HEDGES TO BE FORMED'./.' ?')
6060   FORMAT(' ***MUST BE LESS THAN 5')
6070   FORMAT('-ENTER THE NUMBER OF DAYS USED TO FORM THE HEDGES'./.
     +,              (OPEN CLOSE, I.E. 90 60)')
6080   FORMAT(' ***DAYS OPEN MUST BE 30,60,90,180,360'./.
     +,       PLEASE RE-ENTER')
6090   FORMAT(' ***DAYS CLOSE MUST BE 30,60,90,180'./.
     +,       PLEASE RE-ENTER')
6100   FORMAT(' ***HEDGE FORMED MUST BE GREATER THAN 0 DAYS'./.
     +,       PLEASE RE-ENTER')
6200   FORMAT('0',T5,'CURRENCY: ',A14,/,T5,'POSITION: ',I4,'-DAY'.//.
     +11X,'ACTUAL',10X,'16 OBS',16X,'22 OBS',16X,'28 OBS'./.
     +12X,'ZSTAR',4X,3(' ZSTAR ',2X,'   X   ',4X))
6210   FORMAT(1X,I4,1X,F8.6,4X,3(F8.6,2X,F8.6,3X),4X)
       END
```

APPENDIX C

LISTING OF PROGRAM TO CALCULATE THE HEDGING STRATEGY RETURN

APPENDIX C

Listing of Program to Calculate the Hedging Strategy Return

```
   PROGRAM RTURNER    74/178  OPT=1 ROUND=#/$/%/-D,DS    FTN 4.5+456    06/01/83
DO=-LDNG/-DT,ARG=-COMMON/-FIXED,CS=*USER*/-FIXED,DB=-TB/-SB/-SL/ EN/-ID/-FMD/-CT,PL=50000
FTN5,I=SETFILE,ET,E=ERRORS.

