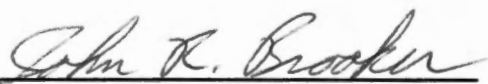
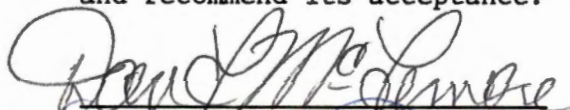
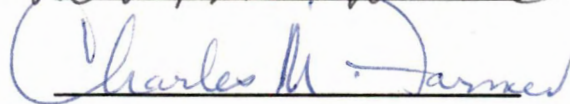


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AN ECONOMIC EVALUATION OF ALTERNATIVE MARKETING
STRATEGIES FOR TENNESSEE COTTON PRODUCERS

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Carleton S. Davis

December 1986

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ABSTRACT

The purpose of this study was to gather information relevant to the marketing decisions with which Tennessee cotton producers are confronted. Specifically, the research focused on the potential of hedging in the futures market as a means of reducing risk associated with cotton price variability. Contents of this study can be divided into three segments: an analysis of the basis for Memphis area cotton, 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 spot prices and daily 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.

In the first segment of the study, the daily basis was calculated for 1974 through 1985 and analyzed with respect to average levels and variability for the 12 years individually and for the period as a whole. Results showed that the variability of the basis was much lower than the variability of Memphis spot cotton prices. It was also found that there was no detectable tendency of the ending basis to increase or decrease during the 1974 through 1985 period.

The evaluation of alternative marketing strategies involved the simulation of 12 marketing strategies using price data for the 1974 through 1985 period. 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 which allowed the hedge to be placed or lifted repeatedly as signalled 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 third part of the study attempted to find 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 to be equivalent to the risk-minimizing hedging ratio in current literature. 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 market position. In other words, the actual returns from spot and futures positions were used rather than spot and futures price changes. The size of the risk-minimizing hedging ratios derived

from price changes over various time intervals were 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.

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CHAPTER I

INTRODUCTION

Description of the Cotton Industry

Farm production of cotton is one of the many stages that form the cotton industry in the United States. As with other commodities, cotton must undergo numerous activities related to transportation, standardization and grading, storage, and processing before it reaches the consumer in its final form. There are six basic segments of the cotton industry: 1) Producers, 2) Ginners, 3) Wholesalers, 4) Merchants, 5) Processors and 6) Retailers [Farmer].

In 1982 there were approximately 33,268 farms in the United States on which cotton was produced. The number of cotton farms in Tennessee in 1982 was approximately 1,850 [U.S.D.A., 1984b]. In harvested form the cotton fibers have not been separated from the cottonseed. For obvious reasons, such cotton is referred to as seed cotton. Harvesting is most commonly performed with either spindle-type cotton pickers which pull the fibers and seeds from the opened cotton boll, or with cotton strippers which gather the dried boll as well as the seed cotton [McArthur].

Seed cotton must be transported to ginning facilities to begin the ginning process. The first stage of ginning cotton is the drying stage. Cotton that is ginned with too much moisture suffers from a reduction in quality due to chipping of the seed coat and the release of immature fibers. Cleaning is the second stage of ginning. The

object of cleaning is to remove as much foreign matter from the cotton as possible. The extracting stage of ginning separates the lint fibers from the seed. Next, the lint cleaning stage removes motes, leaf particles and grass that escape the cleaning and extracting steps. The final step in the ginning process is to compress the lint into bales having a net weight of approximately 480 pounds [U.S.D.A., 1980].

Once it has been baled, most cotton is transported to a warehouse for storage until it is to be processed. When the cotton arrives at the warehouse, the detailed record-keeping process for each individual bale begins. Bales are weighed and sampled upon arrival. An identification tag is placed in the sample, and the sample is normally sent to a government classing office for determination of grade, staple length, and micronaire reading [U.S.D.A., 1980]. The producer receives a negotiable warehouse receipt with detailed information about each bale. Cotton is offered for sale according to the classification of the corresponding sample, and transfer of the warehouse receipt represents transfer of ownership of the cotton [McArthur].

Some warehouses have compression equipment to compress bales to smaller overall dimensions and a greater density to increase storage and transportation efficiency. When cotton is to be shipped, the warehouse must remove the designated bales from storage and load them onto whatever mode of transportation is used. This process is referred to as "breakout" [McArthur].

The fourth segment of the cotton industry consists of merchants who buy cotton in the spot markets and sell to manufacturers and processors. There are eight spot markets in the United States: Montgomery, Memphis, Dallas, Lubbock, Greenville, Greenwood, Phoenix, and Fresno. Some of these merchants buy cotton and sell directly to domestic or foreign textile mills. They actually assume title to the cotton they merchandise. Other merchants act as brokers, agents or commission buyers who do not actually take title to the cotton. They act as intermediaries between growers and other merchants and textile mills [McArthur].

The processing segment of the cotton industry includes textile mills, apparel manufacturers, as well as household good and industrial fabric manufacturers. Textile mills spin yarn from cotton fibers or from mixtures of cotton and other types of fibers. Gray cloth is woven from undyed yarn, and then dyed to produce fabric. Fabric is also produced by weaving dyed yarn. Depending upon the final use, fabric may be printed with a design [McArthur]. In 1982 there were 6,630 textile mills operating in the United States [U.S. Bureau of Census, 1985]. The number of textile mills operating in Tennessee in 1984 was 132 [U.S. Bureau of Census, 1986].

It is at the retail level that consumers come in contact with cotton in its ultimate form. There are three primary uses of cotton at this stage. These end-uses, in order of relative magnitude are clothing, household products, and industrial products. Approximately 53.3 percent of the average bale used in the United States goes to

clothing, 28.8 percent to household furnishings and 13.3 percent to industrial uses as of 1984 [U.S.D.A., 1984b].

Production and Consumption of Cotton

During the 1960 to 1963 period, the production of cotton in the United States represented about 30 percent of the total world production of cotton. That figure dropped to an average of 27 percent for the 1964 and 1965 marketing years. With the exception of 1983, the United States has produced from 15 to 22 percent of all cotton produced annually since 1966 [U.S.D.A., 1985b]. The abnormally low proportion of 11.5 percent in 1983 was due in part to the payment-in-kind program and drought conditions during the growing season in many areas.

While absolute production levels increased moderately up through the late 1950's, acreage planted and harvested in the United States has decreased drastically since the 1930's. Both acres planted and acres harvested decreased by more than 60 percent from 1930 to 1960. The obvious explanation for the opposite trends in production and acres harvested is that yield per acre increased sufficiently to offset the decrease in acreage. Much of the rise in yield during this period can be explained by the adoption of mechanized harvesting. As harvesting became more mechanized, cotton land with rough topography was replaced by more level land with greater productivity [McArthur].

Upland cotton production in Tennessee has typically been between 2 and 5 percent of that for the entire United States. With the exception of 1967, Tennessee has ranked from seventh to ninth in

cotton production among all states during the 1960 to 1985 period. A low level of production in 1967 caused Tennessee's position to fall to twelfth. The magnitude of Tennessee's per acre yield has tended to decrease relative to the yields of other states during the past 25 years. From 1960 to 1972, the average yield for Tennessee was generally above the average yield for the United States as a whole. Beyond 1972, however, the average yield for Tennessee has typically fallen below the national average yield [U.S.D.A., 1985b]. The average staple length (in thirty-seconds of an inch) of United States upland cotton ranged from 33.6 to 34.7 during the 1979 to 1984 period. For the same period, the average staple length of cotton produced in Tennessee varied from 33.9 to 35.2 [U.S.D.A., 1985a]. Figure 1 illustrates the production of cotton in Tennessee by county as of 1984 [Tennessee Crop Reporting Service, 1985].

Along with trends in the characteristics of cotton production, major changes have also occurred in the consumption of cotton during the last 25 years. In the early 1960's cotton was the dominant fiber in the United States textile industry. Domestic consumption of cotton surpassed the consumption of all other fibers combined until 1967. It was also during the 1960's that man-made fibers' percentage share of total domestic consumption almost doubled from 27.5 percent in 1960 to 54.9 percent in 1969. The dominance of cotton fiber use weakened from a 64.4 percentage share to a 40.9 percentage share over the same period. Despite the large change in the relative use of cotton, the decline in per capita consumption of cotton was less drastic. Per capita consumption of cotton fell from 23.5 pounds to 20.9 pounds from

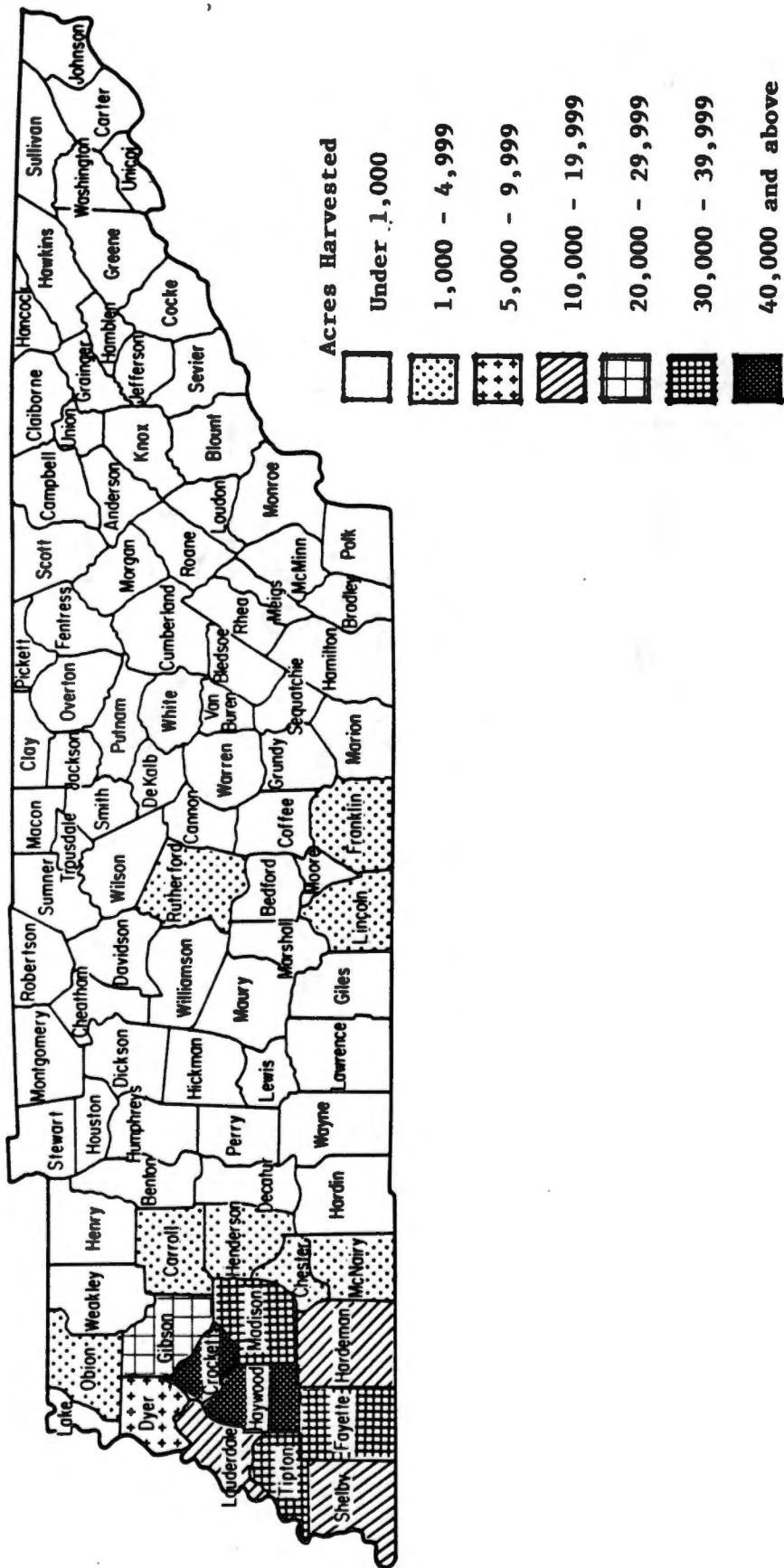


Figure 1. Cotton Production in Tennessee by County, 1984

1960 to 1969. The fact that per capita consumption of all fibers as a whole was increasing explains how the lesser decline in per capita consumption was possible. By 1969 the per capita consumption of all fibers was 50.9 pounds--an increase of 39 percent over the 1960 level.

United States domestic consumption of cotton followed a course during the 1970's that was much like that of the 1960's. Cotton's percentage share of all fiber use continued to be further displaced by man-made fibers, while per capita consumption of total fibers increased [U.S.D.A., 1986b]. The increasing popularity of minimum care clothing was one factor that added to consumers' demand for clothing containing man-made fibers. The "permanent press" process developed by the cotton industry in the 1960's backfired to some extent. Although in theory it was to accentuate preferences for all-cotton garments, the "permanent press" process actually increased usage of man-made fibers instead. Cotton garments subjected to the process suffered from durability problems, whereas garments containing man-made fibers did not [Firch].

Two additional aspects of cotton production and consumption in the United States are exports and imports of textiles. Obviously the relationship between exports and imports of textiles affects the cotton producers in the United States. In terms of raw cotton equivalents textile exports experienced fluctuations from 498 thousand bales to 392 thousand bales during the 1960's. There was a general trend of increases in textile exports in the 1970's. By the end of the decade textile exports had risen to 996 thousand bale equivalents. This trend continued in 1980 to a level of 1.1 million bale

equivalents but reversed in 1981 with relatively large decreases. The raw cotton equivalent of textile exports of the United States for 1985 was 439 thousand bales--a level comparable to that of the 1960's [U.S.D.A., 1985b].

Raw cotton equivalent of textile imports into the United States expanded to 3.08 million bales in 1985 or almost six times the amount in 1960 [U.S.D.A., 1985b]. With imports of textiles rising and textile exports falling, net imports of cotton have obviously increased as well. In 1960 textile imports of cotton represented 5 percent of domestic consumption of cotton. By 1984 the import share of domestic cotton consumption had increased to approximately 37 percent [U.S.D.A., 1984c]. It should be remembered, however, that a portion of the textiles imported into the United States were manufactured from raw cotton purchased from the United States. For example, of the 2.3 million bale equivalents of textile imports in 1983, approximately 22 percent was actually produced in the United States [U.S.D.A., 1984b].

Overview of Government Programs Affecting Cotton Producers

Government programs have influenced the level and distribution of cotton production since the enactment of the Agricultural Marketing Act of 1929. The end of World War I marked a time of economic depression in the farm sector. This act was an attempt to stabilize crop prices and farm incomes that did little towards accomplishing its objectives. Loans were made to marketing cooperatives for the purposes of purchasing and storing surpluses of cotton and other

commodities. Lack of effective production control measures and a weakening demand for commodities caused the act to have minimal impact [McArthur].

The first attempt to control production was seen in the Agricultural Adjustment Act of 1933 which offered benefits to farmers who idled crop acreage. Approximately 10 million acres of cotton were plowed-up in accordance with the provisions of this act. Nonrecourse loans were made available for the first time in 1933, with a loan rate of ten cents per pound of lint. Marketing quotas were introduced in the Bankhead Cotton Act of 1934 as an attempt to keep benefits of acreage control programs from accruing to nonparticipants. Nonparticipants were required to pay a ginning tax from which participants were exempt [McArthur]. Price supports of basic commodities based upon parity was another major concept of this legislation [Starbird].

The Agricultural Adjustment Act of 1938 continued the parity approach to price and income supports. Marketing quotas and acreage allotments were maintained as well [U.S.D.A., 1984b]. Nonrecourse loan rates at 52 to 75 percent of parity served the purpose of supporting cotton prices. Provisions of this act remained in effect through 1942 [McArthur].

Emphasis during 1943 through 1949 was on increasing rather than restricting production of basic commodities. World War II was the reason for such expansion. Cotton prices were supported by nonrecourse loan rates from 85 to 100 percent of parity and no acreage allotments were imposed. The Agricultural Act of 1948 contained

provisions for marketing quotas and flexible price supports at a maximum of 90 percent of parity [McArthur].

Marketing quotas and acreage allotments were included in the Agricultural Act of 1954 with flexible price supports at 82.5 to 90 percent of parity [McArthur]. In 1956 the Agricultural Act of 1956 created the soil bank program which was designed to divert acreage from basic commodities such as cotton to long-term conservation uses [U.S.D.A., 1984b]. The Agricultural Act of 1958 continued the flexible price supports, marketing quotas, and acreage allotments from the 1954 act. Additional options consisting of a trade-off between the acreage allotment and the loan rate were offered to cotton producers in 1959 and 1960 [McArthur].

Growing surplus stocks of cotton in the early 1960's set the tone for the Wheat-Cotton Act of 1964. This act took a different approach to the chronic over-production problem than previous programs. Subsidies to domestic handlers and textile mills, as well as price supports to farmers, were authorized. The subsidies to domestic handlers and textile mills marked an effort to lower the domestic price of cotton to the export price, and thus increase demand for cotton. Both a domestic and a regular acreage allotment was established for each farm. Producers who planted their regular allotment received a price of 30 cents per pound. Those who reduced their plantings even further to comply with the domestic allotment received a price up to 15 percent greater [U.S.D.A., 1984d].

Textile mills wished to disassociate themselves from the adverse publicity of the subsidies authorized in the Wheat-Cotton Act of 1964

[Firch]. Therefore, the more market-oriented Food and Agriculture Act of 1965 discontinued subsidies to domestic handlers. Domestic and regular allotments were continued. Price support payments were made to farmers who reduced their cotton acreage by a minimum of 12.5 percent [U.S.D.A., 1984b]. The support price was set at 90 percent of the estimated world price, and payments were made only on the domestic acreage allotment. Establishment of the price support at 90 percent of the estimated world price marked an attempt to end the United States' role as the world price-setter [Evans]. Prior to 1966, (the first year covered by the 1965 act), the United States' support price was above the equilibrium world price level that would have existed in the absence of the support price. Thus, the United States support price dictated the world market price and encouraged foreign production of cotton [Firch].

Termination of marketing quotas and the separation of the price support rate and loan rate came with the enactment of the Agricultural Act of 1970. Price supports were calculated as the difference between the average market price and the higher of 65 percent of parity or 35 cents per pound of lint, and paid only to farmers participating in a voluntary acreage reduction. The loan rate, however, was based upon 90 percent of a two-year average of the actual world price. This loan rate differed from that of the 1965 act in that it was based on actual, not estimated, world prices [U.S.D.A., 1984d].

A new device of agricultural policy appeared in the Agriculture and Consumer Protection Act of 1973. This new device was the target price. The idea behind the target price concept was to support

producers' incomes without affecting the market price of cotton.

Deficiency payments were to be paid to producers if the average market price of cotton for the year was lower than the target price. The amount of payment was calculated as the difference between the average market price and the target price, but the amount could not exceed the difference between the target price and the loan rate [Evans]. Loan rates were set at 90 percent of the three-year average world price of American cotton. Target prices were adjusted on the basis of changes in the index of prices paid for farm inputs and changes in productivity. Only production from the domestic allotment was eligible for deficiency payments. However, because market prices exceeded target prices, no deficiency payments were paid to producers during the 1974 through 1977 crop years [Starbird].

