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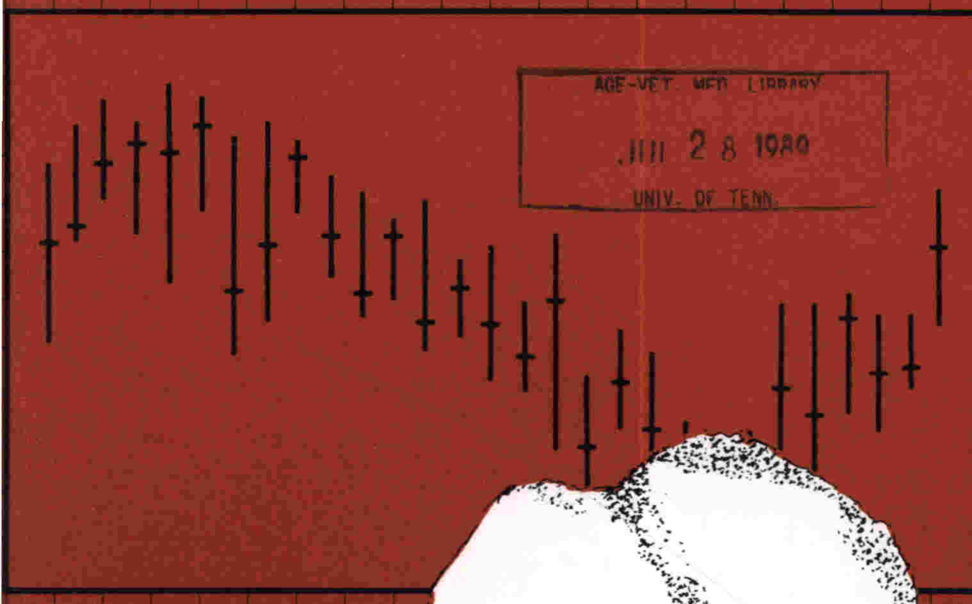

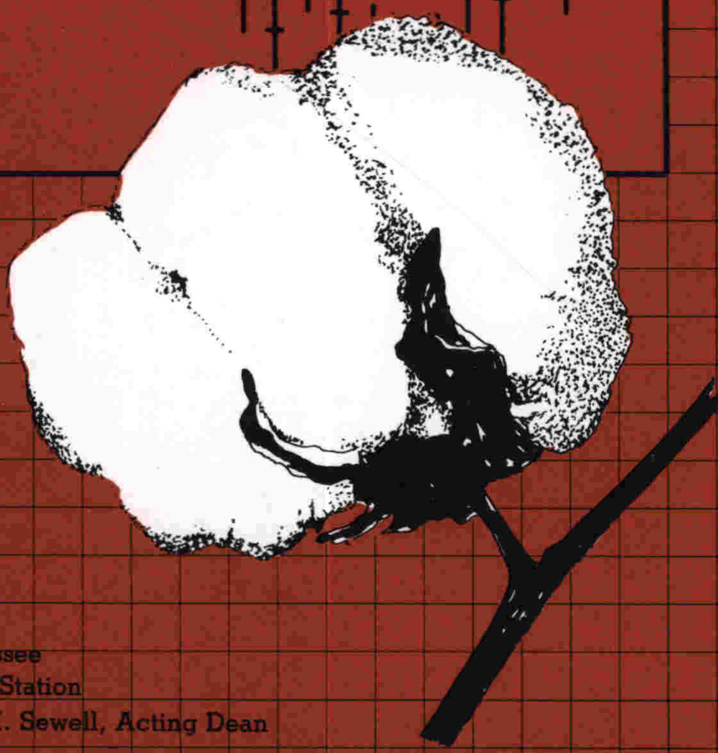

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Abstract

The potential of hedging in the futures market as a means of reducing risk associated with cotton price variability was evaluated. This study was divided into two segments: an economic evaluation of alternative cotton marketing strategies and the derivation of the optimal hedging ratio. The data used for this study consisted of daily Memphis cash prices and daily New York futures price quotations for cotton with a grade of strict low middling, a staple length of 1 1/16 inches, and a micronaire of 3.5 to 4.9.

Evaluation of alternative marketing strategies involved the simulation of 12 strategies using price data for the period 1974 through 1985. The cash sale at harvest strategy served as a benchmark for the 11 other alternatives, all of which were hedging strategies. Computer programs developed to simulate the hedging strategies accounted for brokerage fees, margin calls, margin withdrawals, and interest costs associated with hedging. Two of the hedging strategies were classified as routine strategies since a hedge was maintained continuously once it was placed. There were five hedging strategies categorized as selective strategies that allowed the hedge to be placed or lifted repeatedly as signaled by moving average indicators. The remaining four strategies dealt with the adjustment of moving average lengths to improve the performance of the hedging strategy. Rules based upon the daily highs and daily lows of the futures contract were used to vary the length of the adjustable moving average. The adjustable moving average concept was effective in increasing the producer's return from hedging. However, the variance of return was generally increased as well.

The second part of the study examined the percentage of a producer's cotton that should be hedged in order to minimize the variation of returns. This hedging ratio was estimated first by regressing successive price changes in the spot market on corresponding price changes in the futures market. The slope coefficient of such a regression has been shown in current literature to be equivalent to the risk-minimizing hedging ratio. A risk-minimizing hedging ratio was also found for each hedging strategy simulated. Strategy-specific hedging ratios were estimated by regressing the returns from the spot market position on the returns from the futures price changes. The size of the risk-minimizing hedging ratios derived from price changes over various time intervals was affected by the length of interval used. None of the strategy-specific optimal hedging ratios were significantly different from one at the 95 percent level of significance.

