YEN FUTURES: EXAMINING HEDGING EFFECTIVENESS BIAS AND CROSS-CURRENCY HEDGING RESULTS

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SUBMITTED FOR

THE FIRST ANNUAL

PACIFIC-BASIN FINANCE CONFERENCE

The author wishes to thank Luisa Chong for computer assistance.

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ABSTRACT

The usefulness of yen futures for hedging purposes is examined in several unique ways. The two key concepts are: (1) to determine the extent of the hedging effectiveness bias that is inherent in the portfolio/regression model of hedging, and (2) to examine the hedging effectiveness and the potential instability of the hedge ratios for cross-currency hedging between yen futures and cash currencies of industrialized and lesser developed countries. The analysis also provides evidence on the subperiod yen futures hedging results, the effect of the length of the time interval on the hedging effectiveness, and the effect of changing the timing difference between the futures and cash data.

NOTE: Since DRI (Data Resources Inc.) had considerable difficulty in providing the correct data for the analysis contemplated above, the results given here are incomplete. Therefore, the results of the current draft of this paper only reflects an examination of one week hedges for the yen futures versus yen cash and cross-currency hedges for industrial countries plus an examination of the associated bias; however, the introduction to the paper notes other areas that will be explored, including:

1) Data analysis for 1974-1979

2) Cross currency results for lesser developed countries

3) Two week and one month hedges (each period will be lengthened)

4) Using the open futures price to determine the effect of timing differences.

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INTRODUCTION

Hedging studies for currency futures and other types of futures contracts have concentrated on determining the hedge ratios and hedging effectiveness for a given time period by using the portfolio/regression approach (see Ederington (1979)). Hill and Schneeweis (1982) use this model with currency futures and associated cash data for 1974-78, determining that the yen futures only possess a hedging effectiveness of 16.0% and 14.8% for one week and two week hedges when the nearby contract is employed. Other currencies provide effectiveness results ranging from 46.1% to 67.4% for one week hedges and 74.4% to 83.1% for two week hedges.

The first objective of this paper is to determine the hedging effectiveness of the yen futures for the 1980-86 time period and its subperiods to examine the ability of the yen futures contract to achieve its objective of providing an effective means of hedging cash yen currency fluctuations during the volatile time period of the 1980's. These results will be compared to a recomputation of the 1974-79 data to examine what differences exist. The effect of the time interval used to measure hedging effectiveness and the timing issue of matching the cash and futures quotations also will be explored. The second objective of this paper is to examine the cross-currency hedging effectiveness and hedge ratio stability of yen futures with European/industrialized countries and with lesser developed countries. The third and most important objective of this paper is to develop models that examine the effect of unstable hedge ratios on hedging effectiveness; these models are then tested on the yen futures contract.

The paper is organized as follows: the two models which measure the amount of bias in the typical ex-post hedging effectiveness value are developed, the data and results relating to yen futures hedging are examined, and then conclusions and implications are given.

THE MODELS FOR HEDGING EFFECTIVENESS BIAS

Two models are developed to show the effect of an unstable hedge ratio on hedging effectiveness. The first model assumes that one wishes to hedge against all price changes except changes due to convergence. This simplification provides a straightforward result that is easy to calculate. The second model is based on the desire to hedge against all price changes. This model is more complicated in form but theoretically will be more accurate, especially for markets with trend changes, a large convergence factor, or for cross-hedging situations which have deviations between the behavior of the futures and cash markets.

A Simplified Model

The typical ex-post variance minimizing hedge ratio for time period t+1 is designated as b^*_{t+1} and is defined as:

$$b^*_{t+1} = \sigma_{SF}/\sigma_F^2 \tag{1}$$

Where:

σ_{SF} = the covariance between the spot (S) and futures (F) price changes during time period t+1

σ_F^2 = the variance of the futures price changes during time period

t+1

The basis at a specific time k within the time interval t+1, as defined in terms of the ex-post minimum variance hedge ratio, is:

$$H^*_{t+1}(k) = \text{Basis} = S_{t+1}(k) - b^*_{t+1}\ F_{t+1}(k) \quad (2)$$

Where:

$H^*_{t+1}(k)$ = the basis at time k within time interval t+1, as determined by using the ex-post hedge ratio b^*_{t+1}