1               PROGRAM RTURNER                                                 100
2       *****************************************************************       110
3       *                                                               *       120
4       *       PURPOSE:  EMPIRICALLY DETERMINE THE RETURNS(EX POST) UNDER *    130
5       *                 5 HEDGING STRATEGIES.                         *       140
6       *                                                               *       150
7       *****************************************************************       160
8                                                                               170
9               CHARACTER*14 CURRNCY(2)                                         180
10              CHARACTER*8  SRSNME(5)                                          190
11              CHARACTER*7  $DATE,EDATE,ODATE,DATE(500)                        200
12              CHARACTER*3  ACTION(2)                                          210
13                                                                              220
14              INTEGER      OBS,TOBS,NOBS,FOBS,STRY,FWRD,FC,C,ACT,             230
15             *             POS,TPOS,MPOS,MOBS,BOBS,EOBS,SOBS                  240
16              INTEGER      NRET(4),$RSTIME(2,5),HEDGE(4,3),OPEN(4,2),CLOSE(4,2),250
17             *             NPRD(4),ZFREQ(4,0:21),MINHDG                       260
18                                                                              270
19              REAL         RATES(2,0:5,2),DEL(2,0:5,2)                        280
20              REAL         DEVRATE(2,0:5,500),ERRATE(2,0:5,500),RET(3,4)      290
21              REAL         SUMX(4),SUMY(4),SUMXY(4),SUMY2(4),FMPRD,ZSTAR(4)   300
22              REAL         TOTRET(3,4),TOTRET2(3,4),XBAR(4),SD(4)             310
23                                                                              320
24      *****************************************************************       330
25      *                                                               *       340
26      *   OPEN FILES AND INITIALIZE VARIABLES                         *       350
27      *                                                               *       360
28      *****************************************************************       370
29                                                                              380
30              OPEN(5,FILE='INPUT')                                            390
31              OPEN(6,FILE='OUTPUT')                                           400
32              OPEN(98,FILE='EXFILE',STATUS='OLD',FORM='UNFORMATTED')          410
33              OPEN(99,FILE='RETFILE',STATUS='NEW',FORM='UNFORMATTED')         420
34                                                                              430
35              REWIND 98                                                       440
36                                                                              450
37      ****INITIALIZE CONSTANTS                                                460
38                                                                              470
39              MINHDG=99                                                       480
40                                                                              490
41              CURRNCY(1)='BRITISH POUND'                                      500
42              CURRNCY(2)='DEUTSCHE MARK'                                      510
43                                                                              520
44              ACTION(1)='BID'                                                 530
45              ACTION(2)='ASK'                                                 540
46                                                                              550
47              $RSNME(1)='  30-DAY'                                           560
48              $RSNME(2)='  60-DAY'                                           570
49              $RSNME(3)='  90-DAY'                                           580
50              $RSNME(4)='180-DAY'                                             590
51              $RSNME(5)='360-DAY'                                             600
52                                                                              610
53              $RSTIME(1,1)=30                                                 620
54              $RSTIME(2,1)=4                                                  630
55              $RSTIME(1,2)=60                                                 640
56              $RSTIME(2,2)=9                                                  650
57              $RSTIME(1,3)=90                                                 660
58              $RSTIME(2,3)=13                                                 670
59              $RSTIME(1,4)=180                                                680
60              $RSTIME(2,4)=26                                                 690
61              $RSTIME(1,5)=360                                                700
62              $RSTIME(2,5)=52                                                 710
63                                                                              720
64      ****INITIALIZE STATISTICAL SUMMARY REGISTERS                            730
65                                                                              740
66              DO 530 POS=1,4                                                  750
67                NRET(POS)=0                                                   760
68                DO 510 I=0,21                                                 770
69                  ZFREQ(POS,I)=0                                              780
70      510       CONTINUE                                                      790
71                DO 520 STRY=1,3                                               800
72                  TOTRET(STRY,POS)=0.                                         810
73                  TOTRET2(STRY,POS)=0.                                        820
74      520       CONTINUE                                                      830
75      530     CONTINUE                                                        840
76                                                                              850
77      ****USER SELECT CURRENCY                                                860
78                                                                              870
79              WRITE(6,6010) (C,CURRNCY(C),C=1,2)                              880
80      100     READ(5,*) FC                                                    890
81              IF(FC.NE.1.AND.FC.NE.2) THEN                                    900
82                WRITE(6,6020)                                                 910
83                GO TO 100                                                     920
84              ENDIF                                                           930
85                                                                              940
86      ********READ IN EXCHANGE DATA FOR DESIRED CURRENCY                     950
87                                                                              960
```

APPENDIX C--Continued