Contents

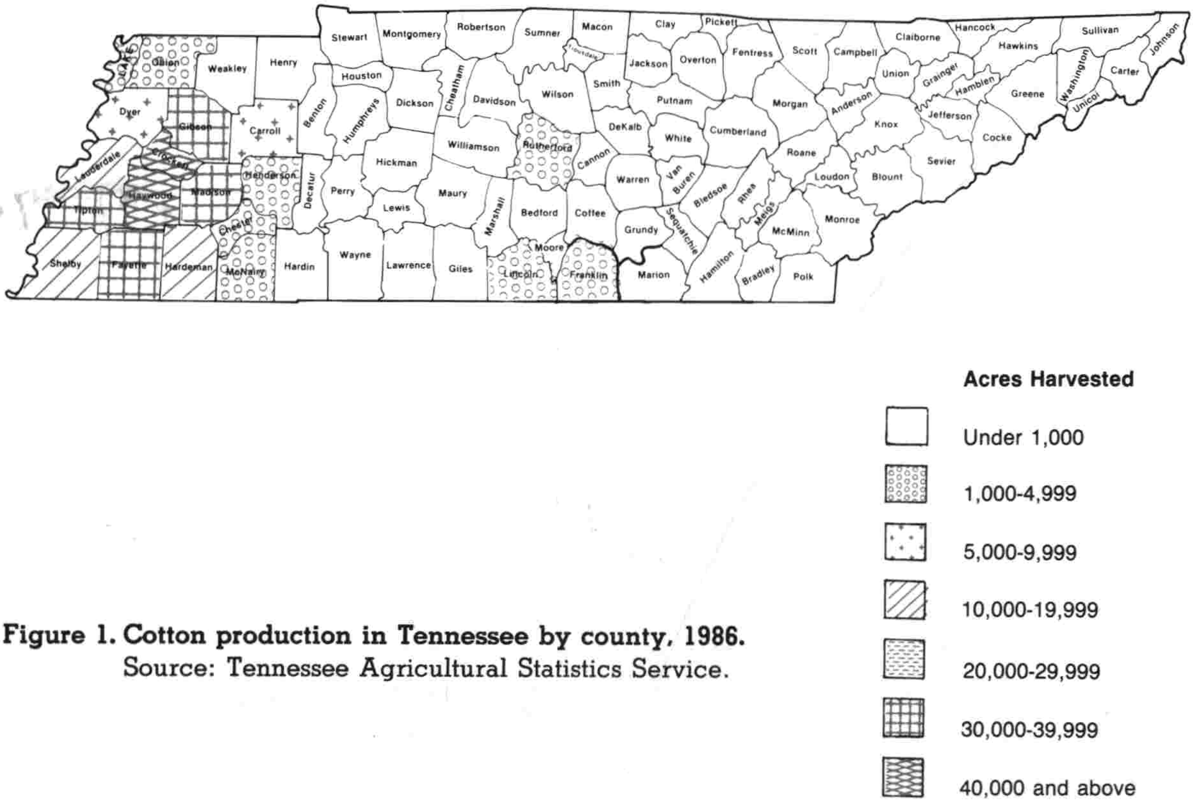

Figure 1. Cotton production in Tennessee by county, 1986.
Source: Tennessee Agricultural Statistics Service.

Cotton Marketing Strategies and Optimal Hedging Ratios

Introduction

Upland cotton production in Tennessee has typically accounted for between two and five percent of total production in the entire United States [USDA 1985]. With the exception of 1967, Tennessee ranked from seventh to ninth in cotton production among all states during the 1960 to 1985 period. Severe weather-related problems in 1967 caused Tennessee's position to fall to twelfth. The distribution of Tennessee's 335,000 acres of cotton in 1986, by county, is illustrated in Figure 1 [Tennessee Agricultural Statistics Service 1987].

Once the decision to produce cotton has been made, producers face not only the risks associated with production of the crop, but also those risks related to marketing the crop. Price fluctuations can result in unfavorable circumstances for farmers. Furthermore, the marketing strategy a farmer chooses determines, to some degree, the amount of price risk to which the farmer is subjected.

Results from a recent survey of randomly selected cotton producers in West Tennessee indicate that the most frequently used marketing strategy is the cash sale at harvest, while forward contracting at a fixed price is the second most common practice. Use of any other alternative was shown to be infrequent [Brooker and Terry 1982].

Depending upon the individual farmer's situation, cash sale at harvest and fixed-price, forward contracting may or may not be the most appropriate strategies for attaining personal marketing objectives. Some farmers, for example, might wish to accept a slightly lower price for their cotton in order to avoid much of the price risk inherent in cash sales at harvest. Other farmers may have an aversion to both the price risk of the cash sale at harvest strategy and to inflexibility of the terms of forward contracting. Hedging cash sales with futures contracts is an alternative approach that may afford producers the opportunity to increase net returns, enhance flexibility, and reduce the variability of net returns.

Although little use has been made of hedging by cotton growers in Tennessee, their need for more information about hedging has been indicated [Brooker and Terry 1982]. In order for growers to successfully select and implement their marketing plans, they need information concerning the mean net returns and variability of returns for alternative marketing strategies. If a producer desires to hedge cotton sales in the futures market, the producer must know what proportion of the expected crop to hedge and which futures contract month to use in the hedge. Depending upon the reason for hedging, the producer may better serve personal objectives by hedging less than 100 percent of the expected cotton crop in the futures market.

The overall goal of this research project was to provide cotton producers with information to aid in their selection and execution of a marketing strategy for their crop. Within this general goal were two specific objectives:

1) to evaluate selected marketing strategies with respect to risk and net returns, and
2) to estimate the optimal hedging ratio for growers who choose to hedge their expected cash sales in the futures market.

Methodology and Procedures

Routine Strategies

One of the major groups of marketing strategies evaluated in this study consisted of routine strategies where actions are executed only once during the marketing period. The cotton producer was assumed to produce and market 50,000 pounds of lint, the equivalent of one futures contract on the New York Cotton Exchange. With the exception of the break-even price hedging strategy discussed below, no assumptions were made as to the producer's per acre yield, nor were any allowances made for possible economies of scale in cotton production. All of the marketing strategies involved a cash sale of the total crop on a given day. The indivisibility of one futures contract necessitated this additional assumption. The date selected for spot sales was the trading day nearest to December 5 each year. December 5 is the ending date of the normal harvest period given by Tennessee Agricultural Statistics [Tennessee Crop Reporting Service 1980].

The first routine strategy was the cash sale at harvest alternative in which the producer did not hedge the cash position and did not store the crop beyond the harvest period. Yearly returns from this strategy were determined by multiplying the Memphis spot price per pound on the assumed date of harvest sale by 50,000 pounds. The second routine strategy evaluated was the planting hedge. In the planting hedge strategy the producer hedged the cotton crop by selling one December futures contract on the last trading day in May. The last trading day in May was chosen as an approximation of the end of the normal planting season. A hedged position was held until December 5, the assumed date of harvest. The break-even price hedge was the third routine strategy evaluated.

Estimations of the variable costs and fixed costs were made for each year corresponding to the time period of the study [Ray and Walch]. Estimates of total cost per acre were then converted to total cost per pound of cotton produced by dividing by the average of the yields in Tennessee for the previous three years. The break-even price for each year was defined as that price per pound necessary to cover both the variable and fixed costs of production.

A hedge was placed when and if the December futures price minus the expected ending basis was equal to or greater than the estimated break-even price for the given year.[1] The expected ending basis was assumed to be the simple average basis for the month of December for the previous three years. If no hedge was placed prior to harvest, the returns from the break-even hedge were calculated exactly the same as for the cash sale at harvest strategy.

For each hedging strategy the margin balance in the hedger's account was calculated each day using the daily close of the future contract and the previous daily close. Along with initial margin requirements, upper and lower margin balance requirements were used in determining the occurrence and magnitude of margin calls and margin withdrawals. In this study a withdrawal of funds from the margin account was treated as a negative margin call. Table 1 shows the initial margin requirements, the upper and lower equity margin limits, the annual interest rates, and the round-turn brokerage fees used in the simulation of all hedging strategies.

Interest on the initial margin and interest charges on margin calls were calculated for each hedge in order to make the results as realistic as possible.[2] Withdrawals of margin balance funds, or negative margin calls, resulted in negative increments to total interest costs.

Selective Strategies

In routine hedging strategies the producer maintained the hedged position continuously once the hedge was placed. Regardless of the behavior of cotton prices in the futures market or in the spot market, the hedge was not lifted until the end of harvest. Selective hedging strategy simulations, on the other hand, allowed the producer to place and lift numerous hedges prior to the end of harvest. The placing and lifting of hedges was based upon moving average indicators.

