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TRADITIONAL VERSUS OPTIMAL HEDGES: A COMPARATIVE ANALYSIS FOR CORN PRODUCERS AND MERCHANDISERS

by Marvin L. Hayenga and John S. McDaniel*

Typical hedging practices used in the grain industry, and taught in agricultural marketing courses, are the bushel-for-bushel, or 1:1 hedge for commodities which have futures contracts. The optimal hedging studies available to date have shown that the optimum price risk-minimizing hedge ratios did not significantly deviate from the typical industry practice of 1:1 hedges, though optimum revenue risk-minimizing hedges often did (Grant, Heifner). In this paper, we reexamine whether the optimum price risk-minimizing hedge ratios deviate from 1:1 for corn hedgers in several hedging situations (requiring two different optimal hedge estimation procedures), and whether the hedging performance differs significantly for typical and optimum hedge positions in several corn producer, elevator operator, or feed lot buyer hedging scenarios.[1]

Witt, Schroeder, and Hayenga reviewed various approaches used in the literature to estimate optimum hedge ratios. They evaluated the comparative merits of the regression models typically used to estimate optimum hedge ratios, and concluded that the "price difference" model (1), involving changes in cash prices being regressed against the change in futures prices over the same period of time, was appropriate for inventory hedges since the current cash price at the time the hedge was initiated was a relevant opportunity cost for the hedger.

$$(1) \quad (C_2 - C_1) = a + b\,(F_2 - F_1) + e_t$$

where:

C_1, C_2 = The cash price when the hedge is placed and lifted, respectively.

F_1, F_2 = The futures price when the hedge is placed and lifted, respectively.

e_t = error term

However, for non-storage hedges, say a growing crop in the field, the current cash price at the time the hedge was initiated was not relevant to the risk-manager; they showed that a "price level" regression model (2) relating cash prices to futures prices during the time of making or taking delivery was appropriate.

$$(2) \quad C_2 = d + gF_2 + e_t$$

In each case, the optimum hedge ratio was the "slope" coefficient in the regression equation (b and g, respectively). Note that yield risk is not considered, as it is by Grant. This estimated hedge ratio would be appropriate in the second stage of a risk-minimizing decision process, after the amount to be hedged is determined by the risk manager.

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[1]After this paper was completed, Grant and Eaker's paper became available which examined a similar question, focusing on complex hedges in a multiperiod setting. Also, Elam and Dixon argue that the estimated OLS slope coefficient is biased downward from 1, and is inappropriate as a test for pricing efficiency. However, they don't deal with the question regarding the appropriate hedge ratio to use in practical risk management, or suggest a better estimation procedure to use (possibly an estimation procedure taking autocorrelation into account, for example?).

Optimal Hedge Estimation

To estimate optimal hedge ratios via models (1) and (2), above, Chicago Board of Trade closing corn futures prices and North Central Iowa cash corn prices (No. 2 Yellow Corn) on Thursdays for 1972-1987 were acquired. Seventeen hedge termination periods during the year were used, corresponding to typical hedger practices (10 half month periods during the five contract expiration months and seven full months when the same nearby contract could be used for the entire month). Using simple ordinary least squares procedures, we estimated the optimum risk-minimizing hedge ratios (autocorrelation corrections were not made to keep their estimation and use simple). Thus, 17 optimum hedge ratios during a year were estimated using the "price level" model, and 204 optimum hedge ratios were estimated using the "price difference" model (using inventory hedges ranging from 1-12 months). To allow out of sample tests of the optimum hedge ratios, we initially estimated optimum hedge ratios using 1972-79 data for use in 1980, then reestimated the hedge ratios in each succeeding year based on the most recent eight years' data.

The regression results and optimum hedge ratios based on 1980-87 data are shown in Tables 1-5. For brevity, only the optimum hedge ratios for 1, 3, 6, and 12 month inventory hedges are shown (the others are available from the authors). The standard t-statistic and the significance of the slope coefficient's difference from zero and one are indicated.

