Hedging Foreign Investments in U.S. Real Estate with Currency Options

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Abstract. **Historically, the volatility in exchange rates appears to have generated so much risk in U.S. real estate returns that, from the foreign investor's viewpoint, it eliminated any potential for obtaining diversification benefits from these assets. Yet during the past twenty years foreigners purchased and continue to hold enormous amounts of U.S. real estate. This study examines the use of currency options as a means of hedging the exchange rate risk associated with a foreign investment in U.S. real estate. The findings indicate that currency options behave very much like an insurance policy. When used on a continuous basis, they insure foreign investors against any large sudden currency losses and spread the cost of these extreme losses out over time. Thus, from the foreign investor's perspective, the total risk in U.S. real estate returns is substantially reduced. However, these improvements are insufficient to make U.S. real estate consistently attractive to these investors in a mean-variance portfolio framework.**

Introduction

There are quite obviously many possible reasons that may explain the strong foreign interest in U.S. real estate.[1] Foreign investment may be motivated by political diversification, arbitraging comparable market conditions, market accessibility, a greater array of investment choices or perceived comparative advantage. Additionally, modern portfolio theory (MPT) would suggest that some foreigners invest in U.S. real estate to improve risk/return portfolio efficiency. The literature has long advocated international diversification to reduce portfolio risk because of the low positive correlation among the economies of different nations (Grubel 1968; Levy and Sarnat 1980; Solnik 1974). A separate and equally compelling body of research has recommended real estate as an investment that enhances portfolio performance because it lacks correlation with most types of traditional financial assets (Brueggeman et al. 1984; Friedman 1970; Roulac 1976; Webb et al. 1988). Thus, it logically follows that foreign real estate should be included in virtually every portfolio to achieve the maximum diversification gains.

Ziobrowski and Curcio (1991) recently tested this hypothesis for the two largest groups of foreign investors in U.S. real estate, the British and the Japanese,[2] to determine whether these foreign investors have historically enjoyed diversification benefits from including U.S. real estate in their portfolios as MPT would predict. For both foreign investors, they constructed an efficient frontier from seven readily available home-country assets (common stocks, corporate bonds, government bonds, Treasury

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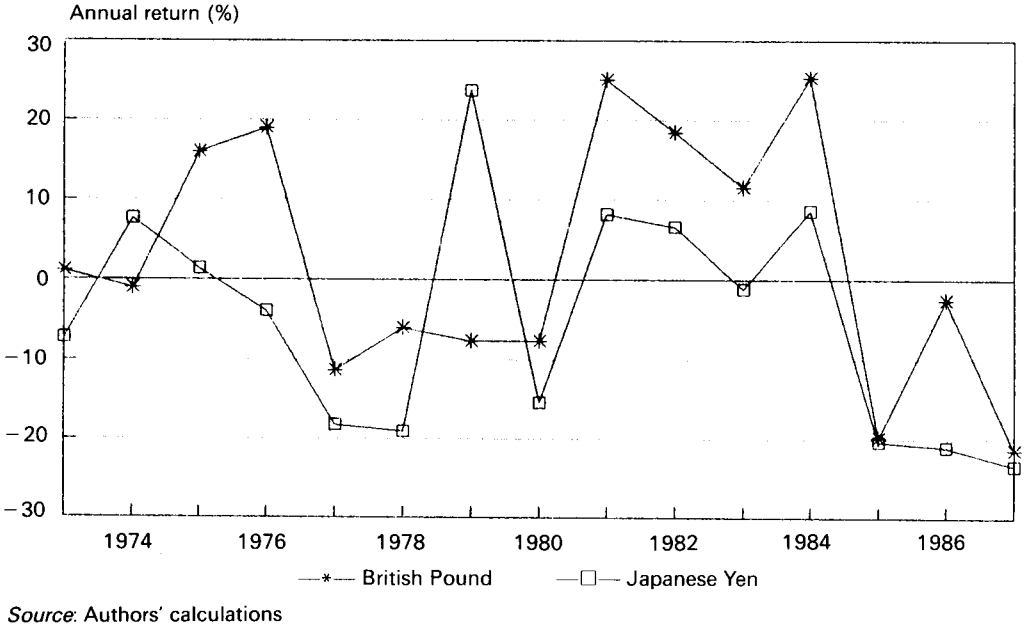
bills, farmland, commercial real estate and residential real estate) to serve as a domestic baseline during the period 1973 to 1987. The British and Japanese investor opportunity sets were then expanded to include U.S. real estate and the two efficient frontiers were regenerated. Comparing the efficient frontiers constructed of domestic assets only with efficient frontiers constructed of domestic assets and U.S. real estate, Ziobrowski and Curcio found no measurable improvement in risk/return performance as a result of adding U.S. real estate to either the British asset-based or the Japanese asset-based portfolios. They also determined that the returns from U.S. real estate (farmland, commercial and residential) were highly correlated with the returns from U.S. stocks, bonds, and bills when the returns were received in British pounds or Japanese yen. This, of course, raised serious questions about the wisdom of foreigners investing in U.S. real estate if the same diversification benefits could be obtained from the much more convenient U.S. financial securities.

Ziobrowski and Curcio attributed their findings to the extreme volatility in exchange rates (see Exhibit 1). During the period examined, a pure British pound investment in the U.S. dollar provided a positive mean annual return of 2.6% with a standard deviation of 15.6%. A pure yen investment in the dollar resulted in a substantial loss to the Japanese investor with a mean annual return of −4.9% and a standard deviation of 14.3%. These highly unstable exchange rates magnified the riskiness of all U.S. asset returns to both British and Japanese investors enormously (in the case of Treasury bills over 500%). Thus, the volatility in exchange rates created so much risk in U.S. real estate returns that the additional risk totally overwhelmed any possibility of increased

Exhibit 1
Annual Returns from a Foreign Investment in the U.S. Dollar (1973–1987)



Source: Authors' calculations

efficiency for these investors. Currency translation also induced a significant source of systematic risk among all U.S. asset returns suggesting that foreign investors saw limited distinction between the return characteristics of U.S. financial assets and U.S. real estate.

In a later study, Ziobrowski and Boyd (1992) examined leverage as a tool for improving the performance of U.S. real estate assets from the perspective of foreigners. The matching of foreign assets (in this case U.S. real estate) with comparable foreign liabilities (such as U.S. dollar-denominated debt) has long been used by multinational corporations as a means of hedging against exchange rate risk exposure. Unfortunately the study revealed that although the use of high leverage greatly reduced the currency risk, it simultaneously induced even higher levels of ordinary financial risk. The net impact was that U.S. real estate still provided no diversification benefits to foreign investors.

Currency options have also been suggested as a means of hedging foreign exchange exposure. A British investor in U.S. real estate could guarantee the value of his or her U.S. dollar returns in British pounds-sterling by purchasing a sterling call option. The option would insure that the value of the dollar would not fall below the strike price during the asset holding period, while allowing the British investor to benefit from any favorable exchange rate movements. In a survey of financial managers, Khoury and Chan (1988) found that currency options possess a number of particularly desirable hedging features. They are highly effective at hedging exchange rate risk while still preserving the upside potential. The cost of the hedge is known and fixed from the beginning. They are readily available in the form of standardized option contracts that are traded on a number of organized exchanges. Additionally, many banks and other financial institutions offer customized foreign currency options with contract size, maturity and strike price tailored to meet the needs of their clients. Thus, they are quite flexible. Finally, the "optional" nature of the hedge is viewed as very attractive.[3]

Currency options also have their critics however. According to Abuaf (1986), an option is like insurance coupled with an investment opportunity and thus its benefits are not readily observable. This leads many to believe that when using options purely as a hedge, they are very expensive. Furthermore, there is a general impression among U.S. institutional investors that over the long term, currency hedging is not really a viable strategy. When currency options are used to hedge foreign asset returns for brief periods of time, they provide excellent protection against a sudden and potentially catastrophic shift in exchange rates by limiting the magnitude of the loss to the cost of the option. But when options are used on a continuous basis over extended holding periods (several years) they tend to resemble the investment characteristics of a casualty insurance policy. More specifically, as with all insurance policies, ultimately the aggregate value of the benefits must be paid for by the aggregate cost of the premiums. Thus over the long run, it would be normally anticipated that the mean annual return from the foreign asset would be nearly the same, with or without currency option hedging. Expressing the point another way, the benefits of hedging currency losses with options may be completely offset by the costs.

