Incorporating Basis Expectation into Hedging Effectiveness Measures

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Abstract

It is suggested that, if the traditional portfolio approach to measuring hedging effectiveness is used, the underlying _ex-ante_ basis-expectation model be specified explicitly. An empirical example comparing the proposed method to a traditional method for soybean hedges during 1966-83 is presented.

Incorporating Basis Expectation into Hedging Effectiveness Measures

Hedging effectiveness has often been measured in one of two methodological contexts. One approach is in a simulation-type framework where risks and returns of routine and selective hedging strategies during a particular time period are measured (surveyed well by Gray and Rutledge; Kenyon; and Leuthold and Tomek). The second approach uses variants of portfolio theory and, in general, focuses on the variance of hedged returns relative to the unhedged-return variance (e.g., Johnson; Heifner; Ederington). Interestingly, the implicit <u>ex-ante</u> basis-expectation process of the hedger is often ignored when measuring hedging effectiveness with either approach. Explicit specification of the process may lead to a more meaningful effectiveness measure. At the very least, as Peck notes, the use of basis in such analyses causes the focus to be more clearly on the rationale of hedging -- to benefit from the relative movements between two prices.

The objectives of this paper are (a) to present a hedging effectiveness measure similar to that used in the traditional portfolio approach but allowing for alternative basis expectation processes, and (b) to use this measure in conjunction with the intertemporal performance of the expectation model to measure the change in soybean hedging effectiveness during 1966-83 for producers at ten locations in Illinois.

Methodology

Following Peck, the general concept used here to measure hedging effectiveness is based on a comparison between the expected hedged (unhedged) outcome to the realized hedged (unhedged) outcome. In this analysis the hedge is placed on a fixed and known quantity at time t and lifted at time T. Thus, the expected outcome of the hedge can be expressed as the futures price at t minus the basis (futures minus cash) expected at t for T. The expected unhedged outcome is the expected cash price.

Assuming that T is the futures contract expiration date and that the futures price is the hedger's mean forecast of the cash price (excluding spatial basis), then define:

F_{tT} = futures price at time t for expiration T

F_{TT} = futures price at expiration

$E[B_{tT}]$ = expected basis at time t for expiration T

B_{TT} = basis at expiration

$E[HP_{tT}] = E[UP_{tT}] = F_{tT} - E[B_{tT}]$

$RHP_{tT} = F_{tT} - B_{TT}$

$RUP_{tT} = F_{TT} - B_{TT}$

$DH_{tT} = E[HP_{tT}]/RHP_{tT}$

$DU_{tT} = E[UP_{tT}]/RUP_{tT}$

where HP is hedged price, RHP is realized hedged price, UP is unhedged price, and RUP is realized unhedged price. E[ ] is the expected value operator.

The focus of this analysis is on DH and DU -- the expected hedged (unhedged) outcome relative to the realized hedged (unhedged) outcome. Nine alternative calculations for these values were considered, depending on the basis-expectation model. Each model is described below. Assume, for illustration, that expected basis for March soybeans is being found each trading day during the 90 day hedging period prior to March.

Method I (MI). The expected basis is the current basis. On a given day, the basis expected for March is equal to that day's March futures price minus the cash price.

Method II (MII). The expected basis is the current basis adjusted according to the return to storage implied by the prices of the two nearest futures contracts. For the March example, the annualized storage return is $(\ln F^2 - \ln F^1)/2/12$, where F^2 is the May futures price and F^1 is the March futures price. An annualized return is found each day. On a given day, this return is used to compound that day's cash price to March. The expected basis is the current futures price minus the compounded cash price.

Method III (MIII). The same procedure as in Method II is followed except only one storage return is used for the entire hedging period. This return is the average return found during the 45 day period prior to the hedging period.

Method IV (MIV). The expected basis is last year's expiration basis. The average basis during March 9 - March 15 of the previous year is used.