```
      WRITE(6,6020)                                                          970
      READ(5,*) SDATE,EDATE                                                  980
C                                                                            990
      READ(98) TOBS                                                          1000
      MOBS=0                                                                 1010
      DO 230 OBS=2,TOBS                                                      1020
        READ(98) MOBS,ODATE,(((RATES(ACT,FWRD,C),DEL(ACT,FWRD,C),           1030
     +                                                 ACT=1,2),FWRD=0,5),C=1,2)  1040
        MOBS=MOBS + 1                                                        1050
        DATE(MOBS)=ODATE                                                     1060
        DO 220 FWRD=0,5                                                      1070
          DO 210 ACT=1,2                                                     1080
100         EXRATES(ACT,FWRD,MOBS)=RATES(ACT,FWRD,FC)                        1090
101         DEXRATE(ACT,FWRD,MOBS)=DEL(ACT,FWRD,FC)                          1100
102   210     CONTINUE                                                       1110
103   220   CONTINUE                                                         1120
104   230 CONTINUE                                                           1130
105       DO 250 OBS=1,MOBS                                                  1140
106       IF(DATE(OBS).LT.SDATE) GO TO 250                                   1150
107         SOBS=0                                                           1160
108         EOBS=OBS                                                         1170
109         DO 240 OBS2=OBS,MOBS                                             1180
110         IF(DATE(OBS2).GT.EDATE) GO TO 240                                1190
111           SOBS=SOBS+1                                                    1200
112           EOBS=OBS2                                                      1210
113   240     CONTINUE                                                       1220
114           GO TO 260                                                      1230
115   250   CONTINUE                                                         1240
116   260   CONTINUE                                                         1250
117       WRITE(6,6040) MOBS,SOBS                                            1260
118                                                                          1270
119       ****USER SELECT PERIOD USED TO FORM HEDGE                          1280
120                                                                          1290
121   300   WRITE(6,6050)                                                    1300
122         READ(5,*) TPOS                                                   1310
123         IF(TPOS.GT.4) THEN                                               1320
124           WRITE(6,6060)                                                  1330
125           GO TO 300                                                      1340
126         ENDIF                                                            1350
127         WRITE(6,6070)                                                    1360
128         DO 310 POS=1,TPOS                                                1370
129   305     OPEN(POS,1)=0                                                  1380
130           CLOSE(POS,1)=0                                                 1390
131           WRITE(6,6000)                                                  1400
132           READ(5,*) ODAY,CDAY                                            1410
133           IF(ODAY.EQ.30) THEN                                            1420
134             OPEN(POS,1)=30                                               1430
135             OPEN(POS,2)=1                                                1440
136           ELSE IF(ODAY.EQ.60) THEN                                       1450
137             OPEN(POS,1)=60                                               1460
138             OPEN(POS,2)=2                                                1470
139           ELSE IF(ODAY.EQ.90) THEN                                       1480
140             OPEN(POS,1)=90                                               1490
141             OPEN(POS,2)=3                                                1500
142           ELSE IF(ODAY.EQ.180) THEN                                      1510
143             OPEN(POS,1)=180                                              1520
144             OPEN(POS,2)=4                                                1530
145           ELSE IF(ODAY.EQ.360) THEN                                      1540
146             OPEN(POS,1)=360                                              1550
147             OPEN(POS,2)=5                                                1560
148           ELSE                                                           1570
149             WRITE(6,6080)                                                1580
150             GO TO 305                                                    1590
151           ENDIF                                                          1600
152           IF(CDAY.EQ.30) THEN                                            1610
153             CLOSE(POS,1)=30                                              1620
154             CLOSE(POS,2)=1                                               1630
155           ELSE IF(CDAY.EQ.60) THEN                                       1640
156             CLOSE(POS,1)=60                                              1650
157             CLOSE(POS,2)=2                                               1660
158           ELSE IF(CDAY.EQ.90) THEN                                       1670
159             CLOSE(POS,1)=90                                              1680
160             CLOSE(POS,2)=3                                               1690
161           ELSE IF(CDAY.EQ.180) THEN                                      1700
162             CLOSE(POS,1)=180                                             1710
163             CLOSE(POS,2)=4                                               1720
164           ELSE                                                           1730
165             WRITE(6,6090)                                                1740
166             GO TO 305                                                    1750
167           ENDIF                                                          1760
168           IF(CLOSE(POS,1).EQ.0.OR.OPEN(POS,1).EQ.0) GO TO 305            1770
169           HEDGE(POS,1)=ODAY - CDAY                                       1780
170           IF(HEDGE(POS,1).EQ.30) THEN                                    1790
171             HEDGE(POS,2)=1                                               1800
172           ELSE IF(HEDGE(POS,1).EQ.60) THEN                               1810
173             HEDGE(POS,2)=2                                               1820
174           ELSE IF(HEDGE(POS,1).EQ.90) THEN                               1830
175             HEDGE(POS,2)=3                                               1840
176           ELSE IF(HEDGE(POS,1).EQ.180) THEN                              1850
177             HEDGE(POS,2)=4                                               1860
178           ENDIF                                                          1870
179           HEDGE(POS,3)=SRSTIME(2,OPEN(POS,2))-SRSTIME(2,CLOSE(POS,2))    1880
180           IF(HEDGE(POS,3).LT.MINHDG) THEN                                1890
181             MINHDG=HEDGE(POS,3)                                          1900
182           ENDIF                                                          1910
183           IF(HEDGE(POS,1).LE.0) THEN                                     1920
184             WRITE(6,6100)                                                1930
185             GO TO 305                                                    1940
186           ENDIF                                                          1950
187   310   CONTINUE                                                         1960
188                                                                          1970
189       WRITE(6,6110)                                                      1980
190       MAXPRD=0                                                           1990
191       DO 320 POS=1,TPOS                                                  2000
192         WRITE(6,6120) HEDGE(POS,1)                                       2010
193         READ(5,*) NPRD(POS)                                              2020
194       MAXPRD=MAX(MAXPRD,NPRD(POS))                                       2030
195   320   CONTINUE                                                         2040
196                                                                          2050
197                                                                          2060
198       WRITE(99) CURRNCY(FC),MOBS,TPOS,SDATE,EDATE                        2070
199       WRITE(99) ((OPEN(POS,I),I=1,2),(CLOSE(POS,I),I=1,2),NPRD(POS),     2080
200      +                                          POS=1,TPOS)              2090
```

APPENDIX C--Continued