This study investigates the hypothesis that currency options can be used to enhance the return characteristics of U.S. real estate to foreign investors sufficiently to make the assets attractive in a mean-variance portfolio framework. Certainly, there is evidence to support the notion that foreign investors may be using currency options extensively to hedge their U.S. investments. According to the Federal Reserve (Goodman 1983), more

than half of the foreign currency options traded on the Philadelphia Stock Exchange are bought and sold by foreigners. Rejection of this hypothesis would suggest that the long-term costs of currency hedging exceed the benefits, as many apparently believe.

Using the same data set as the original Ziobrowski and Curcio (1991) study, the British pound- and Japanese yen-denominated returns from U.S. real estate (farmland, commercial, and residential) were adjusted to reflect continuous hedging with currency options. For comparison, foreign-denominated returns were also calculated for U.S. financial assets (common stocks, bonds, and bills) assuming currency option hedging. A series of alternative efficient investment frontiers were then constructed for British and Japanese investors to determine if U.S. real estate hedged with currency options could improve the performance of a portfolio containing only the investor's home-country assets. The study covered the period 1973 to 1987. All returns were measured on an annual basis. The impact of transaction costs, taxes, and shortselling were not included in the analysis.

It must be noted that currency options did not become actively traded until 1982 when they were first offered on the Philadelphia Stock Exchange. Additionally, even after 1982, it would be impossible to obtain market prices on the types of "customized" currency options assumed in this study. Thus the Black-Scholes (1973) Option Pricing Model was used to calculate option prices. The ability of this model to accurately estimate the market pricing of options has been empirically demonstrated numerous times. However, certain qualifications do exist as a result of using this model. These restrictions are explored fully in the Data section.

Research Design

A total of six efficient frontiers were constructed for this study, three for the British investor and three for the Japanese investor. The portfolio optimization technique developed by Elton, Gruber and Padberg (EGP) (1976) was used to generate the efficient frontiers. All rates of return were measured in the domestic currency of the investor (pound-sterling for the British and yen for the Japanese).

The EGP portfolio optimization technique begins by assuming that the variance-covariance structure of an asset's returns can be adequately characterized by a single index model such that

$$R_i = \alpha_i + \beta_i I_m + \varepsilon_i,$$

where

R_i = return on asset i,
I_m = market index,
β_i = measure of the responsiveness of returns from asset i to changes in the market index, I_m,
α_i = return on asset i which is independent of changes in the market index,
ε_i = an error term with a mean of zero and variance $\sigma_{\varepsilon i}^2$.

The market indices, I_m, were constructed using an equal weighting of the returns from

all the assets in the various opportunity sets. α_i, β_i, and σ_i were estimated via linear regression analysis of the annual returns from each asset versus the market index.

If it is further assumed that there exists a risk-free asset with return R_f, Elton, Gruber and Padberg (1976) have shown that the "desirability" of including an asset in the optimal portfolio can be quickly measured by the asset's "excess return to *beta*" ratio:

$$\phi_i = \frac{\bar{R}_i - R_f}{\beta_i}, \tag{2}$$

where

$\bar{R}_i$ = expected return on asset i.

$\bar{R}_i$ is estimated using the mean annual return of the asset.

When shortselling is disallowed, only assets whose ϕ_i exceed the "cutoff rate," ϕ_k, will be included in the optimal portfolio and

$$\phi_k = \sigma^2_m \frac{\sum_{j=1}^{k} \frac{(\bar{R}_j - R_f)}{\sigma^2_{\varepsilon j}} \beta_j}{1 + \sigma^2_m \sum_{j=1}^{k} \frac{\beta^2_j}{\sigma^2_{\varepsilon j}}}, \tag{3}$$

where

σ^2_m = variance of the market index,

and k is the subpopulation of assets that constitute the optimal portfolio. To determine the percentage of the total portfolio placed in each asset i, X_i:

$$X_i = \frac{Z_i}{\sum_{j=1}^{K} Z_j}, \tag{4}$$

where

$$Z_i = \frac{\beta_i(\phi_i - \phi_K)}{\sigma^2_{\varepsilon i}}. \tag{5}$$

Detailed proofs of these relationships are presented in the original paper.

Note that solving these equations only provides the composition of the optimum portfolio that lies at the single point where a line passing through the riskless rate of

return, R_f, runs tangent to the efficient frontier in the return/standard deviation space. To generate full efficient frontiers, we solved the portfolio composition problem for a large number of different R_f. This procedure also relieves the earlier assumption regarding the existence of a risk-free asset.

The first British efficient frontier was constructed from British domestic assets only (common stocks, corporate bonds, long-term government bonds, Treasury bills, farm real estate and commercial real estate).[4] This frontier established a baseline for measuring diversification gains from U.S. assets to British investors. As a Japanese investor baseline, an efficient frontier was generated from domestic Japanese assets (common stocks, corporate bonds, long-term government bonds, short-term interest rates,[5] farm real estate, commercial real estate, and residential real estate).

U.S. common stocks, corporate bonds, government bonds, and Treasury bills, all hedged with currency options, were then added to the British and Japanese domestic assets to produce the second pair of efficient frontiers. Quite obviously, the use of currency options is not limited to hedging U.S. real estate returns. The options are also available to hedge the returns from U.S. financial assets, which in comparison to real estate are clearly a far more convenient vehicle for U.S. investment. Logically, foreign investors would only move into U.S. real estate if it offered diversification benefits that could not be obtained from the U.S. financial assets.

Finally, an efficient frontier was constructed from the home-country assets of each foreign investor, the option-hedged U.S. financial assets and option-hedged U.S. real estate (farm, commercial, and residential). These frontiers were used to estimate the diversification gains available to British and Japanese investors from U.S. real estate when currency options were used to hedge exchange rate risk exposure.

Data

The raw data used in this analysis is the same data used by Ziobrowski and Curcio (1991), covering the period 1973–1987. All returns from the British, Japanese, and U.S. assets were originally measured on an annual before-tax basis in the home-country currency of the assets (British assets in pounds-sterling, Japanese assets in yen, and U.S. assets in dollars) and included both capital appreciation and operating income.[6] These domestic rates of return were subsequently converted to annual rates of return in other currencies using exchange rates published in the *Wall Street Journal* on the last business day of every year, 1972 to 1987.

As with most studies, the selection of an appropriate holding period (in this case one year) is subject to some debate. The choice may be especially difficult when dealing with mixed-asset portfolios constructed of such diverse types of assets as stocks, bonds, bills, and real estate. Studies involving only stocks and bonds, where the markets are very liquid and the data is all transaction based are frequently done assuming holding periods of a month, a day, an hour, or sometimes even less. In real estate, the normal investment holding period is perceived to be much longer, spanning several years as a minimum. Thus intermediate fluctuations in value of shorter duration are not believed to be very important. However, in order to examine the performance of mixed-asset portfolios in a mean-variance framework, it is clearly necessary to compare all the assets on an equal basis (common holding period). The one-year holding period assumed here may

therefore be viewed as a "compromise" solution to this dilemma which lies between the typical holding periods assumed for stocks and the normal holding periods associated with real estate.

It may also be argued that short-term real estate investment horizons may be more relevant than originally thought. Admittedly, short-term fluctuations in real estate value are perhaps unimportant for investors who do not sell frequently, have complete control over the timing of their sales and are able to perfectly match the maturities of their liabilities with their real estate assets. However, consider the case of real estate investment pools. Since investors can increase or decrease their holdings of these assets at virtually any time, short-term risk versus return relationships become very important.

