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HEDGING STRATEGIES UTILIZING TECHNICAL ANALYSIS: AN APPLICATION TO CORN IN WESTERN NEW YORK

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Hedging production decisions, using futures contracts, can reduce the variability of a farmer's stream of income over a period of years, but the precise effect of hedging on the variability and level of income depends, in part, on the particular hedging strategy which the farmer follows. Strategies require decisions about such factors as the timing of the placement and lifting of futures positions and the size of positions in futures. Naturally, farmers would like to find a strategy for hedging that raises incomes and reduces variability of incomes.

This publication is concerned mainly with the timing decisions related to the placing and lifting of hedges by corn growers in Western New York (for a general discussion, see Tomek). 1/ Simple rules are (a) to never hedge or (b) to always hedge, say, by always selling futures at planting time. In practice, most farmers never hedge. A middle ground is to hedge "selectively," but this raises the question of what rule or principle should be followed in deciding when and when not to hedge. One principle is to sell futures only when the hedge appears to assure a prespecified return over costs, but of course prices may never reach this level. Another approach is to try to sell futures when prices are relatively high, i.e., not sell on an uptrend and then attempt to sell near the top of the trend. Brokerage firms have often suggested technical analysis as a way of identifying trends in prices, and with the increased availability of modern calculators and personal computers, technical analysis is certainly a feasible approach to decision-making. 2/

In this context, our main objective is to explain and illustrate the application of technical analysis of futures prices for corn as a foundation for hedging decisions. First, the general idea of technical analysis is described and specific moving average systems are illustrated. Then, various hedging strategies are discussed, including those based on technical trading

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1/ Citations to the literature are made by author's name. The reference section provides a list of these publications.

2/ Technical analysis is only one way that one might attempt to identify relatively high prices. A second approach is fundamental analysis. This approach attempts to estimate the prices one might expect given existing supply and demand conditions. If market prices rose above those expected, then this would be a sell signal. A discussion of fundamental analysis is beyond the scope of this report.

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rules, and selected strategies are simulated using cash prices for corn for grain in Western New York and Chicago futures prices. In addition, hypothetical, but realistic, futures price data are replicated over a large number of "years" to illustrate the possible benefits and problems of technical analysis in greater detail than permitted by the available price data. A final major section interprets the results, which do not lend themselves to a simple "golden rule." Basically, technical analysis is a tool which may assist hedging decisions, but the value of technical analysis can be exaggerated, especially by those who have a vested interest in selling such systems.

Technical Analysis of Futures Prices

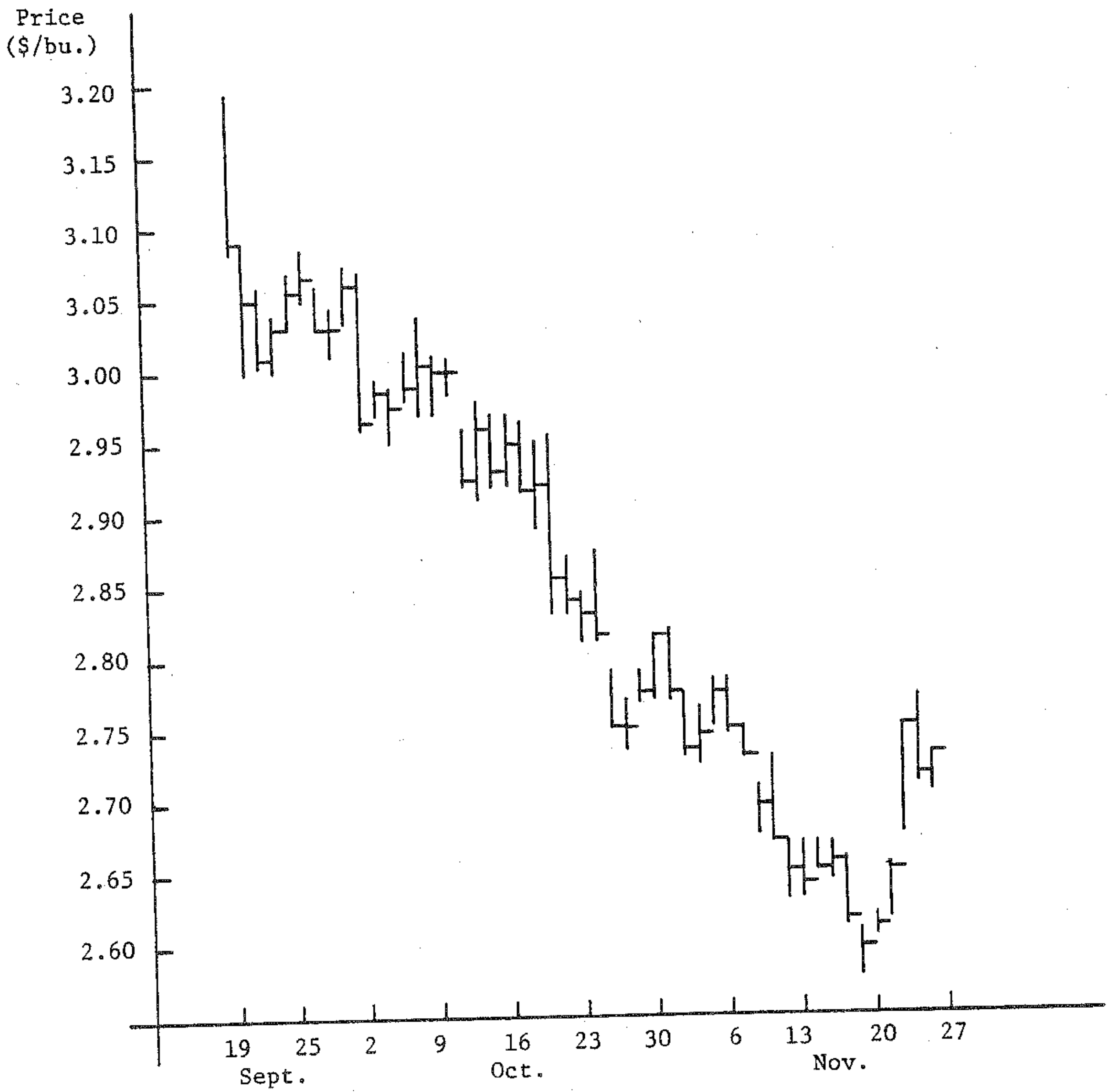
Technical analysis involves techniques that rely on past prices (sometimes supplemented with volume of trading and open interest data) to forecast the future direction of price movements and in some cases the magnitude of these price changes. The chief goal of technical analysis is to identify trends in past prices successfully and to extrapolate these trends into the future (Curley and Bear). A "successful" analysis is one that is profitable, but since a very large number of alternative techniques exists, it is essentially impossible to find "the most profitable" method. Technical analysis is carried out by the "application of specific well defined rules or equations" (Kaufman, 1978, p. 7). These trading rules can range from relatively straightforward to esoteric and complex. In general, technical analysis takes the form of either interpreting past price formations, as reflected in some type of price chart, or relying on a set of mechanistic trading rules designed to isolate commodity price trends (Weaver). In the following paragraphs three of the more popular types of technical analysis are presented to provide an indication of the diversity of the various trading systems.

Chart analysis

A basic tool of the technical analyst is the price chart. All of the trading techniques presented here can be (and often are) represented through the means of such charts. Chart analysis differs from other technical methods in that it relies on interpretation of price formations rather than on a set of mechanical trading rules.

One method of constructing price graphs is the use of vertical line or bar charts. Such diagrams are constructed with the vertical scale referring to price and the horizontal scale referring to time, usually in units of days or weeks. In the case of the daily price chart, the day's high and low price (for a particular commodity and contract month) are plotted and connected with a vertical line, and the closing price is denoted by a small horizontal line or "tick" at the appropriate price. Thus, the chart provides a record of the daily price range and of the daily closing price. An example of a vertical line chart is shown in Figure 1. The chart covers daily trading of the December corn contract from September 19, 1975 through November 26, 1975.

Figure 1. Vertical Line Chart, December Corn, September 19, 1975 - November 26, 1975



The process of forecasting price movements using chart analysis consists of:

> ...identifying the various patterns established by prices as they pursue their various trends and sidewise formations. These patterns disclose the relative strength of supply and demand forces. Each formation has its own significance which the chartist coordinates with various other technical considerations in arriving at market conclusions (Jiler, p. 23).

If a particular pattern of price movement preceded a significant price increase (or decrease) in the past, then this pattern is used as a forecasting tool for future trading decisions. In the colorful lexicon of the chart analyst some examples of price formations are "head and shoulders," "saucers," "triangles," "pennants," "flags" and so on.

Sidestepping the issue of whether the basic concept of chart analysis is valid (i.e. past price formations will repeat themselves and that this provides a useful means for identifying imminent price trends), two important limitations of chart analysis must be recognized. The first limitation is the degree of subjectivity necessary in interpreting price patterns. It is quite difficult to interpret price formations as they develop. The chartist must watch for many trade indicators, which sometimes seem contradictory. Although charting is quite popular among speculative traders, a fairly high level of expertise must be acquired before using this method of technical analysis. For many farmers the time required to gain this expertise may be prohibitive. The subjective nature of chart analysis also prohibits an objective empirical test of this method of technical analysis, making it difficult to assess whether this type of technical analysis can lead to improved marketing performance (for an enthusiastic discussion of chart analysis see Kluis et al).

A second limitation of chart analysis is that formations are often indecisive. The corn-for-grain producer, with an open cash market position, is not protected from price risk, and time spent waiting for an opportune price to place a hedge leaves the cash market position vulnerable to adverse price movements. Indecisive trade signals can result in missing good opportunities at which to initiate a hedge.

Price charts, however, can provide a clear and concise summary of past price movements. Price charts can increase a producer's awareness of current prices and of price behavior and when used in conjunction with other decision criteria can perhaps lead to improved marketing decisions.

Point and figure analysis

Point and figure analysis can be used to aid trading decisions either by assisting in the interpretation of charts or by incorporating the analysis into a set of mechanical trading rules. The following discussion is limited to one of numerous possible sets of trading rules using point and figure analysis.