Many equations exhibited a high positive autocorrelation, probably due to the way in which the data were set up to estimate the optimal hedge ratios and provide individual measures of fit for each delivery period. While autocorrelation would not bias the results, the standard errors of the coefficients could be inflated. Thus, the tests of significance could lead to "conservative" estimates of the number of optimum hedge ratios which differ from one. Since hedgers typically would only have knowledge of error structures 3-6 months prior to delivery (when the hedge is placed), it is not clear that autocorrelation-corrected optimum hedge ratios would be better to use in hedging, though they might be better in the statistical tests, particularly given Elam and Dixon's arguments regarding the downward bias of OLS estimates.

The price difference optimal hedge estimates showed a high degree of variability from one month to the next for equivalent length hedges. This was particularly evident with the shorter length hedges. The longer hedges however, did not exhibit this wide variability from month to month in the estimated hedge ratios.

The high degree of variability associated with the price difference optimal hedge estimates for short hedges can be explained at least in part by the fact that, with the shorter hedges, seasonal shocks in the cash or future markets (e.g. harvest basis variability) are able to exert more influence on the estimated ratios. With longer hedges, however, any seasonal (short-term) shocks are spread out over a longer time frame which dilutes the effects of these short-term shocks on the estimated hedge ratios.

By studying the optimal inventory hedge ratios (Tables 1 through 4) it can be seen that, in general, the longer hedges have estimated optimal hedge ratios closer to one. This seems understandable as one would expect cash and futures price changes to more closely mirror each other over longer periods of time.

On average, eight of the seventeen price difference optimal hedge ratios were found to differ significantly from one for the one through six month inventory hedges. The lowest hedge ratios and poorest fits typically were

Table 1. Risk minimizing hedge ratios for a one month corn hedge using a price difference model, 1980 to 1987[1].

	Intercept	(t-statistic)	Slope[3]	(t-statistic)	R^2	D.W.	MSE
January[2]	.031	(1.500)	.329+	(1.465)	.076	1.431	.012
February	.062	(4.436)	.964*	(8.149)	.689	.936	.005
March 1-15	.056	(3.719)	.728*+	(6.495)	.738	2.034	.004
March 16-31	.078	(6.543)	.831*	(8.310)	.842	.858	.002
April	.026	(2.410)	1.105*	(11.129)	.805	.855	.002
May 1-15	.051	(3.185)	.681*+	(5.970)	.690	.882	.005
May 16-31	.043	(4.087)	.584*+	(8.041)	.844	1.767	.001
June	.016	(1.800)	.742*+	(6.770)	.604	1.225	.002
July 1-15	-.016	(-.615)	1.030*	(6.956)	.763	1.213	.011
July 16-31	-.038	(-1.375)	.835*	(7.126)	.796	1.131	.011
August	-.059	(-3.404)	.908*	(14.349)	.873	1.094	.009
Sept. 1-15	-.094	(-2.332)	.618*	(2.283)	.258	1.624	.026
Sept. 16-30	-.126	(-3.314)	1.164*	(2.382)	.304	1.297	.020
October	-.045	(-3.311)	1.024*	(6.572)	.590	1.529	.006
November	.069	(3.529)	.606*+	(4.441)	.397	.950	.010
Dec. 1-15	.055	(2.221)	.678*+	(4.895)	.615	1.296	.007
Dec. 16-31	-.020	(-1.198)	.218*+	(1.927)	.222	1.925	.003

*Is significantly different from zero at the 5% confidence level.

+Is significantly different from one at the 5% confidence level.

[1]The futures contract closest to delivery is used to hedge with for all delivery months except for a hedge lifted after the 15th of a contract month for which the following futures contract is used.

[2]Ending date of the hedge.

[3]The slope parameter is the optimal hedge ratio and is read bushels futures per bushel cash.