```
****INITIALIZE STATISTICAL REGISTERS USED IN CALCULATING VAR,COV

      DO 410 POS=1,TPOS
        SUMX(POS)=0.
        SUMY(POS)=0.
        SUMY2(POS)=0.
        SUMXY(POS)=0.
410   CONTINUE

      DO 430 POS=1,TPOS
        DO 420 OBS=(BOBS+1),(BOBS-NPRD(POS)),-1
          SUMX(POS)=SUMX(POS)+DEXRATE(1,0,OBS)
          SUMY(POS)=SUMY(POS) + DEXRATE(2,CLOSE(POS,2),OBS)
          SUMY2(POS)=SUMY2(POS) + DEXRATE(2,CLOSE(POS,2),OBS)**2.
          SUMXY(POS)=SUMXY(POS) + DEXRATE(1,0,OBS)*
     +                            DEXRATE(2,CLOSE(POS,2),OBS)
420     CONTINUE
430   CONTINUE

*****************************************************************
*                                                               *
*   DETERMINE RETURNS                                           *
*                                                               *
*****************************************************************

      DO 650 OBS=BOBS,EOBS-1

****CALCULATE Z-STAR
        DO 620 POS=1,TPOS
          ZSTAR(POS)=0.
          RET(1,POS)=-99.
          RET(2,POS)=-99.
          RET(3,POS)=-99.
          IF((OBS+MEDGE(POS,3)).LE.EOBS) THEN
            FNPRD=FLOAT(NPRD(POS))
            COV=SUMXY(POS)/FNPRD-(SUMX(POS)/FNPRD*SUMY(POS)/FNPRD)
            VAR=SUMY2(POS)/FNPRD-(SUMY(POS)/FNPRD)**2.
            ZSTAR(POS)=COV/VAR
******UPDATE ZSTAR FREQUENCY TABLE
            IF(ZSTAR(POS).LT.0.) THEN
              ZFREQ(POS,0)=ZFREQ(POS,0)+1
            ELSE IF(ZSTAR(POS).GE.1.) THEN
              ZFREQ(POS,21)=ZFREQ(POS,21)+1
            ELSE
              DO 610 I=1,20
                IF(ZSTAR(POS).LT.((I-1)*0.05).OR.
     +             ZSTAR(POS).GE.(I*0.05)) GO TO 610
                  ZFREQ(POS,I)=ZFREQ(POS,I) + 1
610           CONTINUE
            ENDIF
620     CONTINUE

