Evidence of Farmer Forward Pricing Behavior

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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 Maryland marketing clubs for 1994-1998. Hypotheses concerning the consistency of farmer behavior with the research literature on hedging are considered. 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. This analysis provides further information to help bridge the gap between academic research and practical hedging.

Keywords: Grain Marketing**,** Hedging, Risk Management.

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Decreased government intervention in commodity markets has created greater price risk for farmers in recent years. With a heightened exposure to price variability, farmers have been expected to use forward pricing markets, like futures and options, to manage this risk. At the same time, agricultural economists have shown a renewed interest in the topic of price risk management. Although this topic has no shortage of applied research studies, it would appear that this methodology has failed to meet the needs of applied practitioners and ultimately farmers. From surveys, we have learned that extension economists believe published risk management research is of little relevance to real world applications (Anderson and Mapp) and there is a sharp difference of opinion between extension and research marketing economists when it comes to the motives for farmer forward pricing (Parcell, et al.).

Close inspection of the forward pricing literature yields two prevailing opinions among agricultural economists. The most commonly held view in the literature is that futures markets are efficient, and farmers are unlikely to consistently profit in the futures market (Zulauf and Irwin). Risk aversion becomes the primary motive for farmers to use forward markets and a considerable amount of research is devoted to determining optimal hedging rules. Much of this research suggests that farmers should forward price a relatively high proportion of their crop (usually over 70 percent) in forward markets (Peck; Kahl; Myers and Thompson). However, it seems that this prescription is seldom followed in real world settings as surveys show significantly less hedging among farmers (Patrick, Musser and Eckman; Goodwin and Schroeder). Although production risk may be one cause for lower hedging (Grant), Patrick, Musser and Eckman found that this was not an important issue for farmers as compared to other

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issues (e.g., credit constraints and margin calls). In contrast, that same survey showed that the majority of farmers believe that forward markets present an opportunity to achieve better prices.

This latter view is consistent with a smaller segment of the literature that suggests farmers can use forward markets to achieve higher prices. This approach considers forward pricing as a way to profit from the forward markets implying that farmers may have more accurate expectations about prices than those portrayed in the forward market. Research in this area has investigated forward pricing strategies that will work in certain market conditions; Wisner, Blue and Baldwin is a recent example of this view.

Whether forward pricing strategies are used by farmers to enhance prices or to manage risk is a debate that will likely continue. However, a common problem in the forward pricing literature is the lack of evidence on farmers' use of forward pricing markets. Before applied research in this area can be improved, we need to observe their forward pricing decisions so that we may better understand how farmers form price expectations (Brorsen and Irwin). Although some information is available from farmer surveys, it is difficult to conduct detailed tests on the basis of one-time surveys.

This study examines farmer forward pricing decisions from a marketing game conducted during 1994-1998. Farmers in Maryland grain marketing clubs participate in a Model Farm exercise, which is a real-time marketing simulation that allows for paper transactions in forward markets over the marketing season. Unlike other studies that utilize survey data at one point in time, these data allow us to study farmer forward pricing behavior over several years and within marketing seasons. Analysis of these data allows us to consider whether farmers use forward markets to manage price risk or enhance prices. The next section of the paper discusses the data from the grain marketing clubs while the third section delineates hypotheses to be considered. The fourth section of the paper provides the results.

Description of Data

A grain marketing club is a group of farmers and agribusiness personnel that discuss marketing strategies and outlook. Clubs are usually associated with the Cooperative Extension Service with agricultural marketing specialists and extension agents providing educational training on the marketing process. In Maryland, the educational component 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. Crop yields are the same for every club and are assumed to be constant so production risk does not enter into pricing decisions. 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 an exercise in understanding how the marketing tools will perform in actual farm 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. 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.[1] Between 1994 and 1998, nine clubs participated in the Model Farm trading exercise. However, three of the clubs only participated

[1] Certainly, decisions made in a game setting may not be consistent with actual behavior. However, applications of experimental economics have shown that the behavior of the participants often mirror the behavior expected from economic agents (Fackler and McNew). While we recognize the inherent limitations in associating Model Farm trading behavior with actual trading behavior, the data is 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 forward pricing behavior and price expectations.

for one year, so they are excluded from the analysis. Table 1 lists the six remaining marketing clubs and the years that they participated in the Model Farm exercise.

