CORN STORAGE MARKETING STRATEGIES FOR VIRGINIA

by

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(ABSTRACT)

The decision between selling corn at harvest or placing corn in storage is investigated. Six marketing strategies are identified and analyzed based on their ability to capture profits and avoid losses. The strategies are implemented when expected profits are positive. The strategies involve storing with no forward pricing and storing with forward pricing using futures, options and cash contracts. Three regression models are developed to forecast change in cash prices and basis. The regression models are incorporated into the strategies to help producers forecast profits and losses. Cash prices and basis are based on markets in the Northern Neck of Virginia for the 1974 to 1994 time period. The distribution of returns for each strategy are analyzed and compared using mean variance analysis and second degree stochastic dominance. The distribution of returns represent the risk associated with each strategy. The results indicate four of the six strategies are worth considering. The strategy with the highest average returns and the highest variance of returns involved storing corn with no forward pricing. The strategy with no forward pricing exhibited

some of the best returns, but exposed the producer to the most risk. A producer faced no risk if the strategy using cash contracts was implemented. The strategy that comprised hedging with a futures contract and the strategy that involved buying a put option and writing a call option exhibited similar returns and risk. Producers can implement the strategy that exhibits the level of risk he or she is willing to accept. A computer program is developed to assist the producer in analyzing the four strategies.

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Chapter 1

Introduction

1.1 Introduction

Every fall, corn producers must decide whether to sell corn at harvest or store their corn and sell it later. The decision to store corn is based on whether an expected price at some point in the spring is greater than the cost of storing corn plus the current cash price at harvest. Since 1974, cash prices in Virginia during the spring months of February, March, and April have been lower than cash prices at harvest in eight out of twenty years, or 40 percent of the time. In addition, cash prices have increased less than storage cost in another four years. Hence, over the last twenty years, cash prices have either decreased or not increased enough to cover storage cost 60 percent of the time. It is apparent that producers in Virginia cannot rely on cash prices regularly increasing from harvest to spring. They need marketing alternatives and a marketing strategy that will assist them in making corn storage decisions.

In years when cash market returns were negative, a producer could have realized profits or avoided losses from storing corn when forward pricing with futures was profitable. A study, entitled "Corn Storage Decision Rule Using Futures" by Hoover and Kenyon, indicates that a producer in the Northern Neck of Virginia with 300 acres of corn could have increased returns from storage by more than $11,000 over a nine year period if corn was stored only when forward pricing with futures at harvest was expected to be profitable. In addition to increasing profits, a producer in the Northern Neck of Virginia could have avoided more than $10,000 in losses from storing corn every year without forward pricing. Returns from storing corn in the Northern Neck of Virginia every year without forward pricing are more variable and have a lower mean than returns from storing corn only when forward pricing with futures is profitable. The Hoover and Kenyon study suggests that there are marketing strategies that can assist corn producers in making grain storage decisions which result in increased profits and reduce losses.

1.2 Objectives

The general objective is to evaluate six marketing alternatives in terms of their ability to improve profits from storing corn. Three specific objectives have been developed. The first objective is to analyze and compare profits from six different marketing strategies a producer could implement when making the decision to store corn. The second objective involves the development of a worksheet that will assist a producer in comparing average returns and the variance of returns from the six marketing strategies. In addition to comparing strategies, the worksheet will assist the producer in choosing a strategy to implement. The third objective is to develop a computer based decision support system that will assist producers in comparing the six marketing strategies and making a storage decision under a given set of circumstances.

The six strategies will be compared over a 20 year period from 1974 to 1994 to determine each strategy's average returns and variance or risk associated with each strategy. The strategies and models developed will be based on the Northern Neck of Virginia, but the framework of the strategies will be general enough to work for all the major corn markets in Virginia. The six marketing strategies are:

1. store without forward pricing,
2. store and cash contract,
3. store and forward price with futures,

4. store and forward price with options,
5. store and buy put and write call options, and
6. sell at harvest and buy call options.

A producer will only implement a strategy when it has positive expected profits. When profits are expected to be less than or equal to zero, the strategy will not be implemented and corn will be sold at harvest. Producers are not limited to these six marketing strategies. However, these strategies are representative and commonly used marketing strategies that producers can follow each fall when corn is harvested.

1.3 Methods of Analysis

Three methods of analysis will be incorporated to compare and contrast the six marketing strategies. The first procedure involves developing a simulation of historical returns to storage and profits for each of the six strategies. The second method involves developing models that forecast the change in basis and the change in cash prices to improve the probability of receiving positive returns to storage for each of the six strategies. Third, a method of ordering the distributions of returns to storage according to their means and variances will be implemented.

Historical profits will be calculated and used as a benchmark to compare estimated profits for the six strategies when using models to forecast basis and changes in cash prices. To calculate historical profits, a simulation of historical storage cost, option premiums, futures, and cash prices must be developed for each of the six strategies. Storage cost will be estimated using budgets and historical data. The strategies involving options will require estimating option premiums during the period when option contracts for corn futures were not available. Option contracts for corn futures did not begin trading until 1985. The 1976 Fischer Black option pricing formula will be used to simulate option premiums for the time period when option contracts for corn were not trading.

To improve the probability of receiving positive returns to storage, three regression models will be developed to forecast basis and change in cash prices. Since these models are being developed for producers with limited access to market variables, it will be important to develop sound statistical models as well as models that contain variables easily obtained by producers.

The distribution of profits for each of the six strategies represent the risk and uncertainty associated with each strategy. Two traditional methods of comparing distributions are mean-variance analysis and second degree stochastic dominance(SSD). SSD will be the method used to rank the six marketing strategies. Even though EV analysis is the most widely used method and the simplest to implement, EV analysis assumes the outcome distributions are normal which is not a realistic assumption to make in regards to the six marketing strategies. It is unrealistic because returns to the strategies using options will exhibit unlimited upside potential or a distribution that is skewed to the right. However, if the results from EV analysis are not significantly different from SSD it might be advantageous to consider using EV analysis.

1.4 Computer Based Decision Support System

Computers are a tool that assist producers in managing records and making complex management decisions. Computers normally help organize financial and production records that would otherwise be done by hand. A computer based decision support system could improve the quality and ease of managing large operations that make complex decisions such as grain storage decisions. Analyzing six different marketing strategies requires a large database and many calculations that can be easily managed by a computer based decision support system.

Computer based decision support systems (DSS) are interactive, flexible and adaptable computer programs, specially developed for supporting the solution of a particular management problem for improved decision making. The DSS utilizes data and models, provides easy user interface, and allows for the decision makers own insights. DSS lends itself to analyzing semi-structured problems. In a structured problem, the procedures for obtaining the best solutions are known. In an unstructured problem, human intuition is frequently the basis for decision making. Semi-structured problems fall between the structured and unstructured, involving a combination of both standard solution procedures and individual judgment. The DSS improves the quality of decisions made by providing not only a single solution but a range of alternate solutions. Analyzing the six marketing strategies represents a semi-structured problem since some of the strategies will require econometric models to estimate the expected returns to storage and stochastic dominance and individual judgment will be used to determine which strategies offer the best returns to storage.

The basic design of the DSS will be in the form of a spreadsheet. The spreadsheet used will be Microsoft Excel. The spreadsheet will be divided into three sections, the user interface, historical data, and computations. The producer will be asked to provide current relevant market information. The computer will then use the current and historical data to compute the expected returns to storage for each of the six strategies. Probability distributions associated with each of the expected returns to storage will then be compared using SSD. The producer will then be presented with the computer's suggested ranking of the six strategies according to mean and variance of returns. The producer will then be able to make a quality decision whether grain should be stored or not and as to which marketing strategy could be implemented.

The next chapter is a review of the literature relevant to the problem at hand. Chapter three discusses how to calculate the returns to storage for each of the six strategies and how to compare the strategies. Chapter four will cover the results of the three regression models and the Fischer Black option pricing formula. Chapter five will report the historical profits of the six strategies over the past 20 years and how they rank according to SSD and EV analysis. Chapter six will explain the development of a decision worksheet and the DSS. Chapter seven will contain the summary and conclusions.

Chapter 2

Review of Literature

Chapter two is a review of literature relevant to the problem stated in chapter one. This literature review will look at three areas of interest: commodity storage, methods of comparing and ranking probability distributions, and agricultural computer use and applications.

2.1 Commodity Storage

In 1949, Working developed the theory of price of storage and the role futures markets play in determining the price of storage. Working uses the United States wheat market as an example to explain the theory. It is observed that only supplies already in existence have any significant bearing on current inter-temporal price relations. The question addressed by Working is how to account for the observation that it is existing supply rather than expected change in supply which is involved in determining inter-temporal price relations. Inter-temporal price relations are price relations at a given time between prices applicable to different times. Traditionally, the relations between prices for delivery at two different dates within a crop year are commonly regarded as depending on the cost of carrying stocks. However, if the return to storage is determined freely and competitively, it will vary according to demand and supply conditions. If stocks to be stored are exceptionally large, the return for carrying a commodity may exceed the cost of storage, as conventionally calculated. If stocks are moderate, competition among firms with storage facilities tends to result in the storage being provided for a rather small return per bushel. This leads to explaining inter-temporal price relations as determined by a competitive "necessary return to storage".

Working points out that the existence of a futures market, coupled with the practice of hedging, gives potential holders of wheat a precise or at least a good approximate index of the return to be expected from storing wheat. It is through supplying a direct measure of the return to be expected from storage, and a means, through hedging, of assuring receipt of that return, or of approximately that return, that a futures market makes its most direct and powerful contribution to the economical distribution of supplies of a commodity over time.

Problems arise in the theory of price of storage when observed inter-temporal price relations exhibit negative returns for carrying a commodity. The question arises whether it is good theory to treat negative values as negative prices. Negative prices will occur when supplies are relatively scarce. Negative prices impose pressure on hedging merchandisers and processors to avoid holding unnecessarily large quantities out of consumption in the form of stocks. Thus a negative price of storage makes available for consumption in a year of shortage supplies which would otherwise remain tied up in convenience stocks. Convenience stocks represents the stocks held by commercial users to ensure stock levels do not become scarce. In relation to the present study, an expected negative price will be used as a signal to sell at harvest and not to store.

A 1986 study by Kenyon represents the ground work on which the present study is based. Kenyon explains a simple decision process which can be used to determine when to store. The storage decision is made at harvest by comparing cash prices with forward cash contract or futures contract prices to determine if the expected cash price appreciation will cover storage cost. The study assumes grain is already in storage condition which means the analysis does not consider grain drying cost or charges. The study uses cash prices of

U.S. No. 2 yellow corn grown in the Northern Neck of Virginia. The decision rule is to store and hedge if the expected net price is greater than the break-even price.

The break-even price is the price required at the end of the storage period to cover the harvest price plus storage cost. Storage cost include costs associated with physically storing the grain, interest cost of stored grain, and physical weight loss during storage. The expected net price represents what the market is offering for corn at some point in the future, in this case March. Two forward pricing alternatives are analyzed. The price offered by the cash contract or the futures price at harvest less the expected ending basis. Ending basis in this study represents the historical difference between Northern Neck cash prices and Chicago futures prices in March. A three year average is used which means that the actual basis may not equal the expected basis. Hence, the expected net price will differ from the actual net price by the difference in expected and actual basis. This difference between expected and actual basis is defined as basis error.

Kenyon points out that the decision process works because the cash price increases relative to the futures price regardless of which direction prices move. Since the farmer has sold futures but owns the cash commodity, the convergence of cash and futures generates profits. The difference between cash and futures at harvest is the beginning basis and the difference between cash and futures in the spring is the ending basis. When a farmer sells futures at harvest and stores grain, the change from beginning to ending basis is the return to storage. If the change is greater than storage cost a profit is made. If the change is less than storage cost, it will pay not to store.

Analyzing the 1980 to 1984 period, Kenyon finds that a farmer following the decision process would have either avoided a 25 to 30 cent per bushel loss in two years or increased profits 25 cents per bushel in the other two years. Farmers storing without forward pricing would have lost money three out of the four years. It is important to note that the decision rule will not always give the greatest profit, but it will keep the farmer from storing grain when storage is unprofitable. This decision process has worked successfully in Virginia for corn since 1973.

A study by Hoover and Kenyon in 1994 reports the results of following the decision rule defined in the 1986 study by Kenyon for the 1984 to 1993 period. Returns from storage were computed assuming 300 acres of corn were grown and priced in the Northern Neck of Virginia. Total production was based on Virginia average corn yield. The producer is assumed to store corn from September 15 to March 15. The study compares the returns from storing corn every year without forward pricing to storing corn only when forward pricing with futures is profitable.

The results of the study indicate that when corn was stored without forward pricing from 1984 to 1993, a producer in the Northern Neck of Virginia could have lost more than $10,000 from storing corn from 300 acres. But storing corn when the expected net price via hedging was greater the break-even price, a producer would have seen profits increase by more than $11,000 during the same time period. Hence, the study indicates that storing corn without some form of forward pricing is a poor marketing strategy.

The study by Hoover and Kenyon relies on the average basis over the previous three years as an estimate for actual basis and ignores the variance around the estimated basis. The present study will consider the variance of estimated returns to storage and will order the six strategies according to mean variance analysis or second degree stochastic dominance.

In 1986, Miller conducted a study investigating producer preference to cash contracting instead of hedging with futures. He cites a 1977 study by the Commodity Futures Trading Commission that indicates only 7.5 percent of surveyed grain farmers had traded futures in 1977, while nearly 20 percent had sold grain under forward cash contracts. The hypothesis tested by Miller is whether the absence of basis risk with forward contracting explains apparent producer preference for forward contracting instead of direct hedging as a forward pricing tool.

Miller follows a model developed by Roflo that derives optimal hedging levels assuming that producers maximize expected utility of income within a mean-variance analysis framework. The model is modified to allow for fixed price forward contracting in the face of price, basis, and yield uncertainty. The model used soybean data from ten Coastal Plain counties in South Carolina for each year from 1975 to 1984. Even though Miller is not analyzing the forward pricing of a stored commodity, the results are still applicable to the present study in terms of the impact of basis variability on farmer preference for cash contracts verses futures contracts. Miller concludes that both theoretical and empirical analysis indicate that the absence of basis risk with forward contracting does not lead to higher levels of forward contracting relative to direct hedging for producers who are risk averse. Hence, the absence of basis risk does not explain producer preference for forward contracting over direct hedging as a forward pricing tool.

A 1992 article by Flaskerud examines the impact of basis and storage cost on marketing decisions. Flaskerud uses a framework for evaluating marketing alternatives that incorporates basis and storage cost which involves several steps adapted from O'connor and Anderson. The first step involves estimating basis for each calendar month relative to the nearest futures contract price. The next step is to subtract the basis number for each month from the nearby futures contract price. The result is an estimate of monthly cash prices. The final step is to derive net expected prices for each month by subtracting variable storage cost from the expected prices. The variable storage cost was divided into two categories. The first category includes those costs primarily associated with grain going into and out of storage. The second category includes a cost per month for interest on investment in the grain in storage and storage shrink. The month with the highest expected profits is the month during which sales should be planned.

To be sure of capturing the expected net price, it would be necessary to establish a production or storage hedge by either selling a futures contract or buying a put option. The risk in the hedge is then limited to the basis. Flaskerud applied his procedure to a North Dakota wheat producer for three crop years between 1989 and 1991. Results indicate that wheat stored during the 1989-90 crop would not be profitable and wheat stored during the remaining two crop years and hedged with futures could realize nine and five cents profit respectively if the estimated basis was equal to the actual basis. Flaskerud makes the point that this procedure is only a tool for planning sales. Flaskerud makes another point that when the differences between futures prices change or expectations of the basis change, then the marketing plan should change too.

A 1987 study by Lowry, Glauber, Miranda, and Helmberger examines the role that storage plays in allocating supplies within the crop year. The authors make the point that in many agricultural markets, storage is the largest component of demand during the harvest period and the largest source of supply in the balance of the marketing year. A model of markets for annually produced commodities is presented that is quarterly in the sense that the amounts consumed, exported, and stored and current and expected future prices in the four quarters of the crop years are endogenous variables. Yield on harvest acreage is stochastic, and additional stochastic terms appear in the acreage supply and demand equations. Competitive speculative storage is formally characterized. Expected prices are endogenous variables, and expected price functions were estimated using computational rational expectation methods. The parameters of other behavioral equations were obtained from econometric work based on U.S. quarterly data. Assuming time-stationary values for the model parameters and the shift variables of the behavioral equations, Monte-Carlo simulations were conducted to estimate the steady state means and variances of the endogenous variables.

The model was applied to soybeans. Quarterly demands were estimated using two stage least squares and quarterly observations for the period 1965 to 1979. Equations were log-linear, with price elasticities held constant across quarters but with dummy variables included to allow for quarterly shifts. The acreage planted to soybeans in the United States was expressed as a log-linear function of the expected first quarter prices for soybeans, corn, and cotton, and the total acreage planted to crops and a trend variable. Futures prices were used as proxies for expected prices and were deflated by an index of production input cost. The supply equations were estimated using ordinary least squares and annual data for the period 1951 to 1979. Yield was assumed log-normally distributed with a time-stationary mean of 29.7 bushels per acre. The quarterly interest rate was set at two percent and the quarterly unit cost of storage services was set at $0.10 per bushel.

The authors draw four conclusions that are of particular interest to the present study. The first result indicates that the speculative demand for stocks makes the total demand relatively elastic in the range in which total quantity demanded is large. This suggests that storage tends to put a floor on prices in light of the extremely high elasticities of the expected price functions at high carryout values. The next conclusion is that the sample means of the quarterly cash prices rise throughout the crop year by the amount of the carrying charge of about 21 cents per quarter. The authors point out that this result provides a stochastic counterpart to Samuelson's 1966 theory of intra-seasonal price movements under certainty that showed prices rising throughout the storage season by the amount of the carrying charge and then falling at the start of a new crop year. Third, the authors indicate while inter-year storage will decrease the variability of price, the effect is asymmetric over the crop year. Prices become more variable towards the end of the crop year when information about the new crop year becomes known. The fourth conclusion drawn by the authors indicates that annual prices fall as the quarterly carrying charge is reduced. In the final concluding remarks, the authors point out two topics of future research. First, the need for modeling risk-averse behavior at the production and storage levels. Second is the need to extend the model to include contingent markets such as a futures market.

A 1989 article by Bond sets forth a simple procedure for estimating the selling price a producer would have to receive at the end of a storage period to be as well off as shortly selling after harvest. Bond indicates that as long as there is a reasonable certainty that the price at the end of the storage period will be above the break even price, holding out for a higher price is an alternative worth considering. The model is relatively simple and the break even selling price is the sum of current market price, interest or opportunity cost, storage cost, insurance cost, and shrinkage or spoilage or quality loss. The example used by Bond to explain the variables in the break even formula deals with alfalfa hay, but the principles can be applied to any crop. Bond makes two assumptions about the storage cost. First, half of the shrinkage occurs in the first month and the rest in the second month. Fractional months are not considered. Second, only out of the pocket storage cost are considered. Fixed cost of storage are ignored.

Bond concludes that crop storage increases the price that a producer must receive to break even. When storage does not involve additional borrowing, it is easy to overlook the opportunity cost of capital. Moreover, shrinkage, spoilage, and general quality losses are often underestimated. All cost should be considered when marketing decisions are made.

A 1986 paper by Jones identifies the capital costs incurred in constructing grain storage bins and the actual physical cost of storing the grain. An evaluation is made of the profitability in on-farm grain storage as part of the marketing function. The results show that 40,000 bushels of grain could be stored for 2 cents per month. Interest as an opportunity cost was not included. The cost included were chemical, electricity, labor, propane, miscellaneous, and depreciation. Electricity and propane were used in drying the grain. The chemical expense was for pesticides. The main results of the cost analysis is that idle storage capacity is extremely expensive.

2.2 Methods of Comparing and Ranking Probability Distributions

Two traditional methods of comparing and ranking risky alternatives are Mean-Variance analysis and second degree stochastic dominance. Definitions and comparisons of these two methods are laid out by Barry (1984). Mean-variance (EV) analysis is the most familiar and most widely used method of analysis. EV analysis requires that the producer making the decision be risk averse. In addition, EV analysis requires the probability distributions be normal or that the producers utility function be quadratic. When these restrictions are met, all relevant information associated with the probability distributions of alternative choices is conveyed by the means and variances. Hence, EV analysis suggests that given a particular mean, the strategy with the lowest variance would be the most viable alternative.

Another way to rank the probability distributions is by way of second degree stochastic dominance. Second degree stochastic dominance (SSD) requires that the decision maker's utility function has a positive, non-increasing slope at all outcome levels. The decision maker must also be risk averse. Under SSD, distributions are compared based on the accumulated area under each distribution. For example, if the accumulated area under the probability distribution associated with the returns to storage for the first strategy is always less than or equal to the accumulated area under alternative distributions, then the first strategy would be considered a preferred alternative. SSD only considers distributions that completely dominate other distributions. If a distribution dominates all other distributions at lower levels of returns to storage, and not at higher levels of returns to storage, then it will not be considered in the SSD efficient set.

These two methods of comparing distributions have limitations. First, the assumption of risk aversion does not always hold. Barry indicates that empirical evidence suggest that decision makers do, at times, exhibit preferences for risk. When this assumption does not hold, the preferred choice may be excluded from the set of viable alternatives. Second, if all distributions analyzed were normal, the results from EV analysis and SSD would be identical. However, when the EV criterion is used to order non-normal distributions, the resulting set of viable alternatives may differ from the SSD set of viable alternatives. It is unrealistic to assume that all six strategies analyzed in the present study will have normal distributions. The strategies using options may exhibit unlimited upside potential or non-normal distribution that is skewed to the right. The question arises whether the rankings of strategies via EV versus SSD criteria differ greatly.

In 1972, Porter and Gaumnitz conducted an empirical evaluation comparing stochastic dominance and mean-variance analysis. The empirical test performed included a stochastic dominance analysis of a set of EV efficient portfolios, a comparison of the EV and SSD efficient sets obtained from a large set of randomly generated portfolios, and a test of the efficiency of diversification as measured by stochastic dominance as opposed to simple variance reduction. For the first test, monthly data from 140 stocks for the period 1960 to 1963 were used to generate an EV efficient set of portfolios based on the Markowitz Index model formulation. For the second and third test, 925 stocks with complete data for the 1960 to 1965 period were randomly generated using data contained on the Chicago Price Relative tapes.

The results indicated that the differences between EV and SSD efficiency were not as great as might have been expected. The most significant difference was the frequency with which SSD eliminated EV efficient portfolios in the low return range. The authors indicate that the results support the conclusion that, except for the highly risk-averse investor, the choice between the more familiar mean-variance analysis and the theoretically superior stochastic dominance model for selecting efficient portfolios is not critical. However, where risk aversion is strong, SSD rules are more consistent with the maximization of expected utility than is mean-variance analysis.

2.3 Agricultural Computer Use and Applications

A 1986 study by Ross indicates that many farmers do not utilize or under utilize their computers. The study consisted of several hundred Canadian farmers, of which, approximately 30 percent with computers did not use them for farm management purposes, but limited their use to educational and recreational purposes. In this study, farmers used their computers, on average, slightly less than one and one-half hours per day, and only 11 percent of the farmers used them for more than three hours per day. The study also shows that the most common uses of computers by both farmers and agribusiness are record keeping and word processing.

A 1991 paper by Baker presents the results of a study of computer usage by New Mexico farmers. The objectives of the article were to report the results of the survey regarding the farmers use of computers, identify characteristics associated with successful computerization, and develop recommendations for improving the use of computers as a management tool. The survey respondents averaged 55 years of age and finished an average of 13.2 years of school.

Baker found that only 20 percent of the farmers utilized computers in their farm operations. Those farmers who operated computers had an average of 1.3 computers per farm and had used them an average of two years and 10 months. The computers were most commonly used for record keeping and word processing functions. At least 50 percent of the farmers utilized computers for the following functions: accounting, word processing, inventory control and purchasing, and financial decision making. Computers were used as aids in production and marketing decision making by 40 percent and 30 percent of the farmers, respectively. No farmers reported the use of a computer made decision making more difficult, indicating that information overload was not a problem. More than 90 percent of the farmers were happy with their computer hardware and software. However, only 82 percent thought software was available that met their needs, and 24 percent thought software instructions were insufficient.

Several implications were drawn from Baker's research. First, it found that farmers who had a high level of education, a favorable attitude toward innovation, and who operated large farms were most likely to adopt computers. On the other hand, there was no indication that the success of the computer systems used was at all related to factors such as age, education, attitude towards change, or farm size. These two findings together indicate there is a large potential for farmers who have not yet computerized their operations to do so and experience the same level of success that early adopters have experienced.

Baker suggest that in order to make the most effective use of the farm's computer system, computer software should support the critical areas of decision making which have the highest impact on the farm's performance. In addition to providing accurate and timely accounting information, these critical areas will probably include decisions relating to production, financing, and marketing.

The use of computers by Virginia farmers has increased over the 1993 to 1995 period (Groover). Results of computer education workshop evaluations show computer ownership from 52 percent to almost 80 percent among workshop participants. More than half of the workshop participants were cash grain producers. As in other areas of the U.S., computers on Virginia farms are mainly used for accounting and maintaining farm business records. Spreadsheet applications were not very popular, but participants indicated that future workshops should include classes ranging from windows applications to spreadsheet applications.

It is important to note that farmers attending computer education workshops are not a representative sample of Virginia farmers. Hence, 80 percent of Virginia farmers do not own computers. However, the study clearly indicates that computer use by Virginia farmers is increasing.

Chapter 3

Marketing Strategies

The purpose of chapter three is to explain the six marketing strategies and how a producer would calculate estimated profits for each of the marketing strategies at harvest. Section 3.1 will cover the cost of storing grain from September to March. Section 3.2 will discuss how to estimate revenues and how to calculate estimated profits. Three regression models will be developed to forecast changes in cash price and basis. The estimated changes in cash prices and basis will be used to calculate an estimate of profits in September for each of the six marketing strategies. The Fischer-Black option pricing formula will also be used to estimate option premiums when options for corn futures were not trading. Section 3.3 will discuss the development of the regression models and explain how the Fischer-Black model will be used. The final section of chapter 3 will explain how the strategies will be compared after estimated profits have been calculated.

3.1 Storage Cost and Break-even Price

The break-even price for each strategy that involves storage is identical. The break-even price is the price required at the end of the storage period to cover the harvest price plus storage cost. Hence, break-even price is equal to the harvest price plus storage cost. This study will assume that storage facilities are on farm and the fixed or overhead cost will not be considered. The variable costs considered are composed of cost associated with physically storing the grain, interest cost of stored grain, and physical weight loss know as shrink during unloading, storage, and load-out.

The first step in calculating storage cost is to decide how many months the grain will be stored. Harvest is assumed to be September 15 for each crop year. Crop years for corn are from the first of September to the end of August. This study will analyze a storage period of six months. Previous analysis by Kenyon and Hoover shows that cash prices in February, March, and April are not significantly different. Also, Virginia is a corn deficit state and storage beyond six months is uncommon. Therefore, grain is stored from September 15 until the second week in March. The selling date is assumed to be March 15[1].

The next step in estimating the break-even price is to estimate storage cost. The first item to consider are the costs associated with physically storing the grain. These costs include physical cost such as labor, electricity, natural gas, etc. On farm storage cost will vary from among different grain producers and it is important for each grain producer to have an accurate estimate of storage cost. A 1986 study of grain stored in the Texas Rio Grande Valley by Jones indicates the average on farm storage cost to be 2 cents per bushel per month when storage facilities were utilized at full capacity. The present study will assume on farm storage cost to be 2 cents per bushel per month when analyzing the six marketing strategies (Jones). As in the 1986 study by Kenyon, the assumption grain is already in storage condition will be made. The cost of drying the grain will not be incorporated into the total cost of storage.

Another variable cost of storing grain is interest cost. Interest cost represents the amount of money a producer would lose in interest if the money from selling the grain at harvest was placed in an interest bearing account and allowed to accrue over the duration of the storage period. The interest rate used to calculate the interest cost is the prime rate on the day corn is stored. This rate can be easily found in the Wall Street Journal and it

[1] It is important to note that weekly cash data for the Northern Neck of Virginia is used and the date closest to the 15 of September and March will be chosen accordingly.

represents the base rate on corporate loans posted by at least 75 percent of the nation's 30 largest banks. A producer may use the prime rate or an interest rate offered by a local bank or lending institution.

The third cost in estimating the cost of storing grain is shrink. Shrink represents the value lost by physically handling the grain. Some grain is lost or destroyed in the storage process due to handling and transportation. This loss will be calculated by multiplying the harvest price by one half of a percent.

3.2 Marketing Strategies

Strategy One: Store without Forward Pricing.

