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Pre-Harvest Pricing Strategies in Ohio Corn Markets: Their Effect on Returns and Cash Flow

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ABSTRACT

This paper contributes to the debate on whether pre-harvest pricing strategies can improve returns over cash sales at harvest. It also examines cash flow needs of such strategies. The analysis is conducted for Ohio corn produced from 1986 through 1999. The pre-harvest strategies evaluated (short futures, long put, synthetic long put, put-call fence) did not statistically improve returns over cash sales at harvest. However, if implemented during or before planting, these naïve strategies reduced the standard deviation of annual gross income. Substantial cash flow may be incurred, either to establish the strategy or meet margin calls. Therefore, assessments of pre-harvest pricing strategies should include cash flow needs, along with return and risk.

Key Words: *cash flow risk, pre-harvest pricing strategies, price risk.*

Grain farmers are continually searching for ways to improve returns and manage the risks associated with grain production. Government farm programs traditionally have been important instruments in managing risk. However, the free market orientation of the 1996 farm bill strongly suggests that producers will have to rely more in the future on private markets to manage risk.

Evaluations of pricing strategies have relied on mean-variance analysis to identify an optimal hedging strategy (see, for example Greenhall *et al.*, 1984; Grant, 1987 and 1989, and Lei *et al.*, 1995). While mean-variance analysis of historical data has improved our understanding of pricing returns and risk, it does not recognize the potential impact of another source of risk: cash flow constraints. Limited borrowing capacity, need to borrow to satisfy margin calls when prices move against a position, and/or increased costs of borrowing as credit limits are approached may influence the selection and even prevent the use of pricing strategies.

The objectives of this paper are to determine how the returns from pre-harvest pricing strategies compare to a cash sale at harvest strategy, and to evaluate daily cash flow re-

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quirements necessary to maintain pre-harvest pricing strategies for Ohio corn produced during the 1986 through 1999 crop years. One reason for selecting corn is that weather-related problems, in particular drought, can cause major changes in price. Thus, cash flow need is an important consideration when pre-harvest pricing corn. Second, corn is the largest U.S. crop in terms of acreage and gross value and is a farm program crop affected by farm policy. Third, pre-harvest pricing strategies based on a perceived premium built into futures and options prices during the planting and early growing season have gained increasing acceptance among corn farmers and their marketing advisors. The premium is usually attributed to production uncertainty resulting from unpredictable risks, such as the threat of drought (Wisner, Blue, and Baldwin, 1998). The fact that droughts do not usually happen leads to a strategy of selling part of the crop before harvest. Existence of a pre-harvest premium is a source of considerable debate (see the debate between Wisner *et al.,* 1998, and Zulauf and Irwin, 1998).

The pre-harvest pricing strategies evaluated in this study are short futures, long put, synthetic long put, and put-call fence. The procedures and data used to evaluate the performance of these strategies within the context of the efficient market hypothesis are discussed below, followed by a discussion of the results and their implications.

The Efficient Market Hypothesis

A market is described as efficient if it incorporates all known information in determining price. This definition is usually attributed to Fama (1970, updated 1991), and has come to be known as the *efficient market hypothesis.* Fama's model assumes no transaction costs and costless information, both of which are costs for traders in real-world markets. Grossman and Stiglitz (1980) incorporate the cost of information into a model of price determination and show that it is impossible for prices to reflect all available information perfectly. The implication is that those who have superior access to information and/or superior analytical ability in using information can earn trading profits.

Since Fama's original article, numerous empirical studies have examined the efficient market hypothesis in the context of agricultural futures markets. Zulauf and Irwin (1998) review the literature on the profitability of trading strategies and conclude that returns to trading strategies generally do not exceed the costs of trading. This conclusion is consistent with Grossman and Stiglitz's model, and leads Zulauf and Irwin to conclude that individual traders in agricultural markets can beat the market only if they have superior access to information and/or possess superior analytical ability. They suggest that few crop farmers are likely to possess these characteristics (Zulauf and Irwin, p. 327).

Pricing Strategies

The following frequently used grain pricing strategies were evaluated:

(1) Cash sale of the crop at harvest (no pre-harvest selling).
(2) Pre-harvest selling of harvest futures, i.e. December futures, to establish a price level.
(3) Pre-harvest purchase of December put options to set a minimum price while retaining upward price flexibility. The strike price nearest to the underlying futures price is used. It will be referred to as the *at-the-money strike price.*
(4) A pre-harvest synthetic long put established by selling harvest futures and buying harvest call options at one strike price out-of the-money.
(5) A pre-harvest fence established by purchasing at-the-money harvest put options and selling one strike price out-of-the-money harvest call options. Selling calls generates cash for purchasing the puts.

