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The current agricultural marketing literature has considerable controversy about the optimal use of hedging for farmers. Much of this literature has very limited data on farmer behavior and an evaluation of the outcome of this behavior. This paper uses data from a hedging game from marketing clubs in Maryland for 1994-1997. Results indicate that farmers do not achieve price enhancement from hedging. However, their decisions do not conform to implications of optimal hedging models in a number of dimensions. Hedge ratios are near the optimal levels under one interpretation. The paper also provides research and extension implications of the results.

Increased price volatility in commodity markets has renewed concern about farmers' ability to manage price risk. This concern has resulted in numerous applied research papers on price risk management issues. Most of this research has developed models of risk averse behavior to prescribe optimal hedging or forward pricing tactics. It would appear, however, that this methodology has failed to meet the needs of applied practitioners. Anderson and Mapp found the majority of extension economists believe published risk management research is of little relevance to real world applications. Parcell, et al. reported extension and research marketing economist had different perceptions about risk management and forward pricing for farmers. In addition, Brorsen and Irwin contend that farmer behavior is not consistent with current forward pricing theories, and they suggest that the discrepancy may be a result of farmers' price expectations. Patrick, Musser and Eckman argue that price expectations explain why farmers use different levels of hedging over a three-year period.

Close inspection of the literature on forward pricing indicates that agricultural economists have conflicting views about the benefits of hedging and the ability of farmers to consistently profit from hedging strategies. One view, expressed most recently by Zulauf and Irwin, contends that futures markets are efficient and traders are unlikely to consistently profit in the futures market. They argue further that even if individuals regularly earn positive profits, they do so on the basis of superior information, which is costly to obtain; from a practical standpoint, it seems unlikely that farmers would fall into this category. The second view contends that selected strategies can yield above normal profits based on farmers having different expectations about forward prices than those portrayed by futures prices. Wisner, Blue and Baldwin is a recent example of this view.

Clearly, these two views are at odds, but do they suggest different implications for hedging behavior? The efficient market hypothesis is consistent with standard hedging theory, as presented in seminal studies like Heifner and Peck. The only reason to use forward pricing strategies would be to minimize risk, since no profits are expected from hedging. If this were consistent with farmers' beliefs, we would expect to see consistent levels of hedging, regardless

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of the time of the year or the marketing year. The second view contends that consistent profits can be made from following certain strategies. In the case of Wisner, Blue and Baldwin, they illustrate a strategy based on fundamental information which could lead to above normal profits. Thus, if farmers have this belief, we would expect to see varying strategies, possibly within the marketing year and across marketing years. Patrick, Musser, and Eckman found behavior that is consistent with this view among Eastern Cornbelt farmers.

The purpose of this study is to examine grain marketing club transactions from 1994-1997 to provide further evidence on farmer forward pricing behavior. Unlike other studies that utilize survey data at one point in time, these data allow us to study farmer hedging behavior over several years and within marketing seasons. Hypotheses concerning the consistency of farmer behavior with the research literature on hedging are considered. This analysis provides further information to help bridge the current gap between academic research and practical hedging.

Description of Data and Marketing Clubs

A grain marketing club is a group of farmers that discuss marketing strategies, trends, and outlook. Clubs are usually associated with the Cooperative Extension Service, and numerous examples exist throughout the country. Specialists and county agents lead these clubs and provide educational programs on the marketing process; farmers that participate in these clubs presumably have considerable knowledge about forward marketing.

In Maryland, the educational process is enhanced through a practical marketing exercise called the Model Farm. The Model Farm is a hypothetical 1,000-acre farm with 600 acres of corn, 200 acres of soybeans and 200 acres of wheat. All crop yields are assumed to be certain so that total crop production is the same for each club. Club participants make joint marketing decisions for the Model Farm at their meetings, which usually occur once every two weeks. The Model Farm serves as a valuable exercise in understanding how the marketing tools will perform in real-life situations. Farmers make decisions about when to price, how much to price, and what tool (cash sale, forward contract, futures contract or options contract) to use. No transactions costs are assumed for futures and options trades, and no constraints are placed on margin balances.