$S_{t+1}(k)$ = spot price at time k within interval t+1

$F_{t+1}(k)$ = futures price at time k within interval t+1

Similarly, we define the change in the basis from time k to time k+1 within time period t+1 as:

$$\Delta H^*_{t+1}(k,k+1) = \Delta S_{t+1}(k,k+1) - b^*_{t+1}\ \Delta F_{t+1}(k,k+1) \quad (3)$$

If one wishes to hedge against all price changes other than those due to convergence or to the average change in the basis over the period, then the variability of the basis change during time period t+1 can be determined by:

$$\text{var}(\Delta H^*_{t+1}) = \sigma_S^2 + {b^*_{t+1}}^2\ \sigma_F^2 - 2\ b^*_{t+1}\ \sigma_{SF} \quad (4)$$

Where: σ_S^2 = the variance of spot price changes during period t+1

When an unstable minimum variance hedge ratio exists between time period "t" and time period "t+1" then b^*_{t+1} can be defined in terms of b^*_t and the change in the hedge ratio from "t" to "t+1":

$$b^*_{t+1} = b^*_t + \Delta b_t \qquad (5)$$

Where:

b^*_t = the minimum variance hedge ratio over the time period t

Δb_t = the change in the hedge ratio from time period t to time period t+1

Consequently, the change in the basis between time k and time k+1 within time interval t+1 can be redefined to consider the effect of employing the previous period's minimum variance hedge ratio b^*_t as an estimate of the true current period's minimum variance hedge ratio. Thus, if $b^*_t + \Delta b_t$ from (5) is substituted for b^*_{t+1} in (3) we have:

$$\Delta H^*_{t+1}(k,k+1) = \Delta S_{t+1}(k,k+1) - (b^*_t + \Delta b_t)\ \Delta F_{t+1}(k,k+1) \qquad (6)$$

The resultant equation for the variability in the basis change is:

$$\mathrm{var}(\Delta H^*_{t+1}) = \sigma_S^2 + (b^*_t + \Delta b_t)^2\ \sigma_F^2 - 2\ (b^*_t + \Delta b_t)\ \sigma_{SF} \qquad (7)$$

Likewise, if at the beginning of time period t+1 one uses the minimum variance hedge ratio b^*_t as the best estimate of b^*_{t+1}, then one may determine what the variability of the basis change would be during t+1 by using b^*_t:

$$\mathrm{var}(\Delta H^t_{t+1}) = \sigma_S^2 + b^{*2}_t\ \sigma_F^2 - 2\ b^*_t\ \sigma_{SF} \qquad (8)$$

Where:

$\mathrm{var}(\Delta H^t_{t+1})$ = the variance of the change in the basis during time period t+1 as determined by using the previous period's minimum variance hedge ratio b^*_t.

Subtracting (7) from (8) we can determine the additional basis risk from using b^*_t as an estimate of b^*_{t+1} when the minimum variance hedge ratio changes over time:

$$\mathrm{var}(\Delta H^t_{t+1}) - \mathrm{var}(\Delta H^*_{t+1}) = - \Delta b^{*\,2}_t \sigma_F^2 - 2\, b^*_t\, \Delta b_t\, \sigma_F^2 + 2\, \Delta b_t\, \sigma_{SF} \quad (9)$$

$$= 2\, \Delta b_t\, (\sigma_{SF} - b^*_t\, \sigma_F^2) - \Delta b_t^2\, \sigma_F^2$$

$$= 2\, \Delta b_t\, \sigma_F^2\, (\sigma_{SF}/\sigma_F^2 - b^*_t\, \sigma_F^2/\sigma_F^2) - \Delta b_t\, \sigma_F^2$$

$$= 2\, \Delta b_t\, \sigma_F^2\, (b^*_{t+1} - b^*_t) - \Delta b_t^2\, \sigma_F^2$$

Since from (5):

$$\Delta b_t = b^*_{t+1} - b^*_t$$

we determine that:

$$\mathrm{var}(\Delta H^t_{t+1}) - \mathrm{var}(\Delta H^*_{t+1}) = \Delta b_t^2\, \sigma_F^2 > 0 \quad (10)$$

Using $E^*_{t+1} = R_{t+1}^2$ as the typical measure of the minimum variance hedging effectiveness for period t+1, equation (11) states this definition in terms of the variability in the basis change by employing the minimum variance hedged position (ΔH^*_{t+1}) and the variability of the changes in the unhedged or cash (ΔS_{t+1}) position:

$$E^*_{t+1} = R_{t+1}^2 = 1 - \mathrm{var}(\Delta H^*_{t+1})/\mathrm{var}(\Delta S_{t+1}) \quad (11)$$