Method V (MV). The expected basis is the average expiration basis for March 9 - March 15 of the past three years.

Method VI (MVI). The expected basis is determined by the basis trend occurring during the 30 days prior to the hedging period. Current basis during the pre-hedging period is estimated as a function of time to expiration (TTE) using ordinary least squares regression. The TTE coefficient is used during the hedging period to extrapolate the current basis to expiration. This is done daily.

Method VII (MVII). Given the regression results used in Method VI, the intercept (TTE = 0) is used as the expected basis. Thus, the expected basis does not change during the hedging period.

Method VIII (MVIII). The same procedure as in Method VI is followed except the sample period used to find the TTE coefficient is the previous year's hedging period.

Method IX (MIX). The intercept of the regression in Method VIII is used as the expected basis.

For a given expected-basis model, the resulting DU and DH returns are assumed to be distributed lognormally at the end of any finite period. Therefore, the variance of the ending distribution of lnDH (or lnDU) over [t,T] is the summation of its instantaneous variances of the instantaneous log returns, given the returns are serially independent. For empirical measurement it is usually (implicitly) assumed that the instantaneous variance is constant over [t, T]. Under this assumption, daily log returns are used in this analysis. Hedging effectiveness is then measured in the portfolio-analysis tradition by dividing the variance of the ending distribution of lnDH by the variance of the lnDU distribution or, equivalently (because of the constant-instantaneous-variance assumption), the variance of $\ln(DH_i/DH_{i-1})$ divided by the variance of $\ln(DU_i/DU_{i-1})$, where $i = 1,2,\ldots n$ and n is the number of days over [t, T]. Given the above definitions, the ratio of the two variances can be expressed as:

$$R = \frac{V(EC) + V(RC) - 2\,Cov(EC, RC)}{V(EC)}$$

where V(•) and Cov(•) is the sample variance and covariance, respectively; EC is $\ln(F_{iT} - E[B_{iT}]) - \ln(F_{i-1,T} - E[B_{i-1,T}])$; and RC is $\ln(F_{iT} - B_{TT}) - \ln(F_{i-1,T} - B_{TT})$. The estimate E = 1-R is similar to the hedging-effectiveness measure often ascribed to Johnson. In this study's basis-expectation context where all quantity is hedged, Johnson's measure (under lognormality and a hedging ratio of one) is found by assuming that the expected basis is the current basis. However, since the basis tends to decrease as expiration approaches, the hedging ratio (cash to futures position) that minimizes the variance of the hedged returns is less than one (e.g., Ederington; Heifner). Unfortunately, the implicit basis-expectation process used to find this minimum-variance ratio is defined by the same sample of prices used to define hedging effectiveness. This simultaneity causes hedging effectiveness to be overstated unless the hedger has perfect foresight in a rational-expectation sense.

An unappealing trait of the relative variance measure is that it is very sensitive to whether the basis expectation model yields different estimates from day to day, regardless of whether the new estimate is a better forecast than the previous day's forecast. The ratio R is very small if the changes in $E[B_{iT}]$ are small, suggesting that hedging effectiveness is high. Assume, for example, that there is no change in expected basis throughout the period (as in Methods IV, V, VII, and IX). Consider the EC and RC definitions given above but, for illustration, do not take the natural logarithm where specified. The result is that the numerator of R is zero since both EC and RC are equal to the first differences of futures price. Taking logs means that the basis terms do not cancel but the resulting numerator is still very small and potentially misleading. Thus, interpertation of this measure should be done with care. Comparisons of the measure across methods should not be made. Comparisons across time for a given method seem appropriate.

Data and Procedures

The hedging effectiveness for soybeans is examined using daily data from ten Illinois elevators (Figure 1) for the period 1966 through 1983. The elevators are members of the Illinois Market News Service sample and were selected to provide a geographic dispersion of prices. The prices, while not generated from a random sample, are considered to be representative of prices paid to producers throughout the state. Daily closing futures prices are for the November, March, and July soybean contracts. These contracts were selected to provide an assessment of the short-term hedging potential throughout the year.

