Hedge Ratios and Basis Behavior: An Intuitive Insight?

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Considerable work has been devoted to the question of the proper volume of futures contracts needed to protect or enhance the value of a given on-hand or anticipated volume of a physical commodity until the time of the commodity's final disposal in the cash market [Blank (1989); Kahl (1983); Witt et al. (1987)].

The purpose of this article is to examine the practical meaning and use of elemental hedge ratios derived from the simple regression of end-of-hedge cash and futures price levels and, alternatively, price changes during the specific length of a hedge. The argument is that the hedge ratio simply indicates the basis behavior at the end of the hedge or, in the case of price changes, during the life of the hedge. Hedge ratios from regressed price levels reveal closing basis behavior and are useful for forecasting the net price resulting from the hedge [Elam and Davis (1990)]. Hedge ratios from regressed price changes give some insight into basis behavior during the hedge and also permit forecasting the net price expected to result from the hedge. A third method of computing simple hedge ratios by regressing changes in cash returns on changes in futures returns is not discussed because it does not yield a straightforward minimum price risk hedge ratio.

The article is organized as follows: (a) review of relevant literature, (b) the basic hedge ratio formulas and data forms, (c) Working's (1953b) hedge tactic with basis changes, (d) the hedge ratio and net price forecasting, (e) an example of the price levels ratio for forecasting net prices for a nondeliverable commodity, and (f) some conclusions.

SOME LITERATURE

Theories on the purpose(s) of commodity hedging using futures markets have been formally partitioned among (1) traditional or pure risk minimization, (2) Working's (1953a; 1953b) profit-motivated approach, and (3) a combination of (1) and (2) leading to the portfolio approach which may result in futures/physical commodity hedging ratios other than the traditional one-to-one [Ederington (1979); Johnson (1960)].

Working (1953b) criticized the traditional approach because of its naive tests of hedging effectiveness associated with routine hedging. He suggested that, realistically, merchants' or dealers' hedging is determined both by inventory levels and expected basis changes. In contrast to much "optimal" hedge ratio research published in recent years, Working was concerned with "discretionary hedging" based on predictable basis changes. Discretionary hedging prescribes cash speculation and low inventory if unfavorable basis changes are expected. If a favorable (profitable)

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basis change is expected, hedge 100%. Using Working's forecast change in basis requires a hedge ratio of one since the direction of change in price level is not anticipated. Working found a fairly high association between the initial basis and the subsequent change in basis for specific seasonal periods during 1922–1952. As shown later, refitting Working's basis relations using 1973–1990 data suggests the behavior has persisted.

Others have preferred to use hedge ratios of one in evaluating hedging effectiveness. Hauser, Garcia, and Tumblin (1982) used alternative basis expectations models in measuring soybean hedging effectiveness incorporating only 1:1 hedge ratios because they are "...more reasonable in risk preference terms, compatible with many previous studies..." and "...are easily understood by hedgers."

In contrast to the simple regression price level or price change ratios and Working's change in basis model, the portfolio model, which includes price change expectations, yields a hedge ratio designed to maximize profit subject to some risk averse weighted variance [Peck (1975); Rolfo (1980)]. However, absent some means of reliably forecasting changes in price over the hedge duration, the portfolio model is reduced to providing a price risk minimization hedge ratio [Heifner (1972); Ederington (1979)]. That is, we are back to the traditional or pure risk minimization approach but not necessarily with a 100% hedge because of the relationship between basis and price levels.

Brown (1985) suggested that the portfolio approach for hedging is not supported because he found hedge ratios of approximately one when regressing cash and futures returns over the duration of the hedge and ratios not equal to one regressing price levels at the close of the hedge. Kahl (1986) commented that finding a hedge ratio of one does not mean the portfolio approach is irrelevant because the size of the hedge ratio is an empirical question. Brown (1986) replied that if empirical hedge ratios for returns, if not price levels, are typically one, then rational people will simply hedge 100% of stocks. No portfolio model is needed.

While Kahl noted that Brown was in error on some points, Brown's idea that it is impractical "...to estimate hedge ratios based on subjective (price) expectations" has merit and suggests that the minimum price risk hedge ratio may frequently be the only practical application of the price regression derived ratios. In addition to the price forecasting problem associated with implementing the portfolio hedge ratio, it appears that the "full" portfolio model is generally not appropriate because hedging as practiced is essentially either (1) an attempt at arbitrage via Working's anticipated change in relative prices (basis change) and/or (2) a zero return process where the objective is a minimum risk target price relative to some break-even price, probably in an anticipatory hedge. Hartzmark (1988, p. 2) has suggested that even large commercial firms are generally risk minimizers rather than "nimble footed speculators" reacting to expected price changes.