Because of yield risk, the optimal share of expected production to hedge (i.e., optimal hedge ratio) is less than one. The most commonly investigated pre-harvest crop production hedge when prices and yields are uncertain uses short futures as the hedging instrument. For corn, estimates of pre-harvest optimal short futures hedge ratios are 0.15 for western New York and Central Illinois over 1972–1982 (Greenhall et.al., 1984), 0.67 for counties principally in Iowa and Nebraska over 1964–1983 (Grant, 1987 and 1989), and 0.51 to 0.79 for Iowa over 1990–1992 (Lei *et al.*, 1995). The average of these studies, all involving non-Ohio locations, is 0.44 or 0.54 depending on whether the low or high value from Lei *et al.* is used. For the Ohio counties of Clinton and Henry, Martines-Filho (1996) estimated an optimal short corn futures hedge ratio of 0.43 and 0.56, respectively, over the 1991–1994 period.

Based on these studies, an optimal hedge ratio for short futures of 0.50 was used in this study. The optimal hedge ratio will likely vary by hedging instrument. However, to improve the ability to compare return and cash flow characteristics, the 0.50 hedge ratio was used for all four pre-harvest pricing strategies. In contrast to a 1.00 hedge ratio, a 0.50 hedge ratio reduces substantially the probability that more corn will be contracted before harvest than is ultimately harvested. For this reason, the analysis does not include strategies that incorporate crop insurance. Furthermore, for the county-level observational units used in this study, the largest shortfall in actual yield relative to expected yield was 22 percent during the 1988 drought. No indemnity would have been collected using the crop yield insurance programs consistently available throughout the analytical period. Hence, including the premium to buy yield insurance would reduce the returns to pre-harvest pricing strategies.

Expected production equaled expected yield times 500 acres, where expected yield was the average of the county's yield for the five previous years. To determine the number of futures and options contracts, expected production was divided by 5000 bushels, multiplied by the 0.50 hedge ratio, then rounded to the nearest whole number. Six contracts were used for the 1986 and 1988–1994 crop years. Seven contracts were used for the 1987 and 1995–1999 crop years.

The pre-harvest pricing strategies were implemented naively by following the same trading rules every year. To evaluate the potential importance of time of initiation of a strategy, the pre-harvest strategies were initiated on four dates: the second Thursday of December during the year before harvest and the second Thursdays of February, May, and July during the year of harvest. December of the year before harvest represents a time immediately following the previous harvest, when a few farmers may be developing pricing plans for the next crop year. The second Thursday in February occurs when farmers are making planting decisions. Mid-May and mid-July represent the planting and crucial growing seasons, respectively.

Cash sales were made and pre-harvest strategies were closed out at harvest. Harvest was set at the Thursday of the week during which 50 percent of the Ohio corn crop was reported harvested. This week varied between the third week in October and the second week in November.

Naïve strategies are important to understanding market performance because the efficient market theory provides a strong null hypothesis that naïve strategies should not be profitable. Traders usually employ more complex strategies that involve different combinations of pricing instruments and placement dates, but complex strategies require analysis as well as time to implement and monitor them. These costs should be included in evaluating returns. In contrast, naïve strategies require no analysis and limited monitoring costs.

Calculating Returns and Cash Flow

Because of space constraints, only key parameters used in calculating the gross returns net of futures and options transaction costs and interest costs, as well as the cash flow characteristics of each strategy, are discussed below. The specific formulas used to make the calculations are available upon request from the authors.

Returns and cash flow were calculated for a hypothetical 500-acre farm that is representative of farms in four major grain-producing counties located in three western Ohio crop-reporting districts (Districts 1,4, and 7) and one central Ohio crop-reporting district (District 5). The counties are Henry, Pickaway, Champaign, and Clinton. They are generally representative of production in their crop reporting district. Each county also had local cash price data available for the 1986–1999 study period. This study began with the 1986 crop year because premiums of option contracts traded on the Chicago Board of Trade were not available consistently until the 1986 crop year for all pricing strategies and dates analyzed in this study.

Calculation of the daily cash flow requirements included futures and option transaction costs, margin levels, and interest costs. The latter is a measure of opportunity cost foregone when using borrowed funds to finance a pricing strategy. Transaction costs included brokerage fees and liquidity costs. Based on a survey of commodity futures and option brokers, brokerage fees for a 5000-bushel corn contract were established at $60 per round-trip futures trade and $30 per single-option trade. Liquidity costs are payments earned by floor traders (scalpers) for filling an order to sell at the market. Brorsen (1989) and Thompson and Waller (1987) estimated them to be one price tick (1/4 and 1/8 cent per bushel for corn futures and options, respectively) for nearby contracts and two price ticks for the more lightly traded contracts that are more than five months from delivery. Summing the two components, transaction costs were assumed to be $97.50 per futures contract, $78.75 per put contract, $176.25 for a synthetic long put contract, and $157.50 for a fence contract.

The Chicago Board of Trade Clearing Corporation requires margin deposits on long and short positions in futures markets and short positions in option markets to ensure the financial integrity of both the market and individual participants (Board of Trade of the City of Chicago, 1989, and Edwards and Ma, 1992). Although individual brokers may require additional margin money, the initial cash flow for a pricing strategy was calculated using the initial per-contract margin amount established by the Clearing Corporation. When the Clearing Corporation changed the initial margin requirement, the cash flow account for the pricing strategies was adjusted likewise. Because the Clearing Corporation's initial and maintenance margins were the same for hedgers over the period of this analysis and a farmer in the situation being investigated would be considered a hedger, daily cash flow updates for the short futures positions were calculated using the amount marked-to-the-market. For short option positions the daily cash flow updates were based on whether and by how much the option premium at the close of trading for the day exceeded the premium received on the date the option was sold.