****CALCULATE RETURN FOR 3 STRATEGIES
        DO 630 POS=1,TPOS
          IF((OBS+MEDGE(POS,3)).GT.EOBS) GO TO 630
            FOBS=OBS+MEDGE(POS,3)
            RET(1,POS)=ABS(EXRATES(1,MEDGE(POS,2),OBS))/
     +                 ABS(EXRATES(1,2,OBS))-1.
            RET(2,POS)=(ABS(EXRATES(1,0,OBS)) -
     +                  ABS(EXRATES(1,DPAY(POS,2),OBS)) -
     +                  ABS(EXRATES(1,CLOSE(POS,2),FOBS))) /
     +                  ABS(EXRATES(1,0,OBS)) - 1.
            RET(3,POS)=(ABS(EXRATES(1,0,FOBS)) -
     +                  ZSTAR(POS)*ABS(EXRATES(1,DPAY(POS,2),OBS)) -
     +                  ZSTAR(POS)*ABS(EXRATES(1,CLOSE(POS,2),FOBS))) /
     +                  ABS(EXRATES(1,0,OBS)) - 1.
******ADD TO SUMMARY RETURN REGISTERS
            NRET(POS)=NRET(POS)+1
            TOTRET1(POS)=TOTRET1(POS)+RET(1,POS)
            TOTRET1S(POS)=TOTRET1S(POS)+RET(1,POS)**2.
            TOTRET2(POS)=TOTRET2(POS)+RET(2,POS)
            TOTRET2S(POS)=TOTRET2S(POS)+RET(2,POS)**2.
            TOTRET3(POS)=TOTRET3(POS)+RET(3,POS)
            TOTRET3S(POS)=TOTRET2(3,POS)+RET(3,POS)**2.
630     CONTINUE
******WRITE OUT RETURNS
          IF((OBS+MIN0(2).LE.EOBS).THEN
            WRITE(99) OBS,DATE(OBS),((RET(STRY,POS),STRY=1,3),ZSTAR(POS),
     +                                                  POS=1,TPOS)
          ENDIF

****UPDATE STATS REGISTERS USED TO CALCULATE COV & VAR
        DO 640 POS=1,TPOS
        IF((OBS+MEDGE(POS,3)).GT.EOBS) GO TO 640
          SUMX(POS)=SUMX(POS)-DEXRATE(1,0,OBS-NPRD(POS))+
     +                        DEXRATE(1,0,OBS)
          SUMY(POS)=SUMY(POS) - DEXRATE(2,CLOSE(POS,2),OBS-NPRD(POS))
     +                        +DEXRATE(2,CLOSE(POS,2),OBS)
          SUMY2(POS)=SUMY2(POS)-DEXRATE(2,CLOSE(POS,2),OBS-NPRD(POS))
     +                        **2.
     +                        +DEXRATE(2,CLOSE(POS,2),OBS)**2.
          SUMXY(POS)=SUMXY(POS)-(DEXRATE(1,0,OBS-NPRD(POS))*
     +                        DEXRATE(2,CLOSE(POS,2),OBS-NPRD(POS)))
     +                        + (DEXRATE(1,0,OBS)*
     +                        DEXRATE(2,CLOSE(POS,2),OBS))
640     CONTINUE
650   CONTINUE

*****************************************************************
*                                                               *
*   PRINT RETURN SUMMARY                                        *
*                                                               *
*****************************************************************

      WRITE(6,6210) CURRNCY(FC),(STRY,STRY=1,3)
      DO 720 POS=1,TPOS
        DO 710 STRY=1,3
          XBAR(STRY)=TOTRET(STRY,POS)/FLOAT(NRET(POS))
          SD(STRY)=((TOTRET2(STRY,POS)/FLOAT(NRET(POS)))
     +              +((TOTRET(STRY,POS)/FLOAT(NRET(POS)))**2.0))**0.5
710     CONTINUE
        WRITE(6,6220) HEDGE(POS,1),NRET(POS),(XBAR(STRY),SD(STRY),
     +                                        STRY=1,3)
```

APPENDIX C--Continued

