ABSTRACT

Incorporation of a Price Forecasting Equation into Selective Hedging Strategies for Corn

David E. Kenyon and Craig D. Cooper*

December futures prices during the growing season for corn were predicted as a function of estimated ending stocks and production. Predicted futures prices were incorporated into hedging strategies. Strategies using predicted futures prices were superior to routine hedging, but not superior to strategies using technical price indicators.

*Authors are Associate Professor and Graduate Research Assistant, respectively, in the Department of Agricultural Economics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Paper presented at AAEA meetings, Pullman, July 29 - Aug. 1, 1979.

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The research of Bolen, et al., Heifner, Leuthold, McCoy and Price indicates that routine hedging reduces price variability. However, the reduction in price variability comes at the expense of lower average prices. In an attempt to maintain or improve price level while reducing price variation, Purcell and Richardson, Link, Brown and Purcell have incorporated both technical and fundamental price analysis into their hedging strategies. Their results indicate higher average price without increased price variation. To date there is very little published literature on hedging strategies for corn that incorporates technical and fundamental price analysis.

This paper reports on the value of technical and fundamental price forecasting equations in pre-harvest corn hedging strategies compared to routine hedging and cash harvest sales during 1973-1977. This paper focuses on the theoretical development of a price forecasting equation for monthly December corn futures prices, estimation of the price model, incorporation of this model into selective hedging strategies, and evaluation of these strategies compared to technical strategies. In formulating the price model, every attempt was made to keep the model simple and to only use data available to producers on a timely basis.

Theoretical Development of Price Model

The basic areas of demand for U.S. produced corn are (1) domestic feed usage, (2) exports, and (3) food, industrial and seed usage. In 1977-1978, approximately 60% was used for domestic feed, 31% was exported, and 9% was used for food, seed or industrial uses. Industrial use varies little from year to year. Therefore, on the demand side, corn price variation is largely dependent on changes in feed and export demand.

The demand for corn by the livestock industry is a derived demand. The quantity of corn demanded is a function of the price of corn, the price of other inputs in feeding livestock, and the price of livestock, the output from feeding. Changes in corn price would constitute movement along the demand function, whereas changes in the prices of other inputs in feeding livestock or the price of the livestock output would constitute a shift in the domestic demand for feed. In the short-run, the demand for feed will be highly correlated with the number of animals on feed.

The other major determinant of demand for U.S. corn is exports. The major use of corn by importing countries is for feed, and like the U.S., the major short-run determinant of feed demand is number of animals on feed, livestock prices, and price of other feed ingredients. Export demand for U.S. corn is also influenced by foreign production. When foreign production is below required levels, rather than reduce herd numbers, countries seek to import corn. Since weather is unpredictable, export demand can change quickly. The U.S. government monitors weather and livestock numbers around the world in an attempt to anticipate foreign demand. In addition to unpredictable weather conditions, unexpected political decisions can cause substantial changes in export demand for U.S. corn. Together these factors make forecasting export demand difficult.

The short-run supply of corn can be divided into two stages; pre-harvest and post-harvest. During pre-harvest, expected corn supply in year t is a function of planted acres and expected yield. Planted acres is a function of expected corn prices, expected prices of alternative crops, input prices and technological restraints. Once planted acreage is determined, supply is determined by weather as it affects yield and the ratio of harvested to planted acreage. After harvest, corn supply is fixed and can be expressed as a function of harvested acreage, yield and excess supply from marketing period t-1 (ES_{t-1}).

The demand and supply factors in year t discussed above interact to determine corn price. However, since corn is a storable commodity, the estimated supply and demand in year t+1 also can affect the price in year t. The interrelationship among supply, demand, and stocks in years t and t+1 are shown graphically in Figures 1, 2, and 3.

Consider two time periods, t and t+1. Time period t for corn extends from October 1 to September 30. This interval is referred to as marketing year t, where t's corn was produced during marketing year t-1 and t+1's corn will be produced during t's marketing year. Therefore, the price that exists during marketing year t will be dependent on the known and expected supply and demand conditions in both t and t+1. Figure 1 represents the supply and demand conditions immediately after harvest at the beginning of time period t. At the beginning of period t, S_t is known. Demand in t is an estimate of expected feed, export, and industrial use and is subject to shifts throughout the t marketing period. At this time, S_{t+1} is a function of the expected price of corn, the expected price of alternatives and the estimated price of inputs for corn production in period t. In this study, the location of the supply function S_{t+1} during period t is estimated based on announced planting intentions, historical yield, and estimated carryover stocks from t. Demand in t+1 is estimated based on expected feed, export, and food demands in t+1. Excess supply in t represents the amount quantity supplied exceeds quantity demanded at various

