Hedge Period Length and Ex-Ante Futures Hedging Effectiveness: The Case of Foreign-Exchange Risk Cross Hedges

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INTRODUCTION

It is a well-known empirical relationship in the hedging literature that effectiveness is proportional to hedge period length; i.e., "longer" hedges manage to reduce the price risk of an underlying spot position better than the same hedge used for a shorter time period [see Anderson and Danthine (1980); Ederington (1979); and Hill and Schneeweis (1981) for discussion of this point]. The economic rationale offered to explain this relationship is not particularly compelling, but it has one or two basic ideas. First, the longer hedging time period is presumed to allow for the resolution of some price uncertainty which might otherwise be reflected in higher basis risk. With lower uncertainty, the "tracking" of the spot price by the futures price hedge is improved and hedging effectiveness is thus increased. A second statistical explanation is that hedging performance is likely to be higher for longer hedges because "noise" in the two price series should be lower for longer intervals. Thus, the "true" economic relationship between spot and futures prices will prevail in the longer run.

Table I provides empirical support for this relationship between hedging period length and hedging performance for the case of foreign-exchange risk hedges. Eight major and minor currencies are hedged by various currency and commodity hedges.[1] The Ederington (1979) risk-minimizing methodology is used here for illustrative purposes.[2]

Although effectiveness is somewhat variable (due to the relatively high basis risk of cross hedges) across strategies, it is clear that performance moderately improves as the hedging period is increased from four to 12 weeks. For example, the Mexican

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[1]Data are obtained from the *IMM Yearbook*, the *CRB Commodity Yearbook*, and *The Wall Street Journal* for the time period August 31, 1973 to December 31, 1985.

[2]For a discussion of the various theoretical drawbacks of the mean-variance (risk-minimizing) hedging approach, refer to Levy and Sarnat (1984) and Marmer (1986).

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Table I

HEDGING EFFECTIVENESS AS A FUNCTION OF HEDGING PERIOD LENGTH (IN-SAMPLE RESULTS FOR FOUR-WEEK, EIGHT-WEEK, AND QUARTERLY PERIODS FOR SAMPLE PERIOD AUGUST 1973 THROUGH DECEMBER 1985)

Spot Currency	Futures Hedge	HP Equals Four Weeks	HP Equals Eight Weeks	HP Equals One Quarter	No. of Datapoints Available
Strategy #1: Commodity futures hedges					
Australia (dollar)	Wheat, wool, cattle (portfolio)	$e = 0.3343$	$e = 0.3129$	$e = 0.3646$	96
Brazil (cruziero)	Orange juice	$e = 0.4725$	$e = 0.4916$	$e = 0.5203$	104
Mexico (peso)	Petroleum	$e = 0.6303$	$e = 0.7119$	$e = 0.7884$	34
South Africa (rand)	Gold, platinum (portfolio)	$e = 0.3410$	$e = 0.3289$	$e = 0.3640$	99
Strategy #2: Currency futures hedges					
China (yuan)	BP, CD, JY, SF, DM (portfolio)	$e = 0.8576$	$e = 0.8503$	$e = 0.8972$	149
Finland (markka)	BP, CD, JY, SF, DM (portfolio)	$e = 0.9594$	$e = 0.9578$	$e = 0.9764$	149
Ireland (pound)	BP	$e = 0.4861$	$e = 0.4848$	$e = 0.5545$	149
Japan (yen)	JY	$e = 0.9758$	$e = 0.9892$	$e = 0.9919$	149

Abbreviations: e = in-sample hedging effectiveness (%); BP = British pound futures; CD = Canadian dollar futures; DM = West German deutsche mark futures; JY = Japanese yen futures; SF = Swiss franc futures.

peso four-week petroleum futures hedge[3] reduces foreign-exchange exposure by 63.05% (relative to an unhedged spot position); yet this same hedge implemented (and rolled over) quarterly increase hedging effectiveness to 78.84%. With few exceptions, this proportional relationship is observed across the other 21 (seven currencies with three hedge periods each) single and portfolio futures strategies examined. Such results are consistent with the findings of earlier studies in the currency hedging and cross hedging literature.