The hedging effectiveness measure, E, was calculated for the three month period prior to maturity for each contract, elevator, and year. Table 1 presents the time periods considered and the forward spreads employed to calculate expected prices where appropriate. It is assumed that the hedge is lifted during the first 15 days of the expiration month and that the realized unhedged price is the average price during this expiration period. For each contract, two hedging periods of approximately 1.5 months each were used in the analysis.

To minimize the effect of outliers and small sample size on the variance calculations, the mean and the standard deviation of the first differences of lnDH and of lnDU were calculated across all elevators, time periods, contracts and years. If the daily first difference was greater than three standard deviations from the mean then the observation was eliminated, reducing the number of observations by less than 1.5 percent. Subsequently, the number of daily observations within a period for any contract was examined. If fewer than 20 observations existed, the contract for that elevator was not used in the analysis. This procedure reduced the number of daily observations by an additional two percent. This data set is used for all calculations and contains approximately 3000 daily observations for each elevator.

The performance of the various basis-expectation models was analyzed by testing if the expected hedged (unhedged) outcome is significantly different than the realized hedged (unhedged) outcome over time. Also, Theil coefficients (U_2) were calculated between the expected and realized outcomes for each basis-expectation model. These procedures demonstrated that using the nearby forward spread to forecast ending basis (MII) performs well for the non-harvest contracts, while during the harvest period it is difficult to "outperform" last year's basis, MIV, as a forecaster of this year's basis level.

For comparative purposes, the hedging-effectiveness measure, E, was calculated under the assumption that the current basis is the expected basis (MI) and under the assumption that the expected basis is based on the market's forward spread (MII). Method IV is not employed because the lack of variability in the hedged position during an individual contract period limits its usefulness in calculating the ending variance.

Ordinary-least squares regression is used to examine the behavior of the measures of hedging effectiveness by contract and individual elevator.

Specifically, for each contract the following equation was estimated for each elevator:

$$E_{iT} = \alpha_{i0} + \beta_{i0}P + \beta_{i1}\ln(T)$$

where E_{iT} = hedging effectiveness measure for the ith elevator (i=1,2,... 10); P = 0 if period is nearest expiration, 1 otherwise; and ln(T) = natural logarithm of a trend variable (i.e., T=1 if 1967, 2 if 1968,...,17 if 1983). The log specification is used because E_{iT} plots over time exhibited non-linearity. The equation was also estimated using the averages across all elevators.

Findings

Table 2 presents the regression results for the hedging effectiveness measure, E, as a function of the dummy variable for time to expiration and the natural logarithm of the trend variable for March soybeans. Since similar results were obtained for the July and November contracts, the results in Table 2 represent the general findings for all three contracts.

In general, the models yield fairly good statistical results. The adjusted R^2s range from 0.21 to 0.72. The Durbin-Watson statistics indicate the presence of some autocorrelation. Not all elevators, however, appear to have serious problems so the autocorrelation was not corrected systematically.

Regardless of the expectation model or contract month, a positive relationship is present between the hedging effectiveness measure and time. The t-values associated with the time coefficient are statistically significant at the one percent level. The results of the dummy variables for the period effect are somewhat mixed. Negative and positive coefficients are obtained and none are significantly different from zero.

There is little to differentiate between the intertemporal relations when using MI versus MII even though MII is considered a more accurate forecast of subsequent basis levels. In part, this might be explained by the short term nature of the forecast period. Further analysis might consider longer hedging periods to determine if similar results are obtained.