Between 1994 and 1997, four to six clubs participated in the Model Farm trading exercise each year. At the end of each year, marketing clubs turn in their trading records. These records describe the date, size, and type of transactions made throughout the marketing year. Tabulations are made to determine which club made the most profits from marketing in that year and the results are shared among all clubs.

Certainly, the Model Farm trading activity has limitations in being representative of actual farmer behavior. Trading is done on paper and not with real money. In addition, many realities of farmer decisions are ignored (e.g., production variability and debt). However, applications of experimental economics in studying commodity markets indicate that hypothetical behavior mirrors actual behavior (Fackler and McNew). Thus, the direction and magnitude of bias in the results is not apparent. While we recognize the inherent limitations in associating Model Farm trading behavior with actual trading behavior, we believe the data are still a reasonably good proxy for understanding expectations and forward pricing behavior. In fact, ignoring the realities of production risk and financial considerations allows us to examine the relationships between hedging behavior and risk management and price expectations.

To simplify the analysis, we consider only pricing strategies for corn and narrow the pricing window from January (prior to planting) until harvest time in November. This time period covering the four years of the study shows a great deal of price volatility as well as different hedging environments. Figure 1 shows the December corn futures price over the marketing season for the four different years and illustrates that any sort of routine hedging strategy would have varied greatly in terms of year-to-year hedging profits. In 1994, prices fell fairly consistently following the spring and bottomed out at harvest time. In 1995, the reverse trend occurred in that prices rose throughout the season and reached a high at harvest. In 1996 and 1997, high or low prices were posted during the summer.



Figure 1. December Corn Futures Price, Chicago Board of Trade: 1994-1997.

Each club has 60,000 bushels of corn production. Farmers may enter cash forward contracts for 1,000 bushels or use futures or options contracts in 5,000-bushel increments. While in practice, the clubs use forward contracts for local markets, this study bases all cash forward prices on the December futures price on the date when a contract is entered. In addition to

forward contracts, clubs may use futures contracts, call options, or put options to forward price their corn, which also are all based on the December contract.¹

A complication for analyzing how much has been hedged concerns the use of options. For example, a \$2.50 put option provides different price protection than a \$2.00 put option. Similarly, 5,000 bushels that are priced with a futures contract at \$2.50 is different than pricing 5,000 bushels with a \$2.50 put option. We make use of an option's *delta* value to determine how much price protection is offered through a certain option position. The option's delta measures how much the value of on option would change from a one-unit change in the underlying futures price.

The theory of option pricing is based on the principle of creating a risk-free portfolio, consisting of a risk-free bond, a futures position and positions in a call and put option. Under the assumption of log-normal futures prices, Black (1976) has shown that the value of a put option and call option, can be expressed as:

$$V_t^c(x) = b(T) \left[F_t \Phi(z + \frac{\sigma}{2}) - x \Phi(z - \frac{\sigma}{2}) \right] \qquad V_t^p(x) = b(T) \left[x \Phi(z + \frac{\sigma}{2}) - F_t \Phi(z - \frac{\sigma}{2}) \right],$$

where $V_t^c(x)$ is the value of a call option with strike price x with T-t days until expiration, b(T) is the price of a risk-free bond paying \$1 at time T, F_t is the current futures price, $\Phi(.)$ is the standard normal distribution function, $z=\ln(x/F_t)/\sigma$ and, σ is the standard deviation for the distribution of the futures price. The same arguments influence the value of a put option, V_t^p(x).

In practice, observed option premiums are used to determine the value of the standard deviation -- commonly referred to as the implied volatility. This requires numerical solution techniques because no closed-form solution exists.

Formally, the delta of an option is:

$$\frac{\partial V_t^c(x)}{\partial F_t}$$
 and $\frac{\partial V_t^p(x)}{\partial F_t}$

which also must be computed numerically. For put options, the delta value is in the range of [-1,0] while for call options the range is [0,1]. A short or long futures position has a delta value of -1 or +1, respectively. An option's delta value will change depending on two main factors.