Farmers are assumed to borrow 100 percent of all costs associated with establishing and maintaining a pre-harvest strategy. Based on telephone interviews with agricultural lenders at major banks and agricultural credit institutions in the four counties, interest costs were calculated using the prime rate plus 0.5 percent.

Borrowing costs are assumed to be linear, so that the interest rate does not change as the amount borrowed increases. This assumption is reasonable during years with normal or above-normal growing conditions because the 50-percent hedge ratio substantially reduces the likelihood that the wealth position of the farmer will be negatively impacted by a shortfall in realized production relative to the amount of production hedged. However, when yield-reducing weather events occur nationally, the assumption of linear borrowing costs may not be appropriate. Even with a 0.50 optimal hedge ratio, price increases may be large enough to result in cash flow needs that substantially exceed borrowing parameters. Brorsen (1995) has shown that when nonlinear borrowing costs are introduced Johnson and Stein's theory of hedging becomes invalid. We acknowledge the important impact of nonlinear borrowing costs during wide-spread weather events that reduce national yield. The response of lending institutions in this situation is hard to predict, in part because it will be conditioned on a multitude of factors including the debt-equity position of the farmer. Thus, we do not include nonlinear borrowing costs in our analysis. However, we ask the

Table 1. Per-Acre Gross Return of Selected Pricing Strategies, 500 Acres of Corn, Henry County, Ohio, 1986–1999 Position Established Second Week of December

Measure	Pricing Strategy[1]				
	Short Futures	Long Put	Synthetic Long Put	Put/Call Fence	Harvest Cash
Mean Gross Return[2] ($/acre)	282.18	281.55	279.77	281.25	279.38
Standard Deviation ($/acre)	56.55	57.90	57.41	55.93	61.85
Mean/Standard Deviation	4.99	4.86	4.87	5.03	4.52
Difference from Harvest Cash					
($/acre)	2.80	2.16	0.39	1.86	—
(%)	1.00	0.77	0.14	0.67	—
Significance Test (t-ratio)[3]	0.33	0.52	0.08	0.24	—

[1] Non-harvest cash pricing strategies are to sell 50% of expected production via the pricing instrument plus sell the realized production for cash at harvest. Non-cash pricing strategies are (1) short futures: sell post-harvest December corn futures, (2) long put: buy post-harvest December put with a strike price nearest to the December futures price (i.e., at-the-money put), (3) synthetic long put: sell post-harvest December corn futures and buy post-harvest December call at one strike price higher than the at-the-money strike price (i.e., one strike price out-of-the-money), and (4) fence: buy at-the-money put and sell one strike price out-of-the-money call.

[2] Returns are net of transaction costs and interest cost on money used to establish and maintain the pre-harvest pricing strategy. Transaction costs include brokerage fees for futures and options positions and liquidity costs for initiating and closing out futures and options positions.

[3] Null hypothesis: gross income from pre-harvest pricing strategy minus gross income from harvest cash strategy equals zero.

readers to keep this issue in mind as they assess the analysis.

Data

The 14-year period of 1986 through 1999 allows the testing of pricing strategies that use market-determined option premiums. This time period also includes a wide range of meteorological, economic, and political conditions that producers encounter, such as drought (1988), large price increases driven by tight stocks (1995), and changes in government programs (1985, 1990, and 1996 farm bills).

Local cash price data for Henry, Pickaway, Champaign, and Clinton counties were obtained from ongoing research at The Ohio State University. County yields were collected from Ohio Agricultural Statistics Service annual reports for 1986 through 1999. The *Weekly Weather and Crop Bulletin,* which is jointly published by the U.S. Departments of Commerce and Agriculture, was used to establish the harvest date. Daily settlement prices of the December corn futures contract were obtained from an electronic database maintained by Technical Tools, Inc. Daily options premiums were obtained from the Chicago Board of Trade. Margin requirements for hedgers were obtained from the Chicago Board of Trade Clearing Corporation.

