A New Measure to Compare the Hedging Effectiveness of Foreign Currency Futures Versus Options

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INTRODUCTION

Since 1973, the exchange rates of major currencies have been permitted to float freely against one another. This, along with increases in the volume of world trade, have escalated the foreign currency risk. To effectively manage the currency risk, a variety of approaches have been employed, such as currency swaps, multi-currency diversification, and hedging via forwards, futures, and options. The question now arises whether these hedging instruments provide different degrees of risk reduction and profit/loss potential. This empirical study focuses on the hedging benefits of the currency futures market versus those of the

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currency options market. For the purpose of comparison, a standardized measure is required to evaluate the effectiveness of different hedging instruments.

Previous studies on hedging with futures have provided several alternatives. Those studies were guided by the work of Ederington (1979), who considered only risk reduction in the hedging strategies. Hedging effectiveness was measured by the square of the correlation coefficient between price changes of the spot and that of the futures.[1] Pure risk-avoidance hedging ignores potential tradeoffs between risk and return and is apparently inconsistent with empirical practices. More recently, various studies have developed measures of hedging effectiveness considering both risk and return. Among these studies, Howard and D'Antonio (1984) proposed optimal hedge ratios and effectiveness measures based on the Sharpe index. Chang and Shanker (1986) compared the hedging effectiveness between currency futures and option synthetic futures using a modified measure. However, these optimal hedge ratios derived from optimizing the Sharpe index are often found inapplicable and the associated measures often yield conflicting results.

This study derives a measure of hedging effectiveness based on the rule of expected-utility maximization. A similar approach has been used by Anderson and Danthine (1980), Gjerde (1987), and Cecchetti, Cumby, and Figlewski (1988) to find optimal hedging strategies with futures contracts. Such an approach assumes that the hedger determines the hedge ratios by maximizing his/her expected utility that is completely ordered by a portfolio's mean and variance. Discretionary hedges are thus allowed according to the hedger's risk attitude. The hedging effectiveness is then measured by the difference of the certainty equivalent returns between the hedged position and the spot position. This approach considers both risk and return in hedging and avoids the problems incurred with those measures based on the Sharpe index.

The same optimal hedging criterion should be applied to both currency futures and currency options for comparing their hedging effectiveness. This study therefore uses an option synthetic futures to evaluate the hedging effectiveness of currency options, such that the mean-variance optimization can be implemented for the options

[1]Various studies have examined variance-minimizing hedges also. For example, Junkus and Lee (1985), Toevs and Jacob (1986), and Marmer (1986). Junkus and Lee (1985) and Toevs and Jacob (1986) examined hedge ratios as well, considering both risk and return; however, they did not report the risk-return hedging effectiveness.

as well.[2] The risk-minimizing delta/gamma hedges are retained in the testing, because they are commonly used hedging strategies. These two approaches of hedging with options, as well as hedging with futures contracts, are all evaluated by a new risk-return measure. This study evaluates the ex-ante hedging effectiveness, which is different from the assumption of perfect foresight by some earlier studies [e.g., see Ederington (1979) and Figlewski (1984)]. Only the information available on the hedging day are used to calculate the hedge ratios. Empirical results of the new risk-return measure indicate that the currency futures contract is a better hedging instrument than the currency option, regardless of whether the latter is tested in the form of synthetic futures or in delta/gamma hedges.

The next section explains the weakness of using the Sharpe index to determine hedge ratios and to evaluate the hedging effectiveness. The optimal hedging schemes for currency futures and currency options, respectively, are then discussed and a new hedging effectiveness measure is presented as well. The data required for testing the hedges and the methods for executing optimal hedging are described, and the hedging performance of two securities, currency futures and currency options, are compared based on different hedging schemes over various lengths of hedge periods. The final section summarizes the article.

A CRITIQUE OF THE APPLICATION OF THE SHARPE INDEX TO OPTIMAL HEDGING

Several studies have applied the Sharpe index to find optimal hedge ratios and measures of hedging effectiveness for futures contracts [e.g., Howard and D'Antonio (1984); Chang and Shanker (1986)]. This section discusses the problems associated with their empirical applications. In their study, Howard and D'Antonio (1984) assumed that only mean and variance are relevant in choosing a portfolio and that there is no margin requirement for futures contracts. It follows that the hedged portfolio has an expected return and a standard deviation as below:

$$E(r_H) = [w_S P_S E(r_S) + w_f P_f E(r_f)]/(w_S P_S) \tag{1}$$

$$\sigma_H = (w_S^2 P_S^2 \sigma_S^2 + w_f^2 P_f^2 \sigma_f^2 + 2 w_S w_f P_S P_f \sigma_S \sigma_f \rho)^{1/2}/(w_S P_S) \tag{2}$$

[2] See also Chang and Shanker (1986) for a discussion on the use of option synthetic futures.

where the subscript s denotes the spot currency, f the currency futures, w_i the holdings in currency spot or futures, P_i the currency rate per dollar on the spot or the futures, $E(r_i)$ the expected one-period rate of return, σ_i the standard deviation of return, and ρ the correlation between the returns of the spot and the futures. With an existing position in a spot asset, an investor's one-period optimization problem is then to maximize the Sharpe index of the hedged portfolio Θ_H, i.e.,

$$\underset{w_f}{\text{Max}}\, \Theta_H = (E(r_H) - i)/\sigma_H \tag{3}$$

where i is the domestic risk-free rate. The optimal hedge ratio for the futures contracts (w_f/w_S) can thus be derived from the first order condition of (3). According to their optimal hedging strategies, they suggested a measure of hedging effectiveness, equal to the ratio of the Sharpe index of the hedged position over that of the unhedged spot position, i.e., $HE_{HD} = \Theta_H/\Theta_S$ where Θ_S is the Sharpe index for the spot position. Chang and Shanker (1986) later noted that this measure HE_{HD} is an ambiguous one when Θ_S is negative. Since a negative excess return on the spot $[E(r_S) - i]$, which implies a negative Θ_S, often occurs in practice, they developed an alternative measure based also on the basis of Sharpe index. Their measure is $HE_{CS} = (\Theta_H - \Theta_S)/|\Theta_S|$ which they claimed to correct the inconsistency of HE_{HD}. For the same purpose, Howard and D'Antonio (1987) proposed another similar measure, i.e., $HE_{HD2} = \Theta_H - \Theta_S$.