Separation of the loan rate and the target price was continued under the Food and Agriculture Act of 1977. There were two major changes from the Agriculture and Consumer Protection Act of 1973. First, target prices were calculated according to costs of production for specific crops rather than a general index of input costs. Secondly, deficiency payments were based on current acreages of cotton planted rather than on historical cotton allotments. The current acreage rule may have encouraged an even greater shift of cotton production to the lower-cost of production regions of the West and Southwest. No deficiency payments were made from 1978 through 1980 [Evans].

Provisions of the Agriculture and Food Act of 1981 were primarily an extension of the Food and Agriculture Act of 1977. Target price

adjustments had failed to keep up with increasing costs of production under the 1977 programs. Therefore, the 1981 act set a target price of 71 cents per pound for 1982, which was to be increased by 5 cents annually through 1985. Record cotton yields and a worldwide recession caused surplus stocks to increase rapidly in 1981 and 1982. In an effort to combat the situation, the payment-in-kind (PIK) program of 1983 was implemented [Starbird]. Producers who idled the required amount of acreage were eligible to receive in-kind payments of up to 80 percent of their farm program yield. The large degree of participation in the program in combination with drought conditions caused cotton stocks to fall from 7.8 million bales to 3 million bales during the 1983 marketing year [U.S.D.A., 1984b]. Although the Food and Agriculture Act of 1981 specified that target prices would increase to 86 cents per pound for 1985, the Agricultural Programs Adjustment Act of 1984 held the target price at 81 cents per pound. The loan rate was set at the 55 cent minimum given by the 1981 Act [Starbird].

The Food and Security Act of 1985 marked a change of tone in agricultural policy. Instead of gradually increasing target prices, this act lowers the target prices for cotton from 81 cents per pound in 1986 to 72.9 cents per pound in 1990 [U.S.D.A., 1986a]. Loan rates are again calculated as a fraction of a moving average of market prices. The objective is to make American cotton more price competitive in the world market without creating incentives for foreign production increases. A new form of payment referred to as a loan deficiency payment may be received by producers who elect not to

receive a loan for which they are eligible. The loan deficiency payment rate is the difference between the loan rate and the loan repayment rate. Another feature of this legislation is the possible reappearance of subsidies to domestic handlers of cotton. The purpose of these subsidies would be to make American cotton more competitive should the other provisions of the act fail to do so [U.S.D.A., 1986b].

Statement of the Problem

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 the marketing of the crop. Price fluctuations can result in unfavorable circumstances for farmers. Furthermore, the strategy a farmer chooses for marketing his crop determines, to some degree, the amount of price risk to which he is subjected.

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

Depending upon the individual farmer's own unique situation, cash sale at harvest and fixed price forward contracting may or may not be the most appropriate strategies for attaining his 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 the 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]. Obviously an evaluation of the performance of various marketing techniques is of value to cotton farmers. 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.

Knowledge about the basis is also useful in the evaluation of marketing alternatives. The basis is the differential between a given futures contract price and the cash or spot price for a particular geographic location. Theoretically, this differential represents the cost of storing the actual commodity until the maturity of the futures contract, and the cost of transporting the commodity to a delivery location specified by the futures contract. An understanding of the behavior of the basis throughout the production period may benefit the farmer in hedging cotton sales in the futures market, forward contracting, or in the timing of sales in the spot market [Brooker, Farmer, and Gray].

There are other basic questions to which cotton growers need answers. For example, regardless of the type of marketing strategy used, timing is critical. Assistance in determining when to implement the stages of one's marketing plan would be beneficial. If a producer desires to hedge his cotton sales in the futures market he must know what proportion of his expected crop to hedge and which futures contract month to use in the hedge. Depending upon his reason for hedging, the producer may better serve his objectives by hedging less than 100 percent of his cotton crop in the futures market. The producer must also have some estimate of how margin requirements will affect his overall credit needs. Given such information as mentioned above, cotton growers should be better able to form their expectations, and hence, choose an appropriate strategy for marketing their crop.

Objectives

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

- 1) Analysis of the basis for Memphis area cotton.
- 2) Evaluation of selected marketing strategies with respect to risk and net returns.
- 3) Estimation of the optimal hedging ratio for growers who choose to hedge their expected cash sales in the futures market.

CHAPTER II

REVIEW OF LITERATURE

Historical Basis Theory

Much of the literature dealing with commodity futures markets focuses on a theoretical understanding of the difference between cash and futures prices, or basis. Various theories to identify the components of the basis have been offered. One such theory is the "supply of storage theory" [Working]. This theory holds that the difference between the cash price and futures price is related to the level of inventories of the given commodity. In other words, the basis for a particular commodity reflects the cost of storing the actual commodity until maturation of the corresponding futures contract. At low levels of inventory, there exists a benefit (or negative cost) from holding additional inventory. This benefit which accrues to merchants or processors of the commodity is referred to as a "convenience yield". As inventories become larger the marginal convenience yield decreases, and at some point, reaches zero. The supply of storage concept states that within some range of inventory levels, the marginal storage costs may be relatively constant. Beyond this range, however, the marginal cost of storage curve becomes very steep as available storage facilities become severely limited [Tomek and Robinson].

A more general view of the factors affecting the basis considers more than the supply of storage. The supply and demand of both the

commodity and its substitute commodities influence the basis.

Furthermore, differences in quality or grade and location between the cash commodity and the specifications of the futures contract are determining forces of the basis. The availability of transportation facilities and interest rates may also affect the basis [Chicago Board of Trade].

The difference between cash price and a given futures price may be either positive or negative. According to the supply of storage concept, a positive basis can be no greater than the marginal cost of storing the cash commodity until the maturity date of the futures contract. The magnitude of a negative basis is not bounded by the supply of storage theory [Tomek and Robinson]. Although it is not an element of the supply of storage theory, there is an effective limit on the size of both a positive and a negative basis during the delivery period of the futures contract. The arbitrage action of traders creates a tendency for the basis to reflect the cost of delivery. If during the delivery period, a positive basis exceeds the costs associated with the actual delivery of the commodity, traders will create upward pressure on cash price and downward pressure on the futures price by selling futures contracts, buying a corresponding quantity of the physical commodity, and delivering that physical commodity according to the provisions of the futures contracts. Such arbitrage will occur until the basis reflects the costs of delivery. If a negative basis exceeds the cost of delivery (in absolute value), traders will acquire long futures positions, take delivery of the physical commodity, and sell that commodity in the cash market. The

actions of these traders will place upward pressure on the futures price and downward pressure on the cash price [Purcell].

Applied Analyses of Basis

Numerous applied analyses of the basis for selected agricultural commodities have been conducted. There are two major types of basis studies. One type deals with storable commodities of which a continuous inventory is maintained from one production period to the next. Cotton and grains are examples of such commodities. The second category is for nonstorable commodities such as livestock and eggs.

The basis studies for the storable commodities have focused upon the level of the basis and its variability. In actuality "the basis" represents the difference between the cash price of a designated location and any one of the futures contract months for which trading is conducted. In pricing a commodity for harvest delivery, basis calculations have typically been made using the futures contract that reaches maturity nearest to, but not prior to, harvest of the commodity. For example, Memphis area cotton is usually harvested in October and November. Thus, the December futures contract would be appropriate for calculating the basis [Brooker, Farmer, and Gray].

Some studies have included an analysis of the nearby basis as well. The nearby basis is the difference between the cash price at a designated location and the price of the futures contract which is the contract nearest to its own date of maturity. Couvillion, Lisowski, and Bateman examined the basis for Mississippi soybeans using the November basis, the January basis, and the nearby basis. A similar

study updating the above analysis was done by Bateman, Couvillion, and Bufkin.

Brooker, Farmer, and Gray examined the December basis and nearby basis for Tennessee cotton. Basis calculations were performed using spot prices for Memphis, Tennessee and futures prices from the New York Cotton Exchange.

Relationship of Hedging and the Basis

Regardless of the type of strategy a producer uses to market his crop, the basis plays a major role in determining the strategy's effectiveness. Hedging strategies, however, are even more dependent upon the behavior of the basis than are the other marketing strategies. In their analysis of soybean hedging strategies, Hudson and Toensmeyer suggest that the most crucial determinant in the profitability of a hedge is the basis.

In illustrations of the fundamentals of hedging, a typical approach of many authors is that of creating a hedging scenario in which the basis at the lifting of the hedge is exactly equal to the basis when the hedge was placed. The next step in the usual oversimplification is to describe the outcome of the above scenario as "a perfect hedge" in that a gain (loss) in the cash position is exactly offset by a loss (gain) in the futures market position. Both Working and Hieronymous criticize this shallow understanding of hedging [Working, pp. 320-325; and Hieronymous, p. 150]. Working states that hedging is perhaps more akin to arbitrage than to insurance. He suggests that the potential for profit from a changing

cash-futures price relationship induces more hedging than does the desire to avoid risk. In accordance with Working's view, Hieronymous states that hedging allows for speculation in the level of the basis as opposed to speculation in price levels [Hieronymous]. Normally the variation of the basis will be less than the variation of the spot price. In this respect hedging reduces the producer's risk.

Garcia, Leuthold, and Sarhan define basis risk not as its total variation, but rather as the variance associated with its random component. They applied the variate difference method to a time series of basis levels for live cattle and hogs in an attempt to isolate the systematic variation from the unsystematic or random variation. The concept behind the variate difference approach is that finite differencing of the time series will remove all but the random variation of the series. Garcia, Leuthold, and Sarhan then used the residual variances from the variate difference procedure in formulating a regression analysis equation to predict basis risk. One of the conclusions reached in this study was that the degree of basis risk (defined as the random component of basis variation) is directly related to the level of cash prices of the commodity and to the consumer price index.

Theories on Motivation of the Hedger

A question that has received much debate is simply what is the motivating force behind hedging. In A Treatise on Money, Keynes viewed the act of hedging as similar to insurance. The hedger, according to Keynes, is motivated to hedge his spot position by the

desire to reduce the price risk associated with an unhedged position [Telser]. In exchange for the opportunity to reduce their price risks, hedgers must be willing to pay a "risk premium". Speculators were believed to assume the risks which hedgers seek to avoid. This risk premium was the remuneration paid to speculators by hedgers. This risk premium would exist as a discount of the current future price below the spot price that is expected to occur at the maturation of the futures contract. This concept was formally stated by Keynes as the "theory of normal backwardation" and expanded upon by Hicks [Johnson, p. 140].

If the theory of normal backwardation is correct then the futures price could not be considered an unbiased estimate of the cash price that is expected to prevail in the future. Telser investigated the validity of the normal backwardation theory empirically using data for cotton and wheat. He hypothesized that if a risk premium does exist, then this premium should decrease as the futures contract nears its date of maturity. Thus, an upward trend in the futures price should be evident over the life of the contract if a risk premium is received by speculators. Using first differences of average monthly futures prices for cotton and wheat, Telser recorded the number of price increases and decreases that occurred. He concluded that since the number of price increases did not significantly outweigh the number of price decreases, no upward trend in futures prices could be suggested. Therefore, Telser did not accept the theory of normal backwardation as proposed by Keynes and Hicks.

Cootner, a supporter of the normal backwardation and risk premium theory, exchanged criticisms with Telser concerning the empirical testing of this theory. Cootner questioned Telser's assertion that futures prices must show an upward trend over the entire length of the contract. Instead he argued that futures prices should exhibit an upward trend only "after the peak of hedging has passed" [Cootner, p. 47]. This idea has been referred to as the "Cootner wrinkle" of the Keynes-Hicks hypothesis [Berck, p. 470]. Using data similar to Telser's, Cootner arrived at the conclusion that the theory of normal backwardation was valid.

A different view of the motivational force behind hedging is that of Working. Working did not favor the risk reduction view of hedging and stated that the majority of hedges are placed not as a form of insurance, but rather as a form of arbitrage from which hedgers seek to profit. According to Working, the motivation to hedge occurs whenever the cash-futures price relationship and the expected change in that relationship are such that hedging affords an opportunity for profit. This view explains why individuals may not always engage in hedging, but it fails to explain why hedgers do not necessarily hedge fully against their entire spot position when they do hedge.

A third theory of hedging involves the application of portfolio theory to the hedging decision. This application marked an attempt to explain why hedging is not always done routinely, and furthermore, why hedgers do not necessarily occupy completely hedged positions. A theoretical foundation for portfolio theory can be found in the work of Markowitz. Although he did not specifically orient his discussion

towards hedging, he provided both mathematical and graphical illustrations of diversification between two alternative activities.

The basic idea behind portfolio theory is as follows. There are two or more alternative "activities" among which the investor may choose. For each of these activities the investor possesses two subjective probability distributions: one for the expected returns from the activity and the other for the expected variance of the activity's returns. Conceptually there exists a set of all the possible combinations of the alternative activities that are available to the investor. Within the boundaries of this attainable set of activity combinations exists an efficient set of combinations. The efficient set refers to those activities within the attainable set which have the "minimum variance for given return or more and maximum return for given variance or less" [Markowitz, p. 82]. In the case of two alternative activities, the efficient set would be formed by the tangencies of the isovariance curves and the isoreturn lines. The efficient set of activities could be plotted in expected return-expected variance of return space. Assuming that the investor possesses an indifference map in terms of expected returns and expected variance, his optimum portfolio, or combination of activities, would correspond to the point of tangency between the efficient set and his indifference curve representing the highest level of utility [Johnson].

Johnson and Stein later applied portfolio theory to the hedging motivation problem. The significance of their work is that the rationale for hedging was no longer considered as either risk

reduction or maximization of returns. Instead, hedging was viewed as a combination of risk reduction and maximization of returns [Ederington; and Rutledge].

Recent Work on Hedging Strategies

Studies examining various hedging strategies have been done for practically all agricultural commodities for which organized futures trading occurs. There are generally three types of hedging strategies. One type is to place a short hedge at some time during the production period and maintain that hedge until the sale of the cash commodity. This is the hedge and hold strategy [Kane, Beierlein, and Dunn].

The second type of strategy is similar to the hedge and hold strategy in that once the hedge is placed, it is held until termination of the cash position. The difference is that the hedger employs some method to determine when to place the hedge instead of placing the hedge at some arbitrarily selected time [Kane, Beierlein, and Dunn].

The third general type is multiple hedging. In multiple hedging the hedge is not necessarily maintained once it is placed. In fact, numerous hedges may be placed and lifted during the period as determined by the method used to generate place and lift signals. According to Purcell, the multiple or selective strategy has "a twofold objective--to attain protection against the risk of downward breaking prices and to allow the benefits of a rising cash market" [Purcell, p. 286].

Analyses of hedging strategies have often employed technical indicators to signal placement and lifting of hedges. A common technical indicator is the moving average. Moving averages are trend following devices that can be used to indicate turning points of price movements. A simple moving average of the daily closing prices of a futures contract can be used in identifying long run price trends. A moving average of "m" number of days is simply the sum of the closing prices for the "m" most recent days, divided by m (the number of days). When this moving average crosses the daily closing price going downward, a signal to place a hedge is generated. Lift signals are generated when the moving average crosses the daily closing price going upward. This is the simple crossover technique [Haden].

Two moving averages of different lengths may be used in hedging strategies as a two-crossover moving average indicator. When the shorter length moving average crosses the longer moving average from above, a signal to place a short hedge is given. The shorter moving average crossing the longer moving average from below signals the lifting of the hedge [Querin and Tomek].

A three-crossover technique may also be used as an indicator for hedging strategies. In this technique there are three moving averages of different lengths. The shortest length moving average plays the role of the confirming device for generated place or lift signals. Place signals would be generated by the crossing of the intermediate length moving average and the longest moving average going downward. The signal would be followed only if the confirming average was below the intermediate average at the time the place signal occurred. Lift

signals would be generated by the crossing of the intermediate length average and the longest average going upward. Similarly, lift signals would be followed only if the confirming average was above the intermediate average during the signal [Querin and Tomek; and Haden]. Each of these techniques, the simple crossover, the two-crossover, and the triple crossover, may also include a penetration rule for the crossing of the various moving averages. A penetration rule is a set minimum amount by which one moving average must cross or penetrate the other before a hedging signal is generated [Querin and Tomek].

Querin and Tomek applied moving average indicators to historical price data and simulated price data in their analysis of hedging strategies for Western New York corn producers. They evaluated a no hedge alternative, a routine hedge, a selective hedge based upon achievement of a specified target price, and two selective moving average strategies. One of the selective or multiple hedging strategies was a two-crossover of three-day and ten-day moving averages. The other was a two-crossover of ten-day and forty-day moving averages. For the period 1972-1980, both the average net price per bushel and its standard deviation for selective hedging strategies was lower than for the cash sale at harvest. For the 1975-1980 period, however, the two selective moving average strategies yielded higher average net prices per bushel and lower standard deviations of net price per bushel than the no-hedge strategy. Querin and Tomek summarized the performance of the selective strategies by stating that "the success of technical analysis depended on matching a particular

set of moving average rules to the existing price behavior" [Querin and Tomek, p. 29].

An evaluation of hedging strategies for Pennsylvania corn was done by Kane, Beierlein, and Dunn. This study also employed moving averages in selective hedging strategies. In addition, a time series model was evaluated with monthly cash corn prices from 1973 to 1982, and used to generate cash price forecasts for certain hedging strategies. These hedging strategies contained decision rules based upon the relationship between the futures price quote, the estimated basis, and the forecast of the cash price for the corresponding time period. In one of their strategies, a hedge was placed if the futures price exceeded the sum of the forecasted cash price, the estimated basis, and the standard error of the forecast. Other strategies incorporated both cash price forecasts and moving averages in decision rules for multiple hedging. Twelve of the nineteen hedging strategies evaluated resulted in higher returns and lower variances of returns than an unhedged cash position [Kane, Beierlein, and Dunn].

Howard analyzed technical cotton hedging strategies separately for the High Plains and for the Rio Grande Valley regions in Texas. He simulated each strategy two different ways. In one simulation he used the December futures contract prices for 1971 through 1977, and in the other simulation he used the nearby futures contract prices for the same period. His reason for applying the hedging strategies to the two separate regions was that Rio Grande cotton typically conforms to the strict low middling 1 1/16 staple length specification of the New York No. 2 futures contract, whereas High Plains cotton has a

usual staple length of 15/16 inch [Howard]. A cash or no hedge strategy was simulated in order to provide a benchmark of comparison for all other strategies. A cash strategy in which one-fourth of the cotton crop (assumed to be equal to 100 bales or one futures contract) was sold at each quarter of the year was also simulated. A total of twenty, two-crossover moving average strategies and four, three-crossover moving average strategies were simulated. The three-crossover indicators contained a linearly weighted confirming moving average. In general, the three-crossover indicators performed more favorably using the December futures contract than with the nearby futures contract. Howard found that the four strategies yielding the highest average returns for both regions were hedging strategies utilizing moving average indicators. The cash strategy of selling one-fourth of the crop each quarter of the year ranked fifth in terms of average returns. The top four strategies according to mean returns were: 1) a three crossover of a 25 day, a 7 day, and a linearly weighted 4-day moving average using December futures (represented as 25-7-4w) with a 0.5 cent per pound penetration rule, 2) a 25-7 two-crossover using December futures with a 0.5 cent per pound penetration rule, 3) a 20-7 two-crossover using nearby futures with a 0.5 cent per pound penetration rule, and 4) a 20-7-4w three-crossover using nearby futures with a 0.5 cent per pound penetration rule [Howard].

Haden compared alternative hedging strategies for Arizona cotton using cash and futures price data from 1974 to 1982. She also used a no-hedge strategy as a benchmark, and a routine planting hedge. Other

hedging strategies employed either moving averages or volatility band techniques as technical indicators.