Annual returns on all U.K. financial assets (stocks, bonds and bills) were provided by Barclays de Zoete Wedd of London, England. Savills, a British real estate investment firm, provided the returns on agricultural real estate in Great Britain. British commercial real estate returns came from the pooled data sets of the London firms, Jones Lang Wootten Consulting and Research, Healey and Baker, Hillier Parker and Richard Ellis. A detailed description of the British real estate data is presented in the original Ziobrowski and Curcio (1991) paper.

Data on Japanese financial assets came from Hamao (1989). Hamao's methodology for tabulating returns is nearly identical to that used by Ibbotson and Sinquefield (1982) and is available from Ibbotson Associates, Inc. of Chicago. Japanese real estate capital gains were provided by the Japanese Real Estate Institute (JREI), a non-profit independent real estate research organization in Tokyo, Japan. Ziobrowski and Curcio (1991) also present a complete discussion of JREI's procedure for tabulating returns. Unfortunately, reliable estimates of operating income on Japanese real estate were unavailable. Consistent with the conservative assumption made by Ziobrowski and Curcio, we also assumed no operating income from Japanese real estate.

Finally, all annual return data on United States assets (both financial and real estate) came from Ibbotson and others (Ibbotson and Fall 1979; Ibbotson and Siegel 1983, 1984; Ibbotson and Sinquefield 1982). Ibbotson Associates, Inc. of Chicago has continuously updated these time series since publication of the original articles.

In this study, we have assumed that foreign investors use currency options to hedge 100% of the purchase price of their U.S. assets only. No attempt is made to hedge either the capital appreciation or income (dividends, interest payments or property rentals) derived from these investments since these returns could only be known ex-post and could therefore only be effectively hedged after the fact. To justify this hedging strategy, consider the British investor who buys property in the U.S. for £100,000 (or $200,000 at $2/£). Furthermore, during the following twelve-month period (a) the property produces a positive cash flow of $20,000 or 10% in dollars, (b) there is no capital appreciation or depreciation in dollars (the property value still equals $200,000), and (c) the value of the dollar versus the pound has fallen by 15% (to $2.3/£). In such a case, the British investor could convert the $20,000 income to pounds and repatriate £8,696 at year-end. Admittedly, this is £1,304 below the amount she might have recovered a year earlier when the conversion rate was $2/£. However, it is still a positive return of almost 9% on the original £100,000 investment. Regrettably, the property value has not fared nearly as well. In pounds, the U.S. property has slumped to a value of £86,956 during the year, and the British investor has suffered a £13,044 capital loss as a direct result of the weakened dollar. Thus, the currency losses associated with the operating income

(£1,304) are small in comparison to the currency losses associated with the property value (£13,044). Also, note that this relationship will always be true as long as the annual operating income from an asset is small in comparison to the asset value, which is, of course, normally the case. It therefore becomes apparent that protecting the principal against currency losses is infinitely more important than hedging any of the intermediate income streams.

Some would suggest that this is a short-term phenomenon. More specifically, if the dollar weakens half the time and strengthens half the time, then exchange rate losses will equal gains and parity will naturally occur over the long term. This is an especially tempting argument with respect to real estate where holding periods are usually very long. Were this true, hedging the principal would be unnecessary because it would be a self-correcting problem. Adler and Lehman (1983), Genburg (1978) and Roll (1979) are but a few of many to investigate this. In general, their results are consistent and reasonably conclusive. Parity is more often violated than not and it can be expected to be violated for any forecasting period. The degree of the violation can be very large and for an indefinite, prolonged time period (often lasting decades). In fact, the evidence suggests that a deviation taking place today would never tend to be corrected in the future. Certainly, this study would support those findings. At the beginning of our sample period, the exchange rate in 1973 for Japanese yen was 300¥/$. At the end of 1987, it had fallen to 120¥/$ and a return to the 300¥/$ level is unlikely anytime soon.

To adjust the annual return time series on U.S. assets for hedging with currency options, it was assumed that the foreign investor purchased the United States asset on January 1 and sold it on December 31, each year 1973 to 1987. The asset was purchased in the investor's home-country currency, converted to dollars at the exchange rate prevailing at the beginning of the year. Also, on January 1, the foreign investor purchased a customized call option to convert the dollar-denominated purchase price of the U.S. asset back to the investor's home-country currency on December 31 of the same year. The exercise price on the option was identical to the exchange rate in effect on the day the asset was purchased (January 1). Thus, currency losses on the foreigner's initial investment were limited to the cost of the option. Only the capital gains and income were exposed to uncertainty with respect to downside currency risk. It was further assumed that all returns from the asset including income, capital gains, and investment recovery would be received at the time of sale on December 31. These funds were repatriated by the foreign investor at the prevailing year-end exchange rate.

Naturally, if exchange rates had moved in a direction that favored the foreign investor (the home-country currency had weakened versus the dollar), the option expired with no value. In this case, the pound- and yen-denominated one-year returns on U.S. assets hedged with currency options R_{xo}, were calculated with:

$$R_{xo}=\frac{X_2(R_\$+1)}{X_1(CX_1+1)}-1 \text{ for } X_2\geq X_1, \tag{6}$$

where

$R_\$$ = dollar-denominated return on U.S. asset,
X_1 = exchange rate at beginning of year (investor's home currency per dollar),

X_2 = exchange rate at year-end (investor's home currency per dollar),
C = cost of the option (dollars per unit of investor's home currency initially invested).

However, when the investor's home-country currency strengthened against the dollar during the one-year holding period, the investor exercised the option to minimize the currency-related losses. Under these conditions the pound- and yen-denominated returns were determined using:

$$R_{\$} = \frac{X_2 R_{\$} - CX_1^2}{X_1(CX_1 + 1)} \text{ for } X_1 > X_2. \tag{7}$$

Neither of the equations include the impact of transaction costs. The Ibbotson time-series data was used for $R_{\$}$. X_1 and X_2 came from the *Wall Street Journal*. A detailed explanation for equations (6) and (7) can be found in Appendix 1.

The most complex problem in this study was estimating C, the cost of the foreign currency call option. In 1973, Black and Scholes (1973) made a major discovery by deriving the formula for pricing options on nondividend paying stocks. Garman and Kohlhagen (1983) later modified the formula to value foreign currency options. The call price, C, on a foreign currency is given as follows:

$$C = Se^{-r_f T}N(d_1) - Ee^{-rT}N(d_2), \tag{8}$$

where

S = spot exchange rate (dollars per unit of foreign currency),
E = exercise price (dollars per unit of foreign currency),
r = United States risk-free rate, %,
r_f = risk-free rate in the foreign currency, %,
T = time till expiration, years,
$N(x)$ = cumulative probability function for a standardized normal variable,

$$d_1 = \frac{\ln(S/E) + (r - r_f + \sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T},$$

σ = volatility of the index, %.

Because we assumed that for all our call options, the exercise price on December 31 was identical to the spot rate on the previous January 1 ($E = S = 1/X_1$) and the time till expiration was always one year ($T = 1$), equation (8) could be greatly simplified to:

$$C = \frac{e^{-r_f}N(d_1) - e^{-r}N(d_2)}{X_1}, \tag{9}$$

where

$$d_1 = \frac{r - r_f + \sigma^2/2}{\sigma}$$

$$d_2 = d_1 - \sigma.$$

The return on the U.S. Treasury bill was used for r. The return on the British T-bill and Japanese STIR was used for r_f when calculating the value of the call options on the British pound and Japanese yen respectively. σ was the standard deviation of the mean annual returns for a pure dollar investment in the foreign currency (pounds or yen) during the fifteen-year test period (1973–1987).

The use of this methodology deserves some additional discussion with respect to possible limitations and cautionary remarks. The Black-Scholes model was developed for use with European options which are options that may only be exercised at the end of trading for the option. Because the model does not allow for the possibility of early exercise, it tends to slightly undervalue "in-the-money" American options that may be exercised at any time prior to the end of trading. This should not be a problem for this study since we are only considering the "insurance" value of the option which our foreign investor would logically wish to obtain for the lowest cost possible (i.e., European options).

In theory, the Black-Scholes (1973) formula is only correct if the short-term interest rates r and r_f are constant. We have used the normal proxies for these values, namely T-bill and STIR returns. However, these returns are indeed a proxy for the risk-free rates and should be viewed with some caution.