The first strategy involves storing grain without forward pricing. Under this strategy a producer deals only in the cash market. A producer could choose to store corn in the fall when the expected cash price in the upcoming spring is greater than the current cash price plus storage cost. In other words, when the expected change in cash price from harvest until spring is positive and greater than expected storage cost, then a producer could store corn and expect to make money. Historical changes in the Northern Neck of Virginia cash prices from September to March have not increased enough to cover storage cost 60 percent of the time in the last 20 years. To improve the probability of making money by storing and not forward pricing, a model will be developed to forecast changes in cash prices from harvest until spring. The regression model developed will attempt to explain the changes in cash prices from year to year.

A producer can determine if storing corn without forward pricing is profitable by comparing the estimated change in cash price to estimated storage cost. A producer would consider this strategy when expected changes in cash prices are greater than storage cost. It is unrealistic to assume the expected change in cash price will always equal the actual change. A producer will need to consider the root mean square error, RMSE. RMSE is what Peck calls the crucial variance which surrounds the accuracy of a producer's forecast. RMSE is essentially the standard deviation of the differences between the actual and estimated observations. The regression model used to explain changes in cash prices is described in detail in section 3.3.

Strategy Two: Store and Cash Contract.

Placing stored corn under a cash contract with a local grain elevator is the second marketing strategy to consider. A producer could make money when the cash contract price is greater than the current cash price plus expected storage cost. This strategy is relatively simple to implement and the risk associated with volatile prices is transferred to the owner of the grain elevator. The only risk taken on by the producer is in estimating storage costs.

Historical cash contract prices are not easily found. Cash contract prices will be estimated by adding a three year average March basis relative to March futures to the March futures price on September 15. This method is used by most grain elevators in the Northern Neck of Virginia[2] . A cash contract price is guaranteed, so there is no variability around the contract price that needs to be considered. Essentially, the grain elevator is assuming the risk associated with basis error which is the difference between actual and estimated basis. A producer will consider strategy two when the returns to storage are positive and when no other strategy offers a larger positive return to storage.

[2] Based on personal conversations with two grain buyers in Eastern Virginia.

Strategy Three: Store and Forward Price with Futures.

The third strategy involves hedging with futures. When corn is harvested in September and placed in storage, a producer can hedge the corn and lock in a price by selling a corn futures contract. Since corn is being stored until March in this study, a producer would sell a March futures contract in September and buy the futures contract back in March when the corn is sold on the cash market. If the change from beginning basis to ending basis is greater than storage cost, then the producer would make money if corn was stored and hedged with futures. Basis is defined as cash price minus futures price.

At the time of harvest the change in basis is not known and a reliable estimate of the change in basis must be developed to calculate the expected returns to storage for strategy three. The change in the basis over time can be estimated because the cash and futures prices must be nearly equal in the delivery month at the delivery point. In other words, the cash and futures prices converge as the delivery month approaches (Cramer and Heid 1983). The regression model that estimates the change in basis for the March futures contract will be explained in section 3.3.

With an estimate of the change in basis, a producer can compare change in basis to storage cost. If the difference between beginning basis and ending basis is larger than storage cost then a producer could store corn and hedge with futures and expect to make money. Once again, a producer will need to consider the RMSE of the forecasted profits.

Strategy Four: Store and Forward Price with Options.

Store corn and forward price using put options is the fourth strategy. Strategy four involves buying a put option at the strike price closest to the May futures trading at harvest. A producer will make money when the actual net price (ANP) is greater than the break-even price. In other words, a producer makes money when the cash price on March 15 plus the returns in the options market, ANP, are greater than the sum of the harvest price and storage cost. This strategy will require an estimate of ending basis to calculate the estimated net price. The estimated net price (ENP) is equal to the strike price plus the estimated ending basis minus the option's premium. Since the producer pays a premium whether or not the option is exercised, this strategy will usually have a lower expected return than the third strategy depending on the premium amount and whether the option purchased is in-the-money or out-of-the-money. As opposed to futures, options provide the opportunity to take advantage of upside price movement in the cash market. Therefore, this strategy might be most beneficial when expected changes in cash prices are high relative to past increases in cash prices.

A producer storing corn from September 15 to March 15 would use a May put option because March options expire mid-February. May options expire in mid-April. To calculate ENP, a producer needs an estimate of ending basis for May futures on March 15. Ending basis will be estimated by developing a regression model that forecast the change in basis from September to March. The beginning basis will be added to the change in basis to come up with an estimated ending basis. When the ENP is greater than break-even price, then a producer could store corn and hedge with options and expect to make money.

To calculate the historical profits for strategy four, an estimate of option premiums will need to be calculated for the 1974 to 1984 period when corn options were not trading. The 1976 Fischer Black option pricing formula will be used to simulate option premiums for the time period when option contracts for corn were not trading. The Fischer Black model is explained in section 3.3.

Fifth Strategy: Store and Buy Put and Write Call Options.

The fifth strategy involves buying a put option with a strike price closest to the May futures price trading on September 15 and writing (selling) a call option to "cheapen" the cost of the put option. The strike price of the call option will be ten cents above the strike of the put option. This is commonly referred to as a fence strategy. This strategy lowers the initial cost, protects against downside price movement, and only restricts upside price movement beyond the call strike price.

Choosing the level of the strike price for the call option is a trade-off between cheapening the cost of the put option and margin calls. A producer will receive margin calls if the call option goes in-the-money. The premium of a call option decreases as the strike price increases. If a producer chooses a higher strike price for the call option the benefit of cheapening the put option is lost. On the other hand, when a higher strike price is chosen, the chances of receiving margin calls decrease. May futures have decreased an average of 11 cents from September to March from 1974 to 1994. May futures increased more than ten cents only three times from September to March from 1974 to 1994. According to historical May futures, the best strike price for the call option that cheapens the cost of the put and avoids margin calls most effectively is ten cents.

A producer will consider this strategy when the expected net price is greater than the break-even price. The expected net price for strategy five is the strike from the put option plus expected ending basis plus the call option's premium minus the put option's premium. The ending basis calculated in strategy four will be used as the estimated ending basis for strategy five.

Sixth Strategy: Sell at Harvest and Buy a Call Option.

The sixth strategy involves selling corn at harvest and buying a call option with the strike price closest to the May futures price trading at harvest. The storage cost can be ignored under this strategy. The intuition behind this strategy is if a producer expects prices to increase from September to March, there is no reason to incur storage cost and the benefits from price increases can be achieved from purchasing a call option. The call option gives the producer the right to buy a futures contract at a predetermined strike price. As the price of the futures contract increase from September to March, the value of the call option increases. The producer will make money if the increase in futures price relative to the strike price is greater than the option's premium.

A producer should implement strategy six when May futures are thought to be too low at harvest. A producer can sell corn at harvest and buy a call option when the cash price on September 15 plus the expected change in cash is greater than May futures on September 15. Essentially this strategy is making an attempt to out guess the futures market. According to the efficient market hypothesis, the May futures contract should be a good indication of the price of corn in the Spring. If the May futures price on September 15 is expected to be an accurate estimate of the price of corn in the spring, then the expected value of the call option is zero. Hence, the estimated profits for strategy six when it's implemented would be the lost premium.

3.3 Regression Models and Option Pricing Formula

Section 3.3 will explain the regression models needed to calculate estimated profits for the six marketing strategies. Since these models will be used by producers with limited access to market variables, it will be important to develop sound statistical models as well as models that contain variables easily obtained by producers. The first regression model will explain changes in cash prices. The next two regression models will explain the changes in basis for the March and May futures contract. Section 3.3 will conclude with a brief explanation of the Fischer Black option pricing equation to be used in estimating option premiums when option contracts were not trading.

Equation 1: Change in Cash Price

The change in cash price can be modeled as a function of market variables. The following model will be used to estimate the change in cash prices in the Northern Neck of Virginia from September 15 to March 15.

$$\Delta C = f\left\{\frac{HP}{MAP}, \frac{HP}{LR}, \frac{VAP}{USP}, ES\%\right\} \qquad (1)$$

ΔC is the change in the Northern Neck of Virginia cash price from September 15 to March 15. *HP* is the cash price in the Northern Neck of Virginia on September 15. *MAP* is the average March 15 cash price over the last twenty years in the Northern Neck of Virginia. *LR* is the United States government loan rate for the current crop year. *VAP* is the September estimate of Virginia production for the current crop year and *USP* is the September estimate of United States production for the current crop year. *ES%* is the September estimate of United States ending stocks divided by the expected total use during the crop year. The data used to estimate equation 1 can be found in appendix A.

The anticipated effect that each independent variable has on the dependent variable, ΔC, follows the logic established by Working's 1949 article reviewed in chapter two. Working states that when the return to storage is determined freely and competitively, it will vary according to demand and supply conditions.

The coefficient of the first ratio, *HP/MAP*, is expected to be negative. When the harvest price is relatively high (low) compared to the March average price, the ratio will be relatively high (low) and expected changes in cash price from harvest to spring will be relatively low (high). When harvest prices are relatively high (low), this is a price signal that the crop just harvested is small (large) and the demand for storage space is relatively low (high). When the demand for storage space is low due to a small crop, the change in cash prices from harvest to spring will tend to be low as well. When the demand for storage space is high due to a large crop, the change in cash prices from harvest to spring will tend to be large.

The coefficient of the second ratio is expected to be negative. When the harvest price is relatively high (low) compared to the loan rate, the ratio will be relatively high (low) and expected changes in cash price from harvest to spring will be relatively low (high). Again, the relatively high (low) harvest price indicates low (high) demand for storage and the changes in cash prices from harvest to spring will tend to be low (high) as well. When the ratio is low, the change in cash cannot be very negative, because the loan rate puts a floor under cash price. When cash is relatively high at harvest relative to the loan rate, the cash price can decline substantially from harvest to spring.

The coefficient for the third ratio is expected to be negative. When Virginia production is large (small) relative to the United States production, the supplies in Virginia are large (small) at harvest which depresses (inflates) harvest prices and causes higher (lower) changes in cash prices from harvest to spring. The high (low) demand for storage space when production is large (small) in Virginia will cause the change in cash prices to be relatively higher (lower) then when the demand for storage is low.

The coefficient associated with the *ES%* variable is expected to be negative. When ending stocks are large (small) relative to use, then the supply levels are high (low) and relatively greater (lower) changes in cash prices can be expected. Once again, the high (low) supply levels indicate that demand for storage space will be high (low) and changes in cash prices will tend to be relatively high (low).

Equation 2: Change in Basis for March futures

The change in basis can be modeled as a function of market variables. The following model will be used to explain the change in basis from September to March for the March futures contract.

$$\Delta Basis_{March} = \left\{ BB_{March}, \frac{VAP}{USP}, \frac{HP}{MAP} \right\} \qquad (2)$$

where $\Delta Basis_{March}$ represents the difference between beginning basis on September 15 and ending basis on March 15 for the March futures contract. The beginning basis, *BB*, is equal to cash price on September 15 in the Northern Neck of Virginia minus the September 15 March futures price. The ending basis is equal to the cash price on March 15 in the Northern Neck of Virginia minus the March 15 March futures price. *VAP* is the September estimate of Virginia production for the current crop year and *USP* is the September estimate of United States production for the current crop year. *HP* is the cash harvest price in Northern Neck of Virginia on September 15. *MAP* is the average March 15 cash price over the last twenty years in the Northern Neck of Virginia. The data used to estimate equation 2 can be found in appendix A.

The expected sign associated with BB is negative. Historically beginning basis has been as high as positive 9 cents and as low as negative 53 cents. When beginning basis is narrow or close to zero, supplies are relatively low at harvest and the change in basis can be expected to be relatively small. A relatively wide beginning basis, between negative 20 and negative 60, indicates that supplies are relatively high at harvest and the change in basis can be expected to be large.

The expected sign associated with the VAP/USP ratio is negative. When Virginia supplies are low relative to United States supplies, the ratio will be relatively lower and the change in basis for the Northern Neck of Virginia will be relatively large. When the ratio becomes relatively higher as Virginia supplies are large relative to the United States supplies, then the ending basis for the Northern Neck of Virginia will weaken or the change in basis will be relatively small.

The expected sign associated with the HP/MAP ratio is negative. When the harvest price is low (high) relative to the historical March average price, the ratio will be relatively lower (higher) and the change in basis for the Northern Neck of Virginia will be relatively large (small). When the ratio is high, this is a price signal that the crop just harvested is small and the demand for storage space is relatively low. Since the demand for storage space is low due to a small crop, the changes in cash prices from harvest to spring will tend to be low as well.

Equation 3: Change in Basis for May futures

The only difference between equation two and equation three is the change in basis and the beginning basis. The change in basis in equation three represents the difference between ending basis on March 15 and beginning basis on September 15 for the May futures contract. The VAP/USP and HP/MAP ratios are the same and follow the same explanation as they did for equation two. The data used to estimate equation three can be found in appendix A.

$$\Delta Basis_{May} = \left\{ BB_{May}, \frac{VAP}{USP}, \frac{HP}{MAP} \right\} \qquad (3)$$

1976 Fischer Black Option Pricing Formula

The 1976 Fischer Black option pricing formula is used to calculate the option premiums during the 1974-1985 time period when option contracts for corn did not exist. The option premium is calculated by inserting the current futures price, desired strike price, days to maturity, interest rate, and historical futures price volatility into the option pricing formula. The historical price volatility is calculated by following the procedures outlined by Kenyon (1987). A 21 day period is used to calculate the historical price volatility. Bobin indicates that it is best to have at least a 15 to 20 day sample when calculating the historical price volatility for the results to be statistically useful..An explanation of the formula and the data used to calculated the option premiums will be discussed in chapter 4.

3.4 Strategy Comparison

When the historical profits of the six marketing strategies are calculated, a comparison of the six strategies can be made to determine which strategies offer the best opportunities to make money. First the strategies will be compared based on their ability to capture profits and avoid losses. For example, when expected profits are positive and the producer decides to implement the strategy the producer expects to make money or capture profits. When expected profits are negative and the producer decides not to implement the strategy, the producer expects to avoid losses by selling at harvest and not storing. A strategy has failed when the producer expects to make money and loses money or when the producer does not implement the strategy and could have made money from implementing the strategy. This comparison is basically analyzing the difference between estimated profits and the actual profits.

Second, the strategies will be ranked according to their means and variances of historical profits via stochastic dominance and EV analysis. The Generalized Stochastic Dominance Program (GSD 2.1) will be used to rank the strategies according to second degree stochastic dominance. GSD 2.1 was developed by Cochran and Raskin in 1988. The EV analysis will be performed by constructing an EV frontier. Producers will then be able to choose the strategy that exhibits the expected means and variances that best fit their own personal preferences.

Chapter 4

Empirical Estimation

The results of the three regression models and the Fischer Black option pricing formula are presented in chapter four. The three regression models include the change in cash price, change in basis from September to March for March futures, and change in basis from September to March for May futures. The Fischer Black option pricing formula is used to estimate option premiums from 1974 to 1994. Options began trading in 1985, so a comparison between estimated and actual premiums can be made for the 1985 to 1994 time period.

4.1 Change in Cash Price

Figure 4.1 shows the change in Northern Neck Virginia cash price from September to March from 1974 to 1994. The average change in cash prices is 14 cents with a standard deviation of 34 cents. The largest change occurred in the 1982-83 crop year and the smallest change occurred in the 1974-75 crop year. There is a very slight upward trend in the change in cash prices, but if the 1974-75 observation were omitted the data would not appear to have any trends.

The data used to estimate the change in cash equation can be found in appendix A. The change in cash equation described in chapter 3 explains 72 percent of the variation of the change in cash prices from 1974 to 1994. All coefficients have the expected signs and

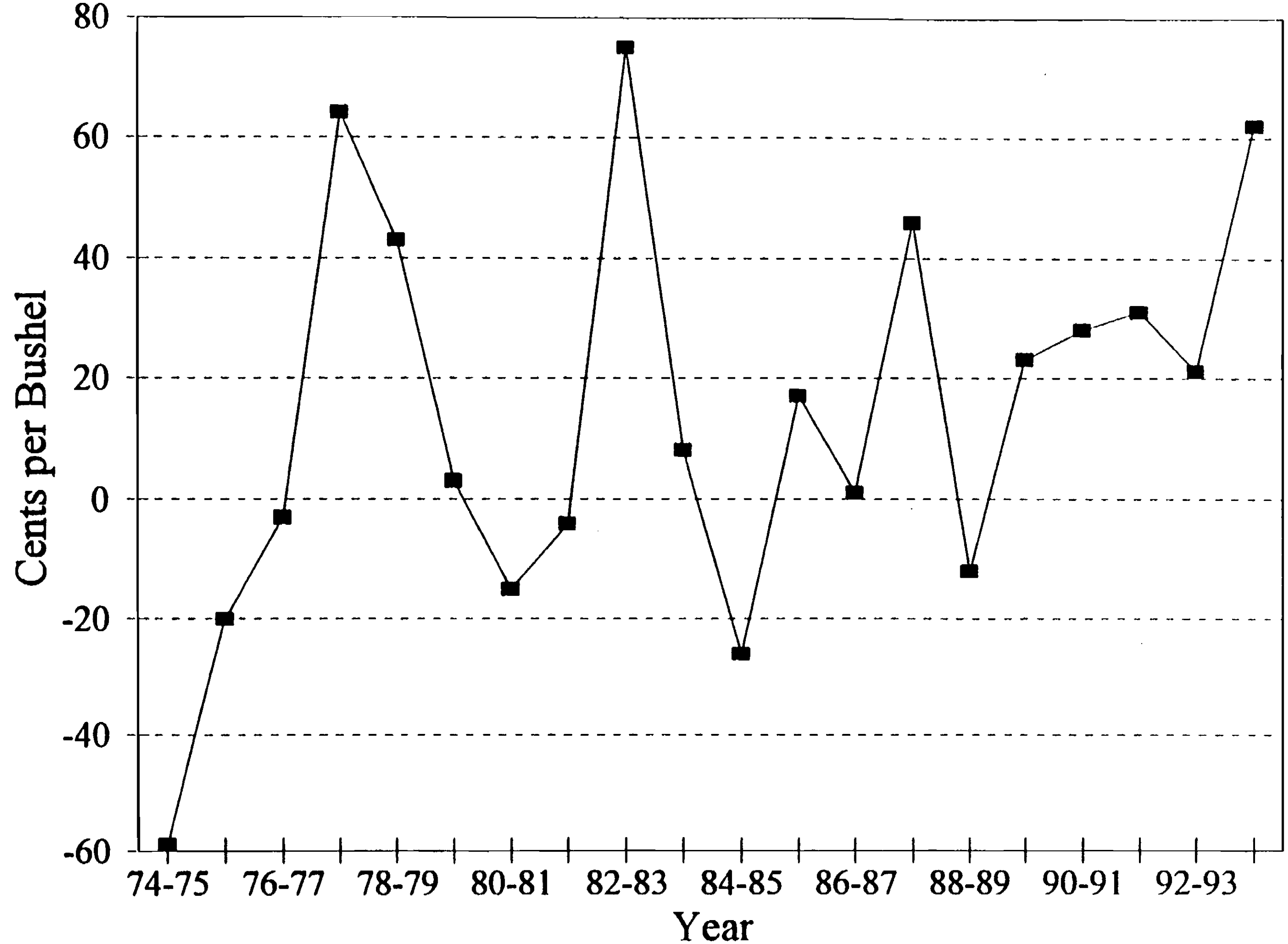


Figure 4.1 Change in Cash Price

are statistically significant at the 0.05 level of significance except for the coefficient associated with the ratio of Virginia production divided by United States production. The VAP/USP coefficient has the expected sign and becomes statistically significant at the 0.09 level of significance. Normally a variable not significant at the 0.05 level of significance is dropped from the equation. However, if the VAP/USP ratio is dropped from the equation, the R-squared drops to .65 and the SER increases from 20.23 to 21.59. Even though the VAP/USP ratio is not significant at the 0.05 level of significance, the variable's ability to explain changes in cash prices is lost when the variable is dropped from the equation. Schwager states that any theoretically meaningful variable with a t-ratio with an absolute value greater than one should usually be retained, even though many analysts prefer to use a cut off level of two. The t-ratio for VAP/USP is -1.79. Hence, VAP/USP will not be dropped from the equation because of its value in explaining changes in cash prices.

Table 4.1 reports the regression summary statistics of the change in cash model. Model one represents the equation explained in chapter three. Model two represents the equation after omitting VAP/USP.

Table 4.1 Summary Statistics for Change in Cash Model.

Statistic	Model 1	Model 2		
R-Square	.72	.65		
Standard Error	20.23	21.59		
Durbin Watson	2.41	2.27		
Model 1 Variables		Coefficients	t-ratio	P-value
Intercept		203.54	5.18	0.00011
HP/MAP		-104.06	-3.23	0.00557
HP/LR		-27.23	-2.44	0.02749
VAP/USP		-5280.14	-1.79	0.09310
ES%		-100.70	-2.55	0.02219
Model 2 Variables				
Intercept		178.29	4.55	0.00033
HP/MAP		-105.82	-3.08	0.00712
HP/LR		-31.38	-2.70	0.01590
ES%		-85.51	-2.08	0.05417

Table 4.2 reports the observed change in cash, the predicted change in cash, the residuals, and the standardized residuals. The residuals from the change in cash equation are tested to assure the underlying assumptions of normality and independence are not violated. Since the standardized residuals fall primarily in the range between +2 and -2, the normality assumption seems to hold. The skewness coefficient of the residuals is 0.855 and the kurtosis coefficient is 4.188. The normality assumption is formally tested following the procedures outlined by Spanos. The calculated statistic, 3.37, is less than Chi_{crit}, 5.99, at the 0.05 level of significance. Hence, the normality assumption cannot be rejected and the residuals are considered normally distributed.

The second assumption to test is independence. The Durbin Watson statistic is used as a measure of autocorrelation. The DW statistic indicates no positive autocorrelation exist and the test for negative autocorrelation is inconclusive at the 0.05 level of significance. A detailed account of the test for normality and independence can be found in appendix A.

Table 4.2 Regression Predictions for Change in Cash Model.

Crop Year	Observed	Predicted	Residuals	Standardized Residuals
74-75	-59	-57.64	-1.36	-0.07
75-76	-20	-32.71	12.71	0.63
76-77	-3	8.42	-11.42	-0.56
77-78	64	59.61	4.39	0.22
78-79	43	37.02	5.98	0.30
79-80	3	11.99	-8.99	-0.44
80-81	-15	-15.31	0.31	0.02
81-82	-4	16.99	-20.99	-1.04
82-83	75	23.93	51.07	2.52
83-84	8	-11.13	19.13	0.95
84-85	-26	-1.00	-25.00	-1.24
85-86	17	19.62	-2.62	-0.13
86-87	1	24.55	-23.55	-1.16
87-88	46	34.97	11.03	0.55
88-89	-12	-9.94	-2.06	-0.10
89-90	23	24.19	-1.19	-0.06
90-91	28	29.39	-1.39	-0.07
91-92	31	31.74	-0.74	-0.03
92-93	21	45.60	-24.60	-1.22
93-94	62	42.72	19.28	0.95

The distribution of the residuals in Table 4.2 are critical to analyzing strategies one and six. It has already been established that the residuals are independently and normally distributed. Now, the range of the distribution will be discussed. On average the change in cash equation miscalculated the change in cash by 12 cents. Large errors occurred from 1980 to 1987. Table 4.3 reports the distribution of the residuals for the change in cash model. Forty percent of the estimates fall within five cents of the actual change in cash, while twenty-five percent of the errors are greater than 21 cents.

The change in cash model uses September estimates of production, stocks, and use. Unexpected changes in estimates of production, stocks, and use can cause the change in cash model to be inaccurate. A producer needs to follow the changes in supply and demand to ensure prices will continue to move in the direction originally estimated by the change in cash model.

Table 4.3 Distribution of Errors for Change in Cash Model.

Error	Number of Observations	Percentage
0-5¢	8	40
6-10¢	2	10
11-15¢	3	15
16-20¢	2	10
21-25¢	4	20
>25¢	1	5

4.2 Change in Basis

Figure 4.2 indicates the change in basis from September to March for March futures. The change in basis is calculated by subtracting beginning basis from the ending basis. The average change in basis over the last twenty years is 25 cents with a standard deviation of 14 cents. The highest change occurred in the 1981-82 crop year with a change of more than 50 cents, and the lowest change occurred in 1984-85 with a change of minus seven cents.

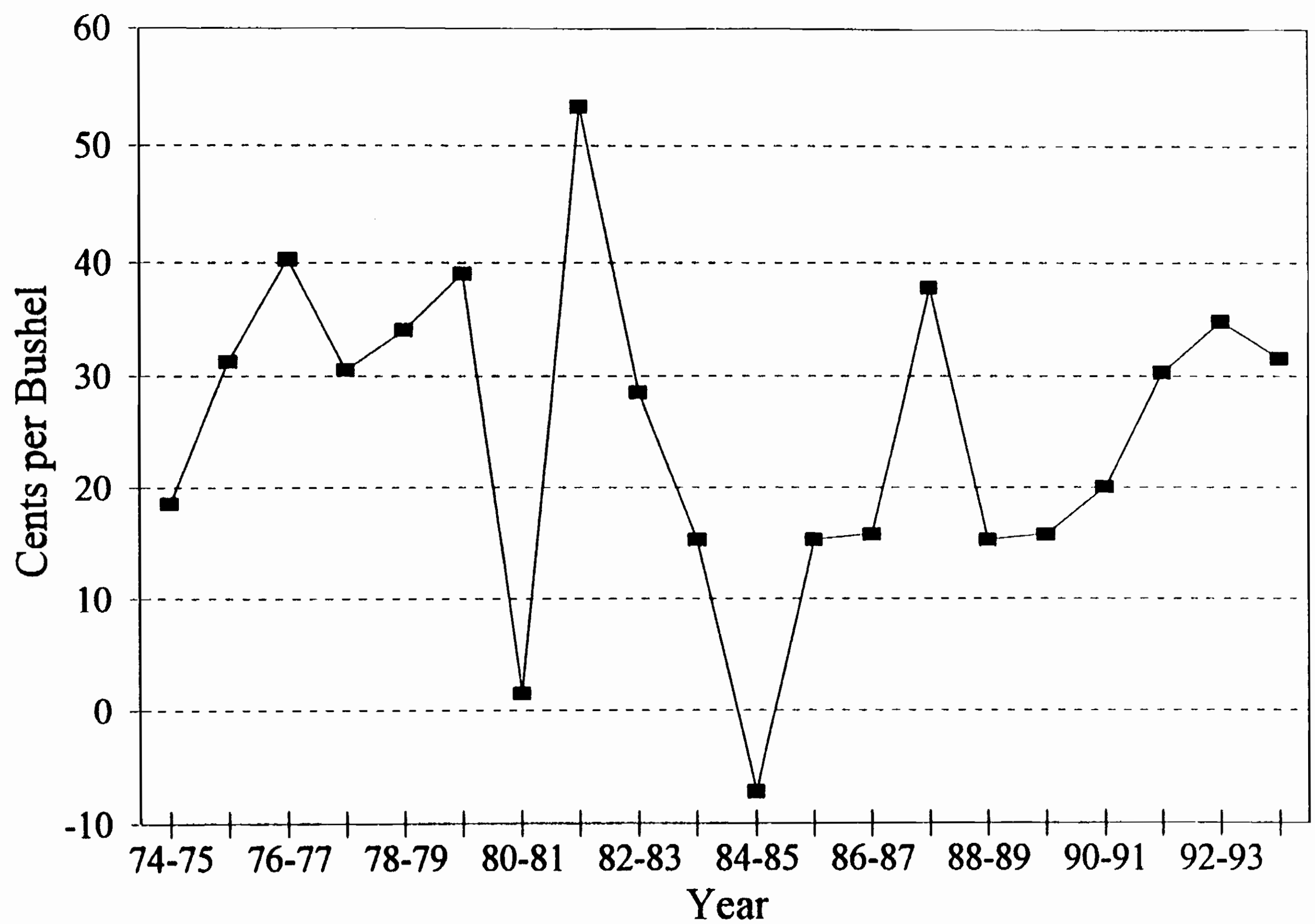


Figure 4.2 Change in Basis for March Futures.

The data used to estimate the change in basis equation for March futures can be found in appendix A. The change in basis equation for March futures from September to March explains 71 percent of the variation in Figure 4.2. All coefficients have the correct sign. The coefficient associated with the beginning basis variable is highly significant at the 0.05 level of significance. The coefficient associated with the VAP/USP ratio is significant at the 0.09 level of significance and the coefficient associated with the HP/MAP ratio is not significant until the 0.36 level of significance. After dropping the HP/MAP ratio from the equation, the R-square drops to .70 and the SER drops from 8.32 to 8.28. The coefficient associated with the VAP/USP is now significant at the 0.05 level of significance after the HP/MAP variable is dropped. Hence, the equation used to explain the change in basis for March futures will drop the HP/MAP ratio and will be a function of beginning basis and VAP/USP.

