J. OF THE NORTHEASTERN AGR. ECON. COUNCIL VOL. XII, NO. 1, SPRING, 1983

PRICE RISK REDUCTION IN MARKETING CORN FROM USING HEDGING STRATEGIES

Michael A. Kane, James G. Beierlein and James W. Dunn

ABSTRACT

The use of hedging with commodity futures markets to reduce the price risk in corn production is examined. Both intra-year and inter-year risk are evaluated with different hedging strategies. Strategies involve no hedge, hedge and hold, controlled hedge placement and hold, and in and out hedging. Both technical and forecasting criteria are used to place hedges in the more active strategies. Substantial risk reduction is possible, often without a reduction in price received. Considerable basis risk diminishes the risk reducing properties of a hedge and hold strategy.

INTRODUCTION

Since 1973 grain prices have exhibited a great deal of volatility both within and across crop years. In such an environment, a cash grain farmer often finds the profitability of his enterprise more dependent on his marketing skills than on his farming skills, since reductions in production costs arising from more efficient farming practices may be more than offset by decreases in the selling price of grain resulting from shifts in marketing strategies. As a consequence, the producer should welcome any simple procedure that allows him to transfer some of the price risk.

One vehicle for transferring price risk is hedging with commodity futures markets. This type of hedging can provide an effective means of reducing price risk, provided the futures and local cash price move in tandem. As long as the differential between the local cash and futures price at the time of sale is predictable, then the sale of a futures contract at planting time with an offsetting purchase of that contract when the crop is sold will be approximately equivalent to selling a portion of the crop for a known price at planting time for delivery at harvest time.

Tomek and Gray distinguish between the stabilizing role of futures markets for non-storable commodities, and the inventory allocation role of futures markets for storage commodities. Hedging potatoes, a non-storable crop, would have substantially reduced the variability in prices received across years. However, use of this same procedure for a storable commodity will not result in this same reduction in price variability. Peck argues that the appropriate measure of price risk reduction through hedging is not the reduction in price variability across years, but rather the reduction in the deviations of the price received at harvest from that price expected at planting time. She argues that before planting a farmer can alter his production if the expected price is unsatisfactory, but once the crop is in the ground he has little recourse. Using Peck's measure of the price risk, futures markets for storable commodities should provide opportunities for price risk reduction as well.

This study examines the effectiveness of several hedging strategies in reducing price risk for a producer of a storable commodity, corn. Both deviations in prices received from average levels and from planting period expectations are measured. Each strategy is evaluated for the relative price risk reduction and the difference in the average price received.

STRATEGIES

As is commonly done in studies evaluating hedging strategies (e.g., Purcell and Richardson, Link, Purcell and Riffe), four general types of hedging strategies are compared. They are (1) no hedging, (2) hedge placed at planting time and held until harvest, (3) hedge placed if placement criteria are met and held until harvest, and (4) hedge placed if placement criteria are met, with the possibility of subsequent lifting, replacement, etc., determined by the placement criteria. Several variations of these strategies are possible. The hedge placement decisions are made using either the forecasts of a predictive time series model or using a technical market signal. Hedge lifting decisions are only made by using the technical signal. A list of the strategies considered is given in Table 1.

Table 1: Hedging Strategies

I.	No hedge
II.	Place hedge at planting and hold until October 15
III.	Hedge and hold with placement determined by technical signal
IV.	Hedge in and out based on technical signals only
V.	Hedge when price forecast signal is given and hold
VI.	Hedge and hold when both a price forecast signal and a technical signal are given
VII.	Hedge in on both technical and price forecast signals and out on technical signals

The technical criteria for either placing or lifting a hedge is based on the activity of two moving averages. In this instance a hedge is placed when a five-day moving average of the price of the relevant futures contract crosses a ten-day moving average of this same price from above. This crossing indicates the halting of an upward market trend. In strategies IV and VII where lifting of a hedge is allowed, the hedge is

---

The authors are, respectively, Research Associate and Assistant Professors at The Pennsylvania State University.

lifted when the five-day moving average crosses the ten-day moving average from below. This signal indicates the halting of a downward market trend. Lifting a hedge in this manner allows the producer to participate in a market rise after having been protected during the fall in the market price. Of course a temporary market correction can signal the lifting of a hedge and then signal its prompt replacement. This "false alarm" increases the cost of the hedge. For this reason it is important to have a signal which is appropriately sensitive with a reasonably prompt signal of a major move, yet gives few "false alarms." For corn, the five and ten-day periods were found most suitable, as they were by Purcell and Richardson.

Strategies V and VI require the use of a price forecast in the hedge placement decision. When the futures price is "too high" relative to the price estimated by the forecast model, a hedge placement signal is given. The signal requires that the futures price be above the forecasted price by at least the standard error of the forecast plus the basis.