Probably the most serious limitation rests in our assumption that the market's perception of exchange rate volatility remained constant over the entire fifteen-year period. Some would argue that more data over longer time periods leads to better accuracy. Others point out that the investor's expectation of future volatility, σ, does change with time, and data that are too old may not be relevant for predicting the future. In this case we support the views of the former rather than the latter. It seems relatively clear that a six-month or even one-year period of relative stability in exchange rates would not be sufficient to convince option writers that twenty years of severe volatility had ended, thus causing them to greatly reduce premiums. We suspect that exchange rate expectations, like inflationary expectations, change very slowly in the minds of investors.

Using equation (9), the estimated average premium for a one-year call option on the British pound was \$.0824/£ during the fifteen-year sample period. The highest premium was \$.1424/£ (1981) and the lowest priced pound option was \$.0432/£ (1985). On average, the cost of the pound call options was 4.35% of the amount being hedged. The estimated premium for the one-year call option on the Japanese yen averaged \$.000283/¥ for the same period, or 6.65% of the amount being hedged. The highest yen call option was \$.000467/¥(1981) and the lowest priced yen option was \$.000123/¥(1975). Because of the number of variables involved and the lack of actual currency option pricing data, it is impossible to truly verify the accuracy of our option premium estimates. However, we do observe from a visual comparison with currency option prices published in the *Wall Street Journal* that our estimates seem to be of the proper

magnitude. Of more significance, as we shall see in the next section, the consistency of our results with our hypothesis suggests that overall our estimates are quite reasonable.

It also seems appropriate at this junction to draw a sharp distinction between the option premium or value of the currency option, which we have already discussed and the transaction costs or brokerage commissions. Transaction costs were deliberately excluded from this study because their magnitude tends to be a strong function of the volume. Smaller investors would therefore tend to pay higher commission as a percentage of their total investment when compared to larger investors. Also transaction costs tend to vary a great deal from broker to broker. Lastly, they are quite small and thus have no material impact on our results.

In general, the transaction costs on currency options tend to be high relative to the value of the options, but very low with respect to the value of the underlying currency. At a typical discount broker, the commission on the purchase of a single contract of British pound call options (£31,250) with a premium of $.0824/£ would be approximately $71.50 or 2.75% of the option contract value ($2,575).[7] However, this commission is only slightly more than one-tenth of 1% of the £31,250 (at an exchange rate of $1.90/£). If the British investor lets the option expire (when the dollar appreciates against the pound) no further commission need be paid. If the option position is closed out by entering into an offsetting trade (when the dollar weakens versus the pound), the same commission is paid again. Finally, if the option is exercised, the investor pays a 1% or 2% commission on the value of the currency. Thus, the commission system encourages investors to sell the options rather than exercise them and our British investor is well advised to refrain from exchanging the dollars for pounds until she is ready to repatriate the funds to Great Britain. In sum, when using the currency options as a covered hedge (as opposed to naked speculation) the brokerage commissions are rather inconsequential, amounting to less than one-half of 1% maximum.

Results

Exhibit 2 shows the mean rates of return, standard deviations and coefficients of variation for all U.S. assets used in this study from 1973 to 1987 when returns were received in dollars, pounds and yen. Pound- and yen-denominated values are presented both with and without currency option hedging for comparison.

For both the British and the Japanese, using currency options resulted in higher mean annual returns. More precisely, the annual cost of the options (premium) was more than offset by the additional returns obtained from exercising the options in years when the dollar weakened against the pound (eight years out of fifteen) and the yen (nine years out of fifteen). Purely from the standpoint of mean returns, the Japanese benefitted from the use of currency options a great deal more than the British. In absolute terms, British mean annual returns on U.S. asset investments increased only .4% on average for a percentage gain of only 3% above levels available without option hedging. The increases were reasonably uniform across all U.S. assets with the mean return on U.S. corporate bonds increasing the least (+.24%) and U.S. farm real estate showing the strongest improvement (+.53%). Had transaction costs for the options been included there would likely have been no gains at all. The Japanese, on the other hand, saw significantly higher returns from the use of currency options during the test period. Yen-denominated mean

Exhibit 2
Foreign-Denominated Mean Annual Rates of Return, Standard Deviations and Coefficients of Variation from U.S. Assets: Hedged with Currency Options versus No Hedging, 1973–1987

	No Hedge[1]			No Hedge[1]			Hedged with Currency Options[2]		
	Annual return (%)	Standard deviation (%)	Coefficient of variation	Annual return (%)	Standard deviation (%)	Coefficient of variation	Annual return (%)	Standard deviation (%)	Coefficient of variation
U.S. Asset									
British Returns		Dollars			Pounds			Pounds	
U.S. Stocks	11.42	18.58	1.63	14.40	26.36	1.83	14.77	23.37	1.58
U.S. Corporate Bonds	9.37	14.24	1.52	12.76	25.87	2.03	13.00	21.26	1.64
U.S. LT Gov. Bonds	8.88	13.77	1.55	12.18	24.92	2.05	12.48	20.21	1.62
U.S. T-Bills	8.20	2.73	.33	11.14	18.22	1.64	11.54	11.84	1.03
U.S. Farm R.E.	10.02	12.24	1.22	12.55	18.92	1.51	13.08	13.24	1.01
U.S. Comm. R.E.	11.24	4.80	.43	14.17	18.34	1.29	14.60	12.00	.82
U.S. Resid. R.E.	9.75	4.29	.44	12.46	16.38	1.31	12.98	9.65	.74
Japanese Returns		Dollars			Yen			Yen	
U.S. Stocks	11.42	18.58	1.63	5.69	22.92	4.03	7.08	19.15	2.70
U.S. Corporate Bonds	9.37	14.24	1.52	3.93	20.34	5.18	5.77	13.97	2.42
U.S. LT Gov. Bonds	8.88	13.77	1.55	3.56	20.30	5.70	5.34	13.98	2.62
U.S. T-Bills	8.20	2.73	.33	3.08	17.08	5.55	4.90	7.98	1.63
U.S. Farm R.E.	10.02	12.24	1.22	4.75	20.48	4.31	6.78	14.76	2.18
U.S. Comm. R.E.	11.24	4.80	.43	6.04	18.58	3.08	7.87	9.95	1.26
U.S. Resid. R.E.	9.75	4.29	.44	4.53	17.62	3.89	6.40	9.95	1.51

[1]from Ziobrowski and Curcio (1991)
[2]Authors' calculations per Appendix 1

annual returns on U.S. assets increased an average of 1.79% in absolute terms or rose nearly 40% when stated as a percentage of the mean annual returns available without option hedging. Again, the increases were generally uniform across all U.S. assets with U.S. farm real estate again benefitting the most (+2.03%) and U.S. common stock improving the least (+1.39%).

However, it should be noted that the Japanese result is period-specific and thus somewhat deceptive. Recalling the "insurance policy" nature of the option, it is important to remember that options are "statistically" priced to produce a profit for option writers over the long run. In essence, the premiums are based on (1) actuarial

estimates of the probability that the currency option buyer will exercise at expiration, (2) the likely size of the loss, and (3) the expected income derived by the option writer from investing the premium until expiration occurs. Assuming these estimates are correct, then writing the option will be profitable. Thus, the gains experienced by the investors in yen currency options from 1973 through 1987 are unlikely to continue indefinitely. Either (a) the probabilities were miscalculated, in which case option writers would likely increase the premiums to restore profitability or (b) this is a short-term phenomenon that will ultimately correct itself long term. In either case, it should be recognized that this is a statistical issue and not an indication of Japanese economic strength or other investment factors. The British experiences are far more indicative of rational long-term investor expectations.

It is also interesting to observe that even with the large option-induced improvements in yen-denominated returns on U.S. assets during our sample period, the yen returns remained almost 40% lower than the dollar-denominated returns on the same assets. Contrary to common belief, this demonstrates that currency options do not eliminate downside currency losses. Rather they limit the magnitude of the loss for relatively short periods of time to the cost of the option premium. Over long periods, their cumulative impact on the mean return should be negligible.