```
      720   CONTINUE                                                          3250
            WRITE(6,6230) (HEDGE(POS,1),POS=1,TPOS)                           3260
            WRITE(6,6240) (ZFREQ(POS,0),POS=1,TPOS)                           3270
            DO 730 I=1,20                                                     3280
              WRITE(6,6250)  ((I-1)*0.05),(I*0.05),(ZFREQ(POS,I),POS=1,TPOS)  3290
      730   CONTINUE                                                          3300
            WRITE(6,6260)  (ZFREQ(POS,21),POS=1,TPOS)                         3310
            STOP                                                              3320
                                                                              3330
      6000  FORMAT(' ?')                                                      3340
      6010  FORMAT(' ENTER THE NUMBER OF THE CURRENCY YOU WOULD LIKE',        3350
     +//,'     TO CALCULATE RETURNS FOR:',                                    3360
     +//,10X,I3,3X,A20.                                                      3370
     +//,10X,I3,3X,A20.                                                      3380
     +//,'     ?')                                                           3390
      6020  FORMAT(' YOU MUST ENTER EITHER A "1" OR A "2".',/,' ?')           3400
      6030  FORMAT(' ENTER THE DATE RANGE TO BE USED IN CALCULATING'./.       3410
     +,'     RETURNS(YYMMDD YYMMDD)'./,' ?')                                 3420
      6040  FORMAT('-NUMBER OF OBSERVATIONS READ IN:',I4,/                    3430
     +,'     NUMBER IN SAMPLE:',I4)                                          3440
      6050  FORMAT('-ENTER NUMBER OF HEDGES TO BE FORMED'./.' ?')             3450
      6060  FORMAT(' ***MUST BE LESS THAN 5')                                 3460
      6070  FORMAT('-ENTER THE NUMBER OF DAYS USED TO FORM THE HEDGES'./.     3470
     +,'     (OPEN CLOSE. I.E. 90 60)')                                      3480
      6080  FORMAT(' ***DAYS OPEN MUST BE 30,60,90,180,360'./.               3490
     +,'     PLEASE RE-ENTER')                                               3500
      6090  FORMAT(' ***DAYS CLOSE MUST BE 30,60,90,180'./.                  3510
     +,'     PLEASE RE-ENTER')                                               3520
      6100  FORMAT(' ***HEDGE FORMED MUST BE GREATER THAN 0 DAYS'./.          3530
     +,'     PLEASE RE-ENTER')                                               3540
      6110  FORMAT(' ENTER THE NUMBER OF OBSERVATIONS USED TO ESTABLISH Z-STAR3550
     +')                                                                     3560
      6120  FORMAT('0',I3,' DAYS?')                                           3570
      6210  FORMAT('1                    CURRENCY:  ',A20.                    3580
     +//,18X,3(6X,'STRATEGY',I2,3X)                                          3590
     +//,2X,'POSITION',2X,'N',9X,3('XBAR',8X,'SD',5X))                        3600
      6220  FORMAT(1X,I4,'-DAY',2X,I3,6X,3(F7.4,3X,F7.4,2X))                  3610
      6230  FORMAT('-     Z FREQUENCIES'                                      3620
     +///,'     RANGE',13X,I4,'-DAY',5X,I4,'-DAY',5X,I4,'-DAY',5X,           3630
     +I4,'-DAY'.                                                             3640
     +//)                                                                    3650
      6240  FORMAT('0       < 0.0',11X,I8,5X,I8,5X,I8,5X,I8)                3660
      6250  FORMAT('0',2X,F4.2,' - ',F4.2,9X,I8,5X,I8,5X,I8,5X,I8)          3670
      6260  FORMAT('0       > 1.0',11X,I8,5X,I8,5X,I8,5X,I8)                3680
            END                                                               3690
```

APPENDIX D

LISTING OF PROGRAM TO CALCULATE THE MEASURE OF HEDGING EFFECTIVENESS $\hat{e}$

APPENDIX D

Listing of Program to Calculate the Measure of Hedging Effectiveness ê

```
   PROGRAM EFFECT     74/175  OPT=1,ROUND= A/ S/ M/-D,-DS     FTN 5.1+564          06/01/83
DO=-LONG/-OT,ARG=-COMMON/-FIXED,CS= USER/-FIXED,DB=-TB/-SB/-SL/ ER/-ID/-PMD/-ST,PL=60000
FTN5,I=SETFILE,ET,E=ERRORS.