Point and figure charts provide a visual record of the magnitude and direction of price changes while eliminating the time dimension of price changes. A chart is constructed by dividing the vertical scale into equal price increments or boxes. From the beginning of the price series, price changes are recorded by marking the chart with a series of X's as prices increase or O's as prices decrease. The same vertical column is used as long as prices are moving in one direction. Each box is filled only if the price change is equal to or greater than the "box size." If prices reverse by a specified multiple of the box size, then the price changes are recorded in the adjacent vertical column starting one box above the bottom of the previous column for a price increase or one box below the top of the previous column for a price decrease. This column is then filled with the appropriate marks as price changes until the next reversal in price occurs. 3/

Part A of Figure 2 is a point and figure chart for the December corn contract between September 19, 1975 and November 26, 1975 using $.01 price increments or box size and a $.03 minimum reversal criterion. It was constructed using the daily closing prices shown in Table 1. (Point and figure charts can also be constructed using high or low prices.) The closing price of $3.09 on the first day of the price series and $3.05 on the second day establish the initial downward direction of prices, and starting with the initial price of $3.09, five O's are plotted in the first column. On Day 3 the price declined to $3.01 and four additional boxes were filled. On Day 4 prices closed at $3.03, an increase in price but less than the minimum reversal size; therefore, no new boxes were filled. On Day 5 prices closed at $3.05 1/2, a 4 1/2 cent increase from the previously plotted low; thus, the price change exceeded the minimum reversal and the adjacent column was used to record the price increase starting one box above the previously plotted low and filling in three boxes to $3.05. The remainder of the chart was then completed in this manner, moving one column to the right if the reversal exceeded $.03.

Point and figure analysis recognizes that prices can trend sideways, fluctuating up and down within relatively small bands while providing no opportunities for the commodities trader. The first four columns of Part A, Figure 2 exhibit this price behavior with corn closing at $3.05 on Day 2, going through three $.03 reversals and closing at $3.06 on Day 9. Trends are not established, and therefore trade signals not given until prices move out of this so-called "congestion" area.

A number of mechanical trading rules for point and figure analysis have been developed; however, the simplest rule generating trade signals is to buy when an X is plotted in the current column at least one box above the highest X in the last column of X's. A sell signal is given when an O is plotted at least one box below the lowest O in the last column of O's (Kaufman, 1980). These buy and sell signals are often referred to as "double tops" and "double bottoms," respectively. The assumption of point and figure analysis (as in all technical methods that attempt

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3/ The minimum number of X's or O's in any vertical column will be equal to the size of the reversal specified divided by the box size.

Figure 2. Point and Figure Charts, December Corn, September 19, 1975 - November 26, 1975

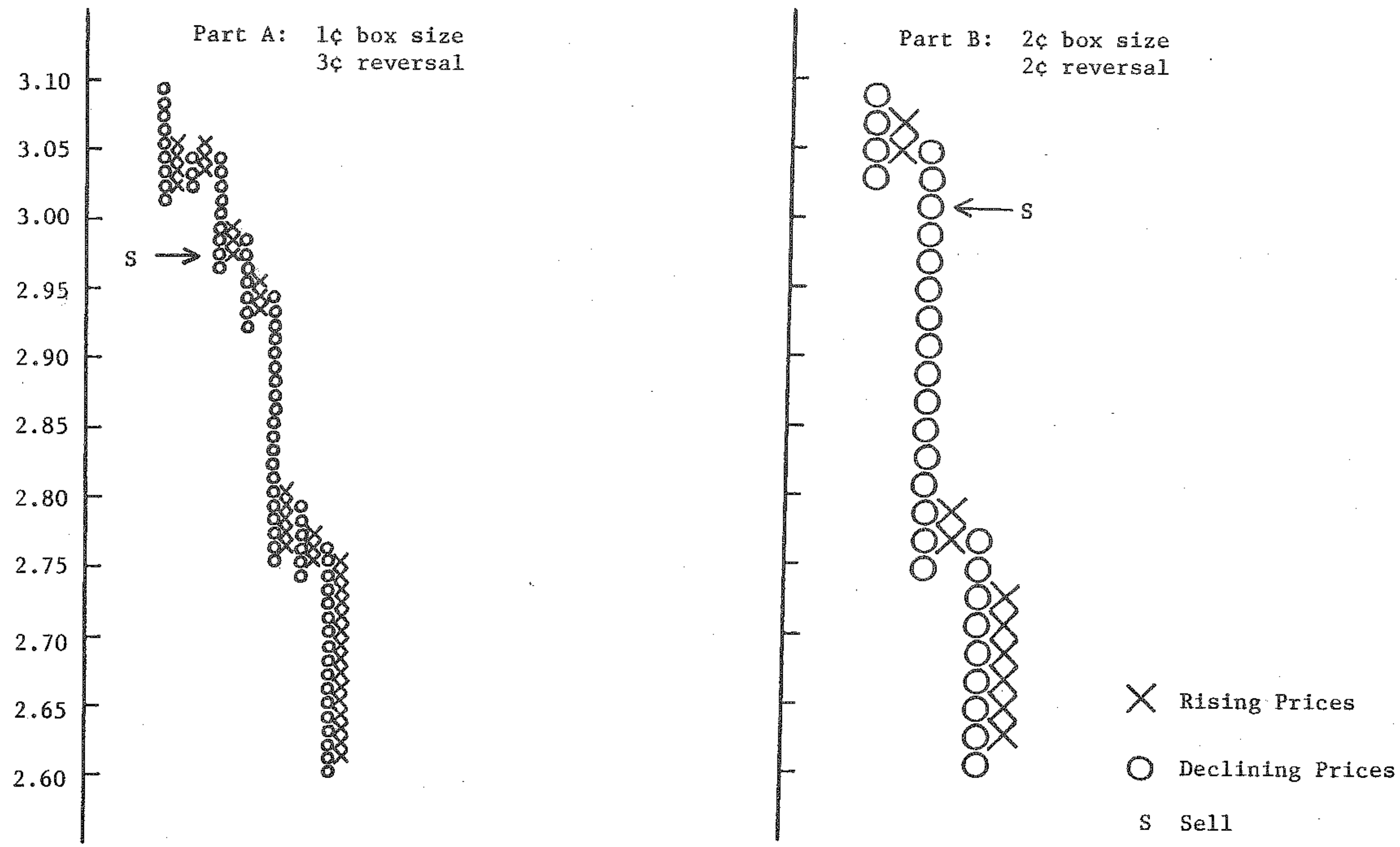


Table 1. Prices Used in Constructing Point and Figure Charts, December Corn

Day	Price[a/]	Day	Price	Day	Price
1	3.09	18	2.96	35	2.75
2	3.05	19	2.93	36	2.73
3	3.01	20	2.95	37	2.69
4	3.03	21	2.91 1/2	38	2.67
5	3.05 1/2	22	2.92	39	2.65
6	3.06 1/2	23	2.85 1/2	40	2.64 1/2
7	3.03	24	2.84	41	2.65
8	3.03	25	2.83	42	2.65 1/2
9	3.06	26	2.81 1/2	43	2.61 1/2
10	2.96 1/2	27	2.75	44	2.59 1/2
11	2.98 1/2	28	2.75	45	2.61
12	2.97 1/2	29	2.77 1/2	46	2.65
13	2.99	30	2.81 1/2	47	2.75
14	3.00 1/2	31	2.77	48	2.71 1/2
15	3.00	32	2.73 1/2	49	2.73
16	3.00	33	2.74 1/2		
17	2.92 1/2	34	2.77 1/2		

a/ Midpoint of closing price range of December corn contract 9-19-75 to 11-26-75. Rounded to nearest 1/2 cent.

to identify trends) is that once a trend in prices has been identified by a double top or bottom the trend will continue into the future long enough for profits to accrue to the trader using such a system.

Again, referring to Part A of Figure 2, a sell signal is given in the fifth column. On the tenth day of the price series, prices declined from \$3.06 to \$2.96 1/2, resulting in the plotting of an O well below the last column of O's and signaling the presence of a downward trend in prices. Four additional double bottoms are seen in the chart, but presumably a trader following such a system would have sold after the first sell signal and would take no action until a buy signal occurred. No buy signal occurs in the remainder of the price series shown here. Towards the end of the price series, however, prices were increasing and, had they reached \$2.78 without reversing, a buy signal would have been given. A trader following this trading rule would have closed out his short position on the basis of such a signal.

The key parameters of the point and figure analysis, which the analyst must select, are the box size and minimum reversal size. Part B of Figure 2 is a chart of the same December corn price series constructed using a \$.02 box size and a \$.04 minimum reversal (or 2 box reversal). As can be seen, larger box and reversal sizes condense the record of price changes. In general, the smaller the box and reversal size the more sensitive the system will be to price changes and the more trade signals will be generated over a given set of prices.

Moving averages

Moving average analysis is a technique that attempts to isolate price trends by calculating averages of past prices. Moving averages act as a smoothing device, removing extreme price fluctuations and (in theory) revealing the true direction of the underlying price movement.

A moving average is easy to calculate, update and graph. Given a price series $P_1, P_2, P_3, \ldots P_t$ and a moving average length of n periods, the moving average price at time t is

$$MA_t = (1/n)\ (P_t + P_{t-1} + P_{t-2} + \ldots + P_{t-n+1}).$$

The value of the moving average price in the next time period (MA_{t+1}) is calculated by adding the current closing price (P_{t+1}) and dropping the oldest price (P_{t-n+1}).

$$MA_{t+1} = (1/n)\ (P_{t+1} + P_t + P_{t-1} + \ldots + P_{t-n+2}).$$

A short-cut formula for updating the moving average is presented by Kaufman (1978, p. 58):

$$MA_t = MA_{t-1} + (1/n)\ (P_t - P_{t-n}).$$

That is, the current moving average price is equal to the previous moving average plus the n day average of the difference between the current price and the oldest price dropped.

For example, if a three-day moving average is computed from the data in Table 1, the averages are as follows:

$(1/3)(3.09 + 3.05 + 3.01) = 3.05$

$(1/3)(3.05 + 3.01 + 3.03) = 3.03$

$(1/3)(3.01 + 3.03 + 3.055) = 3.0317$, and so on.

Alternatively, the last moving average could have been computed as

$3.03 + 1/3\ (3.055 - 3.05) = 3.03 + .0017 = 3.0317.$

Figure 3 shows a plot of 3 day moving average prices calculated from the December corn contract closing prices given in Table 1. The actual closing prices also are plotted.

A simple moving average weights each day's price equally. As prices change over time, each new closing price will affect the moving average, but its influence will be tempered by the magnitude of the preceding prices. When futures prices are declining the moving average will also decline, but will generally lag behind the daily closing price. If prices reverse, the moving average price will continue downward until the weight of the price increases causes the moving average to also reverse.

By itself a single moving average does not provide a forecast. The mechanism used to generate buy and sell signals is, in this example, the crossover of the daily closing price and the 3 day moving average price. While the daily price is greater than the moving average price, futures prices are trending upwards. If the daily price becomes less than the moving average price, it is viewed as an indication of a new downward direction in prices and signals an opportunity to sell futures contracts. For a trader following such a system the short futures position would then be maintained until the daily price becomes greater than the moving average signaling an upward movement. Using a crossover of a 3 day moving average price and daily closing price as a mechanism for a trade signal, fourteen buy and sell signals occur in Figure 3.

