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# Marketing of Cotton Fiber in the Presence of Yield and Price Risk

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### Abstract

An expected utility model and a chance constrained linear programming model were used to analyze four marketing strategies and seven crop insurance alternatives in cotton marketing in Georgia. The results obtained suggest that the existing marketing tools and insurance alternatives can be used successfully as a substitute for government support.

## Marketing of Cotton Fiber in the Presence of Yield and Price Risk

## Introduction

Over the years, agricultural policy in the United States has attempted to protect producers from the uncertainty of market conditions. Recently, the movement toward less government involvement in the pricing of agricultural commodities has increased awareness and importance of tools for managing price risk, such as futures and options, that could be substituted for government price-stabilization programs. The 1996 Farm Bill reduces price support exposing producers to greater price risk. This study examines the feasibility of using existing market tools to manage price and output risk in cotton marketing in Georgia.

Cotton producers may purchase crop insurance to protect their annual production from unfavorable growing conditions. Additionally, they can use forward contracts, and futures and options markets to protect themselves from variability in prices. Crop insurance is a tool that can be used to manage output risk in crop production. Currently available crop yield insurance alternatives range from 50% to 75% of average production history. Price insurance coverage ranges from 60% to 100% of the base price calculated from cotton futures prices.

## Objectives

This study analyzes several management scenarios to determine if existing marketing tools and alternative marketing strategies, used as substitutes for reduced government support, can be useful in managing revenue risk for cotton producers. Marketing tools include forward contracts, futures contracts, and put and call options. The specific objectives of this research are: (1) to examine the potential use of alternative marketing strategies for improving the profitability of cotton production, and (2) to analyze the linkage between yield and price risk by developing alternative marketing strategies which depend upon yield management strategies.

## Literature review

The choice of an optimal combination of marketing strategies requires the knowledge of available marketing instruments and decision rules that lead to best marketing strategies. In this section, we review recent literature on marketing tools utilized in this study. Literature on hedging with futures and options is reviewed first. Then, studies dealing with the firm's decision process under uncertainty are summarized. Finally, the existing tools for evaluation of risky alternatives are reviewed.

### Hedging with Futures and Options

The existence of the futures and options markets provides the possibility of using them as a hedging tool to protect market participants from price variability. Futures and options provide many interesting research questions that have been investigated extensively.

Lapan et al. (1991) analyzed production, hedging, and speculative decisions when both futures and options are used in an expected utility model of price and basis uncertainty. They found that options are redundant when prices are unbiased. Optimal hedging requires only futures. When prices are perceived as biased, options are used together with futures as speculative tools. They concluded that the mean-variance analysis, in general, is not consistent with expected utility when options are allowed.

Lapan and Moschini (1994) derived optimal futures hedges under the assumptions that the three random variables (price, basis, and production) are jointly normally distributed and the decision maker has a constant absolute risk aversion (CARA) utility function. Under these assumptions the optimal hedge ratio does not depend on the level of risk preferences.

Vercammen (1995) investigated the possibility of using commodity options when price distributions are skewed. He concluded that usefulness of options as a price-risk management tool depends on the degree of skewness in market price distributions.

Myers and Hanson (1993) presented option pricing models when time-varying volatility and excess kurtosis exist in the underlying futures price. They employed a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model to price soybean options and showed that this model outperforms the standard Black option-pricing model, which uses historical volatilities.

Hauser and Andersen (1987) used naive, ordinary least squares and time series models to forecast variance in soybean futures prices. In their study a time series model is found to be the best model for variance forecasting. Variance forecasts are then used to price new-crop soybeans with the use of put options.

Brorsen et al. (1998) examined hedging of hard red winter wheat using Kansas City and Chicago wheat futures. They concluded that the producer who maximizes expected utility would choose the Kansas City futures contract to hedge hard red winter wheat. Producers and commercial hedgers will prefer hedges over the cash market only if they are moderately to strongly risk averse.

## Firm’s Behavior under Uncertainty

A firm operating under market conditions is exposed to various kinds of risk. In this study, output price and yield risk are analyzed as they affect the firm. Many researchers addressed the problem of decision making under uncertainty and developed different models to be used in the decision process. We look briefly at the literature related to managing price and output risk.