To simplify the analysis, we consider only the transactions for corn during the pre-harvest pricing window. This time period is from January (prior to planting) until harvest time in November. Figure 1 shows the mid-month price for the December corn futures contract over the five marketing years included in the analysis. As can be seen, forward prices varied substantially not only in terms of their level from one year to the next but also in terms of seasonal pattern, implying that any routine hedging strategy would have led to significant variation in hedging profits. In 1994 and 1998, the forward price fell consistently and bottomed at harvest time. In 1995, the reverse trend occurred as the forward price rose throughout the season and reached a high at harvest. In 1996 and 1997, high and low prices, respectively were posted during the summer.

Each club has 60,000 bushels of corn production that may be priced through forward contracts for 1,000 bushels or exchanged-traded futures and options contracts for 5,000 bushels. Although the clubs use forward contracts for local markets, we base all cash forward prices on the December futures price on the date when a contract is entered, which assumes that the basis was constant. In addition to forward contracts, clubs may use futures contracts, call options, or put options to forward price their corn, which are also based on the December contract.[2] 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

[2] 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 1995 corn on March 31, 1995, we have instead changed their position to short a December 1995 contract on the same date. With options, if a club buys a

with a $2.50 put option. We make use of a *delta* value of an option to determine how much price protection is offered through a certain option position. The option's delta measures the change in the option premium from a one-unit change in the underlying futures price.[3] For put options, the delta value is in the range of [-1,0] while for call options the range is [0,1]. A short futures position has a delta value of –1. Because forward contracts are simply futures contracts that cannot be offset, they too have a delta of -1. An option's delta value will change depending on two main factors. 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 in absolute value, 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.[4]

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 add-up positions in forward, futures, and options contracts. For each club throughout the five-year period, we construct a delta-weighted hedge ratio, which is the quantity-weighted sum of each portfolio instrument. As an example of how this computation is made, consider a portfolio that

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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.

[3] If futures prices are log-normal, then Black (1976) has shown how to compute the value of an option given the standard deviation of the price distribution. Alternatively, one can compute the market's implied volatility from observed option premiums and the delta of an option measures the change in the option value based on a change in the futures price.

[4] 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

consists 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 +0.20, 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 ratio of 0.23.

Study Hypotheses

Traditional hedging theory would suggest that each year farmers 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, forward pricing is purely risk reducing because farmers believe forward prices are unbiased. At a minimum, we would expect to see a high proportion of the crop forward priced if farmers followed this rule. Furthermore, hedging theory would suggest that the amount forward priced does not change over time. The above reasoning suggests several hypotheses for this analysis:

(1) All clubs should forward price a high proportion of their crop (approximately 85-100%) each year.

(2) The hedge ratio should not vary over years based on past price relationships or current price expectations.

(3) The hedge ratio should be established at planting and not vary over the growing season.

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created from a long call option and short put option with the same strike price. Therefore, the delta of the portfolio is δ_c-δ_p which equals the delta of the long futures position (+1).

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 throughout the marketing season and perhaps from one year to the next. If this is true, then an interesting question is what information influences farmers forward pricing decisions? For example, under an adaptive expectations view, farmers current price expectations should be strongly influenced by price levels in the previous year. 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.

Results

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 1994-98. 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. For comparison, the last column of table 2 shows the change in the December futures price between May and November. A positive number indicates that the forward price was lower at harvest time in November as compared to planting time in May. Stated another way, a farmer who routinely hedged his entire production in May would have on average received a 16.5-cent higher price than by selling corn at harvest.

As a group, the clubs made positive profits in 1994, 1996 and 1998 which were years when prices were lower at harvest as compared to early in the season, making any pre-harvest pricing strategies profitable. 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 loss. For the entire time period, forward pricing profits are positive at 10.5 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 five-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 five marketing years were available. With more marketing years, the results may differ.

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. Finally, there appears to be annual variation in the proportion hedged. For example, in 1995 and 1997 the clubs forward priced less as compared to the other three years.

All 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. Instead, it appears 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.

To determine what influences hedging behavior, we begin by estimating a seasonal model of the form:

$$\text{(1)} \qquad \mathrm{H}_{\mathrm{kt}} = a_0 + \sum_k b_{\mathrm{k}} \mathrm{M}_{\mathrm{k}} + \sum_t a_{\mathrm{t}} \mathrm{Y}_{\mathrm{t}} + \mathrm{e}_{\mathrm{kt}}$$

where H_{kt} is the proportion of the crop forward priced in month k of year t;; M_k is a set of seasonal dummy variables and Y_t is a set of yearly dummy variables. Two seasonal dummy variables are used, one for the pre-planting period of January-April and the second during the critical growing season of May-July. The intercept accounts for the case of August-November 1996. Because H_{kt} can take on a value of zero, we use a tobit model for estimation of a truncated model. Although in principle H_{kt} could be unity, no clubs ever achieve that level so we do not account for the upper bound. Both a pooled model, which includes all clubs, and a model for each individual club is estimated. The pooled model can be viewed as a restriction that all clubs have similar forward pricing behavior.

