Multiple-Year Pricing Strategies for Corn and Soybeans

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INTRODUCTION

Grain producers are faced with difficult forward pricing decisions every growing season. With large price volatility in major crops like corn and soybeans, the timing of hedging decisions can be crucial. Occasionally, futures prices are driven to historically high levels. These extremely high prices can be valuable pricing opportunities for grain producers. Figures 1 and 2 plot closing futures prices for December corn and November soybeans from 1980–1995. These plots show that the high prices associated with the droughts of 1980, 1983, and 1988 were followed by several years of lower prices. If producers could lock in prices at these high levels for several years' production, the possibility for substantial profits would exist.

The objective of this study is to analyze multiple-year pricing opportunities for corn and soybeans. Only two articles on multiple-year pricing, Huang, Turner, and Houston (1994) and Kim and Conley (1995), are available. This study extends earlier research on multiple-year pricing by including options and cash contracts, by using current yield expectations to determine entry prices, and by considering margin calls associated with futures positions. The trade-offs among average price, price variation, premium expenses, and margin calls are examined. Multiple-year pricing strategies will be important to producers in the future because the 1996 farm bill removed target prices for feed grains, wheat, and cotton.

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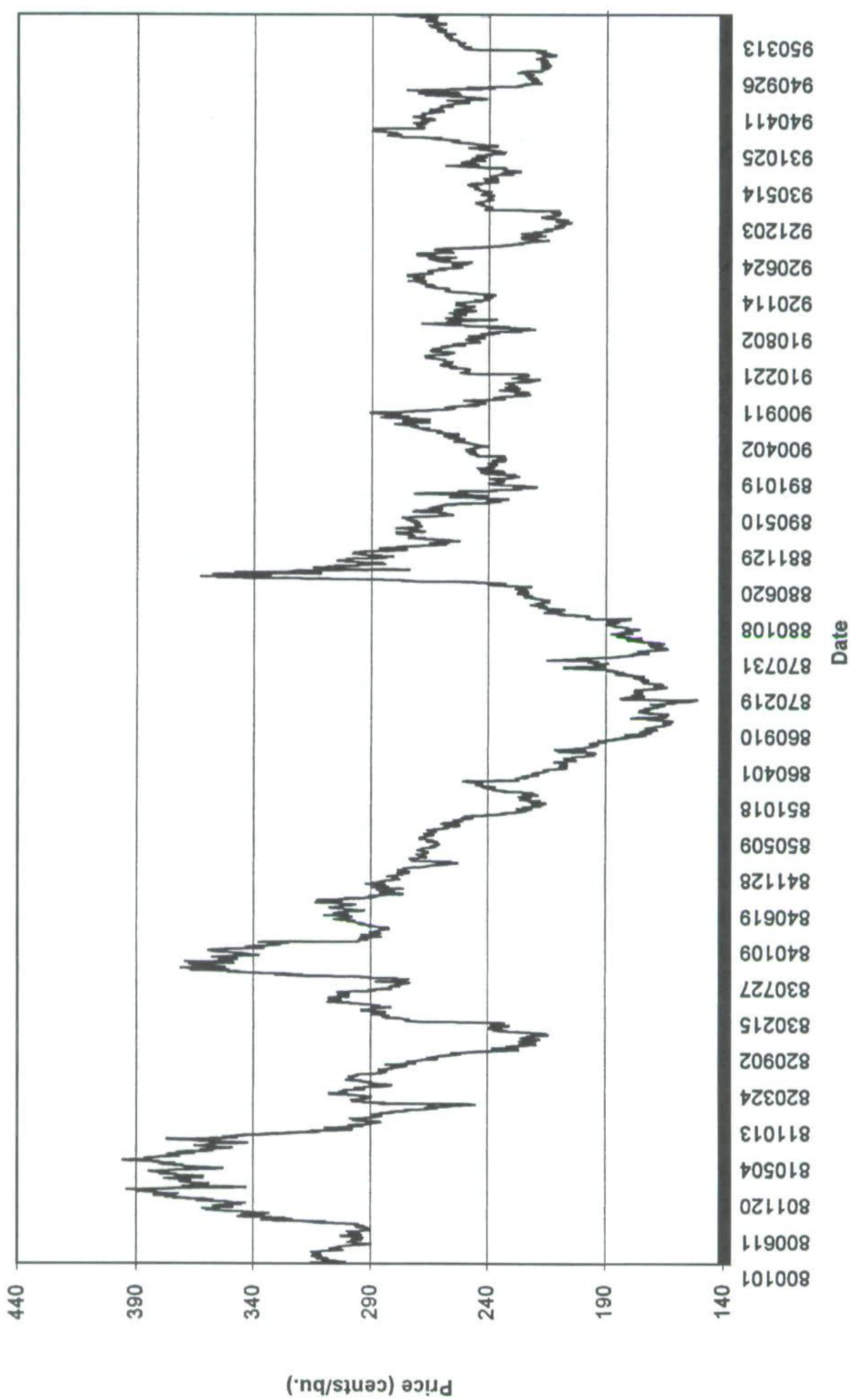

FIGURE 1
December corn futures.