Rolfo (1989) developed a model that derives an optimal hedging strategy for a producing country that is subject to variability in both price and output. He used coconuts as the primary commodity. Employing logarithmic and quadratic utility functions he concluded that the optimal hedging position is less than the level of expected output.

Holthausen (1979) analyzed the hedging strategy of the firm under price risk. Risk aversion affects the firm's optimal hedge, and if the forward price is less than the expected price, the hedge increases as the firm becomes more risk averse. For non-increasing absolute risk aversion, the optimal hedge increases as the riskiness of the price uncertainty increases.

Feder et al. (1980) examined the behavior of a competitive firm under price uncertainty where a futures market exists. The distribution of cash price affects the firm's involvement in the futures market. The production decisions depend only on the futures market price and input prices.

Grant (1985) analyzed producers behavior under price and yield uncertainty. A producer facing joint price and output uncertainty but without forward contracting opportunities behaves in the same way as the one confronting price risk only. If forward contracting opportunities exist in the presence of both price and output uncertainty, the choice of production scale and optimal forward position are interdependent. Both choices depend upon the joint distribution of price and quantity and upon the producer's degree of risk aversion.

**Evaluation of Risky Alternatives**

Based on limited information, a firm makes a decision under price and output uncertainty. The outcomes of a particular decision are revealed ex post, i.e., after the uncertainty is resolved. Since the decision has to be made ex ante (i.e., before the uncertainty is resolved) it has to be evaluated based on ex ante information. This section reviews the existing approaches to the evaluation of risky alternatives.

Markowitz (1952) provides a theoretical foundation for portfolio selection employing first two moments of returns distributions. Given various combinations of mean (E) and variance (V) there exist set of efficient E-V combinations. If a decision maker can state which E-V combination from an attainable set that she/he prefers, we could then find a portfolio which gives the desired combination. The mean-variance criterion ranks alternative A with $Mean_A$ and $Variance_A$ over alternative B with $Mean_B$ and $Variance_B$ if $Mean_A \geq Mean_B$ and $Variance_A \leq Variance_B$ with at least one of the inequalities being strict.

Brorsen et al. (1998) examined hedging of hard red winter wheat using Kansas City and Chicago wheat futures. They concluded that the producer who maximizes expected utility would choose Kansas City futures contracts to hedge hard red winter wheat. Producers and commercial hedgers will prefer hedges over the cash market only if they are moderately to strongly risk averse.

Barry (1974) analyzed the effects of different assumptions about mean, variances and covariances on a risk efficient set. He showed that as increased uncertainty is introduced, the risk associated with a given portfolio increases, but the portfolio identified as efficient under more certain assumptions about mean, variance and covariance remained efficient under more uncertain assumptions. The efficient set in risk-return space shifts causing the optimal portfolio to change.

Paris (1979) used quadratic programming to generalize the traditional mean-variance approach originated by Markowitz's portfolio analysis to farm planning under uncertain revenues. This formulation admits nonzero covariances between revenues and costs of limiting inputs and allows the computation of risk coefficients associated with a companion chance constrained programming.

Menezes et al. (1980) formulated definitions of increasing downside risk. They show that the third derivative of the utility function being positive is the only property necessary to define a set of downside risk averters. They argue also that downside risk aversion is independent of risk preferences, i.e., both risk averters and risk lovers can be downside risk averse. Similarly, individuals with increasing or decreasing utility can be averse to downside risk.

Zacharias et al. (1987) presented stochastic dominance criteria to determine a risk-efficient set of cross-hedging alternatives in the presence of yield risk. They applied the model to cross-hedging rough rice with wheat futures contract.

Chyen et al. (1992) employed stochastic dominance criteria to evaluate different alternative insecticides for soybean stink bug control. Using 1988 and 1989 data for Florida, Georgia and Louisiana, they concluded that alternative, currently available, and less toxic insecticides may reduce producer costs, increase yield and improve soybean quality.

Wetzstein et al. (1992) established a conceptual link among mean-variance, stochastic dominance, mean-risk, and Gini mean difference for determining risk efficient decision sets. Their empirical testing shows that mean-risk, Gini mean difference, and extended mean-absolute Gini efficiency criteria provide a good generalization of efficiency criteria in risk analysis.