In her volatility band technique, exponential smoothing methods were applied to the series of daily highs and lows of the December cotton futures contract. A moving average of a specified length was applied to the series of daily closing prices. Thus a band was formed around the moving average of the daily close by the upper boundary of exponentially smoothed daily highs and the lower boundary of exponentially smoothed daily lows. When the moving average of closing prices penetrated the lower boundary a signal to place a hedge was generated. A lift signal occurred when the moving average of closing prices exceeded the upper boundary [Haden].

The moving average strategies of Haden's study included simple crossover, two-crossover, the three-crossover moving averages. Results of the analysis indicated that moving average hedging strategies performed most favorably in terms of the level and standard deviation of net returns. Volatility band techniques were the only methods that showed lower net returns than the no hedge and planting hedge strategies. Of all strategies evaluated, the 25-13 two-crossover hedging strategy resulted in the largest net return. In addition, this strategy had the lowest coefficient of variation (standard deviation of mean net return divided by mean net return, then multiplied by 100) [Haden].

It is interesting to note that Haden's 25-7-4w three-crossover strategy performed poorly, whereas the same strategy had the highest net returns in Howard's study. Although he provided no evidence of

its performance, Purcell has recommended the use of a 5-10-4w three-crossover moving average indicator for the selective hedging of cotton.

All of the studies mentioned previously have been characterized by hedging simulations using a specified moving average indicator in which the parameters of the moving average remain constant throughout the simulation. Franzmann and Sronce investigated the reoptimization of moving average indicators for hedging live hogs. They used the Box Complex Procedure, an algorithm for solving constrained optimization problems, to arrive at the optimal moving average parameter lengths. Two key considerations in their study were 1) how often to reoptimize the moving average parameters and 2) the amount of historical price data to use in each reoptimization. Franzmann and Sronce described their results as "disappointing" [Franzmann and Sronce, p. 16]. They also evaluated strategies using a number of moving average indicators which were not reoptimized. Comparison of these constant parameter moving average strategies with the reoptimization strategies suggested that reoptimization strategies were inferior.

The usual approach of hedging simulation studies has been to assume that the quantity of the crop to be marketed was exactly equal to the quantity specified in a futures contract. Thus, yield variability was not considered. Furthermore, the simulation of marketing strategies has typically been performed independently of any production or financial considerations of the farm as a whole. Bailey and Richardson, however, have evaluated alternative marketing strategies for Texas High Plains cotton within a whole-farm simulation

model. Instead of evaluating marketing strategies on the basis of net returns using historical price data, they generated price data for ten years into the future and ranked the strategies according to the farm's ending financial stability. The study used moving average indicators in both hedging strategies and cash market transactions.

Bailey and Richardson's results show that the no-hedge strategy using no form of technical indicator produced the lowest chances of survival and success, and the highest leverage ratio at the end of the simulated period. The strategy resulting in the best overall performance was the no-hedge strategy implementing a 62-day simple crossover moving average indicator to signal cash sales. The hedging strategy with the best performance was that of hedging 50% of the expected crop using a 62-day simple crossover indicator and holding the hedged position until harvest.

While the Bailey and Richardson study may be very comprehensive, the assumptions concerning the initial farm size and the production of cotton as the farm's only crop limit the generality of the study. Assumptions were also made with respect to the family living expenses and off-farm income.

The Debate Over the Optimal Hedging Ratio

In the traditional literature, hedging implied taking a position in the futures market equal in magnitude, but opposite to one's cash market position. The majority of early hedging studies adhered to that philosophy of hedging. Later inquiry as to the true motivation for hedging brought about a challenge to the "equal and opposite" view

of hedging. Empirical observation revealed that hedgers did not necessarily maintain fully hedged positions, as would have been expected. Portfolio analysis offered an explanation of hedgers' observed behavior. It was Markowitz who introduced portfolio analysis and Johnson applied it to the theory of hedging [Brown].

Not only did portfolio analysis help to explain the observed behavior of hedgers, but it also provided a foundation for the search for the recommended hedging ratio. The hedging ratio is simply the ratio of the size of the futures position to the size of the cash position. There have been two separate approaches to the "recommended" hedging ratio. One approach was the minimum-risk hedging ratio as determined by Johnson. Risk was viewed as equivalent to the variance of net returns from holding the cash and futures positions. The equation for the total variance of returns was written as:

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

where: X_s = spot or cash market position; $X_s > 0$

X_f = futures market position; $X_f < 0$

σ_s^2 = variance of return from a one unit position in the spot market

σ_f^2 = variance of return from a one unit position in the futures market

COV_{sf} = covariance of return between the spot and futures market positions

By differentiating the above equation with respect to X_f and rearranging terms, Johnson arrived at the risk-minimizing hedging ratio:

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

The negative sign arises from the fact that in a short hedge, X_s is > 0 and X_f is < 0 in Johnson's formulation.

Ward and Fletcher approached the recommended hedging ratio in a different manner from Johnson. They assumed that the problem facing the hedger was that of maximizing his utility rather than simply minimizing the variance of returns. Thus, the hedger sought to choose a hedging ratio such that he maximized his utility based upon the trade-off (between net returns and risk) dictated by his utility function. Although Ward and Fletcher did not derive the ratio mathematically, they provided graphical illustrations of short and long hedging. It should be noted that Ward and Fletcher assumed the spot and futures positions were endogenous and simultaneously determined by the hedger.

Heifner, like Ward and Fletcher, also viewed the recommended hedging ratio as that ratio which maximized the hedger's objective function. He assumed the general form of such an objective function to be:

$$(3) \quad (\Omega) = E(\pi) - \lambda \text{Var}(\pi)$$

where: π = profit or return from both spot and futures positions

λ = risk aversion parameter

$$(4) \quad E(\pi) = X_s \mu_s + X_f \mu_f$$

where: X_s = spot market position

X_f = futures market position

μ_s = expected return per unit of spot position

μ_f = expected return per unit of futures position

$$(5) \text{ Var}(\pi) = X_s^2 \sigma_s^2 + X_f^2 \sigma_f^2 + 2X_s X_f \text{COV}_{sf}$$

After substituting equations (4) and (5) into equation (3), Heifner solved for the optimal spot and futures positions. These optimal positions were found to be dependent upon the risk aversion parameter λ . The optimal hedging ratio, according to Heifner's results, is not dependent upon the risk aversion parameter since the λ in X_f and X_s cancels out [Kahl].

Peck demonstrated the determination of the optimal hedging ratio under the assumption that the spot position is fixed. She also assumed that the hedger attempts to maximize an objective function similar to equation (3) above. In her model, she addresses the expected returns from the futures position in terms of the expected basis. Furthermore, Peck defines risk differently from Johnson or Heifner. Johnson's and Heifner's measures of risk are calculated using the variances of historical cash and futures price series. Peck calculates risk using the mean square errors of the forecast of spot prices and the forecast of basis prices. Because of the assumption that the spot position is given, the optimal futures market position and, therefore, the optimal hedging ratio contains the risk aversion parameter λ [Peck].

A fixed spot position is not the only case in which the optimal hedging ratio is dependent upon the risk aversion parameter. Bond and Thompson showed that the optimal hedging ratio is dependent upon the risk aversion parameter if storage costs or transactions costs are nonlinear.

Ederington applied portfolio theory to hedging in the corn, wheat, and financial securities futures markets. He followed the approach of Johnson to arrive at a recommended hedging ratio. Ederington's recommended hedging ratio was defined as the risk-minimizing ratio of futures position to spot position. Assuming that the cash and futures positions were simultaneously determined, he noted that the risk-minimizing hedging ratio is equivalent to the slope coefficient of the regression of spot price changes on futures price changes. The equivalence of the risk-minimizing hedging ratio and the slope coefficient from the regression of spot price changes on futures price changes can be demonstrated as follows. In a simple linear regression of a dependent variable, S , on an independent variable, F , the formula 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 formula is the corrected sum of cross-products or covariance of S and F . The denominator is the corrected sum of squares or variance of F [Younger]. Therefore, the following equation can be written.

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

In order to arrive at the hedging ratio and hedging effectiveness measure, Ederington found estimates of the variance of return from holding a cash position, the variance of return from holding a futures position, and the covariance between the two returns. The estimates of variance of return from holding a futures position were obtained by simulating successive hedges in the futures market of two-week and four-week durations. The variance of return for an unhedged position was obtained from two-week and four-week changes in the spot price. Ederington's results were that the risk-minimizing hedging ratio for wheat was significantly different from one at the 95% significance level. Therefore, the traditional hedging ratio of unity would entail a greater risk for the wheat hedger than the minimum-risk ratio. For corn, however, the recommended ratio was not found to be significantly different from the traditional ratio of unity.

Brown also applied the portfolio analysis approach to determine whether the optimum hedging ratio was equal to one as suggested by traditional theory. He estimated the risk-minimizing hedging ratio using percentage changes in prices rather than price levels or price level changes. The percentage change in the futures price and the percentage change in the spot price were referred to as the returns from holding a futures position and a spot position, respectively. Instead of defining the hedging ratio in terms of physical units of

the commodity, he calculated it as the ratio of the total value of the futures position to the total value of the spot position.

Using the same data, Brown calculated the risk-minimizing hedging ratio using price levels and again using percentage changes in price levels. His results indicated that the optimal hedging ratios calculated using price levels were significantly less than the traditional hedging ratio of one. The hedging ratios based upon percentage changes in the price level were not significantly different from one, however. Furthermore, Brown pointed out that the residuals of regressions of spot price levels on futures price levels may be subject to strong first order positive autocorrelation. The major conclusion drawn by Brown was that empirical estimates of the optimal hedging ratio do support the traditional hedging ratio of one.

It is obvious that the hedging ratio obtained depends upon whether a minimum-risk hedge or a maximum-return hedge is desired. Furthermore, whether the cash position is fixed or endogenous determines the importance of the hedger's risk aversion. The particular empirical procedure used to estimate the hedging ratio largely influences the results obtained.

CHAPTER III

METHODOLOGY AND PROCEDURES

Analysis of the Basis

The basis for cotton produced in Tennessee was 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. Futures contracts on the New York Cotton Exchange represent cotton with a grade of 41 (strict low middling), a staple of 34 (1-1/16 inches), and a micronaire of 3.5 to 4.9. In this study it was assumed that the grower's cotton met the specifications of the futures contract. Thus, any basis differentials due to quality differences were ignored. Basis calculations can be made using any futures contract. All basis calculations for this analysis were made using the December futures contract month because of its coincidence with the harvest period for Tennessee cotton. By using the Memphis spot price quotation as the common cash price for all areas of Tennessee, geographic influences on the basis for individual areas of production have also been disregarded. It was assumed that individual growers could adjust the basis calculations reported here to account for additional transportation or other handling costs.

The prices for the December futures contract were obtained from computer tapes purchased from the Dunn and Hargitt Commodity Data Bank [Commodity Data Bank] and from daily futures price quotations from The Wall Street Journal. Spot prices were taken from Daily Spot Cotton

Quotations [U.S.D.A.,1974-1985]. It should be noted that the daily closing price for contracts on the New York Cotton Exchange may often be outside the range of the daily high and low. This occurs because the reported close on a given day may be a bid or an ask at which no trading actually occurred. In other words, reported closes may not be true settlement price [Commodity Data Bank].

In order to depict its historical behavior, an average monthly basis was calculated for January through December, for each individual year, 1974 through 1985. Daily basis levels for the 1974 through 1985 period were grouped by calendar month. Variances of the daily basis were then calculated by month for January through December. While the examination of historical basis variances does not provide a numerical forecast of basis variability, it may indicate possible trends. Forecasting of the basis and of basis variability was not within the scope of this study.

Along with plots of the average monthly basis for each year, a single plot of the average monthly basis for the 12 year period as a whole was also done. The purpose of this overall plot was to facilitate a comparison between the "typical" basis pattern of the study period and the basis pattern of a particular year within the period. While calculations and plots such as these do provide a "feel" for typical basis patterns throughout the year, they provide no statistical evidence of changes that may have occurred over the period. Daily basis levels were again grouped by month. For the first week of December, an analysis of variance was done with the years of the study treated as class variables. December was selected

because it was the ending month of the assumed hedging period. Profitability of a hedge depends largely upon the magnitude of the ending basis. Evidence of any trend in the ending basis levels would be useful to cotton producers who use hedging.

The analysis of variance procedure was performed to determine whether there was any significant difference in the average ending basis among the years 1974 through 1985 as a whole. The analysis of variance procedure provided the statistical test of the null hypothesis that the average basis for the given month was equal for all years. Thus, the following hypothesis was tested for the average basis in June and December:

$$H_0: \mu_{1974} = \mu_{1975} = \mu_{1976} = \dots = \mu_{1985}$$

where μ = the average ending basis for a given year.

In addition to the analysis of variance procedure, a mean separation technique was also used. The object of the mean separation technique was to determine not only whether the average ending basis differed significantly among the years of the study as a group, but also to identify the years for which the average ending basis was significantly different from that of the other years. The mean separation technique used was Duncan's multiple range test.

Duncan's multiple range test is designed to avoid statistical errors of rejecting the null hypothesis that means are not significantly different when, in fact, they are not. The calculations for Duncan's multiple range test are based upon the mean square error value (obtained from the analysis of variance procedure), the error degrees of freedom, the significant studentized range probability

values. The significant studentized range probability values are dependent upon three elements: the chosen alpha level, the error degrees of freedom, and the number of means across which the test for significant differences is performed. Probability values of the significant studentized range increase as the number of means considered increases. In turn, the difference between means necessary to be declared a significant difference increases [Bender, Douglas, and Kramer].

Simulation of Routine Strategies

One of the major groups of marketing strategies evaluated in this study consisted of routine strategies. Routine strategies were characterized by actions executed only once during the marketing period. Furthermore, these actions were performed routinely according to some arbitrarily prescribed rules or guidelines. For the purposes of this study, the cotton producer was assumed to produce and market 50,000 pounds of lint, the equivalent of one futures contract of cotton. The reason for this assumption was to provide a common point of reference for the comparison of results from all strategies simulated. 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. These considerations were left to budgeting or economic engineering analyses.

Another common assumption of the routine strategies pertained to the time of harvest. Because of the inclusion of hedging strategies

and the assumption that 50,000 pounds of cotton was the level of production, all of the marketing strategies must involve a cash sale of the total crop on a given day. The indivisibility of one futures contract necessitated this additional assumption. The selection of this arbitrary date for spot sales was based upon the cumulative percentages of the total cotton crop harvested and ginned by specific dates for 1974 through 1984. Table 1 shows these cumulative percentages for December 1 and December 15 for each year. The average

Table 1. Percentage of Total Cotton Ginned by Specified Dates

Year	<u>Percentage of Total Cotton Ginned*</u>	
	December 1	December 15
1974	82.9	90.8
1975	92.5	97.5
1976	87.3	93.9
1977	98.2	98.5
1978	98.3	98.9
1979	77.9	95.5
1980	97.8	99.3
1981	95.2	98.7
1982	98.3	99.1
1983	98.5	98.9
1984	<u>81.1</u>	<u>93.7</u>
Average Percentage	91.6	96.8

* Source: U.S. Department of Commerce. Cotton Ginnings in the United States. U.S. Bureau of Census, Agricultural Division.

percentage ginned by December 1 was above 91 percent. For December 15 the average was almost 97 percent. Since the December cotton futures contract normally expires after December 1, yet prior to December 15, the arbitrarily selected date for spot sales was the trading day nearest to December 5 of each year. This date also corresponded with the ending date of the normal harvest period given by Tennessee Agricultural Statistics [Tennessee Crop Reporting Service, 1985].

The most obvious example of a routine strategy is the cash sale at harvest alternative in which the producer did not hedge his cash position and did not store his crop beyond the harvest period. Yearly returns from this strategy were simply the Memphis spot price per pound on the assumed date of harvest sale times 50,000 pounds. Similarly, the variance of returns is the variance of the series of returns for the 1974 through 1985 period.

The second routine strategy evaluated was the planting hedge. In the planting hedge strategy the producer hedged his cotton crop by selling one December futures contract. This hedge was placed on the last trading day in May. The last trading day in May was chosen as an approximation to the end of the normal planting season. According to the Tennessee Agricultural Statistics of 1985, the end of the planting season is June 5 [Tennessee Crop Reporting Service, 1985]. However, data on cumulative percentages of total plantings by specified dates show that on the average, over 94 percent of the cotton crop has been planted by May 30 (see Table 2). By this date the individual producer most likely has a reasonable expectation of his total acreage of cotton. The planting hedge was held until December 5, the assumed

Table 2. Percentage of Total Cotton Planted by May 30

Year	Percentage
1974	89 ^a
1975	90 ^a
1976	96 ^a
1977	97 ^a
1978	95 ^a
1979	95 ^a
1980	99 ^a
1981	98 ^b
1982	99 ^b
1983	77 ^b
1984	97 ^b
1985	99 ^b
Average Percentage	94

^aSource: Tennessee Crop Reporting Service. Tennessee Weather and Crops: 1980 Summary.

^bSource: Obtained directly from Tennessee Crop Reporting Service.

date of harvest. Interest on the initial margin requirement was calculated for each hedge using the following equation:

$$\text{INTMARG} = \text{IMARG} \times R \times \text{LOH}/365$$

where: INTMARG = interest cost on initial margin requirement

IMARG = initial margin requirement for hedging with one
futures contract

R = annual interest rate

LOH = length of hedge in days

The margin balance of the hedger's account was calculated each day using the daily close of the futures contract and the previous daily close. If the current close exceeded the previous close, the margin balance or equity margin of the hedger was reduced. On the other hand, the margin balance was increased if the current close was less than the previous close. Along with initial margin requirements, upper and lower margin balance requirements were used in determining the occurrence and magnitude of margin calls. In actual hedges the hedger must maintain a given percentage of the initial margin requirement (set by the brokerage firm) in his margin balance. If cotton prices increase enough to reduce the hedger's equity margin below the lower limit, then the hedger will receive a margin call requesting that he add funds to his margin account. The margin call would be for the difference between the initial margin requirement and the hedger's current margin balance. If a decrease in cotton prices increased the hedger's margin equity above the upper percentage of the initial margin, the hedger could withdraw funds from his margin balance equal to the difference between his current margin balance and the initial margin [Thomson McKinnon Securities Inc.].

In this study a withdrawal of funds from the margin account was treated as a negative margin call. Table 3 shows the initial margin requirements, the upper and lower equity margin limits, the annual interest rates, and the roundturn brokerage fees used in the simulation of all hedging strategies.

Table 3. Values of Variables Used in Simulations of Hedging Strategies

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

^aObtained by deflating the 1984 value of margin requirement for a hedger.

^bObtained by inflating the 1984 value of margin requirement for a hedger.

^cAssumed to be 75 percent of initial margin requirement.

^dAssumed to be 125 percent of initial margin requirement.

^eEstimated by deflating the 1984 value of brokerage fee.

^fEstimated by inflating the 1984 value of brokerage fee.

^gInterest rate on operating loans; obtained from Production Credit Association, Brownsville, Tennessee.

^hImplicit price deflator for GNP.

