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# Cross Hedging Hay Using Corn Futures: An Empirical Test

Martin L. Blake and Lowell Catlett

This study examines the use of corn futures contracts to cross hedge both U.S. hay and New Mexico alfalfa hay. Correlations between monthly spot U.S. hay prices and corn futures prices ranged from .828 to .970 and were all significant at the  $\alpha = .0001$  level. Multiple regression was used to determine the optimal corn futures contract month to cross hedge each spot monthly hay price. Regressions were used to determine the coverage ratio of tons of hay per corn futures contracts. A routine cross hedge was simulated and showed that cross hedging hay using corn futures increases gross returns per ton of hay.

The marketing alternatives used by the alfalfa hay industry typically include sale at harvest, storage throughout the year and forward contracting. Outside of forward contracting, no mechanism exists for alfalfa hay producers and handlers to shift risks of unfavorable price changes.

This paper examines the cross hedging possibilities for hay as a means of shifting price risk. This was examined using monthly New Mexico alfalfa hay prices, monthly U.S. average prices for all hay at the farm level and the Chicago Board of Trade corn futures prices.

There is little in the literature about cross hedging. Anderson and Danthine provide a theoretical description of hedging in futures markets that attempts to account for the behavior of a broad class of agents. They derive optimal decision rules for agents concerned with the mean and variance of profit, and use these rules to evaluate how optimal cash and futures positions are related to price expectations, the production possibilities and the number of futures markets available. Anderson and Danthine state "many cash goods

do not have obvious futures. In these cases a "cross hedge" may be attempted by taking positions in a futures for a related commodity" (p. 1187). Cross hedges are in order whenever price relationships between the spot price for the commodity and the futures price are sufficiently similar to produce a correlation coefficient significantly different from zero.

Much of the applied interest in cross hedging is in the area of financial futures (Hartzog; McEnally and Rice; Daane and Fredman). Financial futures and spot financial instruments have mismatched maturity dates such that cross hedging is the predominant form of hedging. T-Bonds and Government National Mortgage Association (GNMA) futures are traded only about 24 months in advance, yet the underlying spot T-Bond and GNMA have maturities up to 20 years later. T-Bill and Certificate of Deposit (CD) futures are less prone to cross hedging because the spot maturity dates are in line with the futures trading months, but do not coincide exactly, so an element of cross hedging still exists.

There have been few applied studies of cross hedging for agricultural commodities. Jackson, Grant and Shafer compared weekly Houston export prices for sorghum and Chicago corn futures prices for 1968-78, and found seasonal patterns

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Journal Article No. 1068 of the New Mexico Agricultural Experiment Station.

which suggest the usefulness of corn futures in reducing sorghum price risk. They pointed out "such hedgers need a full appreciation of the risks involved in cross hedging and, in particular, the fact that sorghum cannot be delivered against a short hedge with corn futures. Delivery is not common, but would be highly desirable in the case of a squeeze" (p. 35).

Jackson, Grant and Shafer also reported, in some cases, futures prices are used to establish specific cash prices. In such cases, the futures and cash prices are clearly linked. As an example, they cited information from the Texas Coastal Bend sorghum producing area that indicated the local export price for U.S. No. 2 sorghum was based on the July corn futures price.

Miller (1980) examined the possibility of food service institutions reducing their price risk by cross hedging steer hinds, boneless beef and sirloin butts with fed cattle futures. He concluded these cross hedges would let food service institutions reduce the variability of wholesale prices for these items without increasing the mean net price. Miller (1982) further argues that distillers grains and solubles can be effectively cross hedged using soybean meal and corn futures. Multivariate regression techniques were used to determine the actual level of cross hedging needed.

Hayenga and Dipietre analyzed the use of cross hedging with wholesale pork product prices and live hog futures, showing the relationship is strong enough to warrant cross hedging. They used regression techniques to solve for the hedging ratio of futures contracts to spot quantities.

From a taxation standpoint, McDonley states, according to tax law and rulings concerning cross hedging, "It is presumed that there is an intimate price relationship between the actuals and the futures but the commodity need not be the same so long as their prices move in relation to each other" (p. 28). If a trade meets this

price relationship criterion, then it can be classified as a hedge or cross hedge and any gains can be treated as ordinary income and any losses as ordinary expenses. If a trade is not classified as a legitimate hedge or cross hedge, then a complicated capital gains netting process applies.

