ALTERNATIVE PRICING STRATEGIES FOR FEED GRAINS IN ARIZONA USING FUTURES AND OPTIONS CONTRACTS ON CORN

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Alternative pricing strategies for feed grains in Arizona using futures and options contracts on corn

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The University of Arizona, 1987

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ALTERNATIVE PRICING STRATEGIES FOR FEED GRAINS IN ARIZONA USING FUTURES AND OPTIONS CONTRACTS ON CORN

by

Khalid Mohammad Al-Butaih

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ABSTRACT

This study concerns the evaluation of alternative pricing strategies involving options on feed grains futures contracts during the period of 1973-1986. To predict the option premiums that would have occurred at various points in this time period, the study did research on market premiums of options on corn futures contracts from March 1, 1985 until December 31, 1985. The research showed that market premiums conformed closely to the premiums estimated by Black model of option pricing. The generalized stochastic dominance with absolute risk aversion function intervals is applied in the study in order to evaluate the strategies. The results showed that under different risk preferences, (DARA and CARA), the commodity options strategies dominate the cash sale strategy, but do not dominate the hedging by selling futures contract strategy. Options may provide alternatives for feed grains producers and traders. Put (call) options provided protection from losses resulting from falling (raising) cash price and may sometimes raise average income/margin of feed grain producers and traders.

CHAPTER I

Introduction

Unstable farm prices in the 1970's and 1980's have increased farmers' interest in the various pricing strategies for their commodities. Prior to 1970 the selection of a marketing strategy was relatively unimportant because farm prices were rather stable from year to year and within the year. Agricultural commodities have three types of uncertainty and risks: production uncertainty as a result of weather conditions; price risk as a result of fluctuations of supply and demand for the product; and financial risk as a result of rising interest rates.

Arizona produces more of wheat and barley than corn. However, corn is the dominant feed grain in the United States and the world and is the basis for pricing feed grain.

Between 1954 and 1971, surplus conditions existed in the feed grain market and feed utilization grew on an annual basis but generally at a slower rate than production. As a result, the nominal price of corn was around the price floor set by the corn loan rate (government price support program with its non-recourse loan program). During this period the farmer had a little opportunity to sell his grain at more than support price because the government owned large quantities of grain which would be sold at prices slightly above support price. The period of surplus in the feed grain market ended in 1972 as farm prices of corn rose far above the loan rate.

Since 1972, corn prices have been highly volatile because of weather induced fluctuations in domestic production and changes in export demand. The coefficient of variation in the farm price of corn more than tripled from 7.4 during 1961-1970 to 26.5 in 1971-1979 (Meyers, 1982).

Between 1977 and 1980, Federal Government policy tried to manage grain reserves to stabilize farm prices and income but allow markets to determine their average level. This stabilization policy relied mainly on farmer-owned rather than government-owned reserves, but there was authority to implement both. In contrast to the late 1970s, policy during the early 1980's has used government reserves and acreage reduction to raise farm incomes with limited success.

In the 1980's, agricultural markets are likely to be more volatile than in the 1970's because of their increased dependence on uncertain exports and domestic macroeconomic policies. Reducing price and income fluctuations can benefit both consumers and producers. The marketing system for corn has responded by making available to producers several alternative methods of pricing their product. The pricing methods have varying implications for producers' returns, their risk, the flexibility they offer, and their financing requirements. Therefore, the choice of suitable pricing method and marketing strategy can be very important in influencing farmer income and risk.

Larry Martin and David G. Hope (1983) defined a set of strategies which Ontario corn producers could have used over the nine crop years 1972/73-1980/81. The research then focused on determining the strategies' effects on producers' returns to marketing and price risk. This provides information which corn producers can use to evaluate alternative marketing strategies. The strategies included spot or cash sales, fixed price forward contracts, deferred pricing, basis or option contract, hedging using futures contracts and replacing physical corn (cash positions) with a long futures position. They ended with a number of conclusions based on the pricing methods used, and they concluded that much of the profit generated accrued from long futures positions later in the year after harvest.

A.B. Sogn, A.C. Vollmers and F. Baatz (1981) evaluated 11 corn and soybean marketing strategies, which could have been used during the years 1972 through 1977. In each marketing strategy, the crop was priced either by the cash market or forward priced with the futures market. They used mean-variance analysis to compare the strategies. They concluded that no corn marketing strategy consistently outperformed other strategies. In fact, corn stored until mid-August yielded the highest net return 2 years and the lowest net return 2 years. The value and necessity of constantly monitoring marketing information and price trends when making decisions is shown by the variance of the net returns from corn sales. The researchers concluded that farmers should evaluate their situation and develop a marketing plan which maximizes income consistent with their risk acceptance level.

K.R. Bolen, C.B. Baker, and R.A. Hinton (1978) evaluated and compared twelve corn and soybean marketing strategies, in terms of averages and the variability of results, using the estimated production from a 600 acre farm in central Illinois, corn prices from 1965 through 1974, and commercial storage rates. The twelve strategies selected for each crop represent several options: selling for cash at harvest, before harvest, and after harvest. They used mean-variance analysis to compare the strategies. They found that marketing strategies which have higher than average prices also have a greater price risk and that strategies which have low price risk generally yielded lower than average prices.

M.A. Kane, J.G. Beierlein and J.W. Dunn (1983) examined the use of hedging with commodity futures markets to reduce the price risk in corn production. They evaluated both intra-year and inter-year risk with different hedging strategies. Strategies include no hedge, hedge and hold, controlled hedge placement and hold, and in and out hedging. In order to place hedges in the more active strategies, they used technical and forecasting criteria. They used the mean-variance technique to compare the strategies. They concluded that risk reduction is possible, often without a reduction in the price received, and basis risk decreases the risk reducing properties of a hedge and hold strategy.

R.P. Dahl and E.C. Ussett (1981) examined corn marketing from several perspectives. First, the seasonality in corn marketing and prices is analyzed. Second, the seasonality of the difference between cash and futures prices (the basis) is analyzed. Finally, several corn marketing strategies are delineated and the effectiveness of each compared over the 10 years, 1971-72 through 1980-81. Three of the more common strategies are (1) selling corn at harvest, (2) storing corn at harvest for sale later in the marketing year, and (3) storage hedging, that is, storing corn at harvest and pricing it through the sale of futures. Their study demonstrates that storage hedging can be a profitable corn marketing strategy. They calculated the net average price to compare the strategies. They conclude that no single marketing strategy is the best for all years. The producer has to be well-informed about current and projected market conditions and study the local basis and basis behavior to evaluate the prospects for storage hedging. Storage costs must also be considered.

Al-Sakkaf (1986) predicted premiums of options on cotton futures contracts for a period 1973-1984 before the options were traded by using the Black model. The premiums were used for evaluation of alternative cotton pricing strategies that would use options on futures contracts. Strategies included a simple cash price on the spot market, forward contracting, hedging using futures contracts, and hedging by buying put options on cotton futures contracts. The study used mean variance technique to compare the strategies. The study showed that over a 12 year period forward contracting and hedging with using futures contracts would have lowered the average income of growers relative to cash sales, but using options as a marketing strategy during the same period would have raised the average income of the growers with respect to simple cash markets. His conclusion was that using options may not only protect from falling price but under certain conditions it may also raise cotton producers' average income.

Al-Shuaibi (1987) evaluated alternative marketing strategies for live cattle throughout the period of 1966-85. Strategies included cash sale with no hedge, hedging using futures contracts, and hedging by buying put options on live cattle futures contracts. Option premiums were predicted for the period 1966-1985 before options were traded by using the Black model. The study used the generalized stochastic dominance technique with absolute risk aversion function intervals to compare the strategies. The results showed that the options provided the dominant alternative for cattle producers under different risk pre ferences. He concluded that the options insures against losses resulting from cash prices falling and in some conditions raised average income of live cattle producers.

Futures contracts on feed grains like corn have been traded for many years. The trading of options on futures contracts on agricultural commodities was prohibited in the United States from 1935 to 1983. Trading in options of corn futures contracts began on January 29, 1985.

Options are a new marketing instrument that agricultural producers may use to reduce price risk and improve their profit. As we know, profit is equal to total revenue minus total cost. The profit function for the perfectly competitive market with one input-one output case is:

$$\pi = TR - TC$$

$$\pi = Pf(X) - rx - b$$

where

P = price of output

$f(x)$=quantity of output which is a function of input

r = price of input x

x = quantity of input

b = fixed cost

The FOC for profit maximization is

$$d\pi/dx = Pf'(x) - r = 0$$

$$Pf'(x) = r$$

$f'(x)$ is the marginal product of x, so

$Pf'(x)$ is the value of marginal product of x

which is denoted by VMP_x

So, VMP = r

Therefore, the profit maximization condition is the value of marginal product (VMP) is equal to price for each input. But this condition might not be held because of instability of commodity prices. This instability in commodity prices is an important source of risk which will always affect farmers.

Sandmo (1971) developed a simple risk model which deals with theory of the competitive market under price uncertainty and risk aversion. The model assumes that a decision maker is risk averse and maximizes expected utility of profit.

The utility is a function of profit:

$u = u(\pi)$ where

u = utility and π = profit

Expected utility of profit $E[U(\pi)]$, is given by $E[u(\pi)] = E\{u[Pf(x) - rx-b]\}$

With the assumption that the decision maker is risk averse, so $u'(\pi)>0$ and $u''(\pi)<0$,

The first order condition for utility function is

$r \leq E(P)f'(X)$

$r \leq \mu f'(x)$ where μ is expected price $E(P)$

From the optimization solution of profit maximization, it is clear that the expected marginal value product (Mfx) of each input exceeds its price.

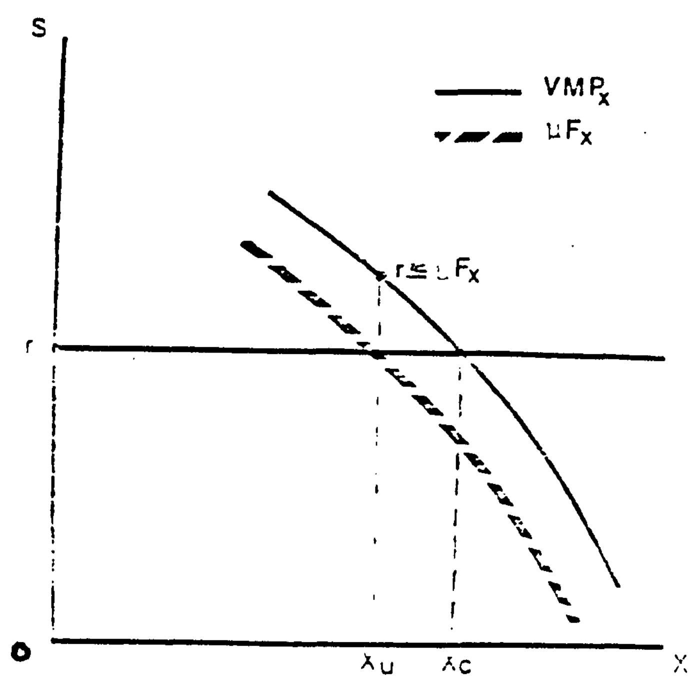

Figure 1. The Optimal Quantity Demanded of input (x) Under Certainty and Uncertainty Equilibrium.