The coefficients across elevators for a given basis-expectation model change considerably. Preliminary statistical tests of intercept and slope shifters supported the hypothesis that the coefficients across elevators are different. The elevators were then grouped into three geographic regions. Region 1 contains elevators 1-3, all of which are northwest of the Illinois River. Region 2 contains elevators 4-6 and elevator 8. These four elevators are in east central Illinois where a large proportion of the state's crop production takes place. Region 3 contains the remaining three elevators, 7, 9, and 10. These regional groupings were used because it is felt that the elevators within these groups are influenced by similar economic factors. F-tests were performed to determine if the estimated coefficients for elevators within each region are statistically different. The results of these tests are presented in Table 3.

The observed F-values for all ten elevators together are almost always significant at the one percent level, indicating that there are statistical differences across elevators. Tests for differences within the designated regions exhibited mixed results. The coefficients for the elevators in the three regions are generally found to be homogeneous for the March contract. These results seem reasonable. The return to storage is the major economic influence on March prices and elevators within these regions would be expected to have similar storage functions. However, the coefficients across elevators within the three regions are found to be statistically different for the November contract. During the harvest period, simple regional differences are not as prevalent as in non-harvest periods. Individual production and marketing decisions may have more importance during the harvest period and therefore regional differences may not exist at that time. The July contract yielded mixed results with some coefficients that were homogeneous and some coefficients that were statistically different within the three regions, perhaps reflecting a mixture between old-crop storage effects and new-crop pricing effects.

Concluding Remarks

This paper suggests that, if the portfolio approach to measuring hedging effectiveness is used, the *ex-ante* basis-expectation model should be made explicit. Such a model is presented for the case where a fixed and known quantity is being hedged. The empirical example revealed that hedging effectiveness has increased over the past 20 years. This general result is consistent across alternative basis-expectation models.

The results of this analysis raise other issues. First, it seems plausible that the similarity in results of the two approaches for the variance measures is a function of the short-term nature of the hedging examined. That is, for the length of time under consideration, the methods used for generating expected price produce rather similar results. Whether this is the case for more extended time horizons is an empirical issue which needs to be addressed. Second, this analysis examines differences associated with two approaches for generating price expectations for one commodity. While the use of forward spreads is intuitively reasonable, the question remains as to whether the results are sensitive to alternative expectations models or to other commodities. Third, the same approach can be used in the minimum variance framework; although to be consistent with the *ex-ante* concept emphasized here, the hedging ratio should also be determined before the hedge is placed and not in the traditional manner. Finally, why do the regression fits, coefficient levels, etc. vary so much in Table 2? Factors such as regional effects due to river or processing markets, elevator pricing practices, and others need to be identified and investigated.

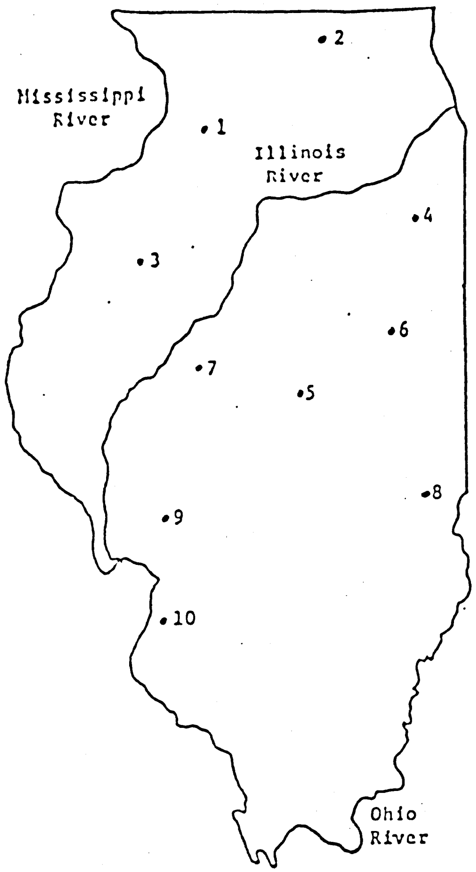

Figure 1. Elevator Locations.

Table 1. Intrayear Periods of Study and Spreads Used to Calculate Expected Storage Return, Illinois Soybeans.