ELEMENTAL HEDGE

To illustrate the connection between a minimum risk price hedge ratio and basis behavior, consider the usual hedge process where:

$F1 =$ the opening futures price in the appropriate delivery month.
$F2 =$ the futures price at the close of the hedge.
$C1 =$ the opening cash price or, possibly, a breakeven cost; i.e., the target price.
$C2 =$ the closing cash price.
$B1, B2 =$ the opening and closing bases, respectively, from $C1 - F1$ and $C2 - F2$.

The net price resulting from the hedge, whether long or short, using a ratio of one unit of physical commodity to one unit of futures, may be determined three ways:

$$NP = C2 + (F1 - F2) \tag{1}$$

$$NP = F1 + B2 \tag{2}$$

$$NP = C1 + (B2 - B1) \tag{3}$$

Formulas (1) and (2) are derived from (3). Each version of the net price formula is instructive. Formula (1) yields the actual net price at the close of the hedge because all values are known. Formula (2) can be used as a net price forecasting equation given some estimate of the closing basis, $B2$. Formula (3) states that the net price is the beginning cash price plus the basis change, the process which interested Working.

If a hedge ratio other than one is appropriate, eqs. (1a), (2a), and (3a) become operative where b is the hedge ratio:

$$NP = C2 + b(F1 - F2) \tag{1a}$$

$$NP = bF1 + (C2 - bF2) \tag{2a}$$

$$NP = C1 + (C2 - bF2) - (C1 - bF1) \tag{3a}$$

PRICE LEVELS

Since the regression between the end-of-hedge cash price and futures price levels,

$$C2 = a + bF2 + e_2 \tag{4}$$

is, in essence, the closing basis relation, then the net price expected at the end of a hedge can be forecast by substituting eq. (4) for $C2$ in eq. (1a) and taking conditional expectations on both sides [Elam (1988)]:

$$NP = a + bF1 + e_2 \tag{5}$$

Equation (5) can be used to forecast the net price resulting from a hedge because it incorporates the systematic basis behavior embodied in eq. (4). Equation (5) does not forecast $B2$ or the change in basis but rather adjusts for the systematic basis change, if any, associated with closing price levels. If b is $+1$, then a is the expected $B2$ value. If b is $\neq 1$, then both a and b form the closing basis relation obtained by subtracting $F2$ from both sides of eq. (4):

$$B2 = a + (b - 1)F2 + e_2 \tag{6}$$

A regression of closing cash and futures price levels with a hedge ratio < 1 implies a weakening basis as the futures price increases and a strengthening basis if the futures price declines. A hedge ratio > 1 indicates the opposite basis behavior.

A price levels regression yielding a hedge ratio greater than one may result from a cross-hedge where the spot price changes more than the futures price. For example, lightweight cattle hedge ratios are typically greater than one while par and heavier weights are one and less than one, respectively [Elam (1988); Schroeder and Mintert (1988)].

PRICE CHANGES

If price changes over specific time lengths are regressed to determine the hedge ratio: i.e.,

$$(C2 - C1) = c + d(F2 - F1) + e_2 \tag{7}$$

the embodied relationship is the change in basis during the life of the hedge. The net price expected at the end of a hedge may also be forecast from the simple regression of the changes in cash and futures prices.[1] From eq. (7),

$$C2 = c + d(F2 - F1) + e_2 + C1 \tag{7a}$$

Substituting (7a) into eq. (1a) yields:

$$NP = c + d(F2 - F1) + e_2 + C1 + d(F1 - F2)$$
$$\text{or} \quad NP = C1 + c + e_2 \tag{7b}$$

Thus, the net price expected from a hedge ratio based on the regression of price changes for a specific time period is simply the opening cash price, $C1$, and the c (intercept) term from the regression equation plus the random error. The intercept term, c, is the change in basis during the hedge. Transposing eq. (7);

$$c = (C2 - C1) - d(F2 - F1) + e_2$$
$$\text{or} \quad c = (C2 - dF2) - (C1 - dF1) + e_2$$

shows that c represents the difference between the two ratio adjusted basis terms in eq. (3a). Equation (7b) is the equivalent of eq. (3a) and may be used to forecast the net price expected at the end of the hedge.