Interest charges on margin calls were also calculated in the planting hedge in order to make the results as realistic as possible. Withdrawals of margin balance funds, or negative margin calls, resulted in negative increments to total interest costs. The equation for calculation of interest cost on margin calls is shown below.

$$IMC = \sum_{i=1}^n MC_i(t_E - t_i)R/365$$

where: IMC = interest cost of margin calls

MC_i = the i th margin call

t_i = date on which the i th margin call occurred

t_E = date on which the hedge was ended

n = total number of margin calls

R = annual interest rate

The return from the hedge, RHED, was calculated as:

$$RHED = (PPRICE - LPRICE) \times 50,000 \text{ pounds}$$

where: PPRICE = futures price at which the hedge was placed

LPRICE = futures price at which the hedge was lifted

Net return from the planting hedge was calculated after the cash sale at harvest as follows:

$$NR = MEMPHC + RHED - INTMARG - IMC - BRKFEE$$

where: NR = net return from hedging

MEMPHC = spot price at which cotton is sold

INTMARG = interest cost on initial margin requirement

IMC = interest on margin calls

BRKFEE = brokerage fee per futures contract for a roundturn
transaction

Variance of net returns from the planting hedge strategy was calculated for the period of the study.

The break-even price hedge is the third routine strategy evaluated. Estimations of the variable costs and fixed costs were made for each year using the variable input prices and fixed input costs from issues of the Farm Planning Manual corresponding to the time period of the study [Ray and Walch]. When possible, identical production practices were assumed from year to year in an effort to hold the effect of technology constant. The same machinery complement was also used for each year. Table 4 shows the assumed machinery complement and the hours of operation per acre of cotton operation for each item. In the calculation of hourly machinery costs, the new cost of the implement from the Farm Planning Manual was used. The use of the new purchase price approaches the estimation of machinery costs from a replacement cost standpoint. For the years in which a current edition was not published, input and machinery prices were obtained by linear interpolation between prices given in adjacent issues. For example, the input and machinery prices for the 1974 budget were found by interpolating between the prices listed in the 1973 and the 1975 editions.

Estimates of total cost per acre were then converted to total cost per pound of cotton produced by dividing by the average of the

Table 4. Hours of Operation Per Acre of Cotton for Machinery Complement^a

Machinery Item	Hours Per Acre
Tractor, 125 HP	3.48
Cotton Picker, 2-Row	0.93
Disk, 21'	0.20
Chisel Plow, 11 Shank	0.20
Cultimulcher, 20'	0.11
Planter, 4-Row	0.30
Cultivator, 4-Row	0.90
Boom Sprayer	1.18
Rotary Mower, 10'	0.36

^aSource: Ray and Walch. Farm Planning Manual. University of Tennessee, Agricultural Extension Service, April 1985.

yields in Tennessee for the previous three years. The break-even price for each year was defined as that price per pound necessary to just cover both the variable and fixed costs of production. As with the planting hedge strategy, the end of planting was taken to be the last trading day of May. For the break-even strategy, however, a hedge was not automatically placed. A hedge was placed when and if the December futures price minus the expected ending basis was greater than or equal to the estimated break-even price for the given year. The expected ending basis was assumed to be the simple average basis for the month of December for the previous three years. The hedge, if placed, was done by selling one December futures contract. Because

placement of the hedge was contingent upon a decision rule, the break-even strategy was not a purely arbitrary strategy. However, since a hedged position was maintained continuously until cash sale at harvest, this strategy was classified as routine.

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. Similarly, if a hedge was placed the returns from the break-even strategy were calculated in a manner identical to that used in the planting hedge alternative.

Methodology of Selective Strategies

In the routine hedging strategies above, 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 strategies, however, differed in that the producer did not necessarily maintain a hedge once it was placed. In fact, the selective strategy simulations allowed the producer to place and lift numerous hedges prior to the end of harvest.

The placing and lifting of hedges in this study was based upon moving average indicators. A moving average indicator is a technical commodity trading tool that attempts to identify turning points in price trends. Moving average indicators are technical tools since they rely only upon the behavior exhibited by prices and not upon the underlying factors or fundamental relationships that may cause prices to behave as they do [Kaufman].

The concept behind 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 benefitting 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. Hopefully these indicators will, however, 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 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 of the key considerations 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 individual moving averages.

Other parameters of moving average indicators 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 average. Because the shorter moving average is the average of fewer observations, a single observation's value has more influence on the value of the shorter moving average than on the value of the longer moving average. Therefore, the longer moving average should mimic a long-term trend in price, while the shorter moving average should aid in the recognition of changes in the long-term trend.

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 crossed or penetrated the longer moving average from above by a specified penetration amount.
- 2) A lift was generated when the shorter moving average crossed or penetrated the longer moving average from below by a specified penetration amount.

The penetration amount requirement represents an attempt to eliminate some of the false place or lift signals that inevitably occur with moving average indicators. Because moving averages are trend following devices, 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.

For all strategies evaluated in this study, the penetration parameter was 0.5 cents per pound, or \$250 per futures contract.

Two different two-crossover strategies were simulated. The first two-crossover strategy tested was a 25 day - 7 day crossover. This strategy was selected because it was the most promising two-crossover (in terms of return relative to variance of return) in a hedging study done by Howard for the Texas High Plains and Rio Grande cotton-producing regions. The second two-crossover strategy simulated was a 25 day - 13 day crossover. In her study of hedging strategies for Arizona cotton, Haden reported this strategy as exhibiting the most favorable results of the two-crossover strategies tested.

The three-crossover moving average strategies employed three individual moving averages and related decision rules. Place and lift signals were generated by the intermediate length moving average crossing the longer moving average. In this respect the three-crossover strategies were similar to the two-crossover strategies. However, 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. The computation of the confirming averages was performed as follows:

$$LWMA = \frac{\sum_{i=1}^n i(CLOSE_i)}{\sum_{i=1}^n i}$$

where: LWMA = linearly-weighted moving average

$CLOSE_i$ = the i th most recent daily close of the December
cotton futures contract

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

For the most recent closing 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. This method of weighting increases 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 greater than or equal to the required penetration amount in order for a place or lift signal to occur.

The required penetration amount was 0.5 cents per pound for this group of strategies. The rationale for inclusion of a penetration rule was the same as for the two-crossover strategies. 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 - 6 day linearly weighted crossover. This strategy was tested because it was the best three-crossover indicator in Haden's work on Arizona cotton. Purcell recommended a 10 day - 5 day - 4 day linearly weighted crossover for use in cotton hedging applications. Purcell's recommendation 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 planting hedge strategy. The actual summation can be represented as:

$$NRS = \sum_{i=1}^n NR_i$$

where: NRS = net return from the selective hedging strategy

NR_i = net return from the i th hedge

n = total number of hedges

Methodology of Adjustable Strategies

There are four major considerations in selecting a moving average indicator for a selective hedging strategy. First, the number of

component averages within the moving average indicator must be chosen. The lengths of these individual moving averages must be specified, as well as the weighting of the daily closing prices on which the moving averages are calculated. Finally, the magnitude of the penetration requirement, if any, must be specified.

Not surprisingly the results of the moving average strategy depend upon the compatibility between the characteristics of the moving average indicator used and the demonstrated behavior of prices [Querin and Tomek]. Furthermore, the best performing indicator during a given period of time may not exhibit the best performance over a subsequent time period. Selection of an appropriate moving average indicator has typically been a matter of trial and error. "Whipsaw" losses often occur, regardless of whether or not a penetration rule is used. 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.

The adjustable moving average concept tested in this study operates on the premise that additional information about price behavior is useful. Thus, a moving average indicator that utilizes more information in generating signals should perform more favorably than a similar indicator based only upon the daily closing prices. Additional information about price behavior was provided by the daily high and low of the futures contract in the adjustable moving average strategies. The high and low were used for two reasons. First, the utilization of the high and low does not alter the classification of the adjustable moving average indicator as a technical indicator. The

adjustable moving average indicator is, therefore a trend following method rather than a predictive technique. A second reason for using the high and low is that anyone who has access to daily closing price data should have little difficulty in acquiring the daily high and low data as well.

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. Conceptually, this is accomplished for an unhedged position by shortening the adjustable moving average when the daily highs have exhibited an upward trend. For a hedged position the length of the adjustable moving average is shortened when the daily lows have shown a downward trend. In each case, the sensitivity of the adjustable average is increased.

If the producer's position is unhedged, and the daily highs have experienced a downward movement, then the length of the adjustable average is increased. This decreases the sensitivity of the adjustable average and the likelihood of a signal to lift the hedge. If the producer's position is hedged, the length of the adjustable average will be increased if the daily lows have shown an upward trend. By lengthening the adjustable average, its sensitivity is decreased. Therefore, a hedge is less likely to be placed while the daily lows have been increasing.

For the adjustable versions of the two-crossover strategies, these adjustment rules applied to the shorter component moving average. Because of its role in generating place and lift signals,

the shorter component moving average was designated as the adjustable average. If the producer's spot position was unhedged, then the adjustment of the shorter moving average was based upon the pattern of daily highs. Conversely, the adjustment of the shorter moving average was based upon the daily lows for hedged positions. When the simulation began, the length of the adjustable moving average was set at its initial value. 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 could be selected. The length of the range was 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 were as follows:

- 1) If the current high was equal to the highest high of the range, then the length of the adjustable average and the range was not changed.
- 2) If the current high was greater than the highest high of the range, and the high of the previous day was less than the previous highest high, then the length of the adjustable average and the range was increased by one day.
- 3) If the current high was greater than the highest high of the range, and the high of the previous day was greater than or equal to the previous highest high, then the length of the adjustable average and the range was increased by two days.

- 4) If the current high was less than the highest high of the range, and the previous day's high was greater than or equal to the previous highest high, then the length of the adjustable average and the range was decreased by one day.
- 5) If the current high was less than the highest high of the range, and the previous day's high was also less than the previous highest high, then the length of the adjustable average and the range was decreased by two days.

The adjustment rules for a hedged position were as follows:

- 1) If the current low was equal the lowest low of the range, then the length of the adjustable average and the range was not changed.
- 2) If the current low was less than the lowest low of the range, and the previous day's low was greater than the previous lowest low, then the length of the adjustable average and the range was increased by one day.
- 3) If the current low was less than the lowest low of the range, and the previous day's low was less than or equal to the previous lowest low, then the length of the adjustable average and the range was increased by two days.
- 4) If the current low was greater than the lowest low of the range, and the previous day's low was less than or equal to the previous lowest low, then the length of the adjustable average and the range was decreased by one day.

- 5) If the current low was greater than the lowest low of the range, and the previous day's low was also greater than the previous lowest low, then the length of the adjustable average and the range was decreased by two days.

In conjunction with the adjustment rules, the adjustable two-crossover strategies employed the same basic decision rules as the non-adjustable two-crossover strategies. For the adjustable two-crossover indicators, place and lift signals were generated by the crossing of the longer (non-adjustable) moving average by the shorter or adjustable moving average. The penetration requirement of 0.5 cents per pound also remained the same for this group of strategies. It should also be noted that the length of the adjustable moving average was reset to its initial value at the occurrence of a place or lift signal.

Arbitrary upper and lower limits were imposed upon the length of the adjustable moving average. Obviously the length of the adjustable average should not be allowed to exceed that of the longer moving average. To do so would alter the initial order of the two-crossover drastically. Therefore 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 truncated to an integer value. For example, the adjustable component average of the 25 day - 7 day two-crossover was allowed to vary from four days to ten days in length. The adjustable average of the 25 day - 13 day two-crossover was permitted to vary from seven to nineteen days in length.

Adjustable versions of the three-crossover strategies operated in the same manner as the adjustable two-crossover strategies. The intermediate length moving average was the adjustable average in the three-crossover strategies. These strategies were simulated using the same adjustment and decision rules as the two-crossover strategies. The limits imposed upon the length of the adjustable average were somewhat different, however, since there are three component averages. Although the confirming averages of the three-crossover strategies evaluated were linearly weighted moving averages, the adjustable average was restricted to lengths greater than that of the confirming average. For this reason no adjustable version of the 10 day - 5 day - 4 day linearly weighted three-crossover strategy was simulated.

A major consideration in the simulation of moving average strategies is the question of when to begin calculating and monitoring the moving averages of the price series. Obviously, the calculation of a moving average with a length of "n" days requires a price series of at least "n" days before the strategy can be implemented. Thus, the length of the longest component moving average determines the minimum number of daily prices needed before the simulation can begin. The length of the longest component average is not the only factor to consider in the simulation of non-routine strategies, however. For routine hedging strategies no moving average indicators were used, and the simulation began at the arbitrarily chosen time. The moving average strategies contained decision rules based upon the relative positions of the component moving averages. For example, in the two-crossovers a place signal was generated when the shorter moving

average crossed the longer moving average from above by a specified penetration amount. It is possible for the shorter moving average to cross the longer moving average by less than the penetration amount initially, thus generating no place signal. Several days could pass before the difference between the two moving averages met the penetration rule and triggered a place signal. If the simulation of the strategy began during such an interim between the crossing of the component averages and the satisfaction of the penetration rule, then the signal to initiate the hedge would be missed. However, if the simulation included the monitoring of the component averages prior to the earliest date on which placing a hedge was permitted, this type of signal would not be missed. Simulations in this study involved advance observation of the moving average indicators beginning the first trading day in May.

Evaluation of Alternative Strategies

In the analysis of results, strategies were grouped and evaluated by type (routine, selective or adjustable) as well as individually. Results from the three types of strategies and the twelve individual strategies were ranked according to mean net return and mean net price per pound. These mean values were the average of the yearly net return and net price for the 12 year period. Strategies were also ranked by type and individually according to standard deviation of net return and net price. A strategy with a higher net return and a lower standard deviation of net return was considered superior to another strategy with an equal or lower net return and a larger standard

deviation of net return. A risk averse hedger would prefer the superior strategies. When mean net returns and the standard deviations of net returns were such that superior strategies could not be identified, strategies were compared with respect to the coefficient of variation of net returns. All other factors aside, a low coefficient of variation would be more desirable than a higher one.

Additional comparisons of strategies involved the total number of trades and the relative proportions of profitable and unprofitable trades occurring in the simulations. The strategies were also evaluated on the basis of margin calls. Margin calls and margin withdrawals (negative margin calls) were recorded for each hedging alternative. Summary information on the average margin call amount, the maximum margin call and the maximum margin withdrawal were reported for all hedging strategies.

Estimation of the Optimal Hedging Ratio

The third objective of this study was to determine the optimal hedging ratio for Tennessee cotton producers. The hedging ratio is the ratio of the size of the producer's futures market position to the size of his spot market position. A hedging ratio of unity corresponds to a fully hedged spot position. Optimal hedging ratio refers to that hedging ratio that minimizes the producer's price risk. It was assumed in this study that the producer's spot position was determined according to those factors which normally influence farmers' crop selection such as price and yield expectations, crop

rotation, and government programs. In other words, the size of the spot position was taken to be determined exogenously. The size of the futures position, however, was determined so as to minimize the producer's price risk.

Risk was defined as the variation of return from holding a hedged position. As discussed in the Review of Literature, the equation used by Johnson for the total variance of return from a portfolio of positions in the spot and futures markets was [Johnson]:

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

where: $\text{Var}(R)$ = 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^2 = variance of return from a one unit position in the
spot market

σ_f^2 = variance of return from a one unit position in the
futures market

The risk-minimizing hedging ratio was arrived at by differentiating equation (1) with respect to X_f and dividing through by X_s . Equation (2) shows Johnson's results.

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

The definition and theoretical derivation of the optimal hedging ratio used in this study were those of Johnson.

Three different empirical procedures were used in this analysis to estimate the risk-minimizing hedging ratio. The first procedure was taken directly from Ederington's work on hedging ratios for financial futures. Ederington showed the minimum-risk hedging ratio to be equivalent to the slope coefficient in the simple regression of cash price changes on futures price changes. As noted in the Review of Literature, he estimated the variance of return from holding a one unit cash position, the variance of return from holding a one unit futures position, and the covariance between the two returns. Ederington obtained these estimates of variances and covariances by calculating successive price changes in the spot and futures markets over both two-week and four-week periods. These two-week and four-week price changes represented proxies for the returns from spot and futures positions.

Application of Ederington's approach to the optimal hedging ratio for Memphis area cotton involved the calculation of two-week and four-week price changes in the Memphis spot cotton market and in 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. Whereas Ederington's price changes were obtained using the nearby futures contracts as well as more distant contracts, this analysis used the December cotton futures contract alone. Only the December contract was used because the marketing strategies simulated were based exclusively upon the December contract. Therefore, it was

appropriate that the hedging ratio should be obtained from the futures contract in which the producer's hedge was placed.

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 variances and covariances of spot and futures returns were found using price data only for those weeks of the calendar year during which a production hedge would normally occur. This typical hedging period was assumed to be 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 the producer should be concerned with the relationship of returns from the two markets only for the period he would potentially hedge his cotton crop.

The first and second methods of deriving the optimal hedging ratio were independent of the particular hedging strategy used in marketing the cotton. Values of the hedging ratio were affected by the futures contract month selected, the portion of the price data used each year, and the length of intervals over which price changes were calculated. Derivation of the hedging ratio did not take into account the hedging strategy to be used. 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 used in this study maintained Ederington's use of successive price

changes in arriving at variances and covariances of returns, the third estimation procedure did not. The third procedure approached the problem from the standpoint of yearly returns from positions in the two markets. Yearly returns from the futures position were found by summing the net returns from each hedge that occurred during the year. Thus, for each strategy there were a total of 12 yearly returns from the futures position. For the yearly cash market returns, the cash price at the end of the hedging period was multiplied by 50,000 pounds (the size of one futures contract). Thus, the return from the spot market position was defined as the revenue from the cash sale of the cotton at harvest. The 12 years of historical spot returns were used, in effect, to obtain an expected return from the spot position.

A regression of spot returns on futures returns yielded a hedging ratio estimate for each strategy. This procedure used the actual returns directly in the calculation of the hedging ratios, rather than price changes in the two markets. The premise of this method is that the farmer should be concerned with the relationship between actual returns in the spot and futures markets rather than with how successive price changes are related.

The hedging ratios obtained from the three alternative methods were compared and tested to determine if they were significantly different from the traditionally accepted hedging ratio of unity. Comparisons of the various hedging ratio estimates involved a sensitivity analysis in which actual returns and variances of return were calculated for each strategy. In the sensitivity analysis, the hedging ratio was permitted to vary from zero to a value of 1.5.

CHAPTER IV

RESULTS OF THE STUDY

Results of the Analysis of the Basis

In order to provide a proper perspective for the behavior of the basis for cotton, it was necessary to examine the volatility of cash prices as well. For the 1974 through 1985 period, spot cotton prices at Memphis, Tennessee varied from a low of 34.75 cents per pound on December 30, 1975 to a high of 93.27 cents per pound on September 12, 1980. The average spot price during the period was 63.90 cents per pound. Variability of the Memphis spot price was characterized by a standard deviation of 11.71 cents per pound over the same 12 years. By comparison, the basis¹ had a range from -19.95 cents per pound on January 2, 1974 to +14.17 cents per pound on January 5, 1982. Basis variability was considerably less than the spot price variability. The standard deviation of the daily basis was 4.37 cents per pound. It is the lower volatility of the basis that makes hedging a viable alternative for avoiding much of the price variability associated with unhedged spot positions. Figure 2 is a graph of the quarterly average Memphis spot price for the period. December basis behavior for the same period is shown in Figure 3.

¹The term "basis" in this analysis refers to the difference obtained by subtracting the Memphis spot cotton price from the closing price of the December futures contract of the New York Cotton Exchange.

