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MULTI-YEAR HEDGING ANALYSIS
FOR CORN, 1973-98

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Abstract:

Multi-year hedging involves placing a hedge for more than one year, and then unwinding it as physical product is sold. This study analyzed a two-year hedge for corn trying to capture high prices. Long-run average prices were no better than annual cash sales or annual hedges.

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The theoretical and empirical evidence on hedging agricultural commodities has been discussed in numerous studies (Wisner; Leuthold, et al.; Working) which suggest that hedging using the futures market is beneficial. However, the full benefits of the hedging may not be obtained or evaluated accurately as long as an incomplete futures market exists. Gardner argued that a futures market may be incomplete due to a missing long-term futures market. He evaluated this missing futures market for corn, soybeans and cotton, and found little empirical support for multi-year futures contracts. The evaluation was based on decisions to place and lift hedges at fixed points in time during the Spring and Fall, respectively. However, Gardner did not evaluate the possibilities of long-term hedging using more flexible decision rules. Four related studies (French and Turner; Huang, Turner and Houston; Kenyon and Beckman; Kim and Conley) followed Gardner's concept but assumed a producer would place a long-term hedge only when prices were favorable. The distribution of futures prices helped identify opportunities for locking-in a favorable price above an average multi-year price. They concluded that a strategic rollover hedging strategy has the potential to increase prices received by producers over a multi-year period. This study applied similar decision rules. It modified the methodology developed by Gardner to evaluate the risks and returns of long-term hedging strategies under certain decision rules designed to take advantage of an unusually high price that occurs during a multi-year period.

Objectives of the Study

The major objective of this study was to empirically analyze a two-year hedging strategy for corn under certain special conditions. This was accomplished through the following sub-objectives:

1. Identify an out-of-sample or ex-ante decision rule for two-year hedging.
2. Derive a two-year hedging model and compare various pricing strategies with respect to the mean and standard deviation of the price received over the period of study.

Methodology

Decision Rules

A decision rule was developed based on the cumulative frequency distributions or CFDs for December corn futures prices over four-year time periods. The CFDs represented a decision maker's historical knowledge of price levels and probabilities of occurrence. For example, the CFD for the 1987-90 time period would be used as the historical perspective for decisions in 1991. The CFD and decision rule were based on out-of-sample data recognizing the decision maker only has known historical information during 1991. The basic decision rule was that a two-year hedge would be placed if the current December futures price was at or above the upper 10 percent level of the CFD.

The time period for this study was 1973 through 1998. The first CFD was created using data for 1969-72. The 0.10 probability or 10 percent trigger price was $151.50 which was applied out-of-sample to the following year of 1973. The December futures prices exceeded the trigger price on April 13, 1973 and was $153.50. This was the starting price for placing a two-year hedge over the 1973-74 period. Subsequently, a CFD was created based on 1971-74 data to identify a 10 percent trigger price applied to 1975. The trigger price was $341.00, but during the year December futures did not reach that level and a mid-October cash sale was made. This sequence of creating CFDs and identifying trigger prices continued up through 1998.

It was assumed that if a December futures price for corn met the condition for a 2-year hedge before September 20 then a decision maker locks in a price for the expected bushels to be harvested each year for the next two years. But futures contracts are available only to hedge bushels for delivery at the end of the first year, and not at the end of the second year or beyond. The 2-year hedge for corn was specified as follows. If the futures price before September 20 was higher than the trigger price, then December futures contracts were sold in a quantity equal to expectations for two years of harvested corn. On October 15 of the first year the first year crop was sold, with the current December futures contracts being lifted. The next year's expected harvest was then hedged. Then, on October 15 of the second year, the second year crop was sold, and the hedge was closed.