The crossover mechanism for generating trading signals can be extended to multiple moving averages of two or more different lengths. Using 3 and 10 day moving averages for illustration (Figure 4), the daily price fluctuations are smoothed twice, first with the shorter 3 day moving average and again with the longer 10 day average. When prices are trending upward, the 3 day moving average price will be increasing more rapidly than the 10 day average, and thus will eventually become greater than the 10 day average. If prices reverse, the faster 3 day average will start decreasing and will eventually become less than the slower 10 day average. A new downward direction in price is indicated by the 3 day average crossing the 10 day average price, and a trader relying on such a system would, for example, sell futures with the expectation that futures price would continue to decline for sufficient duration for profits to accrue to the short futures position.

Figure 3. Daily Closing Price and 3 Day Moving Average, December Corn, September 19, 1975 - November 26, 1975

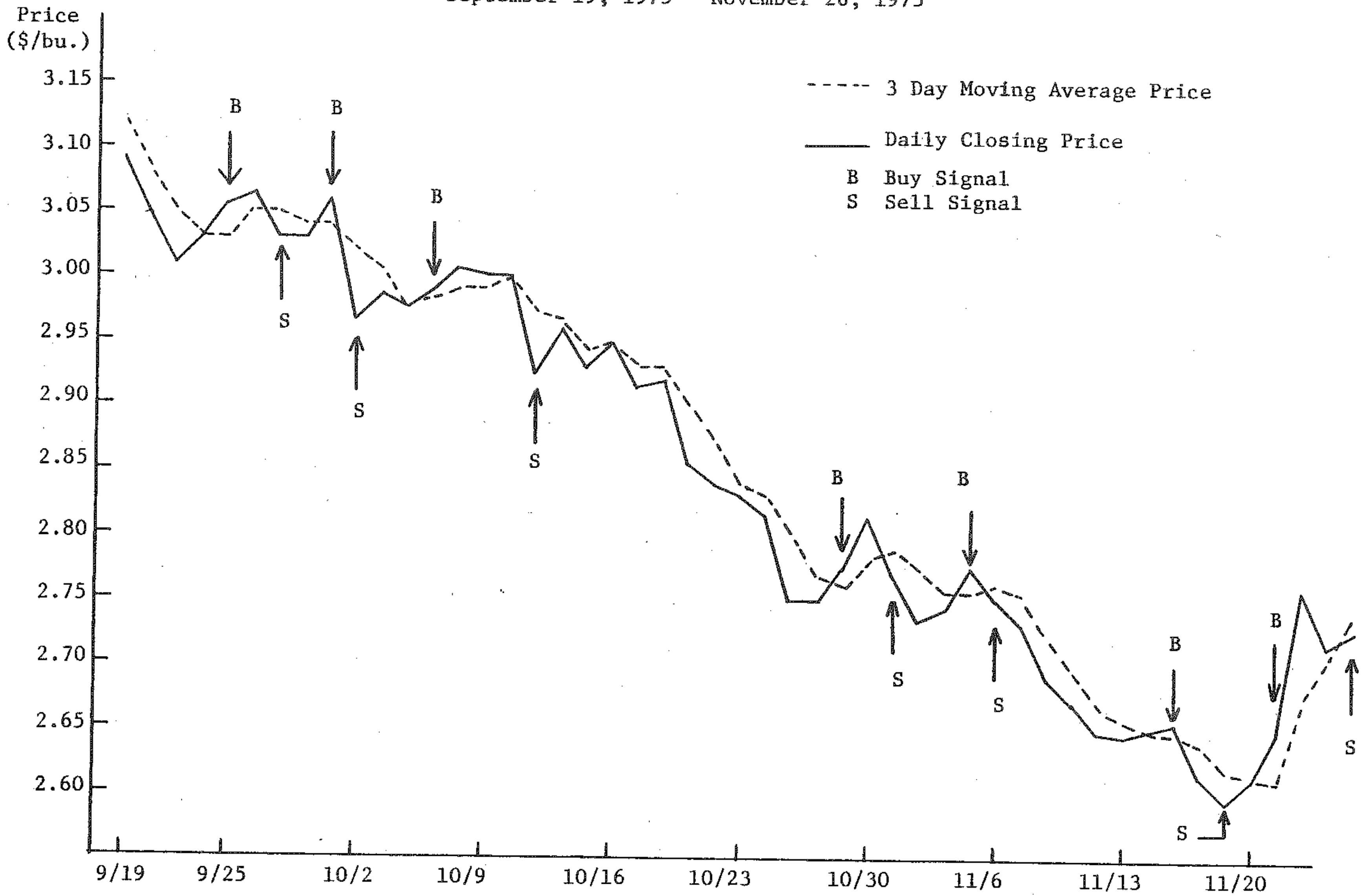
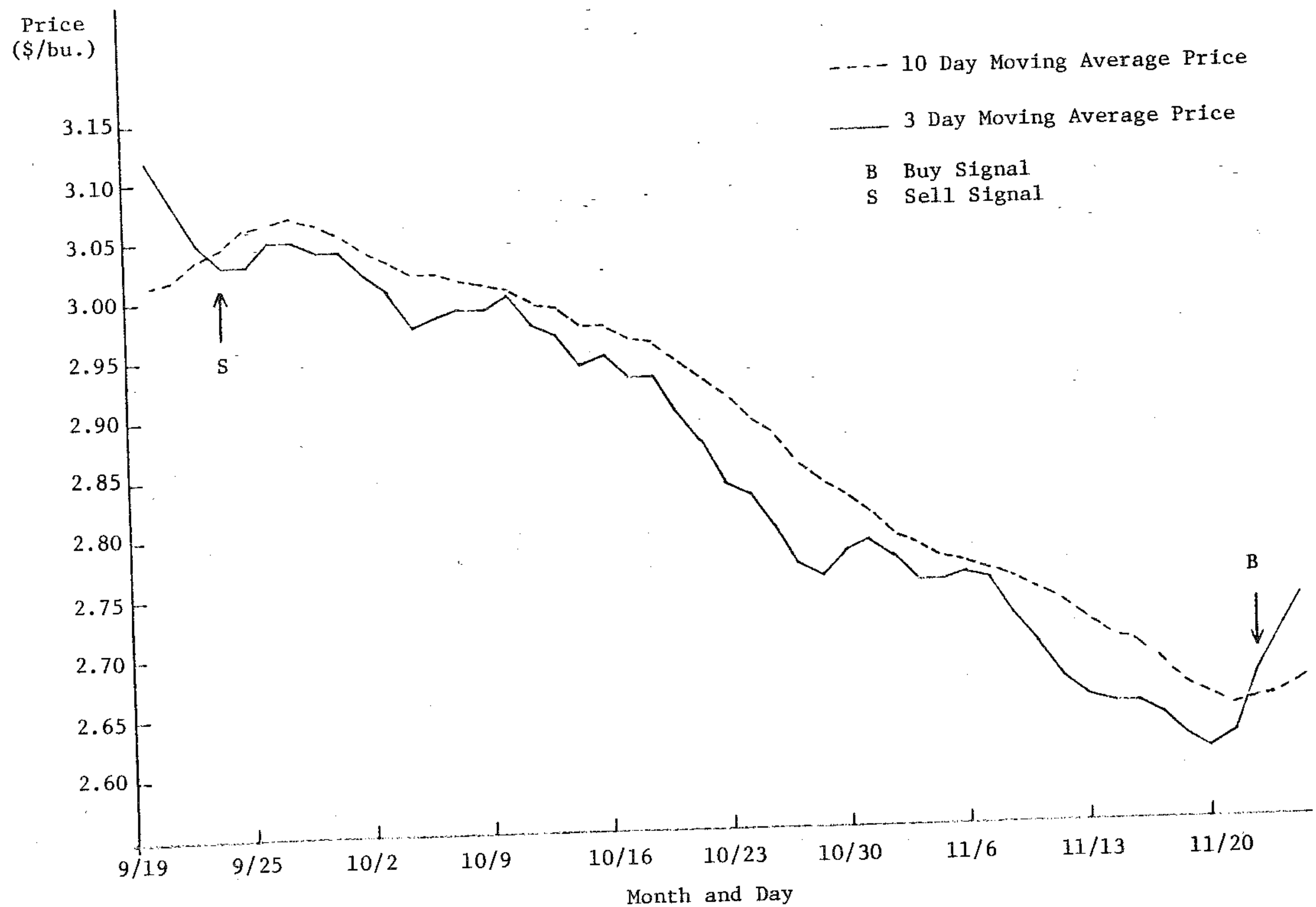


Figure 4. 3 Day and 10 Day Moving Average Prices, December Corn, September 19, 1975 - November 26, 1975