The most significant effect of hedging U.S. asset returns with currency options comes in terms of risk reduction. Because the options limit the currency losses in any one year and spread the losses out via premiums over many years, they dampen the amplitude of the downside risk. For the British investors, pound call options would have reduced U.S. asset risk an average of 25%. For the Japanese, hedging U.S. asset returns with currency options reduced U.S. asset risk an average of nearly 35%. However, unlike the changes in mean annual returns that were evenly distributed across the various U.S. assets, the effectiveness of risk reduction caused by option hedging appears highly dependent on the asset type. Those assets that were most risky, such as common stock, benefitted the least from currency option risk reduction (only 11% in pounds and 16% in yen). Conversely, currency option hedging had the greatest impact on the volatility of low risk assets like the U.S. Treasury bill (reducing risk 35% in pounds and 53% in yen).

The selective nature of the risk reduction is related to the selective nature of currency risk. A comparison of the dollar-denominated U.S. asset returns with both pound- and yen-denominated U.S. asset returns (no hedge) reveals that the lower the dollar-denominated risk of the U.S. asset (domestic risk), the more powerful the impact of currency translation on foreign currency-dominated risk. For example, the standard deviation of U.S. common stock returns was increased relatively little as a result of converting the returns to yen, going from 18.58% in dollars to 22.92% in yen, an increase of only 23%. However, currency translation increased U.S. T-bill risk over 500% when returns were received in yen during the same period (from 2.73% to 17.08%). Thus logically, any instrument that specifically reduces exchange rate risk (such as currency options) will have a more profound impact on foreign-denominated U.S. T-bill returns than on foreign-denominated U.S. common stock returns.

It should also be observed that currency options are incapable of hedging all the currency risk. By design, they only protect the investor against downside volatility. Upside currency-related volatility is left unrestrained. Therefore, foreign-denominated U.S. asset returns hedged with currency options remain substantially more risky than dollar-denominated U.S. asset returns (60% more risky in pounds, 30% in yen).

Exhibit 3
Domestic Rates of Return for Japanese and British Assets (1973–1987)

Asset	Mean annual[1] return (%)	Standard[2] deviation (%)	Coefficient of variation
British			
Common Stocks (BCS)	22.31	43.82	1.96
Corporate Bonds (BCB)	15.18	17.59	1.16
Government Bonds (BGB)	13.89	18.65	1.34
Treasury Bills (BTB)	11.34	2.32	.20
Farm Real Estate (BFRE)	6.46	21.26	3.29
Commercial R.E. (BCRE)	13.18	8.55	.65
Japanese			
Common Stocks (JCS)	13.44	16.99	1.26
Corporate Bonds (JCB)	8.83	5.72	.65
Government Bonds (JGB)	8.84	6.32	.71
S-T Interest (JSTIR)	7.28	2.56	.35
Farm Real Estate (JFRE)[2]	6.59	5.65	.86
Commercial R.E. (JCRE)[2]	4.91	5.42	1.10
Residential R.E. (JRRE)[2]	7.05	6.56	.93

[1]All mean annual rates of return and standard deviation calculations were based on the home-country currency of the assets. That is, British asset returns in pounds-sterling and Japanese returns in yen.
[2]Mean annual rates of return shown for Japanese real estate includes no operating income.
Source: Ziobrowski and Curcio (1991)

Of perhaps more significance to the foreign investors, these hedged U.S. asset returns were still generally uncompetitive with returns from the investor's home-country assets (Exhibit 3). Comparing the coefficients of variation for the hedged U.S. assets versus those for the domestic assets of the foreign investors, British assets outperformed hedged U.S. assets in four out of six cases when all returns were received in pounds. Japanese assets outperformed hedged U.S. assets in all seven asset categories when all returns were received in yen, despite the higher return and lower risk provided by the currency options.

Exhibit 4 shows the correlation coefficients between all British asset returns and option-hedged U.S. asset returns, all denominated in pounds. The correlation coefficients between all Japanese asset returns and hedged U.S. asset returns, denominated in yen, are provided in Exhibit 5. Examination of these matrices reveals that foreigners generally see little correlation (positive or negative) between U.S. asset returns and the returns from their respective home-country assets when they hedge their U.S. asset returns with currency options. The average correlation coefficient between all U.S. and British asset pairings was .16. Between all Japanese and U.S. asset pairs the average correlation coefficient was $-.10$. This strongly suggests that U.S. assets hedged with currency options should provide foreign investors with diversification gains. However, consistent with the findings of Ziobrowski and Curcio (1991), U.S. asset returns

Exhibit 4
British Investor Correlation Matrix (1973–1987)
U.S. Asset Returns Hedged with Currency Options
All Returns Received in Pounds-Sterling

Asset	BCS	BCB	BGB	BTB	BFRE	BCRE	USCS	USCB	USGB	USTB	USFRE	USCRE	USRRE
British													
Common Stocks (BCS)	1.00												
Corporate Bonds (BCB)	.75	1.00											
Government Bonds (BGB)	.70	.91	1.00										
Treasury Bills (BTB)	−.03	−.13	.05	1.00									
Farm Real Estate (BFRE)	.12	.31	.22	−.31	1.00								
Comm. Real Estate (BCRE)	.25	.33	.27	−.17	.80	1.00							
U.S.													
Common Stocks (USCS)	.65	.64	.53	.23	.03	.11	1.00						
Corporate Bonds (USCB)	.31	.57	.49	−.01	−.13	−.23	.69	1.00					
Government Bonds (USGB)	.22	.47	.40	.04	−.20	−.30	.63	.99	1.00				
Treasury Bills (USTB)	.21	.26	.16	.20	−.02	−.16	.55	.71	.71	1.00			
Farm Real Estate (USFRE)	.04	−.04	−.13	−.03	.28	.01	.14	.11	.07	.38	1.00		
Commercial Real Estate (USCRE)	.20	.23	.10	.24	.15	−.01	.57	.59	.59	.96	.39	1.00	
Residential Real Estate (USRRE)	.38	.43	.30	.21	.09	−.12	.65	.70	.70	.90	.52	.89	1.00

Source: Authors' calculation

Exhibit 5
Japanese Investor Correlation Matrix (1973–1987)
U.S. Asset Returns Hedged with Currency Options
All Returns Received in Yen

Asset	JCS	JCB	JGB	JSTIR	JFRE	JCRE	JRRE	USCS	USCB	USGB	USTB	USFRE	USCRE	USRRE
Japanese														
Common Stocks (JCS)	1.00													
Corporate Bonds (JCB)	.46	1.00												
Government Bonds (JGB)	.31	.86	1.00											
Short-Term Interest (JSTIR)	−.31	−.10	−.14	1.00										
Farm Real Estate (JFRE)	−.71	−.61	−.51	.44	1.00									
Comm. Real Estate (JCRE)	−.50	−.66	−.41	−.23	.49	1.00								
Resid. Real Estate (JRRE)	−.59	−.71	−.52	−.12	.66	.93	1.00							
U.S.														
Common Stocks (USCS)	.39	.08	−.23	−.04	−.37	−.37	−.32	1.00						
Corporate Bonds (USCB)	.17	.10	.06	−.03	−.31	−.30	−.36	.49	1.00					
Government Bonds (USGB)	.16	.05	.00	.02	−.29	−.32	−.37	.39	.97	1.00				
Treasury Bills (USTB)	−.21	−.32	−.46	.21	.14	−.09	.08	.18	.26	.37	1.00			
Farm Real Estate (USFRE)	−.59	−.60	−.77	.33	.77	.25	.45	−.07	−.23	−.17	.47	1.00		
Commercial Real Estate (USCRE)	−.14	−.33	−.51	.10	.13	−.13	.10	.27	.11	.21	.95	.50	1.00	
Residential Real Estate (USRRE)	−.24	−.33	−.59	.27	.24	−.22	.00	.31	.20	.30	.86	.67	.88	1.00