Figure 1 shows that the optimal quantity demanded for each input in the case of uncertainty is lower than the quantity demanded in the case of certainty. Therefore, any strategy, such as option hedging, that reduces uncertainty has the potential to increase output and profit.

Because options on corn futures contracts were not traded until early 1985, the premiums (the purchase price of the options) determined in the market place are unavailable for earlier years. Until the development of the Black model there was relatively little basis for determining appropriate premiums on options in the absence of actual market trading. But in 1973, Black developed a mathematical model which predicts the amount of the premiums under different levels of the variables of time to maturity, interest rates, volatility, level of the futures price and difference between the futures price and the strike price.

Chapter two will clarify the characteristics of options on futures contracts and define the terminology used in options. Chapter three will summarize intensive research on premiums on options on corn futures contracts during the first 8 months of trading. Chapter four will explain ten strategies that will be used to evaluate the effectiveness of options if they had been available during 1973-1985. Chapter five will present the results of evaluating the pricing strategies. Chapter six will discuss the important role that options on corn futures contracts may play in the pricing of feed grains in Arizona.

CHAPTER II

Characteristics of Futures and Commodity Options Contracts

On October 29, 1984 the Commodity Futures Trading Commission (CFTC) approved the trading of options on futures contracts on agricultural commodities produced in the U.S. ending a ban that had existed since 1936. Options on corn futures contracts began trading on January 29, 1985.

Commodity options, like commodity futures contracts or cash forward contracts, provide farmers with a means for shifting price risks for a limited time, generally 5 months or less (Hoffman et. al, 1986). The buyer of a commodity option obtains a right, but incurs no obligation, to buy or sell a specified commodity or commodity futures contract for a set price during a given period of time. The set price is called the strike price or exercise price. A right to buy a futures contract is known as a call option, whereas a right to sell a futures contract is known as a put option.

An option hedger (buyer) is one who owns the commodity or is in the process of producing the commodity and buys put options. The option buyer may also be someone who has specific plans to buy a commodity sometime in the future and wants to protect himself from paying prices higher than those currently available in the cash market.

This buyer would operate the hedge by buying call options. The buyer of options acquires either right by paying a premium which is the price of the option.

An option seller (writer) is someone who expects to gain the premium paid by the option buyer for relatively unlimited losses if the futures price rises substantially after selling a call option or the futures price falls substantially after selling a put option. The seller of the right incurs an obligation to sell or buy the futures contract at the set price upon the buyer's (option holder's) demand. Professional option sellers usually "hedge" their exposed positions in options by taking appropriate positions in futures contracts and arbitraging good gains with limited risk. Other option sellers operate in what is called covered options by selling call options representing quantities of the commodity equal to the quantity actually owned or purchased in futures contracts (Al-Sakkaf, 1986).

An option buyer, unlike the buyer or seller of a futures contract, does not have to pay a margin deposit and is not subject to margin calls. The seller (writer) of an option contract, like a futures trader, must make an initial margin deposit, which is normally covered by the option premium that the buyer pays. The option buyer pays additional margin or is allowed to withdraw margin according to the movement of the premiums against or with his position.

In the case of futures contracts, hedgers offset their gains or losses by equal cash market losses or gains. But in the case of the option hedger, unlike futures hedgers, has the right to sell (put option) a futures contract at the strike price which effectively sets a minimum selling price for the spot commodity that has been hedged. But the put option hedger has the advantages of gaining all of the benefits of increases in the value of his spot commodity if the price rises after he has paid the premium and brokerage. If the prices fall, the hedger will exercise the option and get a price higher than the market price. The hedger will not exercise his option if the price goes up. In this case, he loses only the premium and brokerage fee for the purchase transaction. The farmer will gain the advantage of price increasing and could eliminate the risk of market price decreasing by purchasing a put option.

A call option gives a buyer the right to buy a futures contract at the strike price which effectively fixes a maximum buying price without eliminating the opportunity to gain most of the benefit if the market price falls after the option is purchased.

Farmers might buy an option contract just as they might buy insurance. For a known price, the "premium," they can obtain the right to sell (buy) their output (input), at at a specified price (called the "exercise" or "strike price"). Unlike the futures contract, this right to sell places a floor under profits (or limits losses) from price changes, without putting a cap on profits. And in the event of crop failure, the option contract, unlike the futures, does not obligate the farmer to make delivery (Paul Heifure and Douglas Gordon, 1985).

Options with several different strike prices are traded simultaneously for each futures contract that is currently being traded except that the expiration of the option usually comes several weeks before the last day of trading of the underlying futures contract. When the current futures price is lower than the strike for a put option and when the current futures price is above the strike of a call option, the option is said to be "in the money" and the difference is the intrinsic value of the option. Intrinsic value is what the option is worth if exercised at current futures and strike prices. The option is said to be "at the money" if the strike price is equal to the current futures price. The option is said to be "out of the money" when the strike price is lower than the current futures price in a put option and the strike price is greater than the current futures price in a call option. When the option is at-the-money or out-of-the-money, it would have no intrinsic value but it does have time value.

The value of an option (premium) is the sum of its intrinsic value and its time value. The intrinsic value is the positive amount that would be realized by exercising the option immediately and closing out the resulting futures position at the market price. The intrinsic value depends on two variables; the strike price and the current futures price.

The time value of an option is the value of waiting for potentially favorable futures price movements (Linwood A. Hoffman, et. al. 1986). The time value depends on five variables: the price of the underlying futures contract, the difference between the strike price and the futures price, the time to maturation, the futures contract price volatility, and the interest rate. The time value of options rises as the level of the futures price increases. When the difference between the futures and strike prices become larger, the time value of options goes down. As the time to maturity becomes shorter, the time value becomes smaller, assuming other factors are constant, because the probability of the option taking on intrinsic value is reduced with the shorter length of time to expiration. The time value will rise as price volatility increases, because the option seller will insist upon a higher premium due to the probability of the option taking on intrinsic value is increased. The time value of options will decrease as the interest rates increase since the purchase of an option becomes less attractive to the buyer because the buyer of option must pay the premium at time of purchase and the benefits of the option, if there are any, come some time later.

The option can be exercised on any date up to the maturity date and can be bought and sold on any weekday except a holiday. By buying a put option a farmer can establish a minimum selling price while leaving open the possibility of gaining from price increases. A futures position must always be closed out with an opposite trade or by delivery, while an option can simply be allowed to expire on those occasions when its value approaches zero as the actual product is sold (Hoffman et. al, 1986).

An option buyer can always offset his option by trading out of the option any time before the expiration date. The option buyer will exercise his option if that is more beneficial to him than closing with an offsetting transaction. The buyer of the option, like those who deal with futures contracts, rarely make or receive delivery of the actual commodity, but instead the buyer of the option will usually close the position by selling the same option and telling the broker that it is a closing transaction. The person who previously purchased the option would have a net income, after sale of the option, equal to the option premium at sale minus the premium at purchase minus a brokerage charge for each of the transactions.

CHAPTER III
Research on Option Premiums

In order to understand and predict the pricing of options for periods in the past when options were not traded and when they may be traded in the future, intensive research on option premiums is needed. Options on corn futures contracts began trading on January 29, 1985. Premiums consist of intrinsic values and time values. The intrinsic value of a put option, as discussed in a previous chapter, is simply the difference between the strike price and the futures price when the strike price is above the futures price. But in the case of a call option, the intrinsic value exists when the futures price is above the strike price, and it can be known exactly when the strike and futures prices are specified. Calculation of time value is not easy due to the fact that the determinants of the time value (TV) are complex. To forecast the TV, this study computed daily time values of the December and March put options and call options using corn futures prices, strike prices, and the premiums of each one of these strike prices. The data from March 1, 1985 until September 31, 1985 and from May 1, 1985 until December 31, 1985 for December 1985 and March 1986 put options were included in the study. Also the data from March 1, 1985 until September 31, 1985 and from April 1, 1985 until November 29, 1985 for December 1985 and March 1986 for call options were included in the study. The time value is simply obtained by subtracting intrinsic value from premium. The TV was then made a function of the strike price minus the futures price (S-F). The study then fitted special regression functions to the daily time values aggregated by month. The time value, as was discussed in chapter II, depends on five variables: the price of underlying futures contract, the difference between the strike price and the futures price (S-F), the time to maturation, the price volatility and the interest rate. We have market data on strike prices, the futures prices, and the time to maturation which is constant for each underlying futures contract. The unknown variables are the values of interest rates and volatility. So to get their values, we need to summarize the market data. The relationships between TV and S-F will be summarized with fitted regression functions. The multiple regression equation follows:

$$TV=B_0 + b_1(S-F)d_1 + b_2(S-F)^2 d_1 + b_3(S-F)d_2 + b_4(S-F)^2 d_2 + e.$$

where d_1 and d_2 are dummy variables assuming:

$d_1 = 1$ if $S-F <$ zero; $d_1 = 0$ if $S-F >$ zero;

$d_2 = 1$ if $S-F >$ zero; $d_2 = 0$ if $S-F <$ zero;

$d_2 = 1$ if $S-F =$ zero; $d_1 = 1$ if $S-F =$ zero.

Using these specially structured dummy variables with this regression function allowed the fitting of a continuous function to the data which provided generally good fit for options at-the-money, and it allows different curvature and slopes for a given option in-the-money and out-of-the-money, to the two sides of the equation. TV has its highest value where S-F = zero and declines at a decreasing rate as the difference between strike price and futures price becomes larger.

The regression equation with these specially structured dummy variables fits the data very well, other forms of continuous regression functions that have been tried generally fit the data very poorly when S-F = 0. Another interesting characteristic of this regression equation is that that the prediction of the TV when the options is at-the-money is simply the intercept value of the equation. Regression functions for each month of corn put options trading were fitted to the option months and months of trading previously defined. This process was repeated for the same general time periods for call options on corn futures contracts.