The change in basis implicit in eq. (7) may be shown explicitly. Since $B2 - B1 = (C2 - C1) - (F2 - F1)$, then substituting eq. (7) for $(C2 - C1)$ yields

$$B2 - B1 = c + (d - 1)(F2 - F1) + e_2 \tag{8}$$

If the hedge ratio, d, from eq. (7) is < 1, the basis will weaken as price rises and strengthen as price falls unless the intercept value, c, overrides the effect of the d value. If $d > 1$, then the basis weakens as price falls and vice versa, again depending on the size of the intercept value. If $d = 1$, the absolute change in the basis is the c or intercept value in eq. (7)[2].

Thus, minimum price risk hedge ratio equations measure systematic basis behavior, whether using price levels or price changes as data.[3] Relatively elaborate models such as Myers and Thompson's (1989) embody basis behavior but are somewhat complex if forecasting net price is the sole objective.[4]

WORKING'S HEDGE "RATIO"

In contrast to computing hedge ratios, Working pursued the idea of estimating the change in basis over selected periods. His basis changes were independent of the closing price level or changes in prices.

Working (1953b) found the Kansas City December wheat basis usually strengthened between September and December and the July wheat basis generally weakened between

[1]An anonymous reviewer derived this method of estimating the net price from a price change regression relation.

[2]Contrary to Brown (1985, p. 510), a coefficient of determination of unity for price change data is possible with a systematically changing basis during the course of a hedge. The hedge ratio can be one and the intercept value is straight forwardly the change (strengthening or weakening) in the basis.

[3]Hayenga and DiPietre (1982) mention the basis/hedge ratio relation, but do not pursue the further implications.

[4]The effect of the conditional or generalized hedge ratios proposed by Myers and Thompson (1989) on implications for basis behavior are not clear, but the conditional hedge ratios would also embody basis behavior. They argue (p. 861) that "Both common sense and empirical evidence reject... the use of simple regression with price levels to estimate optimal hedge ratios."

May and July during the 1922–1952 period. His regressions of change in basis on opening basis were:

September to December

$$BD - BS = 2.87 - 0.861BS \qquad r^2 = .703 \tag{9}$$

May to July

$$BJ - BM = 0.98 - 0.946BM \qquad r^2 = .95 \tag{10}$$

Usually, a weak or negative basis in September led to a positive change or strengthening in the basis from September to December and a strong or positive basis in May led to a negative change or weakening in the basis from May to July, old crop to new.

An updating of Working's basis relations using 1973–1990 data on Kansas City cash and futures prices from the *Wall Street Journal* yield results similar to the 1922–1952 period:

September to December

$$BD - BS = 11.924 - 0.676BS \qquad \bar{r}^2 = .802 \quad DW = 1.73 \tag{9a}$$

$$t\text{-values } (7.07) \ (-8.01)$$

May to July

$$BJ - BM = 3.389 - 0.830BM \qquad \bar{r}^2 = .925 \quad DW = 1.87 \tag{10a}$$

$$t\text{-values } (1.76)(-14.22)$$

The updated regressions appear to fit as well or better than Working's originals and convey essentially the same relationship between the initial basis and the change in basis during the selected periods. The May to July basis behavior seems to have been more stable because of the usually strong bases which existed on May 1.

Working's basis change equation can be manipulated to provide net price "forecasting" formulae but the process is less direct than the price levels or price changes hedge ratios approach.

Working's basis change equation of the form:

$$B2 - B1 = a + bB1 + e_2 \tag{11}$$

substituted in eq. (3), assuming the requisite 100% hedge ratio, yields a net price formula of

$$NP = C1 + a + bB1 + e_2 \tag{12}$$

A closing basis equation, $B2 = a + (1 + b)B1 + e_2$, may be derived from eq. (11). Working's basis change equations are seasonably specific as expected for a storable crop. Regressing the recent Kansas City wheat cash price levels on the corresponding futures price levels result in hedge ratios of approximately one as might be expected at the terminal delivery point. Such may not be the case at remote country elevators. If the Kansas City wheat price data are fitted as price changes, hedge ratios different than one result.