Table 2. Risk minimizing hedge ratios for a three month corn hedge using a price difference model, 1980 to 1987[1].

	Inter- cept	(t- statistic)	Slope[3]	(t- statistic)	R^2	D.W.	MSE
January[2]	.116	(4.522)	.455*+	(3.851)	.363	.657	.017
February	.070	(2.448)	.540*+	(4.890)	.479	.586	.017
March 1-15	.097	(2.621)	.585*+	(3.668)	.509	1.186	.021
March 16-31	.142	(6.156)	.750*+	(8.024)	.854	2.585	.007
April	.169	(9.498)	.954*	(11.923)	.826	.568	.010
May 1-15	.174	(7.593)	.688*+	(5.930)	.687	.622	.009
May 16-31	.208	(6.993)	.678*+	(4.690)	.647	.559	.012
June	.127	(7.073)	.707*+	(6.240)	.565	.522	.010
July 1-15	.073	(1.612)	.814*	(3.702)	.477	.665	.027
July 16-31	.056	(1.577)	.978*	(7.237)	.801	.814	.016
August	-.031	(-.948)	.956*	(13.137)	.852	.725	.030
Sept. 1-15	-.184	(-2.884)	.879*	(7.069)	.769	1.372	.067
Sept. 16-30	-.258	(-3.144)	.828*	(4.486)	.608	1.311	.088
October	-.243	(-6.644)	.832*+	(8.390)	.701	.922	.040
November	-.105	(-2.908)	.969*	(5.915)	.538	.426	.042
Dec. 1-15	.027	(.572)	.738*	(3.878)	.501	1.033	.034
Dec. 16-31	.093	(2.687)	.510*+	(3.192)	.439	1.041	.017

*Is significantly different from zero at the 5% confidence level.

+Is significantly different from one at the 5% confidence level.

[1]The futures contract closest to delivery is used to hedge with for all delivery months except for a hedge lifted after the 15th of a contract month for which the following futures contract is used.

[2]Ending date of the hedge.

[3]The slope parameter is the optimal hedge ratio and is read bushels futures per bushel cash.

Table 3. Risk minimizing hedge ratios for a six month corn hedge using a price difference model, 1980 to 1987[1].

	Intercept	(t-statistic)	Slope[3]	(t-statistic)	R^2	D.W.	MSE
January[2]	-.125	(-2.912)	.798*+	(8.488)	.735	.465	.044
February	.010	(.245)	.872*	(7.156)	.663	.505	.036
March 1-15	.125	(2.548)	.689*+	(4.424)	.601	1.174	.026
March 16-31	.239	(6.334)	.648*+	(5.228)	.713	.810	.017
April	.292	(9.061)	.825*	(7.969)	.710	.558	.029
May 1-15	.229	(3.784)	.329*+	(2.262)	.282	1.291	.055
May 16-31	.270	(7.456)	.702*+	(6.569)	.797	.865	.016
June	.241	(10.544)	.824*+	(10.798)	.818	.633	.015
July 1-15	.259	(6.147)	.988*	(8.105)	.814	.431	.028
July 16-31	.257	(8.954)	1.244*+	(13.842)	.937	1.432	.011
August	.178	(4.878)	1.008*	(13.329)	.856	.449	.038
Sept. 1-15	.016	(-.254)	.961*	(8.039)	.812	1.034	.067
Sept. 16-30	-.100	(-1.008)	.974*	(4.886)	.647	.968	.123
October	-.164	(-2.716)	.884*	(8.058)	.684	.587	.102
November	-.179	(-3.482)	.909*	(9.638)	.756	.419	.081
Dec. 1-15	-.203	(-2.886)	.818*	(6.195)	.719	.728	.081
Dec. 16-31	-.119	(-1.559)	.991*	(6.453)	.762	.976	.073

*Is significantly different from zero at the 5% confidence level.

+Is significantly different from one at the 5% confidence level.