Results

Returns

Only the results for Henry County are presented because of space limitations and the similarity of results among the four locations. Over the 1986–1999 crop years, selling all of the actual production on 500 acres of corn in Henry County, Ohio at the local harvest cash price generated an average per-acre gross return of $279 (Table 1). Average yield was 132 bushels per acre and average cash price at harvest was $2.15 per bushel. Gross return was highest in 1995 at $406 per acre due to the highest cash price at harvest, $3.03 per bushel, observed over the analysis period. Gross return was lowest in 1987 at $167 per acre, as both yield and price were well below normal

Table 2. Per-Acre Gross Return of Selected Pricing Strategies, 500 Acres of Corn, Henry County, Ohio, 1986–1999 Position Established Second Week of February

	Pricing Strategy[1]				
Measure	Short Futures	Long Put	Synthetic Long Put	Put/Call Fence	Harvest Cash
Mean Gross Return[2] ($/acre)	284.37	281.64	280.38	283.02	279.38
Standard Deviation ($/acre)	60.78	59.89	59.87	60.09	61.85
Mean/Standard Deviation	4.68	4.70	4.68	4.71	4.52
Difference from Harvest Cash					
($/acre)	4.99	2.25	0.99	3.63	—
(%)	1.79	0.81	0.35	1.30	—
Significance Test (t-ratio)[3]	0.62	0.57	0.20	0.51	—

[1] Non-harvest cash pricing strategies are to sell 50% of expected production via the pricing instrument plus sell the realized production for cash at harvest. Non-cash pricing strategies are (1) short futures: sell post-harvest December corn futures, (2) long put: buy post-harvest December put with a strike price nearest to the December futures price (i.e., at-the-money put), (3) synthetic long put: sell post-harvest December corn futures and buy post-harvest December call at one strike price higher than the at-the-money strike price (i.e., one strike price out-of-the-money), and (4) fence: buy at-the-money put and sell one strike price out-of-the-money call.

[2] Returns are net of transaction costs and interest cost on money used to establish and maintain the pre-harvest pricing strategy. Transaction costs include brokerage fees for futures and options positions and liquidity costs for initiating and closing out futures and options positions.

[3] Null hypothesis: gross income from pre-harvest pricing strategy minus gross income from harvest cash strategy equals zero.

at 105 bushels per acre and $1.58 per bushel, respectively.

These gross returns do not include any farm program payments (target price deficiency payments, loan rate deficiency payments, market transition payments, etc.), nor do they include the impact of announced acreage set asides. Because these farm program considerations would be the same for all pricing strategies analyzed in this study, their inclusion would not alter the relative performance of the different pricing strategies.

All combinations of pre-harvest pricing dates and pricing strategies generated higher average gross income per acre than the harvest cash sale (Tables 1–4). This occurred because the non-cash part of the pricing strategy generated trading returns above transaction and interest costs. The improvement over harvest cash sale ranged from $0.39 per acre for a synthetic long put placed during the middle of December (Table 1) to $7.59 per acre for a short futures position placed during the middle of May (Table 3). The number of years in which the non-cash part of the pricing strategy produced positive returns ranged from 5 of 14 years for the mid-December synthetic long put to 9 of 14 years for the mid-December, mid-February, and mid-May short futures, as well as for the mid-May synthetic long put and fence.

When averaged across all four pre-harvest pricing dates, the improvement over a harvest cash sale was $1.40 per acre for the synthetic long put strategy, $2.74 per acre for the long put strategy, $4.11 per acre for the fence strategy, and $5.16 per acre for the short futures strategy (Tables 1–4). Thus, the short futures strategy improved gross returns the most. When examined by pre-harvest pricing date, mid-May stands out as having the highest return (Table 3), with improvements over cash harvest sales that ranged from $2.89 per acre for the synthetic long put to $7.59 per acre for short futures. One potential explanation for the mid-May finding is that over the 14 crop years included in this study early season drought scares that did not materialize into reduced yields were especially prominent during the planting season.

While the pre-harvest pricing strategies nominally improved returns over a harvest

Table 3. Per-Acre Gross Return of Selected Pricing Strategies, 500 Acres of Corn, Henry County, Ohio, 1986–1999 Position Established Second Week of May

	Pricing Strategy[1]				
Measure	Short Futures	Long Put	Synthetic Long Put	Put/Call Fence	Harvest Cash
Mean Gross Return[2] ($/acre)	286.98	283.07	282.27	285.39	279.38
Standard Deviation ($/acre)	58.36	59.29	58.38	58.64	61.85
Mean/Standard Deviation	4.92	4.77	4.84	4.87	4.52
Difference from Harvest Cash					
($/acre)	7.59	3.69	2.89	6.00	—
(%)	2.72	1.32	1.03	2.15	—
Significance Test (t-ratio)[3]	1.03	1.05	0.68	0.91	—

[1] Non-harvest cash pricing strategies are to sell 50% of expected production via the pricing instrument plus sell the realized production for cash at harvest. Non-cash pricing strategies are (1) short futures: sell post-harvest December corn futures, (2) long put: buy post-harvest December put with a strike price nearest to the December futures price (i.e., at-the-money put), (3) synthetic long put: sell post-harvest December corn futures and buy post-harvest December call at one strike price higher than the at-the-money strike price (i.e., one strike price out-of-the-money), and (4) fence: buy at-the-money put and sell one strike price out-of-the-money call.

[2] Returns are net of transaction costs and interest cost on money used to establish and maintain the pre-harvest pricing strategy. Transaction costs include brokerage fees for futures and options positions and liquidity costs for initiating and closing out futures and options positions.

[3] Null hypothesis: gross income from pre-harvest pricing strategy minus gross income from harvest cash strategy equals zero.