Source: Authors' calculations

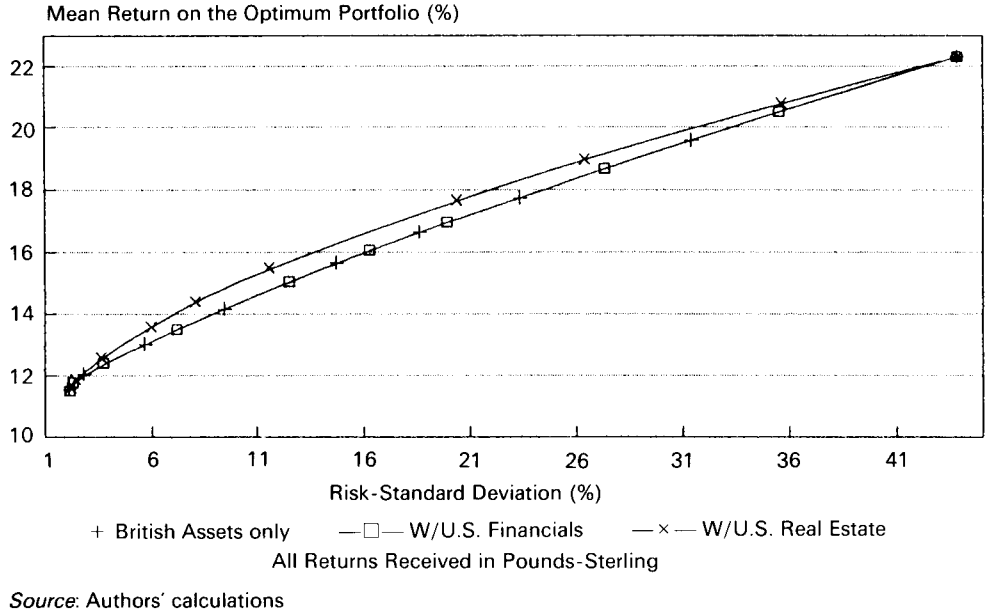
remained strongly correlated with each other. From the foreign perspective, the return characteristics of the different types of U.S. assets all appeared very similar, even when hedged. In sum, any single option-hedged U.S. asset should provide a foreign investor with significant diversification benefits but adding any second option-hedged U.S. asset to the investor's portfolio would be redundant.

Finally, we come to the issue of diversification benefits. Exhibits 6 and 7 show the efficient investment frontiers generated for the British and Japanese investors respectively. Appendix 2 contains the detailed compositions of the optimum portfolios used to produce these frontiers.

Neither the British nor the Japanese obtained any significant gains in portfolio efficiency as a result of hedging U.S. financial asset returns with currency options. The increases in mean annual returns and reductions in risk for these assets were apparently too small to provide any meaningful improvements in portfolio performance. The hedged U.S. financial assets entered the foreign investor's optimum portfolio at only the lowest risk levels and in relatively small amounts (a maximum 2.35% of the British portfolio and 6.41% of the Japanese portfolio). The impact of including these assets was negligible for both foreign investors.

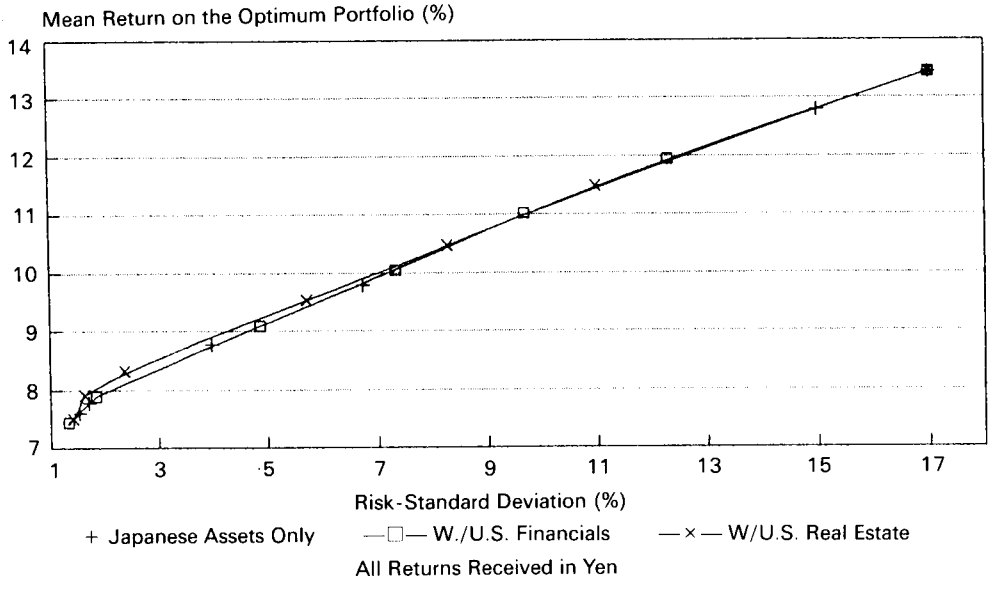
Hedging U.S. real estate investments with currency options yielded mixed results. British investors found benefits at virtually all levels of investor risk preference. The gains were smallest at the very low and very high risk levels, being largest at the mid-levels. Japanese investors, on the other hand, saw gains only at the low risk levels.

Exhibit 6
British Efficient Frontiers (1973–1987)
U.S. Assets Hedged with Currency Options



Source: Authors' calculations

Exhibit 7
Japanese Efficient Frontiers (1973–1987)
U.S. Assets Hedged with Currency Options



Source: Authors' calculations

In comparison to the British, the Japanese gains were extremely small and arguably insignificant.

These results quite naturally raise two important questions. First, why would the use of currency options benefit the British more than the Japanese? This result seems somewhat counterintuitive when one considers that yen-denominated U.S. asset returns seemed to show the greatest improvements from currency option hedging in terms of increased mean returns, reduced risk and even better correlation characteristics. Second, how could hedged U.S. real estate assets provide foreign investors with diversification gains when hedged U.S. financial assets could not? The most attractive U.S. asset to the British was commercial real estate, comprising over 50% of the optimum British portfolio at some risk levels. However, hedged U.S. commercial real estate showed very high positive correlation with hedged U.S. common stocks, U.S. bonds and U.S. T-bills (.57, .59, and .96 respectively). So, why didn't these assets improve the British efficient frontier as well?

The efficiency gains in the British portfolio appear to be related to the currency option's unique ability to greatly reduce the exchange rate risk in foreign asset returns without substantially altering exchange rate-induced foreign asset appreciation or depreciation. As noted by Ziobrowski and Curcio, in the absence of hedging, the strengthening of the U.S. dollar versus the pound during this period caused pound-denominated U.S. asset returns to be higher than dollar-denominated returns on U.S. assets. However, from the British perspective, this higher return was more than offset by the higher currency-induced risk, making U.S. assets unattractive in the mean-variance

portfolio context. But continuous hedging of these returns with currency options allowed the British investor to reduce the currency risk in U.S. assets by offering downside loss protection during years when the dollar depreciated against the pound. This was accomplished while still taking advantage of the higher returns caused by the general appreciation of the dollar versus the pound during the test period.

The situation for the Japanese was quite different. Specifically, because of the general weakening in the dollar versus the yen, currency translation from 1973 to 1987 not only caused yen-denominated U.S. asset return to be excessively risky, but they were also much lower than dollar-denominated returns. As with the British, hedging with currency options therefore alleviated a great deal of the currency risk in U.S. assets for Japanese investors. But the options could not significantly restore the returns which were lost by dollar devaluation. U.S. assets therefore continued to be unattractive to Japanese investors.

This interpretation of the data suggests that, as a long-term hedging strategy, currency options are unreliable. Their benefits depend on the magnitude and direction of currency movements. Given the uncertainty in the currency exchange markets, hedging with currency options does not seem to provide foreign investors in U.S. real estate with an adequately reliable source of relief from currency risk.