Where:

E^*_{t+1} = the hedging effectiveness for period t+1 by using the minimum variance hedge ratio b^*_{t+1}

The upward bias in the t+1 minimum variance hedging effectiveness value when b^*_t is used as an estimate of b^*_{t+1} can be determined by using

(10):

$$E^{*}_{t+1} - E^{t}_{t+1} = 1 - var(\Delta H^{*}_{t+1})/\sigma_S^{2} - [1 - var(\Delta H^{t}_{t+1})/\sigma_S^{2}]$$

$$= \Delta b_t^{2} [\sigma_F^{2}/\sigma_S^{2}]$$

(12)

Where:

E^{*}_{t+1} = the minimum variance hedging effectiveness measure when the ex-post hedge ratio b^{*}_{t+1} is employed during time period t+1

E^{t}_{t+1} = the hedging effectiveness when the ex-ante hedge ratio b^{*}_{t} from period t is employed during time period t+1

Equation (12) determines the upward bias inherent in E^{*}_{t+1} when the ex-post minimum variance hedge ratio b^{*}_{t+1} is employed to determine the hedging effectiveness <u>and</u> the hedge ratio is not stable over time. Equation (12) shows that this bias is related to the size of the change in the hedge ratio squared, Δb_t^{2}, and the volatility scale factor $\sigma_F^{2}/\sigma_S^{2}$.

<u>Including the Average Change in the Basis in the Model</u>

Another model of the effect of unstable hedge ratios on the ex-post hedging effectiveness can be determined by including the effect of the average change in the basis during time period t+1. Since the typical variance model employed in (12) above determines the variability <u>around</u> the mean of the distribution, any trend or convergence in the data that shows up as an average change in the basis will not be considered as variability by the model derived above. However, if we assume that the hedger wishes to minimize variability about a zero change in the basis, then the following model is appropriate to determine the extent of the bias in the hedging effectiveness measure.

Equations (1) through (3), (5), and (6) define basis and the change in the basis in terms of b^*_{t+1}, b^*_t, and the change in these hedge ratios from t to t+1, Δb_t. If we use the regression methodology to define the change in the cash price between intervals k and k+1 during period t+1 we have:

(13) $$\Delta S_{t+1}(k,k+1) = a^*_{t+1} + b^*_{t+1}\ \Delta F_{t+1}(k,k+1) + e^*_{t+1}(k,k+1)$$

Where:

a^*_{t+1} = the y-intercept for the minimum variance hedge ratio regression equation during period t+1

e^*_{t+1} (k,k+1) = the error term for the minimum variance hedge ratio regression equation during period t+1, for the price change occurring during the time interval k to k+1

Then substituting into equation (3) we obtain:

$$\Delta H^*_{t+1}(k,k+1) = [a^*_{t+1} + b^*_{t+1}\ \Delta F_{t+1}(k,k+1) + e^*_{t+1}(k,k+1)] - b^*_{t+1}\ \Delta F_{t+1}(k,k+1)$$

(14) $$= a^*_{t+1} + e^*_{t+1}(k,k+1)$$

Squaring each change in the basis and summing over all of the time intervals k in period t+1, one obtains the <u>total</u> variability in the basis during period t+1:

(15) $$\sum_k (\Delta H^*_{t+1})^2 = \sum_k (a^*_{t+1} + e^*_{t+1})^2$$

Alternatively, if one employs the previous period's minimum variance hedge ratio b^*_t during time period t+1 then the change in the basis for a given time interval is:

$$\Delta H^t_{t+1}(k,k+1) = \Delta S_{t+1} - b^*_t \, \Delta F_{t+1}$$

$$= [a^*_{t+1} + b^*_{t+1} \, \Delta F_{t+1}(k,k+1) + e^*_{t+1}(k,k+1)] - b^*_t \, \Delta F_{t+1}(k,k+1) \quad (16)$$

Substituting from (5), $b^*_{t+1} = b^*_t + \Delta b_t$, squaring each basis change, and summing over k we obtain:

$$(17) \qquad \sum_k (\Delta H^t_{t+1})^2 = \sum_k (a^*_{t+1} + e^*_{t+1} + \Delta b_t \, \Delta F_{t+1})^2$$