Table 1 shows the estimated coefficients, standard errors and adjusted R^2 of each month of option time values for the December put options. Tables 2 and 3 show the estimates for the March 1985 and July 1986 put options, respectively. Tables 4 and 5 report the estimates for the December and March call options, respectively.

Table 1. The estimated coefficients, standard errors and adjusted R^2 month of option time values for the December 1985 put options.

Month	Constant	$(S-F)d_1$	$(S-F)^2d_1$	$(S-F)d_2$	$(S-F)^2d_2$	Adj R^2
March	0.102282a	.505937	.737356	-.375198	-.011338	.882
	0.002796b	.052418	.193692	.070512	.354403	
April	.105661	.495641	.635283	-.364165	-.242782	.947
	.002211	.027281	.070493	.077110	.471404	
May	.101600	.504299	.683702	-.498841	.683381	.963
	.001393	.019412	.055221	.026743	.105252	
June	.104561	.496660	.643769	-.474391	.599494	.952
	.001617	.020703	.053894	.028230	.097892	
July	.079985	.439211	.672632	-.441398	.628560	.948
	.001270	.021513	.072303	.014989	.036981	
August	.056523	.297697	.427774	-.270036	.285502	.880
	.001273	.018804	.054384	.010761	.015939	
September	.042325	.251388	.396678	-.205747	.218327	.856
	.001162	.018008	.054761	.010027	.015009	
October	.022677	.157136	.274455	-.098615	.101931	.645
	.001015	.014337	.039714	.007810	.010740	

Source: Fitted regression functions.

a. The estimated coefficient of the constant.
b. The estimated standard error of the coefficient.

Table 2. The estimated coefficients, standard errors and adjusted R^2 of each month of option time values for the March 1986 put options.

Month	Constant	$(S-F)d_1$	$(S-F)^2d_1$	$(S-F)d_2$	$(S-F)^2d_2$	Adj R^2
May	.128426a	.783864	2.002861	−.722403	1.306463	.805
	.005589b	.127004	.663347	.136767	.706522	
June	.128409	.441996	.274410	−.47.227	.364358	.898
	.002492	.071067	.405682	.061477	.313334	
July	.102342	.550313	.926174	−.530484	.705835	.960
	.001489	.034636	.149515	.121246	.058386	
August	.099297	.442543	.346459	−.490478	.617876	.933
	.002010	.055307	.390497	.020654	.044436	
September	.079539	.442817	.667286	−.429053	.562581	.971
	.000924	.013682	.040495	.009549	.020165	
October	.069040	.404632	.617238	−.409109	.600787	.939
	.001142	.014781	.038213	.013561	.031701	
November	.055961	.331818	.482780	−.355078	.602494	.935
	.000984	.010559	.022797	.013240	.034631	
December	.042740	.255115	.360895	−.304604	.602651	
	.000979	.009361	.018325	.016208	.050392	

Source: Fitted regression functions.

a. The estimated coefficient of the constant.
b. The estimated standard error of the coefficient.

Table 3. The estimated coefficients, standard errors and adjusted R^2 of October of option time values for the July 1986 put options.

Month	Constant	$(S-F)d_1$	$(S-F)^2d_1$	$(S-F)d_2$	$(S-F)^2d_2$	Adj R^2
October	.103518a	.356518	-.185350	-.421584	.358237	.853
1985	.003810b	.132044	.809659	.058232	.184709	

Source: Fitted regression functions

a. The estimated coefficient of the constant
b. The estimated standard error of the coefficient

Table 4. The estimated coefficients, standard errors and adjusted R^2 of each month of option time values for the December 1985 call options.

Month	Constant	$(S-F)d_1$	$(S-F)^2d_1$	$(S-F)d_2$	$(S-F)^2d_2$	Adj R^2
March	.115666a	.812992	1.569910	-.656120	1.362012	.411
	.008345b	.175357	.703357	.106468	.283016	
April	.107141	.593190	.878450	-.417688	.506545	.952
	.001547	.020048	.052746	.021203	.057684	
May	.197990	.537660	.724552	-.381161	.424215	.963
	.001221	.020688	.070494	.013049	.028859	
June	.103425	.565322	.770478	-.387877	.416154	.949
	.101550	.029346	.108225	.015211	.030703	
July	.071900	.289726	-.013822	-.264963	.250770	.931
	.001295	.044159	.242293	.009129	.013477	
August	.051900	.130043	-.590575	-.194149	.172340	.888
	.001274	.048451	.309466	.007301	.008727	
September	.038008	.235947	.378783	-.148852	.134156	.852
	.001019	.028032	.140997	.005700	.006630	
October	.020876	.124758	.231694	-.89344	.087278	.660
	.000911	.022267	.087305	.005346	.006513	

Source: Fitted regression functions.

a. The estimated coefficient of the constant.
b. The estimated standard error of the coefficient.

Table 5. The estimated coefficients, standard errors and adjusted R^2 of each month of option time values for the March 1986 call options.

Month	Constant	$(S-F)d_1$	$(S-F)^2d_1$	$(S-F)d_2$	$(S-F)^2d_2$	Adj R^2
April	.123501	.036445	-18.470687	-.157098	-1.885359	.111
	.023758	.680505	.243037	.900325	7.907932	
May	.120897	.679111	1.855686	-.393386	.383364	.966
	.001705	.091720	.602822	.023836	.053052	
June	.124931	.488878	.291894	-.386267	.365202	.957
	.001653	.050201	.296061	.019269	.046604	
July	.098110	-.028238	-4.241928	-.302929	.268354	.949
	.001575	.133113	1.640158	.012103	.019753	
August	.191819	.320126	-.545841	-.307299	.269847	.946
	.001490	.072517	.553985	.119545	.012774	
September	.071177	.334142	.089653	-.266786	.247650	.953
	.001069	.030687	.158819	.006800	.008985	
October	.066325	.393158	.644636	-.271883	.279100	.931
	.001144	.024769	.100710	.007865	.011184	
November	.054933	.375654	.740885	-.258994	.295835	.911
	.001129	.019325	.061908	.008934	.014543	

Source: Fitted regression functions.

a. The estimated coefficient of the constant
b. The estimated standard error of the coefficient.

The intercept (constant) and slope coefficients in Tables 1 through 5 are used to estimate the time value of put and call options at-the-money and 5, 10 and 20 cents in and out-of-the-money. These are reported in Tables 6, 7 and 8 for December, March and July put options. Tables 9 and 10 report time values of December and March call options. To illustrate the calculation of these estimates, we can follow this example of calculation of the time value for December put options in March 10 cents in-the-money:

$$TV = .102262+(.505937)(10)(0)+(.737350)(10)^2(0)+ (.375198)(10)(1)+(-.011338)(10)^2(1)$$

In the case of call options the calculation of time value for December call options in March 10 cents in-the-money is as follows:

$$TV = .115666+(.812992)(10)(1)+(1.569910)(10)^2(1)+ (-.0656120)(10)(0)+(1.362012)(10)^2(0)$$

Table 6. The estimated time values for December put options

Month	At-the-money	Out-of-the-money			In-the-money		
	0	-.05	-.10	-.20	.05	.10	.20
		Cents per bushel					
March	.1023	.0788	.0590	.0306	.0835	.0646	.0268
April	.1057	.0825	.0624	.0319	.0868	.0668	.0231
May	.1016	.0781	.0580	.0281	.0784	.0585	.0292
June	.1046	.0813	.0613	.0310	.0823	.0631	.0337
July	.0799	.0597	.0428	.0190	.0595	.0421	.0168
August	.0565	.0427	.0310	.0141	.0437	.0324	.0139
September	.0423	.0307	.0212	.0079	.0326	.0239	.0099
October	.0227	.0155	.0097	.0022	.0180	.0138	.0070

Source: The intercept (constant) and slope coefficients.

Table 7. The estimated time values for March put options

Month	At-the-money	Out-of-the-money			In-the-money		
	0	-.05	-.10	-.20	.05	.10	.20
		Cents per bushel					
May	.1284	.1726	.0701	.0518	.0956	.0693	.0362
June	.1284	.1070	.0870	.0510	.1058	.0850	.0489
July	.1023	.0771	.0566	.0293	.0776	.0564	.0245
August	.0993	.0780	.0585	.0246	.0763	.0564	.0259
September	.0795	.0591	.0419	.0177	.0595	.0423	.0162
October	.0690	.0504	.0347	.0128	.0501	.0341	.0112
November	.0560	.0406	.0276	.0089	.0397	.0265	.0091
December	.0427	.0309	.0208	.0062	.0290	.0183	.0059

Source: The intercept (constant) and slope coefficients.

Table 8. The estimated time values for July 1986 put options trading in October 1985.

Month	At-the-money	Out-of-the-money			In-the-money		
	0	-.05	-.10	-.20	.05	.10	.20
			Cents per bushel				
October 1985	.1035	.0852	.0660	.0248	.0833	.0649	.0335

Source: The intercept (constant) and slope coefficients.

Table 9. The estimated time values for December call options

Month	At-the-money	Out-of-the-money			In-the-money		
	0	-.05	-.10	-.20	.05	.10	.20
			Cents per bushel				
March	.1157	.0789	.0506	.0159	.0863	.0637	.0389
April	.1071	.0797	.0566	.0236	.0875	.0704	.0439
May	.0980	.0729	.0515	.0194	.0799	.0641	.0387
June	.1034	.0771	.0546	.0212	.0851	.0688	.0425
July	.0719	.0583	.0455	.0221	.0593	.0479	.0289
August	.0519	.0439	.0330	.0023	.0426	.0342	.0199
September	.0380	.0272	.0182	.0059	.0309	.0245	.0136
October	.0209	.0152	.0107	.0052	.0166	.0128	.0065

Source: The intercept (constant) and slope coefficients.

Table 10. The estimated time values for March call options.

Month	At-the-money	Out-of-the-money			In-the-money		
	0	-.05	-.10	-.20	.05	.10	.20
		Cents per bushel					
April	.1235	-	-	-	-	-	-
May	.1207	.0914	.0714	.0595	.1020	.0852	.0574
June	.1249	.1012	.0789	.0388	.1065	.0899	.0623
July	.0961	.0869	.0565	.0679	.0816	.0685	.0463
August	.0712	.0547	.0387	.0079	.0585	.0469	.0276
September	.0712	.0547	.0387	.0079	.0585	.0469	.0276
October	.0663	.0483	.0335	.0135	.0532	.0414	.0221
November	.0549	.0380	.0248	.0094	.0427	.0320	.0150

Source: The intercept (constant) and slope coefficients.