Using moving average indicators in a selective hedging strategy is an attempt to protect one's spot market position by hedging during price declines, yet benefit from price rises by having an unhedged spot position. Ideally, the moving average indicator would provide the producer with signals to place hedges at price peaks and signals to lift hedges at price troughs. Because moving average indicators are trend-following techniques, signals to place or lift will not correspond exactly to price peaks and troughs, respectively. These indicators are expected, however, to identify trends in a price series soon after they have begun.

A moving average indicator actually consists of one or more component moving averages of a price series and decision rules based upon the

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[1] Basis calculated by subtracting the daily cash price at Memphis, Tennessee, from the daily closing price of the December cotton futures contract of the New York Cotton Exchange.

[2] For detailed explanations of all equations used to calculate simulated returns, see Davis (1986).

Table 1. Values of variables used in simulations of hedging strategies

Year	Maintenance margin: Initial margin requirement	Lower boundary[a]	Upper boundary[b]	Brokerage fee round turn	Interest rate[c]	Price deflator[d] (1972 = 100)
	dollars per contract				percent	
1974	385.93[e]	289.45	482.41	51.46[g]	9.25	115.08
1975	421.85[e]	316.39	527.31	56.25[g]	8.75	125.79
1976	443.82[e]	332.87	554.78	59.18[g]	8.25	132.34
1977	469.67[e]	352.25	587.09	62.62[g]	8.25	140.05
1978	504.45[e]	378.34	630.56	67.26[g]	9.00	150.42
1979	548.05[e]	411.04	685.06	73.07[g]	11.00	163.42
1980	598.35[e]	448.76	747.94	79.78[g]	12.75	178.42
1981	654.42[e]	490.82	818.03	87.26[g]	12.75	195.14
1982	693.79[e]	520.34	867.24	92.51[g]	15.00	206.88
1983	720.35[e]	540.26	900.44	96.05[g]	13.00	214.80
1984	750.00	562.50	937.50	100.00	13.90	223.64
1985	774.95[f]	581.21	968.69	103.33[h]	13.20	231.08

[a]Assumed to be 75 percent of initial margin requirement.
[b]Assumed to be 125 percent of initial margin requirement.
[c]Interest rate on operating loans; obtained from Production Credit Association, Brownsville, Tennessee.
[d]Implicit price deflator for GNP.
[e]Obtained by deflating the 1984 margin requirement for a hedger.
[f]Obtained by inflating the 1984 margin requirement for a hedger.
[g]Estimated by deflating the 1984 brokerage fee.
[h]Estimated by inflating the 1984 brokerage fee.

crossing of the component moving averages. These component averages are typically moving averages of different lengths based upon the daily closing price of the futures contract. One consideration in formulating a moving average strategy is deciding how many individual averages the moving average indicator should have. An indicator composed of two component moving averages is referred to as a two-crossover moving average indicator. Similarly, a three-crossover moving average indicator is made up of three individually moving averages.

Other parameters of a moving average indicator that must be selected are the lengths of the individual moving averages. The length of a moving average determines its degree of smoothing on the price series from which it is calculated. Smoothing refers to how much the moving average evens out changes in the actual price series. The longer the moving average, the greater the smoothing effect. In a two-crossover indicator, the shorter moving average would be more responsive to a given change in the closing price from one day to the next than the longer moving aver-

Decision rules used for the two-crossover strategies in this study were as follows:

1) A place signal was generated when the shorter moving average

penetrated or crossed the longer moving average from above by a specified penetration amount of 0.5 cents per pound.

2) A lift was generated when the shorter moving average penetrated or crossed the longer moving average from below by a specified penetration amount of 0.5 cents per pound.

The penetration amount required represents an attempt to eliminate some of the false place or lift signals that inevitably occur with moving average indicators. A trend may not be indicated by the crossing of the component averages until after a subsequent price trend in the opposite direction is already underway. Inclusion of a penetration rule would theoretically reduce the occurrence of false trading signals and the unprofitable trades associated with these signals.

The first two-crossover strategy tested was a 25 day-7 day crossover. This strategy was selected because of its performance (in terms of return relative to variance of return) in a hedging study done by Howard for the Texas High Plains and Rio Grande Valley cotton-producing regions [Howard 1979]. The second two-crossover strategy simulated was a 25 day - 13 day crossover. In her study of hedging strategies for Arizona cotton, Haden [1983] reported this strategy exhibited the most favorable results of the two-crossover strategies tested.

For the three-crossover moving average strategies, place and lift signals were generated by the intermediate length moving average crossing the longer moving average. The shorter of the three component moving averages was used to confirm signals generated by the other two. This confirming average was a linearly-weighted moving average for all of the three-crossover strategies simulated. Computation of the confirming averages was performed as follows:

$$\mathrm{LWMA} = \frac{\sum_{i=1}^{n} i(\mathrm{CLOSE}_i)}{\sum_{i=1}^{n} i}$$

where:

LWMA = linearly-weighted moving average

CLOSE_i = the ith most recent daily close of the December cotton futures contract

n = length (in days) of the linearly-weighted moving average.

For the most recent price included in the linearly-weighted moving average, the value of i was equal to "n." For the oldest closing price, the value of i was equal to "one." The effect of the linearly-weighted moving average was to weight the recent closing prices more heavily and increase the sensitivity of the confirming average.

Decision rules for the three-crossover strategies were:

1) A place signal was generated when the intermediate length average crossed the longer moving average from above, and the confirming (or shorter) moving average was also below the intermediate length moving average.
2) A lift signal was generated when the intermediate length average crossed the longer moving average from below, and the confirming (or shorter) moving average was also above the intermediate length moving average.
3) The penetration of the longer moving average by the intermediate moving average must have been equal to or greater than the required penetration amount of 0.5 cents per pound in order for a place or lift signal to occur.

Three different three-crossover strategies were simulated. A 25 day-7 day linearly weighted crossover was the first of this group. Howard reported this strategy as his best three-crossover using the December futures contract. The second strategy of this group was a 25 day-16 day linearly weighted crossover. This strategy was the best three-crossover indicator in Haden's study [1983]. A 10 day-5 day-4 day linearly weighted crossover recommended by Purcell [1979] was simulated as the third strategy of this type.

Returns from the selective strategies were calculated by summing the return from each hedge that occurred during the given year. The return from each hedge was computed exactly the same as for the routine hedging strategies.

Adjustable Strategies

The results of the moving average strategy depend upon the compatibility between the moving average indicator used and the demonstrated behavior of prices [Querin and Tomek 1983]. Selection of an appropriate moving average indicator has typically been a matter of trial and error. The fact that the lengths of the individual moving averages are fixed and independent of price behavior may be one reason why a particular moving average indicator might fail. An adjustable moving average concept was tested in this study as a possible solution.

The adjustable strategies simulated were variations of the selective strategies in which the signal-generating component averages were adjusted according to specified criteria. In the adjustable two-crossover strategies, the length of the shorter component moving average was allowed to vary.

For the adjustable three-crossover indicators, the length of the intermediate moving average was permitted to vary.