Balkeslee (1997) developed a method to find a sequence of expected utility maximizing decisions under risk aversion when random elements are time-dependent. A Taylor-series approximation to expected utility was used. The model was applied to marketing stored wheat. Dynamic programming is used to find the optimal sequence of marketing decisions. He found that the optimal sequence of sell-hold marketing decisions depend on the level of wheat prices and the risk aversion of a decision maker.

## Methodology

Four marketing strategies for a cotton producer were designated. The description of these marketing strategies is provided first. Then, a decision rule for choosing the best marketing strategies and insurance alternatives was developed. The decision rule consisted of two alternative models. The first model assumes that the decision maker has a continuous, twice differentiable, and concave utility function. He/she chooses a combination of marketing strategies and insurance level that maximizes expected utility. The second model uses chance constrained linear programming to find an optimal combination of marketing strategies and insurance level, subject to the constraint that the revenue should be greater than costs at a chosen confidence level. Both decision models make use of the price and yield distributions. Those distributions were estimated from historical data on prices and yields.

## Alternative Marketing Strategies

A representative farm growing 500 acres of cotton in south Georgia was selected as the baseline firm. Both yield and price risk are assumed to exist. The representative managing agent chooses an optimal level of yield insurance and optimal marketing strategy or a combination of marketing strategies. Alternative marketing strategies include: (1) cash sale at harvest, (2) forward contract, (3) single future hedge, and (4) cash sale at harvest with a put option purchased at planting time and sold at harvest. Those four marketing strategies are pre-harvest price protection alternatives. The producer can choose one or combination of marketing strategies to protect himself/herself from the price uncertainty. The description of marketing alternatives follows.

1. Cash sale at harvest

The commodity is produced and sold at harvest (November) in the local cash market. The expected price received from cash sale marketing strategy is equal to the expected cash prices at harvest (November). The variance of prices received from the cash sale strategy is equal to the variance of cash prices at harvest. This is a simplest marketing strategy and does not require use of forward contracts. However, this marketing strategy does not eliminate any risk.

2) Forward contract at planting time

A producer will forward contract his/her crop at planting time generally in April. At harvest time the commodity is sold at the price agreed to in the forward contract. The expected price received from this marketing strategy is equal to the forward contract price. The variance of price under a forward contract is equal to zero. According to *Agricultural Statistics* (1997) the use of forward contracts varies by year. The forward contract is the most popular marketing tool for Georgia cotton producers. The producer does not have to enter the futures or options market. There are no margin calls as in the case with a futures contract. Price and basis risk are completely eliminated. The primary drawback of a forward contract is the possibility of paying a fine for non-delivery of the contracted amount. This may happen when the actual yield is below the expected yield.

3. Simple one year hedging

The producer enters the futures market by selling a futures contract in April (at cotton planting time) each year. At harvest the production is sold in the cash market and the futures position is closed by buying an offsetting futures contract. The expected price received from single-year hedging is equal to the December futures prices in April plus the expected basis minus transaction costs. The variance of price received from single-year hedging is equal to the variance of cash-futures basis within n-year period. The futures price is known at the time of making the initial hedging decision and therefore the variance of the futures price is equal to zero. With this marketing strategy, price risk is eliminated but the basis risk is still present. The producer, using the futures market, is exposed to variation in the difference between cash and futures prices. This variation affects the payoff from a given marketing strategy.

4. Cash sale with purchase of a put option

This marketing strategy is based on using put options. A producer, to protect himself from falling prices, purchases a put option with an expiration date after harvest. The purchased option allows him to establish a price floor for the commodity but does not limit gains from rising prices. A put option is bought at planting time and sold at harvest. The expected price received from purchase of a put option strategy is equal to the expected cash price plus the expected sale price of a put option, the expected purchase price of the put option, minus transaction costs. The variance of price received from the purchase of a put option is equal to the variance of cash price plus the variance of the difference between sale and purchase price of a put option plus the covariance between cash price and option price difference.

## Crop Insurance Levels Available to a Cotton Producer

Apart from the choice of marketing alternatives, the grower can protect himself from the unfavorable growing conditions by purchasing available yield insurance. Multiple Peril Crop Insurance (MPCI) was used in this analysis to protect a cotton producer from yield variability. MPCI can be purchased for six different levels of yield protection ranging from 50 to 75 percent of average yield history and 60 to 100 percent of the established base price.