Table 4.4 reports the summary statistics for the change in basis equation for March futures. Model one represents the equation explained in chapter three and Model two represents the same equation after dropping the HP/MAP ratio. HP/MAP is dropped because the absolute value of the t-ratio is less than one.

Table 4.4 Summary Statistics for Change in Basis Equation for March Corn futures.

Statistic	Model 1	Model 2		
R-Square	.71	.70		
Standard Error	8.32	8.28		
Durbin Watson	2.85	2.80		
Model 1 Variables		Coefficients	t-ratio	P-value
Intercept		32.13	3.40	0.00369
Beginning Basis		-0.74	-5.28	0.00007
VAP/USP		-2488.81	-1.81	0.08861
HP/MAP		-9.83	-0.93	0.36427
Model 2 Variables		Coefficients	t-ratio	P-value
Intercept		25.36	4.19	0.00061
Beginning Basis		-0.80	-6.23	0.00001
VAP/USP		-3158.10	-2.71	0.01493

Model 2 will be used to estimate the changes in basis for March futures. Table 4.5 reports the observed change in basis, the predicted change in basis, the residuals, and the standardized residuals. The residuals from the change in basis equation for March futures are tested to assure the underlying assumptions of normality and independence are not violated. Since the standardized residuals fall primarily in the range between +2 and -2, the normality assumption seems to hold. The skewness coefficient of the residuals is -1.22 and the kurtosis coefficient is 3.65. The skewness coefficient is not very close to zero due to a couple of large errors in 1980-81 and 1986-87 which cause the distribution of the residuals to be skewed to the left. The normality assumption is formally tested following the procedures outlined by Spanos. The calculated statistic, 5.35, is less than Chi_{crit}, 5.99, at the 0.05 level of significance. Hence, the normality assumption cannot be rejected and the residuals are considered normally distributed. The DW statistic is used to test for independence. The DW statistic indicates that no positive autocorrelation exist and the test for negative autocorrelation is inconclusive. Hence, the residuals from the regression predictions for the change in basis for March futures are independently and normally distributed. A detailed account of the test for normality and independence can be found in appendix A.

Table 4.5 Regression Predictions for Change in Basis for March Corn futures.

Crop Year	Observed	Predicted	Residuals	Standardized Residuals
74-75	18.50	29.79	-11.29	-1.36
75-76	31.25	27.95	3.30	0.40
76-77	40.25	35.98	4.27	0.52
77-78	30.50	38.03	-7.53	-0.91
78-79	34.00	28.05	5.96	0.71
79-80	39.00	28.40	10.60	1.28
80-81	1.50	22.30	-20.80	-2.51
81-82	53.25	48.12	5.13	0.62
82-83	28.50	29.56	-1.06	-0.13
83-84	15.25	11.47	3.79	0.46
84-85	-7.25	-5.21	-2.04	-0.25
85-86	15.25	9.16	6.09	0.74
86-87	15.75	29.54	-13.79	-1.67
87-88	37.75	32.78	4.97	0.60
88-89	15.25	18.64	-3.39	-0.41
89-90	15.75	11.58	4.17	0.50
90-91	20.00	18.00	2.00	0.24
91-92	30.25	29.39	0.86	0.10
92-93	34.75	31.56	3.19	0.39
93-94	31.50	25.91	5.59	0.68

The distribution of the residuals in Table 4.5 are critical to analyzing strategy three. It has already been established that the residuals are independently and normally distributed. Now, the range of the distribution will be discussed. On average the change in basis model miscalculated the change in basis by six cents. Large errors occurred in 1979-80, 1980-81 and 1986-87. Table 4.6 reports the distribution of the residuals for the change in basis model. Fifty percent of the estimates fall within four cents of the actual change in basis, while twenty percent of the errors are greater than 10 cents.

Table 4.6 Distribution of Errors for Change in Basis for March futures.

Error	Number of Observations	Percentage
0-2¢	4	20
3-4¢	6	30
5-6¢	5	25
7-8¢	1	5
9-10¢	0	0
>10¢	4	20

Figure 4.3 indicates the change in basis from September to March for May futures. The pattern is almost identical to Figure 4.2. The average change in basis for May futures is 25 cents and the standard deviation is 14 cents. The high change of 52 cents occurred in 1981-82 and the low of minus 5 cents occurred in 1984-85. The equation used to explain the change in basis for May futures from September to March was described in chapter three. Given that Figure 4.2 and Figure 4.3 are similar, the equation used to explain the change in basis for the May futures contract should be similar to the equation used to explain the change in basis for March futures. Hence, the equation used to explain the change in basis for May futures from September to March is a function of beginning basis and VAP/USP.

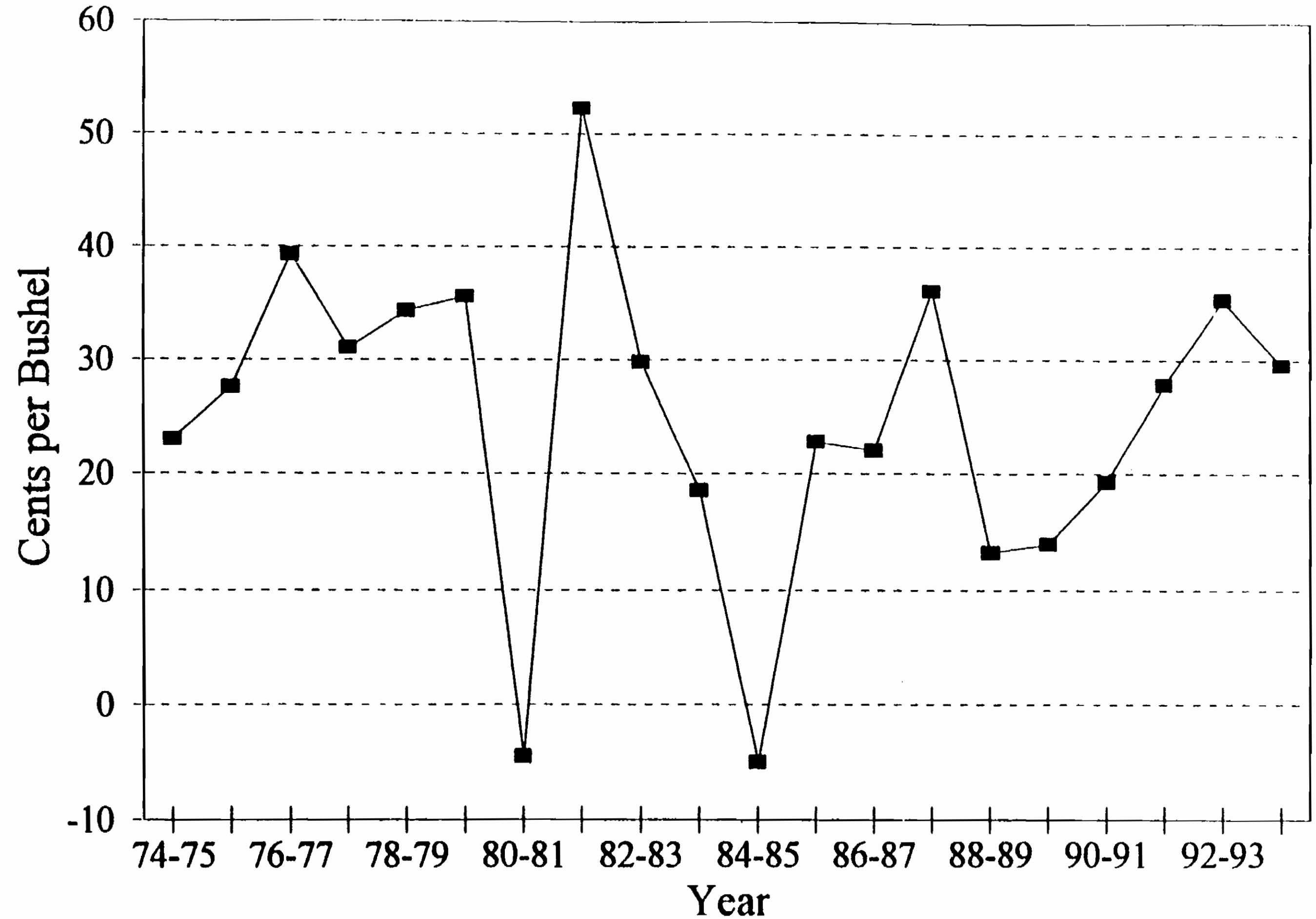


Figure 4.3 Change in Basis for May Futures.

The data used to estimate the change in basis equation for May futures can be found in appendix A. The equation explains 67 percent of the variation in Figure 4.3. All coefficients have the expected sign and the p-values clearly indicate that the independents variables are significant at the 0.05 level of significance. Table 4.7 reports the summary statistics of the regression equation used to explain the change in basis from September to March for May futures.

Table 4.7 Summary Statistics for Change in Basis Equation for May Corn futures.

Statistic				
R-Square	.67			
Standard Error	8.32			
Durbin Watson	2.74			
Variables		Coefficients	t-ratio	P-value
Intercept		21.57	3.55	0.00248
Beginning Basis		-0.71	-5.89	0.00002
VAP/USP		-2836.72	-2.45	0.02532

The residuals from the change in basis equation for May futures are tested to assure the underlying assumptions of normality and independence are not violated. Table 4.8 reports the observed change in basis, the predicted change in basis, the residuals, and the standardized residuals. Since the standardized residuals fall primarily in the range between +2 and -2, the normality assumption seems to hold. The skewness coefficient of the residuals is -1.69 and the kurtosis coefficient is 6.67. The skewness and kurtosis coefficients indicate that the distribution of the residuals has fat tails and is skewed to the left. The normality assumption is formally tested following the procedures outlined by Spanos. The calculated statistic, 20.70, is greater than Chi_{crit}, 5.99, at the 0.05 level of significance. Hence, the normality assumption is rejected and the residuals are not considered normally distributed. The DW statistic indicates that independence is not a problem and that no positive autocorrelation exist and the test for negative autocorrelation is inconclusive. A detailed account of the test for normality and independence can be found in appendix A.

Table 4.8 Regression Predictions for Change in Basis for May Corn futures.

Crop Year	Observed	Predicted	Residuals	Standardized Residuals
74-75	23.00	28.82	-5.82	-0.70
75-76	27.50	25.40	2.10	0.25
76-77	39.25	33.81	5.44	0.65
77-78	31.00	36.05	-5.05	-0.61
78-79	34.25	27.81	6.44	0.77
79-80	35.50	29.20	6.30	0.76
80-81	-4.50	21.48	-25.98	-3.12
81-82	52.25	49.46	2.79	0.33
82-83	29.75	32.37	-2.62	-0.31
83-84	18.50	11.50	7.00	0.84
84-85	-5.00	-2.73	-2.27	-0.27
85-86	22.75	11.18	11.57	1.39
86-87	22.00	29.94	-7.94	-0.95
87-88	36.00	31.76	4.24	0.51
88-89	13.25	17.15	-3.90	-0.47
89-90	14.00	13.01	0.99	0.12
90-91	19.25	19.63	-0.38	-0.05
91-92	27.75	28.21	-0.46	-0.06
92-93	35.25	31.55	3.70	0.44
93-94	29.50	25.66	3.85	0.46

The distribution of the residuals in Table 4.8 are critical to analyzing strategies four and five. It has already been established that the residuals are not normally distributed. Now, the range of the distribution will be discussed. On average the change in basis model miscalculated the change in basis by five cents. A large error occurred in 1980-81 which is the main reason why the residuals are not normally distributed. Table 4.9 reports the distribution of the residuals for the change in basis model. Fifty-five percent of the estimates fall within four cents of the actual change in basis, while 10 percent of the errors are greater than 10 cents.

Table 4.9 Distribution of Errors for Change in Basis for May Corn futures.

Error	Number of Observations	Percentage
0-2¢	5	25
3-4¢	6	30
5-6¢	5	25
7-8¢	2	10
9-10¢	0	0
>10¢	2	10

4.3 Out of Sample Test

A series of out of sample tests were performed to ensure the usefulness of the regression models in forecasting the change in cash price and basis. Fifteen observations were used in the model, 1974-75 to 1988-89, to estimate changes for the 1989-90 crop year. The most recent observation was added to the model each time a new crop year was analyzed. Table 4.10 reports the results of testing the models. The summary statistics of the test models and the data used to estimate the models can be found in appendix A.

Table 4.10 Out of Sample Test for the Three Regression Models.

Year	Change in Cash Model	Estimate
89-90	ΔC = 204.4 - 108.9 HP/MAP - 27.8 HP/LR - 4554.6 VAP/USP - 99.9 ES%	23.76
90-91	ΔC = 203.1 - 108.2 HP/MAP - 27.9 HP/LR - 4445.7 VAP/USP - 99.0 ES%	28.28
91-92	ΔC = 202.7 - 108.1 HP/MAP - 27.9 HP/LR - 4410.7 VAP/USP - 98.7 ES%	29.86
92-93	ΔC = 204.0 - 108.9 HP/MAP - 27.8 HP/LR - 4525.5 VAP/USP - 99.7 ES%	45.48
93-94	ΔC = 183.2 - 97.9 HP/MAP - 28.6 HP/LR - 3231.4 VAP/USP - 85.2 ES%	33.12
	Change in Basis for March Futures	
89-90	$\Delta Basis$= 17.3 - 0.81 BegBas - 2094.7 VAP/USP	8.29
90-91	$\Delta Basis$= 19.4 - 0.78 BegBas - 2251.1 VAP/USP	15.60
91-92	$\Delta Basis$= 20.7 - 0.79 BegBas - 2393.2 VAP/USP	27.33
92-93	$\Delta Basis$= 21.7 - 0.78 BegBas - 2569.1 VAP/USP	29.87
93-94	$\Delta Basis$= 23.0 - 0.79 BegBas - 2782.2 VAP/USP	24.30
	Change in Basis for May Futures	
89-90	$\Delta Basis$= 17.4 - 0.71 BegBas - 2204.1 VAP/USP	11.56
90-91	$\Delta Basis$= 18.1 - 0.70 BegBas - 2261.9 VAP/USP	18.23
91-92	$\Delta Basis$= 18.4 - 0.70 BegBas - 2295.7 VAP/USP	26.64
92-93	$\Delta Basis$= 18.8 - 0.70 BegBas - 2359.6 VAP/USP	30.30
93-94	$\Delta Basis$= 20.0 - 0.71 BegBas - 2580.8 VAP/USP	24.54

Table 4.11 compares the in- and out-of-sample estimates to the actual changes in cash price and basis. Both the change in cash models and change in basis models use September estimates of corn production in the U.S. and Virginia. The change in the September production estimate from harvest to spring is one source of error between actual and estimated changes in cash and basis. The out-of-sample estimates for change in cash are relatively similar to the in-sample estimates except for the 1993-94 crop year. The small production estimate in 1993 is accounted for in the in-sample model but not in the out-of-sample model. Hence the out-of-sample model underestimated the change in cash price more severely than the in-sample model for the 1993-94 crop year.

The in-sample and out-of-sample estimates for change in basis for March futures consistently under estimated the actual change in basis. The change in basis trended up from the 1989-90 crop year to the 1992-93 crop year. However, the models for change in basis take into account the large decreases during the 1980-81 and 1984-85 crop years. These large decreases in basis caused the model to underestimate the change in basis from 1989 to 1994 when basis was trending up.

Table 4.11 Comparison of In and Out of Sample Test Estimates to Actual Changes.

Year		Estimates		Error	
		In	Out of	In	Out of
ΔC	Actual	Sample	Sample	Sample	Sample
89-90	23	24.19	23.76	1.19	0.76
90-91	28	29.39	28.28	1.39	0.28
91-92	31	31.74	29.86	0.74	-1.14
92-93	21	45.60	45.48	24.60	24.48
93-94	62	42.72	33.12	-19.28	-28.88
$\Delta Basis_{\text{March futures}}$					
89-90	15.75	11.58	8.29	-4.17	-7.46
90-91	20.00	18.00	15.60	-2.00	-4.40
91-92	30.25	29.39	27.33	-0.86	-2.92
92-93	34.75	31.56	29.87	-3.19	-4.88
93-94	31.50	25.91	24.30	-5.59	-7.20
$\Delta Basis_{\text{May futures}}$					
89-90	14.00	13.01	11.56	-0.99	-2.44
90-91	19.25	19.63	18.23	0.38	-1.02
91-92	27.75	28.21	26.64	0.46	-1.11
92-93	32.25	31.55	30.30	-3.70	-1.95
93-94	29.50	25.66	24.54	-3.85	-4.96

The out-of-sample estimates for change in basis for May futures consistently under estimated the actual change in basis for the same reasons as the change in basis for March futures. The in-sample estimates of change in basis for May futures were very accurate relative to the out of sample estimates.

The in-sample estimates will be used in chapter five in analyzing the six strategies. The out-of-sample estimates will also be used to determine the forecasting ability of the three regression models.

4.4 Fischer Black Option Pricing Formula

The 1976 Fischer Black option pricing formula is used to estimate option premiums from 1974 to 1994. The Fischer Black commodity pricing model is

$$C = e^{rT}\left[fN(d_1) - EN(d_2)\right]$$

$$d_1 = \frac{\ln\left(\frac{f}{E}\right) + \left(\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \quad , \qquad d_2 = d_1 - \sigma\sqrt{T}$$

where

C = call premium

f = underlying futures price

E = strike price

σ = volatility of underlying futures contract

T = time to maturity

r = risk free interest rate

e = 2.7183

N(d1) = normal cumulative probability of d1

N(d2) = normal cumulative probability of d2

Put-Call parity is used to develop an equation for pricing put options from the Fischer Black model for pricing calls. Put-Call parity is C-P = (f -E)e^{-rT} , where P is the put premium. The equation used to calculate the price of a put is

$$P = C - (f - E)e^{-rT}$$

The interest rate used is the prime rate on the day the option is either bought or sold. This rate can be easily found in the Wall Street Journal and it represents the base rate on corporate loans posted by at least 75 percent of the nation's 30 largest banks. The historic futures price variance is used as an estimate of volatility of the underlying futures contract. The historic futures price variance is calculated over 21 days of closing futures prices and expanded to an annual variance using 250 trading days. Volatility is calculated as

$$\left[250 \times \frac{1}{n-1}\sum_{i=1}^{n}\left(R_i - \overline{R}\right)^2\right]^{1/2} \times 100\%$$

where R_t = natural logarithm of the ratio F_i/F_{i-1} where F_i is the futures settlement price on day i, $\overline{R}$ is the $\sum R_i / n$, n = number of days in month, and 250 is the number of business days per year. The data used to calculate the volatility of the May futures contract can be found in appendix B.

The program used to calculate the option premiums was written by Robin Ernst based on an article in Futures Magazine. Table 4.12 reports the data used to estimate premiums of put options from 1974 to 1994. The estimates were compared to the actual premiums from 1985 to 1994. Large errors occurred in the fall estimates of 1986, 1987, 1988, 1990, and 1993. These years are large crop years which can cause the calculated historical volatility to be low. In cases such as this, the implied volatility will normally move to the historical mean. In September of 1986 the historical volatility was 7.07 percent and the implied volatility was 21.72 percent.

Table 4.13 reports the estimated premiums for call options from 1974 to 1994. Premiums for two sets of strike prices are reported in table 4.13 because the call options for the fence strategy require the strike price to be 10 cents more than the put option's strike price. Large errors occurred during September from 1986 to 1990 and again in September of 1993. These large errors in the fall are mainly due to the historical volatility calculation being much lower than implied volatility. Only a couple large errors occurred in March during 1991 and 1992.

The 1976 Fischer Black model is relatively accurate in calculating option premiums. On average it underestimates premiums in the fall for calls and puts by approximately 2.5 cents. The estimated premiums in the spring are relatively accurate and on average are underestimated by less than one cent. Actual option premiums will be used from 1985 to 1994 when analyzing the six marketing strategies. The differences between the Black model estimates and actual premiums will not present a problem in the future because producers will use actual option premiums.

Table 4.12 Estimated Put Premiums, Using 1976 Fischer Black Model

Day	May Futures	Strike	Days to Expiration	Historical Volatility	Implied Volatility	Interest	Estimated Premium	Actual Premium	Est.-Act.
12-Sep-74	369.50	370	218	32.83%	na	10.00%	35.40	na	na
18-Sep-75	320.75	320	211	29.31%	na	8.00%	26.78	na	na
16-Sep-76	301.00	300	211	19.76%	na	7.00%	16.80	na	na
15-Sep-77	212.75	210	218	10.67%	na	7.25%	5.42	na	na
14-Sep-78	236.00	240	218	14.11%	na	9.25%	11.80	na	na
13-Sep-79	303.00	300	218	20.60%	na	12.75%	16.37	na	na
18-Sep-80	367.50	370	211	15.81%	na	12.25%	17.66	na	na
17-Sep-81	326.25	330	211	19.58%	na	20.00%	19.07	na	na
16-Sep-82	250.50	250	211	21.35%	na	13.50%	14.74	na	na
15-Sep-83	359.75	360	218	26.47%	na	11.00%	27.57	na	na
13-Sep-84	295.50	300	218	14.10%	na	13.00%	14.17	na	na
18-Sep-85	235.25	240	212	13.92%	14.40%	9.50%	11.93	12.25	-0.32
17-Sep-86	182.00	180	212	7.07%	21.72%	7.50%	2.85	10.5	-7.65
16-Sep-87	194.25	190	212	16.81%	24.20%	8.75%	7.45	11.5	-4.05
14-Sep-88	307.50	310	219	23.04%	25.42%	10.00%	21.87	24	-2.13
13-Sep-89	241.75	240	219	16.08%	17.61%	10.50%	10.43	11.5	-1.07
12-Sep-90	249.75	250	219	16.20%	19.47%	10.00%	11.89	14.25	-2.36
18-Sep-91	268.25	270	212	18.89%	20.07%	8.00%	15.59	16.5	-0.91
16-Sep-92	235.25	240	212	17.37%	18.04%	6.00%	14.54	15	-0.46
13-Sep-93	251.75	250	214	11.85%	15.98%	6.00%	7.95	11	-3.05
Average	275.41			18.29%	19.66%	10.01%	15.51	14.06	-2.45
13-Mar-75	287.00	370	36	33.12%	na	8.00%	83.00	na	na
18-Mar-76	273.25	320	29	10.13%	na	6.75%	46.75	na	na
17-Mar-77	258.75	300	29	8.78%	na	6.25%	41.25	na	na
16-Mar-78	245.75	210	36	9.27%	na	8.00%	0.00	na	na
15-Mar-79	244.75	240	36	6.50%	na	11.75%	0.44	na	na
13-Mar-80	270.50	300	36	9.49%	na	17.75%	29.50	na	na
12-Mar-81	357.00	370	36	13.68%	na	18.00%	14.51	na	na
11-Mar-82	270.00	330	36	8.21%	na	16.50%	60.00	na	na
17-Mar-83	295.75	250	29	16.59%	na	10.50%	0.00	na	na
15-Mar-84	349.25	360	36	10.33%	na	11.00%	11.71	na	na
14-Mar-85	274.50	300	36	6.86%	na	10.50%	25.50	na	na
12-Mar-86	229.50	240	37	12.96%	17.76%	9.00%	11.08	12	-0.92
18-Mar-87	161.00	180	30	21.30%	25.91%	7.50%	19.02	19.25	-0.23
16-Mar-88	204.25	190	30	14.90%	18.17%	8.50%	0.16	0.375	-0.22
15-Mar-89	282.25	310	37	11.58%	26.04%	11.50%	27.75	29	-1.25
14-Mar-90	250.75	240	37	8.98%	15.03%	10.00%	0.19	1.125	-0.94
13-Mar-91	258.50	250	37	10.76%	17.03%	8.75%	0.75	2.25	-1.50
18-Mar-92	271.50	270	30	10.56%	16.13%	6.50%	2.56	4.25	-1.69
16-Mar-93	221.00	240	31	7.28%	na	6.00%	19.00	18.75	0.25
15-Mar-94	284.25	250	31	15.03%	21.35%	6.00%	0.01	0.125	-0.12
Average	264.48			12.32%	17.49%	9.94%	19.66	9.68	-0.73

Table 4.13 Estimated Call Premiums, Using 1976 Fischer Black Model

Day	May Futures	Strike	Estimated Premium	Actual Premium	Est.-Act.	Strike	Estimated Premium	Actual Premium	Est.-Act.
12-Sep-74	369.50	370	34.93	na	na	380	30.91	na	na
18-Sep-75	320.75	320	27.50	na	na	330	23.37	na	na
16-Sep-76	301.00	300	17.76	na	na	310	13.58	na	na
15-Sep-77	212.75	210	8.06	na	na	220	3.90	na	na
14-Sep-78	236.00	240	8.02	na	na	250	4.74	na	na
13-Sep-79	303.00	300	19.15	na	na	310	14.96	na	na
18-Sep-80	367.50	370	15.33	na	na	380	11.51	na	na
17-Sep-81	326.25	330	15.72	na	na	340	12.16	na	na
16-Sep-82	250.50	250	15.21	na	na	260	11.28	na	na
15-Sep-83	359.75	360	27.34	na	na	370	23.30	na	na
13-Sep-84	295.50	300	10.00	na	na	310	6.62	na	na
18-Sep-85	235.25	240	7.43	8.00	-0.57	250	4.29	5.00	-0.71
17-Sep-86	182.00	180	4.76	11.25	-6.49	190	1.16	7.50	-6.34
16-Sep-87	194.25	190	11.48	14.50	-3.02	200	7.08	10.25	-3.17
14-Sep-88	307.50	310	19.52	22.00	-2.48	320	15.64	18.00	-2.36
13-Sep-89	241.75	240	12.07	15.00	-2.93	250	8.00	10.75	-2.75
12-Sep-90	249.75	250	11.66	14.00	-2.34	260	7.79	10.50	-2.71
18-Sep-91	268.25	270	13.92	14.50	-0.58	280	10.07	10.50	-0.43
16-Sep-92	235.25	240	9.95	9.75	0.20	250	6.52	6.50	0.02
13-Sep-93	251.75	250	9.63	12.50	-2.87	260	5.51	8.25	-2.74
Average	275.41		14.97	13.50	-2.34		7.34	9.69	-2.35
13-Mar-75	287.00	370	0.08	na	na	380	0.04	na	na
18-Mar-76	273.25	320	0.00	na	na	330	0.00	na	na
17-Mar-77	258.75	300	0.00	na	na	310	0.00	na	na
16-Mar-78	245.75	210	35.75	na	na	220	25.75	na	na
15-Mar-79	244.75	240	5.13	na	na	250	0.39	na	na
13-Mar-80	270.50	300	0.00	na	na	310	0.00	na	na
12-Mar-81	357.00	370	1.38	na	na	380	0.51	na	na
11-Mar-82	270.00	330	0.00	na	na	340	0.00	na	na
17-Mar-83	295.75	250	45.75	na	na	260	35.75	na	na
15-Mar-84	349.25	360	1.07	na	na	370	0.17	na	na
14-Mar-85	274.50	300	0.00	na	na	310	0.00	na	na
12-Mar-86	229.50	240	0.68	1.25	-0.57	250	0.07	0.13	-0.06
18-Mar-87	161.00	180	0.14	0.25	-0.11	190	0.01	0.13	-0.12
16-Mar-88	204.25	190	14.31	14.75	-0.44	200	5.94	6.50	-0.56
15-Mar-89	282.25	310	0.02	0.75	-0.73	320	0.00	0.25	-0.25
14-Mar-90	250.75	240	10.83	11.00	-0.17	250	3.21	4.75	-1.54
13-Mar-91	258.50	250	9.18	11.00	-1.82	260	2.82	4.75	-1.93
18-Mar-92	271.50	270	4.05	5.75	-1.70	280	0.67	1.75	-1.08
16-Mar-93	221.00	240	0.00	0.38	-0.38	250	0.00	1.00	-1.00
15-Mar-94	284.25	250	34.25	30.00	4.25	260	24.25	24.25	0.00
Average	264.48		8.13	8.35	-0.18		4.11	4.83	-0.73

Chapter 5

Strategy Performance

Chapter five will report the results of implementing the strategies over the past 20 years. Section 5.1 will report the data used to calculate the historical profits of the six strategies as well as the historical profits of each strategy. Section 5.2 will compare the strategies according to their ability to avoid losses and make profits, the tradeoffs between returns and risk using EV and SSD analysis, and expected versus actual outcomes using root mean square error analysis. Section 5.3 will use the out of sample estimates calculated in Table 4.7 to test the strategies' performance over the last five years.