In 1973, Black and Scholes published, in the Journal of Political Economy, an article demonstrating the development of a mathematical model for estimating option premiums on options on corporate liabilities (Black and Scholes, 1973). In 1976 Black modified the formula to adapt it for estimating the values of commodity options (Black, 1976).

Al Shaubi (1987) tested the effectiveness of the Black model for the prediction of option premiums. He arbitrarily used the premiums of February futures contract options of 1986 traded in August 1985 to compare with premiums predicted by the Black model. The test showed that premiums predicted by the Black model are very close to those generated in the market place. This shows that the Black model is potentially a very good predictor of actual market premiums.

Option premium computations using the Black model are based on the same five variables that have already been discussed. Appendix A presents the Black model equation for predicting option premiums. The first three variables have values that are easily observed, but interest rate and price volatility values that traders are using at particular points in time cannot be easily observed. For the purpose of simplification, Black suggested that the appropriate interest rate for the model was a riskless and constant interest rate.

There are an infinite number of combinations of interest rate and volatility that cause the Black model to produce a particular time value. Since the TV as a function of S-F is a nonlinear function, a unique set of values for the interest rate and volatility variables applied to the Black can generally be found that best fit points on the regressions that have been fitted to the market generated time value data. The criterion for "best fit" will be the smallest sum of absolute differences between the Black model estimates of time value and the fitted regression function values of S-F at values of -20, -10, -5, +5, +10 and +20 when the two functions are equal at S-F equals zero.

The interest rates and volatilities estimated by the Black model and the regression function time values for December, March, and July put options are reported in Table 11. Table 12 reports the estimated interest rates and volatilities of December and March call options.

Table 11. Interest rates and volatilities implied by Black model for December, March, and July put options

Month	Out-of-the money Interest Rate	Out-of-the money Volatility	In-the-money Interest Rate	In-the-money Volatility
	December Put Options			
March '85	7.00	12.60	7.00	12.65
April	5.5	13.75	13.00	14.30
May	2.5	14.30	8.00	14.75
June	7.8	17.00	4.00	16.75
July	45.00	17.15	-1.00	14.80
August	228.00	22.70	17.50	12.90
September	47.5	25.10	-30.00	12.10
October	-	-	-	-
	March Put Options			
May '85	-	-	25.00	10.00
June	21.00	18.5	10.00	17.50
July	-5.00	14.80	16.50	16.40
August	11.00	18.25	13.00	18.40
September	39.50	18.25	4.50	16.45
October	78.00	19.10	1.00	16.25
November	278.00	23.30	-8.00	16.40
December	-	-	-70.00	21.15
	July Put Options			
October 1985	20.00	15.00	1.00	13.30

Source: Computed as Explained in Text.

Table 12. Interest rates and volatilities implied by Black model for December and March call options.

Month	In-the-money		Out-of-the money	
	Interest Rate	Volatility	Interest Rate	Volatility
	December Call Options			
March	27.00	16.30	-42.50	10.43
April	13.00	14.45	20.00	15.00
May	9.50	14.30	37.00	16.30
June	16.00	17.25	40.00	19.00
July	-4.00	13.25	170.00	22.80
August	2.00	12.35	180.00	18.60
September	-20.00	11.00	-	-
October	-50.00	9.25	-	-
	March Call Options			
April	-	-	-	-
May	-17.00	13.90	28.50	17.85
June	10.00	18.40	39.00	21.00
July	Not enough observations		100.00	23.00
August	36.00	20.30	122.50	26.05
September	6.00	17.25	228.00	27.40
October	-22.00	19.40	326.00	30.10
November	-70.00	27.40	-	-

Source: Computed as explained in text.

The estimated volatilities in Tables 11 and 12 show relatively small variations, and the estimated interest rates have very large variations. In the Black model the premiums change in the same direction as changes in the volatility, and the premiums are relatively sensitive to changes in the volatility. Also in the Black model the premiums change in the opposite direction as the interest rate changes, and the premiums are relatively insensitive to interest rate changes.

Based upon the research on option time values, it was decided that for subsequent research the interest rate would be arbitrarily fixed at 5 percent. The value for volatility to be used in the Black model will be adjusted to the standard deviation of the futures price in the previous trading month. These interest rates and volatilities were used in Black model to estimate the option premiums in all years included in the study (1973-1986).

CHAPTER IV

Alternative Pricing Strategies For Arizona Feed Grains

Prices are usually determined by supply, demand, carry-overs and public policy, beyond the immediate control of individual farmers. These forces cause commodity prices to fluctuate and farmers are subject to substantial price risks. The marketing system for corn has responded to this uncertainty by offering to producers several alternative methods of pricing their product. The pricing methods each have specific implications for producers' returns, the flexibility they offer, and their financing requirements.

Organized trading in futures contracts for corn was begun more than 100 years ago on the floor of the Chicago Board of Trade. Individual Arizona producers of feed grains have made only very limited use of futures trading. This lack of use of futures by individual grain producers is likely explained by lack of knowledge about futures, the fact that corn futures contracts are in fixed amounts of 5000 bushels per contract, a highly variable basis (futures price minus the local cash price) and the availablility of alternative price setting methods including marketing through farmer marketing cooperatives. In recent years substantially more than half of the feed grain produced in

Arizona has been marketed through farmer cooperatives. The managers of these cooperatives have generally been very competant to use and have extensively used futures markets when they have judged it to be in the best interest of their farmer members. Since this contrast between the extent of use of futures contracts by individual farmers and farmer cooperatives is unlikely to change in the near future the pricing strategies explored in this research will be predominantly those that cooperatives are likely to use.

In this chapter, using call and put options on corn futures contracts will be compared with other pricing strategies in order to determine whether using option strategies would be more effective in reducing income variability and/or raising income than other available pricing strategies for feed grain in Arizona. Ten pricing strategies including cash sale with no hedge, hedging with futures contracts and hedging with options will be evaluated. The study will cover the period between 1973 through 1986. Futures prices are available throughout this period but options premiums are not. The research on call and put options on corn futures contracts reported in Chapter III will provide the basis for predicting option premiums for the 1973-1986 time period.

Studies of marketing alternatives usually make extensive use of local cash market prices. In the case of feed grains in Arizona there is no useable local cash market price available. The public agencies do not report daily cash market prices for feed grains in Arizona. Some cash market prices would be available from the cooperatives, but there would be gaps of days and sometimes weeks without any cash market transactions. For this study it will be assumed that the Arizona cash market price is a direct function of the mid-western price which is readily available on a daily basis. In earlier times when Arizona was more nearly self-sufficient in feed grain production and grain marketing cooperatives did not exist in the state it was common practice for buyers to offer a "flat price" which would remain unchanged for days or even weeks while the futures price changed day to day.

The evaluation of alternative pricing strategies will be based on the variability and average level of gross income or gross margin. The basic unit of quantity will be 5,000 bushels, which is the quantity in one corn futures contract. The specific Arizona feed grain pricing strategies that will be studied are illustrated below.

Arizona Feed Grain Pricing Strategies

1. Arizona grown barley harvested and priced June 1 (Prices based mid-west corn prices).

   a. Barley priced on June 1

b. Offer growers "firm" price on November 1:
   sell July corn futures

c. Offer growers a "minimum" price on November 1:
   buy July corn put options

2. Arizona grown corn harvested and priced August 15

   a. Corn priced on August 15

   b. Offer growers "firm" price on June 1:
      sell December corn futures

   c. Offer growers "minimum" price on June 1:
      buy December corn put options

3. Midwest corn purchased on November 1 and sold March 1

   a. Corn priced on March 1

   b. Buy midwest corn on November 1:
      sell March corn futures

   c. Buy midwest corn on November 1:
      sell March corn call options

   d. Buy midwest corn on November 1:
      sell March corn futures
      buy March corn call options

Each of these strategies is discussed in more detail in the following paragraphs.

1. Arizona grown barley harvested and priced June 1 (Price based on mid-west corn prices).

1a. Cash sale of barley on June 1 with no hedge.

Under this strategy, it is assumed that barley producers will sell their product at the cash price at harvest time on June 1 with complete exposure to price risk. This strategy assumes that producers plant barley on November 1 and sell it on June 1. The results of this strategy will be used as a basis of comparison with the other strategies (1b and 1c) that use one of the hedging programs.

1b. Offer growers "firm" price on November 1: sell July corn futures.

Traditional futures contract hedging is used in this strategy that involves selling July corn futures contracts at planting time on November 1. The process of hedging effectively sets the price that the farmer receives because the cash and futures prices usually move up and down closely together. If the prices increase, the value of the hedged commodity increases, but the gain is nearly equal to the loss on the futures contracts when the futures contracts are bought. If the prices fall, the value of the hedged commodity declines, but this loss in value is approximately offset by gains that are realized when the futures contracts are bought. Therefore, by using futures contracts, the hedger can reduce the price risks associated with price changes relative to the risks of simple cash sale without any forward price fixing.

It is assumed that the producer will sell the barley that has been harvested on June 1 at the best available price (cash price) and buy corn futures contracts to offset futures contracts that he sold on November 1. This strategy of hedging allows us to compare the results of no hedging with hedging using futures contracts. The gross income in this strategy is adjusted for transaction cost which includes brokerage charges and the interest cost of margin money.

Corn futures contracts mature (expire) approximately the 20th day of each of the delivery months of December, March, May, July, and September. The July contract has the highest level of use by people who hedge barley because it matures about the time the harvest is complete in Arizona.

1c. Offer growers "minimum" price on November 1: buy July corn put options.

The put option gives the buyer the right, but not the obligation, to sell futures contracts at the option's strike price until the expiration date which is always about three weeks prior to the first delivery date of the underlying futures contract.

The minimum pricing contract (Min. P.C.) is the only cash marketing alternative available that will allow a seller of a commodity to insure against lower prices and still take advantage of increased prices, if they occur. Because of this advantage, sellers of agricultural commodities andthe financial lending institutions are expressing interest in the Min. P.C. as a new and innovative marketing alternative (McDonald, n.d). The Min. P.C. is a cash contract developed by marketing firms and based on the agricultural options market much like the cash forward contract is based upon and made possible by the commodity futures market.

Hedging with options is most effective when the option expires soon after the sale of the cash commodity. In this strategy put options on the July corn futures contract at several different strike prices are purchased on November 1 at barley planting time. At the time the barley is sold at the best available price (cash price), an offsetting sale of the put option is made if the option has intrinsic value (i.e., when strike price is higher than futures price).