Working's basis change eq. (11) is a guide regarding a spread position. If it forecasts an increase in basis, go long cash and short futures using a hedge ratio of one. If an anticipatory situation exists, a net price forecast is the desired information and price levels regression would seem to be appropriate.

HEDGE RATIO/NET PRICE FORECASTING IMPLICATIONS

Assuming that a producer would be content to forward price his/her crop in the futures market at any time during the year (an anticipatory hedge) at some price level equal to or greater than the break-even cost per unit, the producer needs to forecast the net price, subject to basis risk, which would be obtained at the end of the hedge for comparison with current bids or cash price forecasts.[5] Since the producer using an anticipatory hedge is substituting basis risk for price risk, direct or primary evidence of basis behavior should be examined in addition to fitting regressions on price levels or price changes to obtain a hedge ratio; see Naik and Leuthold (1991).

Being able to forecast net prices with some degree of accuracy should be adequate for operating a profitable enterprise if these prices are equal to or greater than break-even costs with sufficient frequency. Such situations have been reported. Hayenga et al., (1984) found that profitable hedging opportunities for Midwest cattle and hogs were frequently available during the feed-out periods for 1972–1981. Russell, Ikerd, and Dickey (1984) determined that short hedge forward prices covering break-even costs were available within the feeding period for 64 of 101 pens of High Plains fed cattle during 1974–1982. While these two studies considered the frequency of profitable hedging opportunities within the feed-out periods, other studies have attempted to "lock in" margins before as well as after feeding started. Kenyon and Clay (1987) found profitable hedging situations for hogs both before and after feeding commenced. Shafer, Griffen, and Johnston (1978) found profit margins per head available (a) occasionally prior to the start of feed-out via a "paper-feed" and (b) frequently within the feed-out period for Texas Panhandle feedlots during 1972 through 1976. Texas High Plains and Lower Rio Grande Valley cotton producers could have obtained profitable prices by short hedging before or during the growing season [Wood, Shafer and Anderson (1989)].

Matching cash volume to futures volume due to crop yield uncertainty is a separate problem to be determined each season depending on expected yields or to simply cover variable costs. Grant (1989) has examined the yield problem and suggests that a lower than usually reported hedge ratio may be warranted due to price levels being inversely correlated with yields. Miller (1986) found direct hedge ratios for cotton ranging from +2.06 to −0.68 among six states "... in the face of price, basis, and yield uncertainty" and varying levels of risk. Regardless of yield risk, a producer wanting to protect some part of a crop by short hedging would be concerned with the net price expected from that part of the crop hedged.

The importance of hedge ratios ($<$ and > 1) derived from regression of price levels and price changes is that they embody basis behavior and facilitate forecasting the net price expected from the hedge. The use of a hedge ratio is a price risk minimizing "portfolio" in that the volumes of actual and futures commodity may not be equal.

AN EXAMPLE

An example of net price forecasting with a hedge ratio using Lubbock, Texas, cash cotton price and N.Y. March cotton futures price levels provides an indication of basis risk associated with minimum risk forecast net prices, Table I.[6] This is a cross-hedge

[5]Elam and Davis (1990) have presented a detailed illustration of ratio hedged basis risk versus a 100% hedge basis risk using feeder cattle. They also derived a generalized basis formula but did not pursue the basis behavior aspect (p. 212).

[6]Hedging ratios should be derived for each futures delivery month because of seasonal influences. Thus, five hedging ratios are needed for Lubbock, Texas, cotton since there are five delivery months for N.Y. cotton futures.

Table I

ACTUAL CLOSING CASH AND FUTURES PRICES, EXPECTED AND ACTUAL CLOSING BASIS, FORECAST AND EX POST NET PRICES WITH HEDGE RATIO AND EX POST NET PRICE WITH 100% HEDGE, LUBBOCK CASH AND NEW YORK MARCH COTTON FUTURES PRICES, 1979–1988