These studies, however, failed to note that the inconsistency of HE_{HD} actually originates from the use of the Sharpe index Θ and cannot be corrected by either HE_{CS} or HE_{HD2}. First, the Sharpe index is a proper measure of portfolio performance only when $[E(r_S) - i]$ and $[E(r_H) - i]$ are positive, and should not be used as an optimization criterion or an effectiveness measure if excess returns are negative. Nonetheless, negative excess returns (ex-ante and ex-post) are common in foreign currency trading and unavoidable in the situations of currency hedging.[5] Second, empirical currency data often violate the second order

[5]Foreign currencies with negative ex-ante returns may still be held by investors. The market may expect negative returns on foreign currencies in response to, for example, anticipation of increases/decreases in foreign/domestic interest rates, adverse economic conditions, or political crisis. Nonetheless, some investors may inevitably include those currencies with negative ex-ante returns as a part of their portfolios. In practice, foreign trade is indeed a portfolio of positions in foreign currencies and other assets. If the entire portfolio of foreign trade is expected to yield positive excess returns, positive positions in the foreign currencies may still be assumed regardless of the expected changes in the foreign currencies. Meanwhile, the choice of positions in foreign currencies cannot simply be replaced with holding a risk free asset in the case of foreign trade. See Hammer (1988) for more discussions on negative expected returns on foreign currencies.

condition (SOC) of the maximization of Θ_H in eq. (3), regardless of the sign of $[E(r_S) - i]$. Although Chang and Shanker correctly indicated that a positive $[E(r_S) - i]$ is not required to satisfy the SOC, a positive $[E(r_S) - i]$ does not guarantee the SOC to hold either. One can easily find examples showing that the SOC could be violated either when both $[E(r_S) - i]$ and $E(r_f)$ are positive or when both are negative.[4] In fact, violations of the SOC are found frequently in the sampled currency data.

OPTIMAL HEDGING SCHEMES AND A NEW HEDGING EFFECTIVENESS MEASURE

Hedging with Futures

This study assumes that the hedger has a negative exponential utility function with constant absolute risk aversion [ARA: Pratt (1964)] and determines optimal hedging strategies by maximizing his/her expected utility. Under the assumption of normally distributed returns of investment, the expected utility function is continuous, strictly concave, increasing in expected return and decreasing in risk. In particular, all portfolios can be ordered in terms of their mean and variance of returns. A monotone increasing function, $V(E(r), \sigma; A)$, of the expected utility then exists and can be used to determine optimal hedge ratios for currency futures.[5] That is, the assumptions of an exponential utility function and normal returns reduce the approach of expected utility maximization to mean variance analysis with a linear, additive function, $V(E(r), \sigma; A)$. Assuming a zero margin requirement for the futures contracts and a fixed positive position in the currency spot, the hedged portfolio has an expected return and a standard deviation as specified in (1) and (2), respectively. The optimal hedging is then achieved by

$$\max_{w_f} V(E(r), \sigma; A) = E(r_H) - 0.5 \cdot A \cdot \sigma_H^2 \tag{4}$$

[4] To illustrate this point, the SOC for eq. (3) of Howard and D'Antonio (1987) is rewritten as: $E(r_f) < [E(r_S) - i] \cdot k$. Here k is equal to $[\sigma_f/\sigma_S - \rho]$ and can be reasonably assumed positive. One can now easily find examples showing that the SOC could be violated either when both $[E(r_S) - i]$ and $E(r_f)$ are positive or when both are negative. If the SOC does not hold, the optimal futures position is infinite under the assumption of a zero margin requirement.

[5] For a negative exponential utility function $u(r, A) = -\exp(-A \cdot r)$, the corresponding expected utility function is $E[u(r); A] = U(E(r), \sigma; A) = -\exp(-A \cdot V)$, where A is the ARA coefficient. The function $V(E(r), \sigma; A)$, which is equal to $[E(r_H) - 0.5 \cdot A \cdot \sigma_H^2]$, is a monotone increasing function of the expected utility. Maximizing the expected utility function U is equivalent to maximizing the function V. Indifference curves can be obtained also by setting $V(E(r), \sigma; A)$ equal to a constant. The intersection of a given indifference curve and the axis of the expected return is the certainty equivalent rate of return for any position on that indifference curve.

where A is the ARA coefficient, and all other notations are according to the specifications in the preceding section. The decision variable w_f in eq. (4) can be rewritten as $(w_S \cdot b)$, where b is the hedge ratio. The optimal hedge ratio b^* can then be derived from the first order condition of (4), and one obtains:

$$b^* = (P_S/P_f) \cdot [E(r_f)/(A \cdot \sigma_f^2) - \rho \cdot \sigma_S/\sigma_f] \tag{5}$$

That is, the optimal hedge portfolio should include units of futures contracts $w_f^* = w_S \cdot b^*$ in order to hedge a given position in the spot currency w_S.[6] Note that $E(r_S)$ does not enter the optimal hedging decision. This optimal hedge allows an investor's subjective marginal rate of substitution between risk and return equal to the marginal rate of transformation of the hedged portfolio. The second order condition (SOC) for the maximization in (4) is

$$-A \cdot [P_f^2/P_S^2 \cdot \sigma_f^2] < 0 \tag{6}$$

It is obvious that the SOC is satisfied as long as the constant ARA coefficient (A) is positive, which is the case for any risk averse investor.

As shown in eq. (5), the optimal hedge ratio b^* changes with the ARA coefficient (A). For an extremely risk averse investor with an ARA approaching infinity, the optimal hedge ratio b^* then reduces to $-(P_S/P_f) \cdot (\sigma_S/\sigma_f^2)$. This is exactly the same optimal hedge ratio when the risk-reduction is the only objective [see Ederington (1979)]. Taking the derivative of b^* relative to A, one obtains:

$$\partial b^*/\partial A = -1/A^2[(P_S/P_f) \cdot E(r_f)/\sigma_f^2] \tag{7}$$

which has the opposite sign of $E(r_f)$. This implies that if the currency futures price is expected to increase (decrease), the less risk-averse investors will use fewer (more) futures contracts to hedge a given spot position than will the more risk-averse investors.

[6] The following example helps explain the concerns regarding the assumption that the futures price is an unbiased predictor of the expected future spot rate. Suppose that the current futures price represents an unbiased predictor of the expected spot rate upon the delivery of the futures, and that the futures contracts are held until the delivery date. Then, the expected return of the futures price equals zero, i.e., $E(r_f) = 0$. Under this condition, the optimal hedge ratio b^* in (5) reduces to $-(P_S/P_f) \cdot (\sigma_S/\sigma_f^2)$, which is actually the optimal ratio when risk is the only concern. Moreover, the expected hedge return equals the expected return for the spot with $E(r_f) = 0$. That is, the expected return on the hedge is independent of the hedge ratio for the futures contract. This empirical study does assume that $E(r_f)$ is equal to zero for the following reasons: (i) Under the condition that $E(r_f)$ equals zero, the evaluation of the hedge is limited to its risk reduction and one cannot consider its effects on the expected return. (ii) This study is an empirical testing of hedging effectiveness. Whether the futures price is an unbiased predictor of the future spot price is left as an empirical issue.