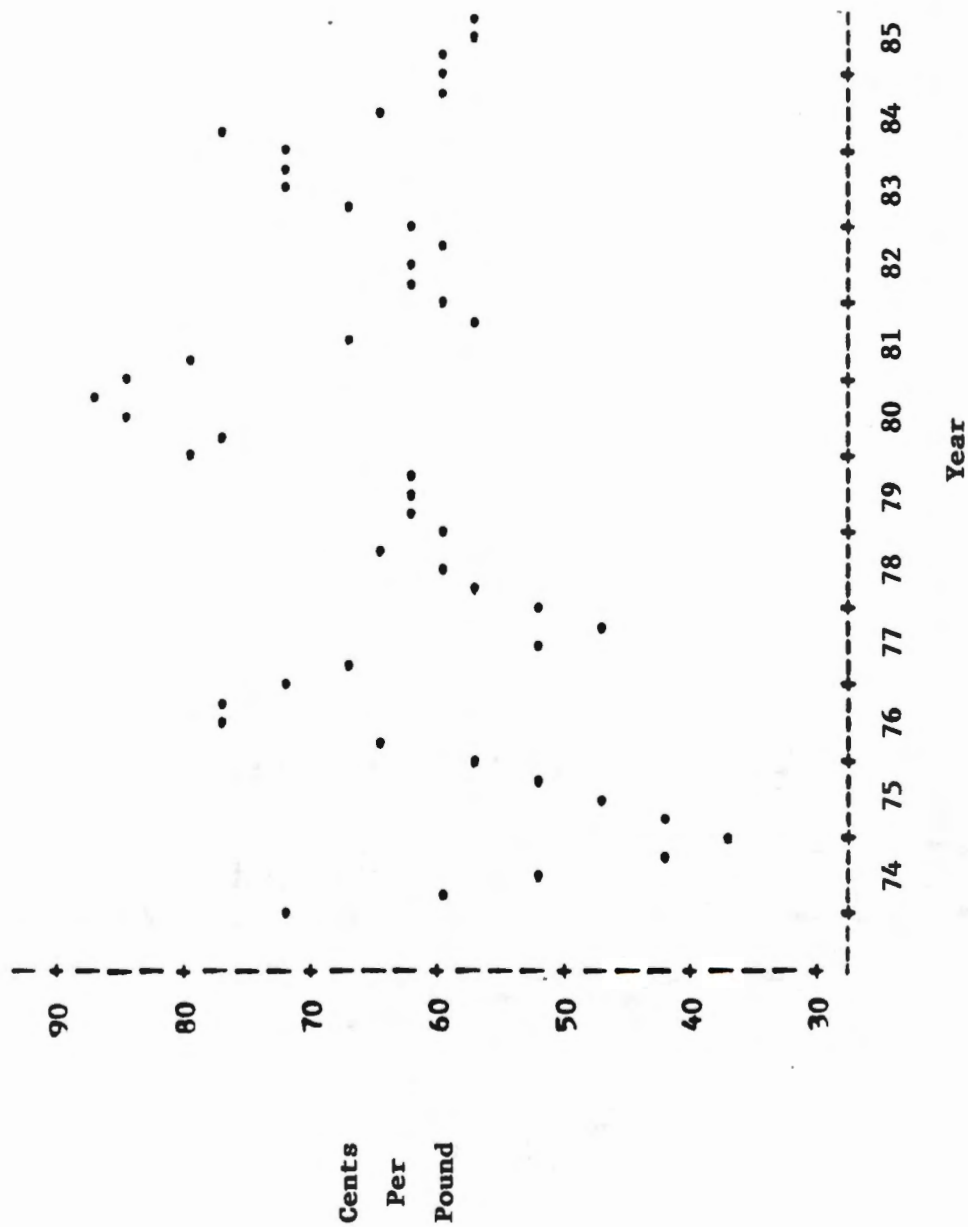


Figure 2. Quarterly Average Spot Market Prices for Cotton (Strict Low Middling, 1 - 1/16 Inch Staple, 3.5 to 4.9 Micronaire) in Memphis, Tennessee, 1974 Through 1985

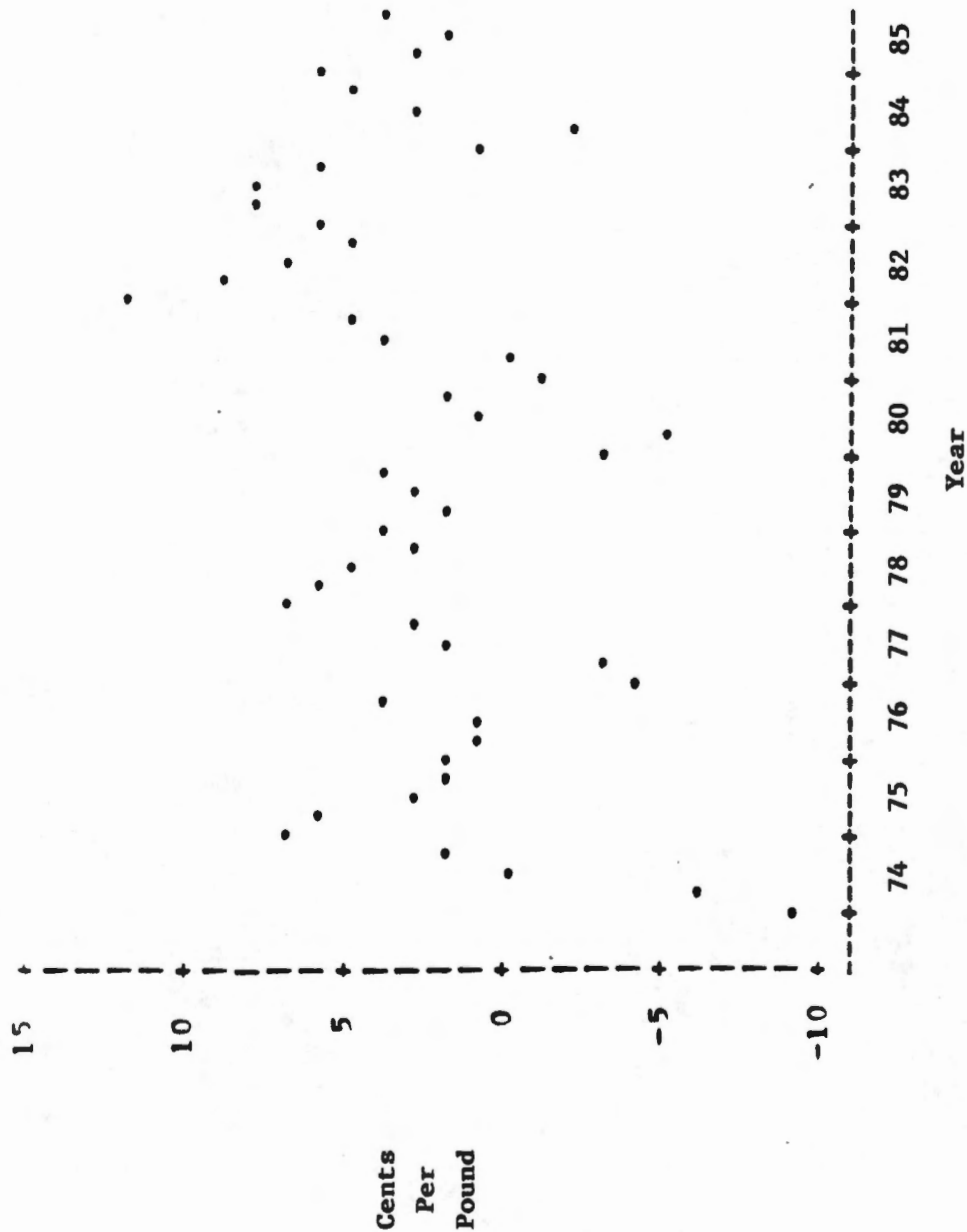


Figure 3. Quarterly Average Basis Levels for the December Cotton Futures Contract in Memphis, Tennessee, 1974 Through 1985

While Figure 3 illustrates the behavior of the basis for the 12 year period, the pattern within a given year is more useful to the producer in making marketing decisions. Daily basis levels for the entire study period were grouped by calendar month and averaged to obtain an average monthly basis for January through December. Figure 4 is the plot of the average basis by calendar month. This plot was generated in order to represent the general basis pattern for January through December of a "typical" year. Obviously, Figure 4 is not necessarily representative of each year. Furthermore, the average of historical basis patterns may or may not accurately reflect future basis behavior.

Yearly plots of the average monthly basis were also generated and are presented in Figure 5. Comparison of the individual yearly plots to Figure 4 reveals the year in which the basis follows the "typical" pattern of the analysis period. The average monthly basis for the study period as a whole was positive. From January to its trough in May, the average monthly basis declined. From June through a peak in September, the average monthly basis increased. Beyond September the average monthly basis declined. The most obvious years that deviated from the general basis pattern were 1975, 1978, and 1982. In these years the average monthly basis was at its highest level in the early months of the year and then experienced a general downward trend for the remainder of the year. Other atypical basis behavior occurred in 1983. The peak basis appeared in June, around the time when the trough occurred in the plot for the overall period.

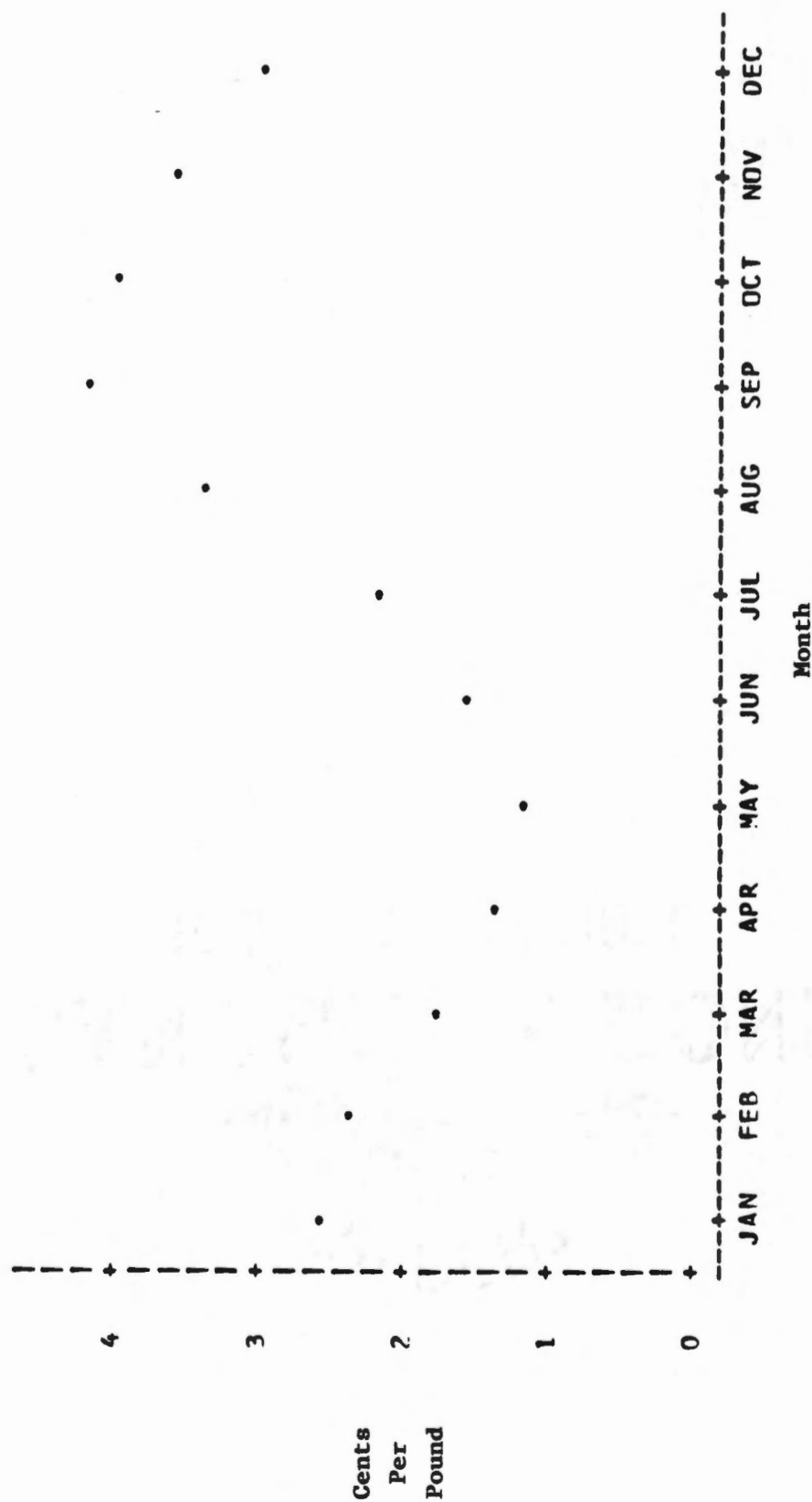


Figure 4. Overall Average Monthly Basis Pattern for the December Cotton Futures Contract in Memphis, Tennessee, 1974 Through 1985

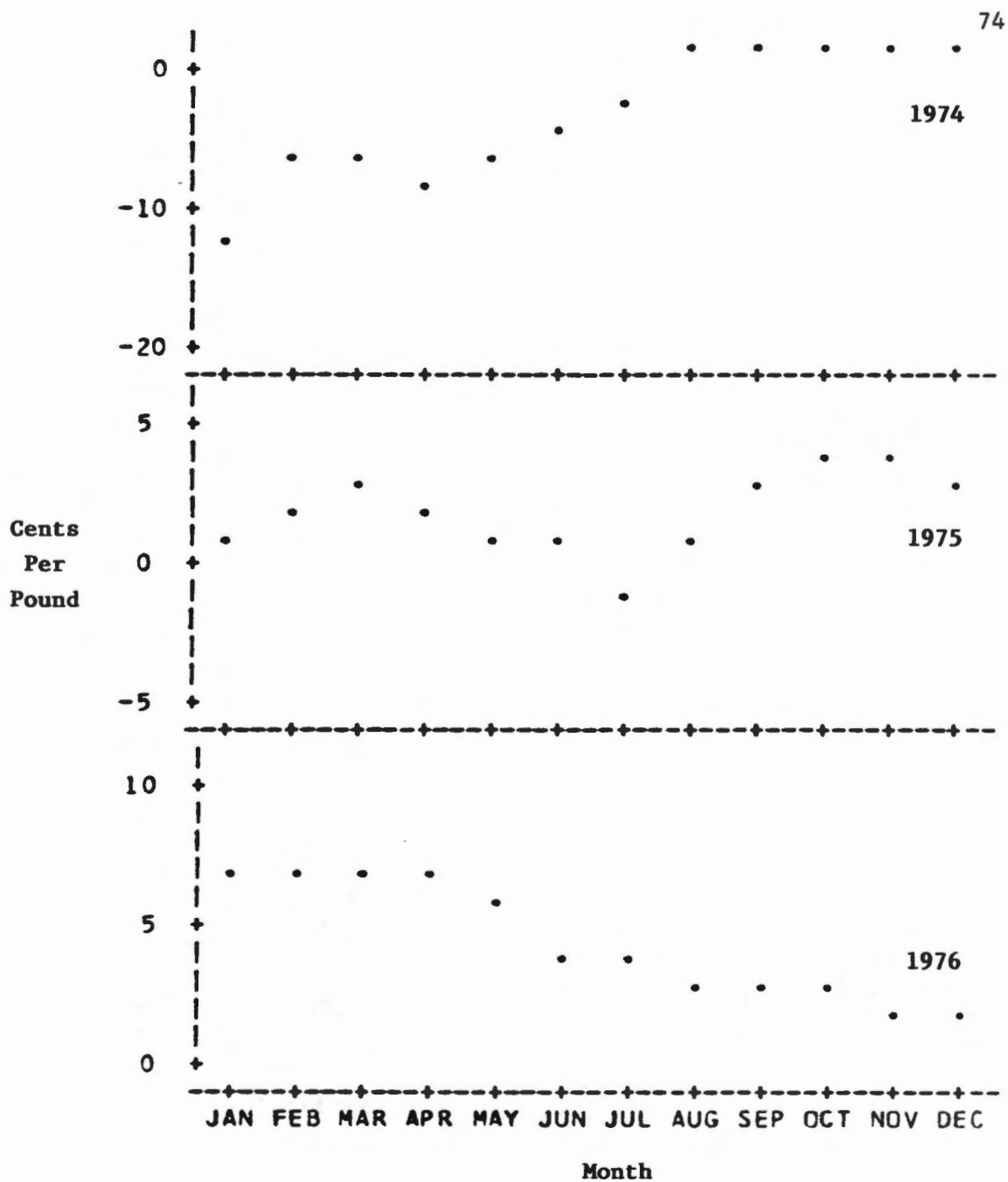


Figure 5. Average Monthly Basis Pattern for the December Cotton Futures Contract in Memphis, Tennessee, 1974 Through 1985

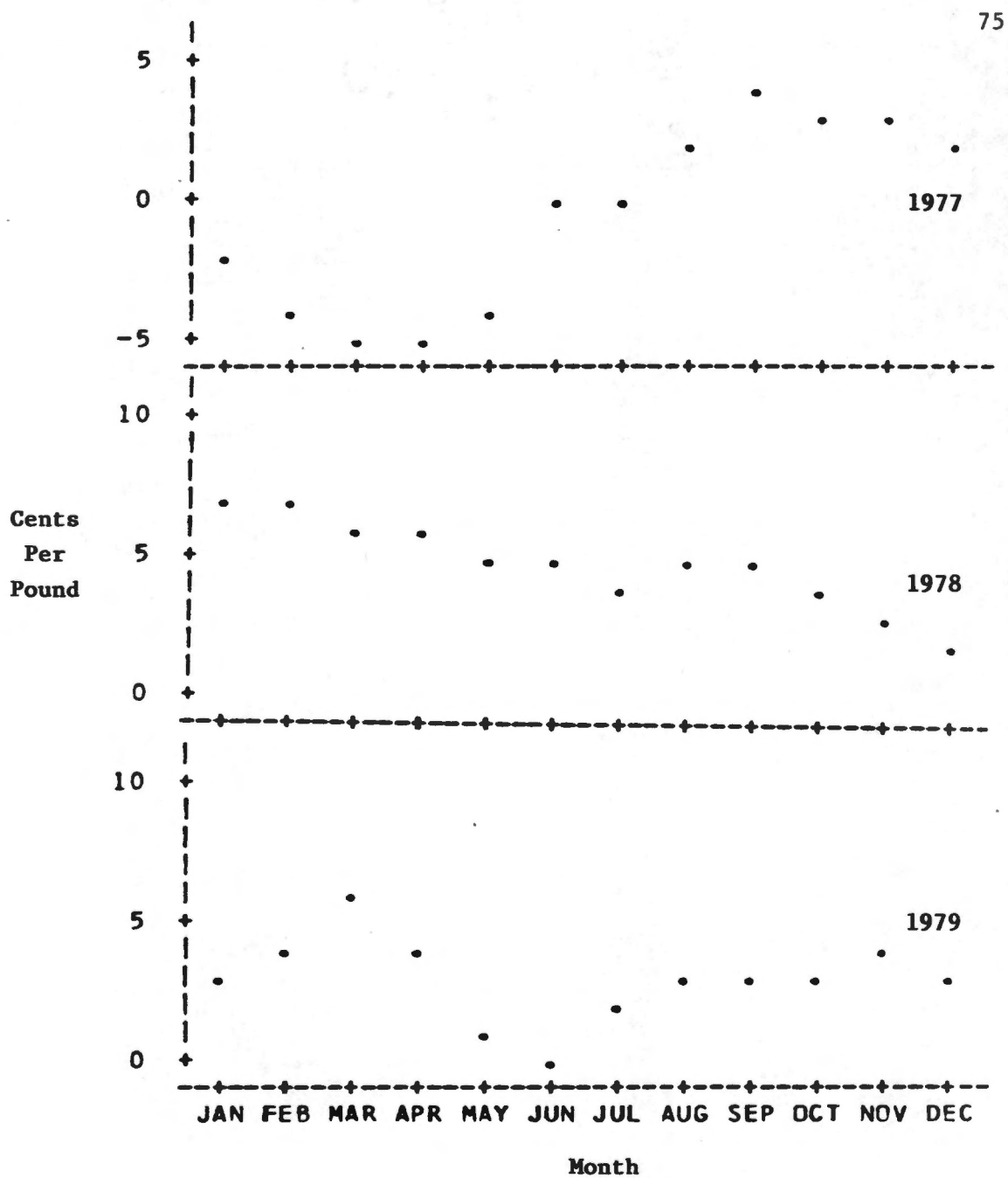


Figure 5 (Continued)