Parameter estimates from equation (1) are given in table 3. The results highlight several key points. First, if clubs were purely risk-minimizers one would expect all of the seasonal coefficients to be zero so that there is no difference across years or within the marketing season.

Given the significance of the annual dummy variables, it is clear that the clubs systematically changed their pricing behavior from one year to the next. As compared to the base of 1996, two clubs hedged significantly more in 1994 while one club hedged significantly less. In 1995, three clubs hedged significantly less while two clubs hedged significantly more as compared to 1996. Likewise, in 1997 and 1998 the participating clubs had significantly different hedging when compared to 1996. Within a marketing year, there seems to be little systematic variation in hedging levels after May. In fact, only Talbot County showed a significantly different coefficient for the May-July period which shows significantly less hedging during this period as compared to the August-November time window. However, for the other clubs, the level of hedging after planting time does not change significantly based on the season. This does not imply that clubs do not change their behavior after May, only that they do not change their hedging in a systematic fashion after May. If clubs change their forward pricing behavior based on expectations, this could lead to different hedging levels across years and within a year.

To investigate whether clubs are responding to information and expectations, we estimate a second model of the form:

$$(2) \qquad \mathrm{H}_{kt} = a_0 + \sum_k b_k \mathrm{M}_k + a_1 \mathrm{TP}_{kt} + a_2 \mathrm{RP}_{kt} + a_3 \mathrm{FP}_{kt} + \mathrm{e}_{kt}$$

where the variables TP, RP and FP are used to measure how farmer pricing is influenced by relative prices. Specifically, TP is a dummy variable that measures the price trend using a 20-day moving average of past prices. If the current price is above the moving average then the trend is higher and the dummy variable takes a value of 1. If farmers are trend followers, as is the case of technical analysis, then we would expect a higher trend to be associated with less hedging. The variable RP measures the current price relative to the previous year’s high price. This represents the extent to which the current year's price is relatively high or low compared to last year. If farmers tend to make forward pricing decisions relative to last year's prices, we would expect this variable to be significant although the sign of the variable is unclear. For example, if farmers have adaptive expectations then a high current price relative to last year would imply greater hedging. On the other hand, if farmers use current prices as the basis for forming expectations, then high current prices relative to last year may signal higher prices down the road and less hedging. The third variable, FP, is the current price less the fundamental price based on the monthly USDA-WASDE supply and demand report. The fundamental price is a forecast of the December futures price from a model using the stocks-to-use ratio. As USDA makes monthly revisions to their supply and demand estimates this price forecast changes to reflect the new fundamental value. A positive value for FP indicates that the current price is above the fundamental price. The exact procedure for estimating the fundamental price is given in the appendix. If farmers make pricing decisions based on market fundamentals, then we would expect them to forward price more when FP is positive.

The estimates for equation (2) are presented in table 4. All clubs show some tendency to hedge less when the price trend is positive as indicated by the negative coefficient on the trend dummy variable (TP). However, only two clubs have a statistically significant coefficient at the 5 percent level. Based on the parameter estimate for TP, clubs tend to hedge 3 to 23 percent less of their entire crop during a higher trending market. As for the relative price, two of the clubs tend to hedge significantly less when the current price is higher relative to last year's high price while one club hedges significantly more. Finally, for the fundamental price measure, the results are also mixed with two clubs hedging significantly more when prices are high compared to the fundamental value and two clubs hedging significantly less.

From these results, it seems that farmers change their forward pricing behavior as market conditions change. Across all clubs, trend following seems to be the most consistent theme as higher trending prices lead to less hedging. In terms of expectations, there seems to be no universal way that farmers as a group form their price outlook. However, there does appear to be a consistent tendency by the clubs to hedge more when prices are relatively low, either in comparison to last year or in reference to a fundamental value. For example, if the variables FP and RP are both –10 cents per bushel, implying that the current price is 10 cents below the fundamental value and the high from last year, then 4 of the 6 clubs would tend to hedge more (a range of 1 to 4 percent). The remaining two clubs would hedge less, with Talbot county hedging 2 percent less and Washington county 8 percent less. Given that the majority of farmers tend to hedge more during low prices periods suggests that farmers use current prices as a gauge for the market outlook. Simply stated, it may be that farmers use low prices as a signal that prices will continue to move lower and forward pricing is warranted. Likewise, during periods of high prices farmers tend to hedge less, possibly in anticipation of better prices to come. In terms of expectations, it is difficult to quantify how farmers form their price outlook. However, our attempt to develop a fundamental value based on market supply and demand suggests that most of the clubs had no significant response or had a significantly negative response implying less hedging when prices were overvalued relative to the fundamental price. However, it is encouraging that Washington county, which showed the greatest positive response to the fundamental value, achieved the highest net-profits from their forward pricing strategies over the 5-year period.