Hedging with Options

This study uses two approaches to evaluate the hedging effectiveness of the currency options market. The first approach combines currency options into synthetic futures, and these synthetic futures are then used to hedge a currency spot position. The second approach examines the effectiveness of delta hedging and delta + gamma hedging with currency options.

Hedging with Option Synthetic Futures

An option synthetic futures can be formed by having a long position in an European call, a short position in an European put, and an investment in a risk-free asset. The option synthetic futures yields the same contingent cash flows as does a traded futures contract [see Giddy (1983); Cox and Rubinstein (1985); Chang and Shanker (1986)].[7] In an option synthetic futures, the call and the put should have the same exercise price K, and the same time to expiration T. The expiration date of the options also becomes the delivery date of the synthetic futures. With no initial investment required for holding a futures contract, the price of the synthetic futures, P_f^*, is

$$P_f^* = (C - P) \cdot \exp(i \cdot T) + K \tag{8}$$

The optimal hedge ratio for the synthetic futures is then determined from eq. (5) by replacing the futures price P_f with P_f^*.

It serves two purposes to use option synthetic futures for evaluating the hedging effectiveness of currency options. First, option synthetic futures allows one to implement the optimal risk-return hedging criterion in eq. (4) for the options. It follows that the options and the futures contracts are compared with each other in terms of the same optimal hedging criterion. By contrast, the delta/gamma hedges consider risk minimization only, as will be discussed below. Second, now that a combination of options (as formed into synthetic futures) is able to simulate the cash flows of a futures contract, an empirical comparison

[7]However, there are empirical limitations that do not allow the formation of an option synthetic futures that generates exact, contingent cashflows of a given, existing futures contract; namely, (i) the use of American options, instead of European options, to form an option synthetic futures; (ii) the data for the call and the put combined in one synthetic futures are not synchronized; and (iii) the specifications of the delivery terms and delivery dates are not the same for the options market (therefore, the option synthetic futures) and for the futures market. Other factors, such as the difference in the margin requirements in these two markets, also cause the divergence of the cashflows of the existing futures contracts from those of the option synthetic futures in this study.

of hedging effectiveness between these two will then indicate whether the existing futures contracts can be replaced by the options for the purpose of foreign currency hedging. Since this study uses American options to form synthetic futures, one has to assume an insignificant early-exercise premium for the options for the synthetic futures to be equal substitutes for the traded futures contracts.

Hedging Based on Continuous Pricing Models—Delta/Gamma Hedges

Pricing models for European currency options have been derived by Biger and Hull (1983), Garman and Kohlhagen (1983), and Grabbe (1983) under the assumption of a geometric brownian motion for the underlying foreign currency exchange rates.[8] For American options, the early exercise premium should be considered in estimating the hedge ratios. Various numerical methods and approximations can be used to calculate the prices for American currency options [e.g., see Cox, Ross, and Rubinstein (1979); Courtadon (1982); Geske and Johnson (1984), Barone-Adesi and Whaley (1987); Shastri and Tandon (1987)]. This study uses the solutions for European options by Biger and Hull (1983) and then implements the analytic approximation by Barone-Adesi and Whaley (1987); to find the American currency option prices and their derivatives relative to the currency rates.

Both delta and delta + gamma hedging with currency options are examined here [see Hull and White (1987)]. First, delta hedging is designed to make the changes in the hedge value independent of the changes in the spot currency rates. An ideal delta hedge can only be achieved if the assumptions for the option pricing model prevail empirically and the hedge ratios can be adjusted continuously.[9] Denote S as the spot currency rate, and C and P the prices of American call and put options, respectively. Given a holding in a foreign currency, w_S, a delta hedge then includes a holding in a call option, $w_C = [-w_S/(\partial C/\partial S)]$, or a holding in a put option, $w_P = [-w_S/(\partial P/\partial S)]$. Next, gamma hedging takes into account the changes of the hedge

[8] Biger and Hull (1983) and Garman and Kohlhagen (1983) assumed constant domestic and foreign interest rates. Grabbe (1983) extended the analysis to value European options when both domestic and foreign pure discount bond prices follow a brownian motion. His closed-form solutions are similar to those obtained by the other two studies. However, Grabbe ignored the fact that the assumed stochastic process for bond prices is inconsistent with the fact that the price of the pure discount bond approaches par value as it approaches maturity.

[9] The assumptions include: the spot currency follows a geometric brownian motion, the interest rates are non stochastic, and the instantaneous volatility is constant

ratios in the delta hedging. The delta + gamma hedge then requires holdings in two different options to hedge a fixed spot position. If one denotes w_1 and w_2 as the holdings in these two options; then, in the delta + gamma hedge, $w_1 = [w_S/(g_2/g_1 \cdot e_1 - e_2)]$ and $w_2 = [w_S/(g_1/g_2 \cdot e_2 - e_1)]$ Here, e_1 and e_2 denote the first derivatives of the two option prices relative to the spot currency, and g_1 and g_2 the second derivatives. These derivatives can be calculated easily from the equations provided in Biger and Hull and the procedures described in Barone-Adesi and Whaley.[10]

A New Measure of Hedging Effectiveness

Ederington (1979) proposed a risk-only hedging effectiveness measure, which has been applied frequently in studies on hedging with futures. This measure is

$$HE_0 = 1. - (\sigma_H^2/\sigma_S^2) \tag{9}$$

HE_0 measures the proportion of risk that has been hedged away and ignores the impacts on portfolio returns due to hedging. Alternatively, Gjerde (1987) derived a measure of hedging effectiveness, HE_G, with the optimal hedge determined by maximizing an expected utility function. However, HE_G suffers inconsistencies when the return on the initial spot position $E(r_S)$ is negative. This problem can be corrected by the following effectiveness measure HE^*.[11]

As described earlier in this section, the hedgers are assumed to make their optimal hedging decisions by maximizing their mean-variance dependent expected utilities. The hedging effectiveness is therefore measured by the change of the certainty equivalent returns relative to the spot position. That is, for investors with an ARA coefficient equal

[10] Equations of these derivatives are available upon request from the authors.