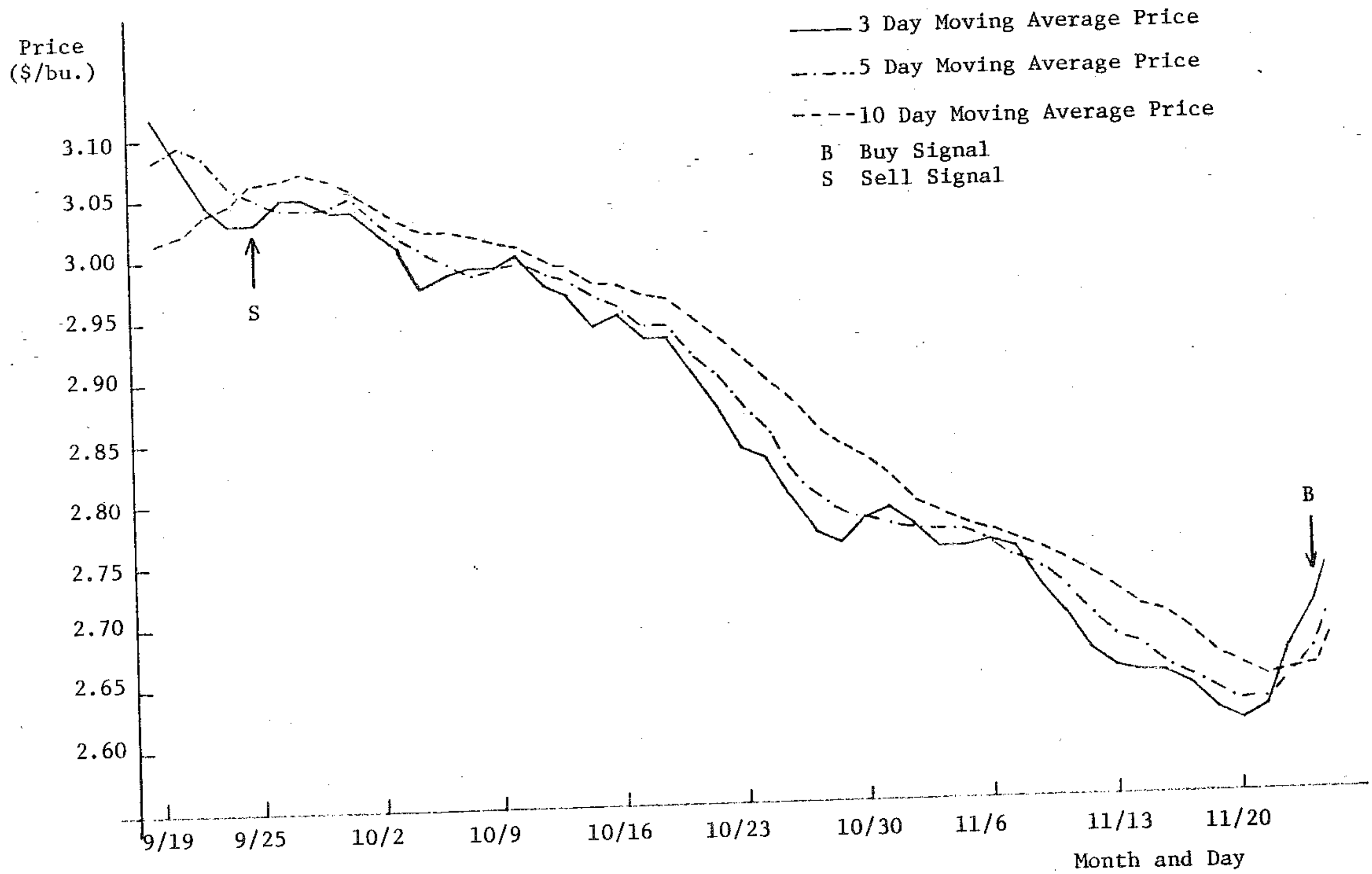
A key concept of moving average analysis must be noted. This type analysis does not attempt to predict imminent trends in prices nor does it attempt to initiate trades at either the high or the low prices in a series. Rather, the objective is to identify trends in prices after they have become established. Moving averages are trend following devices. The underlying assumption is that identifiable trends exist in the price series and that a moving average system can successfully isolate these trends after they have started.

A triple crossover system uses three different length moving averages. In such an analysis, two moving averages are supplemented by a third, shorter length, confirming average. This type analysis is illustrated in Figure 5 using a 3/5/10 day set of moving averages based on the December corn prices from Table 1. A downtrend is indicated when the 3 day moving average price is below the 5 day average price which in turn is below the 10 day average price. A buy signal is given when the opposite condition holds. Although not shown in Figure 5, it is possible for the 5 day average to briefly cross above the 10 day average without the 3 day average confirming a new price trend. The inclusion of the third, confirming average is an attempt to avoid false signals given by temporary reversals in price. The triple crossover system results in trade signals being delayed until trends become better established. The tradeoff is that a delayed trading signal might result in the opening of a futures position after a substantial portion of the price movement has already taken place.

In addition to the number of averages selected, three other parameters must be specified, either explicitly or implicitly, when using a moving average system. As noted above, the nature of moving averages is that they have the effect of smoothing out daily price fluctuations and have the property of lagging behind actual price changes. One parameter that will determine the degree of smoothing and how rapidly the averages reflect changes in prices is the length chosen for the averages. As the length of the moving average increases the sensitivity of the moving average to daily changes in prices is reduced. In general, the longer length moving averages will smooth out the shorter-run reversals in prices, but will still signal major changes in the direction of prices. Conversely, a shorter length moving average is more sensitive to price changes and can generate more frequent trading signals. Since the moving average is lagging behind actual price changes, in times of rapidly fluctuating prices short length moving averages can result in a downtrend being signaled after prices have reversed and are moving higher, followed by an uptrend being signaled when prices are moving lower. Unprofitable trades resulting from such false confirmation of trend are often referred to as "whipsaw" losses.

Attempts to reduce these false signals have been made by developing different penetration or confirmation rules to use in conjunction with moving average rules. Penetration rules specify an amount (in terms of price) that the shorter moving average must penetrate the longer moving average before a trade signal is given. Thus, in a 3/10 day moving average system the penetration parameter might be set, say, at $.03. A sell signal then requires that the 3 day average cross below the 10 day average and be at least $.03 less than the 10 day moving average price. Similar to the tradeoff between length of moving averages and number of trading signals given, the larger the value of the penetration parameter the fewer trends will be identified

Figure 5. 3 Day, 5 Day and 10 Day Moving Average Prices, December Corn, September 19, 1975 - November 26, 1975



and hence fewer trades initiated. The example graphed in Figure 3 has the penetration parameter set at zero. Increasing this parameter to $.03 reduces the number of trade signals from 14 to 4.

Another parameter of a moving average system is the <u>weights</u> chosen for the prices used in calculating the average. In the previous examples, each price in the average is weighted equally. Alternative weighting schemes exist. One is linear weighting, where for an n length moving average the oldest price in the moving average is given a weight of 1, the next price is given a weight of 2, and so on with the current price given a weight of n. The average is computed by dividing the weighted sum of prices by the sum of the weights. Such a system gives more weight to recent prices and is thought to make the system more responsive to abrupt changes in prices. The effect of linear weighting is to reduce the delay between the start of a new trend in prices and the triggering of a trade signal. Two other weighting methods are exponential weighting and weighting past prices by the number of days spent in a specified price range (Kaufman, 1978).

In summary, there are four critical parameters in a moving average system of technical analysis. These are

(1) the number of averages selected,

(2) the length (number of days) chosen for the averages,

(3) the penetration value, and

(4) the weighting of the individual prices used in calculating the moving averages.

Clearly countless parameter combinations may be chosen for a moving average system, and one of the problems of technical analysis is determining an "optimal" parameter mix. Technical analysts view this largely as an empirical question, taking a trial-and-error approach to parameter combinations. A series of past prices are used to test alternatives, and net trading profit is the usual criterion for selecting the "best" system for a particular commodity. Application of such an empirically selected system of trading rules assumes, of course, that a system that worked in the past will also identify trends in the future successfully.

Analysis of Hedging Strategies

Methods

Our research approach is to compare the average price and the variability of price from selling corn via different strategies. This report covers five alternatives. Two represent extremes: never hedge and always (routinely) hedge. These alternatives provide two benchmarks for appraising three selective hedging strategies.

In the never hedge alternative, the farmer's return is simply the harvesttime cash price in Western New York. (Strategies for storing and marketing corn throughout the storage season are not considered in this report.) A second alternative is to hedge routinely. This means selling December futures near planting time of each year and then buying back the futures contract at harvesttime (additional detail is given in appendix). The farmer's return equals the cash price plus the gain or loss from the futures transaction.

A third alternative involves a selective hedging strategy, which specifies a target price and attempts to achieve the target by hedging. A typical objective would be a price that covered production costs plus some additional return, which the farmer sets. To use this strategy, the farmer must have an estimate of the local basis for corn at harvesttime; this basis is the difference between the price of the December future at harvest and the local cash price on the same date. If, for example, the local basis is $0.20, then selling Chicago futures at $3.00 per bushel is equivalent to a local price of $2.80 per bushel. Thus, if a farmer had an objective of obtaining $2.75, he or she would sell futures if the futures price reached $2.95. The hedge is completed, as usual, by selling futures when the cash corn is harvested and sold.

This type selective hedge has an absolute price objective, and as mentioned earlier, such an objective may not be achievable every year. Price may never reach, say, $2.95, and hence no hedge is placed. Thus, the farmer's return in some years will be just the harvesttime cash price. When a hedge is placed, the return will include the gain or loss from the futures position. Clearly the average return will be influenced by the price objective which influences the frequency of hedging. For our simulations, we used cost data from Cornell Cost Account records, and set as an objective a price 10 cents per bushel above costs. The bases--the differences between Chicago and local prices--used in the analysis were obtained from historical relationships in Western New York (see appendix). The precision with which the harvesttime basis can be predicted will influence the performance of this type strategy.

The fourth and fifth alternatives are two "multiple hedging" strategies based on moving average rules. One strategy uses 3/10 day averages, the other 10/40 day averages. Sales and purchases of futures are made during the growing season for corn using rules like those described in the previous section. The particular averages used in this study were selected because they are readily available (or easy to compute) and are frequently used. We made no attempt to find an "optimal" set of parameters, i.e., average lengths or weights which would maximize returns from the futures transactions for this particular period.

Multiple hedging strategies attempt to achieve a high <u>relative</u> price each year. A farmer would not want to sell while prices are trending upward, but would like to sell near the top of the trend. As explained above, a moving average of past prices cannot identify the top of a trend, but it may permit sales at relatively high prices. Assuming the technical analysis has identified a sale of futures, this position is held as long as prices are trending downward, but if prices start to trend upward, the position in futures is offset by a purchase. Thus, "multiple hedging" involves in-and-out trading in futures, and indeed it is analogous to speculation on changes in futures prices. The return to the farmer equals the cash price plus the gains and losses from the (possibly large) series of transactions in futures.

The analyses use prices for the crop years 1972-80. The cash prices represent a harvesttime low price in Western New York; it is a representative price that a typical corn grower, say in the Batavia area, could have obtained at, or just after, harvest. The futures prices used are daily closing prices for the December contract (traded on the Chicago Board of Trade).

Our analysis attempts to parallel reality as closely as possible, but at times simplifying assumptions were necessary to keep the simulations tractable. The same assumptions are made for each strategy, and the hedging results, therefore, should be comparable with each other. But the average incomes and the measures of variability of income, which we report, would not coincide exactly with the figures for an actual hedging program for a specific farmer.

The assumptions made can be classified into two categories: those pertaining to the mechanics of computing returns from the futures trades and certain ancillary assumptions which would be unique to an individual producer. In the first category, for example, we assumed that futures transactions were made at the midpoint of the opening range of futures prices; actual transactions, of course, could have been made at slightly different prices. The second category of assumptions relates to such things as the quality of corn (number 2 yellow) being sold, the cost of hedging, and the costs of production. The important point is, however, that the results should be treated as illustrations of relative performance of selected pricing strategies in a particular time period and not as forecasts of returns that an individual farmer would obtain if the strategy were applied in a different period.

Empirical results

The results of the alternative strategies are presented in terms of "net prices" in Table 2. The net price equals the cash price received at harvest adjusted for the gain or loss from the futures transactions, including the margin and commission costs. 4/ The procedure assumes that the quantity hedged (sold and bought in futures) exactly equals the quantity of cash grain sold. Table 2 also presents the average net price and the standard deviation of price for two time periods. The standard deviation is a common measure of variability, and like the average, is stated in dollars per bushel. A large standard deviation, of course, implies large variability.