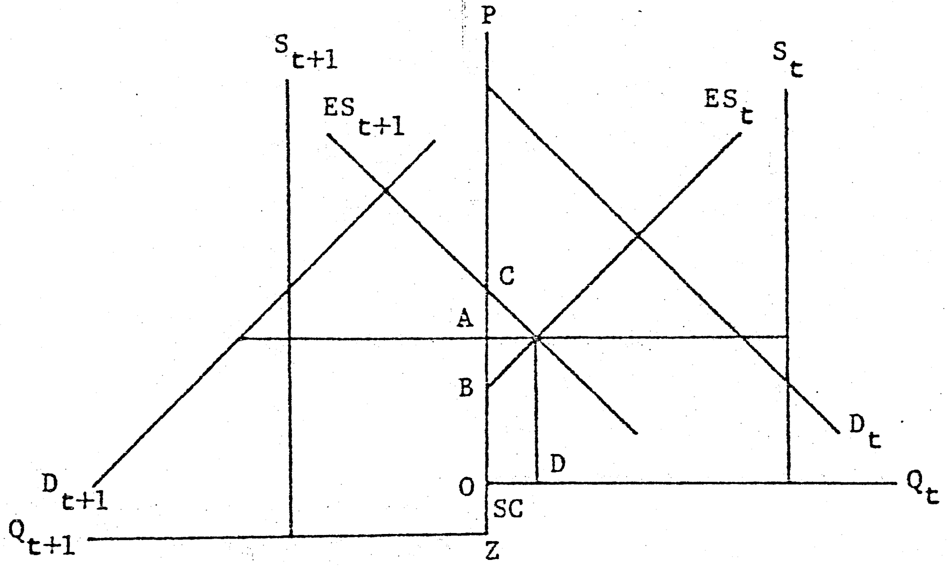

Figure 1.

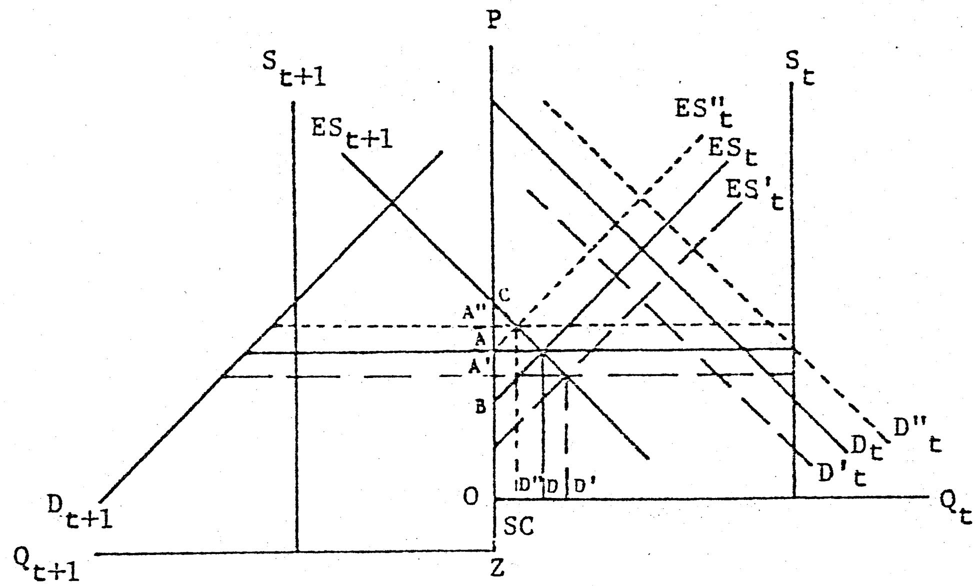

Figure 2.