Brokerage charges on the purchase or sale of options are required which is usually 5 percent of the premium paid for the option, but not less than $25 nor more than $100 per option. These charges have to be paid at the time the option is purchased. An additional brokerage charge is also required if the option is exercised. Interest or opportunity cost, for the brokerage charge for buying and the premium for the option during the time the option is available for exercise, must be calculated. Gross income is adjusted for these costs (premium, brokerage charge and interest) resulting from trading the option contract.

2. Arizona grown corn harvested and priced August 15

2a. Cash sale of corn in August 15 with no hedge.

This strategy assumes that corn producers will sell their product at the cash price at harvest time on August 15 with complete exposure to price risk. This strategy assumes that producers plant corn on June 1 and sell it on August 15. The results of this strategy will be used as a basis of comparison for the other strategies (2b and 2c) that use one of the hedging strategies.

2b. Offer growers "firm" price on June 1: sell December corn futures contracts.

This strategy is similar to 1b except that the cooperative is assumed to sell December corn futures contracts at planting time on June 1. The assumption is also made that the producer will sell the corn that has been harvested on August 15 at the best available price and buys corn futures contracts to offset futures contracts that were sold on June 1.

2c. Offer growers "minimum" price on June 1: buy December corn put options.

This strategy is similar to 1c except that the commodity hedged is Arizona grown corn and the put options are on December corn futures contracts.

3. Mid-west corn purchased on November 1 and sold on March 1.

3a. Cash sale of corn on March 1 with no hedge

This strategy assumes that traders buy mid-west corn on November 1 and sell it on March 1 after storage to take advantage of price differences over time or location. Gross margins of this strategy will be used as a basis of comparison for the other strategies within this group (3b, 3c, and 3d) that use one of the hedging alternatives.

3b. Buy mid-west corn on November 1: sell March corn futures.

In this strategy, it is assumed that the hedger will sell corn futures contracts at the time of buying mid-west corn on November 1. It is assumed also that the hedger will buy March corn futures on March 1 to offset futures contracts that he sold on November 1 and sell the corn at the best available price (cash price). Futures gross margin is adjusted for brokerage charges and interest cost of margin money.

3c. Buy midwest corn on November 1: sell March corn call options.

The call option is a contract that gives the buyer the right, but not the obligation, to buy a futures contract at a set price (strike price) during a specified period of time. The buyer of a call option will pay a premium to the seller of the option. If the buyer of the call option lets the option expire and does not exercise it because it has little or no value, the seller of the call option will gain the entire premium less brokerage and opportunity cost of margin deposits. But if the strike price is lower than the futures price, the buyer of call options will exercise the option and the seller of the call the option will lose because he must buy the futures contract at a high current price and deliver it to the call option buyer at a lower price (strike price). Call option gross margin is adjusted for brokerage charges and interest cost of margin money.

3d. Buy midwest corn on November 1: sell March corn futures and buy March corn call options.

In addition to selling March corn futures contracts (strategy 3b), this strategy includes buying March corn call options on November 1. This gives the right to buy futures contracts at the strike price. The buyer of the call options will lose the option premium if he does not exercise the option at any time before expiration date. Option gross income is adjusted for transaction cost (brokerage charges and interest cost of margin money). Futures gross margin will be added to the option gross income to get the results of this strategy. This strategy has the characteristics that with rising price the value of the corn in storage rises by approximately the amount of the loss on the futures contract position and the call option premiums rise giving a net gain less than would occur without any hedging but better than occurs with just a futures contract hedge. If the price of corn drops while this strategy is in effect the drop in the value of the stored corn will be approximately offset by gains in the value of the futures postion while the call option position loss is limited to the amount of the premium paid for the options. Except for the brokerage and margin money costs of the futures possition this strategy is essentially the same as buying the call option without owning the commodity or the futures position.

CHAPTER V

Evaluation of Alternative Pricing Strategies

The alternative pricing strategies discussed in the previous chapter are divided into three groups: (1) Arizona grown barley harvested and priced June 1. (2) Arizona grown corn harvested and priced August 15. (3) Mid-west grown corn purchased on November 1 and sold on March 1. Each of these three groups have strategies that include simple cash sale without hedging and hedging by selling futures contracts during the period 1973 through 1986. Groups (1) and (2) include hedging by buying put options at-the-money and 10, 20 and 30 cents in-the-money and out-of-the-money. In addition, group (3) includes a strategy of selling corn call options and another strategy of hedging in futures contracts and also buying call options. Since there is no daily Arizona cash feed grain price available this study will base all cash prices on mid-west corn prices.

All marketing costs that are specific to a particular pricing strategy are subtracted from gross income or margin. These specific marketing costs include brokerage costs in buying and selling futures contracts and option contracts, premiums in option contracts, and the foregone interest on money used in paying brokerage fees and margin account deposits on futures contracts and/or on options that are sold. All of the prices used in this study have been adjusted to the value of the dollar in 1982 (Appendix A) using the assumptions discussed in chapter four. The results of the evaluation of alternative pricing strategies are reported in this chapter.

Mean Variance Analysis

To evaluate these pricing strategies, the study calculates the average income and variability of income for each alternative strategy. The measure of variability used here is the standard deviation.

Strategy 1a: Barley priced only on cash market on June 1

Strategy 1b: Sell July futures contract on November 1

Table 13 shows the gross receipts of each year from barley cash sale on June 1 and from selling July futures contracts on November 1. The calculated average income and variability are equal to 18,250 and 4,630 dollars with respect to strategy 1a. Strategy 1b has an average income and variability equal to 19,089 and 6,229 dollars, respectively.

Table 13. The gross receipts of each year from barley simple cash sale and from selling July future contracts during the period of 1973-1986

Crop Year	Cash Prices June 1	Cash Gross Income	Futures Gross Income
	Dollars Per Bushel	Dollars Per 5000 Bushels	
1973	4.954	24774	17175
1974	5.161	25774	25285
1975	4.810	24048	36413
1976	4.760	23836	23688
1977	3.750	18754	21074
1978	3.692	18461	16647
1979	3.438	17192	16983
1980	3.103	15518	17738
1981	3.867	19336	22217
1982	2.674	13370	17273
1983	2.967	14835	11935
1984	3.198	15992	15693
1985	2.532	12660	13696
1986	2.184	10921	11424
mean[a]	3.649	18250	19089
s.d.[b]	0.925	4630	6229

Source: Chicago Board of Trade prices adjusted to the value of dollar in 1982.

[a]The calculated average income.
[b]The calculated standard deviation.

Strategy 1c: Buy Put Options on July Futures Contracts on November 1

Table 14 shows the gross income of each year from selling barley on the cash market on June 1 plus the net results of buying put options on July futures contracts on November 1 (nine months before the end of trading in the July futures contract) at-the-money and 10, 20, and 30 cents in-the-money and out-the-money for the 1973-1986 period. The table shows how those alternative strategies of buying put options would have performed during 1973 through 1986 period if options had been available in this period of time.

Table 14. The gross receipts of each year from put options on the July futures contract on November 1.

Crop Year	Out-of-the-money -30	-20	-10	at 0	In-the-money 10	20	30
				Dollars per 5,000 Bushels			
1973	24537	24291	24185	23920	23597	23253	22866
1974	23274	23018	22749	22466	22281	22449	22604
1975	31122	31362	31591	31811	32020	32220	32411
1976	21668	21419	21156	20877	21040	21208	21362
1977	18194	18442	18669	18894	19104	19295	19467
1978	17981	17790	17557	17281	16991	16664	16305
1979	16677	16482	16246	15973	16082	16232	16649
1980	15188	15439	15673	15896	16106	16292	16456
1981	19014	19253	19494	19721	19930	20122	20298
1982	15266	15583	15856	16081	16285	16456	16591
1983	14609	14465	14256	13986	13659	13312	12923
1984	15340	15130	14882	14617	14642	14795	14918
1985	12499	12507	12792	13007	13153	13269	13366
1986	10837	10755	10712	10937	11074	11149	11200
mean[a]	18300	18288	18273	18248	18283	18337	18365
s.d.[b]	5164	5176	5171	5155	5155	5184	5226

Source: Chicago Board of Trade prices adjusted to the value of dollar in 1982.

[a]The calculated average income
[b]The calculated standard deviation

Strategy 2.a: Corn Priced Only on Cash Market on August 15

Strategy 2.b: Sell December Futures Contract on June 1

Table 15 shows the gross income of each year from simple cash sale on August 15 and from selling December futures contract on June 1 during the period of 1973-1986. The average income and variability are equal to 18,463 and 7,548 dollars with respect to strategy 2a. The average income and variability of strategy 2b are equal to 16,866 and 4.051 dollars, respectively.

Table 15. The gross receipts of each year from corn cash sale during 1973-1986.

Crop Year	Cash Prices August 15	Cash Gross Income	Futures Gross Income
	Dollars per bushel	Dollars per 5,000 bushels	
1973	6.54	32677	21241
1974	6.63	33133	22541
1975	5.28	26403	19460
1976	4.52	22593	22789
1977	2.69	13438	18003
1978	3.11	15545	15932
1979	3.58	17919	17681
1980	3.75	18753	16419
1981	3.37	16856	19675
1982	2.15	10764	13322
1983	3.62	18081	13794
1984	2.78	13910	14686
1985	2.34	11686	12784
1986	1.35	6739	7796
mean[a]	3.69	18463	16866
s.d.[b]	1.57	7548	4051

Source: Chicago Board of Trade prices adjusted to the value of dollar in 1982.

[a]The calculated average income.
[b]The calculated standard deviation

Strategy 2.c: Buy Put Options on December Futures Contarct on June 1

Table 16 shows the gross receipts of each year from buying put options on December futures contracts on June 1 (seven months before the end of trading in the December futures contract) at-the-money and 10, 20, and 30 cents in-the-money and out-of-the-money for the 1973-1986 period. The table shows how these alternative strategies of buying put options would have performed during 1973 through 1986 period if options had been available in this period of time.

Table 16. The gross income of each year from put options on the December futures contracts on June 1 during the period of 1973-1986.

Crop	Out-of-the-Money			at	in-the-Money		
Year	-30	-20	-10	0	10	20	30
	Dollars per 5,000 bushels						
1973	30491	30242	29979	29701	29410	29106	28790
1974	31899	31684	31447	31188	30907	30607	30286
1975	25664	25455	25218	24968	24689	24380	24046
1976	21851	21643	21409	21441	21638	21806	21948
1977	15977	16291	16565	16800	17019	17203	17355
1978	15676	15932	16185	16419	16634	16831	17011
1979	17613	17453	17244	16986	17040	17188	17297
1980	18444	18282	18072	17810	18510	17184	16819
1981	17431	17697	17956	18204	18424	18616	18782
1982	11705	12074	12380	12630	12810	12948	13051
1983	13685	13545	13695	13911	14071	14210	14325
1985	11565	11643	11947	12171	12322	12439	12537
1986	6674	6744	7080	7314	7456	7540	7616
mean[a]	18308	18295	18314	18320	18328	18314	18275
s.d.[b]	6864	6734	6542	6399	6239	6111	5989

Source: Chicago Board of Trade prices adjusted to the value of the dollar in 1982.