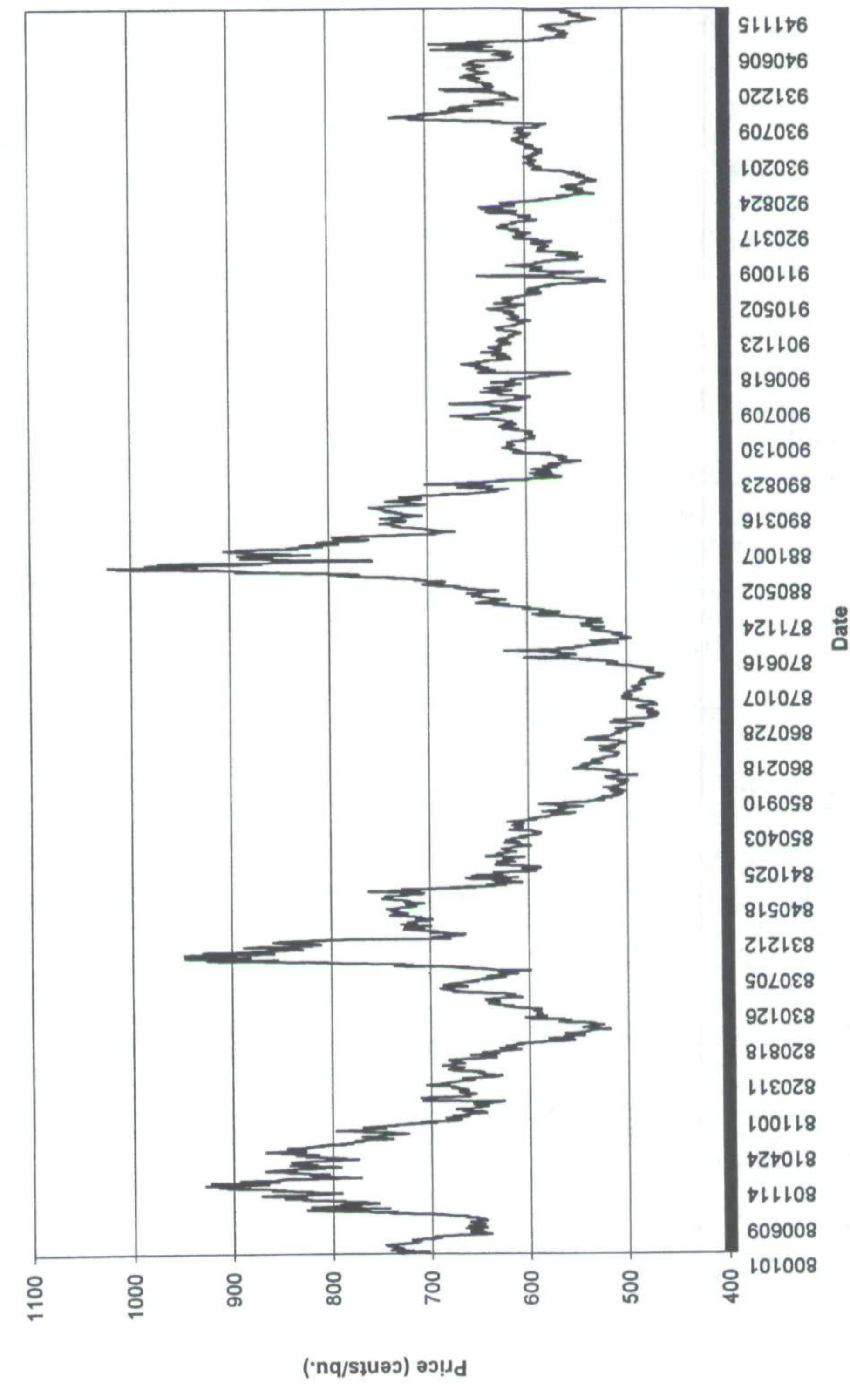

FIGURE 2
November soybean futures.

PREVIOUS RESEARCH

Gardner (1989) examined the possible consequences of not having a long-term futures market by evaluating the effectiveness of rollover hedging for locking in a price and thus increasing producer returns. He found the mean effective hedged price for sequential 3-year rollover hedges were lower than prices locked in annually for corn and soybeans for years 1972–1987. However, Gardner's initial hedges were performed without regard to price level.

Huang et al. (1994) extended Gardner's concept of rollover hedging by assuming a producer would hedge long term only if prices were favorable. Favorable prices were identified as prices in the upper tail of a historical futures price distribution. They used a 7-year window in which upper-tail percentages for a given year were determined from a 7-year historical distribution. Expected returns for corn, soybeans, and feeder cattle were computed for 3-and 5-year hedges for 1982–1991. The upper-tail percentage was set at 7.5% for corn, 2.5% for soybeans, and 5.0% for feeder cattle. The 3-year hedges resulted in a \$0.40 per bushel increase over routine annual hedging for corn, a \$0.56 increase for soybeans, and a \$4.46 per cwt decrease for feeder cattle. The 5-year hedges resulted in a \$0.41 per bushel increase for corn, a \$0.69 increase for soybeans, and a \$3.51 per cwt decrease for feeder cattle.

Kim and Conley (1995) examined long-term hedging possibilities for corn, soybeans, and wheat from 1973 to 1992. Historical price distributions were generated for December corn, November soybeans, and September wheat. Multiple-year hedges were executed at the top 5, 10, 30, and 50% levels over periods of 2–4 years. The highest return strategy for corn, soybeans, and wheat all resulted from executing a 4-year hedge. For corn, the highest returns were obtained from a 4-year hedge when prices reached the top 30% of the 1987–1990 distribution. For soybeans and wheat the highest prices were obtained at the 10 and 5% levels, respectively, using a 4-year hedge.

THEORETICAL FOUNDATION

The lagged effects of supply and demand changes contribute to the basic foundation for a multiple-year pricing strategy. In times of historically high prices, grain producers will increase planted acres to take advantage of the high prices. In addition, if ending stocks are low, or expected to be low relative to previous years, the government will encourage more production by loosening acreage restrictions. In fact, set-aside levels in the 1990 farm bill were tied to ending stock levels. As the ending stocks-to-use ratio declines, the government attempts to increase production by lowering set-aside requirements. The combination of higher prices and lower set asides increases planted acres after a high-price year. The amount of actual production increase in the next year depends upon weather conditions.

The year following high prices, if producers have planted more and yields return to normal levels, a large crop is produced and prices decline. Usage, which was lowered during the previous high-price year, increases in response to lower prices. But expansion of livestock and poultry feeding takes time. Hence, production increases faster than use, so ending stocks increases. With a larger supply on hand, and normal acreage and yields, prices will likely decline further in the following year. Because of these response lags, there is a strong probability that historically high prices will be followed by 1 or 2 years of lower prices. These response patterns between price, acreage, use, and ending stocks are documented by Beckman (1995).

A major assumption involved with a multiple-year strategy is that prices will continue to fluctuate within a range similar to those of previous years. In 1972–1973, the corn and soybean markets underwent a significant structural change when exchange rates switched from fixed to floating, the Soviet Union began buying grain in the world market, and U.S. farm programs were changed substantially. These changes dramatically increased the price level and variability of both corn and soybeans. Season average prices doubled within 2 years and a new level of prices was established. This type of structural change would violate the premise of a multiple-year strategy based on historical price distributions. For instance, if a 3-year pricing strategy had been executed in the summer of 1972, large losses would have resulted from any positions held in the futures markets. Options can now be utilized by producers wanting to avoid risk associated with a structural change in price level.

DISTRIBUTIONS

The first step in developing the multiple-year pricing strategies is to determine the historical futures price distributions. The daily closing futures prices for December corn and November soybean contracts are used for 1974–1993. These prices are used to determine the historical distribution of prices for these two contract months. Distributions are generated based on previous prices for each year from 1980 through 1993. For example, the 1980 distributions are based on futures prices from 1974 to 1979. In each subsequent year, an additional year of futures prices is added to the previous distribution. Some might argue that a moving window of historical prices should be used to reflect more current economic conditions, but careful inspection of December corn and November soybean prices since 1974 indicates no trend in prices or price variability.

Table I reports summary statistics for the futures price distributions. The means and standard deviations of the historical distributions have not changed much over the last 15 years. The tables report the exact futures prices associated with the top 5, 10, and 15% levels of historical distributions. These prices have remained relatively constant over time and are used in conjunction with price forecasts based on estimated yields to trigger the multiple-year strategies.

YIELD EQUATIONS

Analysis of historical prices and research by Kenyon, Jones, and McGuirk (1993) indicate that the highest futures prices have historically been caused by weather conditions that reduced yields during the growing season. Therefore, models are developed with the use of annual data from 1974–1992 to predict the high futures price for both December corn and November soybeans. The high price is defined as the highest closing price from the 10th of May until contract expiration. May 10 corresponds with USDA's first release of yield expectations each year.

The high price prediction models take the form

$$\mathrm{HGHFUT}_t = \beta_0 + \beta_1 \mathrm{DEV}_t + \beta_2 \mathrm{MAYFUT}_t + \mu_t \tag{1}$$

where

HGHFUT = High closing futures price for December corn or November soybeans between May 10th and contract expiration in year t

DEV = Yield deviation from trend-line yield estimate in year t

MAYFUT = Closing price of December corn or November soybeans futures on May 10 in year t

The May 10th futures prices reflect current supply and demand information. Large movements in the futures price after May 10 are largely related to unexpected changes in yields compared to trend-line yields. Trend-line yields are estimated from out-of-sample linear regressions. The trend-line yield estimates start in 1974, based on historical yields from 1959 to 1973. The 1993 trend-line yield is based on historical yields from 1959 to 1992.