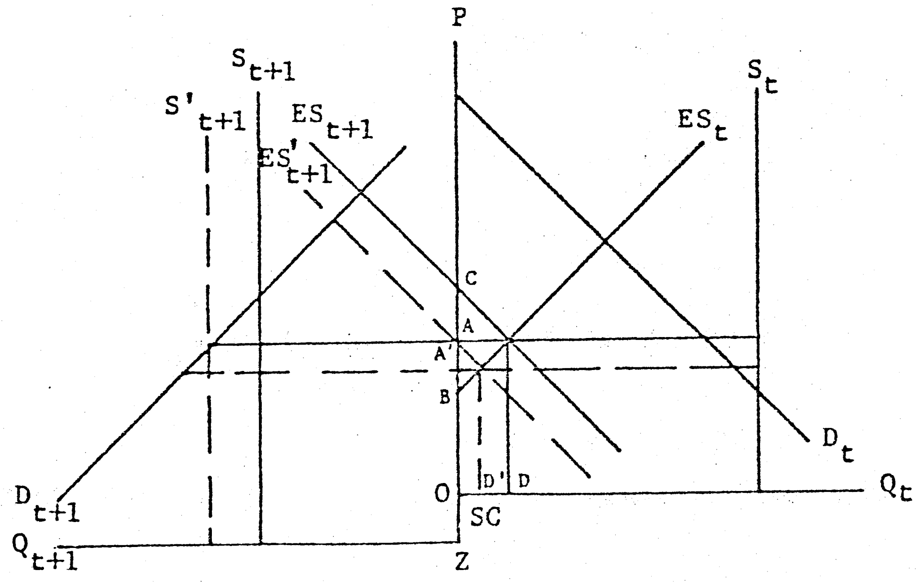

Figure 3.

corn prices. The negative portion of excess supply in t+1 (ES_{t+1}) indicates demand for carryover stocks from period t to period t+1 as a function of the price in period t+1.

Without storage into t+1, the price in t would be OB and the price in t+1 would be ZC. Due to expected supply and demand conditions in t+1, some corn will be carried over into period t+1 from t.[1/] This will have the effect of raising the price in t and lowering the price in t+1. The equilibrium prices with storage is determined by the intersection of excess demand and excess supply, or price OA in t and ZA in t+1, with the difference in the two prices being the storage cost SC. At price OA, quantity OD is stored and carried over into period t+1.

At the beginning of period t, the only factor known with relative certainty in Figure 1 is the supply in t. Demand in t, estimates of supply in t+1, and estimates of demand in t+1 can, and will, shift throughout the marketing period. Figure 2 illustrates what happens to equilibrium price if demand in t shifts. In Figure 2 a decrease in demand to D'_t will result in a shift in ES_t to ES'_t and a decrease in price from OA to OA'. An increase in demand to D''_t will shift ES_t to ES''_t and results in a new equilibrium price OA" and carryover stocks OD". Thus shifts in demand in period t result in new equilibrium prices which result from movement along ES_{t+1}. As Figure 2 indicates, higher (lower) prices in period t result in less (more) carryover stocks from period t to t+1, holding S_{t+1} and D_{t+1} constant.

Supply shifts in t+1 affect prices in t via the excess supply relationship ES_{t+1} (Figure 3). Given D_t and S_t, an increase in expected supply in period t+1 to S'_{t+1}, would shift ES_{t+1} to ES'_{t+1}. Equilibrium price in period t would drop to OA' and carryover stocks would drop to OD'. Similarly, a decrease in supply in t+1 would shift excess supply to the right and result in a higher equilibrium price and larger carryover stocks in period t. Demand increases (decreases) in t+1 would increase (decrease) ES_{t+1} and result in a higher (lower) equilibrium price in t and larger (smaller) carryover stocks in period t.

We have demonstrated that the price in period t and the estimated carryover stocks (ECS) at the end of period t are related. Movement along ES_{t+1} is related to shifts in D_t, with higher prices resulting in reduced carryover stocks. A priori, holding S_{t+1} and D_{t+1} constant, P_t and ECS_t should be inversely related. Shifts in ES_{t+1} are caused by shifts in S_{t+1} and D_{t+1}. A priori, we expect shifts in S_{t+1} and P_t to be inversely related and shifts in D_{t+1} and P_t to be positively related.

Demand shifts in t and t+1 are most likely to result from changes in exports (E) or livestock numbers on feed (LNF). Supply in t+1 is dependent on expected prices in t+1 and yield. However, after mid-January, when planting intentions have been made public, expected production in t+1 (EP_{t+1}) can be estimated based on historical yields. After planting, the major source of variation in S_{t+1} is yield variation caused by weather (W). Therefore, based on these considerations, price in t can be expressed as:

$$(1) \qquad P_t = f(ECS_t, E_t, E_{t+1}, LNF_t, LNF_{t+1}, EP_{t+1}, W_t)$$

This equation is attractive for two reasons. First, this single equation should capture the impact on price of changing supply and demand in t and t+1 without estimating all the relationships depicted in Figures 1, 2, and 3. Second, USDA provides continually updated estimates of all the variables in the price relationship. This eliminates having to estimate the values of the independent variables and makes the equation based on timely information readily accessible to decision makers.