[11] In the study by Gjerde, for each optimal hedge position, a preference-equivalent position (P) can be found with the same risk as the initial cash position (S). Then, the hedging effectiveness, HE_G, is measured by the ratio of the expected payoffs of the preference-equivalent position of the optimal hedge and the initial spot position, namely, $HE_G = [E(r_P)/E(r_S)]$. If the return on the initial spot position $E(r_S)$ is negative, a hedged position giving greater utilities turns out to have a lower value in the measure. In contrast to HE_G, HE^* is actually equivalent to the difference between the expected payoff of the preference-equivalent position and that of the initial spot position, namely, $HE^* = E(r_P) - E(r_S)$. Following the definition of "preference-equivalent position" from Gjerde, one obtains $V(E(r_P), \sigma_P; A) = V(E(r_H), \sigma_H; A), \sigma_P = \sigma_S$, and thus $E(r_P) - E(r_H) = 0.5 \cdot A \cdot (\sigma_H^2 - \sigma_S^2)$. Since a utility function with constant ARA coefficient is assumed, simple algebra can show that $HE^* = E(r_P) - E(r_S)$. HE^* accommodates either positive or negative $E(r_S)$, and corrects the inconsistencies of HE_G.

to A_o, the measure is defined as

$$
\begin{aligned}
HE^* &= V(E(r_H), \sigma_H; A_o) - V(E(r_S), \sigma_S; A_o) \\
&= V(r_H^{ce}, 0; A_o) - V(r_S^{ce}, 0; A_o) \\
&= r_H^{ce} - r_S^{ce}
\end{aligned}
\tag{10}
$$

where r_H^{ce} and r_S^{ce} denote the certainty equivalent returns of the hedged position H and the spot position S, respectively. The advantages of this measure are that it considers both risk and expected returns and that it is a consistent measure regardless of the empirical expected changes in spot exchange rates, unlike those measures based on the Sharpe index. A positive value of HE^* means the hedging is effective, while a negative value indicates a reduction in certainty equivalent returns and an ineffective hedging strategy. Both HE_o and HE^* are employed to evaluate hedging effectiveness in this study. Note that those hedges scoring higher in HE_o may not score as well in HE^*, because HE_o considers risk-reduction only.

DATA AND ESTIMATION OF THE OPTIMAL HEDGES

Data

The tests are based on the market data of four currencies: British Pound, deutsche mark, Japanese Yen, and Swiss Franc. The data consist of daily prices for currency futures traded on the Chicago Mercantile Exchange (CME) and for American currency options traded on the Philadelphia Stock Exchange (PHLX). This sample covers the period from January 1986–December 1989. The currency futures data are obtained from the Yearbook of the International Monetary Market of the CME. The currency options data are from the PHLX. All quotes are closing prices. Only data with less than 200 days to maturity are used for both the options and the futures. Those options being too deep-in-the-money or out-of-the-money are excluded from this sample.[12]

The tests also require daily interest rates and spot currency rates. Daily interest rates on one-month T-bills are collected from the *Wall Street Journal*. Foreign currency interest rates are derived from spot currency rates and one-month forward rates, assuming interest rate

[12]Options with the ratio of exercise price over spot price greater than 1.15 or less than 0.85 are excluded.

parity. Both the spot currency rates and the forward rates are obtained from the Yearbook of the IMM.

Estimation of the Optimal Hedges

This study tests the hedges held over various length of periods, 14, 30, 60, 90, and 120 calendar days. Hedges of different durations are initiated on each trading day. Upon the initiation of a hedge, the hedger chooses the futures contract (or the options) with the time to delivery (expiration) closest to the target hedge duration.[13] Table I lists the numbers of sample hedges for hedging with futures, hedging with option synthetic futures, and delta/gamma hedging. The optimal hedge ratios for futures contracts are calculated by eq. (5), which requires estimates for $(E(r_f), \sigma_S, \sigma_f, \rho)$. Some earlier studies [e.g., Ederington (1979); Howard and D'Antonio (1984); Chang and Shanker (1986)] assumed perfect foresight on spot prices and futures prices and formed ex-post optimal hedges. By contrast, this study uses ex-ante estimates to find the optimal hedge ratios. Assuming that daily returns on the spot and the futures are independently and identically distributed over time, the ex-ante estimates for $(E(r_f), \sigma_S, \sigma_f, \rho)$ are calculated from the prices over the 50 trading days preceding the hedging day for each time a hedge is placed.[14] For hedging with options, two different types of hedges are tested. First, a call and a put are selected, combined with a risk-free T-Bills, to form an option synthetic futures. The price of the option synthetic futures is determined according to eq. (8). Its hedge ratio is calculated according to eq. (5), by replacing the ex-ante estimates for futures contracts with those for the synthetic futures. Next, for the delta and delta + gamma hedges, calculations of these hedge ratios require estimates for the standard deviations of spot currency returns. Daily weighted implied standard deviations (WISD) are computed for this purpose. The daily implied standard deviations (ISD) are first calculated for each option by setting its market price equal to the model price. The ISD's are then weighted averaged over different options, with the greatest weight assigned to at-the-money options.

[13] A new hedge is placed on each trading day, and different portfolios are overlapped over the entire sample period. This approach does not restrict the hedgers to closing their positions exactly on the maturity date of the options/futures and increases the number of sample hedges.

[14] The sample size, 50 trading days, is a compromise in an effort to avoid the lightly traded data and having an adequate sample size. For example, in order to obtain the ex-ante estimates for a 120-day hedge, one has to use the options/futures data with more than 190 days to maturity. Those trading days with maturities longer than 190 days usually have very small trading volumes. After some experimentation, 50 trading days are determined to be effective.

TABLE I
Numbers of Observed Hedged Portfolios of Different Hedge Periods

	14-day	*30-day*	*60-day*	*90-day*	*120-day*
A. British pound					
Futures[a]	987	976	955	922	781
Opt-syn-fut[b]	573	411	241	123	54
Delta-hedge[c]	770	724	614	476	291
B. Deutsche mark					
Futures	989	978	957	936	838
Opt-syn-fut	832	753	543	349	151
Delta hedge	890	875	842	734	473
C. Japanese yen					
Futures	990	979	958	937	843
Opt-syn-fut	766	608	346	168	73
Delta-hedge	890	868	800	619	335
D. Swiss franc					
Futures	987	976	955	934	826
Option-syn	618	454	223	117	50
Delta-hedge	828	766	668	508	286

[a] Number of observed hedges formed with futures contracts.
[b] Number of observed hedges formed with option synthetic futures.
[c] Number of observed positions for delta and gamma hedging with options.

This test uses two strategies to determine the daily hedge ratios for all the hedges. In the first strategy, each hedged portfolio is rebalanced daily. That is, the optimal hedge ratios are recalculated according to the changing security prices and estimates of expectations. At the end of each day, the portfolio is liquidated and any capital gain/loss is then reinvested in the newly rebalanced portfolio. Second, in the buy-and-hold strategy, the hedge ratio is determined on the first day of the hedging period and the hedgers do not adjust the ratio thereafter.