Unfortunately, such ex-post results provide little guidance to real-world hedging practitioners. Results such as those reported in Table I implicitly require that optimal (e.g., risk-minimizing) hedge ratios be known a priori. Of course, it is not possible to know the optimal hedge ratio ex ante, and thus it is reasonable to expect lower real world hedging effectiveness. Such a drop in performance would be greatest in the presence of intertemporal hedge-ratio instability. Some empirical evidence has been presented recently which suggests that this problem is significant when hedging foreign-exchange exposure. See Benet (1992), Grammatikos and Saunders (1983), Malliaris and Urrutia (1991), and Marmer (1986). This study investigates this ex post versus ex ante effectiveness question, and also examines whether or not the proportional relationship between hedging period length and hedging effectiveness holds ex ante.

DATA AND METHODOLOGY

Data for this study are from four sources. Spot exchange rates are from *The Wall Street Journal* and the *London Financial Times.* Currency futures prices are from the *IMM Yearbook,* published by the Chicago Mercantile Exchange. Commodity futures prices are from the *IMM Yearbook* and the Commodity Research Bureau's *CRB Commodity Yearbook.* Due to differing trading histories, currency and commodity strategies tested within this study have various sample periods. The "oldest" futures contracts are the currencies, which in this study are tested from the sample period of August 31, 1973 until December 31, 1985. In most cases the "nearest" contract is used, except that price data is omitted for the last month of trading. The dataset includes 629 total observations across 13 years.[4]

The Ederington methodology is employed to estimate "optimal" (risk-minimizing) hedge ratios and (percentage) degree of hedging effectiveness.[5] This approach reduces to an ordinary least squares (OLS) regression of spot price (percentage changes) onto futures price (percentage changes). This methodology is easily expressed by the following, well-known equation:

$$C_{st} = a + \beta_1 C_{f1t} + \beta_2 C_{f2t} + \ldots + \beta_n C_{fnt} + u_t \qquad (1)$$

where C_{st}, C_{f1t} = the price change during period t of the spot and ith futures contracts, respectively; 2nd β_i = the proportion of integer number of futures contracts used to hedge the spot position.

Ederington (and others) have demonstrated that "optimal" (risk-minimizing) hedge ratios (β's) are the parameter estimates obtained from the above OLS regres-

[3]Two previous studies [Benet (1990); Eaker and Grant (1987)] examine the performance of commodity futures contracts as hedges against foreign-exchange exposure. In the later study, a "primary export commodity hypothesis" is proposed to justify commodity futures selection. Success of commodities is often equal (or superior) to currency futures hedges.

[4]Refer to the Appendix for a detailed description of included futures contracts.

[5]Other researchers lay claim to this approach, including Johnson (1960) and Stein (1961).

sion; while a measure of hedging performance is the regression coefficient of determination (r^2). Anderson and Danthine (1980, 1981) and Levy (1987) extend the single futures hedging methodology to include the possibility of portfolio futures hedges such as those expressed in eq. (1) above.[6]

EMPIRICAL TESTS AND RESULTS

An examination of the relative hedging performance of the same strategy ex post to ex ante is performed for a major currency "direct" hedge (yen futures hedging spot yen foreign exchange exposure) and seven minor currency "cross" hedges. A "naive" ex-ante approach is employed where the sample period is divided into three (estimation) subperiods. Optimal (risk-minimizing) hedge ratios are calculated separately for each subperiod, and prior estimation period optimal hedge ratios (β^*'s in Table II) are then implemented into subsequent hedging periods (periods 1 into 2, 2 into 3, etc.)[7] The Ederington methodology in percentage change form [Eq. (1)] is used to estimate ex-post and ex-ante hedging effectiveness measures (e and $e\hat{}$, respectively).[8]

Table II illustrates a divergence in performance ex post to ex ante. This difference is most pronounced for the minor currency cross hedges. Reduced cross-hedging effectiveness appears to be caused by intertemporal instability of hedge ratios. For example, examination of the β^*'s across subperiods for the currency futures portfolio cross hedge of the Finnish markka demonstrates substantial hedge ratio variability. This cross hedge provides 97.18% risk reduction (relative to an unhedged position) in subperiod 3 ex post; however, the (more realistic) ex-ante approach reduces foreign exchange exposure by only 3.05%. In the second subperiod, ex-ante results suggest that this cross hedge should not be implemented at all, since it actually *increases* foreign-exchange exposure by nearly 388% (relative to an unhedged spot position).