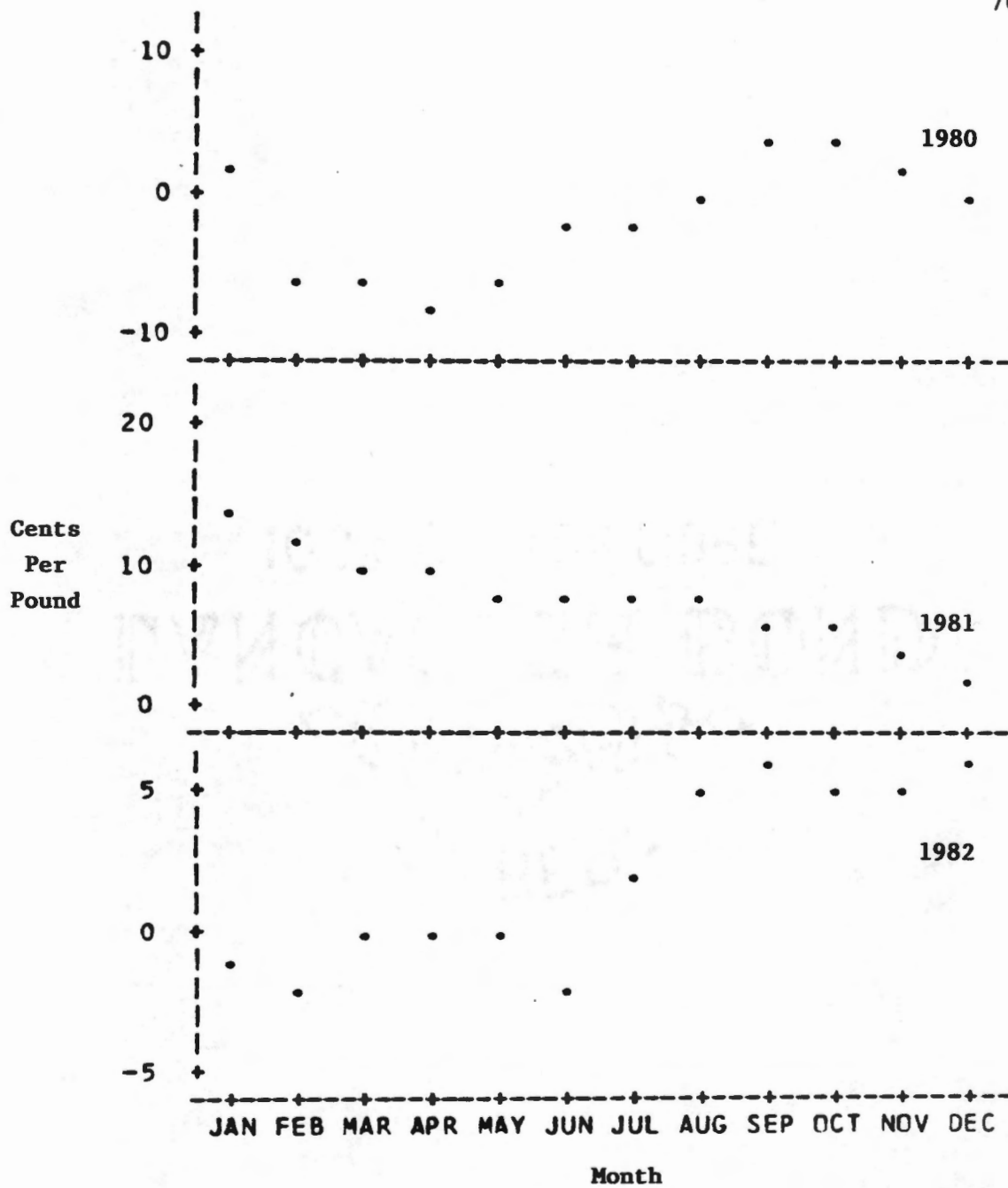


Figure 5 (Continued)

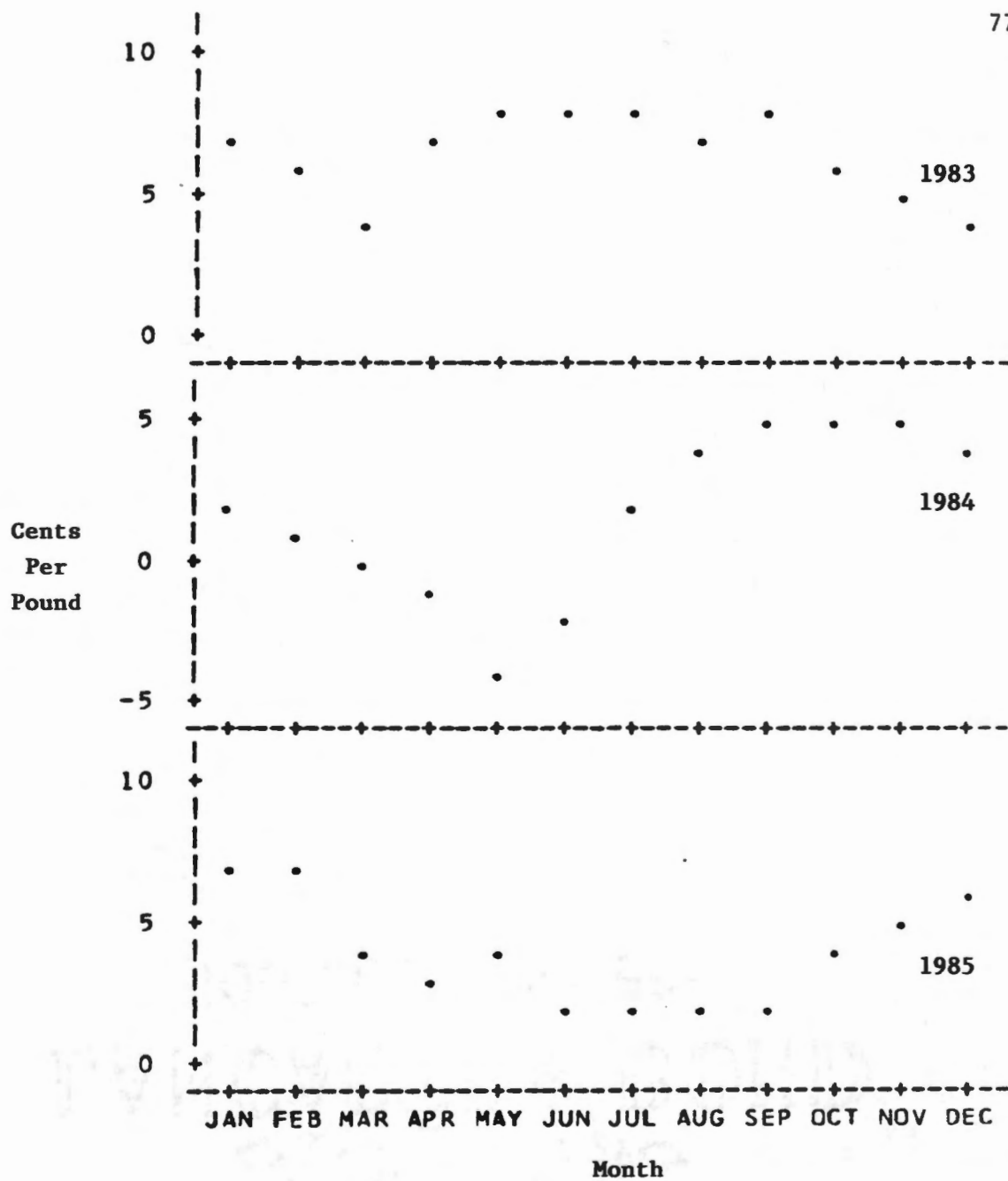


Figure 5 (Continued)

In addition to the calculation and plotting of the overall average monthly basis for the study period, corresponding variances and standard deviations were found for each month. These standard deviations and variances are presented in Table 5. Inspection of Table 5 reveals that the standard deviation of the average monthly basis tended to decrease by over 50 percent from June to December. There was a corresponding decrease of nearly 80 percent in the variance. This suggests that the predictability of the basis may become greater as harvest approaches. Decreasing variability of the

Table 5. Mean, Variance, and Standard Deviation of the December Basis by Month in Memphis, Tennessee, 1974 through 1985

Month	Mean	Standard Deviation	Variance
	- - - - cents per pound - - - -		
January	2.62	6.59	43.41
February	2.38	5.75	33.05
March	1.82	5.25	27.58
April	1.36	5.93	35.17
May	1.17	5.19	26.94
June	1.67	4.02	16.21
July	2.11	3.14	9.86
August	3.41	2.32	5.39
September	4.13	1.81	3.26
October	3.96	1.37	1.87
November	3.65	1.44	2.08
December	3.06	1.86	3.45

basis during the hedging period may account for part of the reduction in price risk associated with hedging.

The importance of the ending level of the basis to producer's hedging activities was noted earlier. Evidence of any trend in the ending basis would be helpful in making estimates of the basis and in anticipating the returns from hedging. For the basis analysis of this study, the ending basis was defined as the average of the basis for the last five trading days of the assumed hedging period. An analysis of variance was performed to determine if any significant differences existed between the ending basis among the years 1974 through 1985. Results of the analysis of variance, given in Table 6, reveal that a significant portion of the total variation in ending basis levels could be attributed to the variation associated with the calendar year. Thus, yearly differences existed among the ending basis at the 95 percent significance level.

Following the analysis of variance procedures, a mean separation technique was applied to the ending basis. Duncan's multiple range

Table 6. Analysis of Variance Table for Ending Basis

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	11	171.60716	15.60065	154.86*	0.0001	0.972594	9.9638
ERROR	48	4.83552	0.10074		ROOT MSE		BASIS MEAN
CORRECTED							
TOTAL	59	176.44268			0.31740		3.18550

* Significant at $\alpha = .05$.

test was the mean separation technique used to determine the years for which the ending basis was significantly different from other years at the 95 percent significance level. The rationale behind using a mean separation method was as follows. If, for example, the ending basis for 1980 through 1985 had been significantly greater than the ending basis for 1974 through 1979, it would suggest that a major change had occurred. Results in Table 7 do not suggest evidence of any such change in the ending basis, however.

Table 7. Duncan's Multiple Range Test on Ending Basis

ALPHA=0.05 DF=48 MSE=0.10074			
MEANS WITH THE SAME LETTER ARE NOT SIGNIFICANTLY DIFFERENT			
GROUPING	MEAN	N	YR
A	6.0200	5	81
B	5.6020	5	85
C	4.6020	5	83
C			
C	4.3260	5	84
D	3.5180	5	76
D			
E D	3.2060	5	79
E			
E	3.0700	5	77
F	2.5060	5	82
G	2.1000	5	74
G			
H G	1.7700	5	75
H			
H	1.6300	5	78
I	-0.1240	5	80

Results of Alternative Marketing Strategies

The results of the alternative strategies simulated are reported in this chapter. Discussion of the results is segmented by the type of strategy. The order in which the results are presented is as follows: routine strategies, selective strategies, and adjustable strategies. Table 8 shows the mean return, standard deviation of return, net price, standard deviation of net price, and coefficient of variation for each strategy. Figure 6 is a plot of the results of the

Table 8. Results of Alternative Marketing Strategies Evaluated

Strategy	Mean Net Return	Standard Deviation of Return	Net Price	Standard Deviation of Net Price	Coefficient of Variation
Cash sale at harvest	30,775.42	6,847.93	61.55	13.70	22.251
Planting hedge	31,394.09	5,075.83	62.79	10.15	16.168
Break-even hedge	31,341.02	5,239.35	62.68	10.48	16.717
Selective 25-7	31,486.81	5,127.28	62.97	10.25	16.284
Selective 25-13	31,344.28	4,995.21	62.69	9.99	15.937
Selective 10-5-4w	31,244.35	5,300.61	62.49	10.60	16.965
Selective 25-7-4w	31,392.94	5,078.44	62.78	10.16	16.177
Selective 25-16-6w	31,508.48	5,186.58	63.02	10.37	16.461
Adjustable 25-7	31,586.01	5,503.11	63.17	11.01	17.423
Adjustable 25-13	31,585.05	5,092.89	63.17	10.19	16.124
Adjustable 25-7-4w	31,474.32	5,166.67	62.95	10.33	16.416
Adjustable 25-16-6w	31,600.77	5,169.95	63.20	10.34	16.360

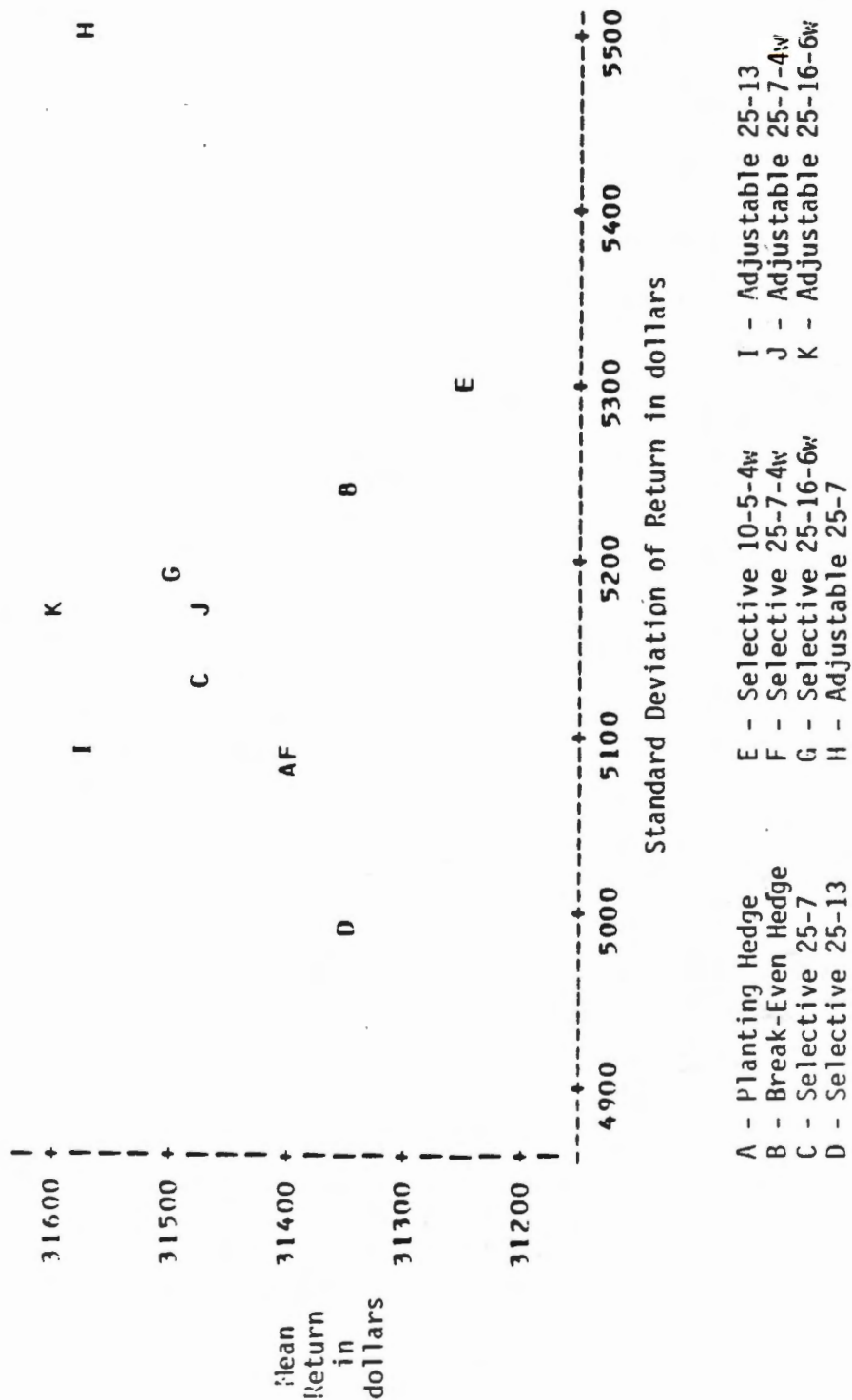


Figure 6. Mean Return-Standard Deviation of Return Plot for Alternative Strategies Simulated

alternative strategies in mean return-standard deviation of return space.

Summary information on futures market transactions is presented in Table 9. For each strategy Table 9 gives the frequency of winning and losing trades as well as the average length of time a hedge was maintained. Details concerning margin calls and margin withdrawals associated with each strategy are given in Table 10. Table 11 presents the mean net return and standard deviation of return for each major strategy group (routine, selective, and adjustable).

Results of Routine Strategies

Cash Sale at Harvest

The first routine strategy simulated was the cash sale at harvest. In this strategy it was assumed that the producer sold a quantity of cotton equal to one futures contract on the trading day nearest to December 5. Therefore, the return from the cash sale at harvest was simply the spot market price prevailing on the day of sale, multiplied by 50,000 pounds. Mean return and standard deviation and variance of return were obtained from the 12 yearly net returns of the cash sale at harvest. The mean return for this strategy was \$30,775, and the standard deviation of return was \$6,848. Yearly net returns ranged from a maximum of \$45,175 in 1980 to a minimum of \$19,225 in 1974. For the cash sale at harvest alternative, no transactions costs or margin calls associated with hedging were incurred. This strategy served as a benchmark of comparison for the 11 other strategies simulated. Mean return of the cash sale at

Table 9. Summary Information on Futures Market Transactions

Strategy	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)
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
Selective 25-13	12	14	46.2	53.8	2342	-1520	263	51
Selective 10-5-4w	13	24	35.1	64.9	2444	-1089	152	37
Selective 25-7-42	9	18	33.3	66.7	2886	-1031	274	48
Selective 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
Adjustable 25-13	12	18	40.0	60.0	2171	-908	324	43
Adjustable 25-7-4w	10	20	33.3	66.7	2581	-871	280	42
Adjustable 25-16-6w	10	14	41.7	58.3	2999	-1435	413	54

Table 10. 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
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
Selective 25-13	251	274	403	-395	-7310	1205	-1170
Selective 10-5-4w	277	288	414	-417	-5505	1205	-1265
Selective 25-7-4w	253	277	404	-406	-10300	1205	-1170
Selective 25-16-6w	246	268	393	-393	-8835	1205	-1170
Adjustable 25-7	261	283	402	-411	-11375	1205	-1170
Adjustable 25-13	253	283	403	-408	-13365	1205	-1170
Adjustable 25-7-4w	249	268	406	-413	-9750	1205	-1170
Adjustable 25-16-6w	246	277	404	-399	-11030	1205	-1170

Table 11. Results of Strategies by Group

Strategy Group	N	Mean Return	Standard Deviation of Return	Coefficient of Variation
		- - - - dollars - - - -		
Routine	36	31,170	5,616	18.018
Selective	60	31,395	4,962	15.806
Adjustable	48	31,562	5,066	16.051

harvest alternative was the lowest of all 12 strategies tested. Not surprisingly, the variance of return was greater than that of all other strategies. 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. Looking at each year of the simulation period, the cash sale strategy had the highest net return of all strategies in 1975, 1978, 1979 and 1980.