Table 4. Per-Acre Gross Return of Selected Pricing Strategies, 500 Acres of Corn, Henry County, Ohio, 1986–1999 Position Established Second Week of July

	Pricing Strategy[1]				
Measure	Short Futures	Long Put	Synthetic Long Put	Put/Call Fence	Harvest Cash
Mean Gross Return[2] ($/acre)	284.64	282.23	280.70	284.33	279.38
Standard Deviation ($/acre)	63.20	65.69	64.69	63.38	61.85
Mean/Standard Deviation	4.50	4.30	4.32	4.49	4.52
Difference from Harvest Sales					
($/acre)	5.25	2.85	1.32	4.95	—
(%)	1.88	1.02	0.47	1.77	—
Significance Test (t-ratio)[3]	0.71	0.65	0.27	0.72	—

[1] Non-harvest cash pricing strategies are to sell 50% of expected production via the pricing instrument plus sell the realized production for cash at harvest. Non-cash strategies are (1) short futures: sell post-harvest December corn futures, (2) long put: buy post-harvest December put with a strike price nearest to the December futures price (i.e., at-the-money put), (3) synthetic long put: sell post-harvest December corn futures and buy post-harvest December call at one strike price higher than the at-the-money strike price (i.e., one strike price out-of-the-money), and (4) fence: buy at-the-money put and sell one strike price out-of-the-money call.

[2] Returns are net of transaction costs and interest cost on money used to establish and maintain the pre-harvest pricing strategy. Transaction costs include brokerage fees for futures and options positions and liquidity costs for initiating and closing out futures and options positions.

[3] Null hypothesis: gross income from pre-harvest pricing strategy minus gross income from harvest cash strategy equals zero.

cash sale, the null hypothesis that the improvement equals zero could not be rejected at the 90-percent confidence level for any combination of pre-harvest pricing date and strategy. Thus, from a statistical perspective the pre-harvest strategies did not generate a per-acre gross return that differed from selling the crop for cash at harvest. Furthermore, economic significance of the improved returns is relatively small. When expressed as a percent of the $279-per-acre average gross return from selling corn for cash at harvest, the average improvement across all four pre-harvest dates ranged from 0.5 percent for the synthetic long put strategy to 1.8 percent for the short futures strategy.

A frequently used measure of risk is standard deviation. The focus of this analysis is on the standard deviation of annual per-acre gross return. It equaled $62 per acre for the harvest cash strategy over the 14 years analyzed. For the pre-harvest strategies, this standard deviation ranged from $56 per acre for the mid-December fence to $66 per acre for the mid-July long put. The pre-harvest pricing strategies were superior at reducing the standard deviation of annual gross return if implemented before or during planting, i.e. mid-May. The reduction was especially noticeable for the mid-December pricing date. In contrast, for mid-July standard deviation of the pre-harvest pricing strategies all were higher than the standard deviation of the harvest cash strategy. Because of weather's impact upon potential yield, futures prices are more variable during the early to middle part of the growing season, i.e. June and July (Anderson, 1985). Similarly, depending on whether weather is favorable or unfavorable for yield, the volatility of corn futures prices and, thus, the value of corn options can vary substantially from year to year during June and July. Consequently, returns to pricing strategies involving futures and options are likely to be more variable when the strategies are implemented during June and July rather than before or during planting.

A measure that combines return and risk is the ratio of the average return per acre to the standard deviation of return. Given the previous discussion, it is unsurprising that the mid-December, mid-February, and mid-May pre-harvest pricing strategies have a higher mean-to-standard deviation ratio than the harvest cash sale. For mid-July, the mean-to-standard deviation ratios are either similar or favor the harvest cash sale strategy.

As mentioned previously, this analysis uses naïve pre-harvest pricing strategies that have low transaction, informational, and monitoring costs. While naïve strategies are important tests of market efficiency, traders usually employ more complex strategies that involve combinations of these basic strategies and different placement dates. Of particular note for this study, Wisner *et al.* (1998) argued that different strategies should be employed after a short crop year than after a normal crop year. They find statistically significant profits for corn over the 1979–1996 crop years for some pre-harvest strategies involving only futures and over the 1985–1996 crop years for some pre-harvest strategies involving options.

We examine their strategies within the hedging parameters and data period used for this article. One difference is that Wisner *et al.* sold 100 percent of expected production before harvest, whereas we sold pre-harvest 50 percent of expected production. They used two strike price out-of-the-money call and put options; we used at-the-money puts and one strike price out-of-the-money calls. Last, we used a different procedure to identify short crop years. They identified a short crop year as one with a U.S. average yield that was more than five percent below the linear yield trend over the 1960–1994 period. We identified a short crop year as a year in which U.S. average yield was five percent lower than the one-year, out-of-sample forecast from a linear trend regression of average U.S. corn yields for the previous 20 years. Our procedure, which is out-of-sample and thus consistent with the information available to traders, identified 1988, 1991, 1993, and 1995 as short crop years. For crop years since 1985, Wisner *et al.*'s procedure identified these years plus 1990.