Multi-Year Hedge Equations

The equations for a two-year hedge and longer given in this section were derived from Gardner's (1989) article on rollover hedging. In the beginning of a 2-year hedge for corn, two years of expected harvest, each of quantity Q, are sold in the futures market shown as 2Q in Equation 1. One year's harvest is for delivery at the end of first crop year, and the second year's harvest for the end of the second year. Denote the price of a futures contract traded at time t=0 for delivery at t=1 as $F_{1,0}$. Then the decision maker's revenue R_O established at t=0 is:

$$(1) \quad R_0 = F_{1,0}\, 2Q$$

Revenue in the first year, t=1 is given in Equation 2. At harvest time of the first year, two futures contracts are bought back with the futures price of $F_{1,1}^{O}$, which is the futures price at the end of the first year in October. At the same time, the first crop is sold for a cash market price on October 15 of P_1^{O}. The remaining contract is rolled over by selling next year's December futures contract at price $F_{2,1}^{O}$. The transaction cost is c times the number of contract traded.

$$(2)\quad R_1 = -F^{O}_{1,1}2Q + P^{O}_{1}Q + F^{O}_{2,1}Q - c2Q$$

Revenue for the second year, t=2, as specified by Gardner is:

$$(3)\quad R_2 = -F^{O}_{2,2}Q + P^{O}_{2}Q - cQ$$

On October 15 of the second year, the second year hedges are lifted at $F_{2,2}^{O}$, and the second year's harvest will be sold in the spot market for P_2^{O}. The transaction cost for the second year is cQ.

Revenue for the whole two-year period is the sum of equations 1, 2 and 3.

Generalizing to an n-year long-term hedge LTH where n is 2, 3, or 4 years and dividing by nQ to express revenue per unit output, the n-year sum is written as:

$$(4)\quad P_{LTH} = F_{1,0} + \frac{1}{n}\sum_{t=1}^{n}\left[(P^{O}_{t} - F^{O}_{t,t}) + (n-t)(F^{O}_{t+1,t} - F^{O}_{t,t}) - (n-t+1)c\right]$$

Equation 4 can be translated into Equation 5 for easier interpretation.

$$(5)\quad P_{LTH} = F_{1,0} + \frac{1}{n}\sum_{t=1}^{n}\left[B^{O} + (n-t)S^{O} - (n-t+1)c\right]$$

Where P_{LTH} is the expected price per bushel for the LTH. The term $F_{1,0}$ is the initial futures price received from selling n crops forward. If receipts are to be perfectly and inexpensively locked in at t=0, the terms in square brackets must sum to zero. This possibility depends on the following three main elements. The first is the term B^O which is the contemporaneous cash-futures basis on October 15 that arises in any short hedge. The second element is the term S^O. This is also a basis, or a spread on October 15, between the year-ahead futures and the nearby futures price. The final term is the transactions cost of the hedge.

Data Sources

The December corn futures prices from the Chicago Board of Trade, reported in the Wall Street Journal, were collected on a weekly basis. The Nebraska cash prices for No. 2 yellow corn were collected from the Omaha World Herald. The transaction cost for the hedging is calculated by adding the brokerage fee and opportunity cost of the margin requirements as Gardner did. The maximum fee and margin requirements were used in the analysis to reflect the cost to a small trader.

Results

With the benefit of hindsight, a corn producer or agribusiness handling grain would see basis and inter-year spread statistics as given in Table 1. Over the 26 year period, the average basis for No. 2 yellow corn at Omaha was 22.1¢ per bushel under the December futures price in mid-October. The standard deviation was 12.4¢ per bushel. The "t" statistic of 8.9 leads to the rejection of the null hypothesis that the average basis was zero. The minimum value for the basis was 46.3¢ under the December futures, and the maximum was 2.0¢ under indicating a considerable range in values.

Table 1. Basis and Inter-Year Spread Statistics for Corn at Omaha, 1973-98.

	Mean	Standard Deviation	Minimum	Maximum
	------------------------------	cents/bushel	------------------------------	
Basis	-22.1	12.4	-46.3	-2.0
Inter-Year Spread	5.7	27.3	-57.5	47.5

Table 2. Price Statistics for Long-Term Marketing Strategies, 1973-97.