¹ Even when pricing prior to harvest, some clubs utilize contract months other than the December month for the purposes of storage or because of early harvest decisions. Therefore, we have taken the liberty of converting all non-December contracts into December contracts. For example, if a club takes a short futures position for September corn on March 31, 1995, we have instead changed their position to short a December contract on the same date. With options, if a club buys a March 270 put option when the March futures price is 280, then we convert this transaction to a December put option that is 10-cents out-of-the-money.

First the strike price of the option relative to the underlying futures price is a key component. With declining futures prices, the delta for a put option will increase and the delta for a call option will decrease. Indeed, arbitrage guarantees that a call option and a put option with the same strike price will have delta values that sum to 1 in absolute value.²

The second factor that influences an option's delta is the length of time until expiration. In the extreme case when the option is at expiration, a call (put) option's delta will be either 0 or 1 (-1) depending on whether the option has intrinsic value. Prior to expiration, an option's delta will be somewhere in between these values depending on the time until expiration and the relationship between the futures price and strike price.

Using the concept of an option's delta, it now becomes straightforward to determine how much is hedged based on a portfolio of different hedging instruments. For each club throughout the 4-year period, we constructed a delta-weighted hedge ratio, which is the quantity-weighted sum of each portfolio instrument. An example of how this computation is given in table 1. For production of 60,000 bushels, consider a portfolio of 10,000 bushels forward contracted, 10,000 bushels of a \$2.50 put option and 5,000 bushels of a \$2.80 call option. With delta values of -1.00, -0.50, and +.20, the weighted-delta position sums to -14,000 bushels. Following the normal convention of reporting a positive number for the hedge ratio, the 14,000 bushels divided by total production of 60,000 bushels gives a hedge ratio of 0.23

Contract Type	Quantity	Delta Value	Weighted-Delta
Forward Contract	10,000 bushels	-1.00	-10,000 bushels
\$2.50 Put Option	10,000 bushels	-0.50	-5,000 bushels
\$2.80 Call Option	5,000 bushels	+0.20	+1,000 bushels
		TOTAL (Hedge-Ratio)	14,000 bushels (0.23)

Table 1. Example of Delta-Weighted Hedge for 60,000 Bushels of Production.

Study Hypotheses

Traditional hedging theory would suggest that each year farmers should forward price a proportion of their crop, known as the hedge ratio. Empirical studies on grains suggest that the hedge ratio is in the range of 0.85 to 1.00 without yield uncertainty (Myers and Thompson); the ratio drops to about 0.55 to 0.90 with yield uncertainty (McNew), which depends on the extent of yield variability and correlation between yields and prices. Under the model assumptions, hedging motives are purely to reduce the variance of revenue whereas speculative motives are eliminated because the futures price is unbiased. At a minimum, we would expect to see this type magnitude for a hedge ratio if farmers followed this rule. Furthermore, hedging theory would suggest that the hedge ratio does not change over time, except in the case when the

² A conceptual proof of this argument can be made by showing that a synthetic futures position can be created from a portfolio of a put and call option with the same strike price. For example, a synthetic long futures position is created from a long call option and short put option with the same strike price. Therefore, the delta of the portfolio is $\delta_c - \delta_p$ which equals the delta of the long futures position (+1).

relevant covariance and variances were time-varying. However, these propositions seem to have limited empirical support (e.g., McNew and Fackler).

The above reasoning suggests several hypotheses for this analysis:

- All clubs should forward price a high proportion of their crop if they ignore yield risk
 (approximately 85-100%) of their corn each year.
- (2) The hedge ratio should not vary over years based on past price relationships or current price
 (2) The hedge ratio should not vary over years based on past price relationships or current price
- (3) The hedge ratio should be established at planting and not vary over the growing season.