To explain U.S. real estate's dominance over U.S. financial assets, we refer back to the relationship between the currency option's capacity to reduce the U.S. asset risk to foreign investors and the asset's domestic (dollar-denominated) risk. The lower the U.S. asset's domestic risk, the more effectively currency options reduce the risk associated with foreign-denominated U.S. asset returns. It is therefore no surprise that foreign returns from U.S. commercial and residential real estate benefitted much more from hedging with currency options than U.S. common stock and bond returns which exhibited approximately three-to-four times more domestic risk. Only U.S. Treasury bills offered a level of domestic risk comparable to the domestic risk from U.S. commercial and residential real estate. And, as we might expect, hedged U.S. T-bills were the only U.S. financial assets to enter both the British and Japanese optimum portfolios in any substantial amount. Unfortunately, the rate of return from U.S. T-bills was too low to measurably improve the efficiency of the foreign portfolios.

This particular result, however, should be viewed with a great deal of skepticism.

Summary and Conclusions

From the viewpoint of mean-variance portfolio efficiency, the attraction of foreign investment to U.S. real estate has not yet been satisfactorily explained. The empirical evidence suggests that the foreign currency-denominated returns from U.S. real estate are far too risky to provide foreigners with any diversification gains. This risk appears to be directly linked to the volatility in exchange rates. The purpose of this study was to test the use of currency options as a long-term hedging strategy that may be used by foreign investors to improve the performance of U.S. real estate assets. Efficient frontiers were constructed for the two largest groups of foreign investors in U.S. real estate, the British and the Japanese, to determine the diversification benefits available from the U.S. real estate assets that were continuously hedged by currency options. The period covered by the tests included 1973 through 1987.

It was observed that over short periods of time, currency options clearly provide a downside limit to the magnitude of losses that could occur as a result of currency volatility. To the foreign investor in U.S. real estate, a call option on their home-country currency would insure their investment against a sudden slide in the value of the dollar. However, when currency options are used over the long term, the periodic cost of the insurance in the form of option premiums offsets the gains. Thus as a long-term strategy, the currency option offers no real protection against foreign asset devaluation caused by currency depreciation.

The main benefit of using currency options by foreign investors to hedge U.S. real estate investments would be exchange rate risk reduction. Unfortunately, the options merely reduce currency risk, but do not eliminate it. Thus from the perspective of foreign investors, the option-hedged U.S. asset returns remain generally noncompetitive with returns from local, home-country assets in terms of risk versus return.

Some diversification gains were found for British investors in U.S. real estate who hedged their investments with currency options. The Japanese saw very little improvement in portfolio efficiency from hedging their U.S. real estate with these options. These "mixed" results suggest that these gains were period- and country-specific and the value of currency options as a long-term hedging strategy depends in large part on the direction and magnitude of the swings in exchange rates. Thus, as a long-term hedge, currency options are not reliable.

In sum, currency options do not seem to explain investment in U.S. real estate by foreign investors. Other financial strategies involving forward contracts, futures, and tax avoidance should be considered to determine if U.S. real estate returns can be made more attractive to foreign investors in a mean-variance context. Additionally, a number of less obvious but equally plausible explanations for the foreign interest in U.S. real estate need to be explored before any firm conclusions can be drawn. Possible motivations include but are not limited to safe haven, political diversification, and perceived comparative advantage.

As a final note, although beyond the scope of this study, we would expect that these results would be generally applicable to U.S. investments in foreign real estate as well. The volatility in exchange rates is clearly a two-way street. If currency fluctuations make U.S. real estate excessively risky to British investors, then British real estate should appear equally risky to U.S. investors. Extending that logic one step further, currency options are therefore unlikely to provide U.S. investors with adequate long-term relief

from this risk, anymore than they helped the investors of other foreign countries. Clearly, currency options should thus be viewed as a short-term hedge only, by investors of all countries.

Appendix 1

This appendix contains the derivation of the expressions used to estimate the annual rate of return to foreign investors in U.S. assets hedged with currency options.

Ignoring taxes and transaction costs, the simple equation for the total annual return from an unleveraged U.S. asset to a U.S. investor can be written:

$$R_{\$} = \frac{V_2 + I - V_1}{V_1}, \tag{1A}$$

where

V_1 = value of the property at the beginning of the year($),
V_2 = value of the property at the end of the year($),
I = operating income received during the year($).

When foreigners both invest and receive funds in their home-country currency and it is assumed that foreign investors repatriate all funds only once a year, equation 1A can be changed as follows to estimate the foreign investor's annual rate of return on U.S. assets:

$$R_{x} = \frac{(V_2 + I)X_2 - V_1X_1}{V_1X_1}, \tag{1B}$$

where

X_1 = exchange rate at beginning of year (investor's home currency per dollar),
X_2 = exchange rate at year-end (investor's home currency per dollar).

As equation 1B clearly shows, when the exchange rate declines substantially (i.e., $X_2 << X_1$), there exists a strong possibility that the foreign investor will suffer serious losses even when the value of the asset has increased in dollar terms ($V_2 > V_1$) and the income, I, is positive. Should the foreigner wish to hedge against these currency-induced losses, one alternative is to purchase currency options. Assume that a foreign currency call option purchased at the beginning of the year having an exercise price equal to X_1 and expiration at year-end, costs C dollars per unit of foreign currency. If the investor desires to hedge only his or her initial investment, V_1X_1, then the return to the foreign investor who buys such an option can be written:

$$R_{xo} = \frac{(V_2 + I)X_2 - V_1X_1 - V_1X_1CX_1 + V_1(X_1 - X_2),}{V_1X_1 + V_1X_1CX_1}, \tag{1C}$$

where

C = cost of a currency call option at the beginning of the year with an exercise price X_1 (dollars per unit of the foreign investor's home currency),

$V_1X_1CX_1$ = total cost of hedging the initial investment V_1X_1 (investor's home-country currency),

$V_1(X_1 - X_2)$ = value of the currency option at year-end when the option finishes in the money, $X_1 > X_2$ (investor's home-country currency),

$= o$ when $X_2 \geq X_1$ and the option is not exercised.

Rewriting equation 1A such that

$$V_2 + I = V_1(R_s + 1),$$

and substituting this expression into (1C) yields

$$R_{xo} = \frac{V_1X_2(R_s + 1) - V_1X_1 - V_1X_1^2C + V_1(X_1 - X_2)}{V_1X_1(1 + X_1C)}. \tag{1D}$$

Simplifying we obtain

$$R_{xo} = \frac{X_2R_s - CX_1^2}{X_1(CX_1 + 1)} \text{ when } X_1 > X_2, \tag{1E}$$

or

$$R_{xo} = \frac{X_2(R_s + 1)}{X_1(CX_1 + 1)} - 1 \text{ when } X_2 \geq X_1. \tag{1F}$$

Appendix 2
Composition of All British and Japanese Optimum Portfolios[A]
All U.S. Asset Returns Hedged with Currency Options

Table 2A
British Domestic Assets Only
Returns Received in Pounds-Sterling

	Percentage of Total Portfolio Invested in Each Asset							
Portfolio	1	2	3	4	5	6	7	8
Asset								
British								
Common Stock	—	2.42	7.89	14.32	26.58	37.82	70.00	100.00
Corporate Bonds	1.34	3.06	4.15	5.44	2.46	—	—	—
Government Bonds	0.10	—	—	—	—	—	—	—
Treasury Bills	90.58	76.54	52.28	23.77	—	—	—	—
Farm Real Estate	—	—	—	—	—	—	—	—
Commercial Real Estate	7.98	17.98	35.68	56.46	70.96	62.18	30.00	—
Mean Annual Portfolio Return (%)	11.54	12.05	13.02	14.16	15.66	16.64	19.57	22.31
Standard Deviation (%)	2.11	2.80	5.65	9.46	14.71	18.60	31.40	43.82

Table 2B
British Domestic Assets and U.S. Financial Assets
Returns Received in Pounds-Sterling