[1]The futures contract closest to delivery is used to hedge with for all delivery months except for a hedge lifted after the 15th of a contract month for which the following futures contract is used.

[2]Ending date of the hedge.

[3]The slope parameter is the optimal hedge ratio and is read bushels futures per bushel cash.

Table 4. Risk minimizing hedge ratios for a twelve month corn hedge using a price difference model, 1980 to 1987[1].

	Intercept	(t-statistic)	Slope[3]	(t-statistic)	R^2	D.W.	MSE
January[2]	.061	(3.848)	.987*	(46.409)	.988	.908	.007
February	.028	(1.314)	.949*+	(29.481)	.971	.579	.012
March 1-15	.014	(.523)	.912*+	(22.189)	.974	.544	.011
March 16-31	.040	(1.279)	.956*	(23.994)	.981	.713	.009
April	.026	(1.032)	.946*	(25.474)	.962	.434	.017
May 1-15	.022	(1.038)	.964*	(26.846)	.982	.701	.006
May 16-31	.030	(.685)	1.053*	(13.288)	.941	1.150	.025
June	.025	(.970)	.987*	(20.999)	.944	.486	.017
July 1-15	.033	(1.598)	.954*	(27.237)	.983	.978	.005
July 16-31	.021	(.342)	.956*	(7.830)	.848	1.173	.043
August	.034	(.991)	.976*	(20.068)	.939	.491	.028
Sept. 1-15	.016	(.270)	.889*	(12.325)	.921	1.704	.049
Sept. 16-30	.0002	(.002)	.853*	(6.430)	.790	1.265	.075
October	.021	(.463)	.918*	(14.546)	.891	.986	.052
November	.036	(1.178)	.878*+	(21.213)	.945	.491	.023
Dec. 1-15	.030	(1.186)	.841*+	(24.617)	.979	.633	.009
Dec. 16-31	.090	(1.592)	1.103*	(11.675)	.925	1.361	.028

*Is significantly different from zero at the 5% confidence level.

+Is significantly different from one at the 5% confidence level.

[1]The futures contract closest to delivery is used to hedge with for all delivery months except for a hedge lifted after the 15th of a contract month for which the following futures contract is used.

[2]Ending date of the hedge.

[3]The slope parameter is the optimal hedge ratio and is read bushels futures per bushel cash.

Table 5. Risk minimizing hedge ratios for corn using a price level model, 1980 to 1987[1].

	Inter- cept	(t- statistic)	Slope[3]	(t- statistic)	R^2	D.W.	MSE
January[2]	-.009	(-.066)	.858*+	(18.037)	.916	.167	.025
February	.022	(.191)	.868*+	(21.022)	.936	.298	.018
March 1-15	-.045	(-.317)	.911*+	(18.019)	.956	.260	.015
March 16-31	.036	(.201)	.865*+	(13.528)	.934	.305	.021
April	-.051	(-.413)	.910*+	(21.455)	.939	.171	.021
May 1-15	-.113	(-.812)	.945*	(19.237)	.959	.240	.010
May 16-31	-.184	(-.818)	.971*	(12.612)	.930	.586	.022
June	-.082	(-.644)	.938*	(20.936)	.936	.272	.016
July 1-15	-.058	(-.653)	.924*+	(29.372)	.983	.519	.006
July 16-31	.249	(1.129)	.834*+	(10.464)	.894	.470	.043
August	-.014	(-.108)	.913*+	(19.315)	.926	.214	.037
Sept. 1-15	-.061	(-.415)	.904*+	(16.994)	.951	1.046	.028
Sept. 16-30	-.068	(-.310)	.872*	(10.371)	.892	.718	.046
October	-.149	(-1.101)	.900*+	(17.783)	.913	.520	.036
November	.113	(1.159)	.821*+	(22.937)	.946	.263	.020
Dec. 1-15	.189	(1.635)	.815*+	(18.790)	.959	.445	.013
Dec. 16-31	.033	(.195)	.839*+	(13.201)	.931	1.613	.025

*Is significantly different from zero at the 5% confidence level.