5.1 Calculation of Historical Profits

Storage Cost

Table 5.1 shows the calculated storage cost used for each year. The second column indicates the cash price at harvest. The third column shows the interest rate used to calculate the interest cost. The column labeled shrink indicates the cost of grain damaged and/or lost while handling the grain. Storage cost (S.C.) represents the two cent per month cost of storing the grain for six months in on farm storage facilities. Total storage costs (Total S.C.) is the sum of interest cost, shrink, and physical storage cost. The break even column is the total storage cost added to the cash price at harvest. The average storage cost over the last twenty years was 26 cents per bushel for six months. The most volatile component of storage cost is interest cost which changes with the interest rate and cash prices at harvest. The average interest cost over the last twenty years was 13 cents with a high of 26 cents per bushel during the 1981-82 crop year and a low of six cents per bushel during the 1986-87 crop year.

Table 5.1 Storage Cost for Six Months (cents per bushel).

Year	Cash Price Sept. 15	Prime Rate[1] Sept. 15	Interest Cost	Shrink	S.C.	Total S.C.	Break-Even
74-75	327	10.00	16.4	1.6	12	30	357
75-76	260	8.00	11.3	1.4	12	25	308
76-77	253	7.00	8.9	1.3	12	22	275
77-78	172	7.25	6.2	0.9	12	19	191
78-79	198	9.25	9.2	0.9	12	22	220
79-80	264	12.75	16.8	1.3	12	30	294
80-81	345	12.25	21.1	1.7	12	35	380
81-82	262	20.00	26.2	1.3	12	40	302
82-83	208	13.50	14.0	1.0	12	27	235
83-84	357	11.00	19.6	1.8	12	33	390
84-85	301	13.00	19.6	1.5	12	33	334
85-86	227	9.50	10.8	1.1	12	24	251
86-87	158	7.50	5.9	0.8	12	19	177
87-88	167	8.75	7.3	0.8	12	20	187
88-89	290	10.00	14.5	1.5	12	28	318
89-90	236	10.50	12.4	1.2	12	26	262
90-91	236	10.00	11.8	1.2	12	25	261
91-92	245	8.00	9.8	1.2	12	23	268
92-93	206	6.00	6.4	1.0	12	19	225
93-94	237	6.00	7.1	1.2	12	20	257

1. Percentage rate.

Since weekly cash data was used, the date closest to the 15th of September and March was used as the transaction date. Table 5.2 shows the actual dates and cash price on the Northern Neck of Virginia for the past twenty years.

Table 5.2 Cash Prices on Dates Closest to September 15 and March 15. (¢/bu.)

Crop Year	September 15	Cash Price	March 15	Cash Price
74-75	12-Sep-74	327	13-Mar-75	268
75-76	18-Sep-75	283	18-Mar-76	263
76-77	16-Sep-76	253	17-Mar-77	250
77-78	15-Sep-77	172	16-Mar-78	236
78-79	14-Sep-78	198	15-Mar-79	241
79-80	13-Sep-79	264	13-Mar-80	267
80-81	18-Sep-80	345	12-Mar-81	330
81-82	17-Sep-81	262	11-Mar-82	258
82-83	16-Sep-82	208	17-Mar-83	283
83-84	15-Sep-83	357	15-Mar-84	365
84-85	13-Sep-84	301	14-Mar-85	275
85-86	18-Sep-85	227	12-Mar-86	244
86-87	17-Sep-86	158	18-Mar-87	159
87-88	16-Sep-87	167	16-Mar-88	213
88-89	14-Sep-88	290	15-Mar-89	278
89-90	13-Sep-89	236	14-Mar-90	259
90-91	12-Sep-90	236	13-Mar-91	264
91-92	18-Sep-91	245	18-Mar-92	276
92-93	16-Sep-92	206	16-Mar-93	227
93-94	13-Sep-93	237	15-Mar-94	299

Strategy One: Store with No Forward Pricing

Strategy one follows the rule that when the expected change in cash price from September to March is greater than storage cost, a producer should store at harvest. When this rule is not met, the corn is sold at harvest. Table 5.3 reports the results of following strategy one over the last twenty years. The expected change in cash price used in Table 5.3 is taken from Table 4.2. The actual change in cash price is equal to the cash price on March 15 minus the cash price on September 15. Storage cost is the total storage cost from Table 5.1. The expected change in cash price was calculated using equation one explained in chapter four. Expected profits are equal to the expected change in cash minus storage cost. The decision to store is based on whether expected profits are positive. Following strategy one and using the equation to forecast changes in cash prices, a producer would have stored corn 8 out of the 20 years. Storage profits during the years when corn is not stored are zero and actual profits during the years when corn was stored are equal to the actual change in cash prices minus total storage cost.

Table 5.3 Strategy One Results, "Store with No Forward Pricing". (¢/bu.)

Year	Actual Change in Cash	Storage Cost	Expected Change in Cash	Expected Profits	Decision	Actual Profits	Missed Profits
74-75	-59	30	-57.64	-87.63	Sell[1]	0	0
75-76	-20	25	-32.71	-57.45	Sell	0	0
76-77	-3	22	8.42	-13.70	Sell	0	0
77-78	64	19	59.61	40.52	STORE	44.9	0
78-79	43	22	37.02	14.87	STORE	20.9	0
79-80	3	30	11.99	-18.16	Sell	0	0
80-81	-15	35	-15.31	-50.17	Sell	0	0
81-82	-4	40	16.99	-22.52	Sell	0	0
82-83	75	27	23.93	-3.15	Sell	0	48
83-84	8	33	-11.13	-44.55	Sell	0	0
84-85	-26	33	-1.00	-34.07	Sell	0	0
85-86	17	24	19.62	-4.30	Sell	0	0
86-87	1	19	24.55	5.84	STORE	-17.7	0
87-88	46	20	34.97	14.83	STORE	25.9	0
88-89	-12	28	-9.94	-37.89	Sell	0	0
89-90	23	26	24.19	-1.38	Sell	0	0
90-91	28	25	29.39	4.41	STORE	3.0	0
91-92	31	23	31.74	8.72	STORE	8.0	0
92-93	21	19	45.60	26.39	STORE	1.8	0
93-94	62	20	42.72	22.43	STORE	41.7	0

1. Sell = Sell in cash market at harvest. No forward pricing.

During the years corn was stored following strategy one, a producer averaged 16 cents per bushel profits. The highest profits received occurred in 1977-78 and the lowest occurred in 1986-87. Once out of the eight years when corn was stored following strategy one, a producer would have received negative profits. In 1982/83, a producer missed the possibility to make 48 cents per bushel profit because expected profit estimated in the fall of 1982 was -3.15 cents per bushel.

Strategy Two: Store Corn and Forward Price with a Cash Contract

Strategy two follows the rule that when the cash contract price is greater than the break-even price, a producer should store corn under cash contract. The expected basis recorded in Table 5.4 represents the average basis over the previous three years. The cash contract price is the expected basis plus the closing price of the March futures contract on September 15. The expected profits are equal to the cash contract price minus the break-even price. The actual profits during the years when corn is not stored are zero and the actual profits during the years when corn is stored are the same as the expected profits. The actual and expected profits are the same since the cash contract transfers the price risk from the producer to the grain elevator providing the cash contract.

A producer following strategy two would have stored corn 13 out of the past 20 years.(Table 5.4) The average profit during the 13 storage years was 7 cents per bushel. The highest profit was 17.52 cents in 1992-93 and the lowest profit was 1.79 cents in 1979-80.

Table 5.4 Strategy Two, "Store and Forward Price with Cash Contract" (¢/bu.)

Year	Break-even	March Fut. Sept. 15	Expected Basis	Cash Contract	Expected Profits	Decision	Actual Profits
74-75	357	364.75	-2.44	362	5.31	STORE	5.3
75-76	308	318.50	-7.86	311	2.94	STORE	2.9
76-77	275	297.00	-11.17	286	10.63	STORE	10.7
77-78	191	208.25	-8.17	200	8.98	STORE	9.0
78-79	220	230.50	-4.47	226	5.93	STORE	5.9
79-80	294	296.00	-0.11	296	1.79	STORE	1.7
80-81	380	363.75	3.03	367	-13.02	Sell[1]	0.0
81-82	302	315.50	-1.56	314	12.44	STORE	12.4
82-83	235	240.50	-3.22	237	2.28	STORE	2.2
83-84	390	356.50	-5.97	351	-39.87	Sell	0
84-85	334	291.25	6.88	298	-35.97	Sell	0
85-86	251	229.50	6.97	236	-14.43	Sell	0
86-87	177	175.50	11.17	187	9.97	STORE	10.0
87-88	187	189.25	4.58	194	6.73	STORE	6.7
88-89	318	305.25	8.42	314	-4.33	Sell	0
89-90	262	236.50	4.92	241	-20.18	Sell	0
90-91	261	243.25	10.08	253	-7.67	Sell	0
91-92	268	264.00	9.89	274	5.89	STORE	5.9
92-93	225	229.00	13.72	243	17.52	STORE	17.5
93-94	257	246.75	13.17	260	2.62	STORE	2.6

1. Sell in cash market at harvest. No forward pricing.

Strategy Three: Store and Forward Price with Futures

Strategy three represents the classic hedge with a futures contract. Strategy three follows the rule that when the expected change in basis from September to March is greater than storage cost, a producer can store corn, sell a futures contract, and expect to make a profit. Table 5.5 reports the results of following strategy three over the past twenty years. The actual basis is the difference between March futures and cash prices on the Northern Neck of Virginia on March 15. The expected basis was previously estimated using equation 2 and reported in Table 4.4. Expected profits are calculated by subtracting total storage cost from expected basis change from September 15 to March 15. The decision to store is based on whether expected profits are positive. Actual profits from storage in years when corn is not stored are zero. In years when corn is stored, actual profits are equal to the actual change in basis minus total storage cost.

A producer following strategy three would have stored corn 11 out of the past 20 years. The 11 years when corn was stored, profits averaged ten cents per bushel and ranged from -2.95 to 18.05 cents per bushel. The only potential profits missed were during the 1979-80 crop year. All other years when corn was sold at harvest, the producer avoided negative profits.

Table 5.5 Strategy Three, "Store and Forward Price with Futures". (¢/bu.)

Year	Actual *ΔBasis*	Expected *ΔBasis*	Storage Cost	Expected Profits	Decision	Actual Profits	Missed Profits
74-75	18.50	29.79	30	-0.2	Sell[1]	0	0
75-76	31.25	27.95	25	3.2	STORE	6.5	0
76-77	40.25	35.98	22	13.9	STORE	18.1	0
77-78	30.50	38.03	19	18.9	STORE	11.4	0
78-79	34.00	28.05	22	5.9	STORE	11.9	0
79-80	39.00	28.40	30	-1.8	Sell	0	8.9
80-81	1.50	22.30	35	-12.6	Sell	0	0
81-82	53.25	48.12	40	8.6	STORE	13.7	0
82-83	28.50	29.56	27	2.5	STORE	1.4	0
83-84	15.25	11.47	33	-22.0	Sell	0	0
84-85	-7.25	-5.21	33	-38.3	Sell	0	0
85-86	15.25	9.16	24	-14.8	Sell	0	0
86-87	15.75	29.54	19	10.8	STORE	-3.0	0
87-88	37.75	32.78	20	12.6	STORE	17.6	0
88-89	15.25	18.64	28	-9.3	Sell	0	0
89-90	15.75	11.58	26	-14.0	Sell	0	0
90-91	20.00	18.00	25	-7.0	Sell	0	0
91-92	30.25	29.39	23	6.4	STORE	7.2	0
92-93	34.75	31.56	19	12.4	STORE	15.5	0
93-94	31.50	25.91	20	5.6	STORE	11.2	0

1. Sell in cash market at harvest. No forward pricing.

Expected profits during the 1979-80 crop year were negative 1.78 and actual profits were positive 8.9 cents per bushel. The difference between actual and expected basis was 11.32 which is the same difference between actual and expected profits.

A producer implementing strategy three needs to consider the risk of incurring margin calls when selling a March futures contract in September. Table A.4 in appendix A list the March futures price on September 15 and March 15. Table A.4 reports the highest and lowest closing price between September and March. When the highest closing price between September and March exceeds the futures price on September 15 by more than 10 cents, a producer will pay margin calls. In seven out of the 11 years when strategy three was implemented, a producer would have paid margin calls. In 1982/83 and 1993/94 when the highest closing price exceeded the September 15 price by more than 50 cents, producers would have incurred margin calls of $2,500 per contract.

Strategy Four: Store and Forward Price with Options.

Strategy four follows the rule that when expected net price, ENP, is greater than the break-even price, a producer should store corn and buy a put option. Table 5.6 reports the results of following strategy four.

The strike price selected is closest to the May futures contract price trading on September 15. The expected ending basis in the third column was calculated by adding the beginning basis to the expected change in basis in Table 4.6. The put option premium is reported in the fourth column. The premiums from 1974 to 1984 were estimated using the Fischer Black option pricing formula. The remaining premiums in bold, 1985 to 1994, are

Table 5.6 Results of Strategy Four, "Store and Forward Price with Options". (cents per bushel)

Year	May Option Strike	Expected Ending Basis	Option Premium Sept. 15	Expected Net Price	Break-even	Expected Profits	Decision	Premium March 15	Option Profits	Cash Price on Mar. 15	Actual Net Price	Actual Profits	Missed Profits
74-75	370	-13.68	35.40	321	357	-36.1	Sell	83.000	47.6	268	316	0.00	0
75-76	320	-12.35	26.78	281	308	-26.9	Sell	46.750	20.0	263	283	0.00	0
76-77	300	-14.19	16.80	269	275	-6.1	Sell	41.250	24.5	250	274	0.00	0
77-78	210	-4.70	5.42	200	191	8.8	STORE	0.000	-5.4	236	231	39.49	0
78-79	240	-10.19	11.80	218	220	-2.1	Sell	0.440	-11.4	241	230	0.00	9.5
79-80	300	-9.80	16.37	274	294	-20.3	Sell	29.500	13.1	267	280	0.00	0
80-81	370	-1.02	17.66	351	380	-28.5	Sell	14.510	-3.2	330	327	0.00	0
81-82	330	-14.79	19.07	296	302	-5.4	Sell	60.000	40.9	258	299	0.00	0
82-83	250	-10.13	14.74	225	235	-9.9	Sell	0.000	-14.7	283	268	0.00	33.2
83-84	360	8.75	27.57	341	390	-49.2	Sell	11.710	-15.9	365	349	0.00	0
84-85	300	2.77	14.17	289	334	-45.5	Sell	25.500	11.3	275	286	0.00	0
85-86	240	2.93	**12.25**	231	251	-20.2	Sell	**12.000**	-0.3	244	244	0.00	0
86-87	180	5.94	**10.50**	175	177	-1.3	Sell	**19.250**	8.8	159	168	0.00	0
87-88	190	4.51	**11.50**	183	187	-4.1	Sell	**0.375**	-11.1	213	202	0.00	14.7
88-89	310	-0.35	**24.00**	286	318	-32.3	Sell	**29.000**	5.0	278	283	0.00	0
89-90	240	7.26	**11.50**	236	262	-25.8	Sell	**1.125**	-10.4	259	249	0.00	0
90-91	250	5.88	**14.25**	242	261	-19.4	Sell	**2.250**	-12.0	264	252	0.00	0
91-92	270	4.96	**16.50**	258	268	-9.6	Sell	**4.250**	-12.3	276	264	0.00	0
92-93	240	2.30	**15.00**	227	225	2.1	STORE	**18.750**	3.8	227	231	5.54	0
93-94	250	10.91	**11.00**	250	257	-7.4	Sell	**0.125**	-10.9	299	288	0.00	30.8

Bold premiums represent actuals
Non-Bold premiums represent estimates

the actual premiums of the May corn option contract. The ENP is calculated by adding the expected ending basis to the strike price and then subtracting the option premium. Expected profits are then calculated by subtracting the break-even from ENP. Expected profits were positive in only two out of the past twenty years.

The profits from the option's market are calculated by subtracting the September premium from the March premium. The actual net price, ANP, is equal to the cash price on March 15 plus the profits from the option's market. Actual profits are calculated by subtracting the break-even from the ANP. A producer following strategy four would have stored corn during two of the past 20 years with profits of 39.49 cents per bushel and 5.54 cents per bushel. A producer following strategy four would have missed four opportunities to make money from storing corn and buying a put option. Opportunities were missed because of the difference between actual and expect ending basis and unforeseen increases in cash prices.

Strategy Five: Store and Buy Put and Write Call Options.

A producer following strategy five would store corn, buy a put option, and write a call option when the ENP is greater than the break-even price. Table 5.7 reports the results of following strategy five. The May put option strike price, expected ending basis, and premium are the same as in Table 5.6. The strike price used to calculate the call option premium is ten cents higher than the strike price in table 5.7. The expected net price is equal to the strike price plus expected basis plus the call option premium less the

Table 5.7 Results of Strategy Five, "Store and Buy Put and Write Call Options". (cents per bushel)

Year	May Option Strike	Expected Ending Basis	Call Option Premium	Put Option Premium	Expected Net Price	Break-even	Expected Profits	Decision	Call Premium March 15	Put Premium March 15	Option Profits	Cash Price on Mar. 15	Actual Net Price	Actual Profits	Missed Profits
74-75	370	-13.68	30.91	35.40	352	357	-5.2	Sell	0.04	83.000	78.5	268	346	0.00	0
75-76	320	-12.35	23.37	26.78	304	308	-3.5	Sell	0.00	46.750	43.3	263	306	0.00	0
76-77	300	-14.19	13.58	16.80	283	275	7.5	STORE	0.00	41.250	38.0	250	288	12.91	0
77-78	210	-4.70	3.90	5.42	204	191	12.7	STORE	25.75	0.000	-27.3	236	209	17.64	0
78-79	240	-10.19	4.74	11.80	223	220	2.6	STORE	0.39	0.440	-7.0	241	234	13.84	0
79-80	300	-9.80	14.96	16.37	289	294	-5.4	Sell	0.00	29.500	28.1	267	295	0.00	0.9
80-81	370	-1.02	11.51	17.66	363	380	-17.0	Sell	0.51	14.510	7.9	330	338	0.00	0
81-82	330	-14.79	12.16	19.07	308	302	6.8	STORE	0.00	60.000	53.1	258	311	9.58	0
82-83	250	-10.13	11.28	14.74	236	235	1.3	STORE	35.75	0.000	-39.2	283	244	8.71	0
83-84	360	8.75	23.30	27.57	364	390	-25.9	Sell	0.17	11.710	7.3	365	372	0.00	0
84-85	300	2.77	6.62	14.17	295	334	-38.9	Sell	0.00	25.500	18.0	275	293	0.00	0
85-86	240	2.93	**5.00**	**12.25**	236	251	-15.2	Sell	**0.125**	**12.000**	4.6	244	249	0.00	0
86-87	180	5.94	**7.50**	**10.50**	183	177	6.2	STORE	**0.125**	**19.250**	16.1	159	175	-1.59	0
87-88	190	4.51	**10.25**	**11.50**	193	187	6.1	STORE	**6.50**	**0.375**	-7.4	213	206	18.48	0
88-89	310	-0.35	**18.00**	**24.00**	304	318	-14.3	Sell	**0.25**	**29.000**	22.8	278	301	0.00	0
89-90	240	7.26	**10.75**	**11.50**	247	262	-15.1	Sell	**4.75**	**1.125**	-4.4	259	255	0.00	0
90-91	250	5.88	**10.50**	**14.25**	252	261	-8.9	Sell	**4.75**	**2.250**	-6.3	264	258	0.00	0
91-92	270	4.96	**10.50**	**16.50**	269	268	0.9	STORE	**1.75**	**4.250**	-3.5	276	273	4.48	0
92-93	240	2.30	**6.50**	**15.00**	234	225	8.6	STORE	**1.00**	**18.750**	9.3	227	236	11.04	0
93-94	250	10.91	**8.25**	**11.00**	258	257	0.9	STORE	**24.25**	**0.125**	-26.9	299	272	14.83	0

Bold premiums represent actuals
Non-Bold premiums represent estimates

put option premium. Expected profits are then calculated as ENP minus the break-even price.

A producer following strategy five would have stored corn 10 out of the past twenty years. Profits from writing a May call option are calculated by subtracting the March premium from the September premium and profits from the May put option are calculated by subtracting the September premium from the March premium. The ANP is calculated by adding the profits from the option's market to the cash price in the spring. Actual profits from strategy five when corn is not stored are equal to zero and when corn is stored profits are equal to ANP minus the break-even price. The average profits during the years when corn was stored is 10 cents per bushel. The high was 18.48 cents per bushel during the 1987-88 crop year and the low was -1.59 cents during the 1986-87 crop year. Strategy five missed profits of less than one cent during the 1979-80 crop year.

As in strategy three, a producer implementing strategy five needs to consider the risk of margin calls. Table A.5 in appendix A reports the May futures price on September 15 and the highest closing price between September and March. When the highest closing futures price exceeds the strike price of the call option written by the producer, a producer will incur margin calls. Margin calls for the written call option would have followed the same pattern as margins calls for the futures contracts in strategy three.

Strategy Six: Sell at Harvest and Buy a Call Option

If a producer expects cash prices to increase during the storage period, the producer can sell corn at harvest and buy a call option. The logic behind this strategy is that when cash prices are expected to increase, a producer can take advantage of the increases and not incur storage cost by purchasing a call option. As prices increase, the value of the call option should increase as well.

To calculate expected profits for strategy six, a producer needs an estimate of the May futures price on March 15 to determine the value of the call option in March. The expected change in cash price from Table 4.2 can be added to the cash price on September 15 to come up with an estimated March 15 price. The expected May basis calculated in Table 4.8 can be subtracted from the expected cash price to calculate the expected May futures price on March 15. Expected profits are equal to the expected May futures price less the May option strike price less the call option premium. The strike price is the price closest to the May futures contract price trading on September 15. When the expected profits are positive, a producer would sell corn at harvest and buy a call option. When the expected profits are negative, a producer would sell corn at harvest with no forward pricing. Table 5.8 reports the results of strategy six over the last twenty years.

Table 5.8 Results of Strategy Six, "Sell at Harvest and Buy a Call Option". (cents per bushel)

Year	Cash Price on Sept. 15	Expected Change in Cash	Expected Cash Price on March 15	Expected Ending Basis	Expected May Futures Price	May Option Strike	Call Premium Sept. 15	Expected Profits	Decision	Call Premium March 15	Option Profits	Actual Profits	Missed Profits
74-75	327	-57.64	269	-13.68	283	370	34.93	-121.9	Sell	0.08	-34.9	0.00	0
75-76	283	-32.71	250	-12.35	263	320	27.50	-84.9	Sell	0.00	-27.5	0.00	0
76-77	253	8.42	261	-14.19	276	300	17.76	-42.2	Sell	0.00	-17.8	0.00	0
77-78	172	59.61	232	-4.70	236	210	8.06	18.3	BUY CALL	35.75	27.7	27.69	0
78-79	198	37.02	235	-10.19	245	240	8.02	-2.8	Sell	5.13	-2.9	0.00	0
79-80	264	11.99	276	-9.80	286	300	19.15	-33.4	Sell	0.00	-19.2	0.00	0
80-81	345	-15.31	330	-1.02	331	370	15.33	-54.6	Sell	1.38	-14.0	0.00	0
81-82	262	16.99	279	-14.79	294	330	15.72	-51.9	Sell	0.00	-15.7	0.00	0
82-83	208	23.93	232	-10.13	242	250	15.21	-23.2	Sell	45.75	30.5	0.00	30.5
83-84	357	-11.13	346	8.75	337	360	27.34	-50.2	Sell	1.07	-26.3	0.00	0
84-85	301	-1.00	300	2.77	297	300	10.00	-12.8	Sell	0.00	-10.0	0.00	0
85-86	227	19.62	247	2.93	244	240	**8.00**	-4.3	Sell	**1.250**	-6.8	0.00	0
86-87	158	24.55	183	5.94	177	180	**11.25**	-14.6	Sell	**0.250**	-11.0	0.00	0
87-88	167	34.97	202	4.51	197	190	**14.50**	-7.0	Sell	**14.75**	0.25	0.00	0.3
88-89	290	-9.94	280	-0.35	280	310	**22.00**	-51.6	Sell	**0.75**	-21.3	0.00	0
89-90	236	24.19	260	7.26	253	240	**15.00**	-2.1	Sell	**11.00**	-4.0	0.00	0
90-91	236	29.39	265	5.88	260	250	**14.00**	-4.5	Sell	**11.00**	-3.0	0.00	0
91-92	245	31.74	277	4.96	272	270	**14.50**	-12.7	Sell	**5.75**	-8.8	0.00	0
92-93	206	45.60	252	2.30	249	240	**9.75**	-0.5	Sell	**0.38**	-9.4	0.00	0
93-94	237	42.72	280	10.91	269	250	**12.50**	6.3	BUY CALL	**30.00**	17.5	17.50	0

Bold premiums represent actuals
Non-Bold premiums represent estimates

A producer would have implemented strategy six in two out of the last twenty years. Average profits would have been 22.6 cents per bushel with a high profit of 27.69 cents per bushel during the 1977-78 crop year and a low profit of 17.5 cents per bushel during the 1993-94 crop year. A producer would have missed the opportunity to make 30.5 cents per bushel during the 1982/83 crop year if options had actually been trading.

5.2 Comparison of Strategies

The strategies will be compared according to their ability to capture profits and avoid losses, EV and SSD criteria, and the RMSE of the forecast. Table 5.9 represents the number of times profits and losses were captured and missed by each of the six strategies. Strategy two captured the most profits while strategies four and six captured the least. Strategy three captured the second most profits. Strategy four missed the most profits and strategy six missed the second most profits.

Table 5.9 Number of Years Profits and Losses were captured and missed.

Strategies	Profits captured	Profits missed	Losses captured	Losses missed
1. Store and no hedge	7	1	1	11
2. Store and cash contract	13	0	0	7
3. Store and hedge with futures	10	1	1	8
4. Store and hedge with put options	2	4	0	14
5. Store and buy put and sell call option	9	1	1	9
6. Sell corn and buy call option	2	2	0	16

Table 5.10 reports the value of profits and losses captured and missed by each of the six strategies. For example, Strategy one captured 146 cents per bushel profits over the past twenty years. Strategy one captured the largest amount of profits in terms of cents per bushel and strategies four and six captured the least. Strategy four missed the most profits and strategy two missed the least. Strategy one captured the most losses and strategies two, four, and six captured the least. Strategy one missed the most losses and strategy two missed the least.

Table 5.10 Value of Profits and Losses captured and missed. (cents per bushel)

Strategies	Profits captured	Profits missed	Losses captured	Losses missed
1. Store and no hedge	146	48	-18	-413
2. Store and cash contract	93	0	0	-135
3. Store and hedge with futures	109	9	-3	-140
4. Store and hedge with put options	45	88	0	-303
5. Store and buy put and sell call option	112	1	-2	-142
6. Sell corn and buy call option	45	31	0	-233

Table 5.11 shows the profits of the six strategies that were calculated in the previous section. None of the strategies were implemented during the 1980/81, 1983/84, 1984/85, 1985/86, 1988/89, and 1989/90 crop years. Strategies four and six never had the highest profits. Strategy one had the highest average profits as well as the highest standard deviation. Strategy four and six had the lowest average profit with a standard deviation of 8.6 and 7.0 cents respectively. Figure 5.1 graphs the six strategies according to their means and variances. Strategy one exhibits the most risk with the highest variance and strategy two has the lowest variance, hence exhibiting the least risk. Strategies two, three, and five have similar means and variances. Strategies four and six are inefficient when

compared to strategies two, three, and five. When comparing strategies four and six, four has a higher variance than six and both strategies four and six have essentially the same mean.

The profits in Table 5.11 were used to rank the strategies according to second degree stochastic dominance. The Generalized Stochastic Dominance Program (GSD 2.1) was used to rank the strategies. Strategies one, two, and five were ranked in the efficient set. A producer implementing strategy one would store and not forward price, strategy two would store and forward price using cash contracts, and strategy five would store and buy a put option and sell a call option.