4/ NP = CP + FR - HC, FR = FPs - FPb, HC = TCC + TIC, where NP = net price ($/bu.), CP = cash price at harvest, FR = return from futures trades, FPs = selling price of futures contract, FPb = buying price of futures contract, HC = hedging costs per bushel, TCC commission charges per bushel, and TIC = interest on margin funds per bushel.

Table 2. Net Prices Under Alternative Hedging Programs

Year	Cash Sale	Routine hedge	Selective hedges[a/] I	Selective hedges[a/] II	Selective hedges[a/] III
	-----	-----	$ per bu.	-----	-----
1972	1.35	1.25	1.35	1.31	1.30
1973	2.30	1.36	1.54	2.12	1.94
1974	3.20	1.96	2.02	2.72	2.90
1975	2.15	1.98	2.01	2.22	2.31
1976	2.15	2.42	2.44	2.38	2.38
1977	1.95	2.32	1.95	2.20	1.95
1978	2.10	2.26	2.10	2.26	2.37
1979	2.45	2.42	2.72	2.57	2.38
1980	3.05	2.21	2.26	2.80	2.80
1972-80					
average	2.30	2.02	2.04	2.29	2.26
standard deviation	0.56	0.44	0.42	0.44	0.48
1975-80					
average	2.31	2.27	2.25	2.41	2.37
standard deviation	0.40	0.16	0.29	0.24	0.27

a/ Selective hedge I is the target price hedge; sales in futures were made if the target (production costs plus 10¢/bu.) could be reached. Selective hedge II is a multiple hedging strategy using 3/10 day averages, and III is a multiple hedging strategy using 10/40 day averages.

The averages and standard deviations are computed for two periods, 1972-80 and 1975-80. Prices in 1972 were still heavily influenced by price supports, and prices in 1973 and 1974 reflected a shift to a period of freer markets with small stocks and were years of volatile prices. The 1975-80 period is perhaps a period that might more nearly represent price behavior in the 1980s.

The results suggest that hedging reduces the variability of prices relative to selling corn in the cash market without hedging, but clearly the specific results of our analysis are influenced by the time period selected. For the entire period, the hedging programs reduced variability by modest amounts, and there was a considerable "cost" in terms of lower prices received, on average, than from the simple cash sale strategy.

The results for the 1975-80 period are probably more representative of those one might expect on logical grounds. Namely, routine hedging sharply reduces the annual variability of price with a small penalty in average price; this penalty is related mainly to the cost of using the futures market; selective hedging strategies result in price variability that is intermediate between not hedging and routinely hedging. The multiple hedging strategies (selective hedges II and III) did provide somewhat higher returns, on average, for the 1975-80 period than did the other alternatives.

The relatively poor performance of the target price strategy (selective hedge I) is related to the difficulty of estimating the harvesttime basis in Western New York. In this approach, futures were sold at the point in time after May 1 when the Chicago futures price minus the assumed basis gave a localized price equal to the desired target. In an initial analysis, the basis was estimated as the arithmetic mean of the median bases in the month of November of the previous three years. In this sample period, however, the historical basis obtained in this way tended to underestimate the actual basis, and if, for example, the basis is expected to be 20 cents per bushel but in fact turns out to be 30 cents, then the net price received will be 10 cents less than the intended target price.

After the initial poor results, we revised our estimate of the basis by averaging the largest basis for each of the three previous years, and these are the results reported in Table 2. In three out of nine years, futures prices did not reach a sufficiently high level to achieve the target, and in these years the return is merely the cash price. In other years, our more conservative approach to estimating the basis still did not yield the intended target. Thus, the target price was reached or exceeded in only two of the nine sample years. Clearly, if this type of selective hedge is going to be successful in Western New York, we need more accurate ways of estimating the forthcoming, harvesttime basis in order to have a more precise estimate of the price being established by the hedge. This must await further research.

Since the multiple hedging strategies had a higher average net price than did the cash sale alternative in the 1975-80 period, the technical analysis provided speculative returns to the futures trading, net of the costs of trading. In contrast, the lower net price for the multiple hedging strategies over the long time period implies speculative losses from the numerous transactions in futures. Even though the 1972-74 period might be considered somewhat unusual, the inability of the technical analysis to handle these unusual years profitably is of concern. Also, as we shall demonstrate in a subsequent section, technical analyses can provide speculative profits in particular years, but this is not necessarily predictive of performance in subsequent years.

The profit performance of multiple hedging strategies is shown in more detail in Tables 3 and 4. The number of futures markets transactions for each year and the gross profit from each transaction are reported. The average number of round-turn trades was seven per year for the 3/10 day strategy. Yearly gross profits ranged from a low of $-1862.50 in 1974 to a high of $1531.15 in 1976. Forty percent of the 63 trades were profitable before deducting hedging costs. Total gross profits for the 1972-80 period were $2793.75, an amount that was not sufficient to cover hedging costs. Total profits were greatly influenced by the 1973 and 1974 performance of the moving average system. Twelve of 16 trades resulted in losses for these two years combined. The moving average system gave sell signals on evidence of downturns in prices, yet these downturns proved temporary resulting in numerous losses.

The longer (10/40 day) averages used in selective hedging strategy III reduced the number of round-turn trades to an average of 1.5 per year for the nine-year test period. Yearly gross profits ranged from a low of $-1712.50 in 1973 to a high of $1287.50 in 1976. Forty-three percent of the 14 trades were profitable and total gross profits for the test period were $-956.25. The smaller number of trades reduced commission costs and the mean net price of $2.26 per bushel was only $.03 per bushel less than that for Strategy II, an indication that the performance of the moving average system was not that sensitive to the lengths of the averages chosen.

The futures market losses seen in the simulation of strategies II and III indicate that a moving average system does not provide a means for consistently extracting profits from the corn futures markets. The trade signals generated by moving average systems were not always correct and often resulted in speculative losses in the futures positions. Nonetheless, the inclusion of technical analysis as a basis for making selective hedging decisions was a significant improvement over routinely hedging and maintaining a hedged position regardless of subsequent price behavior (Table 5).

Not surprisingly, strategy II had the highest average hedging costs of $.075 per bushel. This was due to the commission charges for the large number of trades made within the growing season. The cost of margin money averaged one-half cent per bushel for both multiple hedging strategies. Thus, the increased commission costs incurred in multiple hedging were slightly offset by a reduction in the costs of keeping the hedged positions fully margined.

Table 6 provides an indication of how the funds required to meet margin requirements differed between the multiple hedging strategies and the other

Table 3. Gross Profits from Futures Trades, Using 3/10 Day Averages, (Selective Strategy II), 1972-1980

Trade	1972	1973	1974	1975	1976
	---dollars per contract---				
1	147.00	-231.25	675.00	137.50	-481.00
2	-65.75	-450.00	-350.00	-400.00	-75.00
3	-197.00	-675.00	-675.00	-12.50	-812.50
4	331.25	2400.00	-450.00	-387.50	500.00
5	-172.00	-350.00	0.00	-925.00	-400.00
6		-512.00	-25.00	362.50	887.50
7		-700.00	-1162.50	1975.00	1912.50
8			-87.50		
9			212.50		
Yearly Total	43.50	-518.50	-1862.50	750.00	1531.25

Trade	1977	1978	1979	1980	1972-80 Total
1	368.75	50.00	62.50	0.00	
2	175.00	1450.00	6.25	-118.75	
3	1112.50	25.00	-875.00	-250.00	
4	506.25	-287.50	-50.00	25.00	
5	-400.00	-343.75	1437.50	-50.00	
6	-250.00	187.50	-125.00	-375.00	
7			-262.50	-93.75	
8			487.50		
9			387.50		
Yearly Total	1512.50	1081.25	1068.75	-812.50	2793.75

Table 4. Gross Profits from Futures Trades, Using 10/40 Day Averages, (Selective Strategy III), 1972-1980

Trade	1972	1973	1974	1975	1976
	-------------------dollars per contract-------------------				
1	62.50	-1712.50	-1437.50	-1025.00	-581.25
2	-206.25			25.00	1868.75
3				2006.25	
Yearly Total	-143.75	-1712.50	-1437.50	1006.25	1287.50

Trade	1977	1978	1979	1980	1972-80 Total
1		1393.75	-600.00	-562.50	
2			356.25	-543.75	
3					
Yearly Total	--	1393.75	-243.75	-1106.25	-956.25

Table 5. Gross Returns from Futures Transactions

Year	Routine hedge	Selective hedges II (3/10)	Selective hedges III (10/40)
	----------dollars per contract----------		
1972	-500	43.50	-143.75
1973	-4350	-518.50	-1712.50
1974	-5900	-1862.50	-1437.50
1975	-950	750.00	1006.25
1976	1600	1531.25	1287.50
1977	1650	1512.50	a/
1978	800	1081.25	1393.75
1979	100	1068.75	-243.75
1980	-3400	-812.50	-1106.25
Total	-10,950	2793.75	-956.25

a/ No trades.

Table 6. Maximum Funds Per Contract Needed to Meet Annual Margin Requirements, 1972-1980

Strategy	Routine hedge	Selective Hedges I	Selective Hedges II	Selective Hedges III
	---dollars per contract---			
1972	1530	--a/	1073	992
1973	9969	9279	3533	3857
1974	9274	9274	4836	2732
1975	4787	4787	2871	2833
1976	2870	2870	2554	1841
1977	803	--	1000	--
1978	2317	--	1004	1000
1979	3632	2247	2043	1667
1980	5514	5514	2117	2265

a/ Indicates year that crop remained unhedged.

hedging strategies.[5/] In the simulations, declining prices resulted in profits accruing to the futures position that could be withdrawn and used to reduce the outstanding loan balance, while rising prices resulted in margin calls and the necessity of borrowing additional funds to keep the futures position fully margined. Therefore, the loan balance fluctuated throughout the production period. The figures shown in Table 6 represent the maximum funds borrowed to meet margin requirements at any point in the production periods.

Two points are illustrated in Table 6. First, in years of rising prices (e.g. 1973 and 1974) substantial capital was required to meet margin requirements. Second, the multiple hedging strategies reduced the capital requirements for margin deposits relative to the routine hedging strategy. Further, the number of margin calls observed in the simulation of the multiple hedging strategies was reduced substantially compared to all the other strategies. The behavior of the loan balance is additional evidence that the multiple hedging strategies were somewhat successful in meeting the objective of lifting a hedge in times of rising prices and placing or replacing a hedge in times of declining prices.

Simulation Results with Idealized Data

Given the foregoing results, an important question is whether or not similar results can be expected in future years if these simple multiple hedging strategies are used. To investigate this question, we constructed a series of hypothetical data, with known properties, and applied the trading rules based on moving averages to these data.