+Is significantly different from one at the 5% confidence level.

[1]The futures contract closest to delivery is used to hedge with for all delivery months except for a hedge lifted after the 15th of a contract month for which the following futures contract is used.

[2]Ending date of the hedge.

[3]The slope parameter is the optimal hedge ratio and is read bushels futures per bushel cash.

found when harvest basis variability was a likely contributing factor. For the seven through twelve month hedges, an average of only three of the seventeen price difference optimal hedge ratios for each storage period were found to differ significantly from one. The results of the t-test are consistent with the assumption that over longer periods of time the cash and futures markets will move more closely in a one for one ratio, resulting in a hedge ratio close to one.

For the price level model (Table 5), all estimated optimal hedge ratios were found to be significantly different from zero and thirteen of the seventeen ratios were found to differ significantly from one.

Because of the issues raised about the possible bias of the OLS estimates, and the higher standard errors due to autocorrelation, the critical question is the comparative performance of the "optimum" hedge ratios and naive 1:1 hedges in an out-of-sample period.

Hedging Simulation Results

Using annually updated estimates of optimum hedge ratios for eight year periods (e.g. using hedge ratios based on 1972-79 data for 1980 hedge strategy evaluation), several typical hedging scenarios were postulated to evaluate the relative performance of optimum hedge ratios with the typical 1:1 hedge outside the optimum hedge estimation sample period. No hedge results also are provided, since many hedgers inappropriately consider cash market results as their opportunity cost. The hedging scenarios which were evaluated for 1980-87 include:

1) A corn producer establishing harvest prices (in November) at planting time (May).
2) A feedlot operator, corn processor or merchandiser establishing a corn purchase price three months prior to making a cash purchase.
3) Corn producer or grain elevator corn inventory hedges for 3, 6, and 12 month duration, beginning in November or June.

Planting Hedge Results

In Table 6 the results of a farmer hedge at planting time using the price level model hedge ratio (Table 5), the traditional bushel for bushel hedge (the 1:1 ratio hedge) and no hedge are shown for the years 1980 through 1987. This presumes that yield risk is accounted for by the farmer when determining the proportion of the crop to be hedged; otherwise, the hedge ratio would be lower (Grant). The seven-month hedge was placed each week in May and lifted each week in November when the corn was sold. Revenue per bushel includes the price per bushel received in the cash market plus (minus) any gains (losses) from the futures market position and does not include transaction costs which would vary for each hedger (but would probably be less than two cents per bushel for most hedgers).

In all but one year (1980) the risk minimizing hedge reduced the variability of revenue compared to the one for one hedge, while it had a lower variance of income in four out of eight years when compared to the no hedge option.[2] Over the eight year period the risk minimizing hedge option had the

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[2]An alternative, perhaps preferable, measure of variability to the standard error of the actual weekly hedge results (cash price + futures gain or loss) would compare actual returns with returns expected at the time of placing the hedge.

Table 6. Planting hedge[1] - May to November

	1:1 Hedge		Risk min. hedge[2]		No hedge	
Year	Revenue[3]	Standard Deviation	Revenue	Standard Deviation	Revenue	Standard Deviation
1980	$2.25	$.0388	$2.32	$.0403	$3.08	$.0850
1981	3.10	.0530	2.94	.0467	2.21	.0153
1982	2.64	.0346	2.56	.0328	2.14	.0881
1983	2.56	.0878	2.74	.0717	3.16	.0806
1984	2.73	.0519	2.68	.0374	2.47	.0252
1985	2.41	.0396	2.37	.0349	2.18	.0082
1986	1.73	.0520	1.65	.0487	1.39	.0424
1987	1.72	.0622	1.70	.0477	1.60	.0557
8 year average	2.392	.0525	2.370	.0450	2.279	.0501

[1]The hedge was placed in May and lifted in November when the crop was sold. Typically, four weekly observations of seven month hedges were available each year. Revenue is per bushel, not considering transaction costs.