The federal government subsidizes Multiple Peril Crop Insurance and as a result, the producer buying the yield insurance coverage pays only a part of the base risk premium, the remaining part is covered by the federal subsidy (Crop and Hail Insurance Company, 1998). The level of subsidy varies for different price elections and yield coverage levels. In general, the producer share of the base premium is higher for higher yield coverage levels. Insurance with yield coverage of 50 percent and price election of 60 percent is provided free of charge with a $50 processing fee for producers enrolled in the MPCI program (Crop and Hail Insurance Co., 1998). The cost of this insurance is covered completely by the federal subsidy.

Premiums paid by the producer depend upon the base price, average production history, selected yield coverage, price election chosen, and the number of acres. The premium is calculated in the following way (Crop and Hail Insurance Co., 1998):

*Producer premium = (Base price)(APH)(Coverage level)(Acres)*

*(Base premium)(Producer premium percentage)(Option factor)*

where Base price is equal to 95% of the average price of December futures contracts between January 15 and February 14, APH is actual crop yield production history (minimum of 4 and maximum of 10 years of previous production yields), Coverage level is the level of insurance protection chosen by the farmer, Acres is the number of acres insured, Base premium and Producer premium percentage are from the Rain and Hail Insurance Company tables, and option factor is equal 0.9 if the basic unit option is chosen or 1.0 if hail and fire exclusion are chosen. Premiums are calculated based on the actual data obtained from the Crop and Hail Insurance Company. Alternatively, premiums could be modeled using a distribution of yields; however, distributions of yields for individual farmers are highly correlated and modeling may not reflect the actual choices.

Miranda and Glauber (1997), concluded that without affordable reinsurance, private crop insurance markets are doomed to fail because systematic weather effects induce high correlation among farm-level yields. They developed and applied an empirical model to the U.S. crop insurance market and concluded that U.S. crop insurers' portfolios are twenty to fifty times riskier than they would be otherwise if yields were stochastically independent across farms.

**Estimating distributions of yield and prices**

In order to apply the expected utility model or the chance constrained linear programming model, price and yield distributions are required. Once price and yield distributions are estimated, random draws from those distributions will be used to simulate prices and yields. Simulated prices and yields will then be used in both the chance constrained linear programming model and expected utility model. In the previous research, various models for analyzing price and yield distributions were utilized.

Day (1965) was the first to examine probability distribution of selected field crops. He analyzed yield distribution for major field crops. For most field crops, the distribution was found to be non-normal.

Ramirez et al., in their 1994 study demonstrated a method for estimating multivariate non-normal distributions of crop yields and prices over time, using the inverse hyperbolic sine transformation. The resulting estimates can be used to simulate a multi-variate distribution of crop yields or prices. Ramirez (1997) extended the model by allowing the random variable not only to be non-normal and correlated but also heteroscedastic, skewed and kurtosic. He applied his model to corn, soybean, and wheat yields in the Corn Belt.

Clements et al. (1971) showed how to obtain two correlated random variables. To achieve that objective, independent distributions are simulated first. Then the matrix of the independent distribution is multiplied by the Cholesky decomposition of the covariance matrix between the variables to be simulated.

In order to estimate the distribution of cotton yield, eighteen years of average county data for 53 counties in Georgia were regressed on the annual trend and county dummies. The residuals from this regression were plotted and examined for non-normality by calculating skewness and kurtosis. Then residuals were used to estimate the variance of cotton yield.

To estimate the distribution of cash price, eighteen years of average monthly cotton price at Memphis, Tennessee were regressed against the annual trend and monthly dummies. Then, the residuals from this regression were examined and used to estimate the variance of cotton cash price. Normal distributions for cash price and yield was assumed.

## Models and Assumptions

The mean variance criterion or stochastic dominance criteria will order only two risky alternatives. Chance constrained programming and expected utility have the capability of dealing with n risky alternatives and choosing the combination of those alternatives that give the highest returns for a given confidence level (a chance constrained programming model) or the highest expected utility (an expected utility model).