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. Farmers participating in the marketing clubs did not consistently profit from their forward pricing decisions as the efficient market hypothesis and standard hedging theory would suggest. However, hedging activity was not consistent with the implications of standard hedging theory on a number of dimensions. First, farmers tend to forward price significantly less than what would be dictated by purely risk-minimizing behavior. Even so, there appears to be considerable variation in the amount hedged across marketing years indicating that farmers may be attempting to time the market, although their ability to do so seems limited.

The majority of the clubs seem to be trend followers and use relative prices as a signal of future price direction. Fundamental information, as measured by this study, seems to have little influence on pricing decisions, although one club did appear to positively use fundamental information to make successful pricing decisions.

Even through farmers may not respond exactly as would be expected from the hedging literature, it is comforting that farmers are achieving the results of reducing risk. The results, however, confirm a needed change in the hedging literature away from pure risk-minimizing behavior to strategies that are consistent with risk reduction and expectations.

At the same time, it appears that extension marketing efforts needed to be redirected to helping farmers form better expectations in light of market information. Farmers appear to use prices as a signal of the market outlook, but they seem to have limited ability to respond to market information. Gains could be made by having extension programs that aid farmers in analyzing and interpreting market information in an attempt to achieve better price expectations.

APPENDIX

Every month USDA releases their projections of the annual supply and demand for commodities in the *World Agricultural Supply and Demand* (WASDE) report. These reports are widely followed by commodity traders. Projections for ending stocks are perhaps the single most important projection because it measures the surplus from the current year to be carried forward to the next crop year (Purcell and Koontz). A common way to develop a price forecast is to use the ending stocks as a percent of total use as an explanatory variable. Therefore, we constructed an *ex ante* forecast of the December futures price in November based on the latest USDA estimate of the ending stocks-to-use ratio (SUR). The model is of the form:

$$F_t = a(SUR_t)^b$$

where F_t is the December corn futures price in mid-November and SUR is the stocks-to-use ratio from the November WASDE report. This model captures the essence of a storable commodity market where prices increase proportionally more at low stock levels as compared to high stock levels.

To develop the estimates for *a* and *b*, the previous seven years of data for the SUR estimate in November and the December corn futures price in November are used. This model was then used to forecast the December futures price based on USDA's estimate of the SUR for the current marketing year. The difference between the current December futures price and the forecasted price is the variable FP in equation (2). At the start of a new marketing year, the model is re-estimated using the most recent seven years of data. The choice of seven years of data is based on the need to develop a simple predictive model that responds more rapidly to current conditions. For the five years from 1994-1998, the model fits relatively well with the R^2 ranging from 0.74 to 0.98 and the parameter estimates are reasonably stable. For example, at a

SUR value of 10%, the price projections range from a low of $2.81 per bushel in 1995 to a high of $2.91 per bushel in 1997.

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Table 1. Maryland Grain Marketing Clubs Participating in the Model Farm.

Club Name	Years Participating
Carroll County	1994, 1995, 1996
Harford County	1994, 1995, 1996, 1998
Kent County	1994, 1995, 1996, 1997, 1998
Talbot County	1994, 1995, 1996, 1997, 1998
Washington County	1994, 1995, 1996, 1997
Worcester County	1995, 1996, 1997

Table 2. Average Forward Pricing Profits for All Clubs.

Year	Average Profits (Cents/Bu.)	Number of Clubs	Change in Dec. Futures (Cents/Bu.)[a]
1994	21.0	5	38.5
1995	-26.2	6	-74.0
1996	27.9	6	95.3
1997	-0.6	4	-20.0
1998	30.3	3	42.5
1994-98	**10.5**		**16.5**

[a]Defined as the December futures price in May (planting) less the December futures price in November (harvest).

Table 3. Seasonal Model for Proportion Forward Priced By Marketing Clubs.