TABLE I

December Corn and November Soybean Futures Price Distributions, 1980–1994

							Price Asssociated Top		
Year	*Contracts Included*	*No. of Observations*	*Mean*	*Std dev*	*Max*	*Min*	*5%*	*10%*	*15%*
			December Corn						
1980	1974–1979	1930	$2.65	$0.36	$3.95	$1.91	$3.46	$3.12	$2.91
1981	1974–1980	2256	2.73	0.40	3.95	1.91	3.57	3.37	3.14
1982	1974–1981	2582	2.82	0.46	3.96	1.91	3.72	3.58	3.46
1983	1974–1982	2905	2.81	0.45	3.96	1.91	3.70	3.55	3.41
1984	1974–1983	3252	2.84	0.45	3.96	1.91	3.68	3.55	3.43
1985	1974–1984	3614	2.84	0.43	3.96	1.91	3.66	3.52	3.38
1986	1974–1985	3983	2.82	0.42	3.96	1.91	3.64	3.50	3.33
1987	1974–1986	4352	2.75	0.47	3.96	1.51	3.62	3.47	3.23
1988	1974–1987	4721	2.68	0.51	3.96	1.51	3.61	3.45	3.18
1989	1974–1988	5090	2.66	0.51	3.96	1.51	3.60	3.43	3.15
1990	1974–1989	5499	2.65	0.50	3.96	1.51	3.58	3.39	3.12
1991	1974–1990	5912	2.64	0.48	3.96	1.51	3.57	3.35	3.09
1992	1974–1991	6323	2.63	0.47	3.96	1.51	3.56	3.29	3.05
1993	1974–1992	6737	2.62	0.46	3.96	1.51	3.55	3.23	3.03
1994	1974–1993	7183	2.61	0.45	3.96	1.51	3.53	3.19	3.01
			November Soybeans						
1980	1974–1979	1697	$6.28	$0.85	$9.49	$4.67	$7.66	$7.28	$7.15
1981	1974–1980	2001	6.46	0.93	9.49	4.67	8.11	7.60	7.39
1982	1974–1981	2311	6.64	1.00	9.49	4.67	8.37	8.12	7.72
1983	1974–1982	2617	6.62	0.97	9.49	4.67	8.34	8.00	7.63
1984	1974–1983	2942	6.64	0.99	9.49	4.67	8.43	8.14	7.68
1985	1974–1984	3283	6.67	0.95	9.49	4.67	8.39	8.04	7.60
1986	1974–1985	3630	6.59	0.95	9.49	4.67	8.35	7.91	7.51
1987	1974–1986	3975	6.46	0.99	9.49	4.67	8.32	7.82	7.46
1988	1974–1987	4321	6.36	1.02	9.49	4.63	8.28	7.71	7.41
1989	1974–1988	4667	6.40	1.07	10.22	4.63	8.38	7.91	7.48
1990	1974–1989	5059	6.44	1.05	10.22	4.63	8.35	7.83	7.46
1991	1974–1990	5451	6.41	1.01	10.22	4.63	8.31	7.73	7.42
1992	1974–1991	5840	6.39	0.99	10.22	4.63	8.28	7.67	7.39
1993	1974–1992	6231	6.35	0.97	10.22	4.63	8.26	7.62	7.37
1994	1974–1993	6654	6.34	0.94	10.22	4.63	8.22	7.57	7.30

After May 10, USDA's estimated yield is compared to the estimated trend-line yield to determine the deviation from trend (DEV). The DEV and May 10 futures price are used to forecast the high futures price. A new price forecast is generated each month after USDA's release of a new yield estimate.

Equation (1) is estimated each year based on all previous years' data, with 1974 being the first observation. For example, in 1988, the equation is based on data from 1974 to 1987. The ordinary least-squares estimate based on data from 1974 to 1992 for corn is

$$\begin{array}{lll} \text{HGHFUT}_t = 0.591 & - \underset{(-5.45)}{0.028}\ \text{DEV}_t & + \underset{(4.92)}{0.893}\ \text{MAYFUT}_t \\ \text{DW} = 1.06, & \text{SER} = 0.294, & R^2 = 0.756 \end{array} \tag{2}$$

and the estimated equation for soybeans is

$$\begin{array}{lll} \text{HGHFUT}_t = 4.21 & - \underset{(-6.83)}{0.357}\ \text{DEV}_t & + \underset{(2.86)}{0.533}\ \text{MAYFUT}_t \\ \text{DW} = 1.77, & \text{SER} = 0.655, & R^2 = 0.789 \end{array} \tag{3}$$

A series of misspecification tests for normality, functional form, homoskedasticity, parameter stability, and independence outlined by McGuirk, Driscoll, and Alwang (1993) are performed on eqs. (2) and (3). Under the null hypothesis that the linear model assumptions are appropriate, there are no statistically significant departures at the 5% level of significance for each individual test. However, the Durbin–Watson test for autocorrelation in the corn equation is inconclusive. The estimated parameters have the expected signs and are statistically significant at the 1% level.

According to the estimated corn equation (2), if corn yields decrease by one bushel below trend-line yields, the December corn futures high price increases by \$0.028 a bushel. For soybeans, if yields decrease by one bushel below trend-line yields, the November soybean futures high price increases by \$0.36 a bushel.

In the drought of 1988, corn yields were nearly 36 bushels below the forecast yield, sending December corn futures to a high of \$3.63. The high price forecast by the corn model was \$3.57. In the same year, soybean yields were nearly six bushels below the trend-line yield and November soybean futures reached a high price of \$10.22. The high price forecast by the soybean model was \$9.98.

PRICING PROCEDURES AND INSTRUMENTS

The producer is assumed to produce 5,000 bushels of corn or soybeans each year. The multiple-year strategies involve one futures, options, or cash contract for each of the three crop years. For example, assume the strategy is initiated for corn using only futures in July 1995. The producer would sell three December 1995 contracts. At harvest in 1995, the three December 1995 contracts would be offset, and two December 1996 contracts would be sold. At harvest in 1996, the two December 1996 contracts would be offset, and a December 1997 contract would be sold and then offset at harvest in 1997.

The most significant risk associated with multiple-year strategies is potential margin calls. Strategies utilizing cash contracts in the first year of pricing are included to help reduce margin-call risks. When a cash contract is used for the first year, two futures contracts are sold at strategy initiation in year one to cover the second and third years. At harvest of the first year, the cash contract is satisfied by delivery and the two futures contracts are rolled over to the second year. At harvest of the second year, the two contracts are purchased and one contract is rolled over to the third year.

The use of put options can lower or eliminate margin-call risk. But most options are only traded for 6–8 months into the future. To perform a 3-year strategy with the use of options, twice as many transactions are necessary. At harvest of the first year, a put option for maturity at harvest of the second year is not available. Therefore, at harvest, May options are purchased to serve as a bridge until harvest month options become available. On April 1, the May options are sold and harvest month options are purchased.

In order to limit the number of strategies while allowing for a substantial analysis of the trade-offs between cash, futures, and options contracts, one multiple-year period is selected. The historical futures plots in Figures 1 and 2 indicate that high-price occurrences are followed by at least two years of lower prices. Huang et al. (1994) found no statistical difference in returns for 3- versus 5-year multiple hedges. Kim and Conley (1995) found 3-year multiple hedges for corn and 4-year multiple hedges for soybeans generated the highest average returns when comparing 2-, 3-, and 4-year multiple hedges. For these reasons, a multiple-year period of 3 years is selected.

Seven strategies that use various combinations of futures, options, and cash contracts are evaluated. The cash contracts and options are used to reduce the magnitude of potential margin calls. Options are also used to investigate the costs associated with using them to avoid the risks associated with a structural price change in the future.