What the adjustable moving average method attempts to do is to generate place and lift signals nearer to price peaks and troughs, respectively, than the non-adjustable moving average strategies. If the producer's spot position was unhedged, then the adjustment of the adjustable moving average was based upon the movement of daily highs.

Conversely, the adjustment of the adjustable moving average was based upon the daily lows for hedged positions. At the beginning of each simulation, the length of the adjustable moving average was set at its initial length. The initial length of an adjustable component average was equal to the length of the signal-generating component average of the original selective hedging strategy. The length of the adjustable moving average was also reset to its initial value at each occurrence of a place or lift signal.

Arbitrary upper and lower limits were imposed upon the length of the adjustable moving average. The change in the length of the adjustable average was limited to plus or minus one half of its initial length. If the original length was an odd number, then the amount of allowable change was rounded to a whole number. For example, the adjustable component average of the 25 day-7 day two-crossover was allowed to vary from 4 days to 10 days in length. For the adjustable three-crossover strategies, the length of the intermediate moving average was also restricted to lengths greater than that of the shorter moving average. Therefore, no adjustable version of the 10 day-5 day-4 day linearly weighted strategy was simulated.

There is another major part of the adjustable moving average indicator called the range. The range is the number of previous days from which a maximum high and a minimum low can be selected. The length of the range is always equal to the length of the adjustable moving average. If the producer's position was unhedged, the current high was compared to the highest high of the range. If the producer's position was hedged, the current low was compared to the lowest low of the range.

The adjustment rules for an unhedged position are shown in Table 2. Table 3 gives the adjustment rules for a hedged position. In conjunction with these adjustment rules, the adjustable strategies employed the same place and lift criteria as the non-adjustable strategies.

Optimal Hedging Ratio

The hedging ratio is the ratio of the size of the producer's futures market position to the size of his spot market position. For this study, the optimal hedging ratio was defined as the hedging ratio that minimizes the producer's price risk. Concepts from portfolio theory were used to view a producer's spot market holdings and futures market holdings as alternative "activities" in which the producer could engage.

According to Johnson, the total variance of return from a portfolio of positions in the spot and futures markets was:

Table 2. Adjustable moving average rules for an unhedged position

Condition	Adjustment	Effect on sensitivity
If $H_t = HH_t$	Length of adjustable moving average and the range not changed	None
If $H_t > HH_t$ and $H_{t-1} < HH_{t-1}$	Length of adjustable moving average and the range increased by one day	Sensitivity and likelihood of placing a hedge is decreased
If $H_t > HH_t$ and $H_{t-1} \geq HH_{t-1}$	Length of adjustable moving average and the range increased by two days	Sensitivity and likelihood of placing a hedge is decreased
If $H_t < HH_t$ and $H_{t-1} \geq HH_{t-1}$	Length of adjustable moving average and the range decreased by one day	Sensitivity and likelihood of placing a hedge is increased
If $H_t < HH_t$ and $H_{t-1} < HH_{t-1}$	Length of adjustable moving average and the range decreased by two days	Sensitivity and likelihood of placing a hedge is increased

where: H_t = current high

HH_t = highest high of the range at time t

Table 3. Adjustable moving average rules for a hedged position

Condition	Adjustment	Effect on sensitivity
If $L_t = LL_t$	Length of adjustable moving average and the range not changed	None
If $L_t < LL_t$ and $L_{t-1} > LL_{t-1}$	Length of adjustable moving average and the range increased by one day	Sensitivity and likelihood of lifting the hedge is decreased
If $L_t < LL_t$ and $L_{t-1} \leq LL_{t-1}$	Length of adjustable moving average and the range increased by two days	Sensitivity and likelihood of lifting the hedge is decreased
If $L_t > LL_t$ and $L_{t-1} \leq LL_{t-1}$	Length of adjustable moving average and the range decreased by one day	Sensitivity and likelihood of lifting the hedge is increased
If $L_t > LL_t$ and $H_{t-1} > LL_{t-1}$	Length of adjustable moving average and the range decreased by two days	Sensitivity and likelihood of lifting the hedge is increased

where: L_t = current low

LL_t = highest high of the range at time t

$$\mathrm{Var(R)} = X_s^2\sigma_s^2 + X_f^2\sigma_f^2 + 2X_sX_f\mathrm{COV}_{sf} \quad (1)$$

where:

Var(R) = variance of return from a hedged position
X_s = spot or cash market position; $X_s > 0$
X_f = futures market position; $X_f > 0$
σ_s = variance of return from a one unit position in spot market
σ_f = variance of return from a one unit position in the futures market
COV_{sf} = covariance of return from spot market position and futures market position.

The risk-minimizing hedging ratio in (2) was arrived at by differentiating equation (1) with respect to X_f and dividing through by X_s:

$$\frac{-X_f}{X_s} = \frac{\mathrm{COV}_{sf}}{\sigma_f^2} \quad (2)$$

Ederington [1979] applied portfolio theory to hedging in the corn, wheat, and financial securities futures markets. He demonstrated the equivalence of the risk-minimizing hedging ratio in equation (2) and the slope coefficient from the regression of returns from the spot position on returns from the futures position. Let S and F represent the returns from the spot and the futures positions, respectively. In a simple linear regression of a dependent variable, S, on an independent variable, F, the equation for the slope coefficient is:

$$b = \frac{\sum_{i=1}^{n}(S_i-\bar{S})(F_i-\bar{F})}{\sum_{i=1}^{n}(F_i-\bar{F})(F_i-\bar{F})}$$

The numerator of the equation is the corrected sum of cross-products or the covariance of S and F. The denominator is the corrected sum of squares or variance of F. Therefore, the following equation can be written [Ederington 1979]:

$$b = \frac{\mathrm{COV}_{sf}}{\sigma_f^2} = \frac{-X_f}{X_s}$$

Three different empirical procedures were used to estimate the risk-minimizing hedging ratio. The first procedure was taken directly from

Ederington's work on hedging ratios. Ederington [1979] obtained proxies for the returns from spot and futures positions by calculating successive price changes in the spot and futures markets over both two-week and four-week periods.

Application of Ederington's approach to the optimal hedging ratio for Memphis area cotton involved the regression of changes in the Memphis spot cotton market or corresponding price changes for the December futures contract of the New York Cotton Exchange. For one empirical estimation of the hedging ratio, price changes were calculated for the entire duration of the December futures contract. A second derivation of the optimal cotton hedging ratio differed from the first method in that the price changes in the spot and futures markets were not calculated for the duration of the December futures contract. Instead, estimates of the spot and futures returns were calculated only for the weeks of the calendar year during which a production hedge would normally occur. This assumed hedging period was from the last week of May until the first week of the following December. The rationale for using this fraction of the year in lieu of the entire contract life was that a producer should be concerned with the relationship of returns from the two markets only for the period the cotton crop would potentially be hedged.

The first and second methods of deriving the optimal hedging ratio did not take into account the particular hedging strategy to be used in marketing the cotton. Furthermore, the resulting estimate was assumed to apply to all hedging strategies in general. The third procedure employed in this study marked an attempt to derive unique hedging ratios for each individual strategy simulated.