We examine a short futures strategy proposed by Wisner *et al.* because it was significant at the 90 percent confidence level and was the strategy most comparable to those used in this study. Wisner *et al.*'s strategy was following a short crop year, sell futures in the first week of February; following a normal crop year, sell futures during the first week of July. We implemented their pricing strategy by combining our results from the short futures strategy for either the second week of February or July depending on whether the crop year was after a short or normal crop year. Average return for the February–July futures strategy was $5.86 per acre higher than the cash sale at harvest strategy. The t-ratio was 0.90, which is not statistically significant at the 90-percent confidence level. The difference in findings underscores how sensitive trading return results can be to a study's period of analysis, dates on which strategies were placed and lifted, and other analytical parameters.

The corn pricing strategy examined by Wisner *et al.* that had the largest t-ratio, 2.8, was following a short crop year, sell futures for 100 percent of the expected crop in the first week of February; following a normal crop year, buy a $0.20 out-of-the-money put for 80 percent of expected production in the third week of May and sell the remaining 20 percent of expected production using short futures in the first week of July. We examined this strategy but, to increase comparability with the other strategies examined in the present study, we scaled the proportion hedged so that it totaled 50 not 100 percent, used at-the-money puts, and implemented the positions during the second week of February, May, and July. Average return above the cash sale at harvest strategy equaled $7.31 per acre with a t-ratio of 1.91, which is significantly different than zero at the 90-percent confidence level.

Moving beyond naïve strategies found a strategy that generated significant trading returns. However, it is important to remember that trading returns are sensitive to the analytical parameters used, and it is likely that any analysis of a historical period will find at least one profitable trading strategy. Thus, a trading strategy needs to stand the test of time via substantial out-of-sample testing. It also is desirable for any trading returns that are consistently observed to have an explanation based on an economic principle, such as risk reduction. Without this foundation the return is more likely to be viewed as spurious.

Cash Flow

Selling at harvest incurs no cash flow risk relative to pricing before harvest because margin calls, option premiums, brokerage fees, and interest opportunity cost are not incurred. To save space we present the cash flow results only for mid-December and mid-July. The results for mid-February and mid-May generally fall between the results for mid-December and mid-July in large part because the latter two dates are the farthest from and nearest to harvest, respectively.

The focus of this discussion is on the cumulative cash flow from the date the strategy was established, not on the day-to-day changes in the cash flow account. Cumulative cash flow reflects brokerage cost, initial margin, and the cumulative change in price or option premium as well as the interest opportunity cost incurred since the strategy was initiated. Cumulative cash flow at the close of trading on a given day can be thought of as the total amount of cash needed to keep the strategy active for the next trading day. It is an amount that lending institutions and traders monitor intensely. To provide a simple illustration, assume one corn futures contract (5000 bushels) initially was sold at $2/bushel, corn at the close of trading is now $2.20/bushel, brokerage fees were $60/contract, a $500 initial margin was required, and $50 in interest cost on borrowed money has been incurred. Cumulative cash flow through the day is ((($2.00–$2.20) × 5000) – $60 – $500 – $50) or –$1,610. We specifically examine the maximum cumulative cash outflow that occurred between the opening and close dates of the strategy, and the average of all the daily cumulative cash flows.

Even though a pre-harvest pricing strategy earned positive trading returns, its average cumulative cash flow between the initial pricing date and harvest can be negative. This can occur because of the initial cash outflow asso-

Table 5. Average and Maximum Cumulative Per-Acre Cash Flow Requirements for Selected Pre-Harvest Pricing Strategies Entered the Second Week of December, by Crop Year, Henry County Ohio Yields, 500 Acres of Corn, 1986–1999 ($/acre)

	Short Futures		Long Put		Synthetic Long Put		Put/Call Fence	
Crop Year	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]
1986	17.12	(4.93)	(7.23)	(7.49)	12.70	(9.20)	(5.78)	(6.89)
1987	(2.54)	(26.87)	(7.96)	(8.23)	(9.50)	(33.88)	(5.92)	(20.42)
1988	(44.44)	(114.39)	(11.79)	(12.30)	(55.03)	(125.08)	(28.42)	(91.32)
1989	(4.72)	(21.35)	(14.39)	(15.11)	(15.96)	(32.22)	(8.31)	(13.70)
1990	(10.26)	(33.51)	(14.34)	(14.98)	(19.99)	(43.46)	(9.85)	(20.78)
1991	(5.36)	(14.93)	(11.12)	(11.53)	(15.23)	(24.98)	(5.13)	(8.06)
1992	(1.37)	(19.08)	(11.04)	(11.37)	(11.79)	(29.35)	(5.62)	(10.84)
1993	(4.11)	(16.68)	(9.47)	(9.74)	(13.27)	(26.10)	(3.22)	(7.94)
1994	6.43	(12.98)	(13.23)	(13.67)	(1.84)	(21.29)	(8.57)	(14.82)
1995	(23.42)	(61.88)	(11.70)	(12.15)	(31.85)	(70.62)	(16.63)	(47.54)
1996	(31.00)	(81.19)	(15.18)	(15.77)	(43.45)	(93.75)	(21.51)	(58.83)
1997	(11.07)	(29.85)	(13.89)	(14.43)	(23.50)	(42.60)	(10.47)	(21.59)
1998	18.40	(6.79)	(17.82)	(18.70)	4.36	(20.34)	(10.56)	(13.90)
1999	5.98	(7.34)	(14.57)	(15.07)	(4.43)	(17.61)	(10.78)	(14.26)
Average	(6.45)	(30.57)	(12.41)	(12.90)	(16.34)	(42.18)	(10.77)	(25.06)
Stan. Dev.	17.35	31.49	2.93	3.10	18.06	32.62	7.00	24.30