AN EVALUATION OF THE HEDGES WITH FUTURES AND OPTIONS

This section compares the empirical hedging benefits between the currency futures market and the currency options market. Also discussed are the impacts on the hedges from factors such as rebalancing of the hedges and investors' risk attitude. An ARA coefficient of 2.0 is selected to determine the optimal hedge ratios for the futures contracts and the option synthetic futures.[15] This ARA coefficient, however, does not

[15] Various studies, taking into account the full range of available assets, place the coefficient of ARA for the representative investor in the range of 2.0–4.0; for example, see Friend and Blume (1975), Grossman and Shiller (1981).

affect the compositions of delta and delta + gamma hedges. Average hedge ratios for these hedges are presented in Table II. It shows that the hedge ratios for the futures contracts and for the option synthetic futures range from -0.89 to -0.96, which are less than the ratio of a full hedge (a ratio equal to -1). Such less-than-unity hedge ratios have been reported in previous studies on hedging with futures contracts [e.g., see Kamara and Siegel (1987); Cecchetti, Cumby, and Figlewski (1988)].

Table III reports the summary statistics for the rates of returns on the spots and on the hedges. The means and standard deviations of returns are annualized, and represent the average results over the entire sample period. They indicate that, on average, hedging has significantly reduced the currency risk while yielding lower mean returns for all four currencies. This decrease in mean returns can be considered as a cost of currency hedging. At the same time, this study also finds that during some sub-sample periods, hedging increases the mean returns while reducing the risk of the positions (e.g., the hedges for deutsche mark

TABLE II

Average Hedge Ratios for Futures, Option Synthetic Futures, and Delta Hedging[a]

	14-day	*30-day*	*60-day*	*90-day*	*120-day*
A. British pound					
Futures[b]	0.9076	0.9059	0.9057	0.9044	0.9035
Opt-syn-fut[c]	0.9369	0.9365	0.9409	0.9267	0.9251
Delta (call)[d]	3.2090	-3.0740	2.9900	2.9760	3.0800
Delta (fut)[e]	2.8430	2.6250	2.5620	2.6520	2.6850
B. Deutsche mark					
Futures	0.9161	0.9158	0.9153	0.9119	0.9116
Syn-futures	0.9450	0.9481	0.9480	-0.9490	0.9558
Delta (call)	2.9820	2.8350	2.7990	2.6270	2.5510
Delta (fut)	3.8860	3.4330	3.3720	3.2130	3.0850
C. Japanese yen					
Futures	0.9068	0.9047	0.9010	0.8950	0.8924
Syn-futures	0.9431	0.9395	0.9452	0.9586	0.9545
Delta (call)	3.2390	2.9530	2.7400	-2.6570	2.5000
Delta (fut)	3.6560	3.4610	3.7390	4.0060	3.7750
D. Swiss franc					
Futures	0.9212	-0.9200	0.9174	0.9138	0.9160
Syn-futures	0.9535	-0.9519	0.9449	0.9332	0.9140
Delta (call)	3.3540	3.2610	3.0110	2.8390	2.6870
Delta (fut)	3.0100	2.8920	3.0600	2.8700	2.7470

[a]Numbers shown are hedge ratios with a given positive position in spot currency. Ex ante estimates are used. The coefficient of absolute risk aversion is chosen to be 2.0.

[b]Average optimal hedge ratios for futures contracts.

[c]Average optimal hedge ratios for option synthetic futures.

[d]Average hedge ratios in delta hedging for call options given one position in spot.

[e]Average hedge ratios in delta hedging for put options given one position in spot.

TABLE III

Comparisons of Returns and Risk of Spot and Hedges[a]

	14-day			30-day			60-day			90-day			120-day		
	Mean	σ	% > 0	*Mean*	σ	% > 0	*Mean*	σ	% > 0	*Mean*	σ	% > 0	*Mean*	σ	% > 0
A. British pound															
Spot[b]	0.0278	0.5675	51.57	0.0292	0.3986	49.49	0.0273	0.2861	52.15	0.0259	0.2402	52.28	0.0119	0.2041	53.39
Hedge-fut	0.0158	0.0874	40.02	0.0162	0.0544	36.07	−0.0157	0.0352	27.96	0.0146	0.0277	26.68	0.0148	0.0230	24.71
Hedge-OSF[c]	0.0134	0.0636	32.64	0.0182	0.0430	22.63	−0.0230	0.0273	12.45	0.0227	0.0214	11.38	−0.0252	0.0165	3.70
Delta[d]	0.0341	0.1177	33.77	0.0364	0.0854	30.39	−0.0302	0.0704	31.60	0.0246	0.0688	33.40	0.0325	0.0630	26.46
Dlt+Gma[e]	0.0159	0.3952	41.43	0.0022	0.3056	42.40	0.0391	0.2116	50.49	0.0282	0.1639	50.63	0.0344	0.1562	53.95
B. Deutsche mark															
Spot	0.0916	0.6090	53.38	0.0863	0.4290	56.75	0.0745	0.2902	59.56	0.0689	0.2384	61.22	0.0596	0.2004	59.43
Hedge-fut	0.0464	0.0733	77.15	0.0450	0.0470	86.81	0.0417	0.0290	95.40	0.0403	0.0226	98.82	0.0396	0.0170	99.28
Hedge-OSF	0.0379	0.0493	86.78	0.0354	0.0340	92.30	0.0306	0.0244	95.95	0.0292	0.0210	97.99	0.0284	0.0175	96.68
Delta	0.0268	0.0698	69.89	0.0220	0.0529	69.03	0.0233	0.0466	70.31	0.0216	0.0468	70.98	0.0193	0.0419	70.61
Dlt+Gma	0.0266	0.2816	53.03	0.0464	0.2093	58.17	0.0500	0.1728	64.37	0.0607	0.1665	70.30	0.0511	0.1449	67.44
Japanese yen															
Spot	0.0877	0.6152	52.93	0.0846	0.4487	52.50	0.0756	0.3170	57.31	0.0717	0.2582	58.70	0.0654	0.2253	58.36
Hedge-fut	0.0442	0.0763	74.04	0.0440	0.0505	83.04	0.0437	0.0380	90.19	0.0434	0.0315	92.96	0.0440	0.0257	98.22
Hedge-OSF	0.0474	0.0637	84.20	0.0397	0.0437	89.97	0.0318	0.0307	91.33	0.0252	0.0198	92.86	0.0205	0.0145	91.78
Delta	0.0180	0.1238	64.04	0.0230	0.0997	66.24	0.0236	0.0849	66.50	0.0161	0.0851	65.75	0.0121	0.0694	62.39
Dlt+Gma	0.0598	0.3104	56.63	0.0615	0.2396	60.48	0.0659	0.2134	67.38	0.0602	0.2140	66.88	0.0527	0.1868	68.66
D. Swiss franc															
Spot	0.0752	0.6653	50.46	0.0705	0.4654	52.05	0.0598	0.3258	57.70	0.0554	0.2693	56.42	0.0413	0.2276	56.66
Hedge-fut	0.0491	0.0859	75.08	0.0478	0.0524	84.32	0.0459	0.0335	93.72	0.0453	0.0275	97.64	0.0448	0.0217	99.52
Hedge-OSF	0.0526	0.0834	81.88	0.0414	0.0506	87.67	0.0308	0.0288	89.69	0.0293	0.0230	94.02	0.0264	0.0147	98.00
Delta	0.0367	0.1448	69.32	0.0195	0.1093	68.67	0.0229	0.0880	72.16	0.0258	0.0786	72.05	0.0285	0.0807	75.17
Dlt+Gma	0.0786	0.3961	58.21	0.1026	0.3813	61.49	0.0940	0.2290	71.86	0.0846	0.1766	74.41	0.0907	0.1800	76.57