STRATEGY IMPLEMENTATION

The strategies are initiated on November 7 for corn and December 7 for soybeans. The historical price distribution is used as the only price trigger until May 10. Depending upon the strategy, if distant December corn or

November soybean prices trade in the top 5, 10, or 15% of the historical distribution before May 10, then the multiple-year pricing strategies are executed.

May 10 represents the first release by USDA of production information. From harvest until the following May the supply from the recent harvest is known and demand is uncertain. The price trigger for this time period is established at a high level. Unless prices are exceptionally high before the growing season begins, the multiple-year strategies should not be implemented, because the highest prices have historically been associated with lower-than-normal yields, which occur in the summer or early fall.

After May 10, the trigger price is the higher of the historical distribution percentage price and the high futures price forecast. If December corn or November soybean futures trade above the trigger price, the strategy is implemented. Because the equation price forecast is frequently less than the actual high price, some strategies use the forecast high price plus one forecast standard error.

Each strategy includes a safety-net provision to assure that in the event the model has overpredicted the high price, a price in the upper portion of the futures price distribution will be established. The safety-net price is the forecast price minus one forecast standard error. If futures prices close below the safety net price, then the strategy is executed.

Figure 3 illustrates how the trigger price mechanism works, with 1988 used as an example. Starting on December 7, 1987, the 5, 10, and 15% trigger prices are computed based on historical November futures prices for the 1974–1987 contracts. From the strategy initiation date until May 10, the only trigger is based upon these historical price levels. The strategies are only implemented if prices close above the trigger price for each specific strategy. After May 10, the trigger price is the higher of the historical distribution price and the model forecast price. For example, the 15% distribution cutoff price was $7.41 per bushel, but the model forecast on May 10 was $7.60 per bushel. The trigger price is $7.60 per bushel, and the strategy would be implemented on May 16, 1988, when November 1988 futures closed at $7.77.

The 5% trigger price in 1988 was $8.28 per bushel before May 10. On May 10 the price forecast is below $8.28, so the trigger price remains at this level. But for strategies that include the price forecast plus one standard error of regression, the model forecast is $8.32 per bushel, and this higher forecast price becomes the trigger. Strategies with this price trigger would have been executed on June 2, 1988, when November 1988 futures closed at $8.34 per bushel.

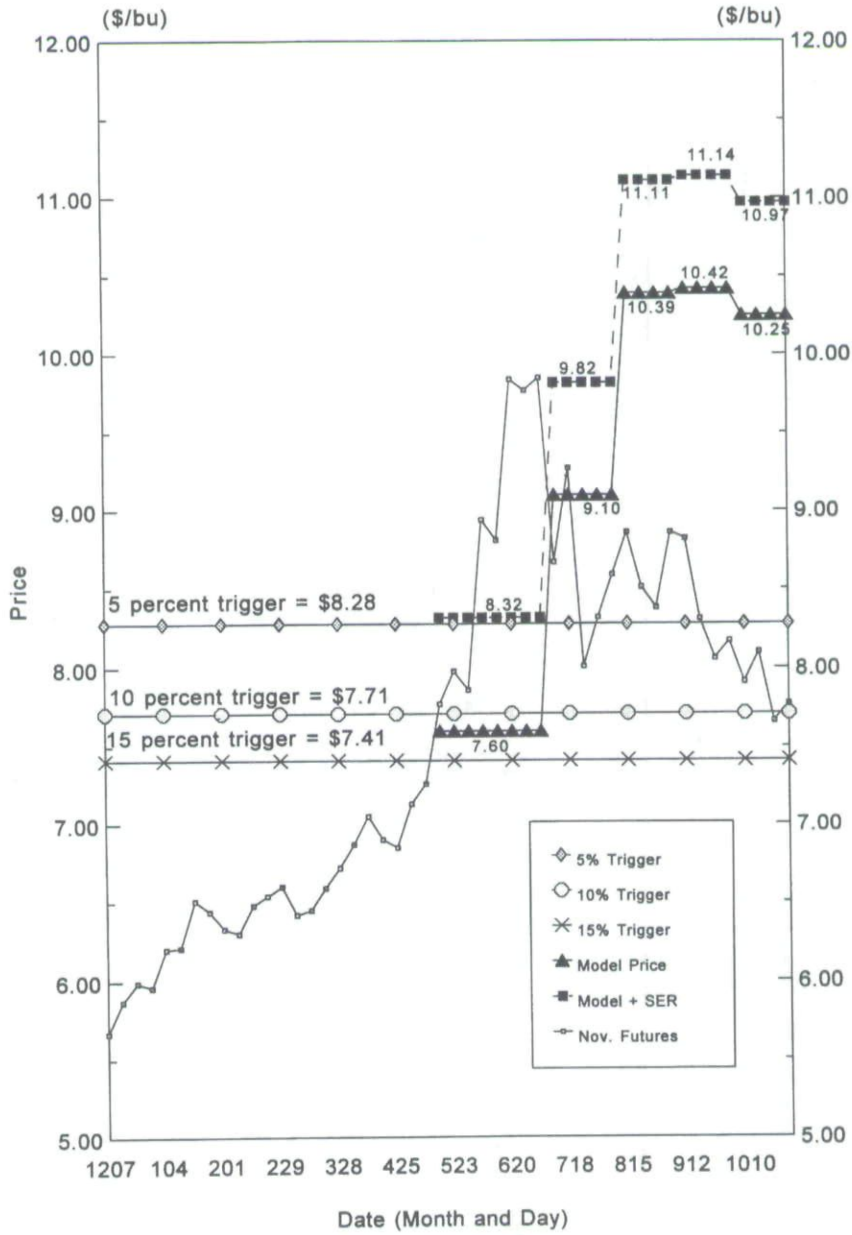

FIGURE 3
November 88 soybean futures, trigger prices, and model forecasts.

Figure 3 demonstrates how the model price forecasts change with each release of new USDA yield estimates. In 1988, the May and June yield estimates were identical, but the July 12 estimate was 29.7 bushels per acre, which was 2.5 bushels below the trend-line yield. As a result, the model price forecast increased to \$9.10 per bushel. Obviously, the futures market had anticipated this reduction in yields before July 12 indicated by November 1988 futures prices above \$9.00 starting on June 15. In practice, producers may want to raise their trigger prices in response to reports of lower yields with the use of the model equations. But for research purposes, the trigger price is only changed after the official USDA estimate is released.

STRATEGY IDENTIFICATION

The 3-year strategies involve three components—the historical distribution trigger prices (5, 10, and 15%), three pricing instruments (cash contract, futures, and options), and the model price forecasts after May 10. Forty-two 3-year pricing strategies are evaluated with the use of combinations of the above three components. The strategies are identified with the use of six fields. The first two fields represent the 5, 10, and 15% trigger prices. The next three fields represent the instrument used to price the first, second, and third year of the multiple-year strategy. They are coded as cash contracts (K), futures (F), and options (O). The last field is reserved for the model price forecast. A 0 indicates the model price forecast, whereas a 1 indicates the model price forecast plus one standard error of regression.

With the use of this identification system, the code 05FFF1 means a 5% trigger price until May 10, with the use of futures contracts to price each year. After May 10, the trigger price is the higher of the 5% price and the model price forecast plus one standard error, indicated by the 1 in space six. The code 15KOO0 has the following interpretation. The trigger price until May 10 is set at 15%. If pricing occurs, price the first year with a cash contract (K) and the second and third years with put options (O). After May 10, the trigger price is the higher of the 15% price and the model price forecast represented by 0 in space six. All of these strategies include the safety-net provision discussion earlier.