Table 5.11 Profits of the Six Strategies. (cents per bushel)

Year	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5	Strategy 6
74-75	0	5.3	0	0	0	0
75-76	0	2.9	6.5	0	0	0
76-77	0	10.7	18.1	0	12.9	0
77-78	44.9	9.0	11.4	39.5	17.6	27.7
78-79	20.9	5.9	11.9	0	13.8	0
79-80	0	1.7	0	0	0	0
80-81	0	0	0	0	0	0
81-82	0	12.4	13.7	0	9.6	0
82-83	0	2.2	1.4	0	8.7	0
83-84	0	0	0	0	0	0
84-85	0	0	0	0	0	0
85-86	0	0	0	0	0	0
86-87	-17.7	10.0	-3.00	0	-1.6	0
87-88	25.9	6.7	17.6	0	18.5	0
88-89	0	0	0	0	0	0
89-90	0	0	0	0	0	0
90-91	3.0	0	0	0	0	0
91-92	8.0	5.9	7.2	0	4.5	0
92-93	1.8	17.5	15.5	5.5	11.0	0
93-94	41.7	2.6	11.2	0	14.8	17.5
Average	6.4	4.6	5.6	2.3	5.5	2.3
Variance	221.2	24.5	47.4	74.4	46.9	48.5
STD	14.88	5.0	6.9	8.6	6.9	7.0

Table 5.11 shows the variability of profits for each strategy over the past 20 years. However, after a decision is made to implement a strategy the relevant variability is between expected profits verses actual profits. Peck uses the root mean squared error of the forecast to measure this crucial variance which surrounds the accuracy of the producer's forecast. Root mean square error, RMSE, is

$$\left[\left(\sum_{n}\left(P_t - P^*_{t-i}\right)^2\right)/n\right]^{1/2}$$

where n is the number of years, P^*_{t-i} is the profit forecast in September and P_t is the actual profit in March. In years when the expected profits are negative, the expected profits and actual profits are treated as zero. A RMSE is not calculated for strategy two. Strategy two has an RMSE of zero since there is no error between estimated profits and actual profits because the risk is being transferred to the elevator.

Table 5.12 reports the data used to calculate the RMSE. The numbers for each crop year is the actual profit minus the expected profit. Strategy two has the lowest RMSE of zero and Strategy one has the highest RMSE of 9.5. The strategies with the lowest RMSE will provide producers with more accurate forecast, hence less chance in making a wrong decision. A producer with a more accurate forecast will be more confident that a decision made is the correct decision.

The errors in the forecast that have been measured by RMSE are inherently related to the residual errors in Chapter Four. In years when the change in cash model and change in basis model missed the actual changes in cash and basis, the estimated profits within each strategy will be inaccurate according to the amount of error found in the residuals. This error is the result of market information that the model is unable to capture, hence producers need to be aware of the models limitation in analyzing current market situations. The model can only capture information innate in the independent variables.

Table 5.12 Difference Between Expected and Actual Profits (¢/bu.)

Year	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5	Strategy 6
74-75	0	0	0	0	0	0
75-76	0	0	3.30	0	0	0
76-77	0	0	4.27	0	5.44	0
77-78	4.39	0	-7.53	30.70	4.95	9.44
78-79	5.98	0	5.95	0	11.24	0
79-80	0	0	0	0	0	0
80-81	0	0	0	0	0	0
81-82	0	0	5.13	0	2.79	0
82-83	0	0	-1.06	0	7.38	0
83-84	0	0	0	0	0	0
84-85	0	0	0	0	0	0
85-86	0	0	0	0	0	0
86-87	-23.55	0	13.79	0	-7.82	0
87-88	11.03	0	4.97	0	12.36	0
88-89	0	0	0	0	0	0
89-90	0	0	0	0	0	0
90-91	-1.39	0	0	0	0	0
91-92	-0.74	0	.86	0	3.54	0
92-93	-24.60	0	3.19	3.45	2.45	0
93-94	19.28	0	5.59	0	13.97	11.19
Absolute Average Over Twenty Years	4.5	0	2.78	1.7	3.6	1.0
Absolute Average Over Years Stored	11.4	0	5.1	17.1	7.2	15.0
RMSE	9.5	0	4.6	6.9	5.2	3.2

The strategies have been compared according to their ability to capture profits and miss losses. The means and variances of historical profits have been compared according to an EV framework and second degree stochastic dominance and the RMSE of the forecast errors have been compared. The efficient strategies were one, two, and five according to the GSD 2.1 program. Strategy one is the riskiest strategy to implement but offers some of the best returns to storage. A producer implementing strategy two takes on no risk and receives average returns to storage. Strategy five is riskier than strategy two but not as risky as strategy one. Even though strategy three was not ranked by the GSD 2.1 program, it has almost the same historical mean and variance and RMSE as strategy five.

Figure 5.2 compares average profits against profit risk. The RMSE on the vertical axis represents the level of profit risk in cents per bushel that a producer could encounter. A producer who implements strategy two averages 4.6 cents per bushel in profits and takes no risk. A producer could average approximately 5.5 cents per bushel from implementing strategies three and five, but the amount of risk increases from zero cents to approximately five cents per bushel. With a five cent profit risk, expected profits of five cents could be wiped out in a given year. If a producer implements strategy one, average profits would be 6.4 cents per bushel and the producer would take on 9.5 cents of risk. Each producer must decide if it is worthwhile to take on five cents of risk to make one additional cent in profits, or to take on 9.5 cents of risk to make two additional cents? This question has no easy answer and will vary from producer to producer depending on the amount of risk each is willing to take. Higher risk usually equals higher returns or higher losses. Lower risk usually equals lower returns and lower losses.

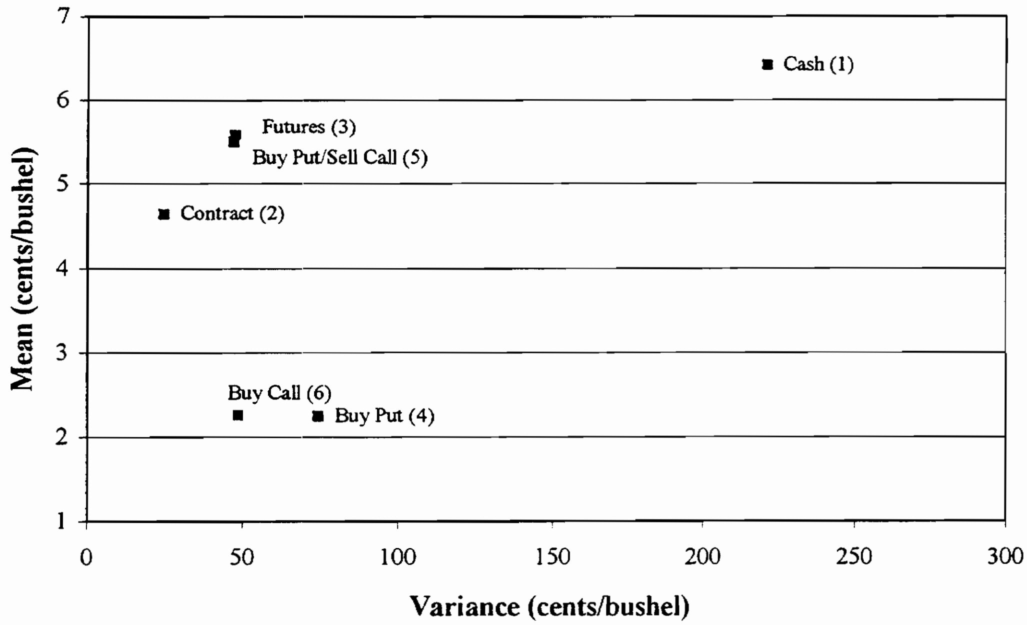


Figure 5.1 Mean-Variance of Strategies

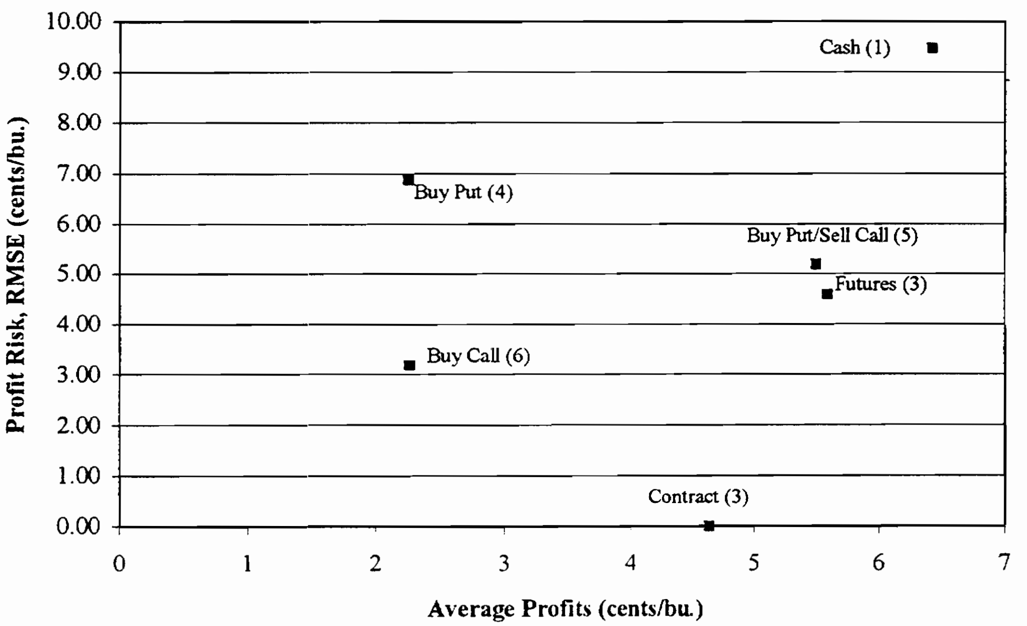


Figure 5.2: Average Profits vs. Profit Risk

A producer should consider strategies one, two, three, and five when deciding what strategy to implement. Strategies four and six never had the best returns to storage and strategy four missed the most profits. If a producer is willing to take on risk, then strategy one offers the best returns. Strategy two offers the best returns to a producer who is very risk averse. Strategies three and five offer good returns to producers willing to take on more risk than strategy two and less than strategy one. Figures 5.3, 5.4, 5.5, and 5.6 are graphical comparisons of Strategies one, two, three, and five. A producer looking at Figure 5.6 can easily see that strategies three and five have similar profits which coincides with the similar levels of risk for strategies three and five. Figure 5.3 and 5.4 visually indicated the large variability of returns from strategy one when compared to strategies two and three.

5.3 Out of Sample Test

So far, all estimated profits and comparisons of estimated profits have been made with in-sample forecast. In chapter 4, estimates of changes in cash prices and basis were tested from 1989 to 1994. The out-of-sample estimates of changes in cash prices and basis for years 1989-90 to 1993-94 are reported in Table 4.11. The same procedures and strategy rules were used to calculate estimated profits for each of the strategies using out-of-sample estimates of cash and basis. If estimated profits were positive, then the strategy was implemented and if estimated profits were negative, corn was sold at harvest. Table 5.13 shows the results of the out-of-sample test on the six strategies. Results of the out-of-sample test on strategies one, two, three, and four produced similar results in terms of

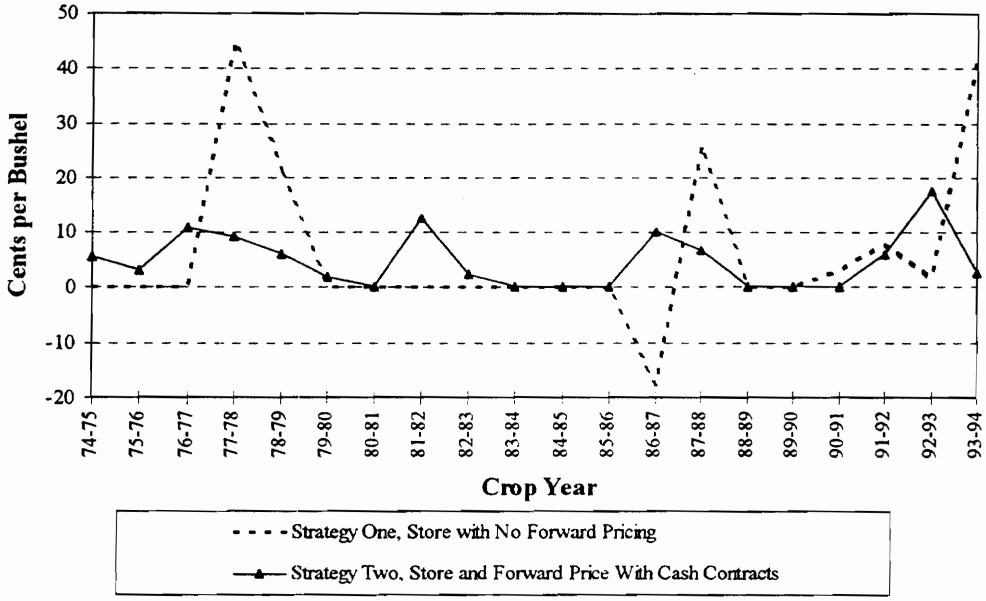


Figure 5.3: Profits From Implementing Strategies One and Two

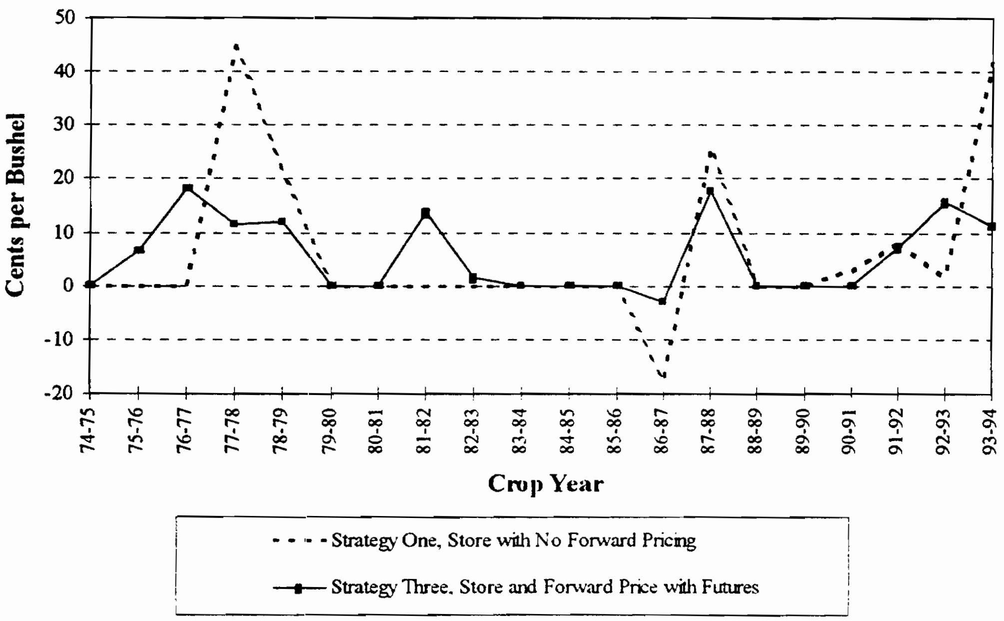


Figure 5.4: Profits From Implementing Strategies One and Three

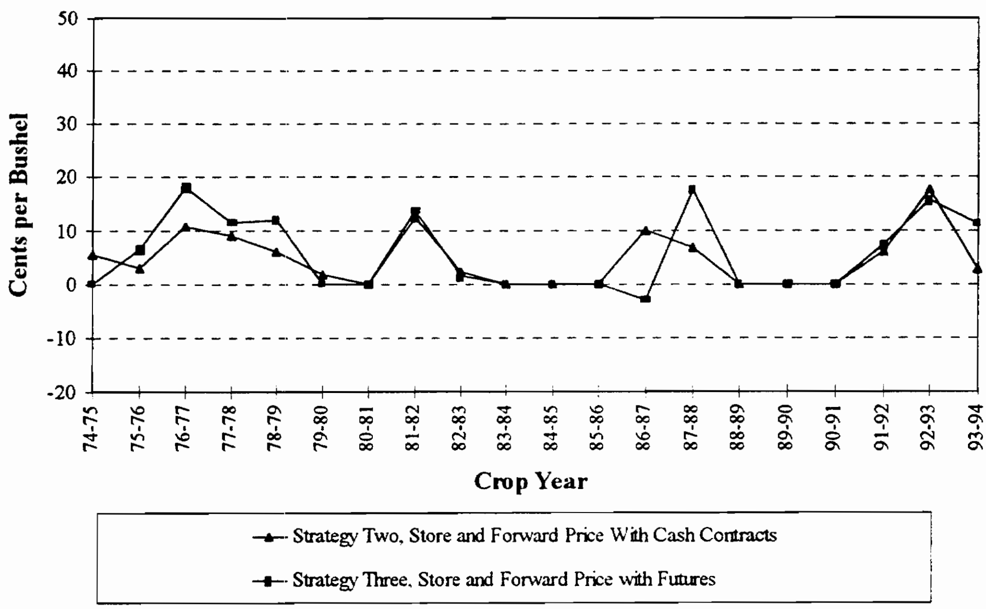


Figure 5.5: Profits From Implementing Strategies Two and Three

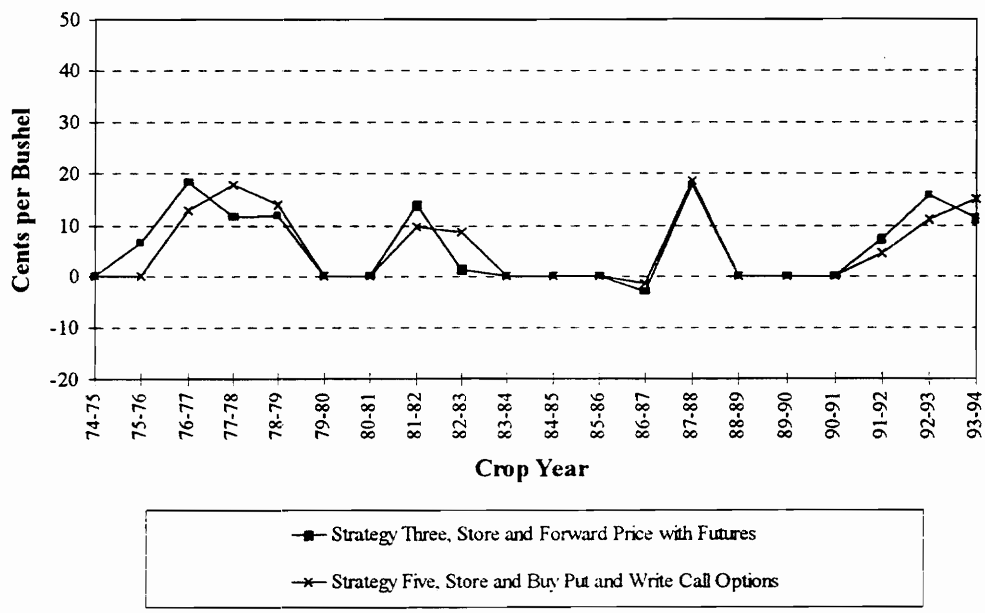


Figure 5.6: Profits From Implementing Strategies Three and Five

providing the producer with the correct signal to store or sell at harvest. Strategies five and six were slightly different. The out of sample test on strategy five missed profits during the 1991/92 and 1993/94 crop year. The out of sample test on strategy six missed the opportunity to make 17.5 cents per bushel during the 1993/94 crop year and experienced a loss of 9.4 cents per bushel during the 1992/93 crop year. For the most part, the out of sample test produced similar results as the in sample test. Hence, following the procedures outlined in chapter 3 would have provided a producer with a good marketing tool over the past five years.

Table 5.14 is a comparison of the in-sample RMSE to the out-of-sample RMSE. In most cases the RMSE actually improved slightly with the out-of-sample test. Strategy one was the only strategy which the RMSE actually increased. This is due to the large forecast error during the 1993/94 crop year. The in-sample forecast error was 19.28 and the out-of-sample forecast error increased to 28.88. The large increase in forecast error is a good example of the risk associated with strategy one. In this case, the error was in favor of the producer because actual profits ended up being significantly larger than estimated profits. However producers need to keep in mind that the risk involved with each of the strategies is a two edged sword in that a producer can experience losses like those incurred under strategy one during the 1986/87 crop year. The estimated profit for the 1986/87 crop year was 5.84 cents per bushel and actual profit was -17.7 cents per bushel.

Table 5.13 In-Sample Versus Out-of-Sample Profits. (cents per bushel)

Strategies		In-Sample	Out-of-Sample
1. Store and no hedge			
	1989/90	0	0
	1990/91	3.0	3.0
	1991/92	8.0	8.0
	1992/93	1.8	1.8
	1993/94	41.7	41.7
2. Store and cash contract			
	1989/90	0	0
	1990/91	0	0
	1991/92	5.9	5.9
	1992/93	17.5	17.5
	1993/94	2.6	2.6
3. Store and hedge with futures			
	1989/90	0	0
	1990/91	0	0
	1991/92	7.2	7.2
	1992/93	15.5	15.5
	1993/94	11.2	11.2
4. Store and hedge with put options			
	1989/90	0	0
	1990/91	0	0
	1991/92	0	0
	1992/93	5.5	5.5
	1993/94	0	0
5. Store and buy put and sell call option			
	1989/90	0	0
	1990/91	0	0
	1991/92	4.5	0
	1992/93	11.0	11.0
	1993/94	14.8	0
6. Sell corn and buy call option			
	1989/90	0	0
	1990/91	0	0
	1991/92	0	0
	1992/93	0	-9.4
	1993/94	17.50	0

Table 5.14 In-Sample Verses Out-of-Sample Differences Between Expected and Actual Profits

Strategies		In-Sample	Out-of-Sample
1. Store and no hedge			
	1989/90	0	0
	1990/91	-1.39	-0.28
	1991/92	-0.74	1.14
	1992/93	-24.6	-24.48
	1993/94	19.28	28.88
	RMSE	9.48	10.7
2. Store and cash contract			
	1989/90	0	0
	1990/91	0	0
	1991/92	0	0
	1992/93	0	0
	1993/94	0	0
	RMSE	0	0
3. Store and hedge with futures			
	1989/90	0	0
	1990/91	0	0
	1991/92	1.92	2.92
	1992/93	2.80	4.88
	1993/94	6.68	7.20
	RMSE	5.10	4.8
4. Store and hedge with put options			
	1989/90	0	0
	1990/91	0	0
	1991/92	0	0
	1992/93	3.45	4.70
	1993/94	0	0
	RMSE	6.87	6.9
5. Store and buy put and sell call option			
	1989/90	0	0
	1990/91	0	0
	1991/92	3.55	0
	1992/93	2.45	3.7
	1993/94	13.97	0
	RMSE	5.19	4.5
6. Sell corn and buy call option			
	1989/90	0	0
	1990/91	0	0
	1991/92	0	0
	1992/93	0	-10.05
	1993/94	11.19	0
	RMSE	3.2	3.2

5.4 Chapter Five Summary

Chapter five has reported the results of individually implementing the strategies over the past twenty years. Strategies were compared according to their ability to avoid losses and capture profits. EV analysis and second degree stochastic dominance were used to rank strategies according to the average and variance of profits. The root mean square error (RMSE) of the actual versus the expected forecast profit indicated the accuracy of profit forecast. The out-of-sample test indicated the six marketing strategies would have performed well during the last five years, 1989/90-1993/94.

Strategies one, two, three, and five were the efficient or dominate strategies. The strategy that a producer implements depends on the amount of risk the producer is willing to take. Figure 5.2 comparing average profits and profit risk (RMSE) indicates strategy one has the highest average returns and the most risk. Strategy two has relatively average returns with basically zero risk. Strategies three and five exhibit approximately the same average returns and risk.

Chapter six will explain how a producer can benefit from the results found in chapter five by using a computer spreadsheet to analyze the six strategies in the fall when corn is being harvested. The spreadsheet will calculate storage cost, expected cash price and basis, estimate profits for each of the six strategies. Producers will be shown expected profit versus historical profit variance. Producers can then choose the strategy that best fits the amount of risk they are willing to accept.

Chapter 6

Computer Based Decision Support System

Chapter six will explain how producers in the Northern Neck of Virginia can use a computer based decision support system (DSS) to analyze strategy one (store with no forward pricing) , strategy two (store and forward price with cash contract), strategy three (store and hedge with futures), and strategy four (store and buy put and write call). Strategies four and six analyzed in previous chapters will not be included since they never had the best returns to storage and strategy four missed the most profits. Essentially, the procedures used in chapter 5 to analyze the six strategies will be performed by the DSS. The DSS developed will be in the form of an electronic spreadsheet. The program used is Microsoft Excel (version 5). Producers will need Microsoft Excel (version 5 or higher) to run the DSS. The DSS is titled, "The Virginia Corn Storage Advisor" (VCSA).

6.1 Design and Implementation

Figure 6.1 is a flow chart describing the framework of the VCSA. VCSA is divided into three sections.

1. User interface.
2. Models and historical data.
3. Output and results.

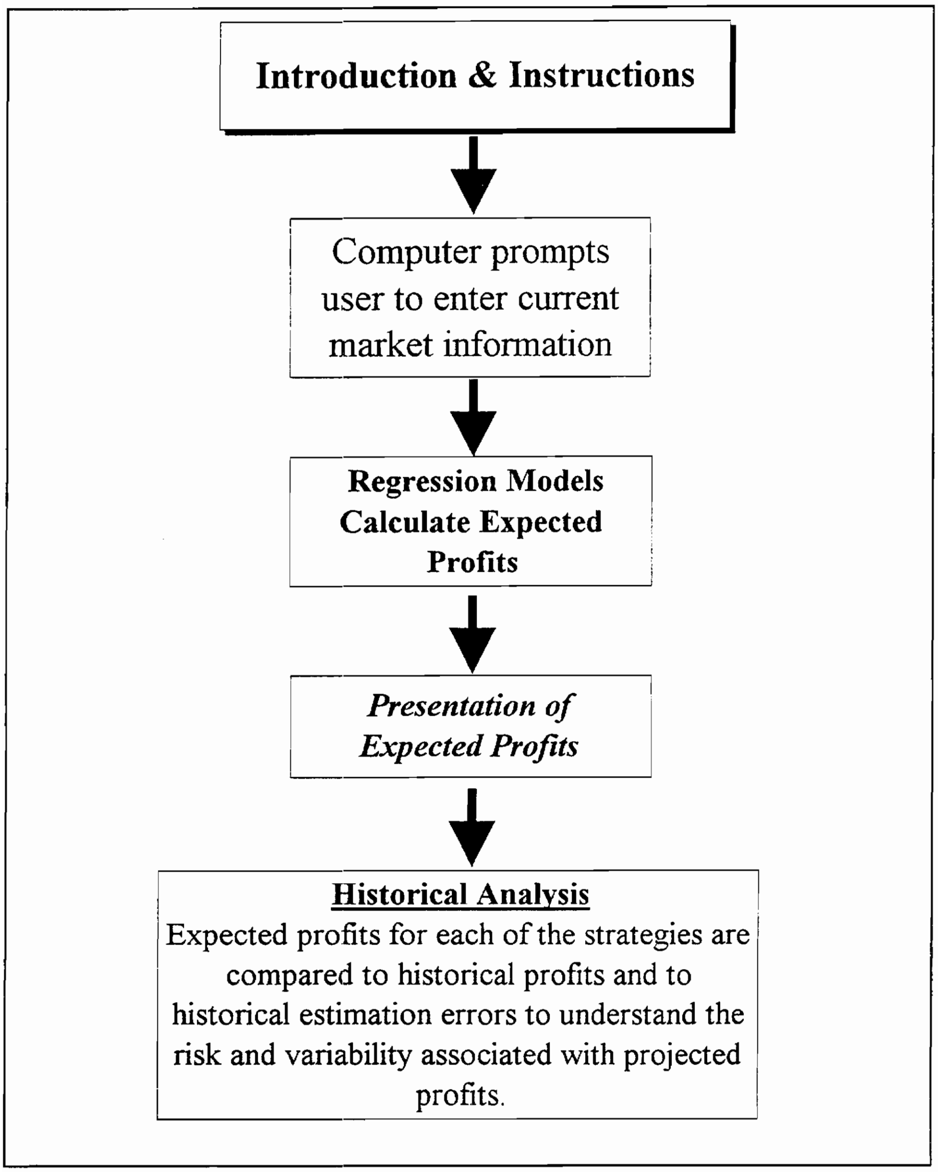


Figure 6.1 Flow Chart of The *VIRGINIA CORN STORAGE ADVISOR*.

The computer will prompt producers to enter current market information pertaining to the September 15 to October 1 time period. With current market information and three regression models, the computer will generate expected profits for the four marketing strategies. The computer will display a table comparing the returns from the four strategies. The computer will also provide a historical account of the profits and forecast error for each strategy. With the information provided, a producer can make a storage decision based on historical analysis of the cash, futures, and options markets and their own attitude towards risk and their financial ability to manage risk.

The VCSA is designed to help corn producers in the northern neck of Virginia. Producers from other regions in Virginia can use the VCSA provided they understand the difference between their local cash prices and basis and prices and basis from the northern neck of Virginia. A detailed account of the regression models used by the VCSA can be found in chapter four. The regression models are based on cash prices and basis in the northern neck of Virginia from 1974 to 1994. The VCSA is designed to analyze a storage period of six months from September 15 to March 15. A producer who wants to analyze a longer or shorter storage period will need a different set of storage cost and change in cash prices and basis that is not included in the VCSA.