Although the results of other cross hedges are less dramatic, the overall results do suggest that ex-ante performance is significantly lower. The diversification benefits of cross-hedging portfolios (e.g., Australia, China, South Africa) are evident ex post; however, the additional variability across multiple-hedge ratios often causes extremely poor ex-ante effectiveness. Close examination across strategies and subperiods reveals that neither the "diversification effect" nor the "hedge ratio variability effect" consistently dominates. Note, however, that the Japanese yen futures strategy does not suffer from the same instability problem. Hedge ratios and hedging effectiveness are quite stable across subperiods for this "direct" hedge.

Since the levels of cross-hedging effectiveness appear to be overstated using the ex-post measures, an important related question is whether or not the accepted proportional relationship between hedging period length and effectiveness holds for cross-hedging strategies ex ante. To test for existence of such a relationship, the

[6]An interesting theoretical offshoot of the portfolio hedging scenario is developed by Levy (1991) who demonstrates that a *decline* in portfolio risk reduction must occur as time horizon increases. This is consistent with ex-ante empirical results found in this study.

[7]Although actual participants in futures markets probably use more sophisticated strategies in establishing hedge ratios, the "naive" strategy provides a convenient performance benchmark for comparison purposes.

[8]For example, the $e\hat{} = 14.83\%$ ex-ante effectiveness (risk-reduction) reported in Table II for the orange juice cross hedge of the Brazilian cruziero results from constraining the hedge ratio at $\beta^* = 0.6089$ (from estimation subperiod 1) for orange juice futures in the *second* subperiod. Ex-post effectiveness is $e = 61.37\%$ for subperiod 2.

"naive" strategy is employed within the Ederington framework, while both estimation period length and hedging period length are varied from four weeks to eight weeks to 12 weeks. If the proportional relationship holds ex ante, then hedging effectiveness should increase as: (1) estimation period increases (due to information flow arguments); and (2) hedging period length increases (due to the information and statistical reasons discussed earlier). The results of these empirical tests are reported in Table III.

A comparison of ex-ante effectiveness ($e^{\wedge}$) as a function of estimation period length (i.e., changes in $e^{\wedge}$ resulting from varying the time interval during which "naive" hedge ratios are estimated) reveals generally *no relation* between performance and estimation periods. Although effectiveness seems to decline across most strategies and hedging periods from panel #1 to panel #2 (estimation period four weeks versus eight weeks), this broad trend reverses itself from panel #2 to panel #3 (eight weeks versus 12 weeks). With these mixed results, one cannot state that any real trend or relationship exists between ex-ante hedging effectiveness and estimation period length.

A trend within each panel (and for each strategy) suggests that some relation may exist, however, between performance and hedging period length. The apparent ex-ante relationship, however, is a *negative* one. For example, the commodity hedge of the Australian dollar and the currency hedge of the Chinese yuan both exhibit (almost monotonically) decreasing performance as hedging period length is increased from four weeks to 12 weeks. These hedge results are consistently negative in all three panels (estimation periods). A generally negative trend is also apparent in Table III for other (e.g., Brazil, Ireland) single and portfolio futures cross hedges.

This negative relationship finding is in contradiction to the "conventional wisdom" in the current hedging literature. Most previous studies stress ex-post empirical results. A few studies [e.g., Grammatikos and Saunders (1983); Marmer (1986)] examine the hedge ratio instability problem. This intertemporal instability of hedge ratios, in combination with the "naive" ex-ante framework used and emphasized in this study, produce variable cross-hedging results which seem to decline as the hedging period increases from four to eight to 12 weeks. The pattern is consistent across all three estimation period lengths (panels) examined.

SUMMARY AND CONCLUSIONS

This study investigates the relative hedging effectiveness of currency futures "direct" and "cross" hedging strategies ex post versus ex ante. The generally accepted proportional relationship between hedging period length and hedging effectiveness is also examined within an ex-ante (out-of-sample) framework. The Ederington (risk-minimization) methodology is employed (despite theoretical drawbacks) due to its simplicity and ease of calculation. Currency and commodity futures contract prices over the period August 31, 1973 through December 31, 1985 are used to hedge foreign-exchange exposure positions for eight major and minor currencies. Hedging period and estimation period lengths are varied between four-week, eight-week, and 12-week time intervals.