The following formulas employ the squared variabilities being summed over the time intervals k during time period t+1 to define the hedging effectiveness measures:

$$(18) \qquad E^*_{t+1} = R_{t+1}^2 = 1 - \sum_k (\Delta H^*_{t+1})^2 / \sum_k (\Delta S_{t+1})^2$$

$$\text{and } E^t_{t+1} = 1 - \sum_k (\Delta H^t_{t+1})^2 / \sum_k (\Delta S_{t+1})^2$$

Note that the summation of the variability of ΔH is the <u>total</u> basis variability of the hedged position. This total basis variability depends on whether b^*_{t+1} or b^*_t is employed as the hedge ratio during period t+1 to determine E^*_{t+1} and E^t_{t+1}, respectively.

The upward bias in the minimum variance hedging effectiveness measure E^*_{t+1} when there exists an instability in the hedge ratio from periods t to t+1 is:

$$E^*_{t+1} - E^t_{t+1} = 1 - \Sigma(\Delta H^*_{t+1})^2 / \Sigma(\Delta S_{t+1})^2 - [1 - \Sigma(\Delta H^t_{t+1})^2 / \Sigma(\Delta S_{t+1})^2]$$

$$= [\Sigma(\Delta H^{t}_{t+1})^2 - \Sigma(\Delta H^{*}_{t+1})^2]/\Sigma(\Delta S_{t+1})^2 \tag{19}$$

Substituting equations (15) and (17) into (19), combining terms, rearranging, and noting that $\Sigma e = 0$:

$$E^{*}_{t+1} - E^{t}_{t+1} = \Sigma\ \Delta b_t^{\,2}\ \Delta F_{t+1}^{\,2} + \Sigma\ 2a^{*}_{t+1}\ \overline{\Delta b_t}\ \Delta F_{t+1} \tag{20}$$

Now, since:

$$\sigma_F^{\,2} = \Sigma \Delta F^2/N - \overline{\Delta F}^2$$

and thus

$$\Sigma \Delta F^2 = N\ \sigma_F^{\,2} + \overline{N}\ \Delta F^2 \tag{21}$$

Where:

$\sigma_F^{\,2}$ = the variance of ΔF over time period t+1

$\overline{\Delta F}$ = the mean of ΔF over time period t+1

and similarly for $\Sigma \Delta S^2$, upon summing and substituting (21) into (20) we obtain:

$$E^{*}_{t+1} - E^{t}_{t+1} = [\Delta b_t^{\,2}\ \sigma_F^{\,2} + \Delta b_t^{\,2}\ \overline{\Delta F}^2 + 2a^{*}_{t+1}\ \overline{\Delta b_t}\ \Delta F]/[\sigma_S^{\,2} + \overline{\Delta S}^2] \tag{22}$$

Where:

a^{*}_{t+1} = the average per period change in the basis during period t+1

Interpreting the Models

The models in the previous sections show that using the variance minimizing hedge ratio technique when hedge ratios are unstable over time results in an upward biased value for the hedging effectiveness measure.

Conceptually, if b^*_{t+1} is the minimum variance hedge ratio during time t+1 using regression, then any other hedge ratio b_t that differs from b^*_{t+1} will have a larger sum of squared errors than b^*_{t+1} and thus possess a lower R^2 or E value.

Model (1) is based on the concept that one wishes to minimize the variance of the price changes around the average change in the basis. Hence, the assumption is made that a systematic change in the basis due to convergence or other external economic factors can not be hedged away. This results in the conclusion that the bias in the hedging effectiveness with an unstable hedge ratio is determined by (12):

$$E^*_{t+1} - E^t_{t+1} = \Delta b_t^2 \; [\sigma_F^2/\sigma_S^2] \qquad (23)$$

Model (2) is based on the desire to minimize the variance of <u>all</u> price changes, i.e. to hedge against any change in the basis, including any systematic change in the basis. Equation (22) shows the bias in hedging effectiveness for model(2):

$$E^*_{t+1} - E^t_{t+1} = [\Delta b_t^2 \; \sigma_F^2 + \Delta b_t^2 \; \overline{\Delta F}^2 + 2a^* \; \Delta b_t \; \overline{\Delta F}]/[\sigma_S^2 + \overline{\Delta S}^2] \qquad (24)$$

The implications of these models for the hedger of using minimum variance hedging effectiveness measures from period t+1 as an estimate of the actual effectiveness value for t+1 are obvious: if there is a large change in the hedge ratio or a large average change in the basis then the minimum variance effectiveness measure may contain a significant upward bias. Thus, unstable hedge ratios increase the basis risk of the hedge compared to the typical R^2 hedging effectiveness results.