It was assumed that the representative agent grows 500 acres of cotton in south Georgia. Both yield and price risk are assumed to exist. The representative agent chooses a level of yield insurance marketing strategy or a combination of marketing strategies. Possible marketing strategies to choose include: 1) cash sale at harvest, 2) forward contract, 3) single future hedge, and 4) cash sale at harvest with a put option purchased at planting time and sold at harvest. Only those four marketing strategies out of ten analyzed were used in modeling marketing alternatives because those four marketing strategies are pre-harvest decisions. Remaining marketing strategies are either post harvest or long term marketing strategies.

In addition to the marketing alternatives for managing price risk, seven different Multiple Peril Crop Insurance levels were considered for yield risk protection. Seven different yield protection alternatives as well as no insurance alternative were considered. Those were: 50/60, 50/100, 55/100, 60/100, 65/100, 70/100, and 75/100 (yield/price coverage in percentages).

The expected utility model and the chance constrained linear programming model were employed to evaluate the elected combination of crop insurance levels and marketing strategies. In both models, 5,000 random drawings from the estimated distributions of yield and prices were used to calculate returns from a given combination.

Expected Utility Model

Under the expected utility model, the representative agent has a continuous, twice differentiable, and concave utility function with Arrow-Pratt constant absolute risk aversion (CARA) coefficient. The utility function is:

$$U = -exp(-aR)$$

where U is utility function, α is the coefficient of risk aversion, and R is revenue from a given marketing strategy or combinations of marketing strategies. The representative agent chooses the combination of marketing strategies and insurance level that maximizes expected utility of revenue. The analysis was performed for three different risk aversion coefficients 0.01, 0.03, 0.1, respectively. This level of risk aversion is most commonly used in the literature (e.g., Balkeslee 1997; Brorsen 1998; Rolfo 1980).

Chance Constrained Linear Programming Model

The chance constrained programming will choose the best combination of marketing strategies given a minimum revenue requirement and a confidence level within which the minimum revenue is to be achieved. The objective function is:

$$MAX\ ( S_{i=1}^{n} P_i Y_i - Ip + Id)$$

subject to:

$$Y_i \text{ ³ } 0,\ \text{"}I$$

$$S_{i=1}^{n} Y_i \text{ £ } EP$$

$$S_{i=1}^{n} P_i Y_i - Ip + Id - K_a\ [Var(S_{i=1}^{n} P_i Y_i)]^{1/2} \text{ ³ } R_{min}$$

where Pi is the expected price received under marketing strategy I, Yi is a share of marketing strategy I, Ip is the insurance premium paid, Id is the indemnity payment received, $K_a$ - is constant for given confidence level $a$, $Var(S_{i=1}^{n} P_iY_i)$ is the variance of revenue numerically calculated, EP is the expected production, and $R_{min}$ is the minimum revenue equal to the variable costs of production. Variable costs are assumed to be $300/acre (Georgia Extension Service).

## Empirical Results

Expected Utility Model

The yield and price distributions and crop insurance information were used in simulations. Yield and price distributions for 1997 were simulated. The actual base price for 1997 was equal to $0.7308/lb and the futures price was equal to $0.7505/lb. Average cotton yield production history (APH) was assumed to be equal to the expected yield for 1997. This value was equal to 737 lb/acre. The 1997 year was chosen in order to compare results obtained with the actual data.

Using 5000 drawings from yield and price distributions and data for 1997, the revenues were calculated for all possible combinations of marketing strategies and all possible crop insurance alternatives. The obtained revenues were than evaluated using the expected utility model. The results of expected utility maximizing model were as follows.

For risk averse preferences with the risk aversion coefficient of 0.01, the optimal combination of marketing strategies was independent of insurance level. The strategy was to sell two futures contracts (100,000 lbs.), forward contract 250,000 lbs., and sell the remaining balance (18,500 lbs.) in the cash market in November. The optimal yield insurance level in both cases was to get the 50/60 crop insurance alternative (50% yield and 60% price guarantee) that is available for a minimal processing fee (Table 3).

