HEDGE RATIO INSTABILITY FOR CURRENCY FUTURES

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FINANCIAL MANAGEMENT MEETINGS

NEW ORLEANS

October 1988

nk Luisa Chong The for computer assistance and Gary Trennepohl and Michael Smyser for comments on an earlier draft of this paper. Nick Webb of Data Resources (DRI) was very helpful in providing the data.

ABSTRACT

Two models are developed to determine the extent of the bias of unstable hedge ratios on hedging effectiveness when the portfolio/regression model of hedging is employed to determine hedge ratios. The bias is affected by the extent of the hedge ratio instability and the ratio of the variances of the futures and cash instruments. These models are then tested by employing currency futures and cash currency values from various countries. Cross- currency hedging results in significant hedging effectiveness bias, while hedging cash currencies with the same futures contract only results in minimal bias.

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INTRODUCTION

The hedging effectiveness literature has concentrated on examining the size of the hedge ratios and associated hedging effectiveness values for ex-post data. Such measures implicitly assume that a static hedge ratio model is appropriate. While several authors have questioned this assumption, the effect of potential unstable hedge ratios has not been addressed. Hence, the critical question is whether any instability in hedge ratios has any effect on hedging effectiveness.

This paper develops two formulations of the effect of unstable hedge ratios on hedging effectiveness and then examines this effect by testing currency futures/cash relationships. The importance of determining the effect of unstable hedge ratios on hedging effectiveness is straightforward: using the previous period's unstable hedge ratio as an estimate of the current period's hedge ratio causes an upward bias in the hedging effectiveness measure that implies the effectiveness is greater than will actually occur. Large biases will create unexpected and undesired results for the unwary hedger. This paper shows that the degree of bias in the ex-post estimate of hedging effectiveness by employing a previous period's hedge ratio is related to the size of the change in the hedge ratio squared and the ratio of the volatilities of the futures and cash instruments.

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 currency 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:

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

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":

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

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:

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

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

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

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:

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

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:

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

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

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

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

Since from (5):

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

we determine that:

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

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:

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

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):

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

$$= \Delta b_t^2\,[\sigma_F^2/\sigma_S^2] \qquad (12)$$

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 and 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 σ_F^2/σ_S^2.

Including the Average Change in the Basis in the Model

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 around 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:

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

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:

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

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

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:

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

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:

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

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

$\Delta F_{t+1}(k,k+1)$ (16)

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

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

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:

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

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

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

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

Where:

σ_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:

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

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):

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

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):

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

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 currency values are employed from 1980-1986 to determine the hedge ratios and hedging effectiveness values for weekly intervals. Weekly data for 26 weeks are used for each 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 as well as 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. Futures values used in the analysis are the opening values from the Chicago Mercantile Exchange; the use of opening futures data (Chicago) and closing cash data (London) eliminates most of the timing differences between the data sets. The use of the open futures data should provide significant liquidity, especially since the nearby contract is employed in the analysis.

Cash currency values for the European/industrialized countries are used for the data analysis. 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 V present the results of using the portfolio/regression methodology to obtain hedge ratios and hedging effectiveness measures.

These tables show the per period or average minimum variance hedge ratio, 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 per period results for the German mark futures versus the mark cash. The hedging effectiveness measures for the mark futures/cash relationships range from 77.3% for the 1982-1 period to 98.8% for 1983-2; all but two subperiods possess effectiveness measures above 90%. These figures are very respectable effectiveness measures and are much larger than those indicated by Hill and Schneeweis (1982) for the 1974-78 period. The changes in the hedge ratios are generally small for the mark futures/cash relationships, causing only small biases in the hedging effectiveness measures, with all but two of the individual biases being less than 1.2%. Table II shows the average values for the relevant variables for the Canadian dollar, German mark, Japanese yen, and United Kindom pound. These results support the mark results from Table I, i.e. there are large hedging effectiveness values and small biases.