### **Correlations between Spot and Futures**

As pointed out by Anderson and Danthine, cross hedges are in order whenever the correlation between cash and futures is a constant other than zero. It is also desirable that the correlation coefficients be positive and as close to 1 as possible. In this paper, the possibility of cross hedging hay using corn futures is explored. The correlations between spot hay prices in the United States and all corn futures delivery months were calculated using monthly data from 1955 to 1981 (Table 1). Monthly hay prices were used because neither daily nor weekly hay price data were available. Given current data availability for hay, it is not possible to do the analysis on anything less than a monthly basis without imposing disaggregation bias. The monthly hay price is quoted in dollars per ton.

The corn futures price used was that at the close for the first trading day in each delivery month, quoted in cents per bushel. This price was used because it provided a simple operational rule for choosing a price for each month. Using the first trading day also avoids the typical fluctuations associated with trading days nearer to the delivery date.

All correlations (Table 1) are significantly different from zero at the  $\alpha = .0001$  level. The lowest correlation was .828 for April spot hay versus the following March corn futures. The highest was .970 for November spot hay for the following May corn futures. In the month preceding delivery and the delivery month, the correlation coefficient between spot and futures

**TABLE 1. Coefficients of Correlation between Monthly Spot U.S. Average Hay Prices and Corn Futures Prices for All Delivery Months, 1955-81.**

Monthly Spot Alfalfa Hay Prices	Corn Futures Delivery Month								
	March	May	July	Sept	Dec	Next March	Next May	Next July	Next Sept
January	.914	.964	.915	.856	.845				
February	.904	.959	.914	.853	.844				
March	.902	.954	.907	.841	.833				
April		.955	.909	.852	.842	.828			
May		.960	.939	.886	.873	.856			
June			.934	.890	.875	.856	.931		
July			.944	.912	.899	.878	.945		
August				.934	.920	.904	.957	.904	
September				.947	.933	.918	.964	.906	
October					.938	.922	.968	.908	.848
November					.934	.924	.970	.912	.851
December					.930	.920	.968	.914	.854

Sources: U.S. Department of Agriculture, *Agricultural Statistics*, various issues. *Wall Street Journal*, various issues.

is never lower than .902. This clearly indicates cross hedging U.S. spot hay using corn futures meets both the theoretical and tax criteria for proper cross hedging.

### Marketing Implications

Because the correlations indicate cross hedging spot hay and corn futures is possible, several cross hedging strategies need to be examined. Cross hedging opportunities exist for hay for both production and storage. Production hedges involve shifting risks of unfavorable price movements before and during the harvesting process. Storage hedges involve the same idea, except they apply to periods during and after harvest and before next season's harvest. Several logical strategies exist for production, storage and combination production-storage cross hedges.

For example, a normal production cross hedge would involve cross hedging sometime before the first cutting and, as each cutting was completed and sold, a portion of the cross hedge would be lifted. The final balance of the cross hedge would be lifted with the final cutting. A normal storage cross hedge would begin with the

first cutting and the corn futures positions would increase as the cuttings were completed and stored. As the hay crop was sold, the corn futures positions would decrease. This type of cross hedge gradually increases in size as harvest proceeds and gradually decreases in size as portions are sold, or terminates if the entire crop is sold out of storage.

Another type of storage cross hedge is rolling the cross hedge as storage continues. This involves cross hedging with the nearest corn futures delivery month and, if the hay is still in storage when the contract matures, the cross hedge is lifted and rolled into the next delivery month.

A combination production-storage decision exists because hay is sometimes stored briefly before sale. This strategy combines normal production and storage cross hedges. Instead of lifting a portion of the production cross hedge with each cutting, the cross hedge is maintained as a storage cross hedge until sale, but rolled forward as necessary to maintain balanced cash/futures positions. Purchased cross hedges for hay are also possible for feedlots and ranches that use hay as an input.

## Optimal Contract Month

When multiple futures contract delivery dates are available for a commodity, the proportion of the commodity that should be hedged for each contract can be determined by a multiple regression of spot cash prices on each futures contract. Anderson and Danthine suggest the partial correlation coefficient between the spot price and a futures contract is a good evaluator of the usefulness of that contract for hedging purposes.