	Closing Values[a]					Net Prices			
						Ratio Hedge[c]			
	$C2$ Cash Price	$F2$ Futures Price	$B2$ Actual Basis	$\hat{B}2$ Expected Basis	Opening Futures Price[b] $F1$	Forecast	ExPost[d]	100% Hedge Expost[e]	Forecast Net Price as Proportion of Ex post Net Price
Year	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
					(Cents per pound)				
1979	52.69	64.47	−11.78	−10.12	62.10	52.61	50.95	50.32	1.032
1980	67.54	84.74	−17.20	−15.53	66.50	55.83	54.16	49.30	1.031
1981	74.40	88.41	−14.01	−16.50	74.12	61.42	63.92	60.11	0.961
1982	49.27	63.13	−13.86	−9.77	83.90	68.60	64.51	70.04	1.063
1983	52.70	66.07	−13.37	−10.55	72.90	60.53	57.71	59.53	1.049
1984	64.06	74.98	−10.92	−12.93	70.43	58.72	60.72	59.51	0.987
1985	51.63	64.16	−12.53	−10.04	75.70	62.58	60.09	63.17	1.041
1986	54.12	62.24	−8.12	−9.53	66.00	55.47	56.88	57.88	0.975
1987	52.55	55.85	−3.30	−7.83	44.30	39.55	44.08	41.00	0.897
1988	54.55	61.64	−7.09	−9.37	53.00	45.93	48.21	45.91	0.953
Mean	57.35	68.57	−11.22	−11.22	66.89	56.13	56.00	55.68	0.999

[a]Closing values are mean values prior to first notice day.

[b]March futures price 12 months earlier; i.e., 62.10¢ is March 1979 futures price in mid-March 1978.

[c]The hedge ratio was 0.734 for the Lubbock cash price–N.Y. Futures contract during the first notice period.

[d]Net price received at close of hedge using hedge ratio.

[e]A 100% ratio means futures contracts used equal the volume of physical cotton.

because the cash price is for one inch staple cotton which is not deliverable. Regressing Lubbock mean cash prices for the period 9 days prior to first notice day of the New York March cotton futures contract (column I) on the mean of cotton futures settle prices for the same contract (column II) over the 1979–1988 period yielded the following price level hedge ratio equation:

$$C2 = 7.0529 + 0.73354F2 + e_2 \tag{13}$$

$$(t\text{-values})\ (1.06)\ (7.68)$$

$$\bar{r}^2 = .86\ D - W = 1.82\ \text{RMSE} = 2.72¢\ \text{Turning Points Missed} = 1/9$$

The resulting net price forecasting equation is

$$NP = 7.0529 + 0.73354F1 + e_2 \tag{14}$$

which suggests that the futures price was more variable than cash price and that the strength of the closing basis varied inversely with the level of the closing futures price as shown in the derived closing basis equation:

$$B2 = 7.0529 - 0.26646F2. \tag{15}$$

The actual closing basis, $B2$, in column III is the cash price in column I minus the futures price in column II. The "expected" basis in column IV is from eq. (15) using the closing futures price in column II. The conditionally "forecast" net price in column VI is from eq. (14) using March "opening" futures prices from March of the previous year (column V). The ex post net price in column VII resulting from the hedge of 0.7335 units of futures per unit of cash is computed from

$$NP = C2 + 0.73354(F1 - F2) \tag{16}$$

which is eq. (1a) with the 0.7335 hedge ratio. Actual and expected closing bases are correlated. The actual basis inversely associated with the level of the closing futures price as implied by the 0.7335 hedge ratio. The 100% hedge (hedge ratio of one) ex post net price in column VIII is higher than the ratioed net price when the futures price fall during the hedge. The 100% hedge is lower when futures price increases.

Net price eq. (14) does a reasonable job of "conditionally forecasting" the ex post net price associated with a ratioed short hedge, column IX. An out-of-sample evaluation using eq. (14) to forecast net prices for 1989, 1990, 1991, and 1992 provided results consistent with those for the in-sample period, Table II. While basis tended to strengthen in the latter 1980s and early 1990s due to declining volumes of short staple cotton and increased foreign demand for it, three of the four (excepting 1990) forecast bases are close to the actual bases and, as expected, varied inversely with the closing futures price. Lubbock area cotton producers presumably could have forecast short hedge net prices for March sales rather closely during the 1989–1992 period, disregarding the effect of yield risk. The net prices from the ratio hedge averaged higher than the 100% hedge due to the tendency for futures prices to increase over the 12-month "hedge" during the 1979–1988 period.