[a]The calculated average income.
[b]The calculated standard deviation.

Strategy 3. Midwest Corn Purchased on Nov. 1 and sold on March 1

Strategy 3.a: Corn Priced Only on Cash Sale on March 1
Strategy 3.b: Sell March Corn Futures on November 1

Table 17 shows the gross margin of each year from corn cash sale on March 1 and from selling March corn futures on November 1 during the period of 1973-1986. The average margin and variability are equal to 442 and 3,489 dollars. The average maring and variability for strategy 3b are equal to 1,248 and 930 dollars, respectively.

Table 17. The gross margin of each year from corn cash sale and from selling March futures contracts on November 1 during the period of 1973-1986.

Crop Year	Cash Prices Nov. 1	Cash Prices March 1	Cash Gross Margins	Futures Gross Margins
	Dollars per Bushel		Dollars per 5000 bushels	
1973	2.860	3.351	2453	30
1974	4.649	6.260	8056	212
1976	6.497	4.658	- 9202	2436
1976	4.215	4.487	1357	2412
1977	3.712	3.923	1050	1879
1978	2.932	3.256	1619	1799
1979	3.077	3.107	150	930
1980	3.022	3.318	586	1802
1981	3.975	3.760	- 1079	1440
1982	2.767	2.660	- 531	2780
1983	2.060	2.673	3066	822
1984	3.261	3.107	- 770	- 50
1985	2.530	2.514	- 83	872
1986	2.083	1.987	- 483	110
mean[a]	3.403	3.492	442	1248
s.d.[b]	1.126	1.047	3489	930

Source: Chicago Board of Trade market prices adjusted to the value of the dollar in 1982.

[a]The calculated average margins.
[b]The calculated standard deviation.

3.c: Sell Call Options on March Futures Contracts on November 1

Table 18 shows the gross margins of each year from buying mid-west corn on November 1, selling the corn on March 1 and selling call options on March futures contracts on November 1 (five months before the end of trading in March futures contracts at-the-money and 10, 20, and 30 cents in-the-money and out-of-the-money for the 1973-1986 period. The table shows how these alternative strategies of selling call options would have performed during 1973 through 1986 period if options had been available in this period of time.

Table 18. The gross margins of each year from selling call options on the March futures contract on November 1 during the period of 1973-1986.

Crop	In-the-Money			At	Out-of-the-Money		
Year	-30	-20	-10	0	10	20	30
	Dollars per 5000 Bushels						
1973	-11	76	247	499	832	1232	1680
1974	1583	1813	2063	2331	2617	2922	3242
1975	-5682	-5952	-6207	-6447	-6674	-6887	-7086
1976	3633	3723	3459	3215	2992	2789	2605
1977	2542	2762	2560	2307	2084	1896	1745
1978	1914	2068	2277	2260	2066	1918	1807
1979	1086	1243	1050	807	613	463	352
1980	2254	2129	1834	1578	1371	1204	1065
1981	1265	965	691	443	219	20	- 159
1982	1013	620	293	45	- 147	- 289	- 395
1983	768	850	1021	1275	1619	2023	2474
1984	213	393	279	29	- 167	- 326	- 451
1985	874	913	565	303	120	- 3	- 71
1986	69	130	89	- 184	- 365	- 464	- 506
mean[a]	823	838	730	631	513	464	450
s.d.[b]	2052	2134	2164	2204	2253	2325	2418

Source: Chicago Board of Trade market prices adjusted to the value of the dollar in 1982.

[a]The calculated average margin.

[b]The calculated standard deviations.

3.d: Sell March Futures Contracts and Buy Call Options On March Futures Contracts on November 1

Table 19 shows the gross margins of each year from selling futures and buying call options on March futures contracts on November 1 (five months before the end of trading in the March futures contract) at-the-money and 10, 20, and 30 cents in-the-money and out-of-the-money for the 1973-1986 period. The table shows how those alternative strategies of buying call options in addition to hedging in futures would have performed during the 1973 through 1986 period if options had been available in this period of time.

Table 19. The gross margins of each year from selling futures and buying call options on March futures contract on November 1 during the period of 1973-1986

Crop	In-the-Money			At	Out-of-the-Money		
Year	-30	-20	-10	0	10	20	30
1973	1965	1897	1787	1808	1353	1027	640
1974	6033	5818	5583	5329	5056	4765	4457
1975	-1399	-1122	- 861	- 615	- 383	- 165	39
1976	- 200	- 242	29	279	507	715	903
1977	38	- 115	102	361	590	797	986
1978	1094	1008	871	974	1218	1403	1536
1979	- 348	- 438	- 221	84	327	515	651
1980	- 165	- 9	293	556	796	1005	1179
1981	-1190	- 883	- 602	- 348	- 119	85	266
1982	969	1371	1726	2038	2276	2454	2569
1983	2594	2531	2426	2245	1995	1663	1271
1984	-1385	-1498	-1355	-1073	- 828	- 529	- 473
1985	- 403	- 379	38	366	592	718	788
1986	- 801	- 792	- 630	- 287	- 82	19	62
mean[a]	486	511	656	823	950	1027	1062
s.d.[b]	1929	1860	1721	1559	1413	1285	1182

Source: Chicago Board of Trade prices adjusted to the value of the dollar in 1982.

[a]The calculated average margin.

[b]The calculated standard deviation.

The results of the first group of strategies, which assumes that Arizona grown barley is harvested and priced on June 1, are reported in Tables 13, and 14. From these tables, which represent the gross income of cash, hedging on July corn futures contracts and hedging on put options on July futures contracts, the highest average income is obtained from hedging by selling futures contracts (strategy 1b), but it has the highest variability of income at the same time. On the other hand, buying put options 10, 20, and 30 cents in-the-money and out-of-the-money (strategy 1c) show higher average income than cash sales and also have higher variability of income than cash sales (strategy 1a), but their average income is lower than the average income received from futures contract hedging.

The results of the second group of strategies, which assumes that Arizona grown corn harvested and priced on August 15, are reported in tables 15 and 16. From these tables, which represent the gross income of cash, December futures contract hedging and put option hedging on December futures contracts, the highest average income is obtained from cash sale (strategy 2a), but it has the highest variability of income at the same time. On the other hand, buying put options at-the-money and 10, 20, and 30 cents in-the-money and out-of-the-money (strategy 2c) show higher average income than selling futures contracts (strategy 2b) and also have higher variability of income than selling futures contracts, but their average incomes are lower than the average income received from cash sales.

The third group strategies assumes that Midwest corn was purchased on November 1 and sold on March 1. The results of the group have been reported in tables 17 through 19. From these tables, which represent the gross margin of cash, hedging on March futures contracts, selling call options on March futures contracts and hedging on March futures contracts associated with buying call options on March futures contracts. The highest average margin is obtained from selling March futures contracts (strategy 3b) which has the lowest variability of margin at the same time. The lowest average margin, on the other hand, is obtained from cash sales which has the highest variability of margin. Moreover, the sell March futures contract and buy call options on March futures contract strategy (strategy 3d) has a higher average margin than sell call options on March futures contract (strategy 3c). Strategy 3d has a lower variability of margins than strategy 3c at-the-money and 10, 20, and 30 cents in-the-money and out-of-the-money. Strategies (3c and 3d) have a higher average of margins than cash sale (strategy 3a), but they have a lower average of margins than gross margin obtained from selling March futures contracts (strategy 3b).

The average of income/margin and variability (S.D.) of income/margin for each strategy of all three groups are reported in Table 20.

Table 20. The average of income/margin and variability of income/margin for each strategy of all three groups.

Strategy	Mean	S.D.	Ranked by Mean	Ranked by Mean-S.D.
Group 1				
Cash 1	18250	4630		*
Futures 1	19089	6229	1	*
Option 1-30	18300	5164		*
Option 1-20	18288	5176		
Option 1-10	18273	5171		
Option 1 0	18248	5155		*
Option 1 10	18283	5155		*
Option 1 20	18337	5184	3	*
Option 1 30	18365	5226	2	*
Group 2				
Cash 2	18463	7548	1	*
Futures 2	16866	4051		*
Option 2-30	18308	6864		
Option 2-20	18295	6734		
Option 2-10	18314	6542		
Option 2 0	18320	6379	3	
Option 2 10	18328	6239	2	*
Option 2 20	18314	6111		*
Option 2 30	18275	5989		*
Group 3				
Cash 3	442	3789		
Futures 3	1248	930	1	*
Option 3c-30	823	2052		
Option 3c-20	838	2134		
Option 3c-10	730	2164		
Option 3c 0	604	2204		
Option 3c 10	513	2253		
Option 3c 20	464	2326		
Option 3c 30	450	2418		
Option 3d-30	486	1929		
Option 3d-20	511	1860		
Option 3d-10	656	1721		
Option 3d 0	823	1559		
Option 3d 10	950	1413	3	
Option 3d 20	1027	1285	2	
Option 3d 30	1062	1182		

In the case of ignoring the issue of risk, the strategies could be ranked according to the means only. Therefore, by reviewing the means in table 20, it has been found that some pricing strategies provide higher average of income/margin for feed grain producers and traders, but the superiority is not clear. With respect to Arizona barley growers (group 1), the best strategy is selling futures contracts which provides the highest average of gross income. Buying put options at different levels of in- and out-of-money on July futures contracts provide better alternatives than cash sales regardless of the producers' preference toward risk. The best strategy, with respect to Arizona corn producers (group 2), is cash sales which provides the highest average of gross income, regardless of the producers' preferences toward risk.

Sell futures contracts (strategy 3b) is the best strategy for group 3 (Midwest corn purchased on November 1 and sold on March 1). The next best strategy for this group is selling futures contracts associated with buying call options on March futures contracts (strategy 3d) regardless of the producers preferences toward risk.

Based on mean-variance analysis, it has been found that some pricing strategies provide little alternative for feed grain producers and traders but superiority is not clear. The decision rules based on mean variance analysis are as follows:

If $\bar{X}A \geq \bar{X}B$ and $\sigma A < \sigma B$, then strategy A is preferred to strategy B.

If $\bar{X}A = \bar{X}B$ and $\sigma A > \sigma B$, then strategy B is preferred to strategy A.