Minor currency cross hedges exhibit a significant decrease in performance from ex post to ex ante. Even casual observation of Table II suggests that variability of (risk-minimizing) hedge ratios is present in virtually all cross-hedging results. More formal statistical tests for instability [as found in Benet (1990), and Grammatikos and Saunders (1983)] would almost certainly demonstrate the clear existence of this

Table II
FUTURES CONTRACTS IN-SAMPLE VERSUS OUT-OF-SAMPLE CROSS HEDGING EFFECTIVENESS
(FOUR-WEEK HEDGING PERIODS FOR SAMPLE PERIOD 08/31/73 TO 12/31/85)

Spot Currency	Futures Hedge	Period 1 Optimal	Period 2, 1 Into 2, Optimal	Period 3, 2 Into 3, Optimal	*N* Per Each Subperiod
Australia (dollar)	Wheat	$\beta^* =$ 0.6786	$\beta^* =$ 0.4923	$\beta^* =$ 0.7126	32
	Wool	−1.2321, $e =$ 0.4076	−1.4754, $e =$ 0.1307	0.0073 $e =$ 0.7984	
	Cattle	0.2735	0.1711, $\hat{e} =$ 0.0439	0.4051 $\hat{e} =$ 0.2089	
Brazil (cruziero)	Orange juice	$\beta^* =$ 0.6089, $e =$ 0.5764	$\beta^* =$ 0.7885 $e =$ 0.6137 $\hat{e} =$ 0.1483	$\beta^* =$ 0.3358 $e =$ 0.2034 $\hat{e} =$ 0.0182	34
China (yuan)	BP	$\beta^* =$ 0.8841	$\beta^* =$ −3.4555	$\beta^* =$ 1.8406	49
	CD	2.6694	7.5612	9.5353	
	JY	0.1012	2.6459	−5.9198	
	SF	1.0787, $e =$ 0.8260	−3.5646, $e =$ 0.8377	3.3537, $e =$ 0.9389	
	DM	−1.8822	6.2282, $\hat{e} =$ 0.3795	−0.7696, $\hat{e} =$ −0.0580	

Finland (markka)	BP	$\beta^* =$ 1.8428	$\beta^* =$ −0.0937	$\beta^* =$ 4.4206		49
	CD	1.4403	0.3148	5.0732		
	JY	0.7946	0.1647	−2.6583		
	SF	1.9769, $e =$ 0.9355	−0.3941 $e =$ 0.8859	−0.5482 $e =$ 0.9718		
	DM	−3.8631	0.6043 $\hat{e} =$ −3.8764	−1.5362 $\hat{e} =$ 0.0305		
Ireland (pound)	BP	$\beta^* =$ 0.6782, $e =$ 0.5657	$\beta^* =$ 0.7931 $e =$ 0.6073	$\beta^* =$ 0.4527 $e =$ 0.2987		49
			$\hat{e} =$ 0.2138	$\hat{e} =$ 0.1035		
Mexico (peso)	Petroleum	$\beta^* =$ 1.2237, $e =$ 0.7934	$\beta^* =$ 0.2542, $e =$ 0.3117	$\beta^* =$ 0.8945 $e =$ 0.6895		12
			$\hat{e} =$ 0.2584	$\hat{e} =$ 0.3789		
Japan (yen)	JY	$\beta^* =$ 1.0723, $e =$ 0.9792	$\beta^* =$ 0.9705 $e =$ 0.9898	$\beta^* =$ 1.0454 $e =$ 0.9981		49
			$\hat{e} =$ 0.9781	$\hat{e} =$ 0.9657		
South Africa (rand)	Gold	$\beta^* =$ 0.8586, $e =$ 0.4326	$\beta^* =$ 0.1950, $e =$ 0.0827	$\beta^* =$ 0.7126, $e =$ 0.4729		33
	Platinum	−1.1758	−0.4754, $\hat{e} =$ −0.0094	−0.3007, $\hat{e} =$ 0.2134		

Abbreviations: β^* = risk-minimizing hedge ratio; e = in-sample effectiveness (%); $\hat{e}$ = out-of-sample effectiveness (%); BP = British pound futures; CD = Canadian dollar futures; DM = West German deutsche mark futures; JY = Japanese yen futures; SF = Swiss franc futures.