	Percentage of Total Portfolio Invested in Each Asset							
Portfolio	1	2	3	4	5	6	7	8
Asset								
British								
Common Stock	—	3.98	9.23	18.32	30.98	41.25	80.00	100.00
Corporate Bonds	0.50	4.14	6.92	9.07	2.12	—	—	—
Government Bonds	—	—	—	—	—	—	—	—
Treasury Bills	89.99	66.78	37.21	—	—	—	—	—
Farm Real Estate	—	—	—	—	—	—	—	—
Commercial Real Estate	7.16	25.10	46.63	72.61	66.90	58.75	20.00	—
U.S.								
Common Stock	—	—	—	—	—	—	—	—
Corporate Bonds	—	—	—	—	—	—	—	—
Government Bonds	0.02	—	—	—	—	—	—	—
Treasury Bills	2.33	—	—	—	—	—	—	—
Mean Annual Portfolio Return (%)	11.50	12.40	13.48	15.04	16.05	16.95	20.49	22.31
Standard Deviation (%)	2.14	3.71	7.16	12.48	16.25	19.91	35.51	43.82

Table 2C
British Domestic Assets and All U.S. Assets Returns Received in Pounds-Sterling

	Percentage of Total Portfolio Invested in Each Asset							
Portfolio	1	2	3	4	5	6	7	8
Asset								
British								
Common Stock	—	2.19	4.77	7.88	18.64	41.20	56.70	100.00
Corporate Bonds	—	—	—	—	—	—	—	—
Government Bonds	—	—	—	—	—	—	—	—
Treasury Bills	86.97	54.62	22.78	—	—	—	—	—
Farm Real Estate	—	—	—	—	—	—	—	—
Commercial Real Estate	6.38	21.49	35.63	44.69	35.65	7.65	—	—
U.S.								
Common Stock	—	—	—	—	—	—	—	—
Corporate Bonds	—	—	—	—	—	—	—	—
Government Bonds	—	—	—	—	—	—	—	—
Treasury Bills	0.09	—	—	—	—	—	—	—
Farm Real Estate	2.10	6.13	9.64	11.16	2.67	—	—	—
Commercial Real Estate	1.93	15.57	27.18	36.27	43.04	51.15	43.30	—
Residential Real Estate	2.52	2.25	—	—	—	—	—	—
Mean Annual Portfolio Return (%)	11.60	12.59	13.57	14.40	15.49	17.67	18.97	22.31
Standard Deviation (%)	2.19	3.61	5.96	8.08	11.54	20.36	26.39	43.82

Table 2D
Japanese Domestic Assets Only Returns Received in Yen

	Percentage of Total Portfolio Invested in Each Asset					
Portfolio	1	2	3	4	5	6
Asset						
Japanese						
Common Stock	2.42	3.18	11.21	21.84	85.88	100.00
Corporate Bonds	13.92	15.65	29.67	44.08	14.12	—
Government Bonds	11.43	12.68	21.62	30.81	—	—
Short-Term Interest Rate	51.39	52.62	37.50	3.27	—	—
Farm Real Estate	8.16	6.62	—	—	—	—
Commercial Real Estate	5.85	2.64	—	—	—	—
Residential Real Estate	6.83	6.61	—	—	—	—
Mean Annual Portfolio Return (%)	7.61	7.79	8.77	9.79	12.79	13.44
Standard Deviation (%)	1.53	1.71	4.00	6.72	14.98	16.99

Table 2E
Japanese Domestic Assets and U.S. Financial Assets Returns Received in Yen

	Percentage of Total Portfolio Invested in Each Asset						
Portfolio	1	2	3	4	5	6	7
Asset							
Japanese							
Common Stock	2.60	4.96	13.53	26.46	47.45	67.39	100.00
Corporate Bonds	12.10	16.73	32.43	36.85	22.41	8.70	—
Government Bonds	9.84	13.56	29.72	36.69	30.13	23.90	—
Short-Term Interest Rate	46.32	49.07	24.31	—	—	—	—
Farm Real Estate	9.39	7.65	—	—	—	—	—
Commercial Real Estate	5.93	—	—	—	—	—	—
Residential Real Estate	7.41	7.26	—	—	—	—	—
U.S.							
Common Stock	0.90	0.77	—	—	—	—	
Corporate Bonds	1.89	—	—	—	—	—	—
Government Bonds	1.17	—	—	—	—	—	—
Treasury Bills	2.45	—	—	—	—		—
Mean Annual Portfolio Return (%)	7.45	7.99	9.08	10.05	11.02	11.94	13.44
Standard Deviation (%)	1.32	1.84	4.87	7.31	9.66	12.28	16.99

Table 2F
Japanese Domestic Assets and All U.S. Assets Returns Received in Yen

	Percentage of Total Portfolio Invested in Each Asset						
Portfolio	1	2	3	4	5	6	7
Asset							
Japanese							
Common Stock	2.15	3.72	6.53	16.91	35.48	57.45	100.00
Corporate Bonds	11.68	15.15	20.26	36.80	31.92	22.33	—
Government Bonds	10.34	13.93	19.37	36.59	32.60	20.22	—
Short-Term Interest Rate	45.77	46.01	39.18	—	—	—	—
Farm Real Estate	7.99	6.51	2.24	—	—	—	—
Commercial Real Estate	5.09	—	—	—	—	—	—
Residential Real Estate	6.40	6.21	4.49	—	—	—	—
U.S.							
Common Stock	0.24	0.40	0.53	—	—	—	—
Corporate Bonds	0.38	—	—	—	—	—	—
Government Bonds	0.08	—	—	—	—	—	—
Treasury Bills	1.96	—	—	—	—	—	—
Farm Real Estate	0.99	0.88	0.47	—	—	—	—
Commercial Real Estate	4.08	5.34	6.94	9.71	—	—	—
Residential Real Estate	2.85	1.94	—	—	—	—	—
Mean Annual Portfolio Return (%)	7.50	7.91	8.31	9.52	10.47	11.48	13.44
Standard Deviation (%)	1.41	1.62	2.37	5.71	8.25	10.97	16.99

[A]All optimum portfolios were constructed with the methodology described by Elton, Gruber and Padberg (1976).
Source: Authors' calculations

Notes

[1]The value of current holdings of U.S. real estate by foreigners is extremely difficult to estimate accurately. In most states, no distinctions are made between foreign owners and U.S. owners. The National Realty Committee (1989), a nonprofit national real estate association, estimates that foreign investors own over $150 billion in U.S. real estate.

[2]See U.S. Department of Commerce (various years) for a breakdown of foreign U.S. real estate holdings by country.

[3]See Hull (1989) for a more detailed description of currency options.

[4]Between 1973 and 1987, British housing laws were extremely biased in favor of tenants making it very difficult for investors to earn a reasonable return in residential real estate. British residential real estate was therefore not regarded as a serious investment vehicle and no meaningful data exists for this time period. Fortunately, the omission of this data has no bearing on our conclusions since deleting British residential real estate returns can only enhance the performance of hedged U.S. real estate in a British investor's portfolio.

[5]The Japanese government does not issue a security that is comparable to the T-bill. Hamao's short-term interest rate (STIR) is therefore derived from the interest rate on Japanese bond repurchase agreements. This is felt to be an appropriate substitute.

[6]It may appear that this procedure ignores the differences in cash flow patterns received during the holding period (one year) from the various types of assets. Typically, stocks pay dividends quarterly, bonds pay interest semiannually, bills are sold at a pure discount and real estate yields monthly rent. But in fact, because the data used in this study is derived from large well-diversified portfolios of assets (such as the S&P 500 for U.S. common stock), income is technically produced and reinvested on virtually a continuous basis (one company or another in the portfolio is always paying a dividend). In an analogous fashion, this would also be true of the well-diversified bond portfolios, Treasury bill portfolios, and even the real estate portfolios from which the data was derived. Thus, because the returns used here come from portfolios composed of many assets rather than an individual asset, there is no appreciable difference between the cash flow stream from these assets. All continuously produce and reinvest cash.

[7]Hull (1989) provides the following commission schedule for a typical discount broker:

Total Dollar Value of Options	Commission
< $2,500	$20 + 0.02 of the dollar amount
$2,500 to $10,000	$45 + 0.01 of the dollar amount
> $10,000	$120 + 0.0025 of the dollar amount

Naturally, full service brokers charge more.

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