[a]The coefficient of absolute risk aversion is assumed to be 2.0. Mean and standard deviations are annualized. Hedges are daily rebalanced.
[b]Hedging effectiveness of hedges with currency futures contracts.
[c]Hedging effectiveness of hedges using option synthetic futures.
[d]Hedging effectiveness of delta hedge with currency options.
[e]Hedging effectiveness of delta-plus-gamma hedge with currency options.

in 1988). Table III also shows that with the exception of the hedges for British Pound, all the hedging strategies have significantly increased the percentages of positions with positive returns. In particular, hedging with futures and with option synthetic futures improves the percentages from less than 60% of the sample spot positions to more than 90% of the hedged positions for all the hedges held over 60 days.

A standardized measure is required to compare the diverse patterns of hedging effects shown in Table III. Two measures of hedging effectiveness are calculated here for this purpose. The traditional measure, HE_0, assesses the degree of risk-reduction only. HE^*, a more comprehensive measure, considers the hedging effects on both risk and return. Table IV reports the ex-ante measures for the hedges with daily rebalancing, and Table V reports those with the buy-and-hold strategy. Listed are the average values calculated over the entire sample period.

Evaluation of the Hedges with HE_0 and HE^*

The HE_0 results for hedging with daily rebalancing (as reported in Table IV) are discussed first. These values indicate that option synthetic futures offer similar risk reduction as do the traded futures contracts for all currencies. Both hedges provide significant risk reduction, with HE_0 ranging from 0.97 to 0.99 (or 97%–99%).[16] On the other hand, the HE_0 values for delta hedges vary between 0.74 and 0.98; and those for the delta + gamma hedges are worse and more erratic, with values ranging from −0.31 to 0.68. These results for delta and delta + gamma hedges are inconsistent with the following suppositions. First, since delta + gamma hedging further considers the dynamics of the delta value, it is expected to offer more risk-reduction than delta hedging alone. Second, the delta/gamma hedges are designed to minimize risk, while the hedges with option synthetic futures are derived to compromise between risk and return. Therefore, the delta/gamma hedges are expected to reduce more risk than the hedges with synthetic futures. The unexpected empirical results may be explained by the following: (i) The continuous time option pricing model may be misspecified. As a result, the derived hedge ratios cannot achieve the objective of risk-minimization. Previous studies on American currency options found that the constant volatility pricing model does not perform well [e.g., see Bodurtha and Courtadon (1987);

[16]One exception occurs with the Swiss Franc, where the performance of option synthetic futures declines slightly when the hedge period is long. This may be caused by an insufficient number of hedges for Swiss Francs for this group.

TABLE IV

Hedging Effectiveness of Foreign Currency Futures and Options (ARA = 2.0) - Daily-Rebalanced[a]

	HE_0					HE^*				
	14-Day	*30-Day*	*60-Day*	*90-Day*	*120-Day*	*14-Day*	*30-Day*	*60-Day*	*90-Day*	*120-Day*
A. British pound										
Futures[b]	0.9763	0.9813	0.9848	0.9867	0.9873	0.2708	0.1106	0.0376	0.0165	0.0145
Opt-syn-fut[c]	0.9789	0.9763	0.9752	0.9808	0.9843	0.1635	0.0541	0.0025	0.0037	0.0034
Delta[d]	0.9295	0.9224	0.8933	0.8669	0.8540	0.1128	0.0113	0.0323	0.0277	0.0311
Delta+gamma[e]	0.2050	0.0065	0.0359	0.2448	0.1027	0.0114	0.0362	0.0028	0.0030	0.0154
B. Deutsche mark										
Futures	0.9855	0.9880	0.9900	0.9910	0.9928	0.3202	0.1405	0.0506	0.0278	0.0198
Opt-syn-fut	0.9906	0.9902	0.9671	0.9826	0.9844	0.2099	0.0637	0.0146	-0.0455	0.0455
Delta	0.9823	0.9798	0.9654	0.9474	0.9409	0.1926	0.0618	0.0018	0.0129	0.0371
Delta+gamma	0.7117	0.6838	0.5245	0.3345	0.2928	0.1180	0.0452	0.0008	0.0006	-0.0245
C. Japanese yen										
Futures	0.9846	0.9873	0.9866	0.9851	0.9870	0.3292	0.1582	0.0671	0.0375	0.0268
Opt-syn-fut	0.9843	0.9835	0.9817	0.9853	0.9852	0.2195	0.0627	0.0264	0.0220	0.0233
Delta	0.9421	0.9266	0.9026	0.8555	0.8587	0.1776	0.0685	0.0172	0.0156	0.0148
Delta+gamma	0.6360	0.5878	0.3849	0.0865	0.0240	0.1386	0.0596	0.0212	0.0101	0.0043
D. Swiss franc										
Futures	0.9833	0.9873	0.9894	0.9896	0.9909	0.4092	0.1911	0.0911	0.0616	0.0549
Opt-syn-fut	0.9747	0.9787	0.9800	0.9536	0.9471	0.2267	0.0926	0.0379	0.0043	0.0042
Delta	0.9298	0.9225	0.8903	0.8314	0.7375	0.2170	0.0537	0.0048	0.0562	0.0727
Delta+gamma	0.4745	0.0563	0.2572	0.1487	0.3061	0.1216	0.0034	0.0216	0.0225	-0.0364

[a] The coefficient of absolute risk aversion is chosen to be 2.0. Hedges are daily rebalanced.

[b] Hedging effectiveness of hedges with currency futures contracts.

[c] Hedging effectiveness of hedges using option synthetic futures.

[d] Hedging effectiveness of delta hedge with currency options.

[e] Hedging effectiveness of delta-plus-gamma hedge with currency options.