If $\bar{X}A > \bar{X}B$ and $\sigma A > \sigma B$, then strategies A and B cannot rank.

Where $\bar{X}A$ = the average income/margin of strategy A

$\bar{X}B$ = the average income/margin of strategy B

σA = the variance of strategy A

σB = the variance of strategy B

The variance here is the standard deviation (S.D.).

From table 20, it is found that for Arizona barley growers (strategies of Group 1) and Arizona corn growers (strategies of Group 2), the superiority of the strategies cannot be ranked because the strategies which have the highest average of income have the highest variability of income and the strategies which have the lower average of income have the lower variability of income. With respect to the third group of strategies, it is found that selling futures contracts (strategy 3b) is preferred to all other strategies within this group, because it has the highest average of margin and, at the same time, it has the lowest standard deviation among the other strategies in the same group. An efficient set of strategies based on mean-variance analysis for each group is denoted by (*).

Therefore, it is difficult to judge about which strategy has superiority among the others because in most cases (except strategies of Group 3) the strategies with higher levels of average income have higher levels of variability of income. And the strategies which have lower levels of variability of income have lower levels of average income. However, when the mean-variance method is used in marketing analysis, the judgment about the superior strategy among the others will be difficult and sometimes cannot be done. Therefore, in order to make the study more useful for feed grain producers and traders, another technique for ranking strategies is needed to make better decisions among selected strategies.

Stochastic Dominance Approach

In order to get an efficient set of pricing strategies, this study will use the more sophisticated technique rather than mean-variance (E-V) technique which is limited by relying on summary statistics such as mean and variance. The stochastic dominance (SD) approach is used as a decision tool in ranking the alternatives to obtain the dominant or efficient set of pricing strategies. The stochastic dominance criteria provide a means of ordering risky alternatives for groups of decision-makers whose utility functions possess similar properties (Zentner et. al., 1981).

The stochastic dominance analysis is based on maximization of expected utility. It involves the area beneath a probability distribution. A specified risky prospect is said to dominate the others if its expected utility exceeds the expected utility of another for all possible utility functions within a defined class (Zentner et. al., 1981). The advantages of stochastic dominance is that it provides more discrimination in the analysis than the mean-variance technique. Moreover, the selection of an efficient set of alternatives can be ordered depending on the preferences of the decision makers by using SD technique. Finally, the stochastic dominance approach ranks most probability distributions for the specified alternative prospects (Wilson and Eidman, 1985).

The advantage of ordinary stochastic dominance is that the decision maker's utility function is not required to be specified. Ordinary stochastic dominance contains three degrees of efficiency that depend on the assumptions concerning the underlying utility function. First-degree stochastic dominance (FSD) which is based on the assumption that decision makers prefer more income to less, that is, marginal utility of money is greater than zero, $U'(M)>0$. Second-degree stochastic dominance (SSD) which assumes, in addition to the assumption of preferring more to less, that the decision maker's (producer's) are risk averse. This assumption requires that the marginal utility of decision maker is increasing as a decreasing rate $U'(M)>0$ and $U''(M)<0$. Third-degree stochastic dominance (TSD) which is based on the assumption that decision makers display decreasing absolute risk aversion, that is, the third derivatives of the underlying utility functions is everywhere positive ($U'(M)>0$, $U''(M)<0$, $U'''(M)>0$).

Generalized Stochastic Dominance Analysis

Meyer (1977a, b) developed a generalization of the ordinary stochastic dominance principles since risk levels are unspecified when these principles are used. Meyer's criterion is the extension of the ordinary SD principles which are referred to as SSD with respect to a function (SDWTF). This criterion assigns an upper and lower bound (intervals) on decision maker's absolute risk aversion functions.

Meyer's approach is based on the Arrow-Pratt absolute risk aversion coefficient which can be observed from the distribution of alternative consequences (outcomes) (Meyer, 1977b). Arrow-Pratt coefficient is defined as $r(m_i) = -U''(m_i)/U'(m_i)$, "the negative ratio of the second and first derivations of the utility-of-money function" (Zentner, et. al, p. 7).

This coefficient can be used to make a comparison between local risk attitudes among decision makers. From the definition, when the decision makers are risk averse, the Pratt coefficient is suggested to be a positive value. A zero coefficient refers to risk neutral decision makers, and a negative coefficient reflects risk preferring decision makers (Therefore, the specification of the utility functions of risky alternatives is required under this approach. This specification depends on decision makers' risk preferences.)

It is very important to specify the risk intervals when generalized stochastic dominance is used (Raskin and Cochran 1986). It is astonishing to observe different values being used in Raskin and Cochran's analysis of commonly used risk aversion coefficients. Wilson and Eidman (1985) have an example of this specification. Therefore, generalized SD provides a means for ordering a pair of risky prospects (pricing strategies) in a specific distribution of alternative strategies. Moreover, this approach has added greater flexibility to the ordinary SD principles and provided it with more discriminating power to differentiate between different risky prospects. Therefore, because of all these reasons, generalized stochastic dominance (SDWTF) will be used in this study to analyze the results of alternative pricing strategies in table 13 through table 22.

Assumptions on the Application of SDWTF

The study covers the years 1973 through 1986 and the data have been divided into three groups:

(1) Arizona grown barely harvested and priced on June 1 (prices based on corn prices).

(2) Arizona grown corn harvested and priced on August 15. Each of these two groups include 9 strategies and contain different hedging techniques (risky prospects).

(3) Midwest corn purchased on November 1 and sold on March 1. This group provides 16 strategies and it contains different hedging techniques.

The Arrow-Pratt intervals, upper and lower bounds, for the first two groups, are assumed as follows: [.001, .0005], [.0002, .0005] and [-.0002, .0002]. These intervals show the decreasing Absolute Risk Aversion for minimum levels of gross income, higher levels of gross income and maximum levels of gross income, respectively.

The Arrow-Pratt intervals, for the third group, are assumed as follows: [.001, .0002] show the Constant Absolute Risk Aversion for all levels of gross margins.

Results from Alternative Marketing Strategies Using Applied SDWTF

Sufficient rules for choosing among alternative risky prospects (outcomes) with respect to particular risk preferences have been developed by Meyer. These rules imply choosing between a pair of risky prospects (pricing strategies) for particular groups of decision makers whose absolute risk aversion functions fall within the given interval. This study used these rules and procedures to find the best alternative pricing strategy with respect to upper and lower bounds as decision makers' absolute risk aversion.

The results of generalized stochastic dominance analysis for the strategies of the first two groups are shown in table 21. Table 22 reports the dominant alternative strategies for constant absolute risk aversion (CARA) decision makers for the strategies of the third group.

Table 21. The dominant alternative strategies for decreasing absolute risk aversion (DARA) decision makers for the first two groups of strategies for the period 1973-1986*

Strategy	Mean	S.D.	DARA[1]
Cash 1	18250	4630	4
Futures 1	19089	6229	1
Option 1-30	18300	5164	5
Option 1-20	18288	5176	
Option 1-10	18273	5171	5
Option 1 0	18248	5155	4
Option 1 10	18283	5155	3
Option 1 20	18337	5184	1
Option 1 30	18365	5226	2
Cash 2	18463	7548	
Futures 2	16866	4051	
Option 2-30	18308	6864	
Option 2-20	18295	6734	
Option 2-10	18314	6542	
Option 2 0	18320	6379	
Option 2 10	18328	6239	
Option 2 20	18314	6111	
Option 2 30	18275	5989	

[1] [6674-12,000] [/001, .0005]
[12,001-22,000] [.0002, .0005]
[22001-36413] [-.0002, .0002]

*The numbers 1, 2, 3, 4 and 5 under DARA mean that #1 dominates all other strategies, #2 dominates all other strategies except #1; #3 dominates all other strategies except #1 and #2; #4 dominates all other strategies except 1, 2 and 3; #5 dominates all other strategies except #1, 2, 3, and 4. If two strategies have the same ranking, they cannot be differentiated.

Table 22. The dominant alternative strategies for constant absolute risk aversion (CARA) decision makers for the strategies of the third group for the period 1973-1986*

Strategy	Mean	S.D.	CARA[1]
Cash 3	442	3789	
Futures 3	1248	930	1
Option 3c-30	823	2052	
Option 3c-20	838	2134	
Option 3c-10	730	2164	
Option 3c 0	604	2204	
Option 3c 10	513	2253	
Option 3c 20	464	2325	
Option 3c 30	450	2418	
Option 3d-30	486	1929	
Option 3d-20	511	1860	
Option 3d-10	656	1721	
Option 3d 0	823	1559	
Option 3d 10	950	1413	4
Option 3d 20	1027	1285	3
Option 3d 30	1062	1182	2

[1][-9202 - 6033] [.001, .0002]

*The numbers 1, 2, 3, and 4 under CARA mean that #1 dominates all other strategies, #2 dominates all other strategies except #1; #3 dominates all other strategies except #1 and #2; #4 dominates all other strategies except 1, 2 and 3.

Some labels were applied to the alternative marketing strategy to simplify the presentation of results running on the mainframe computer of the University of Arizona for generalized stochastic dominance. For example, options -30 means the first option strategy in the distribution 30 cents out-of-the-money which means in table 23 buying put options on July futures contracts at 30 cents out-of-the-money. Option 3c 10 means the third option strategy in the distribution 10 cents in-the-money which means in table 24 selling call options on March corn futures contracts at 10 cents in-the-money---and so on. When a number appears more than one, this should be interpreted as an equal ranking of that order.

As assumed earlier, in order to make the analysis simple and clear, the most dominant strategies with regard to the risk aversion function intervals are selected. From table 23 when feed grain producers are assumed to be decreasing absolute risk averse, selling July corn futures contracts and buying put options on July futures contracts 20 cents in-the-money are the dominant strategies in the distribution with respect to the strategies of the first two groups. Meanwhile, they dominate all 16 strategies at the specified range of coefficients. The dominant strategies mean that if the producer is decreasing absolute risk averse, then he will select these strategies over other strategies available in the same group of strategies. The explanation of this type of risk preference (Decreasing Absolute Risk aversion) would be that as income increases and the decision maker becomes wealthier, he or she will be more willing to take a risk. By looking to the E/V column in the table, it is clear that selling July futures contracts has the highest average gross income and at the same time, it has the highest variability of income among all strategies in the table. Selling corn at prevailing cash prices on August 15, and buying put options on December futures contract at 30 cents out-of-the-money strategies are dominated by all other strategies in the distribution because they reflect the highest risk without having the highest average income. This makes these strategies the least desired by decision makers who are willing to accept high risk associated with higher average income.