The multiple-year results are compared to three different base strategies. The first is routine annual hedging with the use of futures contracts. December corn and November soybean contracts are sold on April 15 of each year and bought back at harvest, which is assumed to be September 15 for corn and November 1 for soybeans. These dates also serve as rollover dates for the multiple-year strategies. The annual routine hedges on April 15 are identified by the code F4/15. The second base strategy is an annual futures hedging strategy that uses multiple-year strategy triggers. These strategies highlight the differences between pricing one versus 3 year's crops while keeping the rules for entering positions the same. These strategies are coded the same as the 3-year strategies. For example, 05F1 means use a 15% trigger price until May 10, price 1 year with the use of futures, and use the higher of that 5% price and model forecast plus one standard error after May 10. The third base strategy, identified as CASH, uses cash sales at harvest.

Futures prices may trade between the trigger price and the safety net price, but never close above the trigger or below the safety net price before harvest. In such cases, the first year's production is sold in the cash market, and the second and third years of the strategy are initiated on the rollover dates. Once a 3-year strategy is executed, no new additional positions are taken in the market for 3 years for the 5,000 bushels for each year that are already priced. This does not preclude other pricing arrangements or pricing additional production, but these are not considered in this research.

STRATEGY PRICE EQUATIONS

To evaluate the pricing strategies, a series of equations are developed to calculate the prices producers would receive each year under each strategy. For Year 1 the net price received (NPR_1) is equal to the initial futures (options) prices minus transaction costs (TC_1). For Year 2, the NPR_2 is equal to NPR_1 plus the gains or losses in Year 2 minus TC_1 and TC_2. For Year 3, the NPR_3 equals NPR_1 plus NPR_2 plus any gains or losses in Year 3. A zero basis is assumed. Including basis estimates would affect all the prices across all strategies equally, so the ranking of the pricing strategies is not changed by assuming a zero basis.[1] Cash contract prices are assumed to be available at 5 cents per bushel less than the futures price on the day contracting occurs. All option strike prices are closest to their current respective futures contract price.

Prior to 1984, no options were traded on agricultural futures. Therefore, to evaluate the strategies using options, put premiums need to be estimated for transactions executed before 1984. To accomplish this, the Black commodity option pricing model is used. All put option premiums used in the rollover strategies are estimated with the use of the Black

[1]This approach eliminates basis risk and hence underestimates the risk associated with these strategies.

model. Volatility is estimated with the use of prices from the previous 21 days. A comparison of actual versus estimated premiums for 32 corn and soybean put options during 1991–1993 produces an average absolute error of 2.6 cents per bushel and a maximum error of 9 cents per bushel. Fifty percent of the estimated premiums are within 2 cents of the actual premium, and 88% are within 5 cents. Premium errors of this magnitude should not affect the rankings of the various strategies.

CORN STRATEGY RESULTS

The strategy rules are used in an out-of-sample analysis of years 1980–1992. The 3-year strategies are implemented in 1980, 1983, and 1988. The average and standard deviation of net price by strategy are reported in Figure 4. The efficient frontier strategies are identified by a line. The cash strategy has the lowest price and next to the smallest standard deviation. Pricing each year on April 15 with the use of futures (F4/15) has the lowest standard deviation. All of the 3-year strategies have average prices \$0.10–\$0.31 above the 1-year strategies with the use of the same trigger prices. The 3-year strategies on the frontier (highest price for a given standard deviation) have average prices approximately \$0.30 above 1-year strategies with a similar standard deviation. Paired t tests for equal means between 15F0 and 10FFO0, 10F0, and 10KFF0, and 05F0 and 05FFF0, indicate all these pairs are statistically different at the 10% level.

The strategies on the frontier use primarily futures and cash contracts. Only two strategies, 05FFO0 and 05FFO1, use options in the third year. These two strategies only improve average price by 2 and 3 cents compared to all futures or cash contract and futures combined strategies. Based on average price and standard deviation of price, futures appear to be the preferred instrument for corn.

Analysis of strategy initiation dates and prices in 1980, 1983, and 1988 indicate the corn model price forecasts do not improve the average price at which the strategies are initiated. In 1980, the 10 and 15% strategies are initiated in November 1979, when the trigger prices are exceeded. The 5% strategy is initiated in August 1980 via the safety net price. In 1983, the December futures prices never reach the forecast price levels. The strategies are entered via the safety net price on the day before harvest. In 1988, the forecast prices are below the three trigger price levels in June when the strategies are initiated. Hence, the corn yield equation price forecasts do not improve the entry price level for the 3-year corn strategies.