Regressing each spot hay monthly price quoted in dollars per ton against the dollar value of the five corn futures contracts (March, May, July, September and December) revealed which of the contracts contained the most pricing information.<sup>1</sup> Each monthly spot hay price was then regressed against the futures contract that performed the best, as determined from the multiple regressions. These results are presented in Table 2.<sup>2</sup> The variable FMAY

<sup>1</sup> The form of the multiple regression used to select the optimal hedging month was: monthly spot hay price =  $f$  (FMAR, FMAY, FJUL, FSEP, and FDEC), where FMAR, FMAY, FJUL, FSEP and FDEC are the March, May, July, September and December corn futures contract prices, respectively. Each monthly spot hay price was regressed on the next five consecutive corn futures contracts. For example, the September spot hay price was regressed on the September and December corn futures prices for the same year and the March, May and July corn futures prices for the following year. This method allowed for a one-year time horizon in choosing the optimal contract. The best contract to use in hedging was selected by choosing the contract with the highest t-value in the multiple regression equation. The results of the multiple regression analysis agree with the correlations in Table 1. As can be seen in Table 1, the next May contract has the highest correlation with each of the 12 monthly spot prices. Although multicollinearity was present, it was not severe. Also, several orderings of the independent variables were tried but this did not affect the results.

<sup>2</sup> This analysis also has been performed for several other commodities. Hay has been the only commodity which resulted in a single contract month being optimal for hedging all 12 monthly spot prices. The predominance of the May price may result

**TABLE 2. Results of Regressing Monthly U.S. Hay Spot Prices on Selected Corn Futures Delivery Months, 1955-81.<sup>a</sup>**

				F	R <sup>2</sup>
JAN =	-2.748 (-1.279)	+ 0.021 (18.094)	FMAY	327.39	.929
FEB =	-2.961 (-1.271)	+ 0.021 (16.926)	FMAY	286.50	.920
MAR =	-2.429 (-1.004)	+ 0.021 (15.896)	FMAY	252.69	.910
APR =	-3.321 (-1.367)	+ 0.021 (16.093)	FMAY	258.99	.912
MAY =	-9.930 (-3.480)	+ 0.026 (17.074)	FMAY	291.54	.921
JUN =	-5.076 (-1.653)	+ 0.021 (12.703)	FMAYL	161.36	.866
JUL =	-5.450 (-2.018)	+ 0.021 (14.344)	FMAYL	205.74	.892
AUG =	-5.234 (-2.224)	+ 0.021 (16.524)	FMAYL	273.03	.916
SEP =	-5.833 (-2.629)	+ 0.022 (18.149)	FMAYL	329.38	.930
OCT =	-6.350 (-2.925)	+ 0.022 (19.059)	FMAYL	363.25	.936
NOV =	-4.768 (-2.364)	+ 0.021 (19.710)	FMAYL	388.49	.939
DEC =	-3.937 (-1.923)	+ 0.021 (19.311)	FMAYL	372.94	.937

<sup>a</sup> t-values are in parentheses.

is the dollar value of a 1,000-bushel May corn futures contract. This was calculated by dividing the close price for a corn futures contract, quoted in cents, by 100 to obtain the price in dollars per bushel and multiplying the result by 1,000 to obtain the dollar value per contract. FMAYL refers to the dollar value of a May corn futures contract for the following year. The quoted price per bushel was converted to dollar value per contract so the coverage ratio per corn contract could be evaluated. The dependent variables in each

from the first cutting of hay for the year, usually occurring in May. From other research, the price received for the first cutting plays a large part in setting the price level for the year.

**TABLE 3. Optimal Contract Months and Ratios of Coverage for Cross Hedging Spot U.S. Hay Using Corn Futures Contracts.**

U.S. Spot Hay Price	Optimal Futures Contract For Cross Hedge	Ratio of Coverage (Tons of Hay per 1,000-Bushel Corn Contract)
January	May	47.6
February	May	47.6
March	May	47.6
April	May	47.6
May	May	38.5
June	Next May	47.6
July	Next May	47.6
August	Next May	47.6
September	Next May	45.5
October	Next May	45.5
November	Next May	47.6
December	Next May	47.6

regression equation are the reported monthly average prices for hay in dollars per ton.