Table III
HEDGING EFFECTIVENESS AS A FUNCTION OF HOLDING PERIOD AND ESTIMATION PERIOD LENGTH (OUT-OF-SAMPLE RESULTS FOR FOUR-WEEK, EIGHT-WEEK, AND 12-WEEK PERIODS)

Spot Currency	Futures Hedge	HP Equals Four Weeks	HP Equals Eight Weeks	HP Equals 12 Weeks
Panel #1: Out-of-sample results for estimation period equal to 4 weeks				
Australia (dollar)	Wheat, wool, cattle (portfolio)	$e^{\wedge} = 0.2089$	$e^{\wedge} = 0.1768$	$e^{\wedge} = 0.1563$
Brazil (cruziero)	Orange juice	$e^{\wedge} = 0.0182$	$e^{\wedge} = 0.1047$	$e^{\wedge} = -0.0021$
Mexico (peso)	Petroleum	$e^{\wedge} = 0.3789$	$e^{\wedge} = 0.4168$	$e^{\wedge} = 0.4019$
South Africa (rand)	Gold, platinum (portfolio)	$e^{\wedge} = 0.2134$	$e^{\wedge} = 0.0642$	$e^{\wedge} = 0.1945$
China (yuan)	BP, CD, JY, SF, DM (portfolio)	$e^{\wedge} = -0.0580$	$e^{\wedge} = -0.6678$	$e^{\wedge} = -1.0648$
Finland (markka)	BP, CD, JY, SF, DM (portfolio)	$e^{\wedge} = 0.0305$	$e^{\wedge} = 0.0478$	$e^{\wedge} = 0.0015$
Ireland (pound)	BP	$e^{\wedge} = 0.1035$	$e^{\wedge} = 0.0297$	$e^{\wedge} = -0.0460$
Panel #2: Out-of-sample results for estimation period equal to 8 weeks				
Australia (dollar)	Wheat, wool, cattle (portfolio)	$e^{\wedge} = 0.1868$	$e^{\wedge} = 0.1074$	$e^{\wedge} = -0.0039$
Brazil (cruziero)	Orange juice	$e^{\wedge} = -0.0307$	$e^{\wedge} = 0.0399$	$e^{\wedge} = 0.0444$
Mexico (peso)	Petroleum	$e^{\wedge} = 0.4213$	$e^{\wedge} = 0.1643$	$e^{\wedge} = 0.3416$
South Africa (rand)	Gold, platinum (portfolio)	$e^{\wedge} = 0.0721$	$e^{\wedge} = 0.0739$	$e^{\wedge} = 0.0656$
China (yuan)	BP, CD, JY, SF, DM (portfolio)	$e^{\wedge} = 0.1768$	$e^{\wedge} = 0.1749$	$e^{\wedge} = 0.0557$
Finland (markka)	BP, CD, JY, SF, DM (portfolio)	$e^{\wedge} = -0.4890$	$e^{\wedge} = 0.0190$	$e^{\wedge} = 0.1907$
Ireland (pound)	BP	$e^{\wedge} = 0.2228$	$e^{\wedge} = 0.2185$	$e^{\wedge} = 0.2715$
Panel #3: Out-of-sample results for estimation period equal to 12 weeks				
Australia (dollar)	Wheat, wool, cattle (portfolio)	$e^{\wedge} = -0.0172$	$e^{\wedge} = -0.0200$	$e^{\wedge} = 0.0036$

Table III (*continued*)

Spot Currency	Futures Hedge	HP Equals Four Weeks	HP Equals Eight Weeks	HP Equals 12 Weeks
Brazil (cruziero)	Orange juice	$e^{\wedge} = 0.0560$	$e^{\wedge} = 0.0477$	$e^{\wedge} = 0.0544$
Mexico (peso)	Petroleum	$e^{\wedge} = 0.2485$	$e^{\wedge} = 0.2647$	$e^{\wedge} = 0.3046$
South Africa (rand)	Gold, platinum (portfolio)	$e^{\wedge} = 0.1770$	$e^{\wedge} = 0.11784$	$e^{\wedge} = 0.0472$
China (yuan)	BP, CD, JY, SF, DM (portfolio)	$e^{\wedge} = 0.2864$	$e^{\wedge} = 0.2792$	$e^{\wedge} = 0.2685$
Finland (markka)	BP, CD, JY, SF, DM (portfolio)	$e^{\wedge} = -0.1369$	$e^{\wedge} = 0.0378$	$e^{\wedge} = -0.0867$
Ireland (pound)	BP	$e^{\wedge} = 0.3048$	$e^{\wedge} = 0.3015$	$e^{\wedge} = 0.2831$