The dominant alternative strategies for decreasing absolute risk aversion decision makers for each set of strategies of the first two groups are reported in table 23. With respect to first group of strategies (Arizona grown barley harvested and priced on June 1), hedging by selling July futures contracts and buying put options on July futures contracts 20 cents in-the-money are the dominant strategies in the distribution assuming that the decision makers have decreasing absolute risk aversion.

Table 23. The dominant alternative strategies for decreasing absolute risk aversion (DARA) decision makers for each set of strategies of first two groups for the period 1973-1986

Strategy	Mean	S.D.	DARA
Cash 1	18250	4630	
Futures 1	19089	6229	1
Option 1-30	18300	5164	
Option 1-20	18288	5176	
Option 1-10	18273	5171	
Option 1 0	18248	5155	
Option 1 10	18273	5155	3
Option 1 20	18337	5184	1
Option 1 30	18365	5226	2
Cash 2	18463	7548	
Futures 2	16866	4051	1
Option 2-30	18308	6864	
Option 2-20	18295	6734	
Option 2-10	18314	6542	
Option 2 0	18320	6379	
Option 2 10	18328	6239	
Option 2 20	18314	6111	3
Option 2 30	18275	5989	2

Hegding by buying put options on July futures contracts 20 cents out-of-the-money is dominated by all other strategies (8 strategies) in this group. Therefore, the Arizona barley growers who have decreasing absolute risk aversion would be willing to select selling July futures contracts and/or buying put options on July futures contracts 20 cents in-the-money strategies for pricing their products. At the same time, buying put options on July futures contracts 20 cents, out-of-the-money would be the least desired strategy for Arizona barley producers who have a decreasing absolute risk aversion.

With respect to the second group of strategies (Arizona grown corn harvested and priced on August 15), hedging by selling December futures contracts is the dominant strategy in this group assuming that the decision makers have decreasing absolute risk aversion. Hedging by buying put options on December futures contracts 30 cents out-of-the-money and selling the corn at prevailing cash prices in August 15 are dominated by all other strategies in this group. Therefore, the Arizona corn growers who have decreasing absolute risk aversion would be willing to select selling December futures contracts for pricing their products. At the same time, cash sale and buying put options on December futures contracts 30 cents out-of-money would be the least desired strategies for producers who like to take risks as income increases (DARA).

For the third group of strategies (Mid-west corn is purchased on November 1 and sold on March 1), hedging by selling March futures contracts would have provided a dominant strategy over all alternative strategies in the group assuming constant absolute risk aversion (CARA) decision makers. This assumes that as the gross margin of corn producers (traders) increase, the producers' attitudes toward taking risk would be constant, and decision makers prefer the lowest risk strategy. Table 24 shows that this strategy has the highest average of gross margin and at the same time it has the lowest standard deviation. This strategy dominates all other 15 strategies in the group. Also hedging by selling March futures contracts and buying call options on March futures contrasts at 10, 20 and 30 cents out-of-the-money are dominant over the rest of the strategies in the group, assuming a constant absolute risk aversion decision makers. This provides the consistency of the model used in this test with the coefficients of utility functions assumed for CARA. These strategies have higher average of margin than most of the strategies in the group while they have the lowest standard deviations. Selling the corn at prevailing cash prices on March 1 is dominated by all other strategies in the group because it reflects the highest risk with the lowest average of gross margin. This makes this strategy the least desired by CARA decision makers who do not want to take risks in marketing their products.

CHAPTER VI

Potential Use of Options on Corn Futures Contracts in Pricing of Feed Grains in Arizona

Organized trading in futures contracts for corn was begun more than 100 years ago on the floor of the Chicago Board of Trade. Individual Arizona feed grains producers have made only very limited use of futures trading. This lack of use of futures trading by individual grain producers is likely explained by lack of knowledge about futures, the fact that corn futures contracts are in fixed amounts of 5000 bushels per contract, a highly variable basis and the availability of alternative price setting methods including marketing through farmer marketing cooperatives. In recent years substantially more than half of the feed grain produced in Arizona has been marketed through farmer cooperatives. Hedging by buying put/call options or by selling call options on corn futures contracts became available in early 1985.

The price of options before 1985 is not known because the options were not traded. The Black model has been used to predict the options premiums in the years when options were not available. Many researchers have tested this model and the predictions are consistent with the actual premiums. The predicted option premiums have been used to estimate the gross income or gross margin of each year for the period of study (1973-1986) to show how options could have performed if the options were available to Arizona feed grain producers or their marketing cooperatives.

In reviewing the average of income for the first group of alternative strategies (Arizona grown barley harvested and priced June 1), it has been found that in and out-of-the-money option strategies raised the average income over cash sales. In the second group of strategies (Arizona grown corn harvested and priced August 15), it has been found that option strategies raised the average income over the hedging in futures contracts strategy. It has also been found that option strategies raised the average margin over cash sales in the third group of strategies (mid-west corn purchased on November 1 and sold on March 1).

Buyers of put options should use options continuously because the loss of money will be limited when prices decline and the benefits when prices rise will be reduced by only the amount of the premium and transaction costs. Buyers of call options should use options continuously to limit losses when prices increase while gaining most of the benefits when prices decline.

The results of evaluating the alternative strategies based on mean-variance analysis produced no clearly preferred strategies because most strategies which have higher average income/margin also have higher standard deviations, and the strategies which have lower average of income/margin have lower standard deviations. The use of generalized stochastic dominance with absolute risk aversion function intervals has provided more information because it allows for producers with different risk preferences.

With the assumption of decreasing absolute risk aversion--which assumes that as a risk averse decision maker realizes more income he will be willing to accept more risk--stochastic dominance analysis indicates that the option hedge would be effective in providing dominant strategies. For example, buying put options at 20 cents in-the-money dominates all other strategies of group one (Arizona grown barley harvested and priced June 1) except hedging with corn futures contract which has the same degree of dominance in the same distribution. In the second group of strategies (Arizona grown corn harvested and priced August 15), buying put options on December futures contracts at several levels of in- or out-of-the-money dominate the cash sales strategy assuming decreasing absolute risk aversion decision makers. This indicates that option hedges would provide good alternative pricing strategies for feed grains producers. It has been found that the dominance of options strategies of in-the-money and out-of-the-money will decrease as we move from in-the-money to out-of-the- money. Another observation from the results of stochastic dominance analysis in the third group of strategies (mid-west corn purchased on November 1 and sold on March 1), is that buying call options while selling futures contracts (strategy 3d) is the dominant strategy for constant absolute risk aversion decision makers except for hedging with corn futures contracts (strategy 3b). In this group of strategies the dominance of hedging in futures contracts over hedging in options will decrease as we move from in-the-money to out-of-the-money options when the decision makers are constant absolute risk averse. Based on the evidence provided by the generalized stochastic dominance approach assumptions, it is found that commodity options would be the best alternatives (after selling futures contract strategy) for feed grains producers throughout the period of study (1973-1986). The accuracy of selecting any option strategy depends on the intervals of the absolute risk aversion function and based on the accuracy of the determination of the utility function of feed grains decision makers (producers or cooperatives).

The flexibility of options allows the buyer of the put option to exercise it if the futures price of corn is below the strike price and to let it expire if the futures price of feed grain is above the strike price. The buyer of call options would have the flexibility to let the option expire if the futures price of corn is below the strike price and to exercise the option it futures price of corn is above the strike price. To conclude, based on the assumptions used in the study, options on corn futures contracts may play an important role in the pricing of feed grains in Arizona in the future when the prices are very volatile.

APPENDIX A

DEFLATED CORN PRICES

Table 1A. Deflated corn prices (1982=100) cash and futures 1973-1986.

Cash Sale	Cash		July Futures		December Futures	
	June 1	Aug. 15	Nov. 1	June 1	June 1	Aug. 15
1973	495.4	653.5	312.8	457.9	407.6	631.8
1974	516.1	662.7	489.1	496.7	441.2	648.8
1975	481.0	528.1	709.5	466.7	408.7	544.2
1976	476.6	451.8	477.5	477.9	450.4	444.5
1977	375.0	268.7	433.0	385.4	392.4	299.9
1978	369.2	310.8	350.6	383.3	388.4	325.3
1979	343.8	358.1	348.5	350.1	358.9	361.3
1980	310.3	375.0	378.7	333.1	353.2	397.4
1981	386.7	337.1	448.1	389.8	399.6	341.7
1982	267.4	215.3	350.7	272.4	279.2	226.4
1983	296.7	361.6	239.2	293.1	268.9	351.7
1984	319.8	278.2	320.9	324.3	281.9	264.5
1985	253.2	233.7	269.7	247.1	227.3	203.5
1986	218.4	134.8	221.9	209.6	171.9	148.9

Table 2A. Deflated corn prices (1982=100), cash and futures 1973-1986.

Sale Year	Cash		March Futures	
	Nov. 1	March 1	Nov. 1	March 1
1973	286.0	335.1	303.2	348.6
1974	464.9	626.0	479.2	631.1
1975	649.7	465.8	696.0	464.9
1976	421.5	448.7	471.2	448.3
1977	371.2	392.3	417.9	399.4
1978	293.2	325.6	340.5	334.8
1979	307.7	310.7	334.7	317.1
1980	302.2	313.8	353.7	327.6
1981	397.5	376.0	449.2	397.5
1982	276.7	266.0	328.5	261.2
1983	206.0	267.3	225.2	267.1
1984	326.1	310.7	326.9	310.5
1985	253.0	251.4	261.0	240.0
1986	208.3	198.7	216.3	202.4

APPENDIX B

THE DIFFERENTIAL EQUATIONS THAT ARE USED IN THE BLACK MODEL TO ESTIMATE THE VALUE OF COMMODITY OPTION

The differential equations that are used in the Black Model to estimate the value of commodity option are as follows:

$$W(X,t) = e^{r(t-t^*)}[XN(d_1)-C^*N(d_2)],$$

$$d_1=[\ln X/c^*+s^2/2(t^*-t)]/s\sqrt{(t^*-t)},$$

$$d_2=[\ln X/c^*-s^2/2(t^*-t)]/s\sqrt{(t^*-t)}$$

where:

$W(x,t)$ = The value of the commodity option

C^* = The exercise price

x = Futures price

(t^*-t) = The days to maturity

$N(d)$ = The cumulative normal density function

$xe^{r}(t^*-t)$ = The same as the value of an option on a security (Black and Schoales, 1973) that pays a continuous dividend at rate equal to stock price times the interest rate when the option can only be exercised at maturity.

r = interest rate (constant through time)

s^2 = The variance rate

TAX and transaction cost = zero

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