	Mean	Standard Deviation	Minimum	Maximum
	------------------------------	cents/bushel	------------------------------	
14 out of 25 Years:				
Cash	255.5	48.0	198.0	366.0
Annual Hedge	257.1	35.2	219.4	332.2
Two-Year Hedge	262.2	64.9	131.1	359.0
11 out of 25 Years:				
Cash	222.7	58.3	132.5	332.0
Annual Hedge	221.4	37.5	157.4	292.7

The average inter-year spread was 5.7¢ per bushel and the "t" statistic of 1.0 suggest the average value was not significantly different than zero. However, one standard deviation of 27.3¢ per bushel along with the range from minus 57.5¢ to plus 47.5¢ shows the amount of variability that occurred from one mid-October date to the next.

Table 2 gives the statistics for two separate situations. During 14 years of the 25 year period a two-year hedge was in place based on the given decision rule. The years were 1973-74, 1979-82, 1988-91 and 1994-97.

When two-year hedges were in place, the average cash price for corn at Omaha in mid-October was 255.5¢, and was essentially the same as the average price of 257.1¢ received by placing an annual hedge on the first of May each year. Statistically the two prices were not different. The annual hedge price included a transactions cost of 2.6¢ which, when added back in, would bring the hedge and cash prices even closer together. The nominal variability of cash prices was greater than for annual hedge prices as shown by the standard deviation of 48.0¢ compared to 35.2¢, respectively. An "F" test showed the variances were not significantly different.

The average price for a two-year hedge strategy was 262.2¢, and in nominal values looked greater than the average prices for cash sales and annual hedging. Statistically, the two-year hedge average price was no different than the other two price averages. Two-year hedge prices had greater nominal variability, as measured by the standard deviation of 64.9¢, when compared to the other two price series. The difference in variability was statistically significant for two-year hedges versus annual hedges, but not for cash sales.

Also given in Table 2 are the statistics for the other 11 years when no two-year hedges were placed. The average cash price was 222.7¢ and was essentially the same as for an annual hedge at

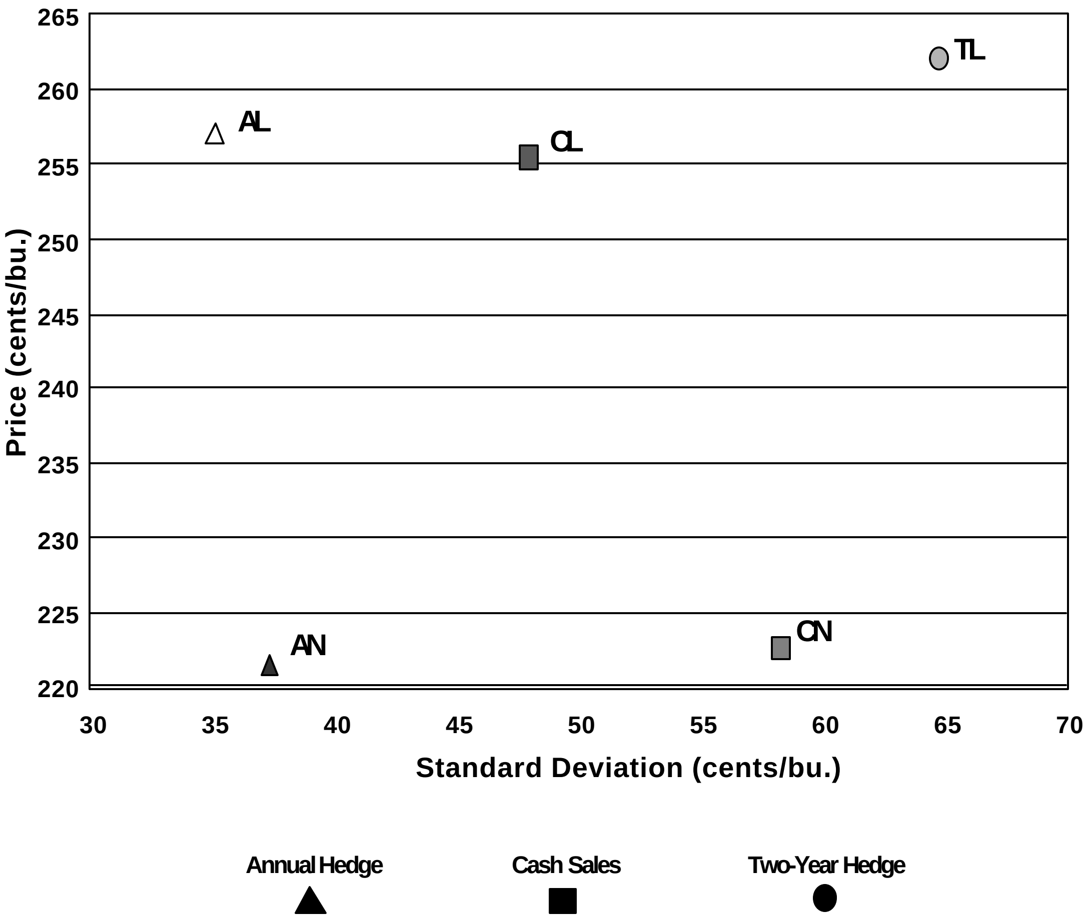
221.4¢. The nominal variability of cash prices at 58.3¢ looks greater than for annual hedges at 37.5¢, but an "F" test showed the variances were not significantly different.