The alternative view that forward pricing increases prices received and perhaps also decreases risk is more ad-hoc than the above reasoning and is therefore not as easy to summarize into hypotheses. However, the presumption is that farmers can identify pricing opportunities that increase price received through the growing season. Thus, we would expect the reverse of the above hypotheses. The amount forwarded priced will vary among clubs, years, and throughout the marketing season.

Besides examining the alternative view of the above hypotheses, two other hypotheses are examined. Technical analysis suggests the use of moving averages to calculate trends. If current prices are above recent trends, a favorable pricing opportunity is indicated (Purcell and Koontz). Alternatively, farmers may increase hedging when the price trend is negative to prevent further losses. This study also explores farmers use of such techniques.

In addition, the relationship of hedging to changes in current prices from those of the previous year is examined. Under an adaptive expectations view, farmers current price expectations should be strongly influenced by price levels in the previous year, particularly at harvest. If current prices are below these expectations, farmers will wait for better opportunities, which presumably will arise in the future. Thus, one would expect less hedging if prices are lower than in the previous year and more if prices are higher. Prospect theory suggests another motivation for such behavior. As Collins, Musser, and Mason demonstrated, farmers are risk averse for gains and risk seekers for losses from a reference point. This reference point is likely to be related to recent experience in the previous year. Thus, lower hedging due to price drops could be related to risk seeking preferences from the reference point of prices in the previous year.

Results

Can Marketing Clubs Beat the Market?

Although one of the main benefits of hedging is to reduce price risk, an empirically important question is whether farmers have the ability to consistently profit from their forward pricing decisions. Based on our discussion earlier, the literature has no resounding answer to this question. Therefore, it seems worthwhile to explore whether our set of farmers participating in marketing clubs can consistently profit from forward pricing. Table 2 presents the average forward pricing profits by year and for the full sample from 1994-97. Forward pricing profits represent the difference between the net price received for corn in each year less the harvest-time price. These profits account for all transactions through forward, futures and options contracts.

(Cents/Bu.)	Number of Clubs	t-Statistic	
21.3	5	5.42	
-26.2	6	-3.48	
27.9	6	6.02	
0.8	4	0.38	
	(Cents/Bu.) 21.3 -26.2 27.9 0.8	(Cents/Bu.) 21.3 5 -26.2 6 27.9 6 0.8 4	

Table 2. Average Forward Pricing Profits for All Clubs

Given the pattern of seasonal futures prices in each of the marketing years (see figure 1), we are not surprised by the forward pricing results. The clubs made significantly positive profits in 1994 and 1996 as indicated by the t-statistic. Both years had lower prices at harvest as compared to early in the season, which makes any pre-harvest pricing strategies profitable. In 1994, harvest time prices were roughly 60 cents below the seasonal high and in 1996 the harvest-time price was \$1.20 below the seasonal high. In contrast, 1995 was a year when prices rose consistently throughout the marketing year and were highest at harvest with a 90-cent difference between the harvest price and the seasonal low. Not surprisingly, the clubs earned negative profits, which were statistically different from zero. In 1997, the harvest-time price was roughly the same as the price in the early spring, after bottoming in the summer. Thus, the clubs on average showed a small gain, but not statistically different from zero. For the entire time period, forward pricing profits are positive at 5.7 cents, but not statistically greater than zero.

The results indicate that the marketing clubs participating in this study did not consistently beat the market or earn statistically significant profits over the four-year period from forward pricing. Thus, these results support the efficient market hypothesis. However, it is important to note that the sample size limits the generality of this conclusion. Although we have numerous clubs on which to base the tests, only four marketing years were available.³ With more marketing years, the results may differ.

Delta-Weighted Hedge Ratios

Figure 2 depicts the variation in the delta-weighted hedge ratios by season and by year for the sample. This graph, which shows the average over all clubs in the sample, illustrates several points. First, the club's appear to have a strong seasonal tendency to hedge less in the spring and more in the summer. Second, it would appear that the amount hedged is significantly less than what is prescribed by hedging theory. The peak amount hedged by the average club is around 0.65, with a more normal level somewhere around 0.5. In 1997, the maximum hedged was about 0.30.