CONCLUSIONS

This article relates the traditional or price risk minimization approach to hedge ratios derived from both price level and price change regressions. These hedge ratios, which have been reported in numerous studies, are a remnant of the portfolio approach absent expectations on the direction of price change. They reflect systematic basis behavior

Table II

ACTUAL CLOSING CASH AND FUTURES PRICES, EXPECTED AND ACTUAL CLOSING BASIS, FORECAST AND EX POST NET PRICES WITH HEDGE RATIO AND EX POST NET PRICE WITH 100% HEDGE, LUBBOCK CASH AND NEW YORK MARCH COTTON FUTURES PRICES, OUT OF SAMPLE 1989–1992

	Closing Values[a]					Net Prices			
						Ratio Hedge[c]			
	$C2$ Cash Price	$F2$ Futures Price	$B2$ Actual Basis	$\hat{B}2$ Expected Basis	Opening Futures Price[b] $F1$	Forecast	ExPost[d]	100% Hedge Expost[e]	Forecast Net Price as Proportion of Ex post Net Price
Year	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
					(cents per pound)				
1989	49.42	58.03	−8.61	−8.38	57.75	49.44	49.14	49.14	1.004
1990	61.01	68.33	−7.32	−11.12	64.23	54.19	58.00	56.91	0.934
1991	68.17	84.60	−16.43	−15.33	66.48	55.84	55.19	50.05	1.012
1992	48.42	53.70	−5.28	−7.25	68.67	57.42	59.40	63.39	0.967

[a]Closing values are mean values prior to first notice day.
[b]March futures price 12 months earlier; 57.75¢ is March 1989 futures price in mid-March 1988.
[c]The hedge ratio was 0.734 for the Lubbock cash price–N.Y. Futures contract during the first notice period.
[d]Net price received at close of hedge using the hedge ratio.
[e]A 100% ratio means futures contracts used equal the volume of physical cotton.

which permits the forecast of the minimum risk net price expected from the hedge [Ederington (1979)]. Unlike this hedge ratio, Working's approach to hedging presumed reliable forecasting of basis changes leading to hedging either 100% or, possibly, none; i.e., discretionary hedging. While the hedge ratios derived from the simple regression of price levels or price changes facilitate forecasting the net price expected from a short or long hedge, they do not forecast the direction of price change, the closing basis, or, unlike Working's model, the change in basis. A hedge ratio other than one implies that the closing basis depends on the price level at the end of the hedge. If, in fact, the market is efficient and price forecasts are not sufficiently reliable, then one is left in the second best situation of forecasting the ex post hedge net price using an estimated hedge ratio. If a fairly strong relationship between closing cash and futures prices is present, the net price forecasting process should provide a better estimate of end-of-hedge net price, subject to basis risk, than simply using a 100% hedge unless, of course, the ratio is one [Elam and Davis (1990)]. Further, producers can use the hedge ratio eq. (5) to examine daily futures prices for expected net prices during the entire crop year; i.e., the expected net price from anticipatory hedging. If reliable basis change models like those reported by Working are available, discretionary hedging on a one-to-one ratio is appropriate for merchants and other handlers of commodities.

If dependable price change forecasts are available, the portfolio approach maximizing profit subject to some level of risk may be appropriate. A forecast price increase would suggest reduced short hedging, possible to the point of "a Texas hedge" and vice versa [Miller (1986)]. While Grant and Eaker (1989) suggest that too much emphasis has been placed on complex hedges, including the estimation of hedge ratios, perhaps effort may be well spent on basis forecasting models and costs of delivery [Garcia, Leuthold, and Sarkan (1984); Naik and Leuthold (1991); Tilley and Campbell (1988)]. Nevertheless, incorporating basis behavior to forecast the net price expected from a hedge may be useful.

Bibliography

Blank, S. C. (1989): "Research on Futures Markets: Issues, Approaches and Empirical Findings," *Western Journal of Agricultural Economics,* 14(1):126–139.

Brown, S. L. (1985): "A Reformulation of the Portfolio Model of Hedging," *American Journal of Agricultural Economics,* 67:508–512.

Brown, S. L. (1986): "A Reformation of the Portfolio Model of Hedging: Reply," *American Journal of Agricultural Economics,* 68(4):1010–1012.

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

Elam, E. (1988): "Estimating Hedging Risk with Cash Settlement Feeder Cattle Futures," *Western Journal of Agricultural Economics,* 13:45–52.

Elam, E., and Davis, J. (1990): "Hedging Risk for Feeder Cattle with a Traditional Hedge Compared to a Ratio Hedge," *Southern Journal of Agricultural Economics,* 22:209–216.