While the first and second methods of hedging ratio estimation followed Ederington's use of successive price changes as proxies for returns, the third procedure used the actual returns from the simulated cash and futures positions. The returns from the spot market position was defined as the revenue from the cash sale of the cotton at harvest. Yearly returns from the futures position were found by summing the net return from each hedge that occurred during the year. Thus, for each strategy there were 12 yearly returns from the futures position and 12 yearly returns from the cash position.

A regression of spot returns on futures returns yielded an optimal hedging ratio estimate for each strategy. The premise of this method is that the optimal hedging ratio may vary for different hedging strategies.

Results

The results of the alternative strategies simulated are reported by the type of strategy. The order in which the results are presented is as follows: routine strategies, selective strategies, and adjustable strategies. The frequency of winning and losing trades as well as the average length of time a hedge was maintained are presented in Appendix Table 1. Details concerning margin calls and margin withdrawals associated with each strategy are given in Appendix Table 2.

Routine Strategies

Cash sale at harvest

The mean return for this strategy was $30,775, and the standard deviation of return was $6,848 (Table 4). Mean return of the cash sale at harvest alternative was the lowest of all 12 strategies tested. The coefficient of variation, a measure of the relative magnitudes of the mean and standard deviation of net returns, was the largest of all strategies.

Planting hedge

The mean return from the planting hedge was $31,394 and the standard deviation of return was $5,076. Based on mean returns, this strategy ranked seventh among the 12 strategies. Its standard deviation was the second lowest of all strategies evaluated, and its coefficient of variation was the third lowest.

Break-even hedge

This strategy was routine in that if a hedge was placed, it was maintained until harvest. In the break-even hedge simulation no hedges were

Table 4. Mean net return, standard deviation of return, and ranking of alternative marketing strategies

Strategy	Mean net return	Rank[a]	Standard deviation of return	Rank[b]	Coefficient of variation	Rank[b]
Routine						
Cash sale at harvest	$30,775.42	12	$6,847.93	12	22.251	12
Planting hedge	31,394.09	7	5,075.83	2	16.168	3
Break-even hedge	31,341.02	10	5,239.35	9	16.717	9
Selective						
25-7	31,486.81	5	5,127.28	5	16.284	5
25-13	31,344.28	9	4,995.21	1	15.937	1
10-5-4w	31,244.35	11	5,300.61	10	16.965	10
25-7-4w	31,392.94	8	5,078.44	3	16.177	4
25-16-6w	31,508.48	4	5,186.58	8	16.461	8
Adjustable						
25-7	31,586.01	2	5,503.11	11	17.423	11
25-13	31,585.05	3	5,092.89	4	16.124	2
25-7-4w	31,474.32	6	5,166.67	6	16.416	1
25-16-6w	31,600.77	1	5,169.95	7	16.360	6

[a]In descending order.
[b]In ascending order.

placed in 1977 and 1985. Mean net return for this strategy (including 1977 and 1985) was $31,341, and the standard deviation of net return was $5,239. Compared to all other strategies simulated, the break-even hedge had the tenth largest mean return and the ninth smallest standard deviation of net return.

Selective Strategies

The selective hedging strategies were based upon moving average indicators. "Selective" refers to the fact that hedges were placed and lifted in response to signals of moving average indicators rather than routinely placed and maintained until harvest.

The 25-7 two-crossover

In relation to all other strategies, the 25-7 moving average strategy had the fifth largest mean return and the fifth lowest standard deviation of return. For the simulation as a whole, the mean return of the 25-7 moving average strategy was greater than the mean return of the cash sale at harvest.

The 25-13 two-crossover

This strategy ranked ninth with a mean net return of $31,344. The standard deviation of net return of $4,995 was the lowest among the 12 simulated strategies.

The 10-5-4w three-crossover

The third selective strategy was a 10 day-5 day moving average with a 4 day linearl-weighted confirming average (referred to as a 10-5-4w three-crossover). This strategy had a lower mean return than all other strategies except the cash sale at harvest. Its standard deviation of net return was the tenth largest of the 12 strategies simulated. Furthermore, only two other strategies had a greater coefficient of variation.

The 25-7-4w three-crossover

The next selective hedging strategy simulated was a variation of the 25-7 two-crossover. In this variation, a 4-day linearl-weighted moving average was used to confirm or reject trading signals generated by the 25-day and the 7-day component averages. With respect to mean returns, this strategy ranked eighth. Its standard deviation of return was the third lowest, and its coefficient of variation was the fourth lowest with a value of 16.177. Although the 25-7 two-crossover produced a greater mean return, the 25-7-4w three-crossover resulted in a lower variance of return and a smaller coefficient of variation.

The 25-16-6w three-crossover

The fifth selective hedging strategy evaluated was the 25-16-6w three-crossover. In relation to all strategies tested, the mean return of this strategy was the fourth largest, and the standard deviation of return was the eighth lowest.

Adjustable Strategies

The adjustable strategies of this study were based upon the two-crossovers and three-crossovers of the selective strategy group. Conceptually, the adjustable strategies attempted to avoid the problems arising from the static nature of the parameters of traditional moving average indicators. Two adjustable versions of selective two-crossovers and two adjustable versions of selective three-crossovers were evaluated.

The adjustable 25-7 two-crossover

The first adjustable strategy simulated was a 25-7 two-crossover in which the 7-day moving average was permitted to range from 4 days to 10 days in length. In relation to other strategies the adjustable 25-7 moving average yielded the second largest mean return and the second largest standard deviation of return. Its coefficient of variation of 17.423 was higher than that of all other strategies except the cash sale at harvest.

Comparison of the results from the adjustable and non-adjustable 25-7 moving-average strategies does not suggest the superiority of either strategy over the other. Mean return of the adjustable strategy (H) increased at the expense of an increase in standard deviation of return as well. For each $1.00 increase in mean return over the 25-7 two-crossover, the standard deviation of return for the adjustable 25-7 two-crossover increased by approximately $3.80.

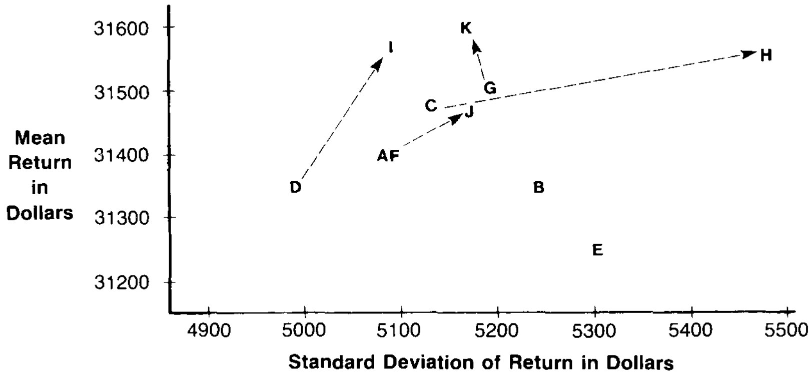
The adjustable 25-13 two-crossover

The second adjustable hedging alternative evaluated was based upon the 25-13 two-crossover. Adjustment rules using the daily high and low of the December futures contract were used to regulate the length of the shorter moving average within a range of 7 to 19 days. The mean return of the adjustable 25-13 moving average was the third largest of the 12 simulated strategies with a value of $31,585. It should be noted that the mean return of this strategy was only $1.00 less than that of the strategy with the second highest mean return. Standard deviation of net return for this strategy was $5,093, the fourth lowest of all strategies. The only strategy with a lower coefficient of variation was the non-adjustable version of the 25-13 two-crossover.