The estimated coefficients from Table 2 were used to determine the optimum level of cross hedging; that is, the number of corn futures contracts (using the Mid-America Exchange's 1,000-bushel contract) needed to cover the price risk per ton of hay. Alternatively, this was stated as the number of tons of hay covered by one corn futures contract (Table 3). Although Chicago Board of Trade futures prices were used in the analysis, the Mid-America Exchange's 1,000-bushel corn contract is used in this example because the resulting coverage ratios were more typical of the acreage in most hay producing operations. A 5,000 Board of Trade contract would cover five times as much. The actual price differences on these two exchanges are negligible.

The regression equation and the corresponding coverage ratios account for a portion of basis risk because they are explaining the differences in the price relationships between the spot and futures. This is done by adjusting the quantity of hay hedged per futures contract to reflect

the price differences. They, of course, do not capture all of the basis risk because the  $R^2$  is not 1.0.

Table 3, which contains the optimum contract months and cross hedging ratios, provides the information to formulate production and storage cross hedging strategies.

### Examples of Cross Hedging Strategies

A normal production cross hedge involves selecting a corn futures contract to cross hedge some time before harvest. For example, to cross hedge the first cutting in May, during January, a May corn futures would be selected (Table 3). If the producer has 100 acres and expects a yield of one ton per acre, the amount to be cross hedged is 100 tons. From Table 3, the ratio of coverage per 1,000-bushel corn contract is 47.6 tons. To cover 100 tons of hay, one would need two Mid-America corn futures contracts (a coverage ratio of 95 tons) with 5 tons unhedged.

A normal storage cross hedge would take place any time after harvest up to the next harvest, but usually would be for a shorter period. For example, a storage cross hedge for May hay to be sold in August should be cross hedged with the following May corn contract.

A combination production-storage cross hedge is possible by cross hedging the expected volume for all cuttings, if the crop is expected to be sold in larger units than one or two cuttings. For example, if the sale of the crop is expected after all cuttings are completed (September), the optimum cross hedge would be with the following May contract and would cover at least 45.5 tons per futures contract. Using the example of 100 acres and 6 tons per acre, the producer would have 600 tons to cover for price risk. This could be covered with 13 1,000-bushel futures contracts (Mid-America) with 8 tons unhedged. If part of the crop is sold before all cuttings

**TABLE 4. Results of Regressing Monthly New Mexico Alfalfa Hay Spot Prices on Selected Corn Futures Delivery Months.<sup>a</sup>**

			F	R <sup>2</sup>
JAN =	-5.246 + 0.029 FMAY	(-1.484) (15.366)	236.10	.904
FEB =	-3.619 + 0.028 FMAY	(-1.030) (15.032)	225.96	.900
MAR =	-4.164 + 0.029 FMAY	(-1.279) (16.402)	269.04	.915
APR =	-4.798 + 0.029 FMAY	(-1.290) (14.441)	208.54	.893
MAY =	-6.788 + 0.027 FMAY	(-2.247) (16.654)	277.35	.917
JUN =	-2.563 + 0.021 FMAYL	(-0.740) (11.586)	134.24	.843
JUL =	-1.879 + 0.022 FMAYL	(-0.568) (11.561)	133.66	.842
AUG =	-3.650 + 0.022 FMAYL	(-1.207) (13.402)	179.22	.878
SEP =	-3.709 + 0.022 FMAYL	(-1.280) (14.416)	207.83	.893
OCT =	-4.297 + 0.024 FMAYL	(-1.345) (14.130)	199.67	.889
NOV =	-4.216 + 0.026 FMAYL	(-1.361) (15.533)	241.28	.906
DEC =	-5.921 + 0.029 FMAYL	(-1.731) (15.642)	244.67	.907

<sup>a</sup> t-values are in parentheses.

are completed, the cross hedged position would be reduced accordingly.

### New Mexico Alfalfa Hay

The U.S. monthly hay price is an aggregated price that includes all types of hay from across the United States. One component of that aggregated U.S. monthly hay price is the New Mexico monthly alfalfa hay price. The previous analysis was repeated using the New Mexico monthly alfalfa hay price to examine how this analysis would work for a more disaggregated state level price.

All correlations were significantly different from zero at the  $\alpha = .0001$  level.