The result for risk aversion coefficient of 0.03 and 0.1 differed by the yield insurance level selected. The expected utility and the best combination of marketing strategies, that maximizes expected utility for a given insurance option are as follows. Insurance alternative is the selected coverage level and price election, e.g., 65/100 means that 65% of the farm's average production history and 100% of base price coverage are chosen. The optimal insurance level for 0.03 risk aversion coefficient was 65/100 insurance alternative. The optimal insurance level for 0.1 risk aversion coefficient was 75/100 insurance alternative.

The solution for the expected utility maximizing model can be compared to the actual payoffs from the alternative marketing strategies. The payoffs from using four different marketing strategies for 1997 are as follows: cash sale - 70.27 cents/lb.; forward contract - 73.30 cents/lb.; futures hedge -72.55 cents/lb.; and cash sale with a put option - 69.56 cents/lb. The best payoff was achieved using forward contracting. It was not optimal, however, to forward contract the entire production because of the existing yield risk and possibility of paying a penalty for delivery failure.

An interesting question is, how the optimal combination of marketing strategies and insurance alternative change when we change the level of futures prices used in calculation. To answer this question, a sensitivity analysis of different marketing strategies and insurance alternatives was performed to evaluate a change in futures price level on the optimal marketing strategies. The spring futures price level was changed from 60 to 75 cents per pound which is about 8 cents below and 7 cents above the average futures prices before planting for the period of 1980-1997. The results for different levels of futures prices are summarized in Tables 4 to 6.

For risk averse preferences (Table 4) with the risk aversion coefficient of 0.01 the results are as follows. It is optimal to purchase a 50/60 crop insurance coverage. The optimal marketing strategies vary from cash sale at low levels of futures prices utilizing options market as futures prices rise and then forward contracting for higher levels of futures prices. Futures prices are used only with the highest levels of cotton futures prices in the spring and then with a combination of forward contracts and put options.

As the risk aversion coefficient increases to 0.03 (Table 5), the optimal combination of marketing strategies and insurance coverage change. For this level of risk aversion, the optimal marketing strategy is to wait and sell the output in the cash market at harvest for low levels of futures prices. The preferred insurance level is the 50/60 yield/price coverage when futures prices are low. As the futures price levels increase, it becomes optimal to enter the options market and then the forward market. It is never optimal to enter the futures market at this level of risk aversion. The optimal insurance coverage at higher level of futures prices is to buy the 65/100 insurance coverage.

When the expected utility model with a risk aversion coefficient of 0.1 was utilized, the optimal crop insurance coverage was 75/100 which is the maximum possible insurance level (Table 6). The optimal marketing strategies consisted of a combination of put options, forward contracts, and cash sale. The amount of forward contracted output increased with the increase in futures price level.

Chance Constrained Linear Programming Model

The chance constrained linear programming model was applied to the 1997 initial cotton data. The data required for the analysis included futures price of 75.05 cents per pound, expected yield of 737 lbs./acre, and put option price of 3.01 cents per pound. The expected production on 500 acres was equal to 368,500 lbs. Results of optimization model using the above assumptions are shown in Table 7. For the initial data in 1997, and at the 95% confidence level, the optimal level of insurance coverage was 50/60 and the following combinations of marketing strategies: two futures contracts that are equivalent to 100,000 lbs. and 250,000 lbs. of forward contract, with the remainder of expected production (18,500 lbs.) to be sold at cash market at harvest. The optimal combination of marketing strategies was the same for other insurance levels.

For the initial cotton data in 1997 and at the 99% confidence level, the optimal level of insurance coverage was the 65/100 insurance alternative (Table 8). The following combinations of marketing strategies are: one futures contract corresponding to 50,000 lbs. of cotton, 250,000 lbs. of forward contract, 1 put option that corresponds to 50,000 lbs, and the remainder of the expected production (18,500 lbs.) to be sold in the cash market at harvest.

Similarly to the expected utility model, the response to a change in futures price levels was analyzed. Sensitivity of the solution to a change in futures price level in the spring was analyzed by varying futures price levels from 65 to 75 cents per pound.

Regardless of the level of futures prices, the optimal insurance option was 50/60 at the 95% confidence level that expected revenue will be greater or equal to the variable costs (Table 9). The combination of marketing alternatives is different for alternative levels of futures prices. At low levels of futures prices, it is optimal to buy put options for only part of the expected production. As the level of futures prices increases the number of put options purchased goes up. For the futures prices above 70 c/lb, it becomes optimal to forward contract or enter the futures market.