The evaluation of the intra-year price risk depends on a comparison of actual prices received with some expected price. Two expected prices are used, the forecasted price and the local equivalent of the futures market price. The first represents a personal estimate of price and contains both basis risk and the risk that these personal expectations are at odds with market expectations. The second price represents market expectations and contains only basis risk if the hedge is placed immediately.

THE FORECASTING MODEL

A Box-Jerkins time series model is used to generate the price forecasts. This model was estimated using monthly corn price data for Pennsylvania (Pennsylvania Crop Reporting Service) for the period June 1973 - February 1981. The model was tested for forecasting ability on data from March 1981 - February 1982. Using methods outlined in Nelson and Anderson and illustrated by Beilock and Dunn, a model was selected from the many possible models. The model chosen was SARIMA $(2, 1, 1) \times (1, 0, 1)_3$, i.e., a first differenced model with two monthly autoregressive terms, AR1 and AR2, one monthly moving average term, MA1, one seasonal autoregressive term, SAR1, and one seasonal moving average term, SMA1, with a seasonal period of three months. The estimated model is

$$P_t = 2.307\, P_{t-1} - 1.653\, P_{t-2} - 0.526\, P_{t-3} + 2.011\, P_{t-4} - 1.441\, P_{t-5} + 0.302\, P_{t-6} + \varepsilon_t - 0.992\, \varepsilon_{t-1} + 0.689\, \varepsilon_{t-4}$$

where P_t is the price in period t and ε_t the error term in period t. The model in SARIMA notation is given in Table 2.

ANALYSIS

The hedging strategies given in Table 1 are applied to the 1975-1980 crop years. For this test it was assumed that the farmer planted his corn crop on May 15 and sold his corn on October 15 each year. The quantity of corn which he chooses to hedge is assumed to be 5000 bushels, therefore requiring one corn futures contract to be sold on the Chicago Board of Trade. The December corn contract was used in the analysis as it is the closest delivery month to the time the cash position is to be liquidated. The total return from the cash position is assumed to be the average monthly corn price in Pennsylvania in October of each year. To account for the costs of hedging, both margin requirements with the appropriate interest cost and brokerage fees are included.

The results of the various hedging strate-

Table 2

Estimated Model for SARIMA $(2, 1, 1) \times (1, 0, 1)_3$

Parameter	Estimate	Standard Error
AR1	1.307	0.102
AR2	-0.346	0.105
MA1	0.992	0.021
SAR1	-0.872	0.029
SMA1	-0.694	0.187

Residual Mean Square 0.0300.
Chi Square for the White Noise Test - 15.68 (19 d.f.)
5% Critical Value-28.87.
Proportion of Total Sum of Squares Explain ($\sim R^2$) - 0.86.

gies are given in Table 3. These results are expressed as the average price per bushel received, net of the costs of hedging, for the inter-year comparisons, and as the difference between the price received, net of the cost of hedging, and the expected price for the intra-year comparisons. In each instance the mean and standard deviation is presented.[1]

As the Peck findings would suggest, less variability is found in intra-year comparisons than in inter-year comparisons. However, the decrease in variability for strategy 2, hedge and hold, is less than the Tomek and Gray study would suggest might be expected. Even when the expected price is the local equivalent of the futures price, the standard deviation of the intra-year comparison is $0.17, compared to $0.29 for the inter-year comparisons. This suggests that the risk associated with variation in the basis is nearly as great as the risk associated with inter-year price variation. Basis risk of this magnitude indicates substantial independence between the local and futures price at harvest.

In all cases hedging reduces price risk relative to the no hedge strategy. A hedge and hold strategy reduces price risk to about 45 percent of the no hedge level on an intra-year basis. However this reduction in price risk is achieved at a cost of $0.09 per bushel in lower income. Other strategies do not require this sacrifice in income to lower the price risk. Strategies IV-VII all have lower price risk than the no hedge strategy with no loss of income. Strategy VII has the highest income level, $0.09 per bushel greater than strategy I, with about 70 percent of the intra-year price risk.

The level of intra-year price risk depends on which forecast is used to measure expected price. The lowest risk occurs when the SARIMA forecast reflects the expected price and this forecast is used to determine when a hedge should be placed (Strategy V).

The trading strategies (IV and VII) both produce higher income, with an intermediate level of risk. In periods of volatility, the moving averages generated several rapid signals, raising transaction costs, especially for strategy IV, which averaged five trades per year. Strategy VII averaged two trades per year.

Overall the hedging strategies provided protection against downward price moves while the crop was in the ground. This alone reduced price risk. Additionally those strategies with controlled placement of the hedge prevented the locking in of a low price in some instances. Unfortunately, basis risk offset some of the market risk reduction from hedging.

CONCLUSIONS

The use of hedging reduced price risk in Pennsylvania corn production substantially. Even using the inter-year comparison of risk, hedging provided a reduction in price risk. This reduction was greater than that suggested by Tomek and

[1] The larger reductions in the variances are statistically different from the no hedge strategy but the large variances and the small sample render price differentials statistically identical. However, the similarity between these results and those of other hedging studies suggest that these price differentials are not coincidental but rather are characteristic of the returns available from these strategies.