The procedures used to calculate expected profits are described in chapter four. The producer will be asked to enter 12 numbers that should represent market conditions from September 15 to October 1. The current market information the producer is required to enter is:

1. A September Virginia northern neck cash price of dry corn (cents per bushel). Source: local grain elevator.
2. March 15 cash contract price (cents per bushel). Source: local grain elevator.
3. US Loan rate (cents per bushel). Source: Farm Service Agency
4. Virginia production (1,000 bushels). Source: USDA's September *Crop Production.*
5. US production (1,000 bushels). Source: USDA's September *Crop Production.*
6. Projected US total use (million bushels) for the new crop year beginning in September. Source: September WASDE[1].
7. Projected US ending stocks (million bushels) for the new crop year beginning in September. Source: September WASDE.
8. March corn futures at harvest (cents per bushel). Source: WSJ[2].
9. May corn futures at harvest (cents per bushel). Source: WSJ.
10. May put option premium for strike price closest to May futures. Source: WSJ.
11. May call option premium for strike price closest to May futures. Source: WSJ.
12. Prime interest rate. Source: WSJ.

It is important to understand that recommendations made by the VCSA are only as reliable as the numbers entered by the user. The majority of the information is currently available via electronic transmission, i.e., internet, USDA fax service, etc. Local grain elevators,

[1] World Agricultural Supply and Demand Estimates.
[2] Wall Street Journal.

extension agents, and Farm Service Agency personnel are also good sources for market information.

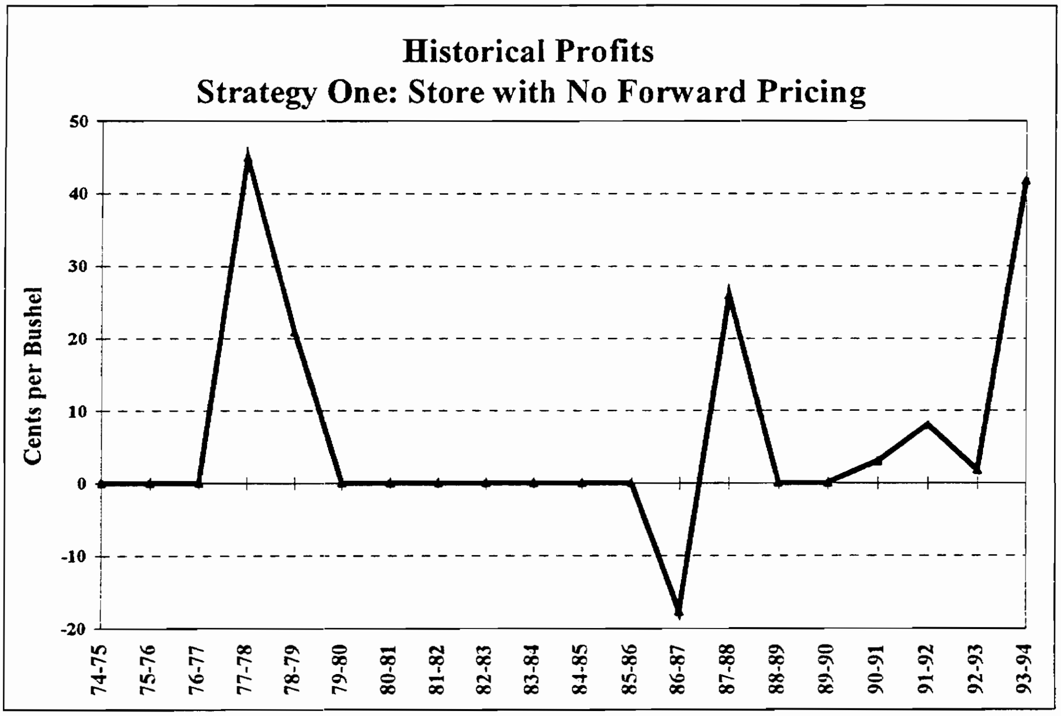
The procedures used to calculate expected profits are described in chapter four. The computer model will use current market information to estimate storage cost, expected change in cash price, March basis, and May basis. The following list is a brief explanation on how expected profits are calculated. For a more detailed explanation, please refer to chapters four and five.

1. Expected profits for strategy one (store and no forward price) are computed as estimated change in cash price minus estimated storage cost.
2. Estimated profits for strategy two (store and forward price with a cash contract) are computed as the cash contract price minus the break-even price.
3. Estimated profits for strategy three (store and forward price with March futures) are computed as expected change in basis minus estimated storage cost.
4. Estimated profits for strategy four (buy put and write call) are computed as the put option's strike price plus expected ending basis plus the call option's premium less the put option premium minus the break even price.

The output will include estimated storage cost for six months and estimated profits for the four strategies. Estimated profits for the four strategies are compared to historical averages, highs, and lows. The producer will have the option to view more information about individual strategies. The information will include a detailed explanation of the strategy and the historical strategy performance. The historical distributions of profits and root mean squared error for the forecast estimates are graphed for the producer to compare with current estimated profits. These graphs should give a producer an idea of the risk associated with the individual strategies.

Figures 6.2 through 6.5 are the graphical representations of returns for the four strategies. Figures 6.6 through 6.9 are the graphical representations of risk associated with each strategy. Figure 6.7 indicates that there is no risk associated with strategy two (store and forward price with a cash contract) Figure 6.9 indicates that the estimated profits tend to be under estimated for strategy four. Figure 6.6 indicates that forecast errors for strategy one (store and do not forward price) are more evenly distributed with higher levels of variability in the last few years when storage has become more important in an era of low stock levels.

It is important for a producer to understand the risk associated with each strategy. The relevant risk is the variability between the expected profits and historical profits. Looking at the historical differences between the estimated profits and actual profits can begin to give a producer an idea of the type of risk a certain strategy will exhibit. Historically, strategy one is the riskiest strategy to implement and strategy two is the least risky to implement. Strategy three and four demonstrate similar levels of risk and returns. The level of risk each producer is willing to take will determine the strategy implemented.



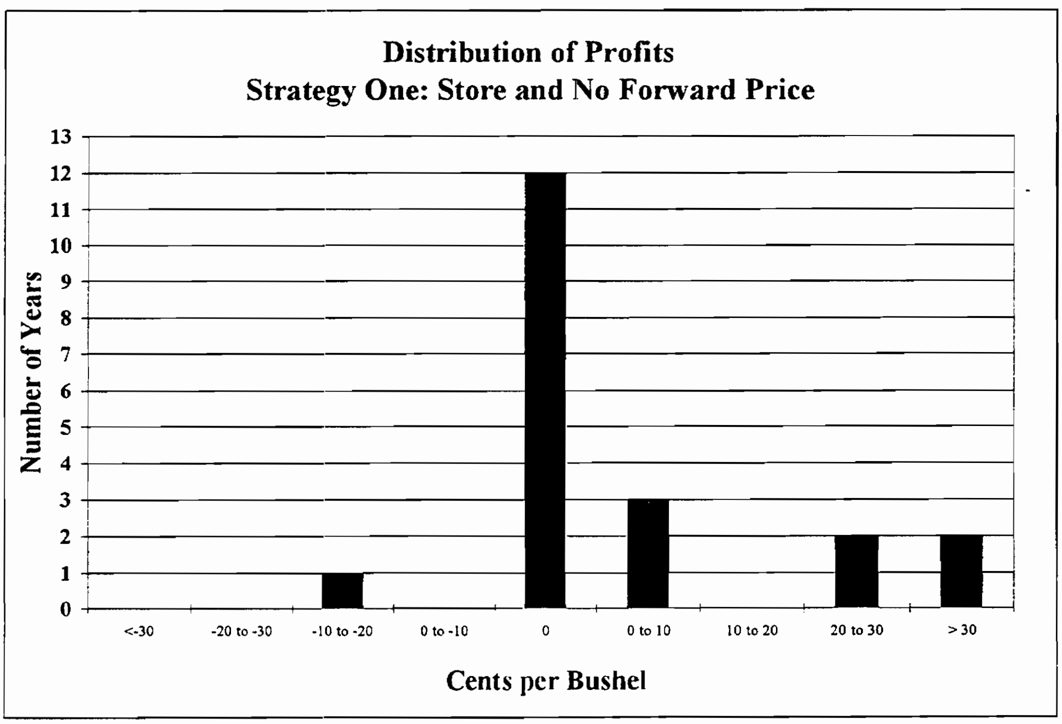


Figure 6.2 Historical Profits for Strategy One.

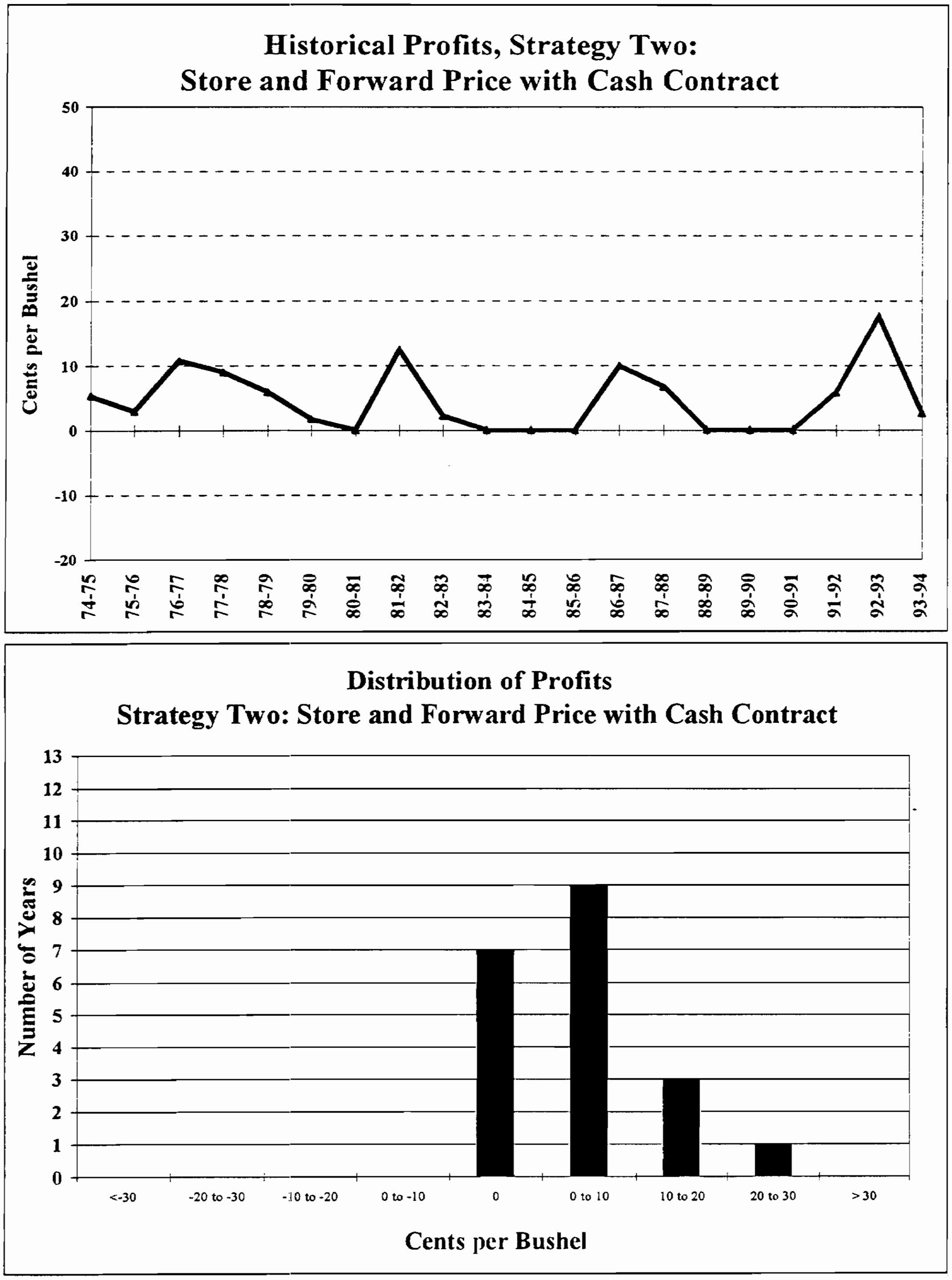
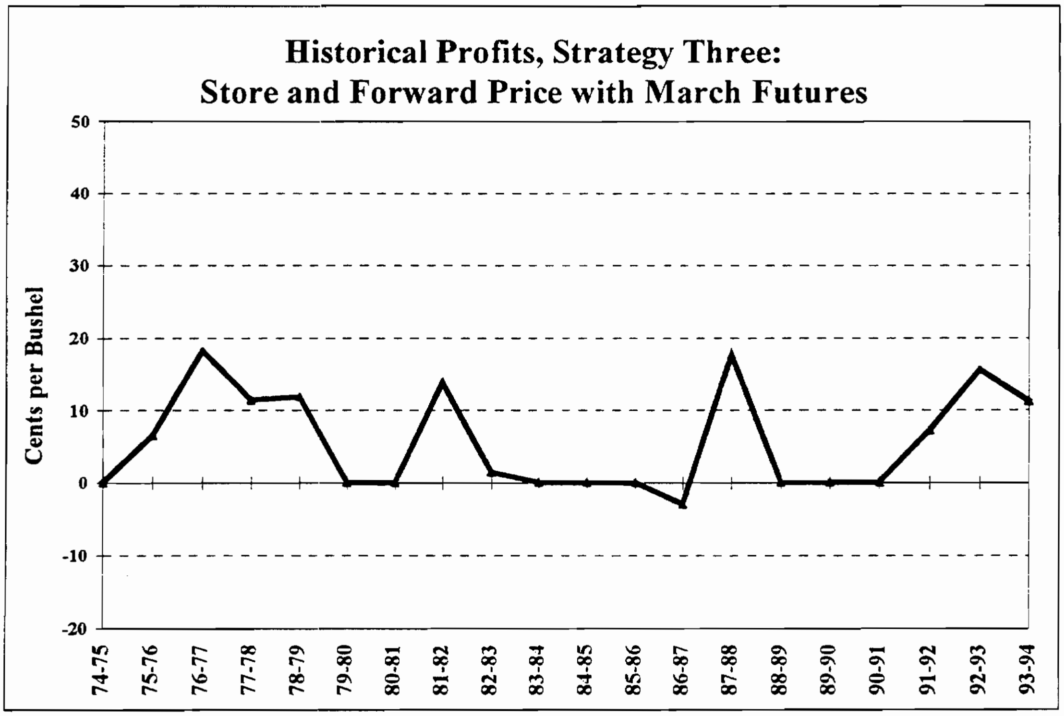


Figure 6.3 Historical Profits for Strategy Two.



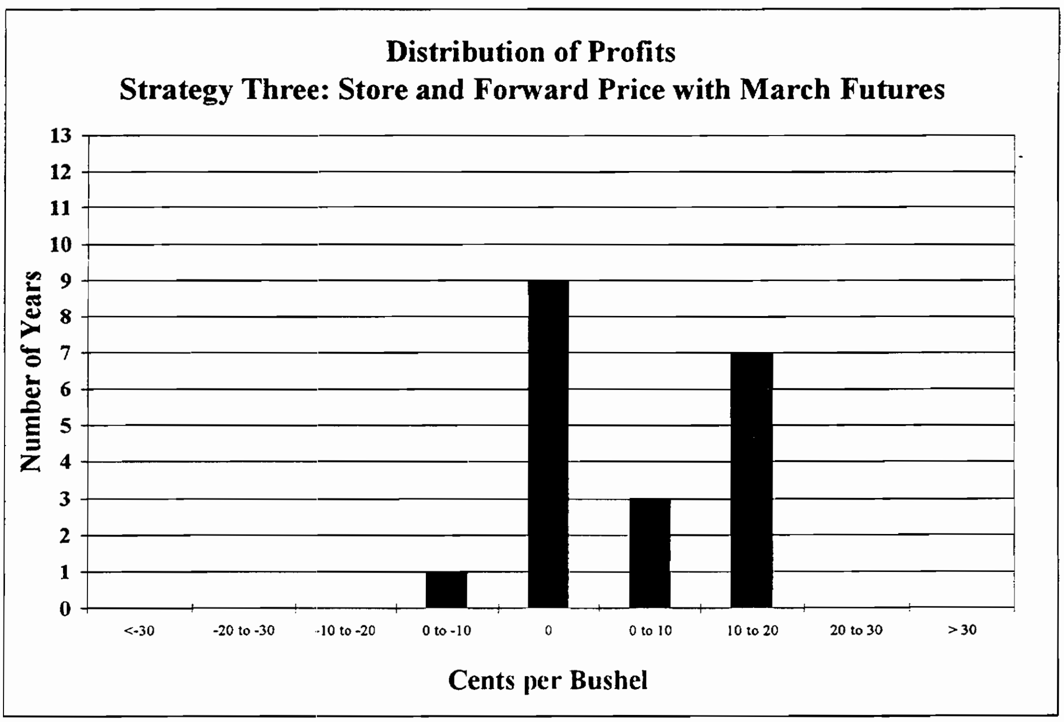
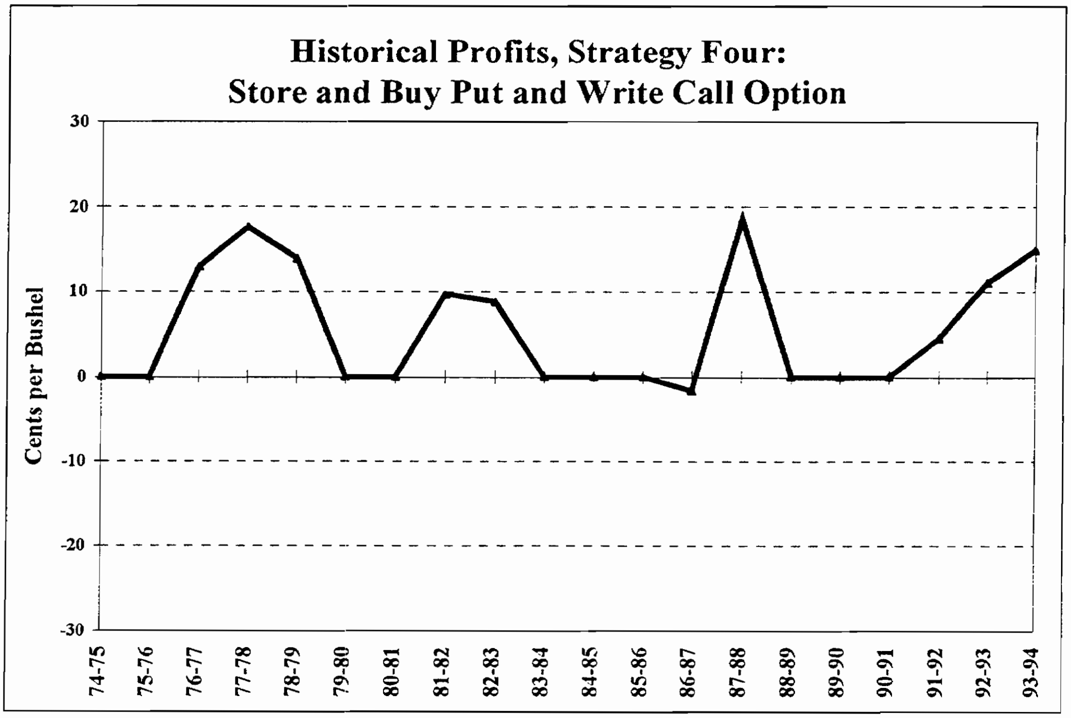


Figure 6.4 Historical Profits for Strategy Three.



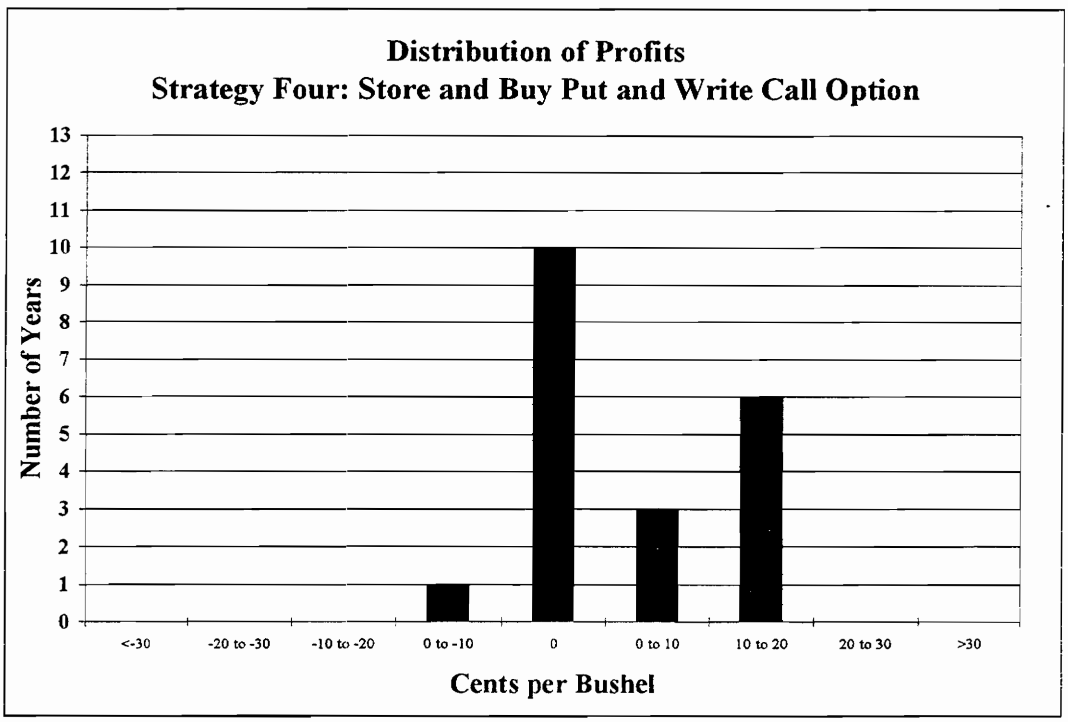
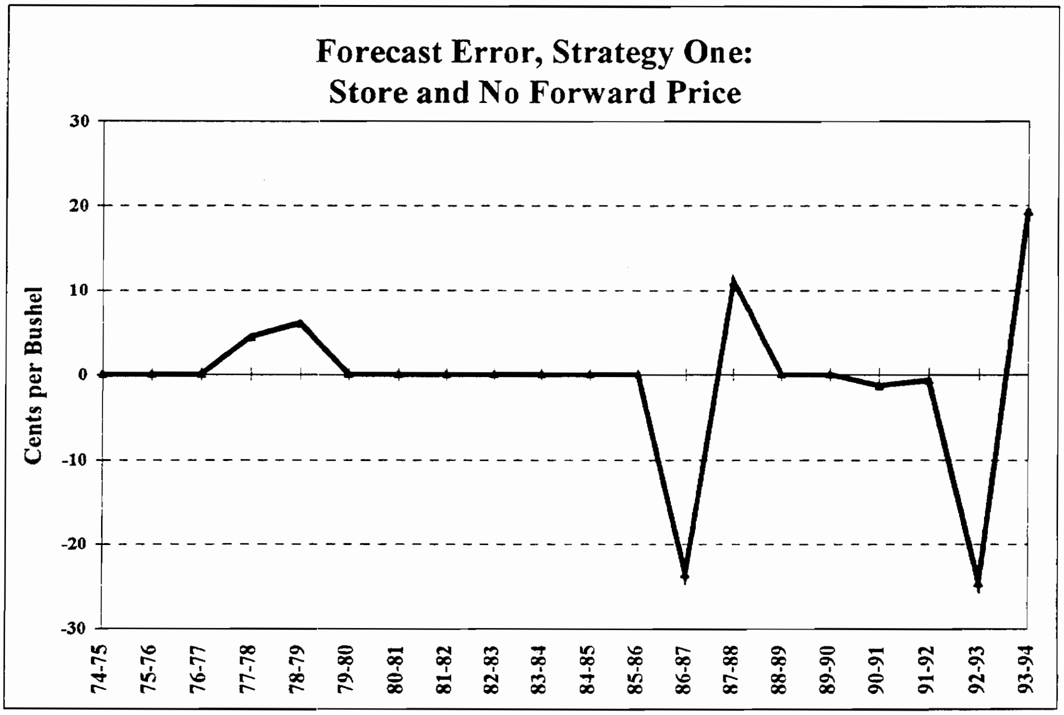


Figure 6.5 Historical Profits for Strategy Four.



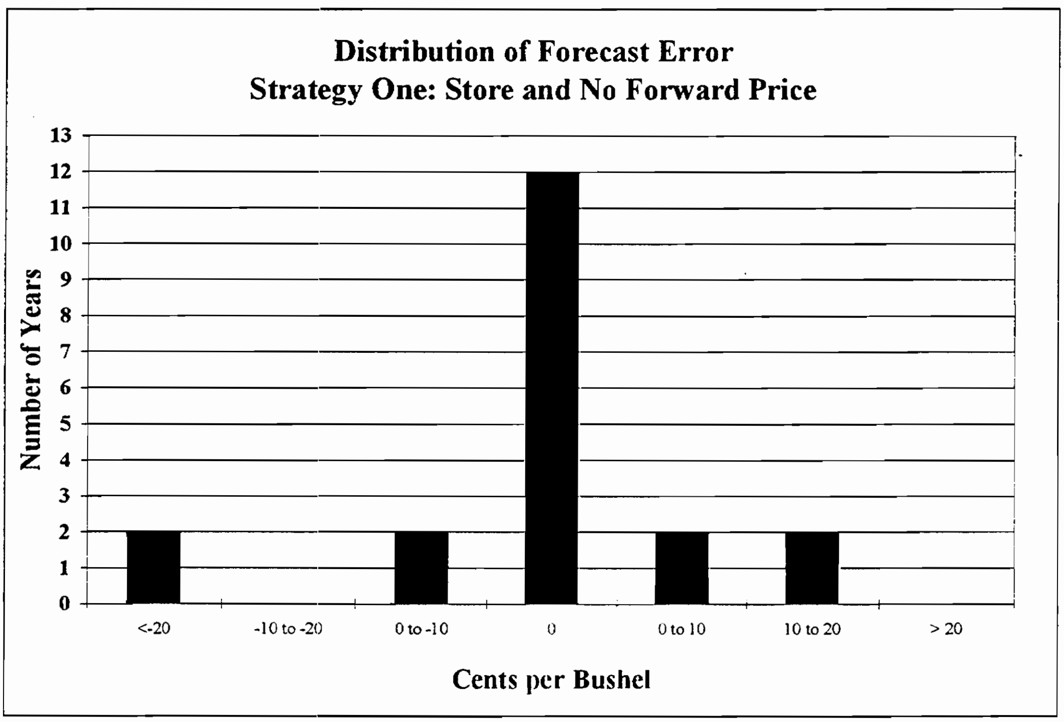
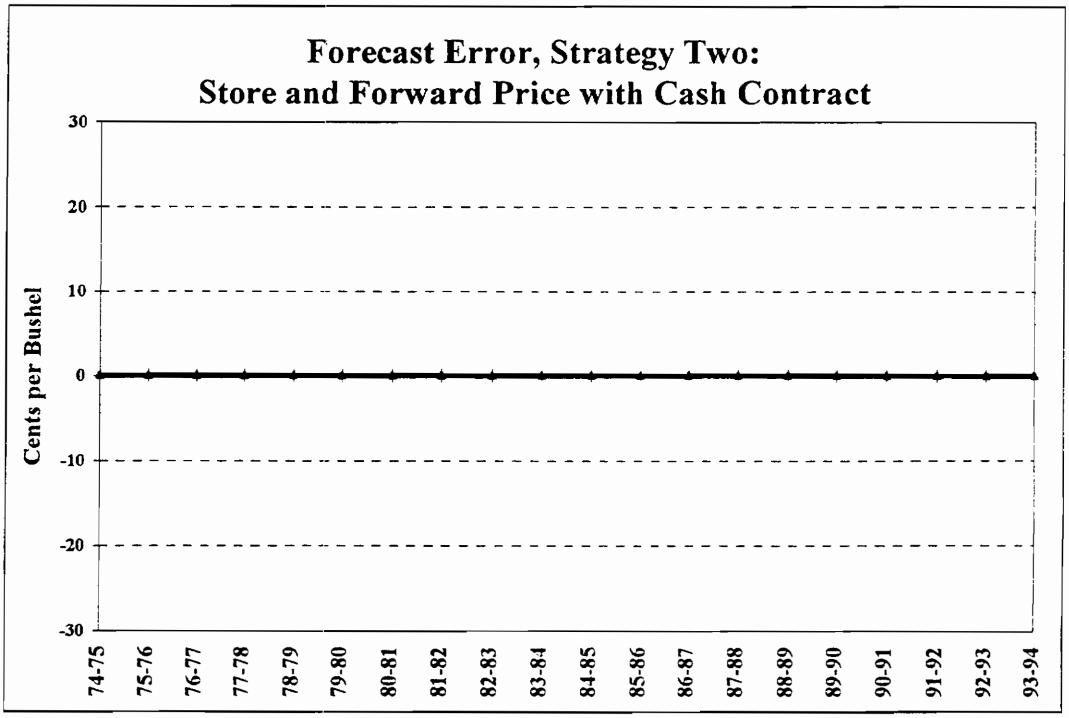


Figure 6.6 Historical Forecast Error for Strategy One.