Neither the adjustable or non-adjustable form of the 25-13 two-crossover was clearly superior to the other. Each strategy out-performed the cash sale at harvest in one-half of the years simulated. While the adjustable form (I) had a greater mean return, the non-adjustable version (D) had a lower and, therefore, more desirable standard deviation of return (Figure 2). For each $1.00 increase in mean return above the basic 25-13 two-crossover, there was a corresponding increase of approximately $0.41 in the standard deviation of net return.

The adjustable 25-7-4w three-crossover

The third strategy of the adjustable group was a variation of the 25-7-4w three-crossover in which the intermediate average was allowed to vary from 4 to 10 days in length. This strategy produced a mean return of $31,474



A - Planting Hedge
B - Break-Even Hedge
C - Selective 25-7
D - Selective 25-13
E - Selective 10-5-4w
F - Selective 25-7-4w
G - Selective 25-16-6w
H - Adjustable 25-7
I - Adjustable 25-13
J - Adjustable 25-7-4w
K - Adjustable 25-16-6w

Arrows indicate direction of shift from selective to adjustable technique.

Figure 2. Mean return and standard deviation of return plot for 11 simulated strategies.

and a standard deviation of net return of $5,167. Based upon mean return, this strategy ranked sixth. Its standard deviation of return was the sixth lowest of all strategies evaluated. The coefficient of variation was the seventh lowest with a value of 16.416.

Comparison of the mean return and standard deviation of return for the adjustable (J) and non-adjustable (F) forms of the 25-7-4w moving average reveals that neither version dominates the other as a clearly preferred strategy (Figure 2). The standard deviation of return increased by approximately $1.10 for each $1.00 of return from the adjustable strategy above that of the non-adjustable strategy.

The adjustable 25-16-6w three-crossover

The final adjustable moving average tested was based upon the 25-16-6w strategy. Adjustment rules were applied to regulate the length of the intermediate average between 12 and 20 days. This strategy produced the highest mean return of all strategies simulated in this study. Its standard deviation of return was the seventh lowest. Values of the mean return and standard deviation of return were $31,601 and $5,170, respectively. The coefficient of variation was the sixth lowest with a value of 16.360. No other strategy's net returns exceeded those of the cash sale alternative as frequently as the adjustable 25-16-6w three-crossover's.

Examination of the mean return and standard deviation of return for the two versions of the 25-16-6w three-crossover reveals that the adjustable version is clearly superior (Figure 2). The adjustable 25-16-6w strategy (K) was the only one of the adjustable strategies that was superior to its non-adjustable counterpart (G). Interestingly, the 25-16-6w moving average produced the highest mean return in both the selective and the adjustable strategy groups.

Strategy results were discussed above in terms of mean return and standard deviation of return. Ranking of strategies was done by the simple ordering of magnitudes of mean return and standard deviation of return. In order to determine whether any significant differences existed among mean returns of the 12 strategies, an analysis of variance test was performed. The calculated F value of 0.02 suggests that no significant differences existed among the mean returns of the strategies at any reasonable level of significance.

Tests for equality of variances of return from the strategies were also performed. Pairwise comparisons of variances of return from each strategy were made at the 95 percent level of significance. No calculated F value exceeded the critical F value of 2.82. Therefore, no significant differences were found among the variances of return from the alternative strategies.

Optimal Hedging Ratio

The derivations of the hedging ratio that used successive price changes over two-week and four-week intervals were classified as fixed interval estimations. Two of the fixed-interval estimations were performed using the entire contract duration of the 1974 through 1985 December futures contracts. For the 12 years of futures contracts there were 443 two-week intervals and 221 four-week intervals.

The other two fixed-interval estimations used spot prices and Decem-

Table 5. Fixed-interval estimation of the optimal hedging ratios: regression results

Estimation method[a]	Intercept	Hedging ratio	R^2
Two-week intervals over contract duration	-3.811 (9.71)[b]	1.130* (0.046)	0.58
Four-week intervals over contract duration	-8.280 (20.512)	1.108 (0.068)	0.55
Two-week intervals over hedging period[c]	-11.949 (8.530)	1.067* (0.031)	0.88
Four-week intervals over hedging period[c]	-40.464 (18.862)	1.036 (0.053)	0.84

[a]Price changes in spot market regressed on corresponding changes in futures price.
[b]Standard errors in parentheses.
[c]Defined as beginning with last trading day of May and ending on the trading day nearest to December 5.
*Denotes slope coefficient significantly different from one at the 0.05 level.

ber futures price changes during the assumed hedging period. There were 156 two-week intervals and 73 four-week intervals within the 12 years of the study period. Table 5 presents the results of the fixed-interval estimations of the optimal hedging ratio. The slope coefficients (hedging ratios) of both regression equations for two-week intervals were significantly greater than one at the 95 percent significance level. Neither of the hedging ratios in the four-week interval regressions was significantly different than one at the 95 percent significance level.

As anticipated, the hedging ratios estimated using the hedging period differed from those ratios derived using the duration of the December futures contract. The substantially higher R^2 values with the hedging period regressions support the contention that cash and futures price movements mimic each other more closely as the expiration of the futures contract approaches.

Intercept terms in the regression equations for the fixed-interval estimations have no readily useful meaning. These intercepts do indicate the size and duration of the spot price change that would be expected given a zero change in the futures price. For example, the intercept of -11.949 in the regression of two-week price changes over the hedging period implies that a decrease in the spot price of approximately 0.12 cents per pound would be expected given a zero change in the futures price. While the intercepts are interpretable, they are not directly applicable to the concept of a portfolio of spot and futures positions.

A regression of yearly spot returns on yearly futures returns was done for each of the 11 hedging strategies (Table 6). A major difference in the regression results of this method and the results of the fixed-interval methods should be noted. In the regression equations of the fixed-interval estimations, the slope coefficient was equal to the minimum-risk hedging ratio. The slope coefficients in these estimations were positive in sign, indicating that changes in spot prices and changes in futures prices tended to move in the same direction. Because the hedger is typically long in cash position and short in futures position, a change in spot and futures prices in the same direction means a loss from one position and a gain from the other. Although the slope coefficients in the regression of price changes were positive, the actual returns from the spot and futures positions were negatively related. Therefore, when yearly returns from the cash position are regressed on yearly returns from the futures position, the slope coefficient is expected to have a negative sign. The optimal hedging ratio should be the absolute value of the slope in the regression of cash returns on futures returns.