Since the minimum variance $E^*_{t+1} = R_{t+1}^2$ values have been employed in most of the previous research to determine hedging effectiveness, and since unstable hedge ratios affect the more realistic E^{t}_{t+1} values, the empirical implications of the above result need to be examined. Specifically, to what extent do unstable hedge ratios affect the hedging effectiveness of the model? The next section explores this question.

DATA AND RESULTS

Data

Cash and futures yen currency values are employed from 1974-1986 to determine the hedge ratios and hedging effectiveness values for weekly, biweekly, and monthly intervals. Weekly data for 26 weeks are used for each time period, while the biweekly results are based on annual periods, and the monthly intervals use two years to form one time period. Each observation is taken as of the Wednesday of the week; Wednesday was chosen to avoid anomalies which may occur when traders close positions on Friday and to provide a more extensive database for cross-currency rates. The cash currency values are based on late afternoon prices from The Bank of American in London; the data was obtained from Data Resources Inc. Futures values used in the analysis are the close and the open rates from the Chicago Mercantile Exchange. The close data often are used by other researches examining hedging effectiveness and typically provide significant liquidity, especially for the nearby contract. Open data more closely correspond in time to the late afternoon London cash prices, given the six hour difference between Chicago and London.

Cash currency values are employed for the yen, European/industrialized countries, and lesser developed countries. The cross-currency data allows an examination of cross hedging for currencies that has previously not been explored. Cash and futures currency values are converted to percentage changes to execute the regression hedging model.[1] Subperiod results allow for the examination of potential instability of the hedge ratios and the effect on the hedging effectiveness via the models developed earlier in this paper.

Results

Tables I to IV present the results of using the portfolio/regression methodology to obtain hedge ratios and hedging effectiveness measures. Tables I to III show the minimum variance hedge ratio for each period, b^*_{t+1}, the absolute value of the change in the minimum variance hedge ratio from the previous period, $|\Delta b_t|$, the hedging effectiveness value for period t+1, $E^*_{t+1} = R^{*2}_{t+1}$, and the bias in the hedging effectiveness that exists when the hedge ratio is unstable over time. The results are based on using weekly intervals over 26 week periods and therefore are designated in terms of the first and second half of the year. Table I shows the results for the yen futures versus the yen cash. The hedging effectiveness measures for the yen futures/cash relationships range from 66% for the 1986-1 period to 93%; these are respectable effectiveness measures and are much higher than indicated by Hill and Schneeweis (1982) for the 1974-48 period. The changes in the hedge ratios are generally small for the yen futures/cash relationships, causing only small biases in the hedging effectiveness measures, with most of the individual biases being 3% or less.

TABLE I ABOUT HERE

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Table II presents the relevant results for the yen futures/Australian dollar cash relationships. The hedging effectiveness measure for the 1986-1 period is essentially 0%, and five periods have effectiveness measures below 10%. The 1980-2 period provides poor hedging results for all of the yen futures/cash relationships summarized in Table IV; during this period the yen experienced several weeks of extremely large changes. The other periods for the yen/Australian dollar comparisons provided effectiveness measures up to 59%. While 8 of the 13 periods produced insignificant hedging effectiveness biases, the other five periods possessed large changes in the hedge ratios, causing biases as large as 33%. Table III shows somewhat better results for the yen futures/French franc comparisons: effectiveness measures here are above 10% for all but the 1980-2 period. However, the effectiveness biases are above 10% for five of the periods. In particular, note that the 1980-2 period had a bias of 68%; this indicates that using the previous period's hedge ratio would create a variability which is 68% larger than if no hedge was undertaken (the 1980-2 E^* measure was 0%). Such distressing results typically occurred for several periods for each of the futures/cash relationships summarized in Table IV.

TABLES II AND III ABOUT HERE

Table IV provides summary results for the 1980-86 periods for the yen futures/cash associations and for six European/industrialized countries.