[2]The eight year earlier period was used to estimate the risk minimizing hedge ratio for each year.

[3]Revenue is the average revenue received for a bushel of corn sold (including futures gains and losses) under each option during November of the year in question.

lowest standard deviation of income followed by the no hedge option and the one for one hedge option, respectively. However, the variance of revenue for the risk minimizing hedge was not significantly less at the 5% level of confidence than either the no hedge or one for one hedge strategies.

The one for one hedge showed the highest average return over the eight years followed closely by the risk minimizing hedge (approximately $.02/bu. less) and the no hedge option, which showed an eleven cents lower average revenue per bushel than the traditional hedge.

While the results of these simulations would seem to favor the use of a one for one hedge or optimal hedge over the no hedge option, neither the one for one nor the risk minimizing hedge exhibit significant differences in variance or return.

Purchase Hedge Results

Three purchase options--traditional, optimal and not hedging--were considered for a livestock producer, corn processor or merchandiser with no available storage space. In January, the hedger decides to establish an approximate purchase price for corn, using futures, for an April cash corn purchase. The price level optimum hedge ratios (Table 5) are used.

For 1980-87, the risk minimizing hedge proved to have a standard deviation of cost less than or equal to that of the one for one hedge for every year except 1987 (Table 7). The risk minimizing hedge exhibited a lower standard deviation of cost in only three of eight years when compared to the no hedge strategy. Over the eight years, 1980-1987, the no hedge option had the least variable cost for a bushel of corn purchased in April followed by the risk minimizing hedge and one for one hedge options, respectively. This suggests that the cash market was substantially less volatile than the futures market during the month of April. All three options had very similar average costs over the eight years, with the one for one hedge having the lowest.

Again, it is not obviously clear which of the two hedging strategies would be preferred over the other in this hedging scenario, as neither shows any significant differences in variance or return. Also, the variance of cost for the no hedge option was not significantly less at the 5% level of confidence than the other two purchase strategies.

Storage Hedge Results

For an elevator or corn producer who has the commodity on hand, has available storage, and wishes to sell it at a later date, three different length hedges ranging from three to twelve months were evaluated. The price difference model optimum hedges from Tables 2-4 were contracted with the 1:1 hedge and no hedge strategies.

Two different three month storage periods (one having a September delivery and one a February delivery) were used to test if the potentially different basis behavior in those periods changed the relative effectiveness of any of the hedging methods. Table 8 shows the results of one of the three month storage hedges (the results of the other were very similar).

The results of both three month storage periods show quite conclusively that hedging a cash position substantially reduces price risk when storing corn for three month periods (significant at the 5% level). Both hedged options also showed more favorable returns to storage than the no hedge option for both delivery months. The question of interest again has no definitive answer, however, as the differences in variance and return of the two hedging options were not large enough to be considered significant.

Table 7. Purchase hedge[1] - January to April

Year	1:1 Hedge Cost[3]	1:1 Hedge Standard Deviation	Risk min. hedge[2] Cost	Risk min. hedge[2] Standard Deviation	No hedge Cost	No hedge Standard Deviation
1980	$2.38	$.0783	$2.38	$.0751	$2.18	$.0265
1981	3.26	.0518	3.26	.0518	3.10	.0300
1982	2.47	.0344	2.46	.0289	2.41	.0383
1983	2.48	.1034	2.56	.0937	2.95	.0316
1984	3.08	.0329	3.10	.0293	3.27	.0638
1985	2.56	.0169	2.56	.0169	2.62	.0100
1986	2.41	.0224	2.41	.0224	2.19	.0216
1987	1.38	.0238	1.38	.0304	1.41	.0922
8 year average	2.502	.0455	2.514	.0436	2.516	.0393

[1]The hedge was placed in each week in January and lifted each week in April when the corn was purchased. Cost is per bushel, including relevant futures gains or losses, but not considering transaction costs.