The expected or average prices and standard deviations of prices are given in Figure 1. The E-V points are for the two situations discussed in Table 2. In 14 out of 25 years the level of average prices for cash sales (CL), annual hedges (AL), and two-year hedges (TL) are respectively higher than the average prices of cash (CN) and annual hedges (AN) for the 11 years of no long-term hedges. The comparison of the two-year hedge price (TL) of 262.2¢ to the cash price (CN) of 222.7¢ or even the annual hedge price (AN) of 221.4¢ may lead one to conclude that two-year hedging is a superior strategy when it can be executed. However, such comparisons are misleading because during the same 14 years both the cash(CL) and annual hedge(AL) prices are also at higher levels, and as noted earlier are not significantly different than the two-year hedge price.

Visually, the higher level E-V points of AL, CL, and TL for the 14 years suggests that to receive a higher average price, a decision maker would end up assuming more risk. However, the visual interpretation is not statistically confirmed because, as discussed earlier, the nominal average prices for the two-year hedge at 262.2¢ and for the annual hedge at 257.1¢ were not significantly different. The variability of annual hedges was significantly different and lower than for two-year hedges. The variability of cash sales was not significantly different than either annual hedges or two-year hedges.

In general, a risk-averse producer or agribusiness wants to receive the best price with the lowest variability. In this analysis, annual hedging is better than a two-year hedge strategy even when trying to set two-year hedges triggered at a price in the upper 10 percent of past prices.

Figure 1. Expected Price and Standard Deviation of Price for Corn, Selected Years, 1973-97



Conclusions

Over the 26 year period of 1973-98, corn prices were at times very high caused by a number of uncertain factors. These high prices generally moved back down to traditional levels under normal supply and demand conditions. Reflecting on these price patterns over an extended period of time suggests the possibility of trying to capture the benefits of higher prices for more than one year. The institutional mechanism for doing this is the futures market. Hedging for an annual period, or within a crop year, eliminates price risk but still involved basis risk. Hedging over multiple crop years involves additional uncertainties related to supply and demand conditions and adds the risk associated with inter-year spreads.

This analysis empirically explored the possibility of capturing higher prices for more than one year. A reasonable and pivotal assumption was a decision maker's perception of historical price levels, and how the hedge decision was based on these historical prices. The analysis relied on an out-of-sample decision rule based on the cumulative frequency distribution of the past four years of prices with a trigger price for a hedge set at the upper 10 percent of the distribution.

The results showed that even using a high trigger price for a two-year hedge, when applicable, the average price over 14 of the 25 years was no better than for cash sales at harvest, or a simple annual hedge set in May. The variability or risk associated with the two-year hedge was higher than for annual hedging.

One conclusion is that attempts to capture multi-year benefits from a higher price, when it happens even at the upper 10 percent level of past prices, is very elusive. Another conclusion, primarily intuitive versus empirical, is that in the long-run, the underlying conditions for supply, demand, and price determination appear to even out the pricing strategies. In a short-run period, a decision maker may achieve greater price benefits from a multi-year strategy versus a simple strategy, but in a subsequent period may experience losses, which argues for a convergence of pricing outcomes over an extended period. It appears the judicious use of the futures market can reduce the variability of prices, but not for multi-year hedging.

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