This table states the averages of the per period results for the same statistics given in tables I to III. The table shows that the average hedge ratio varies among countries just as the previous table showed that it varied among periods for a given currency, with the cross currency hedge ratio being significantly lower than the yen futures/cash hedge ratio. The average absolute change in the hedge ratio is small for the yen only relationship but large for the cross currencies, especially when the average change is compared to its average hedge ratio. The hedging effectiveness measures are much lower than the yen futures/cash value, but these effectiveness values are still respectable for cross hedging associations. However, the hedging biases for these cross currency results <u>average</u> 9% to 24% per period, while the bias for the yen futures/cash hedging results averages only about 1%. Note that Model (2) does result in slightly higher biases, although the difference only amounts to several percent per period.

TABLE IV ABOUT HERE

IMPLICATIONS AND CONCLUSIONS

This paper examines two issues. First, it derives two models which determine the extent of the bias in the R^2 values when hedge ratios are unstable over time and the previous period's minimum variance hedge ratio is employed as the estimate of the current period's hedge ratio. Empirical results showing the size of this bias are provided for hedges involving yen futures and cash currencies from six European/industrialized countries. Second, the paper shows the minimum variance hedge ratios and hedging effectiveness values for these cross currency hedges.

The same period hedging effectiveness values for the cross currency hedges are reasonable; <u>however</u>, if one assumes imperfect knowledge about the futures minimum variance hedge ratio and uses the <u>previous</u> period's hedge ratio as the best forecast then the resulting bias in the cross currency hedge effectiveness measures range from 9% to 24% per period. Moreover, most currency results possess several periods where the variability in price changes are actually increased by using the previous period's hedge ratio as compared to using a no hedge strategy.

The importance and implications to the hedger of unstable hedge ratios and the resultant effect on hedging effectiveness is obvious, namely: the use of past data to forecast future hedge ratios and hedging effectiveness must be undertaken with greater care for cross hedging. On the other hand, when the hedger uses the same cash and futures instrument to create a hedge then the biases resulting from unstable hedge ratios tend to be negligible overall. Previous research using the minimum variance hedge ratio approach implicitly assumed that the hedger possessed ex-post data to determine the hedging effectiveness, whether a hedge should be employed, and the resultant consequences of the proposed hedge position. This assumption needs to be reevaluated.

These results also suggest that additional futures contracts would be desirable for those who intend to hedge cash instruments that are "significantly different" from currently traded futures contracts. Additional research is needed to identify those cash instruments that possess a large degree of bias <u>and</u> which would have sufficient liquidity to justify a futures contract.

FOOTNOTES

[1] Technically, price changes rather than percentage changes are typically employed in the regression model. Percentage changes are used here in order to provide a straightforward comparison of the size and variability of the hedge ratios across currencies. Using percentage changes does not affect the hedging effectiveness measures and one may easily convert the hedge ratios to correspond to price changes by multiplying by a scale factor. Rollovers for the futures contracts are conducted during the month of expiration of the futures; the appropriate percentage change is employed in the analysis, i.e. all percentage changes used to compute the hedge ratios are completed between like-maturity contracts.

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TABLE I

HEDGING EFFECTIVENESS BIASES:

YEN FUTURES VERSUS CASH

Period	b^*_{t+1}	$\lvert\Delta b_t\rvert$	E^*_{t+1}	Hedging Effectiveness Bias: Model (1)*	Hedging Effectiveness Bias: Model (2)**
80-1	0.970		0.776		
80-2	0.815	0.155	0.826	0.030	0.027
81-1	0.941	0.127	0.777	0.014	0.007
81-2	0.898	0.043	0.926	0.002	0.002
82-1	0.922	0.024	0.759	0.001	0.000
82-2	0.886	0.036	0.838	0.001	0.000
83-1	0.960	0.073	0.839	0.005	0.004
83-2	0.832	0.127	0.808	0.019	0.018
84-1	1.032	0.199	0.827	0.031	0.027
84-2	0.938	0.094	0.846	0.008	0.014
85-1	1.004	0.066	0.903	0.004	0.004
85-2	0.970	0.034	0.906	0.001	0.001
86-1	0.819	0.151	0.660	0.022	0.012
86-2	0.897	0.078	0.851	0.006	0.006

*Model (1): $E^*_{t+1} - E_{t+1} = \Delta b_t^2 \, [\sigma_F^2/\sigma_S^2]$

**Model (2): $E^*_{t+1} - E_{t+1} = [\Delta b_t^2 \, \sigma_F^2 + \Delta b_t^2 \, \overline{\Delta F}^2 + 2a^* \, \Delta b_t \, \overline{\Delta F}]/[\sigma_S^2 + \Delta S^2]$