Optimal hedging ratio estimates ranged from a value of 0.826 for the planting hedging strategy to a value of 1.270 for the adjustable 25-13 strategy. While the results of regression equations for each strategy are reported in Table 6, the emphasis of these equations is not upon their predictive ability. The primary reason for performing the regression analyses was that the absolute value of the slope coefficient is mathematically equivalent to the minimum-risk hedging ratio. Therefore, the relatively low R^2 values are of no consequence to the hedging ratio estimate. None of the

Table 6. Strategy-specific estimation of optimal hedging ratios: regression results

Strategy	Intercept	Hedging ratio[a]	R^2
Routine			
Planting hedge	31286.139	0.826	0.47
	(1516.691)[b]	(0.276)	
Break-even hedge	31308.525	0.943	0.42
	(1596.731)	(0.353)	
Selective			
25-7	31646.733	1.225	0.42
	(1560.454)	(0.424)	
25-13	31397.506	1.094	0.47
	(1521.791)	(0.366)	
10-5-4w	31238.778	0.988	0.40
	(1614.726)	(0.382)	
25-7-4w	31499.490	1.173	0.46
	(1543.658)	(0.402)	
25-16-6w	31603.432	1.130	0.43
	(1591.099)	(0.410)	
Adjustable			
25-7	31547.632	0.953	0.36
	(1697.227)	(0.406)	
25-13	31804.026	1.270	0.44
	(1551.325)	(0.428)	
25-7-4w	31561.679	1.125	0.44
	(1582.332)	(0.405)	
25-16-6w	31680.103	1.096	0.43
	(1594.615)	(0.396)	

[a]Absolute value of slope coefficient.
[b]Standard errors in parentheses.

strategy-specific hedging ratios were significantly different from one at the 95 percent significance level.

Intercepts in the strategy-specific regression equations are both interpretable and directly applicable to portfolio concept of hedging. In these regression equations the intercept represents the return from the spot position that would be expected given a return of zero from the futures position. If the mean return per contract for each strategy is substituted for the yearly return from the futures market position in that strategy's regression equation, the resulting value for the yearly return from the spot market position would be equal to the mean return of the cash sale at harvest.

In order to demonstrate the effects of the hedging ratio upon the level and variability of return, a sensitivity analysis was done for the hedging strategies of this study. The hedging ratio was varied from 0 to 1.5 by increments of 0.1 for the 1974 through 1985 simulation period. For each of the 16 hedging ratios simulated, the mean return of each strategy is presented in Table 7. Table 8 shows the corresponding standard deviation of return of each strategy for the range of hedging ratios. These tables would be of value to cotton producers who cannot hedge in the exact proportion they desire due to the indivisibility of futures contracts. For example, a producer with an expected harvest of 80,000 pounds of cotton could hedge a spot position with one futures contract at a hedging ratio of 0.625, or with two futures contacts at a hedging ratio of 1.25.[3]

The sensitivity analysis on the hedging ratio reveals two meaningful points. First, it demonstrates that the optimal strategy-specific hedging ratios did, in fact, result in the minimum standard deviation of return for each strategy. The sensitivity analysis confirms that the hedging ratio that minimizes risk is estimated using historical returns from spot and futures positions rather than historical spot and futures price changes. The second point the sensitivity analysis illustrated is the effect on risk in the event that the indivisibility of futures contracts prohibited the producer from hedging in the optimal ratio for a given strategy. Conceivably, the farmer could make the choice between alternative hedging strategies based upon relative ability to meet the optimal hedging ratio of each. Such an example can be shown from the information in Tables 7 and 8.

Suppose a farmer initially selected the planting hedge strategy because of its relatively low standard deviation of return. Furthermore, assume that the farmer would like to hedge at the optimal ratio of 0.8, yet cotton production precludes this. If a hedging ratio of approximately 1.1 could be used, then the selective 25-13 strategy could be considered. At a hedging ratio of 1.1, this strategy had a standard deviation of return equal to that of the planting hedge strategy at a hedging ratio of 0.8. The mean return for the selective 25-13 strategy was also greater than the mean return of the planting hedge strategy at their respective optimal hedging ratios.

[3]Calculated by dividing futures contract volume by expected harvest volume, e.g., 50,000 ÷ 80,000 = 0.625 and 100,000 ÷ 80,000 = 1.25.

Table 7. Mean return of strategies in hedging ratio sensitivity analysis

Hedging ratio	Planting hedge	Break-even hedge	Selective 25-7	Selective 25-13	Selective 10-5-4w	Selective 25-7-4w	Selective 25-16-6w	Adjustable 25-7	Adjustable 25-13	Adjustable 25-7-4w	Adjustable 25-16-6w
0.0	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
0.1	30,837	30,832	30,847	30,832	30,822	30,837	30,849	30,856	30,856	30,845	30,858
0.2	30,899	30,889	30,918	30,889	30,869	30,899	30,922	30,937	30,937	30,915	30,940
0.3	30,961	30,945	30,989	30,946	30,916	30,961	30,995	31,018	31,018	30,985	31,023
0.4	31,023	31,002	31,060	31,003	30,963	31,023	31,068	31,099	31,099	31,054	31,105
0.5	31,085	31,058	31,131	31,060	31,010	31,085	31,141	31,180	31,180	31,124	31,188
0.6	31,147	31,115	31,202	31,117	31,057	31,146	31,215	31,261	31,261	31,194	31,270
0.7	31,209	31,171	31,273	31,174	31,104	31,208	31,288	31,342	31,342	31,264	31,353
0.8	31,270*	31,228	31,344	31,230	31,151	31,270	31,361	31,423	31,423	31,333	31,435
0.9	31,332	31,284*	31,415	31,287	31,198	31,332	31,434	31,504	31,504	31,403	31,518
1.0	31,394	31,341	31,486	31,344	31,245*	31,394	31,508	31,585*	31,585	31,473	31,600
1.1	31,456	31,397	31,557	31,401*	31,292	31,456	31,581*	31,666	31,666	31,543*	31,682*
1.2	31,518	31,454	31,628*	31,458	31,338	31,517*	31,654	31,747	31,747	31,612	31,765
1.3	31,580	31,510	31,700	31,515	31,385	31,579	31,727	31,828	31,828*	31,682	31,847
1.4	31,642	31,567	31,771	31,572	31,432	31,641	31,800	31,909	31,909	31,752	31,930
1.5	31,704	31,624	31,842	31,629	31,479	31,703	31,874	31,990	31,990	31,822	32,012

*Mean return for hedging ratio nearest to the optimal strategy-specific hedging ratio.