Variables Used and Data Sources

Since we want to make pricing decisions during period t with respect to the crop to be grown during period t, but harvested and sold during period t+1, the dependent price variable became December futures prices ($FUTP_t$). Although harvest was assumed to occur the third week of September, in practice it frequently lasts until mid-October. Thus, the December rather than the September futures contract was used. Estimated ending stocks in period t were obtained from the Agriculture Supply and Demand Estimates published by the U.S.D.A. These reports are issued approximately monthly following the release of major crop reports. This caused an irregularity of the time interval between observations. On the average this interval was thirty-one days. Daily December futures settlement prices were averaged over the time interval between reports and used as the dependent variable. The simple correlation between December corn futures and estimated corn stock estimates was -0.73.

From January through June, EP_{t+1} was determined by planted acres as reported in Prospective Plantings (adjusted for historical difference between planted and harvested acreage) times the five year moving average of historical yields per harvested acre. For July through October, estimated production reported in Crop Production was used. The variables ES_t and EP_{t+1} explained 62% of the variation in December futures prices during 1973 through 1977.

Other variables tried in the model were various methods of incorporating the effects of changes in t's export demand, a weather variable indicating deviation of rainfall from normal levels in major corn producing states, and a livestock index used to anticipate demand in t+1. These variables did not add significantly to the performance of the model. Analysis of the fitted and actual values of the dependent variable indicated the model predicted turning points reasonably well but was frequently missing the absolute price level. To remedy this problem, the average December futures price in the previous period was added to the model. The lagged price variable improved the model's ability to forecast the price level but reduced its ability to predict turning points. Calculation of Press residuals[2/] indicated the model with lagged price did a superior job of predicting a data point when it was not included in the data base.

The Estimated Equation

Thus the model became:

$$(2) \qquad FUTP_t = \beta_0 + \beta_1 ES_t + \beta_2 EP_t + \beta_3 FUTP_{t-1} + \Sigma_t$$

where:

$FUTP_t$ = average December corn settlement price at time t (¢/bu.),

ES_t = September 30 corn stocks estimates at time t (million/bu.),

EP_t = corn production estimates at time t (million/bu.), and

t = time periods within marketing season t.

The residuals of equation (2) had a significant degree of autocorrelation when tested with a Durbin H statistic at the .05 level of significance. The first order autocorrelation coefficient rho (ρ) from the above estimated equation was 0.3435. This value was used to perform a data transformation on the original variables. The OLS estimated equation based on 53 transformed observations during 1973-1977 is:

$$(3) \qquad FUTP - \rho FUTP_{t-1} = \underset{(2.85)}{153.6} - \underset{(-1.19)}{0.0224} (ES_t - \rho ES_{t-1})$$

$$- \underset{(-2.01)}{0.0137} (EP_t - \rho EP_{t-1}) + \underset{(9.57)}{0.7722} (FUTP_{t-1} - \rho FUTP_{t-2})$$

The parameter estimates in equation (3) have the expected sign, although the estimated parameter on ES_t is not statistically significant at the 10% level. Equation (3) has an $R^2 = .92$, a standard deviation of 16.3 cents per bushel and an average absolute residual of 5.74% of the mean of the dependent variable. The Durbin H test failed to reject the hypothesis of no first order autocorrelation at the .01 level. Theil's U_2 inequality coefficient from equation (3) is 0.76. Equation (3) provides an estimate of average December futures prices during marketing year t based on fundamental economic information. These futures price predictions were incorporated into hedging strategies in an attempt to improve their performance compared to routine hedging strategies.

Hedging Strategies

Pre-harvest hedging strategies were evaluated over the period 1973-1977. Basis estimates, cash prices, and cost of production estimates were for Virginia. Cost of production estimates were based on 100 bushel yields. Yield variation was not considered. Asking prices were calculated based on 7% management fee and 10% profit above production cost. Hedging costs of 2 cents per bushel were assumed. Futures contract sizes were assumed to be available to hedge all of production at various levels. The production season began the second week of April and ended the third week of September.