Note: $e^{\wedge}$ = out-of-sample hedging effectiveness (%) (i.e., risk reduction relative to unhedged position). See Table II for list of abbreviations.

problem. The instability problem does not appear in the Japanese yen "direct" hedging strategy, however. Results reported here should caution real world hedging practitioners that the ex-post results found in the existing literature may substantially overstate cross-hedging effectiveness in foreign currency futures and commodity futures markets.[9]

Ex-ante hedging effectiveness does not appear to be related to estimation period length. A general *negative* relationship between hedging period length and performance is supported by the results presented in Table III. This negative finding is in direct contrast to previous studies which suggest that a positive or proportional relation exists between these hedging factors. These earlier studies, however, emphasize ex-post empirical results. It is likely that the intertemporal instability of hedge ratios is driving the unusual ex-ante results found in this research.

Although a growing body of empirical literature supports the existence of hedge ratio variability in currency futures markets, this study documents the (often serious) *consequences* of this problem. It also identifies a difference in the impact of the problem for minor currency "cross" hedges versus major currency "direct" hedges. Hedge ratio instability is magnified for portfolio futures hedging strategies, since multiple hedge ratios are affeeted simultaneously. This "hedge ratio variability effect" often outweighs the "diversification effect" benefits of the portfolio.

On the basis of the empirical results of this study, hedging practitioners are encouraged to actually *minimize* the time period which futures contracts are used to reduce foreign exchange exposure, particularly for minor currency cross hedges. Although longer hedge periods should (theoretically) improve performance, changing spot and futures market conditions cause variable correlations, very high

[9]A case can also be made, based upon the poor ex-ante cross-hedging results reported in this study, for an expansion of the available hedging vehicles for minor currencies.

basis risk, unstable hedge ratios, and poor ex-ante hedging effectiveness for longer time periods.

Bibliography

Anderson, R.W., and Danthine, J. P. (1980): "Hedging and Joint Production: Theory and Illustrations," *Journal of Finance,* 35:487–498.

Anderson, R.W., and Danthine, J. P. (1981): "Cross Hedging," *Journal of Political Economy,* 89:1182–1196.

Benet, B. A. (1990): "Commodity Futures Cross Hedging of Foreign Exchange Exposure," *The Journal of Futures Markets,* 10:287–306.

Benet, B. A. (1992): "Reduction of Exchange Rate Exposure via Hedge Ratio Adjustment," *Review of Futures Markets,* 9 (forthcoming).

Chen, K. C., Sears, R. S., and Tzang, D. (1987): "Oil Prices and Energy Futures," *The Journal of Futures Markets,* 7:501–518.

Dale, C. (1981): "The Hedging Effectiveness of Currency Futures Markets," *The Journal of Futures Markets,* 1:77–88.

Eaker, M. R., and Grant, D. (1987): "Cross-Hedging Foreign Currency Risk," *Journal of International Money and Finance,* 4:124–153.

Eaker, M. R. (1989): "Complex Hedges: How Well Do They Work?," *The Journal of Futures Markets,* 9:15–27.

Ederington, L. H. (1979): "The Hedging Performance of the New Futures Markets," *Journal of Finance,* 34:157–170.

Grammatikos, T., and Saunders, A. (1983): "Stability and the Hedging Performance of Foreign Currency Futures," *The Journal of Futures Markets,* 3:296–305.

Hill, J., and Schneeweis, T. (1981): "A Note on the Hedging Effectiveness of Foreign Currency Futures," *The Journal of Futures Markets,* 1:660–663.

Hill, J., and Schneeweis, T. (1982): "The Hedging Effectiveness of Foreign Currency Futures," *Journal of Financial research,* 5:95–104.