Table 3

Results of Simulated Hedging Strategies for Pennsylvania Corn, 1975-1980

	Actual Return		Actual Return Relative to Expected Return			
			SARIMA Forecast		Futures Forecast	
Strategy	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
			Dollars Per Bushel			
I	2.62	0.54	0.20	0.45	0.12	0.37
II	2.53	0.29	0.11	0.20	0.03	0.17
III	2.58	0.42	0.16	0.34	0.08	0.33
IV	2.68	0.43	0.26	0.33	0.18	0.23
V	2.68	0.19	0.26	0.14	0.18	0.28
VI	2.62	0.26	0.20	0.21	0.11	0.33
VII	2.71	0.39	0.29	0.30	0.20	0.27

Gray, probably because the level of stocks relative to production was fairly low over the period studied, making price more dependent on the current year's crop size.

Examination of intra-year price risk indicated a lower level of price risk overall and a greater proportional price risk reduction from the hedge and hold strategy, as suggested by Peck. More complicated strategies provided both risk reduction and income enhancement.

The SARIMA model was an effective tool in implementing these strategies, producing forecasts which revealed situations where the futures price was apparently "too high," and therefore identifying a hedging opportunity.

The study found a relatively large amount of basis risk, nearly as large as the inter-year price variation. This illustrates a little appreciated characteristic of the Pennsylvania corn market, caused by the lack of local grain storage capacity.

At harvest, the local corn crop is used locally to the degree that storage allows and the remainder is exported, either to neighboring states or internationally. Then later in the year when the stored corn is gone, corn is imported to the state (Abshere, Dunn, and Moore). As a result the corn price is determined largely by local conditions during the harvest period, and by national conditions at other times of the year. This has the effect of making the basis risk large when the farmer wishes to hedge and smaller when he does not. Peck used portfolio analysis to show that in such circumstances the farmer would hedge only part of the crop.

A similar circumstance occurs with yield risk. Rolfo shows that when price and quantity forecasting errors are negatively correlated (as they should be with negatively sloped demand curves), hedging is less attractive for a risk averse producer. Since harvest prices are determined largely by local conditions, price and quantity risk are undoubtedly not independent and the farmer would wish to hedge only part of his crop.

The simulations in this study deal only with that portion of the crop which is hedged. The producer must use other criteria such as those in Rolfo, to decide how much to hedge. Once this is determined the results of this study come into play. Although the study is historically based on only a few years, it demonstrates that a variety of methods are available for price risk reduction through hedging. As was found in other studies (e.g., Purcell and Riffe, Brown and Purcell), the use of controlled placement of the hedge generally does not require the sacrifice of income to reduce price risk.

REFERENCES

Abshere, Shaun K., James W. Dunn and H. Louis Moore. "Grain Movements to and From Pennsylvania Grain Handling and Processing Firms, 1977," AE & RS 155, Pennsylvania State University, 1981.

Anderson, O. D. Time Series Analysis and Forecasting: The Box-Jenkins Approach. Boston: Butterworths, 1977.

Beilock, Richard P. and James W. Dunn. "An Application of the Box-Jenkins Approach to Forecasting the Cold Storage of French Fries," Journal of the Northeastern Agricultural Economics Council, 9(1980), 51-54.

Brown, Robert A. and Wayne D. Purcell. Price Prediction Models and Related Hedging Programs for Feeder Cattle. Oklahoma Agricultural Experiment Station Bulletin B-734, January 1978.

Link, William D., Jr. "Quantitative Models to Predict Monthly Slaughter Hog Prices in Conjunction with Related Hedging Strategies," M.S. Thesis, Oklahoma State University, 1976.

Nelson, C. R. Applied Time Series Analysis for Managerial Forecasting. San Francisco: Holden-Day, 1973.

Peck, Anne E. "Hedging and Income Stability: Concepts, Implications, and an Example." American Journal of Agricultural Economics 57(1975) 410-19.

Pennsylvania Crop Reporting Service. Pennsylvania Crop and Livestock Annual Summary, Annually, 1973-1982.

Purcell, Wayne D. and Don A. Riffe. "The Impact of Selected Hedging Strategies on the Cash Flow Position of Cattle Feeders," Southern Journal of Agricultural Economics, 12(1980):85-93.

Purcell, Wayne D. and Thomas W. Richardson. Quantitative Models to Predict Quarterly Average Cash Corn Prices and Related Hedging Strategies. Oklahoma Agricultural Experiment Station Bulletin B-731, December 1977.

Rolfo, Jacques. "Optimal Hedging under Price and Quantity Uncertainty: The Case of a Cocoa Producer," Journal of Political Economy 88(1980) 100-116.

Tomek, William G. and Roger W. Gray. "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles." American Journal of Agricultural Economics, 52(1970), 372-80.