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TABLES I AND II ABOUT HERE

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Table III presents the relevant results for the yen futures/Australian dollar cash relationships. The hedging effectiveness measure for four periods are essentially 0% (1980-2, 1983-1, 1986-1, and 1986-2).[2] The other periods for the yen/Australian dollar comparisons provided effectiveness measures up to 68.6%. While 7 of the 13 periods produced insignificant hedging effectiveness biases of less than 2%, five periods possessed large changes in the hedge ratios, causing biases of 19% to 54.7%. Note that the 1980-2 period had a bias of 30.9% while the hedging effectiveness measure was 0%; this indicates that using the previous period's hedge ratio would create a variability which is 30.9% larger than if no hedge was undertaken. Such distressing results typically occurred for many of the futures/cash relationships summarized in Table V, especially those involving the yen.

TABLE III ABOUT HERE

Table IV shows a different picture for the mark futures/French franc cross hedge: effectiveness measures here are above 70% for all but two periods and biases are below 2% for all but two periods. Hence, the existence of a cross hedge does not automatically imply a large bias in the effectiveness measure.

TABLE IV ABOUT HERE

Table V provides summary results for the 1980-86 periods for the yen, mark, and pound futures with cash currency positions for six European/ industrialized countries. This table states the averages of the per period results for the same statistics presented in previous tables. The table shows that the average hedge ratio varies among countries just as the Tables I and II showed that hedge ratios vary among periods for a given currency; in general, the cross currency hedge ratio are significantly lower than the futures/cash hedge ratio for the same currency. The average absolute change in the hedge ratio is much larger for the cross hedges than for the same currency results in Table II, especially when the average change is compared to its average hedge ratio. The hedging effectiveness measures are much lower for the cross hedges involving the yen and pound than for the same currecny hedges in Table II, although many of the mark cross currency hedges possess respectable effectiveness measures. The per period hedging biases for these cross currency results <u>average</u> 12% to 28% for the yen, 1% to 11% for the mark, and 5% to 12% for the pound. Typically at least several individual period cross currency biases are very large. Recall from Table II that the same currency biases average about 1%.

TABLE V ABOUT HERE

IMPLICATIONS AND CONCLUSIONS

This paper 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 is then determined for currency futures hedges and cross-hedges.

When the same currency is employed for both the cash and futures then the same period hedging effectiveness is excellent, typically above 90%. Moreover, even if one assumes imperfect knowledge about the futures minimum variance hedge ratio and use the previous period's hedge ratio as the best forecast, then the resulting bias in the hedging effectiveness measures are typically very small and average about 1% for the same futures/cash relationships. On the other hand, when cross currency hedges are examined the resulting average bias for the hedge effectiveness measures are much larger, ranging from 12% to 28% per period for the yen futures, with individual period biases often being above 20%. Moreover, most cross 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 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. The effect of this assumption on actual hedging effectivness needs to be reevaluated.

These results also suggest that new 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 and 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.

[2] The 1980-2 period provides poor hedging results for all of the yen futures/cash relationships summarized in Table V; during this period the yen experienced several weeks of extremely large changes.

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TABLE I

HEDGING EFFECTIVENESS BIASES:

MARK 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	1.064		0.968		
80-2	1.177	0.113	0.921	0.008	0.004
81-1	0.971	0.206	0.952	0.043	0.054
81-2	0.992	0.021	0.961	0.000	0.001
82-1	0.935	0.056	0.773	0.003	0.006
82-2	1.015	0.080	0.965	0.006	0.007
83-1	0.927	0.089	0.965	0.009	0.011
83-2	0.977	0.051	0.988	0.003	0.000
84-1	0.973	0.004	0.973	0.000	0.000
84-2	1.000	0.027	0.974	0.001	-0.001
85-1	0.974	0.027	0.914	0.001	0.001
85-2	0.961	0.013	0.972	0.000	0.000
86-1	1.011	0.051	0.969	0.002	0.003
86-2	0.805	0.206	0.884	0.058	0.037

*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:

SUMMARY OF SAME CURRENCY HEDGING RESULTS

	Average Per Period Results				
				Hedging Effectiveness Bias	
Country	b^*_{t+1}	$\lvert\Delta b_t\rvert$	E^*_{t+1}	Model (1)*	Model (2)**
CANADA	0.892	0.112	0.831	0.017	0.015
GERMANY	0.985	0.072	0.941	0.010	0.009
JAPAN	0.940	0.078	0.928	0.009	0.007
U.K.	0.979	0.056	0.934	0.005	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 III

HEDGING EFFECTIVENESS BIAS:

YEN FUTURES VERSUS AUSTRALIAN DOLLAR 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	0.191		0.223		
80-2	-0.003	0.194	0.000	0.309	0.293
81-1	0.326	0.329	0.521	0.529	0.547
81-2	0.302	0.025	0.610	0.004	0.004
82-1	0.291	0.010	0.686	0.001	-0.007
82-2	0.340	0.049	0.672	0.014	0.002
83-1	0.241	0.099	0.020	0.003	0.000
83-2	0.430	0.189	0.265	0.051	0.052
84-1	0.323	0.107	0.167	0.018	0.014
84-2	0.941	0.618	0.480	0.207	0.198
85-1	0.867	0.073	0.072	0.001	0.001
85-2	0.333	0.535	0.107	0.277	0.353
86-1	-0.035	0.367	0.001	0.149	0.190
86-2	-0.135	0.101	0.020	0.011	0.010

*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:

MARK FUTURES VERSUS FRENCH FRANC 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	0.942		0.911		
80-2	1.080	0.138	0.862	0.014	0.012
81-1	0.814	0.266	0.785	0.084	0.073
81-2	0.809	0.005	0.702	0.000	0.000
82-1	0.892	0.083	0.390	0.003	0.003
82-2	0.928	0.036	0.942	0.001	0.001
83-1	1.039	0.111	0.667	0.008	0.007
83-2	0.923	0.116	0.955	0.015	0.015
84-1	0.925	0.002	0.970	0.000	0.000
84-2	0.996	0.071	0.962	0.005	0.005
85-1	0.950	0.045	0.899	0.002	0.002
85-2	0.941	0.010	0.972	0.000	0.000
86-1	0.935	0.006	0.825	0.000	0.000
86-2	0.692	0.243	0.808	0.099	0.099

*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 V

HEDGING EFFECTIVENESS BIAS:

SUMMARY OF THE CROSS HEDGING RESULTS

	Average Per Period Results				
				Hedging Effectiveness Bias	
Cross Hedge	b^*_{t+1}	$\lvert\Delta b_t\rvert$	E^*_{t+1}	Model (1)*	Model (2)**
JAPAN VS.					
AUSTRALIA	0.315	0.366	0.275	0.121	0.128
BELGIUM	0.652	0.313	0.360	0.133	0.148
ITALY	0.641	0.399	0.416	0.219	0.239
NETHERLANDS	0.734	0.365	0.443	0.175	0.185
SPAIN	0.556	0.345	0.319	0.281	0.278
FRANCE	0.721	0.389	0.398	0.183	0.199
GERMANY VS. AUSTRALIA	0.239	0.215	0.256	0.112	0.099
BELGIUM	0.890	0.145	0.777	0.047	0.037
ITALY	0.831	0.100	0.802	0.024	0.016
NETHERLANDS	0.945	0.085	0.911	0.014	0.011
SPAIN	0.714	0.166	0.673	0.087	0.061
FRANCE	0.919	0.087	0.832	0.018	0.017
UK VS. AUSTRALIA	0.223	0.172	0.215	0.060	0.053
BELGIUM	0.612	0.309	0.383	0.092	0.113
ITALY	0.575	0.250	0.373	0.078	0.090
NETHERLANDS	0.648	0.250	0.435	0.078	0.087
SPAIN	0.645	0.237	0.458	0.123	0.120
FRANCE	0.665	0.241	0.422	0.057	0.067

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

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