Two sets of prices were constructed: one based on conditions representing the 1975-80 situation and the other for the 1973-74 situation. Each data set consisted of 20 replications or "years," each containing 300 "days" of prices and were constructed in the form of a random difference price series. The "daily" price change represents the price effect of new information entering the market as a random variable. In 1973/74, prices were highly variable, and the standard deviation of the daily price change was 5.5 cents per bushel; average price was $2.40. In 1975-80, prices were less variable, and the standard deviation of the daily price change was 3.3 cents per bushel; average price was $2.70. 6/

5/ The hedger is assumed to be able to borrow sufficient funds to meet margin requirements. The interest charged on the loan balance is used as a measure of the cost of margin deposits.

6/ The series were generated assuming that the average change in price was zero, that changes were statistically independent of each other, and that the changes were normally distributed. The standard deviations of the changes were those estimated for the respective time periods as are the average levels of prices. This probably represents an "idealization" of price behavior--i.e., the series contains fewer imperfections than actual prices--but the data do contain the constraint that daily price changes cannot exceed 10 cents, which is the daily limit on price moves on the Chicago Board of Trade. If the computer program generated a change larger than 10 cents in one day, the excess over 10 is added to the next day's price.

In the analysis which follows, replications 1-20 represent the type of conditions experienced in 1975-80 while replications 21-40 represent the conditions of the more variable 1973-74 period. The high and low "price" for each random difference price series is shown in Table 7. These price ranges illustrate that even a truly random price series will exhibit price movements or "trends." Comparison of the price ranges for the two sets of replications indicate that, as expected, a higher variability in daily price changes (replications 21-40) results in a greater range in price movements. That is, the more variable the daily price change, the greater the distance the price series can wander.

Speculative trading of one 5,000 bushel corn contract was simulated for each of the forty price series based on signals generated by a double-crossover moving average system, using the same two sets of moving average lengths used in the hedging analysis: the 3/10 day moving average system, a "faster" set of moving averages, and the 10/40 day moving average system, a "slower" set of averages. In both cases the shorter average had to penetrate the longer average by a minimum of 1/4 cent before a trade signal was given. This was done to minimize the effect of rounding errors when computing the moving averages.

The trading simulations were carried out so that once a trade signal was given a position was held until the opposite signal emerged. For example, if the initial signal indicated a downtrend, a short (sale of futures) position was taken and held until the moving average system signalled an uptrend. The short position was then closed and a long position taken. Market position was reversed in this manner until expiration of the contract. A commission charge of $50 per round-turn trade was deducted from gross profits to determine net profits for the individual trades.

The results are shown in Tables 8 and 9. Examining first the results of replications 1-20, the 3/10 day system resulted in positive gross profits in 13 out of 20 trials. When aggregated over all 20 replications the trading rule resulted in $14,253 profit before deducting commissions. The large number of trades, however, resulted in a total brokerage charge of $30,400, resulting in a total net loss of $16,147. For the 10/40 day system, six of 20 trials had positive gross profits. Total losses were $16,495 before deducting for commission charges. A total of 170 trades added brokerage charges of $8,500, increasing the total loss to $25,047.

For replications 21-40, with a higher variability of daily price change, the performance of the two moving average systems is reversed (Table 9). Only seven of 20 trials of the 3/10 day system resulted in positive gross profits, and again, the large number of transactions resulted in high trading costs leading to a net loss of $36,813. For the 10/40 day system, 12 of 20 replications had positive gross profits, and after deducting commission charges on 141 trades, total net profits were $18,941--a fairly impressive performance of the trading rule.

The results of the speculative trading simulations show that even an arbitrarily chosen trading rule can, at times, generate profits from a random price series. These results could possibly be improved through

Table 7. Price Ranges of Hypothetical Price Series, All Replications

Replication[a/]	High Price	Low Price	Replication[b/]	High Price	Low Price
	-dollars per bushel-			-dollars per bushel-	
1	2.80	2.29	21	2.44	.44
2	2.95	2.02	22	2.51	.58
3	2.77	2.20	23	3.18	1.70
4	4.18	2.50	24	2.72	1.59
5	3.06	1.75	25	5.05	2.32
6	3.28	2.49	26	3.10	1.91
7	2.98	2.49	27	2.75	1.57
8	2.70	1.85	28	2.58	.57
9	3.36	2.56	29	3.45	2.05
10	3.05	2.55	30	3.09	1.39
11	2.70	1.75	31	3.99	2.31
12	2.82	1.48	32	3.13	1.66
13	3.03	2.48	33	2.53	1.51
14	3.16	2.62	34	3.42	2.29
15	2.91	2.37	35	2.49	1.38
16	3.08	2.26	36	2.84	1.70
17	3.84	2.66	37	3.24	1.85
18	3.70	2.55	38	4.03	2.17
19	2.84	1.60	39	3.89	2.38
20	4.02	2.63	40	2.82	.51

a/ Initial price, $P_0 = 2.70$ Daily price change, $\varepsilon_t \sim N(0,.033)$

b/ Initial price, $P_0 = 2.40$ Daily price change, $\varepsilon_t \sim N(0,.055)$

Table 8. Profit Results from Simulation of Speculative Trading, Replications 1-20

Replication	3/10 Moving Average Gross Profit[a/]	3/10 Moving Average Net Profit	10/40 Moving Average Gross Profit	10/40 Moving Average Net Profit
	-----------------	dollars per	contract	-----------------
1	5543	4423	-4069	-4619
2	809	-791	3649	3348
3	-389	-2093	-4089	-4539
4	1129	-221	7630	7480
5	2013	813	2329	2079
6	500	-900	-2488	-3088
7	1071	-179	-2224	-2724
8	2977	1577	-5171	-5621
9	401	-1249	-174	-624
10	-1432	-3232	-5392	-5992
11	-206	-1906	-2070	-2572
12	-1731	-3431	1977	1727
13	-2064	-3964	-1420	-1920
14	487	-863	-2524	-3024
15	897	-502	-2042	-2492
16	-4556	-6356	-1073	-1523
17	3041	1441	2812	2561
18	3432	2082	-197	-697
19	3758	2308	-3241	-3691
20	-1428	-3128	1282	882
Total[b/]	14,253	-16,171	-16,495	-25,047

a/ All profit results rounded to the nearest dollar - represent trading of one 5000 bushel "contract."

b/ Totals may not add due to rounding.

Table 9. Profit Results from Simulation of Speculative Trading, Replications 21-40

Replication	3/10 Moving Average: Gross Profit[a/]	3/10 Moving Average: Net Profit	10/40 Moving Average: Gross Profit	10/40 Moving Average: Net Profit
	dollars per contract			
21	-4086	-5886	-3090	-3590
22	-2016	-3766	-121	-321
23	2513	1213	6379	6079
24	-4282	-6082	-117	-517
25	-364	-1814	-2304	-2654
26	4577	2927	1193	943
27	-3991	-5941	1533	1233
28	-6159	-7959	3391	3141
29	5043	3593	3422	3072
30	728	-922	9237	9087
31	-3169	-4919	-4434	-4984
32	-9	-1809	5719	5469
33	9788	8588	-2332	-2732
34	3958	2758	-474	-874
35	-2646	-4046	-722	-1072
36	-903	-2653	950	550
37	-1860	-3510	3705	3305
38	-1564	-3314	3162	2712
39	-4354	-6354	1427	1127
40	4534	3084	-536	-1036
Total[b/]	-4263	-36,813	25,991	18,941

a/ All profit results rounded to nearest dollar - represents trading of one 5000 bushel "contract."

b/ Totals may not add due to rounding.

"optimization" of the trading rules. That is, one could search for a rule or rules that maximizes profits for the given price series. However, such a trading rule would be dependent only on the particular data used and could not be expected to generate profits for another price series. This is perhaps obvious, but given the unresolved debate over the true model of commodity price behavior, these simulations illustrate how results of technical analyses may be erroneously interpreted as detecting a systematic component in price behavior when none exists.

The example of the 10/40 day system with net losses of $25,000+ in replications 1-20 and net gains of $18,900+ in replications 21-40 demonstrates that changes in price behavior (in this case an increase in the variability of the daily price changes) can lead to a quite different performance of a trading rule. This illustrates a statement sometimes seen in the technical analysis literature that a trading rule must be updated to conform to changes in price behavior (e.g. increasing price volatility). This, however, requires the analyst to predict changes in price volatility in order to develop a trading rule that will predict changes in price levels.

Moving average systems are designed to follow the maxim of "cutting losses short while letting profits run." This idea is seen in the results of the speculative trading simulation. For most of the individual "years" the trading rules resulted in numerous losses and fewer gains (Table 10). However, the magnitude of the profit from individual trades was often greater than the magnitude of the losses from the losing trades (Table 11).

For all the simulations, the 3/10 day system had 39 of 40 results with a larger gain than the largest loss, while for the 10/40 day system 28 of 40 results had gains larger than the largest loss. While not shown in Table 11, a pattern of gains from individual trades being larger than losses was seen in the majority of the replications. Of course, as implied when reporting the profit results, the large number of relatively small losses more than offset the small number of relatively large gains resulting in an aggregate loss for many of the simulations.

The question then is, given the results obtained in the hedging simulations, are moving average systems worthwhile to a corn grower? This question should be answered in the context that a producer must be willing to absorb the price risk inherent in growing a crop if no hedge is placed. On the other hand, if a producer makes the decision to attempt to reduce price risk through hedging, it is natural to ask whether the performance of the hedging program can be improved relative to that offered by routine hedging. Thus, in the narrow context of choosing between routine hedging and multiple hedging based on technical analysis, our research indicates that technical analysis can be partially successful in identifying turning points in price movements and in increasing net price relative to routine hedging while reducing price risk relative to unhedged (cash) sales.

Our analysis also indicates, however, that the success of technical analysis depended on matching a particular set of moving average rules to the existing price behavior. The 10/40 day moving average scheme worked best, for example, when price changes were relatively variable. But the ability to match the rule to price behavior would require that the analyst know before trading started whether prices were going to be variable or not, and clearly this is something the farmer would not know. This difficulty in defining an appropriate set of rules for the current situation is a significant limitation of technical analysis.