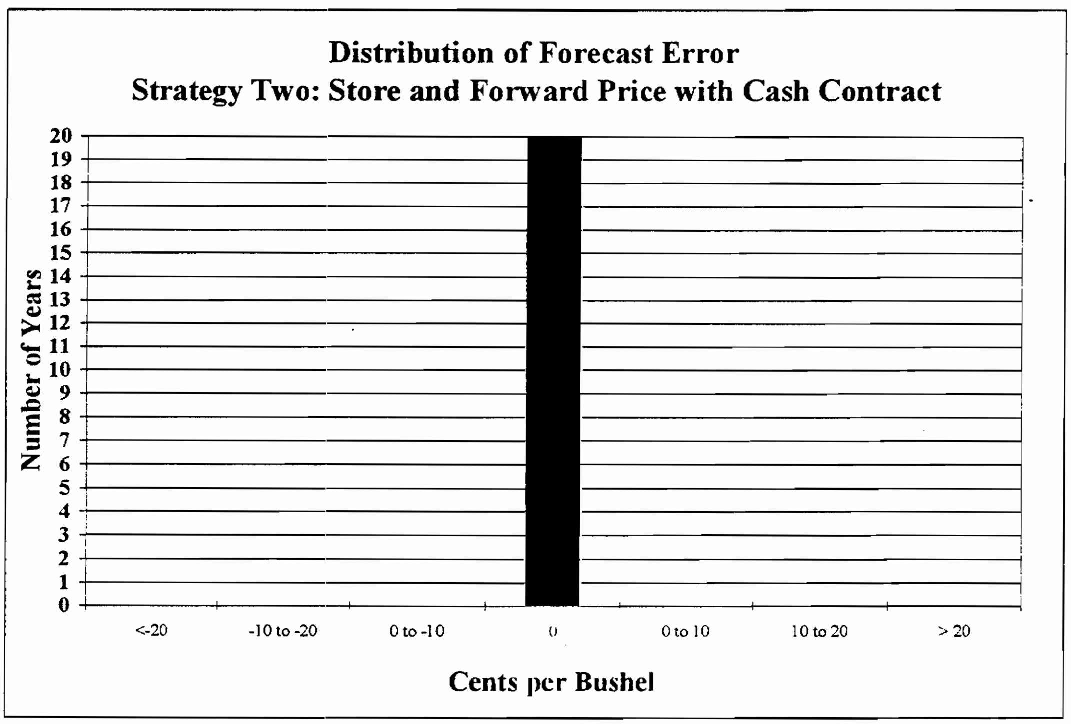
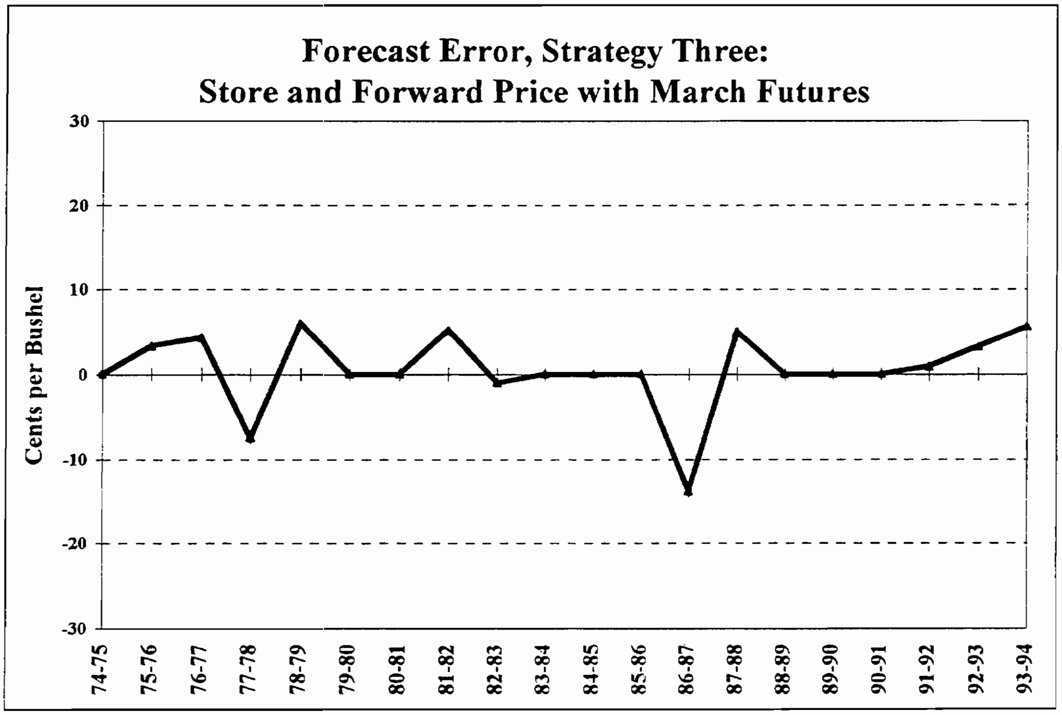


Figure 6.7 Historical Forecast Error for Strategy Two.



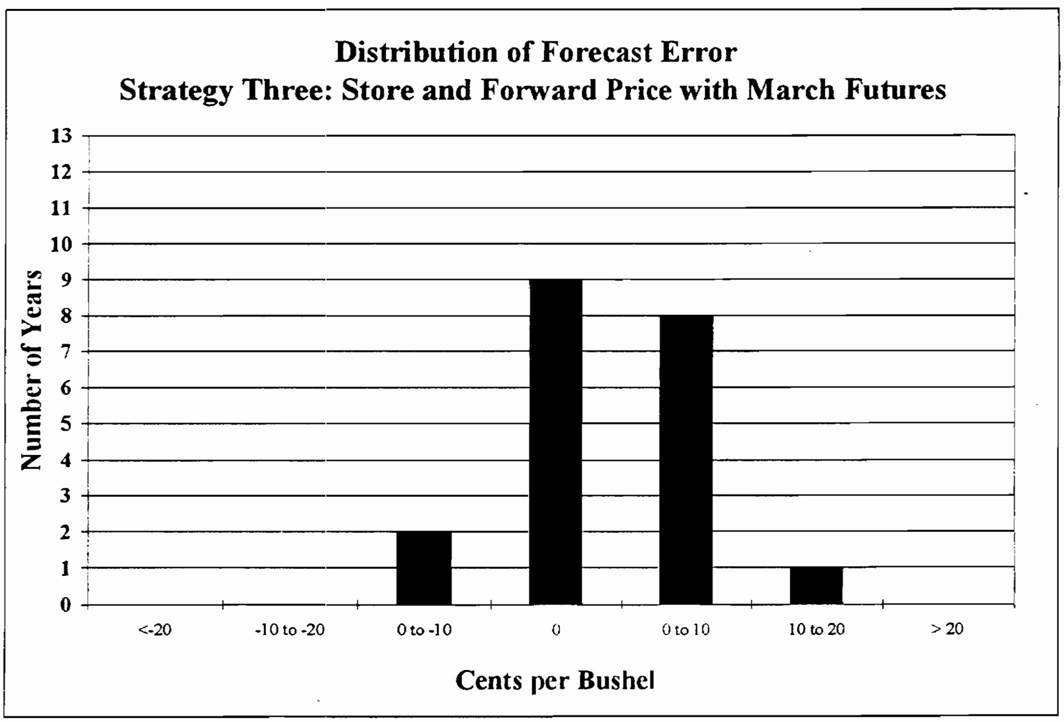
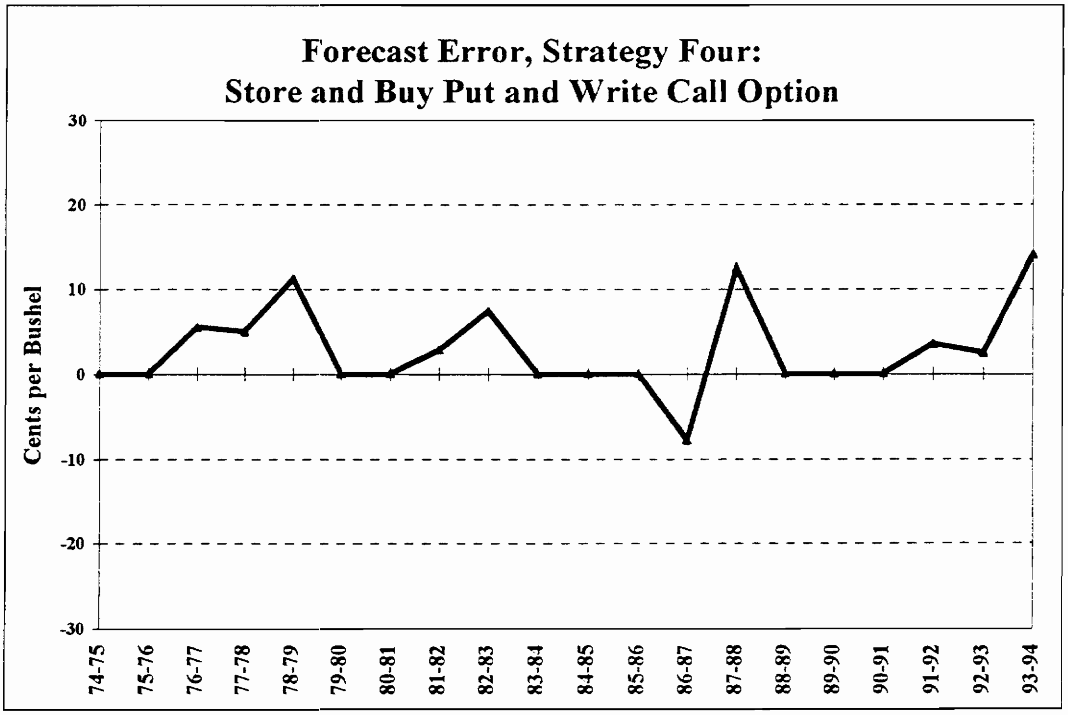


Figure 6.8 Historical Forecast Error for Strategy Three.



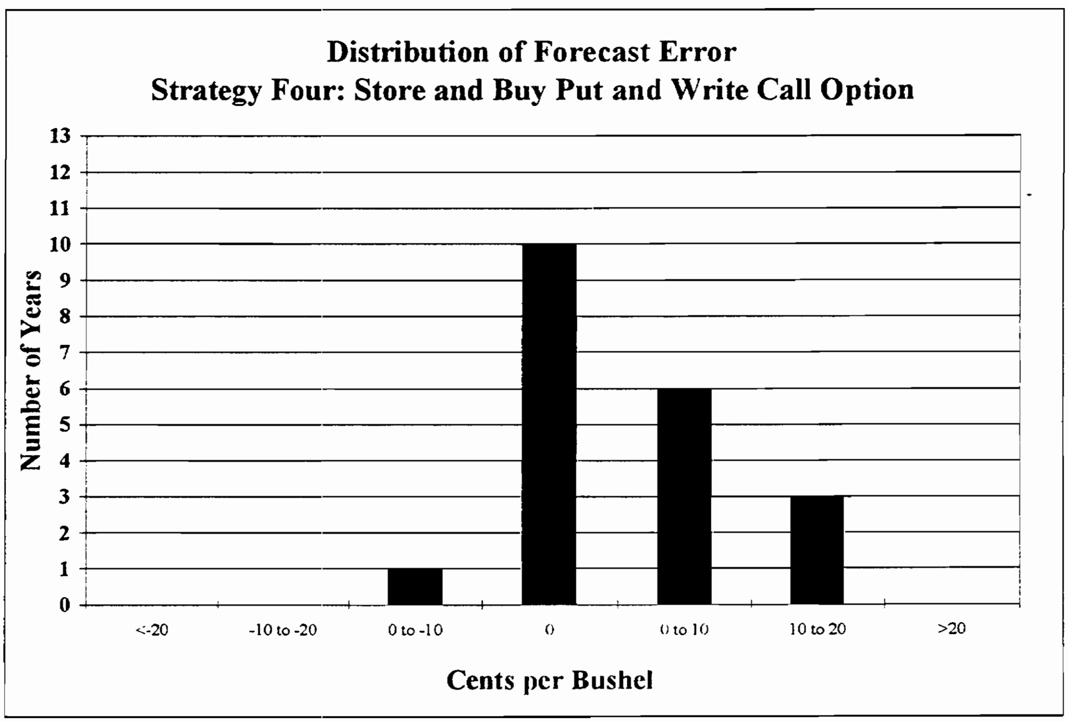


Figure 6.9 Historical Forecast Error for Strategy Four.

6.2 Example

The 1994/95 crop year will be used as an example of the procedures a producer would follow when using the Virginia Corn Storage Advisor to make a storage decision. All calculations will be made by the VCSA computer model which are based on the regression models in Chapter 4. The VCSA will calculate storage cost based on the methods described in Chapter 3. A producer will need to gather the current market information to enter into the computer program. The information is available around the second week of September. The following 12 variables are what a producer needs to gather.

Input Variables	September 1994
1. Cash Price at Harvest	220 cents per bushel
2. Cash Contract Price	239 cents per bushel
3. U.S. Loan Rate for Corn	189 cents per bushel
4. VA Production Estimate	31,960 thousand bushels
5. U.S. Production Estimate	9,257,170 thousand bushels
6. U.S. Corn Use Estimate	8,485 million bushels
7. U.S. Ending Stocks Estimate	1,601 million bushels
8. March Corn Futures	227.75 cents per bushel
9. May Corn Futures	234.5 cents per bushel
10. May Put Option Premium	10 cents per bushel
11. May Call Option Premium	8.25 cents per bushel
12. Interest Rate	6 percent

There are several important notes concerning the units of the variables collected. All prices are in cents per bushel. Production numbers are in **thousand** bushels because USDA's *Crop Production* publication reports production in thousand bushels. Stocks and Use numbers are in **million** bushels because WASDE reports stocks and use in million bushels. A producer needs to be aware that any data collection or entry error will produce erroneous output.

After the producer is assured that data for the current market variables have been entered correctly, the CSA will generate the estimated profits. A producer must then decide which strategy to implement. The following table reports the estimated storage profits for the 1994/95 crop year and compares them to the actual profits each strategy would have received if implemented.

Table 6.1 1994/95 Strategy Results

	Estimated Profits cents/bushel	Actual Profits cents/bushel	Actual - Estimated cents
Strategy One Store and No Forward Price	27.15	10.00	-17.15
Strategy Two Store and Forward Price with Cash Contract	-0.70	-0.70	0.00
Strategy Three Store and Forward Price with March Futures	0.96	-1.25	-2.21
Strategy Four Store and Buy Put and Write Call Option	-3.88	0.63	4.51

Strategy one had the highest estimated profits of 27 cents per bushel. Strategy four had the lowest estimated profits of negative 3.8 cents per bushel. It would appear that the only strategies worth considering in the fall of 1994 would be strategy one and three. Strategy one has an RSME of 9.5 cents (see table 5.12). According to historical price patterns, strategy one would not be expected to have negative returns. The largest forecast error for strategy one was 24.6 cents in 1992/93. In fact, strategy one had an actual profit of 10 cents per bushel in 1994/95, making the difference between actual and expected profits 17 cents.

Strategy four had an estimated profit of about 1 cent per bushel. The RSME for strategy four is approximately 5 cents. This means the estimated 1 cent profit could be easily wiped out or increased to 6 cents per bushel. The actual returns in 1994 would have been -1.25 cents per bushel with a forecast error of -2.21 cents if strategy four was implemented, which is in line with the historical RMSE. The largest forecast error for strategy three was 13 cents in 1986/87.

Strategy four is interesting to look at in this example because estimated profits were negative and actual profits turned out to be positive. The RMSE for strategy four is 5 cents. On average, this means the estimated profits of -3.8 cents per bushel could turn into -8.8 per bushel or 2.8 cents per bushel. In this case profits turned out to be positive and the producer could have made about half a cent per bushel of strategy four had been implemented.

The key to understanding the risk associated with each of the strategies is within a producers ability to understand RMSE (table 5.12) When a producer is analyzing estimated profits and trying to make a decision, the RMSE of each respective strategy is the best measure of risk associated with that strategy. When the RMSE is greater than estimated profits, there is a chance that a positive estimated profit could turn negative. However, when the RMSE is less than the estimated profits, there is a good chance that a positive estimated profit will remain positive. The last item to look at is the absolute historical error. Although future results are not guaranteed to fall within the historical bounds, the probability of an estimate falling outside historical limits are small.

Chapter 7

Summary

The decision between selling corn at harvest or placing corn in storage has been investigated. The decision to store corn is based on whether an expected price at some point in the spring is greater than the cost of storing corn plus the current cash price at harvest. Since 1974, cash prices in Virginia during the spring months of February, March, and April have been lower than cash prices at harvest in eight out of twenty years, or 40 percent of the time. In addition, cash prices have increased less than storage cost in another four years. Hence, over the last twenty years, cash prices have either decreased or not increased enough to cover storage cost 60 percent of the time. It is apparent that producers in Virginia cannot rely on cash prices regularly increasing from harvest to spring. Producers need marketing alternatives and a marketing strategy that will assist them in making corn storage decisions.

Six marketing strategies, outlined in chapter 3, were identified and analyzed based on their ability to capture profits and avoid losses. The six marketing strategies are:

1. Store without forward pricing,
2. Store and cash contract,
3. Store and forward price with futures,

4. Store and forward price with options,

5. Store and put and write call options,

6. Sell at harvest and buy call options.

Three regression models were developed to forecast change in cash prices and basis. The regression models were incorporated into the strategies to help producers forecast profits and losses. The three regression models are described in chapter three. Cash prices and basis were based on markets in the Northern Neck of Virginia for the 1974 to 1994 time period. The distribution of returns for each strategy were analyzed and compared using mean variance analysis and second degree stochastic dominance.

The strategies were compared according to their ability to capture profits and miss losses. The means and variances of historical profits have been compared according to an EV framework and second degree stochastic dominance and the RMSE of the forecast errors have been compared. The efficient strategies were one, two, and five according to the GSD 2.1 program. Strategy one is the riskiest strategy to implement but offers some of the best returns to storage. A producer implementing strategy two takes on no risk and receives average returns to storage. Strategy five is riskier than strategy two but not as risky as strategy one. Even though strategy three was not ranked by the GSD 2.1 program, it has almost the same historical mean and variance and RMSE as strategy five.

A producer should consider strategies one, two, three, and five when deciding what strategy to implement. Strategies four and six never had the best returns to storage and strategy four missed the most profits. If a producer is willing to take on risk, then strategy one offers the best returns. Strategy two offers the best returns to a producer who is very risk averse. Strategies three and five offer good returns to producers willing to take on more risk than strategy two and less than strategy one.

A computer based decision support system (DSS) was described in chapter six. The DSS is entitled *Virginia Corn Storage Advisor* (VCSA) and it incorporates the three regression models and calculates estimated profits for four strategies based on 12 current market variables. The 1994/95 crop year was used as an example how a producer would incorporate the VCSA into the storage decision process. The four strategies considered by the VCSA are:

1. Strategy one, store and no forward pricing,
2. Strategy two, store and forward price with a cash contract,
3. Strategy three, store and forward price with a March futures contract, and
4. Strategy four, store and write call and buy put option.

The first strategy, store with no forward pricing turned out to be the best alternative for the 1994/95 crop year. The key to understanding the risk associated with each of the strategies is within a producers ability to understand RMSE (table 5.12) When a producer is analyzing estimated profits and trying to make a decision, the RMSE of each respective strategy is the best measure of risk associated with that strategy. When the

RMSE is greater than estimated profits, there is a chance that a positive estimated profit could turn negative. However, when the RMSE is less than the estimated profits, there is a good chance that a positive estimated profit will remain positive. The last item to look at is the absolute historical error. Although future results are not guaranteed to fall within the historical bounds, the probability of an estimate falling outside historical limits are small.

Implications for Future Research

The model developed is based on the northern neck of Virginia. Future research should involve expanding the model to include other regions in the United States, including grain deficit and grain surplus areas. Future research should consider more closely the demand for stored grain in various regions and any structural changes in grain marketing for specific regions should be examined. Additionally, future research on storage profitability in wheat and soybeans would provide useful insight on the dynamics of grain supplies and price movements over storage periods of different durations.

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Appendix A

Data used in Regression Models

Table A.1 Data Used to Estimate Change in Cash Equation

Line Number	Year	Actual Change in Cash[1]	Cash Price[1] on Sept. 15	Cash Price[1] on Mar. 15	Harvest Price/Loan Rate	Harvest Price/ March Average Price(260.84)	% Ending Stocks	VAP/USP	Loan Rate	Ending Stocks[2]	Use[2]	Virginia Average Production[3]	U.S. Average Production[3]
1	74-75	-59	327	268	2.97	1.25	0.069	0.0081	110	350	5,074	40,500	4,994,730
2	75-76	-20	283	263	2.57	1.08	0.103	0.0081	110	568	5,515	46,200	5,687,248
3	76-77	-3	253	250	1.69	0.97	0.073	0.0077	150	421	5,785	45,500	5,891,823
4	77-78	64	172	236	0.86	0.66	0.245	0.0051	200	1401	5,730	31,900	6,229,084
5	78-79	43	198	241	0.99	0.76	0.224	0.0073	200	1436	6,420	49,880	6,797,650
6	79-80	3	264	267	1.26	1.01	0.143	0.0071	210	1066	7,440	51,600	7,268,175
7	80-81	-15	345	330	1.53	1.32	0.094	0.0057	225	704	7,465	37,200	6,534,370
8	81-82	-4	262	258	1.09	1.00	0.190	0.0063	240	1432	7,525	49,800	7,940,421
9	82-83	75	208	283	0.82	0.80	0.378	0.0069	255	2871	7,600	57,040	8,318,678
10	83-84	8	357	365	1.35	1.37	0.130	0.0043	265	900	6,925	18,750	4,390,443
11	84-85	-26	301	275	1.18	1.15	0.140	0.0072	255	1016	7,250	54,540	7,551,991
12	85-86	17	227	244	0.89	0.87	0.384	0.0058	255	2717	7,070	48,760	8,468,504
13	86-87	1	158	159	0.82	0.61	0.768	0.0031	192	5339	6,950	25,500	8,268,141
14	87-88	46	167	213	0.87	0.64	0.606	0.0033	192	4557	7,515	23,250	7,140,505
15	88-89	-12	290	278	1.64	1.11	0.215	0.0060	177	1559	7,260	26,640	4,462,475
16	89-90	23	236	259	1.43	0.90	0.224	0.0045	165	1679	7,500	32,860	7,321,005
17	90-91	28	236	264	1.50	0.90	0.170	0.0042	157	1375	8,075	33,750	8,118,117
18	91-92	31	245	276	1.51	0.94	0.143	0.0035	162	1102	7,725	25,600	7,295,071
19	92-93	21	206	227	1.20	0.79	0.227	0.0038	172	1826	8,035	33,600	8,769,865
20	93-94	62	237	299	1.38	0.91	0.166	0.0023	172	1340	8,050	16,500	7,229,427

1. Cents per bushel
2. USDA September Estimate (million bushels)
3. USDA September Estimate (1,000 bushels)

Table A.2 Data Used to Estimate Change in Basis for March Futures

Line Number	Year	Cash Price[1] on Sept. 15	Cash Price[1] on Mar. 15	March Futures on Sept. 15	March Futures on Mar. 15	Beginning Basis	Ending Basis	Change in Basis	Harvest Price/ March Average Price(260.84)	VAP/USP
1	74-75	327	268	364.75	287.25	-37.75	-19.25	18.50	1.25	0.0081
2	75-76	283	263	318.50	267.25	-35.50	-4.25	31.25	1.08	0.0081
3	76-77	253	250	297.00	253.75	-44.00	-3.75	40.25	0.97	0.0077
4	77-78	172	236	208.25	241.75	-36.25	-5.75	30.50	0.66	0.0051
5	78-79	198	241	230.50	239.50	-32.50	1.50	34.00	0.76	0.0073
6	79-80	264	267	296.00	260.00	-32.00	7.00	39.00	1.01	0.0071
7	80-81	345	330	363.75	347.25	-18.75	-17.25	1.50	1.32	0.0057
8	81-82	262	258	315.50	258.25	-53.50	-0.25	53.25	1.00	0.0063
9	82-83	208	283	240.50	287.00	-32.50	-4.00	28.50	0.80	0.0069
10	83-84	357	365	356.50	349.25	0.50	15.75	15.25	1.37	0.0043
11	84-85	301	275	291.25	272.50	9.75	2.50	-7.25	1.15	0.0072
12	85-86	227	244	229.50	231.25	-2.50	12.75	15.25	0.87	0.0058
13	86-87	158	159	175.50	160.75	-17.50	-1.75	15.75	0.61	0.0031
14	87-88	167	213	189.25	197.50	-22.25	15.50	37.75	0.64	0.0033
15	88-89	290	278	305.25	278.00	-15.25	0.00	15.25	1.11	0.0060
16	89-90	236	259	236.50	243.75	-0.50	15.25	15.75	0.90	0.0045
17	90-91	236	264	243.25	251.25	-7.25	12.75	20.00	0.90	0.0042
18	91-92	245	276	264.00	264.75	-19.00	11.25	30.25	0.94	0.0035
19	92-93	206	227	229.00	215.25	-23.00	11.75	34.75	0.79	0.0038
20	93-94	237	299	246.75	277.25	-9.75	21.75	31.50	0.91	0.0023

1. Cents per bushel

Table A.3 Data Used to Estimate Change in Basis for May Futures

Line Number	Year	Cash Price[1] on Sept. 15	Cash Price[1] on Mar. 15	May Futures on Sept. 15	May Futures on Mar. 15	Beginning Basis	Ending Basis	Change in Basis	Harvest Price/ March Average Price(260.84)	VAP/USP
1	74-75	327	268	369.50	287.50	-42.50	-19.50	23.00	1.25	0.0081
2	75-76	283	263	320.75	273.25	-37.75	-10.25	27.50	1.08	0.0081
3	76-77	253	250	301.00	258.75	-48.00	-8.75	39.25	0.97	0.0077
4	77-78	172	236	212.75	245.75	-40.75	-9.75	31.00	0.66	0.0051
5	78-79	198	241	236.00	244.75	-38.00	-3.75	34.25	0.76	0.0073
6	79-80	264	267	303.00	270.50	-39.00	-3.50	35.50	1.01	0.0071
7	80-81	345	330	367.50	357.00	-22.50	-27.00	-4.50	1.32	0.0057
8	81-82	262	258	326.25	270.00	-64.25	-12.00	52.25	1.00	0.0063
9	82-83	208	283	250.50	295.75	-42.50	-12.75	29.75	0.80	0.0069
10	83-84	357	365	359.75	349.25	-2.75	15.75	18.50	1.37	0.0043
11	84-85	301	275	295.50	274.50	5.50	0.50	-5.00	1.15	0.0072
12	85-86	227	244	235.25	229.50	-8.25	14.50	22.75	0.87	0.0058
13	86-87	158	159	182.00	161.00	-24.00	-2.00	22.00	0.61	0.0031
14	87-88	167	213	194.25	204.25	-27.25	8.75	36.00	0.64	0.0033
15	88-89	290	278	307.50	282.25	-17.50	-4.25	13.25	1.11	0.0060
16	89-90	236	259	241.75	250.75	-5.75	8.25	14.00	0.90	0.0045
17	90-91	236	264	249.75	258.50	-13.75	5.50	19.25	0.90	0.0042
18	91-92	245	276	268.25	271.50	-23.25	4.50	27.75	0.94	0.0035
19	92-93	206	227	235.25	221.00	-29.25	6.00	35.25	0.79	0.0038
20	93-94	237	299	251.75	284.25	-14.75	14.75	29.50	0.91	0.0023