Table 8. Standard deviation of return of strategies in hedging ratio sensitivity analysis

Hedging ratio	Planting hedge	Break-even hedge	Selective 25-7	Selective 25-13	Selective 10-5-4w	Selective 25-7-4w	Selective 25-16-6w	Adjustable 25-7	Adjustable 25-13	Adjustable 25-7-4w	Adjustable 25-16-6w
0.0	6,848	6,848	6,848	6,848	6,848	6,848	6,848	6,848	6,848	6,848	6,848
0.1	6,470	6,555	6,600	6,560	6,579	6,586	6,593	6,602	6,601	6,589	6,585
0.2	6,122	6,284	6,364	6,289	6,329	6,337	6,352	6,375	6,366	6,346	6,337
0.3	5,808	6,037	6,142	6,036	6,100	6,105	6,129	6,169	6,144	6,119	6,107
0.4	5,536	5,818	5,936	5,804	5,895	5,890	5,923	5,987	5,937	5,911	5,897
0.5	5,312	5,629	5,747	5,595	5,717	5,694	5,738	5,831	5,746	5,723	5,709
0.6	5,140	5,473	5,578	5,413	5,567	5,520	5,575	5,703	5,573	5,558	5,544
0.7	5,028	5,355	5,429	5,259	5,449	5,369	5,437	5,605	5,419	5,418	5,407
0.8	4,979*	5,275	5,304	5,137	5,364	5,244	5,325	5,538	5,287	5,305	5,297
0.9	4,995	5,236*	5,202	5,048	5,315	5,147	5,241	5,504	5,178	5,221	5,218
1.0	5,075	5,239	5,126	4,995	5,301*	5,079	5,186	5,503*	5,093	5,166	5,171
1.1	5,217	5,284	5,077	4,979*	5,324	5,041	5,162*	5,535	5,034	5,142*	5,156*
1.2	5,415	5,369	5,056*	5,000	5,382	5,033*	5,168	5,600	5,001	5,150	5,173
1.3	5,664	5,494	5,063	5,058	5,475	5,058	5,205	5,697	4,996*	5,189	5,223
1.4	5,957	5,654	5,098	5,151	5,601	5,112	5,271	5,823	5,018	5,258	5,305
1.5	6,288	5,848	5,160	5,277	5,758	5,197	5,367	5,978	5,066	5,357	5,417

*Standard deviation of return for hedging ratio nearest to the optimal strategy-specific hedging ratio.

Conclusions and Implications

Alternative Marketing Strategies

The major conclusion concerning the simulation of marketing strategies in this study is that all 11 hedging strategies were superior to the cash sale at harvest during the 1974-85 period. The cash sale at harvest yielded the lowest mean net return and the largest standard deviation of net return. Therefore, the emphasis shifts away from the question of whether to utilize some type of forward-pricing technique and towards the question of which forward-pricing alternative to use. Because of the inflexibility of forward cash contracts and the unavailability of options during the study period, hedging was selected. The principal concern of the evaluation was which hedging strategy was most effective. While all of the hedging strategies evaluated in this study performed better than the cash sale alternative, this by no means implies that all hedging strategies are superior to the cash sale at harvest in terms of both risk and return.

Comparison of the results shows that both the selective strategies and the adjustable strategies were dominant over the routine strategies. Without knowledge or assumptions about the producer's degree of risk aversion, neither the selective strategy group nor the adjustable strategy group could be declared superior to the other. Both the mean return and the standard deviation of return were higher for the adjustable group than for the selective group.

In terms of mean net return, the adjustable strategy concept appears to have been most successful. The three strategies with the highest mean return were all adjustable strategies. All but one of the four adjustable strategies, the 25-7-4w three-crossover, generated higher mean returns than all other non-adjustable strategies. In addition, each adjustable strategy generated higher mean returns than the corresponding selective strategy upon which it was based. The adjustable 25-16-6w strategy was the only adjustable moving average that resulted in a higher mean return and a lower standard deviation of return than its base selective strategy.

Theoretically, the adjustable moving average should generate signals to place a hedge nearer futures price peaks and generate signals to lift a hedge nearer futures price troughs. Evidence of the success of the adjustable concept could surface in any one or more of the following ways. First, the response of the adjustable component average could improve the percentage of profitable trades; however, this did not occur (Appendix Table 1). Another possibility is that the adjustable moving average may have increased the average return on profitable trades compared to its non-adjustable version. This was the case for the adjustable 25-7 strategy and the adjustable 25-16-6w strategy. The third source of improvement may have been the ability of the adjustable mechanism to decrease the average loss from unprofitable trades. Average losses from unprofitable trades were lower for all four adjustable strategies than their selective strategy counterparts.

Optimal Hedging Ratio

Both fixed-interval estimation methods using two-week price changes yielded optimal hedging ratios significantly greater than one at the 95 percent significance level. Neither of the optimal hedging ratios derived from the regression of price changes over four-week intervals was significantly different from one at the 95 percent level of significance. The question that should be asked is if the fixed-interval estimation of the optimal hedging ratio is a valid procedure, then why does the choice of interval length affect the significance of the hedging ratios? A possible answer is that the relationship between successive spot and futures price changes over arbitrary intervals may have little relevance to the actual relationship between returns from spot and futures markets. As suggested earlier, the strategy-specific procedure derives the optimal hedging ratio via an approach more directly related to portfolio theory.

Derivation of the minimum-risk hedging ratios and the sensitivity analysis of this study suggest three points. First, there is no apparent reason to expect a single hedging ratio to be optimal regardless of the hedging strategy used. Second, estimates of the optimal hedging ratio using price changes over fixed intervals may be particularly dependent upon the interval length chosen. Finally, it should be restated that none of the strategy-specific hedging ratios were significantly different from one, and that the hedging ratios derived from historical data may not be optimal in the future. Therefore, hedging in the traditional ratio of unity may very well be a reasonable choice.

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Appendix Table 1. Summary information on futures market transactions

Strategy[a]	Number of profitable trades	Number of unprofitable trades	Percentage profitable trades	Percentage unprofitable trades	Average return on profitable trades (dollars)	Average return on unprofitable trades (dollars)	Average return on all trades (dollars)	Average length of hedge (days)
Routine								
Planting hedge	5	7	41.7	58.3	6344	-3471	619	189
Break-even hedge	5	5	50.0	50.0	4844	-3486	679	134
Selective								
25-7	11	19	36.7	63.3	2295	-879	285	43
25-13	12	14	46.2	53.8	2342	-1520	263	51
10-5-4w	13	24	35.1	64.9	2444	-1089	152	37
25-7-42	9	18	33.3	66.7	2886	-1031	274	48
25-16-6w	14	17	45.2	54.8	1968	-1103	284	40
Adjustable								
25-7	11	21	34.4	65.6	2522	-858	304	41
25-13	12	18	40.0	60.0	2171	-908	324	43
25-7-4w	10	20	33.3	66.7	2581	-871	280	42
25-16-6w	10	14	41.7	58.3	2999	-1435	413	54

[a]Margin transactions are summarized in Appendix Table 2.

Appendix Table 2. Summary information on margin transactions

Description	Number of margin calls	Number of margin withdrawals	Average amount of margin calls	Average amount of margin withdrawals	Total net amount of margin calls/withdrawals	Largest occurring margin call	Largest occurring margin withdrawal
Routine							
Planting hedge	494	521	449	-442	-8790	1205	-1190
Break-even hedge	301	317	439	-441	-7765	1205	-1190
Selective							
25-7	255	283	405	-408	-12190	1205	-1170
25-13	251	274	403	-395	-7310	1205	-1170
10-5-4w	277	288	414	-417	-5505	1205	-1265
25-7-4w	253	277	404	-406	-10300	1205	-1170
25-16-6w	246	268	393	-393	-8835	1205	-1170
Adjustable							
25-7	261	283	402	-411	-11375	1205	-1170
25-13	253	283	403	-408	-13365	1205	-1170
25-7-4w	249	268	406	-413	-9750	1205	-1170
25-16-6w	246	277	404	-399	-11030	1205	-1170

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