[2]The eight year earlier period was used to estimate the risk minimizing hedge ratio for each year.

[3]Cost is the average cost during April.

Table 8. Return to storage - Three month hedge[1] - February delivery

	1:1 Hedge		Risk min. hedge[3]		No hedge	
Year[2]	Return	Standard Deviation	Return	Standard Deviation	Return	Standard Deviation
1980	$.20	$.0226	$.18	$.0170	$.06	$.1181
1981	.28	.0260	.24	.0182	-.06	.0933
1982	.32	.0736	.32	.0733	.04	.0594
1983	.01	.0322	.18	.0219	.32	.0316
1984	-.13	.1016	-.16	.1003	-.20	.1088
1985	.24	.0872	.14	.0758	.03	.0658
1986	.08	.0224	.05	.0138	.02	.0252
1987	.16	.0480	-.01	.0596	-.17	.0764
8 year average	.145	.0517	.118	.0475	.005	.0723

[1]The hedge was placed each week in November and lifted each week during February. Return is calculated per bushel of stored corn and is the average of the February observations, combining cash returns and relevant futures gains or losses.

[2]Year corresponds to when the hedge is lifted and the crop sold.

[3]The eight year earlier period was used to estimate the risk minimizing hedge ratio for each year.

Table 9 shows the results of the three alternative strategies for the six month storage period. The no hedge option exhibited the lowest variance of return, while the risk minimizing hedge was found to have the highest average return over the eight years studied. The variance of return for the risk minimizing hedge was not found to be significantly different from the variance of the no hedge option; however, the no hedge variance did prove to be significantly less than the variance of the one for one hedge. The variance of returns from the risk minimizing hedge were lower than they were for the 1:1 hedge, but not significantly lower.

In the twelve month storage scenario (see Table 10), an individual typically would have fared much better when hedging stored corn for this twelve month period. The results of the one for one and risk minimizing hedges are very similar, with the risk minimizing hedge having the lowest average variance of return for the twelve month storage periods and the no hedge option having the highest variance of return. The variance of return for the risk minimizing hedge was not found to be significantly different from the variances of the other two strategies.

Summary and Conclusion

Both price level and price difference models have been used in this analysis to estimate optimal price risk minimizing hedge ratios for non-storage and storage hedges, respectively. Many of the estimated hedge ratios differed significantly from 1, but questions raised in a recent paper about OLS estimates being downward biased, and autocorrelation in many equations due to the methods used in constructing the data suggest that autocorrelation-adjusted estimates should be considered for improved tests as we continue this research. The usefulness of the estimated optimal hedge ratios was then evaluated in several practical hedging scenarios.

Statistically, the risk minimizing and one for one hedges exhibited a significantly lower variance of return than the no hedge strategy in two of the six hedging scenarios. For both three month hedges the two hedged strategies proved to have significantly lower variances of return than the no hedge strategy, with the risk minimizing hedge having the lowest variance in both cases (not significantly lower than the one for one hedge, however). In no instance did the risk minimizing hedge have a significantly lower variance of return than the one for one hedge strategy, although it did consistently have a lower variance in all six cases. Had the sample size been larger in the hedging scenarios, some of the differences in the variances of return may have proven to be significant.

The no hedge strategy was found to have a significantly lower variance of return than the one for one hedge in only one of the six hedging situations (six month hedge), while it never exhibited a significantly lower variance of return than the risk minimizing hedge.

The results, while mixed, seem to favor the risk minimizing hedge to the no hedge strategy, as the risk minimizing hedge exhibited a lower variance of return in four of the six hedging situations modeled, and in two of these four situations the difference was significant. The results also seem to favor the risk minimizing hedge on a return basis, as it showed a more favorable return than the no hedge strategy in all six hedging situations for the 1980-87 period, when transaction costs were not considered. Transaction costs of two cents per bushel would switch the ranking in one hedging situation.