	Period 1	Period 2
November Contract	August 1 to September 15[a] January-November[b] spread	September 16 to October 31 January-November spread
March Contract	December 1 to January 15 March-January spread	January 16 to February 28 May-March spread
July Contract	April 1 to May 15 July-May spread	May 16 to June 30 August-July spread

[a] Period over which hedging-effectiveness measures were calculated.

[b] Forward spread used in calculating expected price. The expected storage return and resultant expected price was calculated daily.

Table 2. Illinois Soybean Hedging Effectiveness Regressions for March Contract by Basis Expectation Model and Elevator, 1966-1983.

Elevator	Method I					Method II				
	Intercept	Period	ln(Time)	$\bar{R}^2$	D.W.	Intercept	Period	ln(Time)	$\bar{R}^2$	D.W.
1	-0.07 (-0.47)[a]	0.01 (0.15)	0.37 (5.49)	0.51	1.09	-0.15 (-0.89)	0.05 (0.49)	0.39 (5.20)	0.48	1.57
2	-0.02 (-0.19)	-0.06 (-0.79)	0.35 (7.75)	0.67	1.48	-0.08 (-0.74)	0.01 (0.13)	0.37 (7.11)	0.63	1.21
3	0.06 (0.25)	-0.05 (-0.30)	0.32 (3.14)	0.21	1.33	-0.16 (-0.69)	0.09 (0.58)	0.37 (3.66)	0.28	1.61
4	0.002 (0.02)	0.06 (0.87)	0.33 (7.00)	0.59	1.53	-0.22 (-1.72)	0.15 (1.64)	0.39 (6.87)	0.59	1.57
5	0.16 (1.35)	0.06 (0.74)	0.25 (4.79)	0.42	1.66	-0.12 (-0.87)	0.15 (1.56)	0.34 (5.85)	0.53	1.79
6	0.13 (1.78)	0.02 (0.39)	0.29 (9.31)	0.72	2.09	-0.04 (-0.39)	0.10 (1.60)	0.34 (7.97)	0.66	1.92
7	0.09 (0.77)	0.002 (0.02)	0.31 (5.97)	0.53	1.12	-0.11 (-0.83)	0.08 (0.89)	0.38 (6.60)	0.58	1.58
8	0.05 (0.43)	-0.01 (-0.13)	0.32 (5.82)	0.56	0.74	-0.09 (-0.74)	0.07 (0.71)	0.35 (5.86)	0.57	1.20
9	0.01 (0.09)	-0.07 (-0.89)	0.34 (6.67)	0.58	1.50	-0.27 (-2.20)	0.03 (0.32)	0.43 (8.02)	0.66	1.74
10	0.20 (2.01)	-0.03 (-0.42)	0.24 (5.57)	0.47	1.02	-0.04 (-0.44)	0.08 (1.17)	0.33 (7.65)	0.64	1.63
All	0.44 (5.83)	0.01 (0.28)	0.19 (5.57)	0.47	1.47	0.12 (1.14)	0.08 (1.06)	0.30 (6.30)	0.54	1.65

[a] Values in parentheses are t-value.

Table 3. Test Statistics for Homogeneity of Estimated Slope and Intercept Coefficients of Illinois Hedging Effectiveness Regressions by Contract and Basis-Expectation Model, 1966-1983.

Region[a]	Method	Contract		
		March	July	November
Illinois, 10 Elevators	I	8.79**	22.72**	22.75**
	II	5.88*	26.12**	22.89**
Region 1	I	0.39	3.41	6.58*
	II	0.23	4.57*	6.71*
Region 2	I	3.46	1.28	9.03**
	II	2.06	1.93	9.52**
Region 3	I	3.36	18.29**	4.13*
	II	4.31*	17.21**	3.95*

[a] See text for explanation of regions.

** Significant at the .01 level; * significant at the .05 level.

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