1. Cents per bushel

Table A.4 March Futures Highest and Lowest Closing Price

Year	March Futures on Sept. 15	March Futures on Mar. 15	Highest Closing Price Between Sept. and Mar.	Lowest Closing Price Between Sept. and Mar.	Sept. 15 price minus High Closing Price
74-75	364.75	287.25	402.50	258.25	-37.75
75-76	318.50	267.25	332.75	259.50	-14.25
76-77	297.00	253.75	299.00	240.00	-2.00
77-78	208.25	241.75	249.50	270.75	-41.25
78-79	230.50	239.50	247.50	226.25	-17.00
79-80	296.00	260.00	304.75	260.00	-8.75
80-81	363.75	347.25	409.00	345.50	-45.25
81-82	315.50	258.25	321.00	255.50	-5.50
82-83	240.50	287.00	291.50	227.75	-51.00
83-84	356.50	349.25	377.00	316.50	-20.50
84-85	291.25	272.50	295.75	262.00	-4.50
85-86	229.50	231.25	250.75	225.25	-21.25
86-87	175.50	160.75	188.00	142.75	-12.50
87-88	189.25	197.50	203.75	177.50	-14.50
88-89	305.25	278.00	305.25	264.75	0.00
89-90	236.50	243.75	253.00	234.50	-16.50
90-91	243.25	251.25	251.25	230.00	-8.00
91-92	264.00	264.75	271.50	246.50	-7.50
92-93	229.00	215.25	234.50	210.25	-5.50
93-94	246.75	277.25	310.00	244.50	-63.25

Table A.5 May Futures Highest and Lowest Closing Price

Year	May Futures on Sept. 15	May Futures on Mar. 15	Highest Closing Price Between Sept. and Mar.	Lowest Closing Price Between Sept. and Mar.	May Option Strike	Sept. 15 price minus High Closing Price
74-75	369.50	287.50	406.75	242.50	370	-37.25
75-76	320.75	273.25	324.50	264.25	320	-3.75
76-77	301.00	258.75	305.50	236.75	300	-4.50
77-78	212.75	245.75	265.75	212.25	210	-53.00
78-79	236.00	244.75	267.00	232.25	240	-31.00
79-80	303.00	270.50	313.25	258.25	300	-10.25
80-81	367.50	357.00	415.75	339.50	370	-48.25
81-82	326.25	270.00	329.50	266.75	330	-3.25
82-83	250.50	295.75	318.75	236.25	250	-68.25
83-84	359.75	349.25	380.25	321.25	360	-20.50
84-85	295.50	274.50	300.50	270.50	300	-5.00
85-86	235.25	229.50	258.75	225.25	240	-23.50
86-87	182.00	161.00	192.50	150.75	180	-10.50
87-88	194.25	204.25	216.00	186.00	190	-21.75
88-89	307.50	282.25	307.50	259.00	310	0.00
89-90	241.75	250.75	290.75	239.50	240	-49.00
90-91	249.75	258.50	259.00	237.00	250	-9.25
91-92	268.25	271.50	278.75	244.00	270	-10.50
92-93	235.25	221.00	236.00	218.50	240	-0.75
93-94	251.75	284.25	315.00	248.50	250	-63.25

Appendix B

Data used to Calculate Historical Volatility

May Futures Price Used to Calculate Volatilities

	1974-75		1975-76		1976-77		1977-78
Date	Close	Date	Close	Date	Close	Date	Close
13-Aug-74	349.00	19-Aug-75	329.50	17-Aug-76	283.00	16-Aug-77	208.25
14-Aug-74	359.00	20-Aug-75	338.00	18-Aug-76	287.00	17-Aug-77	207.50
15-Aug-74	354.00	21-Aug-75	332.75	19-Aug-76	291.50	18-Aug-77	206.50
16-Aug-74	364.00	22-Aug-75	332.50	20-Aug-76	290.25	19-Aug-77	206.00
19-Aug-74	363.75	25-Aug-75	330.25	23-Aug-76	294.75	22-Aug-77	204.25
20-Aug-74	353.75	26-Aug-75	320.25	24-Aug-76	292.75	23-Aug-77	203.75
21-Aug-74	355.00	27-Aug-75	325.25	25-Aug-76	290.50	24-Aug-77	205.75
22-Aug-74	365.00	28-Aug-75	320.25	26-Aug-76	291.25	25-Aug-77	205.75
23-Aug-74	370.50	29-Aug-75	313.75	27-Aug-76	294.75	26-Aug-77	205.25
26-Aug-74	361.00	02-Sep-75	306.00	30-Aug-76	292.00	29-Aug-77	204.25
27-Aug-74	352.50	03-Sep-75	308.75	31-Aug-76	293.00	30-Aug-77	206.00
28-Aug-74	358.50	04-Sep-75	307.75	01-Sep-76	297.75	31-Aug-77	205.50
29-Aug-74	354.25	05-Sep-75	309.50	02-Sep-76	303.25	01-Sep-77	206.00
30-Aug-74	352.00	08-Sep-75	304.25	03-Sep-76	303.50	02-Sep-77	207.00
03-Sep-74	342.00	09-Sep-75	298.25	07-Sep-76	313.50	06-Sep-77	209.75
04-Sep-74	338.00	10-Sep-75	302.50	08-Sep-76	308.75	07-Sep-77	210.75
05-Sep-74	347.75	11-Sep-75	300.50	09-Sep-76	307.75	08-Sep-77	212.50
06-Sep-74	351.50	12-Sep-75	310.50	10-Sep-76	305.50	09-Sep-77	214.50
09-Sep-74	361.50	15-Sep-75	310.50	13-Sep-76	303.25	12-Sep-77	216.00
10-Sep-74	356.75	16-Sep-75	316.25	14-Sep-76	300.25	13-Sep-77	215.00
11-Sep-74	360.75	17-Sep-75	324.50	15-Sep-76	302.00	14-Sep-77	212.75
11-Feb-75	314.75	18-Feb-76	275.25	15-Feb-77	260.75	14-Feb-78	230.25
12-Feb-75	312.75	19-Feb-76	275.50	16-Feb-77	263.50	15-Feb-78	230.00
13-Feb-75	313.25	20-Feb-76	274.50	17-Feb-77	264.75	16-Feb-78	229.75
14-Feb-75	312.75	23-Feb-76	275.25	18-Feb-77	265.50	17-Feb-78	230.50
18-Feb-75	304.50	24-Feb-76	274.25	22-Feb-77	263.50	21-Feb-78	230.50
19-Feb-75	294.50	25-Feb-76	275.50	23-Feb-77	264.00	22-Feb-78	230.50
20-Feb-75	289.25	26-Feb-76	275.25	24-Feb-77	265.25	23-Feb-78	230.25
21-Feb-75	284.75	27-Feb-76	278.00	25-Feb-77	263.50	24-Feb-78	230.25
24-Feb-75	282.75	01-Mar-76	276.75	28-Feb-77	262.00	27-Feb-78	229.00
25-Feb-75	277.25	02-Mar-76	272.75	01-Mar-77	261.25	28-Feb-78	228.50
26-Feb-75	277.25	03-Mar-76	274.50	02-Mar-77	260.00	01-Mar-78	229.50
27-Feb-75	271.75	04-Mar-76	275.50	03-Mar-77	259.75	02-Mar-78	231.50
28-Feb-75	262.25	05-Mar-76	276.00	04-Mar-77	260.25	03-Mar-78	233.25
03-Mar-75	268.50	08-Mar-76	274.25	07-Mar-77	260.75	06-Mar-78	233.50
04-Mar-75	269.50	09-Mar-76	275.00	08-Mar-77	263.00	07-Mar-78	236.00
05-Mar-75	274.50	10-Mar-76	274.50	09-Mar-77	262.50	08-Mar-78	237.50
06-Mar-75	283.25	11-Mar-76	273.50	10-Mar-77	261.00	09-Mar-78	237.75
07-Mar-75	278.00	12-Mar-76	271.75	11-Mar-77	260.75	10-Mar-78	236.00
10-Mar-75	280.50	15-Mar-76	269.00	14-Mar-77	258.50	13-Mar-78	239.75
11-Mar-75	290.50	16-Mar-76	268.00	15-Mar-77	258.75	14-Mar-78	242.50
12-Mar-75	296.50	17-Mar-76	271.00	16-Mar-77	260.75	15-Mar-78	243.75

May Futures Price Used to Calculate Volatilities

Date	1978-79 Close	Date	1979-80 Close	Date	1980-81 Close	Date	1981-82 Close
15-Aug-78	245.25	14-Aug-79	296.00	19-Aug-80	351.25	18-Aug-81	341.25
16-Aug-78	238.75	15-Aug-79	296.75	20-Aug-80	349.00	19-Aug-81	342.25
17-Aug-78	239.75	16-Aug-79	300.00	21-Aug-80	350.50	20-Aug-81	341.50
18-Aug-78	242.00	17-Aug-79	299.25	22-Aug-80	349.75	21-Aug-81	332.25
21-Aug-78	242.25	20-Aug-79	298.75	25-Aug-80	356.25	24-Aug-81	327.00
22-Aug-78	241.00	21-Aug-79	306.50	26-Aug-80	363.00	25-Aug-81	325.25
23-Aug-78	239.75	22-Aug-79	301.50	27-Aug-80	360.75	26-Aug-81	329.50
24-Aug-78	242.00	23-Aug-79	299.75	28-Aug-80	362.75	27-Aug-81	325.00
25-Aug-78	241.50	24-Aug-79	302.50	29-Aug-80	368.75	28-Aug-81	328.75
28-Aug-78	238.50	27-Aug-79	301.25	02-Sep-80	372.25	31-Aug-81	333.75
29-Aug-78	235.50	28-Aug-79	299.50	03-Sep-80	371.75	01-Sep-81	335.25
30-Aug-78	237.25	29-Aug-79	303.25	04-Sep-80	369.75	02-Sep-81	334.75
31-Aug-78	236.25	30-Aug-79	302.75	05-Sep-80	371.75	03-Sep-81	338.25
01-Sep-78	237.00	31-Aug-79	303.50	08-Sep-80	377.00	04-Sep-81	332.00
05-Sep-78	235.50	04-Sep-79	293.50	09-Sep-80	372.75	08-Sep-81	325.75
06-Sep-78	235.00	05-Sep-79	294.00	10-Sep-80	369.75	09-Sep-81	325.75
07-Sep-78	236.50	06-Sep-79	290.25	11-Sep-80	371.50	10-Sep-81	327.00
08-Sep-78	237.25	07-Sep-79	291.00	12-Sep-80	365.50	11-Sep-81	323.25
11-Sep-78	238.75	10-Sep-79	296.50	15-Sep-80	365.25	14-Sep-81	327.50
12-Sep-78	239.25	11-Sep-79	292.75	16-Sep-80	367.50	15-Sep-81	329.50
13-Sep-78	237.50	12-Sep-79	294.25	17-Sep-80	365.75	16-Sep-81	327.50
13-Feb-79	244.75	12-Feb-80	287.25	10-Feb-81	370.75	09-Feb-82	280.50
14-Feb-79	247.25	13-Feb-80	288.75	11-Feb-81	373.50	10-Feb-82	282.75
15-Feb-79	247.25	14-Feb-80	286.50	12-Feb-81	371.50	11-Feb-82	282.75
16-Feb-79	247.50	15-Feb-80	285.50	13-Feb-81	374.50	12-Feb-82	281.50
20-Feb-79	248.25	19-Feb-80	282.75	17-Feb-81	375.25	16-Feb-82	280.25
21-Feb-79	249.00	20-Feb-80	283.25	18-Feb-81	371.75	17-Feb-82	279.25
22-Feb-79	249.75	21-Feb-80	283.00	19-Feb-81	374.75	18-Feb-82	278.50
23-Feb-79	249.00	22-Feb-80	281.00	20-Feb-81	373.75	19-Feb-82	275.25
26-Feb-79	247.25	25-Feb-80	282.25	23-Feb-81	371.00	22-Feb-82	275.25
27-Feb-79	246.75	26-Feb-80	281.50	24-Feb-81	371.50	23-Feb-82	273.25
28-Feb-79	246.75	27-Feb-80	279.25	25-Feb-81	370.75	24-Feb-82	272.50
01-Mar-79	247.25	28-Feb-80	278.25	26-Feb-81	369.00	25-Feb-82	270.25
02-Mar-79	246.25	29-Feb-80	276.25	27-Feb-81	369.75	26-Feb-82	270.00
05-Mar-79	247.00	03-Mar-80	274.25	02-Mar-81	360.00	01-Mar-82	271.25
06-Mar-79	247.00	04-Mar-80	277.00	03-Mar-81	361.25	02-Mar-82	272.50
07-Mar-79	247.50	05-Mar-80	277.50	04-Mar-81	356.50	03-Mar-82	272.75
08-Mar-79	246.25	06-Mar-80	275.75	05-Mar-81	355.75	04-Mar-82	272.25
09-Mar-79	246.00	07-Mar-80	274.75	06-Mar-81	356.75	05-Mar-82	270.75
12-Mar-79	244.25	10-Mar-80	271.75	09-Mar-81	359.75	08-Mar-82	268.25
13-Mar-79	243.25	11-Mar-80	271.00	10-Mar-81	355.75	09-Mar-82	267.00
14-Mar-79	243.00	12-Mar-80	273.25	11-Mar-81	354.25	10-Mar-82	268.50

May Futures Price Used to Calculate Volatilities

Date	1982-83 Close	Date	1983-84 Close	Date	1984-85 Close	Date	1985-86 Close
17-Aug-82	253.00	16-Aug-83	375.25	14-Aug-84	302.75	19-Aug-85	236.25
18-Aug-82	256.75	17-Aug-83	370.25	15-Aug-84	301.25	20-Aug-85	235.25
19-Aug-82	253.00	18-Aug-83	362.00	16-Aug-84	301.50	21-Aug-85	236.25
20-Aug-82	253.00	19-Aug-83	368.00	17-Aug-84	297.75	22-Aug-85	237.75
23-Aug-82	256.75	22-Aug-83	378.00	20-Aug-84	291.75	23-Aug-85	236.50
24-Aug-82	260.00	23-Aug-83	383.75	21-Aug-84	292.25	26-Aug-85	235.25
25-Aug-82	264.00	24-Aug-83	381.25	22-Aug-84	296.25	27-Aug-85	235.00
26-Aug-82	257.75	25-Aug-83	378.25	23-Aug-84	295.00	28-Aug-85	232.00
27-Aug-82	254.00	26-Aug-83	383.25	24-Aug-84	296.00	29-Aug-85	233.50
30-Aug-82	252.50	29-Aug-83	376.00	27-Aug-84	300.50	30-Aug-85	235.00
31-Aug-82	255.75	30-Aug-83	366.00	28-Aug-84	299.00	03-Sep-85	233.75
01-Sep-82	255.25	31-Aug-83	374.50	29-Aug-84	294.75	04-Sep-85	234.25
02-Sep-82	257.50	01-Sep-83	366.50	30-Aug-84	295.75	05-Sep-85	237.50
03-Sep-82	255.25	02-Sep-83	373.25	31-Aug-84	295.50	06-Sep-85	234.00
07-Sep-82	249.25	06-Sep-83	378.50	04-Sep-84	295.75	09-Sep-85	232.25
08-Sep-82	248.50	07-Sep-83	376.75	05-Sep-84	297.50	10-Sep-85	233.75
09-Sep-82	248.00	08-Sep-83	377.75	06-Sep-84	297.50	11-Sep-85	235.25
10-Sep-82	245.25	09-Sep-83	380.50	07-Sep-84	296.00	12-Sep-85	236.00
13-Sep-82	251.00	12-Sep-83	379.25	10-Sep-84	299.75	13-Sep-85	234.25
14-Sep-82	252.50	13-Sep-83	371.50	11-Sep-84	299.50	16-Sep-85	239.25
15-Sep-82	252.00	14-Sep-83	369.75	12-Sep-84	300.50	17-Sep-85	238.75
15-Feb-83	288.25	14-Feb-84	321.25	12-Feb-85	277.75	10-Feb-86	242.25
16-Feb-83	285.50	15-Feb-84	323.50	13-Feb-85	277.50	11-Feb-86	240.00
17-Feb-83	288.25	16-Feb-84	323.00	14-Feb-85	276.75	12-Feb-86	238.75
18-Feb-83	289.00	17-Feb-84	323.00	15-Feb-85	277.50	13-Feb-86	237.50
22-Feb-83	285.25	21-Feb-84	322.00	19-Feb-85	275.25	14-Feb-86	238.00
23-Feb-83	288.00	22-Feb-84	327.25	20-Feb-85	273.75	18-Feb-86	239.00
24-Feb-83	290.00	23-Feb-84	326.75	21-Feb-85	272.50	19-Feb-86	237.75
25-Feb-83	287.50	24-Feb-84	327.00	22-Feb-85	272.25	20-Feb-86	236.25
28-Feb-83	281.50	27-Feb-84	327.25	25-Feb-85	270.50	21-Feb-86	236.00
01-Mar-83	284.00	28-Feb-84	326.00	26-Feb-85	271.25	24-Feb-86	236.25
02-Mar-83	287.75	29-Feb-84	332.25	27-Feb-85	271.75	25-Feb-86	234.25
03-Mar-83	288.75	01-Mar-84	333.00	28-Feb-85	271.25	26-Feb-86	232.25
04-Mar-83	289.25	02-Mar-84	336.00	01-Mar-85	270.75	27-Feb-86	231.75
07-Mar-83	288.50	05-Mar-84	338.25	04-Mar-85	271.00	28-Feb-86	227.00
08-Mar-83	286.00	06-Mar-84	341.00	05-Mar-85	272.50	03-Mar-86	228.50
09-Mar-83	287.25	07-Mar-84	340.75	06-Mar-85	273.75	04-Mar-86	225.25
10-Mar-83	283.75	08-Mar-84	340.50	07-Mar-85	271.25	05-Mar-86	227.00
11-Mar-83	282.75	09-Mar-84	344.25	08-Mar-85	271.50	06-Mar-86	229.50
14-Mar-83	287.00	12-Mar-84	343.00	11-Mar-85	273.00	07-Mar-86	229.50
15-Mar-83	287.00	13-Mar-84	344.00	12-Mar-85	273.00	10-Mar-86	232.00
16-Mar-83	292.25	14-Mar-84	346.75	13-Mar-85	273.75	11-Mar-86	230.50

May Futures Price Used to Calculate Volatilities

Date	1986-87 Close	Date	1987-88 Close	Date	1988-89 Close	Date	1989-90 Close
18-Aug-86	187.00	17-Aug-87	183.00	15-Aug-88	309.00	14-Aug-89	245.50
19-Aug-86	186.00	18-Aug-87	182.00	16-Aug-88	301.75	15-Aug-89	251.00
20-Aug-86	185.25	19-Aug-87	186.50	17-Aug-88	300.25	16-Aug-89	251.00
21-Aug-86	186.50	20-Aug-87	184.00	18-Aug-88	301.25	17-Aug-89	249.75
22-Aug-86	186.00	21-Aug-87	184.50	19-Aug-88	299.50	18-Aug-89	249.50
25-Aug-86	184.50	24-Aug-87	182.75	22-Aug-88	291.50	21-Aug-89	249.25
26-Aug-86	183.75	25-Aug-87	183.50	23-Aug-88	289.00	22-Aug-89	253.25
27-Aug-86	184.00	26-Aug-87	184.50	24-Aug-88	298.75	23-Aug-89	250.50
28-Aug-86	183.00	27-Aug-87	185.25	25-Aug-88	295.25	24-Aug-89	248.25
29-Aug-86	183.00	28-Aug-87	184.50	26-Aug-88	292.75	25-Aug-89	246.75
02-Sep-86	182.25	31-Aug-87	181.75	29-Aug-88	290.75	28-Aug-89	244.75
03-Sep-86	182.50	01-Sep-87	180.75	30-Aug-88	295.75	29-Aug-89	246.00
04-Sep-86	182.00	02-Sep-87	182.75	31-Aug-88	302.25	30-Aug-89	246.25
05-Sep-86	182.50	03-Sep-87	182.00	01-Sep-88	306.00	31-Aug-89	249.50
08-Sep-86	183.00	04-Sep-87	182.75	02-Sep-88	306.75	01-Sep-89	247.50
09-Sep-86	183.50	08-Sep-87	187.00	06-Sep-88	311.00	05-Sep-89	246.00
10-Sep-86	181.50	09-Sep-87	188.75	07-Sep-88	309.50	06-Sep-89	250.50
11-Sep-86	180.75	10-Sep-87	190.00	08-Sep-88	309.75	07-Sep-89	250.50
12-Sep-86	181.00	11-Sep-87	188.75	09-Sep-88	307.00	08-Sep-89	251.00
15-Sep-86	180.25	14-Sep-87	191.00	12-Sep-88	306.25	11-Sep-89	251.25
16-Sep-86	181.00	15-Sep-87	191.00	13-Sep-88	307.50	12-Sep-89	247.25
17-Feb-87	152.00	16-Feb-88	204.50	13-Feb-89	272.25	12-Feb-90	247.75
18-Feb-87	151.25	17-Feb-88	209.25	14-Feb-89	276.50	13-Feb-90	248.00
19-Feb-87	152.50	18-Feb-88	207.75	15-Feb-89	277.75	14-Feb-90	249.00
20-Feb-87	157.25	19-Feb-88	207.50	16-Feb-89	275.00	15-Feb-90	249.00
23-Feb-87	155.75	22-Feb-88	205.75	17-Feb-89	276.50	16-Feb-90	247.75
24-Feb-87	154.75	23-Feb-88	203.50	21-Feb-89	276.50	20-Feb-90	248.25
25-Feb-87	151.75	24-Feb-88	205.75	22-Feb-89	279.75	21-Feb-90	250.00
26-Feb-87	152.00	25-Feb-88	205.00	23-Feb-89	278.25	22-Feb-90	252.50
27-Feb-87	153.75	26-Feb-88	206.50	24-Feb-89	277.75	23-Feb-90	253.25
02-Mar-87	156.50	29-Feb-88	209.25	27-Feb-89	276.75	26-Feb-90	253.00
03-Mar-87	153.25	01-Mar-88	209.25	28-Feb-89	278.50	27-Feb-90	251.50
04-Mar-87	154.00	02-Mar-88	207.00	01-Mar-89	278.00	28-Feb-90	253.25
05-Mar-87	155.75	03-Mar-88	206.50	02-Mar-89	281.50	01-Mar-90	252.75
06-Mar-87	156.75	04-Mar-88	205.25	03-Mar-89	283.25	02-Mar-90	252.50
09-Mar-87	158.75	07-Mar-88	207.75	06-Mar-89	283.75	05-Mar-90	252.00
10-Mar-87	156.00	08-Mar-88	207.75	07-Mar-89	282.50	06-Mar-90	251.00
11-Mar-87	156.75	09-Mar-88	206.00	08-Mar-89	279.75	07-Mar-90	249.25
12-Mar-87	157.25	10-Mar-88	204.25	09-Mar-89	281.75	08-Mar-90	249.50
13-Mar-87	159.00	11-Mar-88	203.75	10-Mar-89	279.50	09-Mar-90	250.50
16-Mar-87	159.00	14-Mar-88	205.75	13-Mar-89	280.75	12-Mar-90	253.75
17-Mar-87	162.25	15-Mar-88	205.50	14-Mar-89	282.00	13-Mar-90	251.50

May Futures Price Used to Calculate Volatilities

	1990-91		1991-92		1992-93		1993-94
Date	Close	Date	Close	Date	Close	Date	Close
13-Aug-90	257.25	19-Aug-91	252.00	17-Aug-92	241.00	12-Aug-93	256.25
14-Aug-90	258.00	20-Aug-91	250.75	18-Aug-92	237.00	13-Aug-93	255.00
15-Aug-90	259.00	21-Aug-91	260.75	19-Aug-92	234.50	16-Aug-93	252.25
16-Aug-90	258.50	22-Aug-91	266.75	20-Aug-92	235.50	17-Aug-93	254.50
17-Aug-90	260.00	23-Aug-91	266.50	21-Aug-92	237.25	18-Aug-93	254.00
20-Aug-90	260.25	26-Aug-91	270.25	24-Aug-92	238.25	19-Aug-93	255.00
21-Aug-90	259.50	27-Aug-91	267.50	25-Aug-92	240.25	20-Aug-93	255.75
22-Aug-90	260.25	28-Aug-91	265.75	26-Aug-92	238.25	23-Aug-93	257.75
23-Aug-90	266.00	29-Aug-91	264.00	27-Aug-92	234.25	24-Aug-93	256.75
24-Aug-90	265.25	30-Aug-91	266.50	28-Aug-92	230.75	25-Aug-93	256.50
27-Aug-90	259.75	03-Sep-91	266.00	31-Aug-92	231.75	26-Aug-93	252.75
28-Aug-90	258.50	04-Sep-91	266.25	01-Sep-92	234.75	27-Aug-93	254.50
29-Aug-90	253.00	05-Sep-91	265.00	02-Sep-92	236.00	30-Aug-93	254.25
30-Aug-90	249.25	06-Sep-91	263.25	03-Sep-92	235.75	31-Aug-93	251.00
31-Aug-90	249.25	09-Sep-91	262.75	04-Sep-92	237.25	01-Sep-93	248.25
04-Sep-90	250.50	10-Sep-91	262.00	08-Sep-92	240.25	02-Sep-93	249.00
05-Sep-90	251.00	11-Sep-91	264.25	09-Sep-92	236.25	03-Sep-93	250.00
06-Sep-90	252.75	12-Sep-91	266.75	10-Sep-92	233.25	07-Sep-93	247.00
07-Sep-90	249.50	13-Sep-91	265.25	11-Sep-92	233.25	08-Sep-93	248.25
10-Sep-90	249.50	16-Sep-91	266.50	14-Sep-92	232.00	09-Sep-93	249.50
11-Sep-90	251.50	17-Sep-91	265.75	15-Sep-92	236.00	10-Sep-93	248.50
11-Feb-91	250.00	18-Feb-92	271.50	12-Feb-93	220.25	11-Feb-94	304.25
12-Feb-91	246.75	19-Feb-92	272.00	16-Feb-93	220.00	14-Feb-94	304.00
13-Feb-91	247.75	20-Feb-92	272.00	17-Feb-93	220.25	15-Feb-94	299.25
14-Feb-91	247.50	21-Feb-92	271.25	18-Feb-93	220.25	16-Feb-94	300.25
15-Feb-91	248.25	24-Feb-92	270.75	19-Feb-93	220.25	17-Feb-94	294.50
19-Feb-91	248.50	25-Feb-92	268.75	22-Feb-93	219.75	18-Feb-94	294.50
20-Feb-91	247.50	26-Feb-92	268.00	23-Feb-93	219.75	22-Feb-94	295.50
21-Feb-91	247.50	27-Feb-92	269.25	24-Feb-93	219.75	23-Feb-94	294.00
22-Feb-91	247.00	28-Feb-92	273.50	25-Feb-93	218.50	24-Feb-94	293.25
25-Feb-91	248.50	02-Mar-92	276.00	26-Feb-93	219.25	25-Feb-94	291.75
26-Feb-91	249.75	03-Mar-92	275.00	01-Mar-93	222.00	28-Feb-94	293.75
27-Feb-91	249.25	04-Mar-92	275.00	02-Mar-93	222.50	01-Mar-94	293.75
28-Feb-91	251.00	05-Mar-92	275.25	03-Mar-93	221.50	02-Mar-94	291.00
01-Mar-91	254.75	06-Mar-92	275.75	04-Mar-93	222.25	03-Mar-94	286.00
04-Mar-91	256.00	09-Mar-92	278.75	05-Mar-93	221.25	04-Mar-94	286.00
05-Mar-91	256.50	10-Mar-92	276.00	08-Mar-93	221.00	07-Mar-94	288.25
06-Mar-91	256.00	11-Mar-92	275.50	09-Mar-93	220.75	08-Mar-94	283.25
07-Mar-91	255.50	12-Mar-92	273.75	10-Mar-93	222.25	09-Mar-94	284.00
08-Mar-91	257.00	13-Mar-92	271.50	11-Mar-93	221.00	10-Mar-94	281.75
11-Mar-91	254.50	16-Mar-92	269.25	12-Mar-93	219.50	11-Mar-94	282.00
12-Mar-91	258.25	17-Mar-92	270.00	15-Mar-93	220.25	14-Mar-94	287.00

VITA

Michael G. Hoover, son of Glenn M. Hoover and Barbara A. Hoover, was born on January 18, 1971 in Winchester, VA. He grew up in Frederick county Virginia where he graduated from James Wood High School in 1989. He began attending Virginia Polytechnic Institute and State University in the Fall of 1989 and graduated with a B.S. in Agricultural and Applied Economics in the Spring of 1993. In the fall of 1993, Michael entered graduate school at VA Tech, specializing in commodity marketing and price analysis. In December 1995, Michael joined the WEFA Group's agriculture department as an associated economist.