Table 10. Number of Trades and Profitable Trades in the Speculative Trading Simulations, All Replications

	3/10 Moving Average		10/40 Moving Average			3/10 Moving Average		10/40 Moving Average	
Rep.	No.	Prof.	No.	Prof.	Rep.	No.	Prof.	No.	Prof.
1	22	12	11	4	21	36	10	10	2
2	32	10	6	4	22	35	12	4	2
3	33	10	9	1	23	26	13	6	3
4	27	10	3	3	24	36	14	8	3
5	24	10	5	2	25	29	12	7	2
6	28	14	12	3	26	33	15	5	4
7	26	11	10	1	27	39	10	6	3
8	28	12	9	2	28	36	11	5	3
9	33	11	9	2	29	29	11	7	3
10	36	14	12	2	30	33	10	3	2
11	34	12	10	3	31	35	8	11	3
12	34	12	5	3	32	36	12	5	2
13	38	13	9	5	33	24	12	8	5
14	27	11	10	1	34	24	9	8	4
15	28	13	9	2	35	28	10	7	2
16	36	10	9	3	36	35	11	8	4
17	32	14	5	2	37	33	9	8	5
18	27	11	10	3	38	35	12	9	3
19	29	12	9	4	39	40	16	6	2
20	34	11	8	3	40	29	11	10	3
Total	608	233	170	53		651	228	141	60
% Prof.	38		31			35		43	

Table 11. Largest Individual Trade Result Observed in the Speculative Trading Simulations, All Replications

Replication	3/10	10/40	Replication	3/10	10/40
	dollars per contract			dollars per contract	
1	1515	-1197	21	3389	-1372
2	3669	3357	22	1512	-1488
3	1111	-1177	23	1383	4586
4	1202	5363	24	1781	1627
5	1070	3430	25	2141	2004
6	2281	1344	26	1453	-1455
7	1008	744	27	2301	3298
8	1850	-1265	28	1931	2812
9	1431	2279	29	2558	2941
10	1338	-1098	30	3979	5846
11	2345	1343	31	2807	2185
12	1677	2164	32	3343	4501
13	1222	-800	33	3004	-1566
14	969	-841	34	2203	1038
15	1089	-1261	35	2754	1752
16	-828	1304	36	3117	2535
17	1139	3280	37	2466	3325
18	2695	2166	38	1990	6086
19	1539	-1632	39	1875	3239
20	1657	2678	40	5359	3317
Number Positive	19	12		20	16

a/ Rounded to nearest dollar.

Conclusions

Multiple hedging--a summary

Multiple hedging strategies, unlike other hedging strategies, allow "hedges" to be placed and lifted and replaced during a production period. The intent is to lift a hedge during periods of rising prices and to place or replace the hedge during periods of declining prices. Multiple hedging strategies are unorthodox. A more traditional view of production hedging calls for a hedged position, once taken, to be maintained until the cash sale of the commodity. The grower presumably is satisfied with the price established by the sale of futures. Losses (or gains) in the futures market should be offset by gains (or losses) in the cash market. As a practical matter, however, hedgers often find it difficult to maintain positions in futures until the crop is sold, a la' a bonafide hedge. The temptation may be to liquidate the futures position either to take profits that have accrued or conversely to cut short mounting losses. Our analysis can be viewed as testing multiple hedging strategies to examine whether simple technical trading rules can provide a disciplined means for determining whether to place a hedge and whether it should be lifted or replaced given subsequent developments in prices.

Over the nine-year test period the multiple hedging strategies yielded a significantly higher average price than that received from routine hedging. The variability of returns was slightly greater. The mean net price for the two multiple hedging strategies averaged $.03 per bushel below that received from a cash sales (only) strategy. For the 1975/80 sub-period the multiple hedging strategies had an average price that exceeded the price received by all other strategies including the cash marketing control strategy. The risk, as measured by the standard deviation of returns, fell slightly below the midpoint of the range delimited by the standard deviations observed in cash marketing and routine hedging. The relative results for the two periods indicate that during 1973 and 1974, multiple hedging would have required a producer to forego a portion of the higher prices, but by a much smaller amount than that observed in the other hedging strategies. The most consistent result was that the multiple hedging strategies reduced losses in futures positions in years that prices rose (but typically did not increase futures markets profits in years of declining prices).

Technical analysis did not, however, provide a means for extracting profits from intra-year changes in futures prices consistently. In fact, when totaled over the nine year test period, futures market profits were negative for both multiple hedging strategies. A producer who uses trend-following devices with the sole objective of reaping speculative profits from corn futures is apt to be disappointed. Nonetheless, average price was improved relative to routine hedging while risk was reduced relative to not hedging.

Thus, our analyses cannot be summarized in a single, simple conclusion. It seems likely that no single "golden decision rule" is available from technical analysis. One can find profitable rules for particular historical periods, but such a rule, say based on 3/10 day averages, will not necessarily be profitable in an individual future year. In other words, a rule that was profitable in 1982 may not be profitable in 1983. Our analysis does suggest, however, that if the same rule is applied consistently over a period of years, the variance of income will be reduced relative to not hedging and perhaps average incomes can be raised relative to routinely hedging.

The benefits (and disadvantages) of any hedging program are realized over a period of years. A routine hedge, if followed rigorously, will tend to provide net returns above cash prices when price levels are low and conversely provide returns below cash prices when price levels are high. A target price-type selective hedge can provide the farmer with the target in some years, but in other years it may be impossible to achieve the target. Moreover, even if the target is achieved, higher returns may have been foregone as the result of the hedge.

Likewise, multiple hedging can help avoid large margin calls in years when prices trend upward. But, at the beginning of the year, say at planting time, the hedger cannot antitipate actual price behavior, and the multiple hedging strategy can result in significant speculative losses. No program is likely to provide consistent gains every year. Hence, as suggested above, the hedging program must be judged by its performance over a period of years. This may provide little consolation to the hedger who experiences large losses from his futures positions during a particular year.

Other considerations in hedging

A grower considering a hedging program should establish an objective for the program, and the program should be carried out in light of available information. With respect to objectives, does the grower wish to reduce the variance of income over a period of years while maintaining (approximately) the average market price? Or, does the grower wish to obtain prices that are high relative to production costs in those, usually rare, instances when such prices are available in the market? Or, is the grower primarily interested in speculation?

The hedger needs to be familiar with the economic climate--fundamentals--even if he is relying on technical analysis. Price objectives will be established in light of market prices, production costs, and government loan rates. If current prices are near support levels and assuming farmers are participating in the support program, then little downside price risk exists, and it makes little sense to place a selling hedge. Prices might rise, but a limit exists on any possible decline. In contrast, if prices are well above support levels, the risk of either a price increase or decrease exists, and hedging strategies should be considered.

After the grower has established an objective for a hedge program, then he or she will want to discuss it with a broker and credit agency. The hedger must have adequate credit to meet margin calls and to see the hedge program through to completion. The hedger also needs to have confidence that the broker will work to achieve the hedger's objective. Brokers often work with speculative accounts and in some instances may be less familiar with farmer-hedger accounts than with purely speculative traders.

Finally, a hedging program should be judged relative to its objectives and not relative to some especially high prices, which could have been obtained with 20/20 hindsight. The use of moving averages, for example, can provide the benefit of reducing margin calls, and hence hedging costs, relative to a routine hedging program. Hedging programs also reduce the variability of income, but it is doubtful that they can consistently provide higher than average incomes.

APPENDIX

Definitions of Hedging Strategies

Five hedging strategies are evaluated in this report; each was simulated for the 1972-1980 crop years resulting in nine observations of each strategy. An attempt was made to choose strategies that are directly comparable to not only the control strategies, but to each other as well. Each strategy has decision criteria that differs in only one aspect from that used in at least one other strategy, and the results are therefore comparable. In addition, strategies have been selected that are:

(1) applicable to the corn for grain producer;

(2) easily implemented by individual producers;

(3) have indicated potential in previous research.

In all strategies "placing a hedge" involves selling December corn futures contracts traded on the Chicago Board of Trade.

Unhedged Production. This strategy calls for routinely selling corn at harvest in the local cash market on November 15th of each year.

Routine Hedge. This program involves routinely placing a short hedge at planting and lifting the hedge at harvest to coincide with the cash sale of grain in local markets. May 1st of each year is selected as the representative hedging date. The first two alternatives act as controls in the experimental design and serve as the primary reference points in evaluating performance of the other strategies.

Target Price (Selective hedge I). A short hedge is placed if the localized futures price (current price of the December contract minus expected local basis at harvest) equals or exceeds a producer's break-even price plus a $.10 per bushel return. Futures prices are monitored from May 1 on, and the hedge, once placed, is left in effect until harvesttime sale of corn. This strategy attempts to use the futures market to "lock-in" a favorable price. The price at which the futures contracts are sold, minus the basis, becomes the producers' price objective.

The two remaining strategies depend on technical analysis of futures prices. Although a wide variety of technical systems have appeal as trend following devices, moving average systems are selected as the technique used for the following reasons:

(1) Moving averages give precise buy and sell signals, eliminating subjectivity in the simulated hedging decisions.

(2) Moving averages are easily calculated, updated and graphed and therefore meet the objective of being easily used by individual producers.

(3) Moving averages have shown relatively good performance in identifying significant turning points in market prices.

(4) Weaver's results suggest that moving averages outperform point and figure analysis when used as a trend following device.

These two multiple hedging strategies are purely technical strategies. They call for placing and lifting short hedges throughout the growing season based on signals given by a moving average system.

Selective Strategy II. This strategy calls for selling futures if the 3 day moving average crosses the 10 day moving average from above. The futures position is maintained until the 3 day average crosses the 10 day average from below, signaling an upward trend in prices. At this time, the futures contracts are bought back and an unhedged position is maintained until the next sell signal is given at which time the hedge is replaced. Futures prices are monitored from the beginning of the planting season. Any open futures positions are closed at harvest to correspond with the sale of corn in the cash market.

Selective Strategy III is identical to the 3/10 day strategy with the exception that a 10/40 day moving average system is used to generate buy and sell signals.

Test Period and Sources of Price Data

The simulation of the hedging strategies requires a continuous series of daily opening and closing prices for the December corn futures contract. This contract represents the first delivery month of the new crop year and is the delivery option nearest to harvest. The daily futures price series allows for testing of the selective hedging strategies decision criteria as outlined above. The series also allows for calculation of the effects of price changes on a producer's margin requirements while hedges are in place. This leads to improved estimates of hedging costs, as the cost of funds needed to meet margin requirements must be considered as part of the costs of hedging. The futures price series used in the study were obtained from the Chicago Board of Trade for each December delivery corn contract traded between January 1972 and the expiration of the December 1980 contract.

The hedging simulations also require a series of harvesttime cash prices for the nine years included in the study. In this study, "harvest-time" is denoted as the month of November in each year. This led to obtaining cash prices from an individual grain elevator in western New York State for the month of November. The use of actual prices, rather than a regional average, allows corn marketings to be simulated at prices that were available to individual producers.

Assumptions for Simulation of Hedging Strategies

Assumptions for futures trading mechanics

Our analysis attempts to parallel reality as close as possible, but a number of simplifying assumptions were necessary in order to keep the simulations tractable. The following assumptions pertain to the mechanics of futures trading as carried out in the simulations.