Strategy I. Unhedged Production

This strategy provides a benchmark for evaluating the other strategies. The entire crop was priced and sold at harvest. The resulting average price and price variance were:

Mean = \$2.47 Variance = \$0.25

Strategy II. Hedge When Futures Price > Asking Price + Basis

Hedge when the futures market is offering a price adjusted for basis that is large enough to cover production costs, plus returns to management and profit. This strategy is recommended by Nichols and Ikerd under certain conditions. This strategy resulted in going short December futures at planting and removing the hedge at harvest, since the criterion was satisfied at planting time each year. Therefore, a routine hedging strategy at planting without regard to asking price would give identical results. The results of this strategy were:

Mean = \$2.11 Variance = \$0.23

Strategy III. Hedge ¼ of Expected Production in June, ¼ in July, ¼ in August, ¼ in September if Futures Price ≥ Asking Price + Basis

This strategy places emphasis on pricing production during months of historical high prices for December futures. Although yield risk was not considered, this strategy would be less risky since a smaller portion of the crop is hedged early in the production season. If hedging criteria are not met in June, the June portion is hedged in July. If the June and July criteria are not met, 3/4's of crop is hedged in August, etc. The results of this strategy were:

Mean = \$2.29 Variance = \$0.10

Strategy IV. Hedge ¼ of Expected Production in June, ¼ in July, ¼ in August, ¼ in September When Futures Price > Predicted Futures Price

Strategy IV is the first strategy to use the price projection equation. If current futures prices are higher than the predicted futures price, the appropriate portion of the crop is hedged. If current futures prices are less than predicted futures price, no hedging occurs. Thus the predicted futures prices are used to initiate hedges when current futures prices are higher than those indicated by fundamental conditions and to defer hedging when current prices are below the level indicated by fundamental conditions. The results of this strategy were:

Mean = $2.45 Variance = $0.16

Strategy V. Hedge When 4-Day Moving Average < 10-Day Moving Average and Remove Hedge When 4-Day Moving Average > 10-Day Moving Only After June 1

Extensive analysis of moving averages over the period 1973-1977 indicated the 4 and 10-day moving averages were superior to other combinations over this time period. This pricing strategy places and lifts hedges throughout the season without regard to month, asking price, or predicted futures price. The results of this strategy were:

Mean = $2.54 Variance = $0.08.

Results and Conclusions

All the strategies decreased price variance compared to cash sales at harvest (Strategy I). Strategy II, which only permitted hedging when an "acceptable" asking price could be established, reduced variance slightly but decreased mean price by 36 cents a bushel. This result is consistent with previous livestock hedging studies cited earlier. Spreading the hedging decision over the months June through September increased average price and reduced variance (Strategy III). The increase in mean price is the result of delaying the pricing decision in 1973 and 1974 when prices were trending up during the summer months.

Incorporation of the price predicting equation into hedging Strategy IV improved the average price considerably compared to Strategies II and III. The average price from Strategy IV was only 2 cents below Strategy I (cash sale at harvest) and had a variance 1/3 smaller. Compared to routine hedging at planting (Strategy II), Strategy IV increased mean price 34 cents per bushel and lowered variance by 1/3. These results suggest that inclusion of fundamental information in the form of price projections into hedging strategies can significantly improve their performance.

The technical 4 and 10-day moving average strategy had the highest mean price and lowest variance of the five strategies. This is the only strategy that permitted lifting and replacing hedges during the production season. The potential of becoming a speculator versus a hedger with Strategy V is large, in light of the fact that 70% of the farmers who traded futures were speculating rather than hedging in 1977 (CFTC).

It is of interest that the purely technical strategy outperformed the fundamental strategy. Brown and Purcell found a similar result in feeder cattle. For short-run hedging decisions, technical indicators appear to have strong merit in discerning changes in price direction compared to fundamentally based models. An argument could be made that more sophisticated fundamental models would perform better. But the time and effort involved in constructing the models, obtaining the data (if available), and estimation of the model would have to produce a substantial improvement in the timing and accuracy of price projections before they would be superior to the technical models which are easy to use and understand.

Footnotes

1. Some stocks will be carried from t to t+1 although prices in t+1 are lower than in t, due to what Kaldor terms convenience yield.
2. Raymond Myers, "Topics in Regression" (Virginia Polytechnic Institute and State University: Classnotes from Statistics 5070, 1978).

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