³ Although one could argue that the club's are independent, the outcomes are not because of the marketing years. Thus, instead of having 21 independent observations (see bottom of table 1), we really have only 4 independent observations.

Both of these characteristics do not support the optimal hedge hypotheses which implies that amounts hedged would be nearly 0.9 for all years and that farmers would reach this hedge level at planting. An alternative explanation is that the farmers did not acknowledge the production certainty of the Model Farm when making marketing decisions. If so, the levels of hedging in most years are consistent with the optimal hedge model, except in 1997 when overall hedging was significantly less than even can be explained by yield uncertainty. However, the overall results suggest that farmer forward pricing behavior is more complex than traditional hedging theory would suggest. Given that hedging behavior appears to be dynamic, and not myopic or static, we now consider whether these decisions are influenced by observable factors.



Figure 2. Average Proportion Forward Priced by Marketing Clubs, Maryland, 1994-1997.

Regression Results

Regression analysis was used to explore the impact of dynamic factors on hedging decisions. Formally, the model estimated is:

$$Q_{kl} = \alpha_0 + \sum_k \beta_k M_k + \sum_l \gamma_l Y_l + \alpha_1 TREND_{kl} + \alpha_2 RELPRICE_{kl}$$

where Q_{kt} is the quantity hedged in month k of year t, defined as the delta-weighted hedge ratio times 60,000 bushels; M_k is a set of monthly dummy variables and Y_t is a set of yearly dummy variables; November is the deleted monthly dummy and 1997 the deleted yearly dummy. Coefficients on these variable would be zero if the hedging model applied. The variable TREND_{kt} is a dummy variable which takes on a value of 1 if the current prices trend is up and a value of 0 if the current price trend is down; this trend indicator was based on a 50-day moving average of prices. This variable attempts to capture changes in hedging behavior based on the market trend. The RELPRICE_{kt} is the futures price in month k of year t, less the futures price at harvest in the previous year. This variable measures the price spread between the current forward price and last harvest, which measures farmer's willingness to hedge less as current prices are below those for the previous season. Because Q_{kt} can take on a value of zero, we use a tobit model for estimation of a truncated model. Both a pooled model, which includes all clubs, and a model for each individual club are estimated. The pooled model can be viewed as a restriction that all clubs have similar forward pricing behavior.

Estimated parameters are presented in table 3. The results highlight several key points. First, the amount hedged prior to May differs from the amounts after May. Prior to May, clubs tend to hedge less as compared to harvest time, as is indicated by the significantly negative parameter estimates for January-April for many of the clubs. For May and beyond, only two clubs showed a significant parameter estimate. These results are consistent with the patterns in figure 2. To provide a formal test of the proposition that hedging in the later period was unpredictable, we tested the hypothesis that all monthly dummy variables for May-October are zero. This test, as indicated by the likelihood ratio test at the bottom of the table, was significant for only one club. Thus, no clear evidence exists that clubs systematically change their hedging positions after April. As figure 2 indicates, these results do not imply routine hedging; rather the amounts hedged in these months depend on the current expectation that vary from year to year.

	All Clubs	Carroll	Harford	Kent	Talbot	Washington	Worcester
Int.	19344	36036	16690	17729	18778	15085	21955
Jan.	-30610 [*]	-101214	-52459	-35616*	-28579 [*]	-14746*	-15586
Feb.	-18646 [*]	-30437*	-52549	-7341	-22065	-7960	-9318*
Mar.	-14569 [*]	-34723*	-24314*	-5998	-18913 [*]	-7486 [*]	-3549
Apr.	-10174*	-13877	-19009*	-4605*	-17263*	-6066*	-2815
May	-6110	-2904	-9070 *	-1861	-16997*	-4623	1640
June	-2537	-1920	-8 493 [*]	-1939	-7701	328	4473
July	-159	-3378	-1329	1861	-3953	2047	4181
Aug.	-1580	-3239	-3534	1623	-5689	52	2631
Sept.	-1334	-7086	62	1835	-3704	-2458	1108
Oct.	-268	276	3066	408	-2318	-1218	-1179
1994	10646*	4329	10935*	22945	13102	5723*	· .
1995	11132*	-22690*	8187*	30564*	30261*	-5949	11041
1996	9194 [*]		•	-97	19238	40959*	-9858
Trend	-1862	-7182	6271*	339.6	-6476	-5470	-3204
RelPrice	-95*	-40	-206*	-229*	2	-92*	-96*
LR Test ^a	2.754	0.92	16.56*	4.32	5.76	9.26	7.48