	All Clubs	Carroll	Harford	Kent	Talbot	Washington	Worcester
Intercept	0.493*	0.526*	0.358*	0.384*	0.597*	0.846*	0.202*
Jan-Apr Dummy	-0.345*	-0.429*	-0.384*	-0.242*	-0.471*	-0.149*	-0.133*
May-Jul Dummy	-0.073	-0.074	-0.069	-0.060	-0.199*	-0.005	0.032
1994 Dummy	0.041	0.101	0.209*	0.387*	-0.078	-0.566*	.
1995 Dummy	-0.112*	-0.471*	-0.128*	0.191*	0.148	-0.679*	0.202*
1997 Dummy	-0.188*	.	.	-0.074	-0.328*	-0.645*	0.126*
1998 Dummy	-0.044	.	0.337*	-0.153*	-0.015	.	.

*Indicates significance at the 5% level.

Table 4. Proportion Priced By Marketing Clubs Based on Relative Prices.

	All Clubs	Carroll	Harford	Kent	Talbot	Washington	Worcester
Intercept	0.519*	0.348*	0.377*	0.575*	0.689*	0.446*	0.411*
Jan-Apr Dummy	-0.315*	-0.334*	-0.284*	-0.160*	-0.478*	-0.305*	-0.071
May-Jul Dummy	-0.044	0.080	0.042	0.008	-0.201*	-0.098	0.092*
TP	-0.134*	-0.194	-0.073	-0.027	-0.103	-0.233*	-0.071*
RP	-0.0006	-0.0061*	-0.0041*	0.0013	0.0023*	0.0006	0.0005
FP	0.0004	0.0047*	-0.0001	-0.0057*	-0.0008	0.0089*	-0.0032*

*Indicates significance at the 5% level.

Figure 1. December Corn Futures Price, Chicago Board of Trade: 1994-1998.

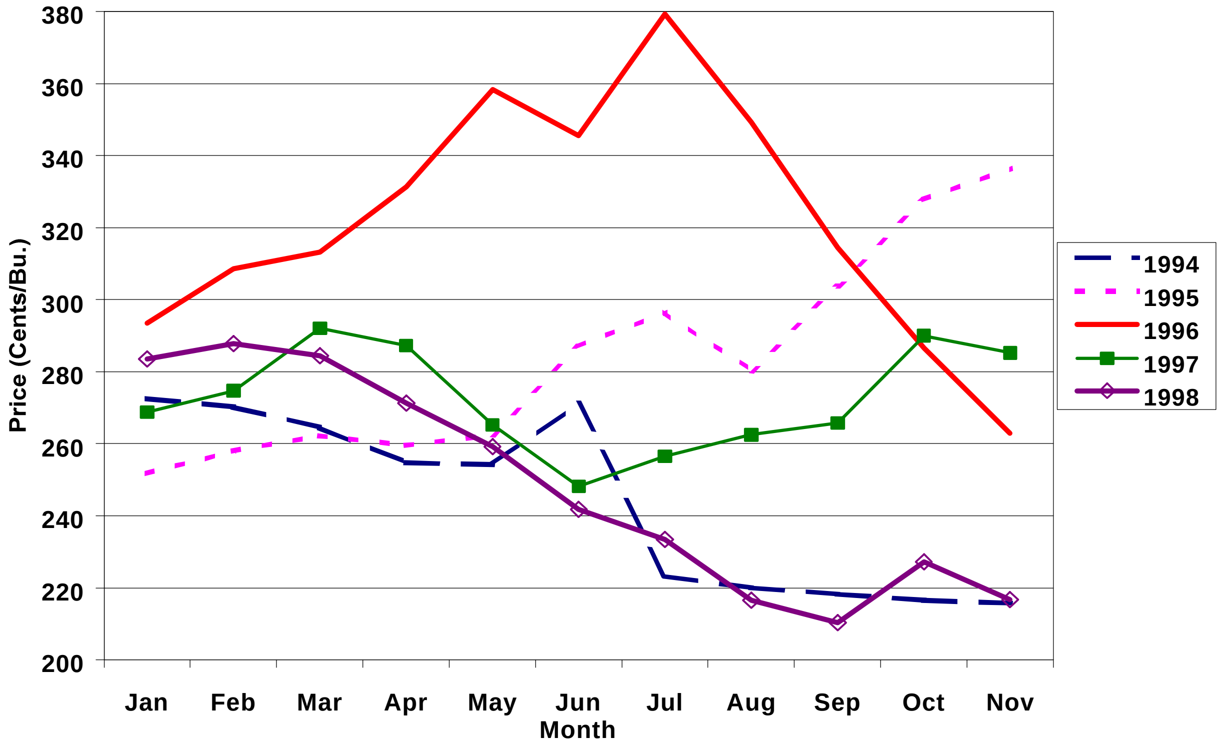

Figure 2. Average Proportion Forward Priced by Marketing Clubs, 1994-1998.