Planting Hedge

For the planting hedge strategy, the simulation program placed a hedge on the last trading day of May by selling one December futures contract of cotton. The hedge was maintained until the trading day nearest to December 5, at which time the futures position was offset and the spot cotton was sold at the prevailing Memphis cash price. Yearly returns for the planting hedge strategy were equal to the gain or loss on the futures market plus the revenue from the sale of the spot cotton. Gains or losses from the futures position accounted for brokerage fees and interest costs. 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.

Examination of the futures market transactions associated with the planting hedge alternative revealed that losses from the futures position occurred in seven years of the 12 year study period. Gains from the other five years were sufficient, however, to produce a \$619 average gain from each futures position undertaken. There was a total of 494 margin calls over the simulation. The largest occurring margin call was for \$1,205, and the average margin call was \$448. Margin withdrawals numbered 521 with an average of \$442. The largest margin withdrawal was \$1,190. Margin calls and withdrawals for this strategy were such that the net result was a total margin withdrawal of \$8,770 during the 12 year period.

Break-Even Hedge

The break-even hedge strategy involved placing a hedge on the condition that the December futures contract price, minus the expected ending basis, was greater than or equal to the break-even price. Break-even price was defined as the price per pound of cotton that would cover both variable and fixed production expenses. The variable and fixed costs were obtained as described in Chapter III. Ending basis estimates were arrived at by averaging the actual ending basis for the previous three years, and expected per acre yields were found

by averaging actual yields for the previous three harvests of Tennessee.

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 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.

The number of profitable hedges occurring during the period was five. Losses from the futures position were experienced in the other five hedges. However, because the average gain exceeded the average loss, there was a net average gain of \$679 from each hedge. The average length of the ten hedges was 134 days. Three hundred one margin calls were experienced in the simulation of the break-even strategy. The largest margin call was \$1,205. In addition, 317 margin withdrawals occurred; the largest being \$1,190. The net effect of margin transactions was a total margin withdrawal of \$7,765 for the entire simulation period.

Results of Selective Strategies

The selective hedging strategies of this study 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. Two of the selective strategies utilized a moving average indicator

with two component moving averages of the December futures closing price. The remaining three selective strategies were based upon a moving average indicator with three component averages. Moving average indicators with two component averages, and those with three component averages are referred to as two-crossovers and three-crossovers, respectively.

The 25-7 Two-Crossover Strategy

The first selective strategy simulated was a 25 day-7 day two-crossover (referred to as a 25-7 two-crossover) with a 0.5 cent per pound penetration rule. This strategy produced a mean return of \$31,487 and a standard deviation of net return equal to \$5,127. 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. However, examination of yearly results revealed that the 25-7 moving average strategy produced a net return greater than the cash sale at harvest in only six years out of 12.

The number of profitable trades in the futures market with this strategy was 11, and the average return from these trades was \$2,295. Losing trades numbered 19 and averaged \$879. Net average gain from each hedge was \$285. The average length of the 30 hedges that occurred in the simulation was 43 days. There were 255 margin calls averaging \$405 during the study period. Two hundred eight-three margin withdrawals averaging \$408 were generated. The net result of

margin transactions was a total margin withdrawal of \$12,190 for the entire simulation of the 25-7 two-crossover strategy.

The 25-13 Two-Crossover Strategy

The second selective strategy evaluated was a 25 day-13 day two-crossover with a 0.5 cent penetration requirement. This strategy ranked ninth with a mean net return of \$31,344. The standard deviation of net return for the 25-13 two-crossover was \$4,995. No other strategy simulated in this analysis had a lower standard deviation of return. As with the 25-7 two-crossover strategy, the 25-13 day moving average strategy produced yearly net returns greater than the cash sale at harvest in only six of the 12 years.

Twenty-six hedges were placed in the simulation of this strategy. Fourteen of these hedges were unprofitable with an average loss of \$1,520. Twelve profitable trades averaging \$2,342 were also generated by the 25-13 two-crossover. Overall average gain for all hedges was \$263. The average length of the 26 hedges was 51 days. Two hundred fifty-one margin calls were generated over the simulation period. These margin calls averaged \$403, and the largest margin call was for \$1,205. There were 274 margin withdrawals averaging \$395 each. The maximum margin withdrawal was for \$1,170. The balance of margin transactions for the 25-13 two-crossover was a net withdrawal of \$7,310.

The 10-5-4w Three-Crossover Strategy

The third selective strategy evaluated was a 10 day-5 day moving average with a 4 day linearly-weighted confirming average (referred to

as a 10-5-4w three crossover). As discussed in Chapter III, the rationale for the confirming average is to reduce losses due to false trading signals generated by the crossing of the other moving averages. The 10-5-4w two-crossover resulted in a mean net return of \$31,244 and a standard deviation of net return equal to \$5,301. 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. Although its mean return was greater than that of the cash sale at harvest strategy, the 10-5-4w three-crossover's returns exceeded the cash sale at harvest's returns in only four out of 12 years.

This strategy generated more hedges than any other strategy. Of the 37 hedges, only 13 recorded gains. The 13 profitable trades averaged \$2,444 and the 24 unprofitable trades averaged \$1,089. The average gain from all hedges was \$152, and the average hedge length was 37 days. Two hundred seventy-seven margin calls with a mean value of \$414 were generated in the simulation of the 10-5-4w three-crossover. There were 288 margin withdrawals that averaged \$417. This strategy generated a maximum margin call of \$1,205. Its largest margin withdrawal of \$1,265 marked the largest margin withdrawal of all the strategies evaluated. The balance of margin transactions was a net withdrawal of \$5,505 over the 12 year period.

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 linearly-weighted

moving average was used to confirm or reject trading signals generated by the 25-day and the 7-day component averages. The 25-7-4w three-crossover posted a mean net return of \$31,393 and a standard deviation of return of \$5,078. 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. In six out of the 12 simulated years, the net return from this strategy exceeded the net returns from the cash sale at harvest strategy. 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.

Twenty-seven hedges occurred in the simulation of this strategy; nine of which were profitable. The nine profitable trades averaged \$2,886 each, and the remaining 18 losing trades averaged \$1,031. Overall, each hedge averaged \$274. Comparison of the information on futures market trades reveals that the addition of the 4-day linearly-weighted confirming average to the 25-7 two-crossover did reduce the total number of trades. The percentage of profitable trades was also reduced, however. The average length of hedge for the strategy was 48 days. There were 253 margin calls and 277 margin withdrawals occurring in the simulation of the 25-7-4w strategy. Margin calls averaged \$404 and margin withdrawals averaged \$406. The result was a net margin withdrawal of \$10,300 over the entire simulation.

The 25-16-6w Three-Crossover

The fifth selective hedging strategy evaluated was the 25-16-6w three-crossover. This strategy resulted in a mean return of \$31,508

and a standard deviation of return of \$5,187. 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. Although the mean return for this strategy exceeded the mean return of the cash sale at harvest, its yearly net returns exceeded those of the cash sale at harvest strategy only six of the 12 years.

Of the 31 hedges simulated by the 25-16-6w moving average, 14 hedges posted gains averaging \$1,968. The other 17 unprofitable hedges averaged losses of \$1,103. For all 31 hedges the average gain was \$284. There were 246 margin calls and 268 margin withdrawals generated by the simulation of this strategy. Both margin calls and margin withdrawals averaged \$393. The net result of all margin transactions was a withdrawal of \$8,835 in margin money.

Results of 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. Adjustment of the parameters was performed according to the rules set forth in Chapter III. 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 four

days to 10 days in length. This strategy produced a mean return of \$31,586 and a standard deviation of net return equal to \$5,503. 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. Examination of yearly net returns revealed that this strategy resulted in a net return greater than the cash sale alternative in six of the 12 simulated years.

The number of profitable trades that occurred with this strategy was 11. These profitable trades averaged \$2,522, while the 21 unprofitable trades averaged \$858. The adjustable 25-7 two-crossover had a lower percentage of winning trades than the non-adjustable version. Net average gain on all trades was \$304, and the average hedge length was 41 days. There were 261 margin calls averaging \$402 and 283 margin withdrawals averaging \$411 generated by the adjustable 25-7 two-crossover. The end result of all margin transactions was a total margin withdrawal of \$11,375 for the entire simulation.

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. Both strategies had higher net returns than the benchmark cash sale strategy in six out of 12 years. Mean return of the adjustable strategy 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.

Figure 7 and Table 12 illustrate an instance in which the adjustable 25-7 strategy was able to avoid part of the losses that occurred in the simulation of the selective 25-7 strategy. Figure 7 is an overlay plot of the 25-day moving average, the 7-day moving average and the adjustable component average of the adjustable 25-7 strategy. The crossing of the 25-day moving average by the 7-day moving average represents a trade signal of the selective 25-7 strategy. Penetration of the 25-day moving average by the adjustable component average marks a trade signal of the adjustable 25-7 strategy. No trade signal is implied, however, by the crossing of the 7-day moving average and the adjustable component average.

The "day" column of Table 12 corresponds to the horizontal axis of Figure 7. The simulation programs were written so that a place signal generated on the current day was executed on the following trading day at the opening price. Thus, the place signal generated by the selective strategy on day 6 was executed on day 7 at 76.05 cents per pound. A corresponding place signal from the adjustable strategy occurred on day 5 and was executed on day 6 at 75.80 cents per pound. Prior to day 5 the length of the adjustable component average had been decreasing in response to a downward trend of the daily highs. The decreasing length caused current daily closing prices to have a greater influence on the value of the adjustable component average than upon the 7-day moving average. For this reason the place signal of the adjustable strategy occurred before the place signal of the selective strategy. In the selective strategy the lift signal occurred on day 27 and was executed on day 28 at 78.48 cents per

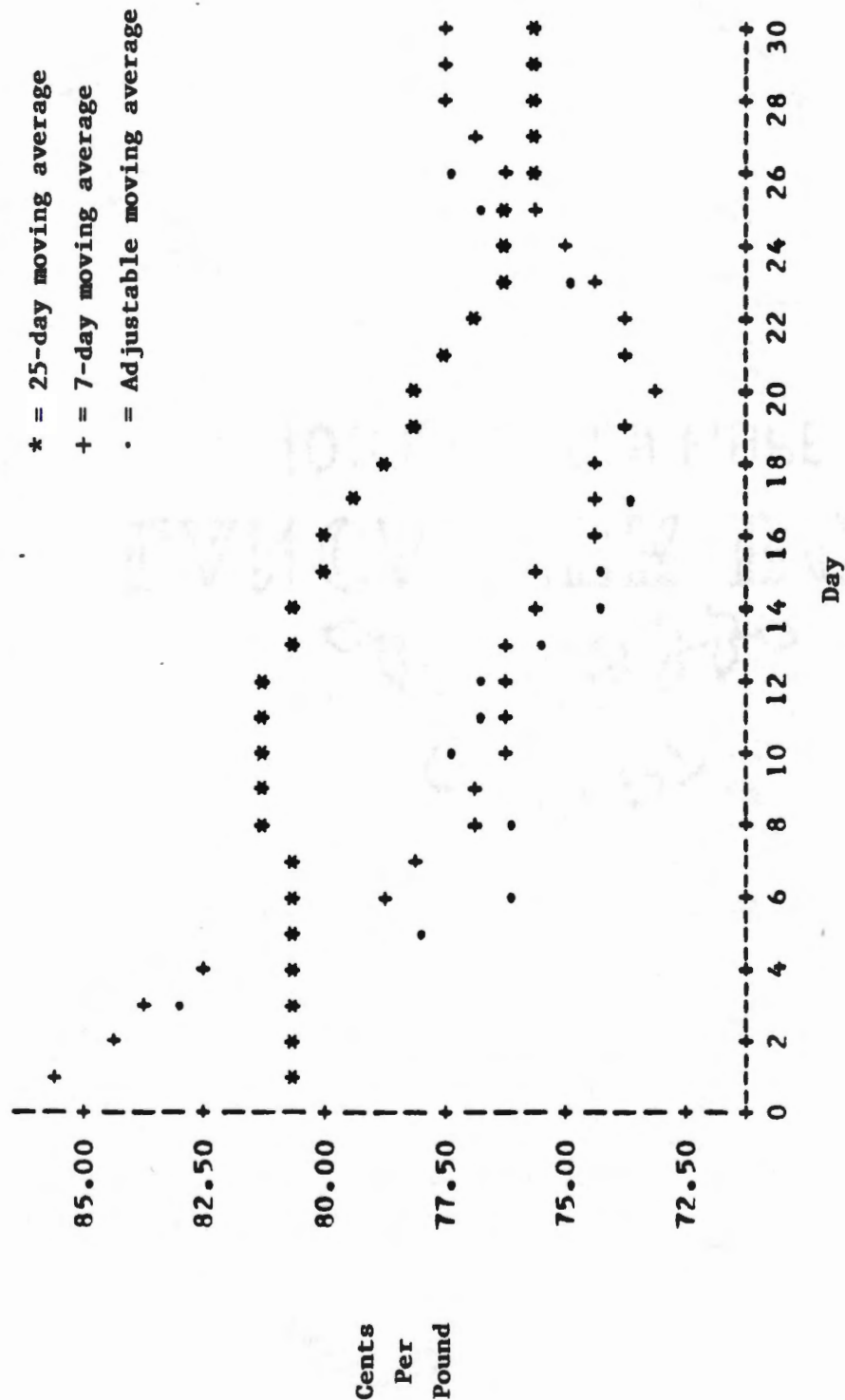


Figure 7. Plot of Selective 25-7 Strategy and Adjustable 25-7 Strategy Signals

Table 12. Comparison of Selective 25-7 Strategy and Adjustable 25-7 Strategy Positions

Day	Date	Open (cents per pound)	Selective Strategy Position	Adjustable Strategy Position	Adjustable Moving Average Length (days)
1	7/14/76	83.00	Unhedged	Unhedged	7
2	7/15/76	83.30	Unhedged	Unhedged	6
3	7/16/76	78.84	Unhedged	Unhedged	5
4	7/19/76	79.21	Unhedged	Unhedged	4
5	7/20/76	75.90	Unhedged	Unhedged	4
6	7/21/76	75.80	Unhedged	Hedged	4
7	7/22/76	76.05	Hedged	Hedged	5
8	7/23/76	78.05	Hedged	Hedged	4
9	7/26/76	80.05	Hedged	Hedged	4
10	7/27/76	76.70	Hedged	Hedged	4
11	7/28/76	75.35	Hedged	Hedged	5
12	7/29/76	74.85	Hedged	Hedged	4
13	7/30/76	77.50	Hedged	Hedged	4
14	8/2/76	72.70	Hedged	Hedged	5
15	8/3/76	70.50	Hedged	Hedged	6
16	8/4/76	74.00	Hedged	Hedged	4
17	8/5/76	74.20	Hedged	Hedged	4
18	8/6/76	74.60	Hedged	Hedged	4
19	8/9/76	73.53	Hedged	Hedged	4
20	8/10/76	71.15	Hedged	Hedged	5
21	8/11/76	72.95	Hedged	Hedged	4

Table 12 (Continued)

Day	Date	Open (cents per pound)	Selective Strategy Position	Adjustable Strategy Position	Adjustable Moving Average Length (days)
22	8/12/76	75.35	Hedged	Hedged	4
23	8/13/76	77.10	Hedged	Hedged	4
24	8/16/76	78.60	Hedged	Hedged	4
25	8/17/76	78.50	Hedged	Hedged	4
26	8/18/76	76.50	Hedged	Unhedged	4
27	8/19/76	78.50	Hedged	Unhedged	6
28	8/20/76	78.48	Unhedged	Unhedged	5
29	8/23/76	78.60	Unhedged	Unhedged	4
30	8/24/76	78.05	Unhedged	Unhedged	4

pound. A loss of \$1,215, excluding brokerage fee and interest expenses, resulted from the selective strategy. For the adjustable strategy the lift signal occurred on day 25 and was carried out on day 26 at 76.50 cents per pound. The loss from the adjustable strategy was \$350, excluding brokerage fee and interest expenses. Although both strategies experienced losses in this example of a roundturn trade, the adjustable strategy was able to reduce the loss.

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 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. In one-half of the years of the simulation, the adjustable 25-13 moving average yielded greater returns than the cash sale at harvest alternative.

There were 30 hedges undertaken in the simulation of the adjustable 25-13 two-crossover. Twelve of these hedges were profitable with an average gain of \$2,171. The other 18 hedges

experienced losses with a mean value of \$908. Average return from all hedges was \$324. The average length of each hedge was 43 days. The 40 percent profitable trade ratio of the adjustable 25-13 moving average is less than the 46.2 percent profitable trade ratio of the non-adjustable form. Two hundred fifty-three margin calls and 283 margin withdrawals occurred during the test of this strategy. Mean values of margin calls and margin withdrawals were \$403 and \$408, respectively. Over the simulation period a total margin withdrawal of \$13,365 was recorded.

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 had a greater mean return, the non-adjustable version had a lower and, therefore, more desirable standard deviation of return. 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 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. Just as the non-adjustable form of the 25-7-4w two-crossover, this adjustable version generated net returns greater than those of the cash sale at harvest in six out of 12 years.

Ten of the 30 hedges undertaken in the simulation were profitable and had an average return of \$2,581 per hedge. Unprofitable hedges averaged a loss of \$871. The average return for all 30 hedges was \$280, and the average length of each was 42 days. It is interesting to note that although the adjustable version of the 25-7-4w two-crossover generated three more hedges than the non-adjustable version, the proportion of profitable trades for each strategy was 33.3 percent. Two hundred forty-nine margin calls averaging \$406 each occurred in the simulation of this strategy. In addition, 268 margin withdrawals with a mean value of \$413 were generated. The end result of all margin transactions was a total margin withdrawal of \$9,750 for the entire period.

Comparison of the mean return and standard deviation of return for the adjustable and non-adjustable forms of the 25-7-4w moving average reveals that neither version dominates the other as a clearly preferred strategy. Furthermore, the equal percentages of winning trades offers no assistance in ranking the performance of these two strategies. 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. The adjustable 25-16-6w moving averaged posted net returns greater than the cash sale at harvest in eight years out of 12. No other strategy's net returns exceeded those of the cash sale alternative as frequently as the adjustable 25-16-6w three-crossover's.

Twenty-four hedges were undertaken in the simulation of this strategy. Losing hedges out-numbered the profitable hedges 14 to ten. However, because the average returns from profitable hedges and unprofitable hedges were \$2,999 and -\$1,435, respectively, the return from all hedges averaged \$413. Two hundred forty-six margin calls with a mean value of \$404 and 277 margin withdrawals averaging \$399 were generated. There was a net margin withdrawal of \$11,030 during the 12 year simulation.