The optimal insurance option for 99% confidence level and the futures price greater or equal to 70 c/lb. is 65/100 (Table 10). For the lower futures price level, the optimal coverage level is higher than 65%. For the futures prices of 65 c/lb. and below, no feasible solution was found that would guarantee the expected revenue to be greater or equal to variable costs at the 99% confidence level.

The most popular insurance level bought by cotton producers is 65/100 according to the data obtained from Rain and Hail Crop Insurance Company (1998). The results from the expected utility model as well as the chance constrained linear programming model correspond very closely to the actual data for the state of Georgia.

## Conclusions

This study examined the feasibility of using existing marketing tools to manage price and output risk in the marketing of cotton products in Georgia. The significance of the research is increased by the fact that the 1996 Farm Bill reduces protection for agricultural producers exposing them to more price and revenue risk than at any time since 1930s.  There are two major practical implications resulting from this research.

First, existing marketing tools can be used successfully in price risk management as demonstrated in this study. A marketing strategy or a combination of marketing strategies can be substituted for previous government price-protection programs. This is of particular importance in the age when government programs are being eliminated or reduced. The optimal marketing strategy or combination of marketing strategies depends, in the most part, on the level of the futures prices prior to planting in the spring.

Second, crop yield insurance coverage can complement the marketing tools in providing better protection for producers' revenues. The federal government subsidizes the basic yield insurance coverage. This makes the insurance more affordable for agricultural producers. Some of the yield insurance alternatives are available free of charge for a minimal processing fee of $50. This is at the 50/60 (yield/price) crop insurance level. The optimal insurance level depends on the level of risk aversion which varies for individual producers.

Less government intervention in the agricultural products market increases market efficiency. By substituting government programs with marketing tools, the tax burden for taxpayers is reduced, dead weight loss from transferring welfare from taxpayers to producers is eliminated, and the market forces are allowed to determine the supply and demand of agricultural commodities. The results of this study demonstrate that the existing marketing tools can be used to reduce price and output uncertainty. Moreover, government intervention in the agricultural product market can be reduced without exposing agricultural producers to full price and output risk.

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Table 1. Actual Base Premiums for Cotton by Different Actual Production History (APH) and Yield Coverage Level of Multiple Peril Cotton Insurance Levels

| APH Yield | Base premium by coverage level | | | | | |
|---|---|---|---|---|---|---|
| (lbs/acre) | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 |
| 0-355 | 0.153 | 0.166 | 0.186 | 0.211 | 0.254 | 0.325 |
| 336-396 | 0.142 | 0.153 | 0.171 | 0.196 | 0.238 | 0.301 |
| 397-457 | 0.123 | 0.134 | 0.149 | 0.170 | 0.207 | 0.262 |
| 458-518 | 0.110 | 0.119 | 0.134 | 0.152 | 0.185 | 0.234 |
| 519-579 | 0.099 | 0.108 | 0.120 | 0.138 | 0.167 | 0.211 |
| 580-640 | 0.091 | 0.098 | 0.110 | 0.125 | 0.152 | 0.193 |
| 641-703 | 0.084 | 0.091 | 0.101 | 0.115 | 0.140 | 0.177 |
| 704-764 | 0.078 | 0.085 | 0.094 | 0.107 | 0.131 | 0.165 |
| 765-825 | 0.072 | 0.080 | 0.089 | 0.101 | 0.122 | 0.155 |
| 826-886 | 0.068 | 0.074 | 0.084 | 0.095 | 0.115 | 0.146 |
| 887-947 | 0.065 | 0.070 | 0.080 | 0.090 | 0.109 | 0.139 |
| 948-1008 | 0.062 | 0.067 | 0.075 | 0.086 | 0.104 | 0.132 |
| 1009 and up | 0.060 | 0.065 | 0.073 | 0.084 | 0.102 | 0.129 |

Source: Rain and Hail Insurance Company, *Agent Training Manual*, 1998.