TABLE V

Hedging Effectiveness of Foreign Currency Futures and Options (ARA = 2.0) - Buy-and-Hold[a]

	HE_t					HE_t^*				
	14-Day	*30-Day*	*60-Day*	*90-Day*	*120-Day*	*14-Day*	*30-Day*	*60-Day*	*90-Day*	*120-Day*
A. British pound										
Futures[b]	0.9766	0.9815	0.9848	0.9861	0.9869	0.2720	0.1099	0.0327	0.0091	0.0067
Opt-syn-fut[c]	0.9791	0.9763	0.9754	0.9814	0.9846	0.1640	0.0547	0.0030	0.0031	0.0036
Delta[d]	0.8079	0.5205	0.0441	0.2767	1.1095	0.0743	0.0462	0.0952	0.0974	0.1113
Delta+gamma[e]	0.3706	-0.0900	0.3816	0.3956	0.3444	0.0663	0.0169	0.0099	0.0100	0.0310
B. Deutsche mark										
Futures	0.9857	0.9889	0.9910	0.9907	0.9922	0.3205	0.1400	0.0489	0.0256	0.0176
Opt-syn-fut	0.9905	0.9901	0.9873	0.9831	0.9873	0.2094	0.0629	0.0157	0.0467	0.0482
Delta	0.9444	0.7524	0.6386	0.5091	0.6685	0.1745	0.0174	0.0294	-0.0311	-0.0431
Delta+gamma	0.6462	0.4592	0.2096	0.1380	0.0023	0.1148	0.0231	0.0084	0.0304	-0.0502
C. Japanese yen										
Futures	0.9843	0.9873	0.9848	0.9822	0.9839	0.3294	0.1584	0.0661	0.0353	0.0262
Opt-syn-fut	0.9840	0.9829	0.9811	0.9850	0.9841	0.2200	0.0633	0.0267	0.0224	0.0239
Delta	0.8060	0.2529	0.1003	0.7821	0.4988	0.1423	0.0424	-0.0631	-0.1152	-0.0818
Delta+gamma	0.6979	0.5081	0.2136	0.0018	0.2929	0.1644	0.0418	0.0021	-0.0221	-0.0053
D. Swiss franc										
Futures	0.9833	0.9882	0.9904	0.9892	0.9909	0.4100	0.1910	0.0893	0.0592	0.0517
Opt-syn-fut	0.9744	0.9784	0.9796	0.9522	0.9467	0.2269	0.0921	0.0368	0.0033	-0.0050
Delta	0.7880	0.3559	0.4564	0.2747	0.1074	0.1630	0.0656	-0.0430	-0.0758	-0.0971
Delta+gamma	0.4952	-0.0381	0.0535	-0.2280	0.5439	0.1322	0.0154	0.0103	-0.0229	0.0505

[a] The coefficient of absolute risk aversion is chosen to be 2.0. Hedges are daily rebalanced.
[b] Hedging effectiveness of hedges with currency futures contracts.
[c] Hedging effectiveness of hedges using option synthetic futures.
[d] Hedging effectiveness of delta hedge with currency options.
[e] Hedging effectiveness of delta-plus-gamma hedge with currency options.

Shastri and Tandon (1987)]. Furthermore, Hull and White (1987) indicated that when the option does not have a fairly constant volatility and has a long time to maturity, the delta + gamma hedge could perform far worse than the delta hedge alone. This suggests that a stochastic volatility pricing model may improve the estimation of the hedge ratios and thus the performance of delta and delta + gamma hedges. (ii) the WISD's may be biased estimates for the standard deviations of currency returns. The bias could be caused by misspecification of the option pricing model, or by nonsynchronization of the data for currency spot rates and currency option prices. (iii) The prices quoted for the pair of options in a delta + gamma hedge are not synchronized. This would result in biased estimates of the hedge ratios and therefore poor performance of delta + gamma hedging.

The right half of Table IV demonstrates the HE^* values for the same hedges that are evaluated by HE_0. Although the results of HE_0 show that currency options, while being combined into synthetic futures, can be as effective as futures contracts in reducing risk, the empirical results of the risk-return measure HE^* demonstrate a different perspective. When both risk and return are considered, the option synthetic futures are less effective than the futures contracts according to HE^*. This situation prevails for all currencies across various hedging period lengths.[17] As shown in Table VI, all the hedges with currency futures have positive HE^*, ranging from 0.0145 to 0.4092. However, the hedges with option synthetic futures yield consistently lower values of HE^*, ranging from −0.0455 to 0.2267, where the negative values are present for some of the longer hedges and they indicate ineffective hedging.[18] Now, since the results of HE^* demonstrate that the option synthetic futures do not perform as well as the existing futures contracts, the

[17] Note that this superior performance of hedging with futures, as compared to option synthetic futures, also prevails for almost all the sub sample periods. Those results are available upon request. In addition, although Chang and Shanker (1986) also found that the option synthetic futures do not perform well as futures contracts in currency hedging, their results are affected by the problems with the Sharpe index. In fact, most of their hedging effectiveness measures for both futures and option synthetic futures, are negative.

[18] Previous studies found that longer hedges are more effective than the hedges held over a shorter time period. However, the literature has not offered any compelling economic rationale to explain this relationship. In Table IV, the hedging results for the futures contracts show a similar but insignificant, relationship between durations and the HE_0 values; whereas, an opposite relationship exists between durations and the HE^* values. Without further investigation, the phenomenon is attributed to the statistical estimation procedure used in this test. This study makes use of the same length of data (50 days) for the ex ante estimation regardless of the hedging durations. Therefore, the statistical explanations offered by Benet (1992) do not apply. In addition, note that HE^* measures the absolute size of risk reduction, while HE_0 is based on the relative risk-reduction (σ_H^2, σ_S^2).

TABLE VI

Hedging Effectiveness of Foreign Currency Futures and Options (ARA = 6.0) - Daily-Rebalanced[a]