      1               PROGRAM EFFECT                                                    100
      2         *****************************************************************       110
      3         *                                                               *       120
      4         *     PURPOSE:  MEASURE THE EFFECTIVENESS OF THE THREE HEDGING  *       130
      5         *               STRATEGIES UNDER ALTERNATIVE ALPHA LEVELS.      *       140
      6         *                                                               *       150
      7         *****************************************************************       160
      8                                                                                 170
      9               CHARACTER*14   CURRNCY                                            180
     10               CHARACTER*10    DATE,RDATE                                       190
     11               CHARACTER*7    BDATE,EDATE,OBSDATE                               200
     12               CHARACTER*3    REPHD1,REPHD2,REPHD3                              210
     13               INTEGER        OPEN(4,2),CLOSE(4,2),HEDGE(4,2),NPRD(4),NRET(4)   220
     14               INTEGER        ALVL,MAXLVL,STRY,SOBS,POS,TPOS,LKNT,PAGE          230
     15               REAL           RET(3,4),ZSTAR(4),F(3,4,20),EAB(4),EAC(4),EBC(4)  240
     16               REAL           BEGA,ENDA,DELA,ALPHA,TGTREG                       250
     17               DATA           REPHD1/'A/B'/,REPHD2/'A/C'/,REPHD3/'B/C'/         260
     18                                                                                 270
     19               OPEN(5,FILE='INPUT')                                              280
     20               OPEN(6,FILE='OUTPUT')                                             290
     21               OPEN(7,FILE='REPORT',STATUS='NEW')                                300
     22               OPEN(99,FILE='RETFILE',STATUS='OLD',FORM='UNFORMATTED')           310
     23                                                                                 320
     24               REWIND 99                                                         330
     25                                                                                 340
     26               WRITE(6,6010)                                                     350
     27               READ(5,*) TGTRET                                                  360
     28                                                                                 370
     29               WRITE(6,6020)                                                     380
     30               READ(5,*) BEGA,ENDA,DELA                                          390
     31               MAXLVL=ABS(BEGA-ENDA) / DELA + 1                                  400
     32                                                                                 410
     33               READ(99) CURRNCY,SOBS,TPOS,BDATE,EDATE                            420
     34               READ(99) ((OPEN(POS,I),I=1,2),(CLOSE(POS,I),I=1,2),               430
     35              +                                NPRD(POS),POS=1,TPOS)             440
     36               DO 110 POS=1,TPOS                                                 450
     37                 HEDGE(POS,1)=OPEN(POS,1)-CLOSE(POS,1)                           460
     38          110  CONTINUE                                                          470
     39                                                                                 480
     40               DO 230 ALVL=1,MAXLVL                                              490
     41                 DO 220 POS=1,TPOS                                               500
     42                   DO 210 STRY=1,3                                               510
     43                     F(STRY,POS,ALVL)=0                                          520
     44          210        CONTINUE                                                    530
     45                     NRET(POS)=0                                                 540
     46          220      CONTINUE                                                      550
     47          230    CONTINUE                                                        560
     48                                                                                 570
     49               DO 240 POS=1,TPOS                                                 580
     50                 EBC(POS)=0.                                                     590
     51                 EAC(POS)=0.                                                     600
     52          240    CONTINUE                                                        610
     53                                                                                 620
     54               PAGE=1                                                            630
     55               RDATE=DATE()                                                      640
     56               WRITE(7,7000) RDATE,PAGE,CURRNCY,BDATE,EDATE                      650
     57               LKNT=4                                                            660
     58          300  READ(99,END=399) OBS,OBSDATE,((RET(STRY,POS),STRY=1,3),ZSTAR(POS),670
     59              +                                POS=1,TPOS)                       680
     60                                                                                 690
     61               IF(MOD(LKNT,48).EQ.0) THEN                                        700
     62                 PAGE=PAGE+1                                                     710
     63                 WRITE(7,7000) RDATE,PAGE,CURRNCY,BDATE,EDATE                    720
     64                 LKNT=4                                                          730
     65               END IF                                                            740
     66               WRITE(7,7010) OBS,OBSDATE                                         750
     67               LKNT=LKNT+1                                                       760
     68               DO 305 POS=1,TPOS                                                 770
     69                 WRITE(7,7020) HEDGE(POS,1),NPRD(POS),ZSTAR(POS),(RET(STRY,POS),780
     70              +                                  STRY=1,3)                       790
     71                 LKNT=LKNT+1                                                     800
     72          305    CONTINUE                                                        810
     73                                                                                 820
     74               ALPHA=BEGA-DELA                                                   830
     75               DO 330 ALVL=1,MAXLVL                                              840
     76                 ALPHA=ALPHA + DELA                                              850
     77                 DO 320 POS=1,TPOS                                               860
     78                 IF(RET(1,POS).LE.-1.OR.RET(1,POS).GE.TGTRET) GO TO 320          870
     79                   NRET(POS)=NRET(POS)+1                                         880
     80                   DO 310 STRY=1,3                                               890
     81                   IF(RET(STRY,POS).GE.TGTRET) GO TO 310                         900
     82                     F(STRY,POS,ALVL)=F(STRY,POS,ALVL) +                         910
     83              +                              (ABS(TGTRET-RET(STRY,POS)))**ALPHA  920
     84          310        CONTINUE                                                    930
     85          320      CONTINUE                                                      940
     86          330    CONTINUE                                                        950
     87                                                                                 960
     88               GO TO 300                                                         970
     89                                                                                 980
     90          399  CONTINUE                                                        990
     91                                                                                1000
     92               DO 405 POS=1,TPOS                                                1010
     93                 NRET(POS)=NRET(POS)/MAXLVL                                     1020
     94          405  CONTINUE                                                        1030
     95               WRITE(6,6110) RDATE,CURRNCY,BDATE,EDATE                          1040
     96               WRITE(6,6120) (HEDGE(POS,1),POS=1,TPOS)                          1050
     97               WRITE (6,6125) (NRET(POS),POS=1,TPOS)                            1060
     98               WRITE(6,6130) (REPHD1,REPHD2,REPHD3,POS=1,TPOS)                  1070
     99               ALPHA=BEGA-DELA                                                  1080
    100               DO 420 ALVL=1,MAXLVL                                             1090
```

APPENDIX D--Continued