[1] Negative cash balances are reported in parentheses.

ciated with the initial futures margin or option premium and brokerage costs, the cumulative nature of interest expense, the fact that usually prices do not change much until spring, and the random walk nature of price changes unless a major news event occurs.

Examining the results by pricing strategy reveals that either the long put or the synthetic long put had the highest average cumulative cash outflow, except for the mid-July 1994 pricing date (Tables 5 and 6). The short futures strategy never had the smallest average cumulative cash flow for a pricing date because the synthetic long put strategy required the purchase of a call in combination with a short futures position.

For the synthetic long put, short futures, and fence, maximum cumulative cash flow need occurred on June 27, 1988 during the worst growing season drought in the U.S. since the 1930s. It totaled -$125 per acre for the synthetic put, -$114 per acre for short futures, and -$91 per acre for the fence (Table 5). Among these pre-harvest pricing strategies, the synthetic long put consistently had the highest maximum cumulative cash flow need because cash is paid to purchase call options on the initial day of the strategy. The fence's maximum cumulative cash flow need is usually, but not always, the lowest among these three strategies because income is received from selling calls.

For the long put strategy, maximum cumulative cash flow need occurs just before harvest, i.e., at the end of the trading period. The reason is that interest expense is highest at that time, reflecting its cumulative nature. Unlike the other three strategies, no margin calls occur with this strategy. Thus, maximum cumulative cash flow for the long put strategy was substantially lower.

Maximum and average cumulative cash

Table 6. Average and Maximum Cumulative Per-Acre Cash Flow Requirements for Selected Pre-Harvest Pricing Strategies Entered the Second Week of July, by Crop Year, Henry County Ohio Yields, 500 Acres of Corn, 1986–1999 ($/acre)

	Short Futures		Long Put		Synthetic Long Put		Put/Call Fence	
Crop Year	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]	Average Cumulative Cash Flow[1]	Maximum Cumulative Cash Flow[1]
1986	(2.05)	(9.43)	(5.68)	(5.75)	(6.97)	(14.29)	(3.68)	(5.75)
1987	(0.90)	(10.12)	(8.39)	(8.48)	(6.46)	(15.74)	(5.80)	(5.86)
1988	23.55	(10.62)	(24.26)	(24.62)	0.50	(33.33)	(5.67)	(7.04)
1989	2.90	(8.07)	(9.98)	(10.14)	(4.56)	(15.41)	(6.00)	(6.57)
1990	10.25	(6.72)	(9.66)	(9.81)	5.06	(11.88)	(7.89)	(8.01)
1991	(22.95)	(32.32)	(5.98)	(6.05)	(27.79)	(37.13)	(14.27)	(23.44)
1992	9.36	(5.82)	(6.43)	(6.50)	3.46	(11.66)	(3.89)	(4.01)
1993	(1.19)	(10.63)	(9.30)	(9.40)	(9.97)	(19.49)	(3.80)	(4.58)
1994	(2.44)	(7.52)	(7.42)	(7.50)	(5.38)	(10.46)	(7.83)	(8.50)
1995	(12.54)	(33.65)	(13.35)	(13.51)	(22.00)	(43.22)	(8.98)	(18.27)
1996	31.23	(22.37)	(18.36)	(18.63)	12.15	(41.17)	(4.97)	(10.64)
1997	(30.23)	(48.95)	(6.64)	(6.73)	(37.49)	(56.29)	(21.11)	(37.81)
1998	15.42	(6.79)	(11.59)	(11.73)	6.53	(15.52)	(9.16)	(9.65)
1999	(17.92)	(35.79)	(9.45)	(9.55)	(24.45)	(42.30)	(14.19)	(28.06)
Average	0.18	(17.77)	(10.46)	(10.60)	(8.38)	(26.28)	(8.37)	(12.73)
Stan. Dev.	17.32	14.13	5.21	5.29	14.53	15.29	5.01	10.27

[1] Negative cash balances are reported in parentheses.

flow need was lower for mid-July than for mid-December (Tables 5 and 6). This result was expected because interest expense is smaller since the strategy is active for a shorter period. In addition, part of the uncertainty surrounding corn yields is resolved by mid-July and time to expiration is less, resulting in a lower put and call premiums. Nevertheless, maximum cumulative cash flow needs approached or exceeded −$40 per acre for a mid-July synthetic put, short futures, and fence.