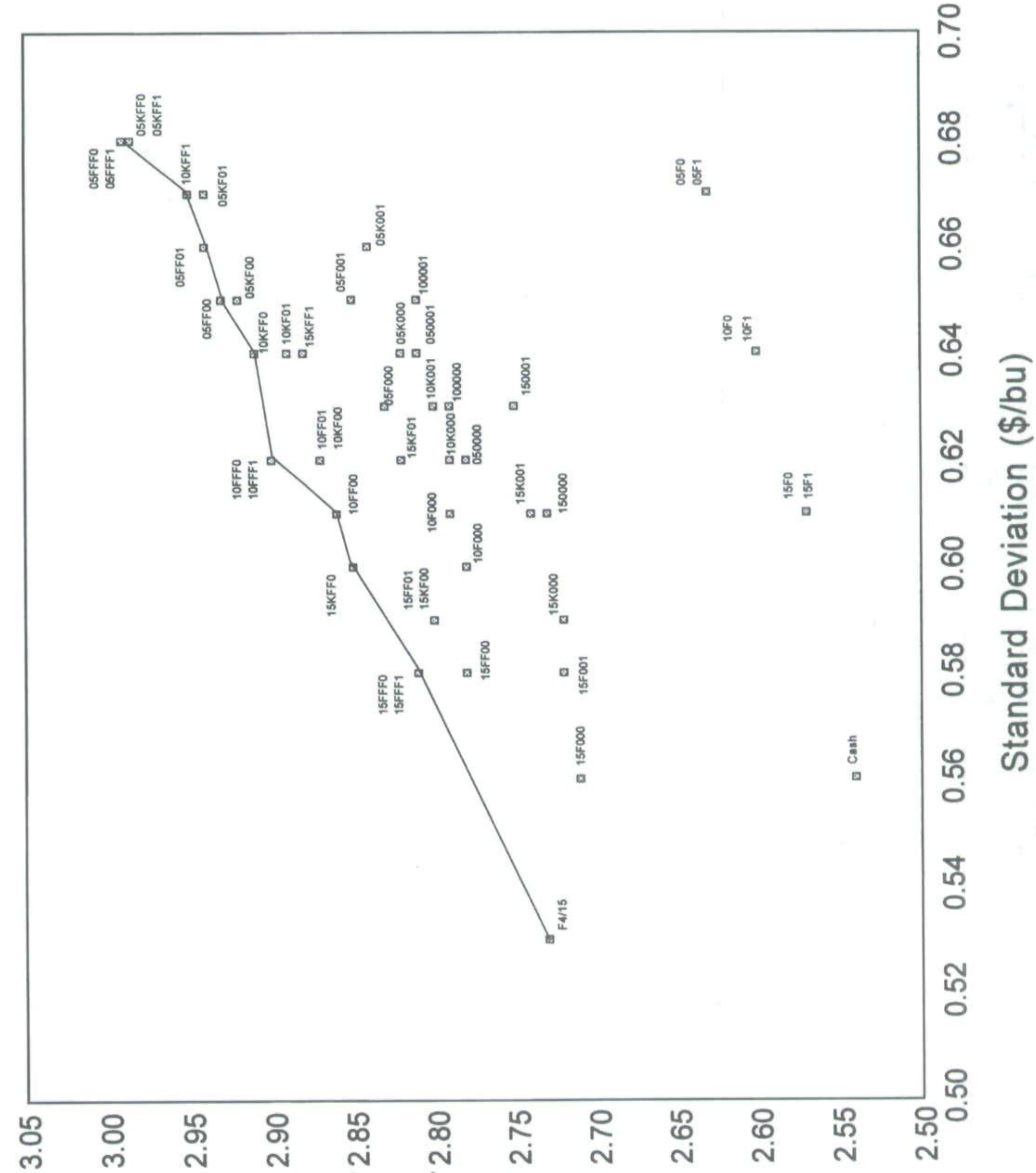

FIGURE 4
Corn strategies net price and standard deviation.

The lowest and highest average price strategies on the frontier (F4/15 and 05FFF0) are statistically different from each other at the 10% level, where a paired t test is used. All other average price comparisons to F4/15 along the frontier are not statistically significantly different at the 10% level, largely because the price differences are not large enough to offset the large differences in their respective standard deviations. But some other average price differences along the frontier are statistically different. For example, strategy 10FFF0 has equal or higher prices than strategy 15FFF0 each year. A paired t test comparing the average price of these two strategies indicates the \$0.08 higher price under strategy 10FFF0 is statistically different at the 5% level. Hence, depending upon an individual producer's attitude toward risk, many of these strategies along the efficient frontier are potentially desirable 3-year pricing strategies.

Second-degree stochastic dominance is used to determine the efficient set among the 50 strategies. Stochastic dominance is used to avoid the normality assumption of mean-variance analysis. Strategies including options, which truncate the underlying probability distribution, may not be normally distributed. A computer program developed by Cochran and Raskin (1988) is utilized to derive the efficient set.

The efficient set includes strategies F4/15, 05FFF0, and 05FFF1. Routine annual hedging is risk efficient when compared to multiple-year pricing, although the mean price received is lower. The highest average price strategies dominate all other strategies along the EV frontier (Figure 4). These strategies use all futures contracts. Hence, both the EV frontier and stochastic dominance efficient set indicate that multiple-year pricing is most efficient for corn when carried out with cash contracts and/or futures contracts. Statistical tests indicate the efficient 3-year strategies return higher prices, although individual producers might choose different efficient strategies based on their personal risk preference.

SOYBEAN STRATEGY RESULTS

The soybean strategy results are presented in Figure 5 according to average and standard deviation of net price. Cash sale at harvest has the lowest price and a relatively large standard deviation. Hedging on April 15 (F4/15) each year increases returns 17 cents compared to cash and has the smallest standard deviation. The cash and F4/15 strategy average prices are not statistically different at the 10% level.

The efficient 3-year strategies have means 60–70 cents above 1-year strategies with comparable standard deviations. Pairwise t tests of equal

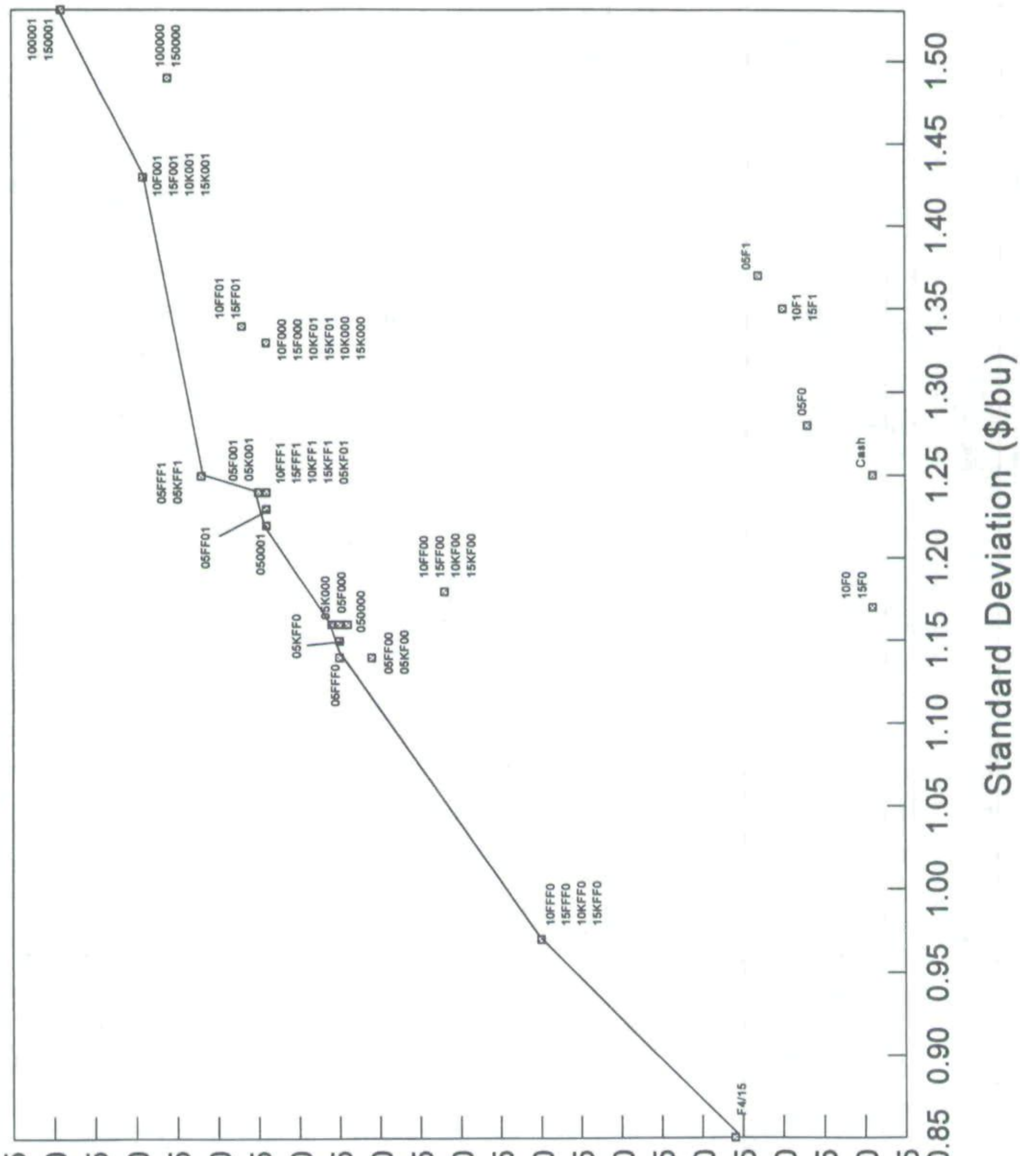

FIGURE 5
Soybean strategies net price and standard deviation.

means among these strategies indicate the multiple-year average prices are significantly higher at the 10% level.

The efficient frontier strategies include all three pricing instruments—futures, options, and cash contracts. The lowest-risk set of efficient strategies (10FFF0, 15FFF0, 10KFF0, 15KFF0) use futures and cash contracts. Moving up the efficiency frontier, the next set of strategies from 05FFF0 to 05FFF1 contain all three instruments in various combinations. The most risky and highest-return strategies use only options (10OOO1 and 15OOO1).