Although the majority of hedgers presently use the traditional one for one hedge, the results of this analysis suggest that hedgers can reduce their exposure to price risk slightly by using the risk minimizing hedge. Even

Table 9. Return to storage - Six month hedge[1] - May delivery

Year[2]	1:1 Hedge Return	1:1 Hedge Standard Deviation	Risk min. hedge[3] Return	Risk min. hedge[3] Standard Deviation	No hedge Return	No hedge Standard Deviation
1980	$.42	$.0361	$.38	$.0205	$.24	$.0283
1981	.50	.0141	.41	.0130	.07	.0919
1982	.68	.0447	.58	.0361	.25	.0224
1983	.21	.0284	.68	.1478	.83	.2052
1984	-.38	.7014	-.19	.3705	.06	.0566
1985	.19	.0117	.13	.0038	.10	.0000
1986	.11	.0557	.10	.0301	.10	.0587
1987	.28	.0500	.27	.0238	.27	.0071
8 year average	.251	.1178	.295	.0807	.240	.0588

[1]The hedge was placed each week in November and lifted each week during the first two weeks of May. Return is calculated per bushel of stored corn and is the average of the May observations of cash returns plus relevant futures gains or losses.

[2]Year corresponds to when the hedge is lifted and the crop sold.

[3]The eight year earlier period was used to estimate the risk minimizing hedge ratio for each year.

Table 10. Return to storage - Twelve month hedge[1] - November delivery

	1:1 Hedge		Risk min. hedge[3]		No hedge	
Year[2]	Return	Standard Deviation	Return	Standard Deviation	Return	Standard Deviation
1980	$-.21	$.0232	$-.13	$.0247	$.94	$.0469
1981	.17	.0884	.07	.0761	-.87	.0787
1982	.37	.0867	.30	.0623	-.06	.0804
1983	-.15	.0247	.12	.0476	1.01	.1354
1984	.07	.0235	-.09	.0245	-.68	.0583
1985	.06	.0399	-.004	.0315	-.29	.0287
1986	-.09	.0963	-.22	.0862	-.79	.0416
1987	.06	.0698	.08	.0586	.20	.0263
8 year average	.035	.0566	.016	.0514	-.067	.0620

[1]The hedge was placed each week in November and lifted each week during November (12 months later). Return is calculated per bushel of stored corn and is the average of the November observations of cash returns plus any relevant futures gains or losses.

[2]Year corresponds to when the hedge is lifted and the crop sold.

[3]The eight year earlier period was used to estimate the risk minimizing hedge ratio for each year.

though the differences in variance of return between the optimal (risk minimizing) hedge and the traditional hedge were not statistically significant for any of the six hedging situations, the optimal hedge did consistently have a lower variance of return than the traditional one for one hedge for all six simulations. Conversely, the one for one hedge exhibited a higher return than the risk minimizing hedge for all but the six month hedge. These findings, while not conclusive, do slightly favor the use of the risk minimizing hedge ratio to the one for one hedge ratio when a hedger is most concerned with reducing price risk. However, for those hedgers whose primary concern does not lie with reducing risk, the trade-offs between risk and return should be evaluated on an individual basis in order to come to a conclusion as to which hedge ratio (risk minimizing or one for one) satisfies the needs of their own operation. Also, a comparison of actual results with expected results might be a better measure of risk, which will be considered further in the next stage of this research.

A risk manager also needs to consider that the optimal hedge estimation process is not only time consuming but can also be quite costly (in terms of both time and effort), and could well negate the relatively small gains from using the optimal hedge ratios. Therefore, it is likely that only the largest volume risk-averse hedgers would have the incentive to estimate and use optimal hedge ratios, unless public agencies or private firms (e.g. brokerage or consulting firms, or futures exchanges) made them available at a small or no cost to hedgers.

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