Johnson, L. L. (1960): "The Theory of Hedging and Speculation in Commodity Futures," *Review of Economic Studies,* 27:139–151.

Levy, H. (1987): "Futures, Spots, Stocks and Bonds: Multi-Asset Portfolio Analysis," *The Journal of Futures Markets,* 7:383–395.

Levy, H. (1991): "Across Assets Versus across Time Diversification as a Function of the Investment Holding Period," unpublished working paper.

Levy, H., and Sarnat, M. (1984): *Portfolio and Investment Selection: Theory and Practice.* Englewood Cliffs, NJ: Prentice-Hall.

Malliaris, A. G., and Urrutia, J. L. (1991): "The Impact of the Lengths of Estimation Periods and Hedging Horizons on the Effectiveness of a Hedge: Evidence from Foreign Currency Futures," *The Journal of Futures Markets,* 11:271–289.

Malliaris, A. G., and Urrutia, J. L. (1991): "Tests of Random Walk of Hedge Ratios and Measures of Hedging Effectiveness for Stock Indexes and Foreign Currencies," *The Journal of Futures Markets,* 11:55–68.

Markowitz, H. (1952): "Portfolio Selection," *Journal of Finance,* 7:77–91.

Marmer, H. S. (1986): "Portfolio Model Hedging with Canadian Dollar Futures: A Framework for Analysis," *The Journal of Futures Markets,* 6:84–92.

Miller, S. E., and Luke, D. B. (1982): "Alternative Techniques for Cross-Hedging Wholesale Beef Prices," *The Journal of Futures Markets,* 2:122–129.

Overdahl, J. A. (1987): "The Use of Crude Oil Futures by the Governments of Oil-Producing States," *The Journal of Futures Markets,* 7:603–617.

Stein, J. (1961): "The Simultaneous Determination of Spot and Futures Prices," *American Economic Review,* 5:1012–1025.

Working, H. (1953): "Futures Trading and Hedging," *American Economic Review,* 43:314–343.

Appendix

DESCRIPTION OF FUTURES CONTRACT DATA

CHARACTERISTICS OF INCLUDED CURRENCY AND COMMODITY FUTURES CONTRACTS, INCLUDING PER UNIT DENOMINATIONS, TRADING DATES, AND PLACE OF TRADE

Futures	Currencies Hedged	Contract	Included Trading Dates	Denomination	Exchange	Data Source
British pound	Yuan, Irish pound, markka	"Nearest"	08/31/73 to 1985	U.S. dollars per British pound	IMM of CME	*IMM Yearbook*
Canadian dollar	Yuan, markka	"Nearest"	08/31/73 to 1985	U.S. dollars per Canadian dollar	IMM of CME	*IMM Yearbook*
Cattle	Australian dollar	June	04/29/77 to 1985	Cents per pound	CME	*CRB Commodity Yearbook*
Gold	Rand	"Nearest"	10/31/77 to 1985	Dollars per ounce	IMM of CME	*IMM Yearbook*
Japanese yen	Yuan, markka, yen	"Nearest"	08/31/73 to 1985	U.S. dollars per Japanese yen	IMM of CME	*IMM Yearbook*

Orange juice	Cruziero	May	03/31/73 to 1985	Cents per pound	NY Cotton Exchange	*CRS Commodity Yearbook*
Platinum	Rand	April	02/28/77 to 1985	Dollars per ounce	NY COMEX	*CRB Commodity Yearbook*
Petroleum	Peso	December	03/31/83 to 1985	Dollars per barrel	NY COMEX	*CRB Commodity Yearbook*
Swiss franc	Yuan, markka	"Nearest"	08/31/73 to 1985	U.S. dollars per Swiss franc	IMM of CME	*IMM Yearbook*
West German deutsche mark	Yuan, markka	"Nearest"	08/31/73 to 1985	U.S. dollars per deutsche mark	IMM of CME	*IMM Yearbook*
Wheat	Australian dollar	May	04/29/77 to 1985	Cents per bushel	CBOT	*CRB Commodity Yearbook*
Wool	Australian dollar	"Nearest" (3-month)	08/31/73 to 08/30/85	Australian cents per kilogram	Sydney COMEX	*London Financial Times*