There are 16 strategies along the EV frontier in Figure 5. Many of these strategies have identical means and standard deviations. Of these 16 strategies, 10 strategies have as their trigger price the 10 or 15% level of historical prices. All of the highest price strategies use the 10 or 15 percent trigger prices until May 10. Using a lower trigger price compared to corn in conjunction with options contracts provides earlier entry with downside price protection without eliminating the potential of higher prices at harvest.

All of the efficient strategies with average prices above \$7.00 use the soybean yield equation forecast price plus one standard error of regression, indicated by a 1 in the last space for each strategy identification. Soybean prices are very responsive to relatively small expected yield changes. During the summers of 1980, 1983, and 1988, the USDA yield estimates resulted in price forecasts plus one standard error that are higher than the 5% trigger prices. Hence, the yield equation is instrumental in raising the average entry price for the highest average price soybean strategies.

Paired t tests are used to determine if the average prices along the efficient frontier are statistically different. Strategy 05OOO1 has a higher average price than F4/15 at the 5% significance level. All efficient strategies with average prices less than strategy 05OOO1 are not statistically different from F4/15. Strategy 10OOO1 has an average price statistically different than strategy 05OOO1 at the 10% level. Hence, many of these strategies are not statistically different. Some of the strategies have higher standard deviations because of higher rather than lower prices compared to other strategies. In such cases, the lack of a statistical difference is not important to a producer, who could receive higher prices without increasing the risk of lower prices.

Second-degree stochastic dominance is used to determine the efficient set of strategies. The efficient set includes F4/15, 05FOO1, 05FFF1, 05KFF1, 10OOO1, and 15OOO1. All of these strategies are on the EV frontier in Figure 5. Not all of the EV efficient strategies are efficient according to second-degree stochastic dominance (SDSD). The SDSD comparison includes yearly prices for each strategy, whereas the EV analysis only compares average price and standard deviation. Hence, the SDSD procedure can identify strategies that have dominant cumulative density functions that the EV analysis cannot identify.

The efficient strategies give producers a wide range of alternatives. Routine hedging on April 15 has the lowest price and standard deviation. Pricing 3 years' production with futures when prices reach the top 5% of the historical distribution before May 10 or exceed the yield equation price forecast plus one standard error (05FFF1) increases average price by 66 cents but also increases the standard deviation by 47%. Compared to the cash strategy, 05FFF1 increases average price by 83 cents without increasing the standard deviation. The highest-return strategies (10OOO1 and 15OOO1) increase price 17 cents compared to 05FFF1. But these strategies use all options and hence do not involve margin calls, a factor that is not considered in EV and SDSD analysis, but is important to producers. Each of the SDSD efficient soybean strategies use the yield price forecast plus one standard error.

CASH FLOW ANALYSIS

The EV and SDSD comparisons are based on yearly net prices, average net price, and variation in net prices, respectively. These comparisons do not reflect the cash flows associated with a multiple-year strategy, a major concern to many producers. When pricing 2–3 years in advance, the futures or options positions held in Year 1 for a crop to be produced 2 or 3 years later generates a cash flow in the current year. If prices move higher after implementing the 3-year strategy, the margin calls associated with futures positions may be substantial. The strategies using options avoid these margin calls, but involve substantial premium expense. With both instruments, the final result is higher net prices, but there are frequently substantial cash flows involved in reaching these higher net prices. Producers and bankers need to anticipate these cash flows and be prepared to manage them.

The cash flows by year for some selected corn strategies are presented in Table II. The two futures and cash contract strategies (05FFF0 and 05KFF1) are the most efficient, according to the SDSD comparisons. They have the highest prices and standard deviations of all the strategies compared. The two options strategies do not fall on the efficient frontier, but they are chosen to show the initial premium expense associated with option-based strategies, and how much revenue must be given up to avoid

TABLE II

Comparison of Selected Corn Strategy Revenue, Margin Calls, and Initial Option Premiums[a] (in Dollars)

	Strategy[b]			
Year	*05FF0 Total Margin Calls*	*05KFF1 Total Margin Calls*	*05OOO0 Initial Option Premium*	*05KOO1 Initial Option Premium*
1980	5,400	3,600	4,350	3,500
1981	2,250	2,250	2,850	2,850
1982	0	0	500	500
1983	900	900	5,700	4,700
1984	0	0	1,150	1,150
1985	0	0	350	350
1988	0	0	5,950	4,600
1989	1,350	1,350	1,950	1,950
1990	2,250	2,250	500	500
Maximum	5,400	3,600	5,950	4,700
Average[c]	1,350	1,150	2,589	2,233
Average revenue increase[d]	3,250	3,322	1,806	1,878

[a]Assumes 5000 bushels priced each year.
[b]Strategy definitions in text.
[c]Average across nine years.
[d]Strategy return above cash returns at harvest.

margin calls. The initial margin requirements for corn and soybeans are assumed to be \$750 and \$1,750, respectively. When 60% of the initial margin is depleted, a margin call occurs. Table II records the total margin calls for the years when the multiple-year strategies are in place. The calculations assume 5,000 bushels are priced initially for each year in the three-year strategy.

Margin calls reach \$5,400 in 1980 when futures are used to price all 3 years (05FFF0). These margin calls are approximately twice the margin calls for the other years. There are 4 years with no margin calls, but there are margin calls each time a 3-year strategy is implemented. Using a cash contract for Year 1 reduces the margin calls by \$1,800 in 1980, but margin calls are not lower in the other years. The average margin call per year is \$1,350 and \$1,150 under strategies 05FFF0 and 05KFF1, respectively. The average revenue increase per year during these 9 years is \$3,250 and \$3,322, respectively, under these two strategies.

The option-based strategies require relatively large initial premium expense, as reported in Table II. When the 3-year strategies are executed, prices are high and volatility is larger than normal, resulting in large premiums. The dollar amounts in Table II only reflect the initial cost of the options. They do not take into consideration the price at which these contracts are sold. The Table II calculations are designed to show that increasing average net price under these options strategies would require a substantial cash flow. For example, using options to price each year (Strategy 05OOO0) would require $4,350 to $5,950 during the first year each time the 3-year strategy is implemented. The premium expenses drop substantially in the second and third years when fewer contracts are traded and futures prices are generally less volatile. Using a cash contract to price the first year (05KOO1) does lower first-year premium expenses substantially. Over the 9-year period, the average premium expense for these two strategies is $2,233 and $2,589. Average strategy revenue increase is $1,806 and $1,878 under strategies 05OOO0 and 05KOO1, respectively.

For these selected corn strategies, the average initial premium expense is almost twice the average margin calls. Of course, the first-year initial premium expense is known when the strategy is implemented, whereas the total of potential margin calls is not. But for the strategies compared, the initial premium expense exceeds the maximum margin call in the first and second year each time the 3-year strategy is implemented. Given that the futures-based strategies have higher average returns compared to the options-based strategies, the cash-flow considerations discussed above seem favorable to the futures strategies. Hence, both the efficiency analysis and cash-flow analysis seem to favor futures instead of options for corn. The results for soybeans are different.