	HE_U					HE^*				
	14-Day	30-Day	60-Day	90-Day	120-Day	14-Day	30-Day	60-Day	90-Day	120-Day
A British pound										
Futures[b]	0.9802	0.9857	0.9889	0.9894	0.9891	0.8989	0.4202	0.1959	0.1267	0.0930
Opt-syn-fut[c]	0.9851	0.9858	0.9833	0.9872	0.9842	0.5376	0.2048	0.0593	0.0420	0.0370
Delta[d]	0.9295	0.9224	0.8933	0.8669	0.8540	0.4781	0.1647	0.0507	0.0340	0.0154
Delta+gamma[e]	0.2052	0.0065	0.0359	0.2448	0.1027	0.0693	0.0350	0.0005	0.0204	0.0210
B Deutsche mark										
Futures	0.9890	0.9918	0.9937	0.9940	0.9947	1.0490	0.5007	0.2137	0.1367	0.0955
Opt-syn-fut	0.9924	0.9925	0.9900	0.9864	0.9859	0.7189	0.2934	0.0732	0.0012	0.0095
Delta	0.9823	0.9798	0.9654	0.9474	0.9409	0.7331	0.3333	0.1231	0.0660	0.0188
Delta+gamma	0.7117	0.6838	0.5245	0.3345	0.2928	0.5096	0.2347	0.0667	0.0285	0.0071
C Japanese yen										
Futures	0.9880	0.9910	0.9899	0.9893	0.9905	1.0733	0.5531	0.2621	0.1654	0.1251
Opt-syn-fut	0.9902	0.9904	0.9879	0.9891	0.9852	0.7200	0.2854	0.1234	0.0720	0.0498
Delta	0.9421	0.9286	0.9026	0.8555	0.8587	0.6766	0.3272	0.1509	0.0702	0.0437
Delta+gamma	0.6360	0.5878	0.3849	0.0865	0.0240	0.4753	0.2233	0.0782	0.0014	0.0060
D Swiss franc										
Futures	0.9855	0.9900	0.9922	0.9922	0.9931	1.2790	0.6170	0.2989	0.2027	0.1547
Opt-syn-fut	0.9828	0.9856	0.9844	0.9663	0.9617	0.7568	0.3220	0.1162	0.0242	0.0021
Delta	0.9298	0.9225	0.8903	0.8314	0.7375	0.7722	0.3379	0.1209	0.0047	0.0361
Delta+gamma	0.4745	0.0563	0.2572	0.1487	0.3061	0.4043	0.0207	0.0579	0.0116	0.0516

[a] The coefficient of absolute risk aversion is chosen to be 6.0. Hedges are daily rebalanced.
[b] Hedging effectiveness of hedges with currency futures contracts.
[c] Hedging effectiveness of hedges using option synthetic futures.
[d] Hedging effectiveness of delta hedge with currency options.
[e] Hedging effectiveness of delta-plus-gamma hedge with currency options.

currency futures are thus not replaceable by the currency options as a hedging instrument even though the latter are able to simulate the cashflows of the former. As to delta and delta + gamma hedges, the risk-return measure HE^* again shows that their hedging performance is inferior to that of the hedges with futures contracts. In fact, some of these delta/gamma hedges yield negative HE^* while having positive HE_{σ}. This suggests that these hedges, even though they help reduce currency risk, sacrifice too much return such that they actually reduce the investor's expected utility.

A comparison of the results between HE_{σ} and HE^* indicates that currency futures contracts have the advantage in preserving (improving) hedge returns over the option synthetic futures, though both are similarly effective in risk reduction. In other words, the risk-return measure HE^* instead of HE_{σ} is able to reveal that the currency futures market consistently provides more effective hedging than does the currency options market, regardless of whether the options are compared in the form of synthetic futures or in delta/gamma hedges. This superior hedging performance of futures contracts suggests that the currency futures market can better predict the currency rate movements than the currency options market. There are, however, some reservations regarding the conclusion that currency futures contracts serve as a better hedging instrument. (i) This test does not exhaust all the possible hedging strategies with these two securities. For instance, one could include more options in a hedged position. (ii) This test does not consider the difference of margin requirements in these two markets. (iii) The hedges are evaluated according to their returns and variances only. Consideration of the skewness in the hedge returns might offer a different result.

Effects of the Hedge Rebalancing

Table V summarizes the hedging performance when the buy-and-hold strategy is used. In comparison with Table IV, one can see that daily rebalancing has little effect, in terms of both HE^* and HE_{σ}, on the hedges with futures and the hedges with option synthetic futures. This result suggests that if transaction cost is considered, buy-and-hold is a better hedging strategy for these hedges, as long as the hedging period is not over 120 days. On the other hand, the daily rebalancing does affect the performance of delta and delta + gamma hedging. Table V shows that these hedges have become even less effective without daily rebalancing. For instance, the average HE^* of the 60-day delta hedges for Japanese Yen drops from 0.0172 to −0.0631, and the average HE_a drops from 0.9026 to 0.1003. The loss in the hedging effectiveness for these hedges is more pronounced with longer hedging periods. This relationship is expected because, as the hedging period gets longer, the ratio determined at the initiation of the hedge becomes more outdated and cannot react to the upcoming dynamics.

Effects of the Hedger's Risk Attitude

The test is repeated for those investors with an ARA coefficient of 6.0, which represents highly risk-averse investors with risk reduction as their primary concern. The results of hedging with daily rebalancing are presented in Table VI. Because more risk-averse investors allow a larger marginal rate of substitution of risk reduction for returns, their choices of hedge ratios are expected to reduce more proportional risk. Indeed, the resulting HE_a values are larger than those from investors with a smaller ARA ($A = 2.0$).[19] In general, the comparisons between the futures and the options, in terms of both HE^* and HE_a, parallel those found with an ARA equal to 2.0. The delta and delta + gamma hedging are still the least effective strategies among those tested here. The results of HE^* again indicate that the currency futures market provides better hedging benefits than does the currency options market.

SUMMARY

This empirical study examines the ex-ante hedging effectiveness provided by the futures market and by the options market in foreign currency hedging. The hedge ratio for the futures contract is determined by maximizing the hedger's expected utility. For the purpose of comparison, currency options are tested with two approaches. In one approach, the options are combined into synthetic futures, and the hedge ratios for these synthetic futures are determined from expected utility maximization. Another approach evaluates the hedging effectiveness of currency options using delta and delta + gamma hedges. A new measure of hedging effectiveness HE^* is employed to evaluate all the hedges. This measure considers both risk and return, and avoids the empirical problems confronted by some risk-return measures from earlier studies.

[19]Note that HE^* represents the evaluation of hedges based on an investor's personal risk attitude and should not be compared among different investors. The authors have also examined the results for ARA=6.0 with the buy-and-hold strategy. Since the comparisons parallel those for the less risk-averse investors (ARA = 2.0), the table is not included in this article.

The empirical results indicate that currency futures contracts serve as a better hedging instrument than currency options. This result holds regardless of whether the options are compared in the form of synthetic futures or in delta/gamma hedges. In particular, the traded futures contracts are found more effective in improving (reserving) the hedge returns than the option synthetic futures, whereas both provide a similar degree of risk reduction. At the same time, both effectiveness measures, HE_u and HE^*, indicate that the hedges with futures contracts are more effective than the delta and delta + gamma hedges to a greater extent. The significance of the risk-return measure HE^* is supported by the result that this measure, instead of the risk-only measure HE_u, can distinguish the hedging performance of the traded futures from that of the option synthetic futures. Finally, these conclusions hold for both conservative (ARA = 6.0) and aggressive (ARA = 2.0) investors.

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