(1) The midpoint of the daily closing price range is used as the representative futures price for generating trade signals.

(2) All hedges are placed and liquidated at the midpoint of the opening price range on the day following a trade signal. This assumption recognizes that an individual placing a market order does not know beforehand the price at which the futures transaction will be made.

(3) Trades are prohibited on days that corn futures prices open limit up or down. Hedge placement or liquidation is deferred until the futures market opens at less than a limit price move.

(4) No futures market transactions can occur before the assumed hedging date of May 1st in each year of the test period.

(5) Any open futures positions are closed on the assumed harvest date of November 15th to correspond with the sale of corn in the cash market.

Simulation of the hedging strategies requires discrete starting and stopping points between which the decision criterion is evaluated. In practice, a producer becomes subject to price risk as soon as resources are committed to the production of corn. This can occur quite early in the year. However, the producer is also subject to production risk. Estimates of final yield will improve as the planting and growing season progresses. Using May 1st as the starting date assumes that planting intentions are fully formulated and that some assessment of springtime planting conditions can be made.

For each strategy simulated, all corn is marketed at the cash price posted on November 15th of each year. Using the same cash price for each strategy in any given year allows comparision of hedging performance to focus on how returns from the futures market differed among strategies.

Additional assumptions for simulation of the hedging strategies

A second group of assumptions is related to factors that may be unique to individual farmers, but are necessary to perform the simulations. These include:

(1) The CBOT corn contract calls for delivery of 5000 bushels of No. 2 yellow corn. In the simulations it is assumed that the producer is marketing a deliverable grade corn. Thus, quality discount schedules were not considered when obtaining the cash prices.

(2) Yield variability and lumpiness of contract size are two factors that influence the proportion of production that would be hedged. A farmer harvesting 300 acres at an average yield of 85 bushels per acre has 25,500 bushels of corn. In this example, an "equal and opposite" position in futures would require the sale of five futures contracts. However, at the beginning of the growing season, final output is not known. If production is overhedged by selling more futures contracts than the amount of grain harvested, the excess futures position is best characterized as price speculation rather than hedging. Conversely, underhedging results in a portion of the cash grain position remaining exposed to price risk. For the purposes of this study, the trading of one 5000 bushel contract is simulated and the average returns are reported on a per bushel basis. The effect is to simulate a 100% hedged position.

(3) Commission Costs. A producer would use a broker as an intermediary in conducting futures market transactions and is subject to a commission charge on each round-turn (sale and purchase) trade of one contract. An assumed rate of $50.00 per contract or $.01 per bushel is charged in each year of the test period. The multiple hedging strategies permit more than one round-turn trade within a production period. Each trade increases hedging costs by $.01 per bushel.

(4) Margin Deposits. A producer is required to deposit margin money with his broker for each futures contract traded. The margin acts as a performance bond. Margin requirements consist of the initial margin deposited when a futures position is taken and a maintenance margin level below which the futures account may not fall. A rise in futures prices (in the case of a short hedge) can lead to margin calls that require additional funds to restore the futures account to the original margin level. The opportunity cost of margin funds increases hedging costs and decreases the net returns received from a hedging program.

In order to estimate the costs associated with margin deposits, a producer is assumed to borrow sufficient funds to keep the futures position fully margined. The interest charged on these loans is then used as a proxy for estimating the opportunity cost. Implicit in this assumption is that by maintaining a hedged position (and hence decreasing price risk) a producer's line of credit is increased at least by an amount sufficient to cover all loans for hedging activities.

Once a producer deposits margin money and a loan balance is established, interest on the loan is charged over the life of the hedge. Rising futures prices, resulting in margin calls, lead to an increased loan balance while decreasing prices can result in profits accruing to the futures position. These profits can be withdrawn and used to reduce the outstanding loan balance. Thus, the funds borrowed to meet margin requirements are not static, but instead fluctuate over the production period. In the simulations, this loan balance is charged interest on a daily basis. Interest costs are accumulated and added to the commission costs to provide an estimate of total hedging costs. The annual loan rate to borrowers averaged for all Production Credit Associations in the Springfield Massachusetts district of the Farm Credit Banks was used as the interest rate charged on funds borrowed to meet margin requirements (Appendix Table 1).

Appendix Table 1. Interest Rates Used in the Hedging Simulations to Estimate Cost of Margin Money, 1972-1980

Year	Percent per annum
1972	6.92
1973	7.62
1974	8.88
1975	8.85
1976	8.05
1977	7.75
1978	8.37
1979	10.36
1980	11.97

Source: Farm Credit Banks of Springfield.

Minimum margin requirements for corn futures are established by the CBOT and are changed according to Exchange's perception of price volatility and the level of risk. However, brokerage firms often require that their customers deposit more than the Exchange minimum. It is assumed that a broker require 200% of the Exchange minimum as the initial margin requirement. The maintenance margin is assumed to be 75% of this initial margin level (Appendix Table 2).

(5) Cost of Production. The decision criterion for selective hedge I is based on selling futures only if the localized futures price equals or exceeds a producer's target price. The target price is calculated from an estimated cost of production plus a specified margin.

Production costs will vary for each individual depending on harvested acreage, cropping practices, machinery complement and the method used in calculating land charges. This study estimates production costs in a somewhat *ad hoc* way, but the resulting estimates are adequate to illustrate the different hedging strategies.

The cost of production estimates used in the simulations are based on cost data collected by Cornell researchers in each year of the test period (Farm Cost Accounts). These costs, collected primarily from producers with

Appendix Table 2. Initial Margin Requirement for Corn Futures Contracts Used in Hedging Simulations, 1972-1980

Year	Margins[a]
1972	$600
9-20-72[b]	800
1973	800
5-29-73	1000
5-30-73	1500
6-4-73	2000
10-18-73	1500
1974	1000
7-19-74	2000
1975	1000
1976	1000
1977	1000
10-20-77	800
1978	1000
1979	1000
1980	1000

a/ Initial margin requirements represent 200% of the CBOT hedging minimums.

b/ Only changes in margin requirements that occurred within the growing season are given.

Source: Chicago Board of Trade.

relatively small harvested acreage, were adjusted downward to reflect size economies available to the larger cash grain producers operating in Western New York. The size economy adjustment was based on a 1980 survey of production costs incurred by relatively larger producers of corn for grain (Snyder, 1981). The specific technique used for calculating cost of production estimates was as follows: (a) The observed ratios of growing and harvesting costs between the 1980 survey of field corn producers and the 1980 Farm Cost Accounts were used as the adjustment factors. (b) The growing and harvesting costs per acre published in the Farm Cost Accounts for 1972-1979 were then adjusted by these factors. (c) The drying and hauling cost components observed in the 1980 survey were then adjusted by the Prices Paid Index (USDA Ag. Prices) to estimate these costs for the 1972-1979 period. (d) Finally, the estimated total costs of production per acre were divided by the 10 county Western New York average yield to obtain an estimate of the production costs on a per bushel basis. The production cost estimates are presented in Appendix Table 3.

Appendix Table 3. Estimated Corn Production Costs, Western New York, 1972-1980

Year	Costs dollars per bushel
1972	1.54[a/]
1973	1.57
1974	1.86
1975	2.02
1976	2.19
1977	2.14
1978	2.48
1979	2.68
1980	2.58

a/ Production costs estimated by adjusting costs published in Farm Cost Accounts, 1972-1980.

The second component of the target price is the specification of a profit margin, and a \$.10 per bushel profit objective was used in each year of the test period. In practice, an individual would formulate his own objective.

Basis Calculations

A general definition of the term "basis" is the difference between the price of a futures contract and the cash price of a commodity (Tomek, 1978). Specific usage of the term depends on time and location considerations that determine which futures contract and cash price is used. (Also, in calculating the basis, the trade tends to subtract futures from cash while researchers often do the opposite.) For the producer-hedger, the relevant futures contract is often the delivery option nearest his marketing period, and the relevant cash price is the current price available in his local marketing area. Therefore, the term basis as used in this study is specifically defined as the difference between the December corn futures contract and the harvesttime cash price available in Western New York.

A perfect forecast of the harvesttime basis allows a producer to use futures markets to establish a precise price prior to harvest. This is illustrated by a simplified example:

> On July 1st the December corn contract is trading at \$2.96 per bushel. A producer, expecting the harvesttime basis to be \$.18, calculates a localized futures price of \$2.78 per bushel (current futures price minus expected basis: \$2.96 - \$.18 = \$2.78). If \$2.78 is an attractive price, the producer sells futures contracts against his cash crop. By November 15th the futures price declines to \$2.50 and, as expected, the local cash price is \$.18 under the futures price or \$2.32. The producer sells corn at \$2.32 and buys back the futures contracts at \$2.50.

The returns from the futures position of \$.46 per bushel when added to the \$2.32 received from the cash sale would result in a price before deducting hedging costs of \$2.78 - exactly equal to the producer's price objective.

In reality, however, it is not possible to forecast exactly the harvesttime basis. Hence, the convention of using quotation marks when stating that futures markets can be used to "lock-in" a price for a growing crop is used here. The magnitude of the deviation of the actual basis from the expected basis will determine how close the actual price realized is to the price objective.

For this study, the basis calculations represent the futures-cash price relationship observed at a Western New York location. In calculating the basis, the harvesttime period was defined as the month of November in each year. Summary statistics for the November basis are presented in Appendix Table 4.

Appendix Table 4. Calculated November Corn Basis, Western New York Location, 1972-1980

Year	Low	High	Median	Expected Basis[b/]
	---------------dollars per bushel---			
1972	-.02[a/]	.08	.02	.12
1973	-.01	.27	.08	.10
1974	.26	.59	.43	.09
1975	.45	.67	.50	.18
1976	.10	.29	.22	.34
1977	.15	.51	.31	.38
1978	.20	.22	.21	.34
1979	.11	.21	.15	.25
1980	.56	.82	.69	.22

a/ A negative sign indicates that the cash price exceeded the futures price.

b/ Expected basis calculated as the average of three previous years' median November basis.

Sources: Futures Prices: Midpoint of daily closing price range, December corn contract, Chicago Board of Trade.

Cash Prices: Daily posted prices supplied by an individual grain elevator.

The variability of the observed basis within and among years during the test period indicate that the Western New York basis is characterized by instability. Visual examination of Table 4 yields no readily apparent trends in harvesttime basis behavior. This instability translates into increased basis risk for the producer following a hedging strategy that attempts to "lock-in" a price for his growing crop.

The expected basis shown in Appendix Table 4 is the average of the median basis for the prior three years. As explained in the body of our report and as is clear from the table, the average is a rather poor estimate of the basis that actually prevails in a particular year. A more conservative approach, which is reported in the text, is to use the average of the high basis.

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