Garcia, P., Leuthold, R. M., and Sarkan, M. E. (1984): "Basis Risk: Measurement and Analysis of Basis Fluctuations for Selected Livestock Markets," *American Journal of Agricultural Economics,* 66:499–504.

Grant, D. (1989): *Optimal Futures Positions for Corn and Soybean Growers Facing Price and Yield Risk,* U.S. Department of Agriculture, Economics Research Service, Technical Bulletin 1751, Washington, D.C.

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

Hartzmark, M. L. (1988): "Is Risk Aversion a Theoretical Diversion?" *Review of Futures Markets,* 7:1–34.

Hauser, R. J., Garcia, P., and Tumblin, A. D. (1990): "Basis Expectations and Soybean Hedging Effectiveness," *North Central Journal of Agricultural Economics,* 12(1):125–136.

Hayenga, M. L., and DiPeitre, D. D. (1982): "Cross Hedging Wholesale Pork Products Using Live Hog Futures," *American Journal of Agricultural Economics,* 64:747–751.

Hayenga, M. L., DiPeitre, D. D., Skadberry, J. M., and Schroeder, T. C. (1984): "Profitable Hedging Opportunities and Risk Premiums for Producers in Live Cattle and Live Hog Futures Markets," *The Journal of Futures Markets,* 4:141–154.

Heifner, R. G. (1972): "Optimal Hedging Levels and Hedging Effectiveness in Cattle Feeding," *Agricultural Economics Research,* 24:25–36.

Johnson, L. L. (1960): "The Theory of Hedging and Speculation in Commodity Futures," *Review of Economic Studies,* 27(2):139–151.

Kahl, K. H. (1983): "Determination of the Recommended Hedging Ratio," *American Journal of Agricultural Economics,* 65:603–605.

Kahl, K. H. (1986): "A Reformation of the Portfolio Model of Hedging: Comment," *American Journal of Agricultural Economics,* 68(4):1007–1009.

Kenyon, D., and Clay, J. (1987): "Analysis of Profit Margin Hedging Strategies for Hog Producers," *The Journal of Futures Markets,* 7(2):183–202.

Miller, S. E. (1986): "Forward Cash Contracting of Cotton," *The Journal of Futures Markets,* 6(2):249–259.

Myers, R. P., and Thompson, S. R. (1989): "Generalized Optimal Hedge Ratio Estimation," *American Journal of Agricultural Economics,* 71:858–868.

Naik, G., and Leuthold, R. M. (1991):"A Note on the Factors Affecting Corn Basis Relationships," *Southern Journal of Agricultural Economics,* 23:147–154.

Peck, A. E. (1975): "Hedging and Income Stability: Concepts, Implications and an Example," *American Journal of Agricultural Economics,* 57:410–419.

Rolfo, J. (1980): "Optimal Hedging Under Price and Quantity Uncertainty: The Case of a Cocoa Producer," *Journal Political Economy,* 88:110–116.

Russell, J. R., Ikerd, J. E., and Dickey, M. C. (1984): "Using Profit Objectives in a Hedging Program for High Plains Fed Cattle: Opportunities, Timing and Empirical Validation," *Oklahoma Current Farm Economics,* 57:27–39.

Schroeder, T. C., and Minert, J. (1988): "Hedging Feeder Steers and Heifers in the Cash-Settled Feeder Cattle Futures Market," *Western Journal of Agricultural Economics,* 13:316–326.

Shafer, C. E., Griffin, W. L., and Johnston, L. D. (1978): "Integrated Cattle Feeding Hedging Strategies," *Southern Journal of Agricultural Economics,* 10:35–42.

Tilley, D. S., and Campbell, S. K. (1988): "Performance of the Weekly Gulf–Kansas City Hard Red Winter Wheat Basis," *American Journal of Agricultural Economics,* 70:929–935.

Witt, H., Schroeder, T. C., and Hayenga, M. L. (1987): "Comparison of Analytical Approaches for Estimating Hedge Ratios for Agricultural Commodities," *The Journal of Futures Markets,* 7:135–146.

Wood, W. C., Shafer, C. E., and Anderson, C. G. (1989): "Frequency and Duration of Profitable Hedging Margins for Texas Cotton Producers 1980–1986," *The Journal of Futures Markets,* 9:519–528.

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

Working, H. (1953b): "Hedging Reconsidered," *Journal of Farm Economics,* 35:544–561.