**TABLE 5. Optimal Contract Months and Ratios of Coverage for Cross Hedging Spot New Mexico Alfalfa Hay Using Corn Futures Contracts.**

U.S. Spot Hay Price	Optimal Futures Contract For Cross Hedge	Ratio of Coverage (Tons of Hay per 1,000-Bushel Corn Contract)
January	May	34.5
February	May	35.7
March	May	34.5
April	May	34.5
May	May	37.0
June	Next May	47.6
July	Next May	45.5
August	Next May	45.5
September	Next May	45.5
October	Next May	41.7
November	Next May	38.5
December	Next May	34.5

The lowest correlation was .776 for February spot alfalfa versus December corn futures, while the highest was .958 for May spot alfalfa and May corn futures. In the month preceding delivery and the delivery month, the correlation coefficient between spot and futures was never lower than .892. Although these correlation coefficients are slightly lower than those for the United States, they indicate cross hedging New Mexico spot alfalfa hay using corn futures also meets both the theoretical and tax criteria for cross hedging.

Multiple regression was used to determine the optimal futures contract for each monthly spot alfalfa price. Each monthly spot alfalfa price was then regressed on the futures contract identified as the optimal month from the multiple regressions (Table 4). As with the U.S. hay prices, the optimal futures contract for each monthly spot alfalfa price in New Mexico was May.

The ratios of coverage calculated from these equations are reported in Table 5.

### Simulation Results

To test the effectiveness of cross hedging hay with corn futures, a simulation of

a routine cross hedge was run for the years 1975–82. The typical price pattern for hay is a steady increase through December, with prices becoming erratic from January through the beginning of the first cutting. The routine cross hedge evaluated was to sell a May corn futures contract on the first trading day of January and lift the hedge on May 15 at the time of the first cutting. This was done for both U.S. hay and New Mexico alfalfa hay. A single 1,000-bushel May corn contract would cover 47.6 tons of U.S. hay and 34.5 tons of New Mexico alfalfa hay, as determined from the coverage ratios for January when the cross hedge was placed.

The simulation showed a routine cross hedge would increase the gross returns per ton of U.S. hay by an average of \$2.74 per year over the no-hedge scenario. This represented an increase of 4.2 percent of the mean May spot U.S. hay price for the period 1975–82. For New Mexico alfalfa hay, the increase in gross returns was an annual average of \$3.79 per ton. This was an increase of 5.3 percent of the mean spot New Mexico alfalfa hay price. Brokerage fees and interest on margins were not deducted in this analysis.

Distribution of returns from the cross hedge with corn futures showed losses on the futures transactions for three of the eight years of simulation. The losses ranged from \$172 per 1,000-bushel corn futures contract to \$356, while the gains ranged from \$137.50 to \$738. Short-run cross hedging losses occurred for some years; however, these were offset by gains in other years such that the mean gain from hedging over the simulation was \$130.63 per corn futures contract.

More complicated strategies are certainly possible, given more information, and may further increase the gross returns above what is indicated in this analysis. Hedging strategies exist such as speculating on basis changes and selective hedging strategies that use price forecasting techniques to place and lift hedges to take ad-

vantage of increasing or decreasing prices. Also, if hay prices were available more frequently than on a monthly basis, the inter-delivery month price relationships could be explored. This opens up a whole new set of possible hedging strategies. However, hay prices were only available on a monthly basis for both the United States and New Mexico, so these inter-delivery month price issues could not be explored. This analysis simply indicates cross hedging hay using corn futures on a regular basis can increase average gross returns in the long run with, as in all forms of hedging, some short-run losses.

### Summary

This analysis showed cross hedging both U.S. hay and New Mexico alfalfa hay using corn futures meets both the theoretical and tax criteria for proper cross hedges. The correlations between all monthly spot hay prices and all delivery dates for corn futures are significantly different from zero at the  $\alpha = .0001$  level. Multiple linear regression was used to identify the best corn futures contract to use for cross hedging each spot monthly hay price. The best corn futures contract to use was May, for both U.S. spot hay prices and New Mexico spot alfalfa hay prices. Each hay price was then regressed on the May corn futures contract to determine the amount of hay covered by each corn futures contract in dollar equivalency.

The coverage ratios were slightly higher for U.S. spot hay than for New Mexico spot alfalfa hay. The coverage ratios for U.S. spot hay ranged from a high of 47.6 tons per contract to a low of 38.5 tons per contract, while the coverage ratios for New Mexico spot alfalfa hay ranges from a high of 47.6 tons per contract to a low of 34.5 tons per contract.

Simulation results indicate cross hedging hay with corn futures does, in fact, increase gross returns per ton for both U.S. hay and New Mexico alfalfa hay.



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