The discussion has focused on cumulative cash flow, not the economic value of the strategy. Specifically, it has not considered that the value of a long call increases as price increases. For example, on June 27, 1988, the premium for the long call used as part of the synthetic long put established in mid-December 1987 ($2.10 strike price) was $1.535 per bushel, compared with a purchase premium of $0.16 per bushel. The positive value for a long call does not yield a flow of cash until the long call is sold, but a lending institution may recognize the long call as an asset that can be borrowed against. Thus, they may charge a lower interest rate on loans to cover a large exposure resulting from margin calls on short futures. In this situation the increasing value of corn due to its increasing price also may serve as potential collateral for margin calls. Therefore, it is not clear why a long call would be a superior hedge against cash flow risk, provided the amount of corn contracted does not exceed expected production.

One measure of cash flow risk is the additional cash flow that may be needed to maintain a position after it is established. One indicator of this risk is the absolute difference between the maximum cumulative cash flow and the average cumulative cash flow. Over the 1986–1999 crop years, this average difference was much smaller for the long put strategy than for the other pre-harvest pricing strategies. To illustrate, for the mid-December pricing date, per-acre average absolute difference between the maximum cumulative cash flow and the average cumulative cash flow was \$26 for the synthetic long put strategy, \$24 for the short futures strategy, \$14 for the fence strategy, and less than \$1 for the long put strategy.

Standard deviation of the maximum cumulative cash flow, a measure of cash flow risk across crop years, also was substantially smaller for the long put. To illustrate, using the pricing date with the smallest range, mid-July, standard deviation of the maximum cumulative cash flow was \$15 per acre for the synthetic long put, \$14 per acre for short futures, \$10 per acre for the fence, and \$5 per acre for the long put.

The lower cash flow risk of the long put strategy occurred because it was the only pre-harvest pricing strategy not subject to margin calls. However, to obtain this lower cash flow risk, the full purchase price of the put must be paid up front.

Conclusions

For the 1986–1999 corn crops in the four Ohio counties analyzed in this study, naïve pre-harvest short futures, long put, long synthetic put, and put/call fence pricing strategies improved average gross income per acre compared with the strategy of selling in the cash market at harvest. For Henry County, the county discussed in this article, the largest average improvement was \$7.59 per acre for a short futures position placed during the middle of May. The smallest average improvement was \$0.39 per acre for a synthetic long put position placed during the middle of December. For most pre-harvest pricing dates and strategies, return increased by \$5.00 per acre or less. As a comparison, average gross return from selling corn for cash at harvest was \$279 per acre. Thus, economic magnitude of the increased return was relatively small. Furthermore, the increased returns were not different statistically from zero at the 90-percent confidence level. Thus, from a statistical perspective, the pre-harvest strategies did not generate a per-acre gross return that differed from selling for cash at harvest.

The cash outflow incurred by pre-harvest pricing strategies can be substantial, especially when price increases rapidly during a short crop year. For example, even when using an optimal hedge ratio of 50 percent of expected production, cash outflow during the drought of 1988 approached and exceeded \$100 per acre for the short futures, long synthetic put, and put/call fence due to margin calls on futures and short option positions. The long put strategy substantially reduces cash flow risk resulting from pre-harvest pricing, but to obtain the lower cash flow risk the full premium of the long put must be paid up front.

The naïve pre-harvest pricing strategies did reduce the standard deviation of annual returns provided the strategies were implemented before or during planting. The use of futures markets by short hedgers to reduce the risk of return is conventionally associated with a market situation referred to as normal backwardation (Keynes, 1930). In normal backwardation prices tend to rise over the life of a futures contract, leading on average to trading losses for short hedgers as they pay long speculators for assuming their price risk. Even though the returns to the naïve pre-harvest pricing strategies investigated in this study are not economically large nor statistically different from zero, the existence of positive returns in the presence of a lower risk of return for short hedges implemented before and during planting is interesting and calls for additional research. It is possible that the increased cash flow risk associated with pre-harvest pricing strategies compared with the sale cash at harvest strategy may explain the observed positive returns in the presence of a lower risk of return.

Two strategies proposed by Wisner *et al.* (1998) were investigated to examine their argument that different strategies should be used after a short crop year than after a normal crop year. Wisner *et al.* (1998) found that both strategies produced significantly higher returns than selling for cash at harvest, but only one of the strategies produced significantly higher returns in this study despite a substantial overlap in analytical periods. While additional analysis of the strategies proposed by Wisner *et al.* (1998) is warranted, the findings of this study raise caution. Thus, in general, the results of this study support the traditional implication from the market efficiency literature that pre-harvest pricing is unlikely to increase returns without the ability to time the market successfully. Few farmers are likely to possess this skill.

In summary, the findings of this study suggest that reducing the risk of return is probably a greater incentive for pre-harvest pricing than is revenue enhancement. However, the potential magnitude of the cash outflow needed to maintain a pre-harvest pricing strategy implies that, along with measures of return and risk of return, measures of cash flow risk should be explicitly incorporated into assessments of pricing strategies being considered by producers and analyzed by academics.

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