```
                ALPHA=ALPHA + DELA
                DO 410 POS=1,TPOS
                  EAB(POS)=F(1,POS,ALVL) / F(3,POS,ALVL)
                  EAC(POS)=F(1,POS,ALVL) / F(3,POS,ALVL)
                  EBC(POS)=F(2,POS,ALVL) / F(3,POS,ALVL)
          410   CONTINUE
                WRITE(6,6140) ALPHA,(EAB(POS),EAC(POS),EBC(POS),POS=1,TPOS)
          420   CONTINUE
                STOP
         6010   FORMAT(' ENTER TARGET RETURN ',/,' ?')
         6020   FORMAT('OENTER BEGINNING ALPHA,ENDING ALPHA,DELTA',/,' ?')
         6110   FORMAT('1',T4,A30,T56,'HEDGING EFFECTIVENESS',/,
                +T60,A14,/,T57,A7)
         6120   FORMAT('0',T7,4(10X,I3,'-DAY',14X))
         6125   FORMAT(T7,4('RS',I3,' RETURNS',10X))
         6130   FORMAT('T5,'ALPI',T7,4(3X,A3,7X,A3,5X))
         6140   FORMAT(12X,F5.3,T14,F8.4,2X,F8.4,2X,F8.4,3X))
         7000   FORMAT('1',T3,A30,T37,'RETURNS',T65,'PAGE:',I4,/,
                +T35,A14,T32,A7,' - ',A7,//,
                +T63,'RETURNS',/,
                +T4,'DBS',T11,'DATE',T22,'POSITION',T32,'NPRD',T43,'ZSTAR',T58,'A',
                +T67,'B',T77,'C',/)
         7010   FORMAT(T4,I3,T10,A7)
         7020   FORMAT(T21,I3,' - DAY',T33,I2,T42,F6.4,T51,3(3X,F7.4))
                END
```

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