 Table 3. Tobit Regression Estimates for Hedge Ratios for Maryland Marketing Clubs.

^{*}The null hypothesis for this test is that the monthly dummy variables from May-October are zero. ^{*}Indicates significance at the 5% level.

Indeed, the yearly dummy variables, which are significant for all clubs, indicate some change in the amount hedged every year. The intercept accounts for 1997, so the monthly

dummy variables measure how much, on average, clubs hedge in those years as compared to 1997. In 1994, all clubs hedged significantly more than in 1997. However, club hedging in 1995 and 1996 was mixed, with some clubs hedging more or less in relation to 1997. Nonetheless, the results support the notion that farmers hedge different amounts from year-to-year.

The trend variable evaluates the response in hedging to current price trends in the market. The results are mixed as to whether the trend variable consistently influences hedging decisions. The pooled model and three of the club models had no significant change in hedging based on the trend indicator, while one club had a positive effect, implying that a higher trend meant more hedging. The remaining two clubs had a significantly negative effect so that a downward trending market results in more hedging. Perhaps, different formulations of trends would have had clearer results. Obviously, trading was associated with recent trends for some of the clubs.

The final variable (relprice) measured the extent to which the current price was above or below the previous year's harvest price. All but one club had a significantly negative estimate, indicating that when prices were below the previous year, farmers tended to hedge less. These results provided strong support for the adaptive expectations and/or prospect theory hypotheses discussed above. Farmers hedged less in this situation due to expectations that price would rise or because of risk seeking behavior due to losses from last year's prices.

Conclusions

The analysis in this paper provides support for the positions of both the research and extension marketing views in the current debate on the correct hedging position for farmers. The clubs did not have a net gain over harvest price for their hedging activity as the efficient market hypothesis and standard hedging theory would suggest. However, hedging activity was not consistent with the implications of the optimal hedging model. The level of hedging varied from year to year and among months during the growing season. While only some of the clubs seemed to be influenced by recent trends, most hedged much less when current futures prices were lower than the harvest price for the previous year.

These clubs were obviously practicing some of the ideas that at least some extension marketing specialist advocate. Inasmuch as these clubs were established and led by extension personnel, this result is not surprising.

Another difference from the optimal hedge paradigm is that the clubs have a much lower ratio than this literature implies. Thus, the farms were not gaining sufficient risk protection while also not realizing net price enhancement. However, the hedge ratios in most years were near that suggested for the case when production is uncertain. If the farmers were utilizing the rules for actual farm conditions rather than adapting fully to the Model Farm, adequate risk protection was being achieved. Given the importance of hedging in this modern risk environment, it is comforting that farmers are achieving the results of the optimal hedge model even though they are not behaving consistently with the model.

The one exception to this consistency with the optimal position is 1997 when prices were much below the previous year. Given that two theoretical explanations are presented for this behavior in this paper, the results are plausible. Thus, these results have implications for extension programs. An educational effort to point out this tendency to farmers might help overcome this problem. As with other cognitive biases, it is questionable whether such a program could overcome this tendency.

The analysis in this paper does have limitations. As stated previously, the number of years of data is limited and the trading activity is not real, but simulated. Some of the formulations of variables could be altered as is true of most similar regressions. Despite these limitations, the results had interesting implications. If other states have marketing clubs with similar exercises, research with data from these clubs would also be a source of time series of actual hedging decisions for similar research.

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