The cash flow and initial premium expense analysis for selected soybean strategies are in Table III. All of the strategies are on the EV efficient frontier, and are selected to show the difference between futures- and option-based strategies. They are also selected to show the difference between using cash contracts in Year 1 and the difference between using the yield equation price forecast versus price forecast plus one standard error. The all-futures-based strategies experience large margin calls in the first year ranging from $10,500 to $25,350. Margin calls are substantially less in the second and third years. Using a cash contract for the first year along with futures reduces margin calls about $6,000 in the first year. Using the yield model price forecast plus one standard error (05FFF1) lowers margin calls by $6,750 in 1983 compared to the same strategy using the model forecast price (05FFF0). The average margin calls for the three futures-based strategies range from $6,583 to $8,550 per year. The average revenue increase under the three futures strategies ranges

TABLE III

Comparison of Selected Soybean Strategy Margin Calls and Initial Option Premiums[a] (in Dollars)

	Strategy[b]			
Year	*05FF0 Total Margin Calls*	*05FFF1 Total Margin Calls*	*05KFF1 Total Margin Calls*	*10OOO1 Initial Option Premiums*
1980	25,350	25,350	18,300	14,350
1981	750	750	750	5,800
1982	0	0	0	1,900
1983	17,250	10,500	12,900	15,950
1984	2,100	2,100	2,100	14,850
1985	0	0	0	900
1988	25,200	25,200	18,900	12,650
1989	3,150	3,150	3,150	3,950
1990	3,150	3,150	3,150	950
Maximum	25,350	25,350	18,900	15,950
Average[c]	8,550	7,800	6,583	7,922
Average revenue increase[d]	4,767	5,417	5,994	7,222

[a]Assumes 5,000 bushels priced each year.
[b]Strategies defined in text.
[c]Average across nine years.
[d]Strategy returns above cash returns at harvest.

from $4,767 to $5,994 per year. Hence, the average margin calls are greater than the average revenue increases, and the maximum margin calls are three to four times average revenue increases. Margin calls of this magnitude are a major concern to many producers.

The option strategy included in Table III has the highest average price and standard deviation of all the soybean strategies tested. The initial premium expenses during the first year are substantial, ranging from $12,650 to $15,950. But these premium expenses are lower than the corresponding margin calls during the first year of the 3-year strategies using futures. The initial option premiums are larger than margin calls during the second year. Both premium requirements and margin calls are greatly reduced by the third year.

The average initial premium expense is slightly greater than the average increase in revenue for the option strategy 10OOO1 in Table III. Compared to the three futures-based strategies, the options strategy has higher revenue and comparable average cash flows, but considerably smaller maximum cash flows. Based on cash-flow considerations, most producers would prefer the relatively more stable initial premium expense over the highly variable margin call flow, given that the option revenues are substantially higher than the futures revenues. In addition, the option strategy would have higher net prices should a structural price change occur after the 3-year strategy is initiated.

CONCLUSIONS

Selective 3-year pricing of corn and soybeans can improve producer returns for those willing to accept higher risk strategies. The highest-return 3-year strategies all have average prices that are statistically higher at the 10% level from cash sales at harvest, from routine annual pricing on April 15, and from pricing 1-year instead of 3-years with the same entry price rules.

The 3-year corn strategy with the highest return (05KFF1) involves selling 3 years of production when December futures prices reach the top 5% of the historical futures price distribution. The first year's production is priced with the use of a cash contract and the other two years are priced with the use of futures contracts. The multiple-year corn strategy increases average price $0.47 per bushel compared to harvest sales, $0.37 per bushel compared pricing 1 year with the use of the same price signals (05F1), and $0.27 per bushel compared to pricing on April 15 each year.

The 3-year soybean strategies with the highest return (10OOO1 and 15OOO1) involve selling 3 years of production when November futures prices are higher than the 10 or 15% price from the historical futures price distribution or the yield equation price forecast plus one standard error, whichever is higher. Pricing is accomplished with the use of put options with strike prices closest to current futures prices. The 3-year option soybean strategy has average prices that are $1.00 per bushel above harvest cash sales, $0.83 above routine annual pricing on April 15, and $0.86 per bushel or more above pricing 1 years' production with the same entry price rules.

The strategies are selective in that pricing only occurs when current futures prices exceed either a predetermined percent of the historical futures price distribution before May 10 and/or exceed a price forecast based on current yield expectations after May 10. For corn, the 5% trigger price gives the highest average prices. The 10 and 15% trigger strategies are on the efficient frontier at lower risk levels and lower prices. The corn yield equation price forecasts do not improve strategy returns. The price forecasts in 1980, 1983, and 1988 are either too high relative to futures or too low relative to the 5% historical distribution prices to affect the entry-level price for the 3-year strategies.

In contrast, all the highest return strategies for soybeans incorporate the soybean yield equation price forecast plus one standard error. The yield equation forecasts increase entry price levels after May 10 each year above the 5% trigger price level. Incorporating the impact of expected yields improves the strategy results for soybeans.

The analysis includes various combinations of cash contracts, futures, and put options. For corn, the all-futures strategy dominates the EV efficient frontier. Strategies involving cash contracts in Year 1 and futures for Years 2 and 3 have only slightly lower returns. When the cash flow implications of using cash contracts instead of futures in the first year are considered, some producers may prefer the strategies using cash contracts in the first year. For soybeans, the EV efficient frontier strategies move generally from futures-based strategies at lower average prices to option-based strategies at higher average prices. The higher-option soybean strategy prices are the result of avoiding large losses in the first year compared to using futures.

The mean-variance and stochastic dominance comparisons do not consider the cash-flow implications of using futures versus options. For corn, the initial premium expense with an all-options strategy is greater than margin calls using the all-futures strategy. Hence, both the efficiency analysis and cash flow analysis seem to favor using futures instead of options for corn. For soybeans, margin calls associated with all futures strategies are substantially larger than initial premium expenses. Margin calls exceed revenue increases on a yearly basis, sometimes as much as four times. Initial option premiums are large, but the amounts are known in the critical first year of a 3-year strategy. The cash flow for the options-based strategies is more stable compared to that for futures.

Efficient 3-year selective strategies can improve producer returns. By choosing to enter these strategies when prices are at historically high price levels and/or exceed price forecasts based on current yield estimates, average net prices over the years 1980–1992 are improved. The selective nature of the strategies improves returns, whereas Gardner's (1989) non-selective long-term hedging strategies reduced returns. This study also demonstrates that options are viable alternatives to futures in some instances. When the more stable cash flows associated with options compared to futures are considered, the desirability of using options increases. In addition, if producers believe there is a substantial risk of a structural change resulting in a new higher price level in the long run, the option strategies become more attractive compared to futures and cash contracts. Although the price risk from a structural change is not directly measured in this study, it is always an important consideration in multiple-year pricing.

The strategy results beg the question, "Will these strategies continue to be effective in the future?" These strategies should continue to be profitable for grains that are characterized by large yield variations and large feed usage. These two factors together set up a dynamic situation where Year 1 high prices reduce current use substantially. The higher prices result in increased acres and production in years two and three that are not matched by equal increases in usage. The result is lower prices in years two and three as discussed in the theoretical section. Similar strategies are not expected to work on continuously produced livestock commodities as Huang et al. (1994) reported for feeder cattle. In fact, the authors of this study investigated similar strategies for wheat, but found no statistically significant 3-year strategies. Wheat yield variations are not as large as soybeans and corn. A small percentage of wheat is fed to livestock and poultry, and wheat is produced in many northern and southern hemisphere countries around the world. Hence, small crops in the U.S. have not resulted in price patterns similar to corn and soybeans that make multiple-year pricing successful. Future research in multiple-year pricing should focus on individual commodity characteristics and market dynamics that determine whether or not these strategies will be successful in the long run.

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