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 to the other. The adjustable 25-16-6w strategy was the only one of the adjustable strategies that was superior to its non-adjustable counterpart. Interestingly, the

25-16-6w moving average produced the highest mean return in both the selective and the adjustable strategy groups. The adjustable 25-16-6w moving average recorded net returns above the cash sale alternative in eight out of 12 years, whereas the selective 25-16-6w strategy's returns exceeded those of the cash sale strategy in only six out of 12 years.

Results of Analysis of Variance Test on Strategies

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 rather than by statistical methods to detect significant differences among strategy results. In order to determine whether any significant differences existed among mean returns of the 12 strategies, an analysis of variance test was performed. The analysis of variance procedure calculates an F value for comparison to a critical F value for the desired level of significance and the appropriate degrees of freedom. The calculated F value was obtained as follows:

$$F_{\text{calculated}} = \frac{\text{Variance Among Returns Explained by Strategies}}{\text{Unexplained Variance Among Returns}}$$

$$= \frac{\text{Mean Square Strategy}}{\text{Mean Square Error}}$$

Analysis of variance results are presented in Table 13. The calculated F value of 0.02 suggests that no significant differences

Table 13. Analysis of Variance Table for Alternative Marketing Strategies

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	11	6655290.27638	605026.38876	0.02	1.0000	0.001767	16.9993
ERROR	132	3759603756.39696	28481846.63937		ROOT MSE		NRETURN MEAN
CORRECTED							
TOTAL	143	3766259046.67334			5336.83864		31394.45694

existed among the mean returns of the strategies at any reasonable level of significance. Therefore, any mean separation technique such as Duncan's multiple range test was of no value in ranking the strategies.

Tests for equality of variances of return from the strategies were also performed. Pairwise comparisons of variances of return from each strategy were made using the following equation:

$$F_{\text{calculated}} = \frac{\sigma_i^2}{\sigma_j^2}$$

where: σ_i^2 = variance of return from the i th strategy

σ_j^2 = variance of return from the j th strategy

$i \neq j$

$n - 1$ = numerator degrees of freedom

$n - 2$ = denominator degrees of freedom

$n = 12$

The critical F value at the 95 percent level of significance with 11 degrees of freedom in the numerator and in the denominator was 2.82. Table 14 shows the variance of net return for each strategy. Table 15 presents the calculated F values from all the pairwise comparisons of variances of return. Examination of Table 15 reveals that 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.

Table 14. Variances of Return from Alternative Marketing Strategies

Strategy	Variance of Return
Cash Sale at Harvest	46,894,129
Planting Hedge	25,764,005
Break-Even Hedge	27,450,800
Selective 25-7	26,288,993
Selective 25-13	24,952,140
Selective 10-5-4w	28,096,454
Selective 25-7-4w	25,790,598
Selective 25-16-6w	26,900,562
Adjustable 25-7	30,284,205
Adjustable 25-13	25,937,514
Adjustable 25-7-4w	26,694,461
Adjustable 25-16-6w	26,728,429

Table 15. Calculated F Values for Pairwise Comparisons of Variance of Return

Strategy	Cash Sale at Harvest	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
Cash Sale at Harvest	--	1.820	1.708	1.784	1.879	1.669	1.818	1.743	1.548	1.808	1.757	1.754
Planting Hedge		--	1.065	1.020	1.033	1.091	1.001	1.044	1.175	1.007	1.036	1.037
Break-Even Hedge			--	1.044	1.100	1.024	1.064	1.020	1.103	1.058	1.028	1.027
Selective 25-7				--	1.054	1.069	1.019	1.023	1.152	1.014	1.015	1.017
Selective 25-13					--	1.126	1.034	1.078	1.214	1.039	1.070	1.071
Selective 10-5-4w						--	1.089	1.044	1.078	1.083	1.053	1.051
Selective 25-7-4w							--	1.043	1.174	1.006	1.035	1.036
Selective 25-16-6w								--	1.126	1.037	1.008	1.006
Adjustable 25-7									--	1.168	1.134	1.133
Adjustable 25-13										--	1.029	1.030
Adjustable 25-7-4w											--	1.001
Adjustable 25-16-6w												--

Results of the Optimal Hedging Ratio Estimation

As noted in the Review of Literature, much of the work on optimal hedging ratios has been characterized by two major concepts. First, these hedging ratio derivations calculated successive price changes in historical spot and futures price series. Then price changes in the spot market were usually regressed on the corresponding changes in the futures price to arrive at an estimate of the optimal hedging ratio. Another characteristic common to most hedging ratio studies was that they focused only on hedges maintained continuously. No attempts were made to find hedging ratios that were optimal for other types of hedging strategies.

While two of the procedures used to calculate hedging ratios in this study were based on the two concepts above, the third method attempted to derive hedging ratios specific to the hedging strategy used. Instead of using successive price changes as proxies for returns in the cash and futures markets, the third method used actual returns associated with the particular strategy. The return from the spot position was defined as the expected return from the cash sale of the cotton at harvest. Similarly, the return from the futures position was defined as the expected return from participation in the futures market.

Fixed-Interval Estimation Over the Contract Duration

The first type of optimal hedging ratio derivation began by calculating price changes in the cash and futures markets over two-week and four-week intervals. These price changes were calculated for

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. Cash price changes over the two-week intervals were regressed on the corresponding futures price changes. A similar regression was performed using the price changes over the four-week periods. Table 16 shows the results of the two regressions of this hedging ratio derivation. For the regression equation of two-week price changes, the intercept was not significant at the 95 percent level of significance.

Table 16. Results of Fixed-Interval Estimation of the Optimal Hedging Ratio Over the Contract Duration

Regression Equation of Two-Week Price Changes

$$\begin{array}{lcl} \text{Standard Error (S}_b\text{)} & \text{SPCH} = & -3.811 + 1.130 \text{ FPCH} \\ & & (9.71) \quad (0.046) \\ R^2 & = & 0.580 \end{array}$$

where SPCH = spot price changes at two week intervals
 FPCH = futures price changes at two week intervals

Regression Equation of Four-Week Price Changes

$$\begin{array}{lcl} \text{Standard Error (S}_b\text{)} & \text{SPCH} = & -8.28 + 1.108 \text{ FPCH} \\ & & (20.512) \quad (0.068) \\ R^2 & = & 0.551 \end{array}$$

where SPCH = spot price changes at four week intervals
 FPCH = futures price changes at four week intervals

The slope coefficient (or hedging ratio estimate) was significant at the 95 percent significance level. Furthermore, this hedging ratio of 1.13 was significantly different from one at an alpha level of 0.05. For the regression equation of four-week price changes, the intercept was not significant at the 95 percent significance level. The slope coefficient for futures price changes was significant at that level of significance. However, the hedging ratio estimate of approximately 1.11 was not significantly different from the traditional hedging ratio of one at the 95 percent significance level.

Fixed-Interval Estimation Over the Hedging Period

In this estimation of the minimum-risk hedging ratio, price changes were calculated over two-week and four-week intervals as in the previous method. For this method, only the spot and futures prices within the assumed hedging period were used. The assumed hedging period of each year began on the last trading day of May and ended on the trading day nearest to December 5. There were 156 two-week periods and 73 four-week periods within the 12 years of the study period.

Table 17 presents the results of the two regressions performed in this method of estimation. It was hypothesized that the hedging ratios estimated using the hedging period data would be smaller than the hedging ratios derived from the duration of the December futures contract. The rationale behind this hypothesis is that cash and futures price movements should mimic each other more closely as the

Table 17. Results of Fixed-Interval Estimation of the Optimal Hedging Ratio Over the Hedging Period

Regression Equation of Two-Week Price Changes

$$\begin{array}{rcl} \text{Standard Error (S}_b\text{)} & \text{SPCH} = & -11.949 + 1.067 \text{ FPCH} \\ & & (8.530) \quad (0.031) \end{array}$$

$$R^2 = 0.883$$

where SPCH = spot price changes at two week intervals
 FPCH = futures price changes at two week intervals

Regression Equation of Four-Week Price Changes

$$\begin{array}{rcl} \text{Standard Error (S}_b\text{)} & \text{SPCH} = & -40.464 + 1.036 \text{ FPCH} \\ & & (18.862) \quad (0.053) \end{array}$$

$$R^2 = 0.842$$

where SPCH = spot price changes at four week intervals
 FPCH = futures price changes at four week intervals

expiration of the futures contract approaches. Examination of the R^2 values in Table 16 and Table 17 suggests that a stronger relationship exists between cash price changes and futures price changes during the hedging period than during the entire contract life.

For the regression equation of two week price changes the intercept was not significant at the 95 percent significance level. The slope coefficient or hedging ratio estimate was significant at the 95 percent level of significance. Furthermore, the hedging ratio of approximately 1.07 was greater than the traditional hedging ratio of one at an alpha level of 0.05. As hypothesized, this hedging ratio

for the hedging period was significantly less than the corresponding hedging ratio for the contract duration at the 95 percent significance level.

In the regression equation of four-week price changes, both the intercept and the slope coefficient were significant at the 95 percent level. The hedging ratio of 1.04 was not found to be greater than one at an alpha level of 0.05. Contrary to the hypothesis, the hedging ratio calculated from the hedging period was not significantly different (at the 95 percent significance level) than the corresponding hedging ratio derived from the contract duration.

Strategy-Specific Estimation from Yearly Returns

The third approach used in the calculation of the optimal hedging ratio focused on individual hedging strategies simulated in this study. As stated earlier, variances of cash and futures prices were no longer used as proxies for the variances of returns from cash and futures holdings. Instead, actual yearly returns from each of the 11 hedging strategies evaluated were used to arrive at the minimum risk hedging ratio for each strategy. The rationale behind deriving strategy-specific hedging ratios is that there is no reason to expect the risk-minimizing hedging ratio to be equal for all strategies. Furthermore, the use of historical spot and futures market returns to obtain an expected variance of return from the portfolio of spot and futures positions would appear to be a more direct approach than the previous two methods of this study.

For this estimation of the optimal hedging ratio, the yearly return from the spot position was defined as the revenue from the cash

sale of the cotton at harvest. In other words, the spot return for each year was the spot market price per pound prevailing at harvest times 50,000 pounds. The return from the futures position was defined as the profit or loss on a one unit futures position resulting from a particular strategy.

A regression of yearly spot returns on yearly futures returns was done for each of the 11 hedging strategies. A major difference in the regression results of this method and the results of the previous two 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. The results of the strategy-specific hedging ratio derivations are given in Table 18.

Optimal hedging ratio estimates ranged from a value of 0.826 for the planting hedge strategy to a value of 1.270 for the adjustable

Table 18. Results of Strategy-Specific Estimation of Optimal Hedging Ratios

Regression Equation for the Planting Hedge Strategy

$$\begin{array}{lcl} \text{SRETURN} & = & 31286.139 - 0.826 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1516.691) \quad (0.276) \\ R^2 & = & 0.472 \end{array}$$

Regression Equation for the Break-Even Hedge Strategy

$$\begin{array}{lcl} \text{SRETURN} & = & 31308.525 - 0.943 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1596.731) \quad (0.353) \\ R^2 & = & 0.416 \end{array}$$

Regression Equation for the Selective 25-7 Strategy

$$\begin{array}{lcl} \text{SRETURN} & = & 31646.733 - 1.225 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1560.454) \quad (0.424) \\ R^2 & = & 0.416 \end{array}$$

Regression Equation for the Selective 25-13 Strategy

$$\begin{array}{lcl} \text{SRETURN} & = & 31397.506 - 1.094 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1521.791) \quad (0.366) \\ R^2 & = & 0.471 \end{array}$$

Regression Equation for the Selective 10-5-4w Strategy

$$\begin{array}{lcl} \text{SRETURN} & = & 31238.778 - 0.988 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1614.726) \quad (0.382) \\ R^2 & = & 0.401 \end{array}$$

Table 18 (Continued)

Regression Equation for the Selective 25-7-4w Strategy

$$\begin{array}{rcl} \text{SRETURN} & = & 31499.490 - 1.173 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1543.658) \quad (0.402) \\ R^2 & = & 0.460 \end{array}$$

Regression Equation for the Selective 25-16-6w Strategy

$$\begin{array}{rcl} \text{SRETURN} & = & 31603.432 - 1.130 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1591.099) \quad (0.410) \\ R^2 & = & 0.432 \end{array}$$

Regression Equation for the Adjustable 25-7 Strategy

$$\begin{array}{rcl} \text{SRETURN} & = & 31547.632 - 0.953 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1697.227) \quad (0.406) \\ R^2 & = & 0.355 \end{array}$$

Regression Equation for the Adjustable 25-13 Strategy

$$\begin{array}{rcl} \text{SRETURN} & = & 31804.026 - 1.470 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1551.325) \quad (0.428) \\ R^2 & = & 0.436 \end{array}$$

Regression Equation for the Adjustable 25-7-4w Strategy

$$\begin{array}{rcl} \text{SRETURN} & = & 31561.679 - 1.125 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1582.332) \quad (0.405) \\ R^2 & = & 0.436 \end{array}$$

Table 18 (Continued)

Regression Equation for the Adjustable 25-16-6w Strategy

$$\begin{array}{rcl} \text{SRETURN} & = & 31680.103 - 1.096 \text{ FRETURN} \\ \text{Standard Error (S}_b\text{)} & & (1594.615) \quad (0.396) \end{array}$$

$$R^2 = 0.433$$

where SRETURN = yearly return from the spot market position
 FRETURN = yearly return from the futures market position

25-13 strategy. While the results of regression equations for each strategy are reported in Table 18, 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. Standard errors of the slope coefficients were used in statistical tests to determine whether any of the hedging ratio estimates were significantly different from one. None of the strategy-specific hedging ratios were significantly different from one at the 95 percent significance level. Intercept and slope coefficients for all strategies were, however, significantly different from zero at the 95 percent level of significance.

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 19. Table 20 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 his spot position with one futures contract at hedging ratio of 0.625, or with two futures contracts at a hedging ratio of 1.25.

Table 19. 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 20. 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	5,948	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.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary of the Study

The primary purpose of this study was to gather information relevant to the marketing decisions facing Tennessee cotton producers. Specifically, this analysis focused on the use of hedging as a pricing technique. Methodology and procedures were oriented towards answering potential questions of farmers who consider hedging to reduce the risk associated with the variability of cotton prices. The objectives of this study were the following:

- 1) Analysis of the basis for Memphis area cotton.
- 2) Evaluation of selected marketing strategies with respect to risk and net returns.
- 3) Estimation of the optimal hedging ratio for growers who choose to hedge their expected cash sales in the futures market.

Objective one attempted to provide information about the general behavior of the basis using historical data. Variability of the basis was compared to the relatively larger variability of spot cotton prices. The level of the ending basis determines the hedger's gain or loss from hedging. Therefore, knowledge of the basis behavior is important in understanding the use of hedging as a marketing tool.

The second objective was directed towards determining whether or not hedging is of potential use to Tennessee cotton producers.

Furthermore, this segment of the study attempted to identify hedging strategies that appeared to be the best in terms of expected mean return and variation of return. Hedging strategies from two previous works by Haden for Arizona cotton and by Howard for Texas cotton were selected and simulated for cotton in Tennessee. These strategies were chosen based upon the conclusions of Haden and Howard. The adjustable moving-average strategies of this study were aimed at improving upon the results obtained from the non-adjustable or selective moving-average indicators. Conceptually, the adjustable moving average was designed to signal trades nearer to the actual turning points of price movements.

Objective three addressed the issue of the optimal hedging ratio. The optimal hedging ratio was defined as that percentage of spot cotton to be hedged in order to result in the minimum variation of net returns to the producer. One of the goals of this part of the study was to determine whether the minimum-risk hedging ratio was equivalent to the traditional hedging ratio of one. The strategy-specific estimation of the optimal hedging ratio arrived at minimum-risk hedging ratios for each of the strategies tested. Using the results obtained from the strategy simulations, a sensitivity analysis varying the hedging ratio was done for each strategy. The purpose of the sensitivity analysis was to show the effect of the hedging ratio on the variability of net return.

Each of the three objectives of this study addressed a question related to a cotton producer's use of hedging. The first objective attempted to provide insight into the behavior of the basis as it

relates to hedging. Objective two dealt with the decision of what form of marketing strategy a producer should employ. Finally, the third objective focused on what portion of the farmer's expected cotton crop should be hedged.

Conclusions and Implications of the Analysis of the Basis

The most obvious point from the analysis of the basis is that the variability of the December basis for cotton is much less than the variability of spot prices. Standard deviation of spot cotton prices at Memphis during the 1974 through 1985 period was 11.71 cents per pound. For the same period the standard deviation of the basis was 4.37 cents per pound. Therefore, the variability of expected return from a hedged spot position should be less than the variability of expected return from an unhedged position. With a routine hedge such as the planting hedge strategy, the hedger is trading the risk associated with cash price variability for the risk associated with the lower basis variability.

Examination of Figure 4 (page 73) reveals that the average monthly basis for the 1974 through 1985 period as a whole has been positive. The plot of the average monthly basis for the study period shows that the basis has generally risen between the planting season and the beginning of harvest. Beyond the beginning of harvest, a decline in the basis until planting season has been the overall pattern. Although in some years the basis pattern differed considerably from the pattern for the overall period, the overall

basis pattern is useful in forming expectations of basis levels for a given time of the year.

The ending basis level is particularly important to the outcome of a hedge. Knowledge of the historical ending basis is particularly helpful in the break-even hedge alternative evaluated in this study. In this strategy the hedge was placed when the futures price minus the expected ending basis exceeded the break-even price per pound. A mean separation technique was applied to the ending basis to identify any tendency for the ending basis to increase or decrease throughout the 1974 to 1985 period. Evidence of such a tendency would aid in the estimation of basis levels and in forming expectations of returns from hedging. There was, however, no evidence of an upward or downward tendency in the ending basis suggested by the results of the mean separation tests.

Conclusions and Implications of the 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. 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 or not to utilize hedging and towards the question of which hedging strategy to choose. 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.

Four of the five selective strategies simulated were taken from studies by Haden and Howard. These four strategies were also superior to the no-hedge strategy in the original studies from which they were chosen. Furthermore, the adjustable versions of these four strategies were also superior to the cash sale alternative.

Comparison of the results of the three types of strategies simulated 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 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. However, 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. Inspection of Table 9 (page 84) shows that this did not occur, however. 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.

Conclusions and Implications of the 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 were significantly different from one at the 95 percent level of significance. The question that should be asked is the following. 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 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.

Intercept terms in the regression equations for the fixed-interval estimations have no readily useful meaning. These intercepts do indicate the size and direction 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.

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.

The sensitivity analysis on the hedging ratio was done for two primary reasons. First, the sensitivity analysis demonstrates that the optimal strategy-specific hedging ratios did, in fact, result in the minimum standard deviation of return for each strategy. In other

words, 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 purpose for the sensitivity analysis was to illustrate 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 his relative ability to meet the optimal hedging ratio of each. Such an example can be shown from the information in Table 19 and Table 20 (pages 117 and 118). Suppose a farmer initially selected the planting hedge strategy because of its relatively low standard deviation of return. Furthermore, assume that he would like to hedge at the optimal ratio of 0.8, yet his cotton production is such that he cannot. If he could utilize a hedging ratio of approximately 1.1, then he might consider the selective 25-13 strategy. 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.

In summary, the 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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