TABLE II

HEDGING EFFECTIVENESS BIAS:

YEN FUTURES VERSUS AUSTRALIAN DOLLAR CASH

				Hedging Effectiveness Bias	
Period	b^*_{t+1}	$\lvert\Delta b_t\rvert$	E^*_{t+1}	Model (1)*	Model (2)**
80-1	0.185		0.177		
80-2	0.051	0.134	0.020	0.140	0.132
81-1	0.313	0.262	0.415	0.291	0.299
81-2	0.261	0.052	0.552	0.022	0.021
82-1	0.256	0.004	0.515	0.000	0.003
82-2	0.301	0.044	0.587	0.013	0.003
83-1	0.234	0.067	0.016	0.001	0.001
83-2	0.269	0.036	0.123	0.002	0.003
84-1	0.314	0.044	0.106	0.002	0.004
84-2	0.888	0.574	0.415	0.173	0.169
85-1	0.857	0.031	0.056	0.000	0.000
85-2	0.336	0.521	0.108	0.258	0.332
86-1	-0.074	0.410	0.005	0.148	0.192
86-2	-0.229	0.155	0.051	0.023	0.021

*Model (1): $E^*_{t+1} - E_{t+1} = \Delta b_t^2\ [\sigma_F^2/\sigma_S^2]$

**Model (2): $E^*_{t+1} - E_{t+1} = [\Delta b_t^2\ \sigma_F^2 + \Delta b_t^2\ \overline{\Delta F}^2 + 2a^*\ \Delta b_t\ \overline{\Delta F}]/[\sigma_S^2 + \Delta S^2]$

TABLE III

HEDGING EFFECTIVENESS BIAS:

YEN FUTURES VERSUS FRENCH FRANC CASH

				Hedging Effectiveness Bias	
Period	b^*_{t+1}	$\lvert\Delta b_t\rvert$	E^*_{t+1}	Model (1)*	Model (2)**
80-1	0.624		0.412		
80-2	-0.044	0.667	0.003	0.629	0.677
81-1	0.568	0.612	0.208	0.242	0.379
81-2	0.326	0.242	0.106	0.059	0.059
82-1	0.752	0.426	0.326	0.105	0.148
82-2	0.353	0.398	0.325	0.413	0.409
83-1	0.799	0.445	0.317	0.099	0.116
83-2	0.924	0.125	0.568	0.010	0.007
84-1	0.906	0.017	0.387	0.000	0.000
84-2	1.291	0.384	0.489	0.043	0.049
85-1	1.645	0.354	0.527	0.024	0.025
85-2	0.849	0.796	0.658	0.579	0.561
86-1	0.694	0.155	0.459	0.023	0.041
86-2	0.477	0.217	0.338	0.070	0.053

*Model (1): $E^*_{t+1} - E_{t+1} = \Delta b_t^2 \, [\sigma_F^2/\sigma_S^2]$

**Model (2): $E^*_{t+1} - E_{t+1} = [\Delta b_t^2 \, \sigma_F^2 + \Delta b_t^2 \, \overline{\Delta F}^2 + 2a^* \, \Delta b_t \, \overline{\Delta F}]/[\sigma_S^2 + \Delta S^2]$

TABLE IV

HEDGING EFFECTIVENESS BIAS:

SUMMARY OF YEN AND CROSS HEDGING RESULTS

	Average Per Period Results				
				Hedging Effectiveness Bias	
Yen futures vs. Country	b^*_{t+1}	$\|\Delta b_t\|$	E^*_{t+1}	Model (1)*	Model (2)**
Japan	.920	.093	.824	.011	.009
Australia	.283	.362	.225	.083	.090
Belgium	.679	.308	.345	.116	.130
Italy	.644	.269	.371	.188	.212
Netherlands	.746	.353	.409	.169	.181
Spain	.571	.370	.293	.242	.241
France	.726	.389	.366	.177	.194

*Model (1): $E^*_{t+1} - E_{t+1} = \Delta b_t^2 \, [\sigma_F^2/\sigma_S^2]$

**Model (2): $E^*_{t+1} - E_{t+1} = [\Delta b_t^2 \, \sigma_F^2 + \Delta b_t^2 \, \Delta\bar{F}^2 + 2a^* \, \Delta b_t \, \Delta\bar{F}]/[\sigma_S^2 + \Delta S^2]$