Table 2. Producer Premium Percentage

| Price | Yield Coverage Level | | | | | |
|---|---|---|---|---|---|---|
| Election | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 |
| 60% | 0 | | | | | |
| 67 | | | | | | 0.719 |
| 68 | | | | | | 0.724 |
| 69 | | | | | | 0.728 |
| 70 | | | | | | 0.731 |
| 71 | | | | | | 0.735 |
| 72 | | | | | 0.646 | 0.739 |
| 73 | | | | | 0.651 | 0.742 |
| 74 | | | | | 0.655 | 0.746 |
| 75 | | | | | 0.660 | 0.749 |
| 76 | | | | | 0.665 | 0.753 |
| 77 | | | | 0.567 | 0.669 | 0.756 |
| 78 | | | | 0.572 | 0.673 | 0.759 |
| 79 | | | | 0.578 | 0.677 | 0.762 |
| 80 | | | | 0.583 | 0.681 | 0.765 |
| 81 | | | | 0.588 | 0.685 | 0.768 |
| 82 | | | | 0.593 | 0.689 | 0.771 |
| 83 | | | | 0.598 | 0.693 | 0.773 |
| 84 | | | 0.509 | 0.603 | 0.696 | 0.776 |
| 85 | | | 0.515 | 0.607 | 0.700 | 0.779 |
| 86 | | | 0.521 | 0.612 | 0.704 | 0.781 |
| 87 | | | 0.526 | 0.616 | 0.707 | 0.73 |
| 88 | | | 0.531 | 0.621 | 0.710 | 0.733 |
| 89 | | | 0.537 | 0.625 | 0.714 | 0.736 |

Table 2. continued

| Price | Yield Coverage Level | | | | | |
|---|---|---|---|---|---|---|
| Election | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 |
| 90 | | | 0.542 | 0.629 | 0.717 | 0.739 |
| 91 | | 0.448 | 0.547 | 0.633 | 0.720 | 0.742 |
| 92 | | 0.454 | 0.552 | 0.637 | 0.723 | 0.745 |
| 93 | | 0.459 | 0.557 | 0.641 | 0.657 | 0.747 |
| 94 | | 0.465 | 0.561 | 0.645 | 0.661 | 0.750 |
| 95 | | 0.471 | 0.566 | 0.649 | 0.665 | 0.753 |
| 96 | | 0.476 | 0.571 | 0.652 | 0.668 | 0.755 |
| 97 | | 0.482 | 0.575 | 0.656 | 0.671 | 0.758 |
| 98 | | 0.487 | 0.579 | 0.659 | 0.675 | 0.760 |
| 99 | | 0.492 | 0.584 | 0.663 | 0.678 | 0.763 |
| 100 | 0.400 | 0.497 | 0.588 | 0.583 | 0.683 | 0.765 |

Source: Rain and Hail Insurance Company, *Agent Training Manual*, 1998.

Table 3. Optimal Combination of Marketing Strategies for Different Insurance Levels for 1997 Expected Cotton Yield and Futures Price Level Prior to Spring Planting

| Utility | Insurance coverage chosen | Number of futures contracts | Number of forward contracts [1] | Number of put options | Cash sale (1000 lbs.) |
|---|---|---|---|---|---|
| Results for risk aversion coefficient of 0.03 | | | | | |
| -0.001735 | 0/0 | 0 | 4 | 3 | 18.5 |
| -0.001582 | 50/60 | 0 | 4 | 3 | 18.5 |
| -0.001693 | 50/100 | 0 | 4 | 3 | 18.5 |
| -0.001678 | 55/100 | 0 | 4 | 3 | 18.5 |
| -0.001640 | 60/100 | 0 | 4 | 3 | 18.5 |
| ***-0.001534*** | ***65/100*** | ***0*** | ***4*** | ***3*** | ***18.5*** |
| -0.001567 | 70/100 | 0 | 5 | 2 | 18.5 |
| -0.001678 | 75/100 | 0 | 5 | 2 | 18.5 |
| Results for risk aversion coefficient of 0.1 | | | | | |
| -1.724E-7 | 0/0 | 0 | 2 | 0 | 268.5 |
| -5.294E-8 | 50/60 | 0 | 3 | 0 | 218.5 |
| -4.263E-8 | 50/100 | 0 | 4 | 0 | 168.5 |
| -2.664E-8 | 55/100 | 0 | 4 | 0 | 168.5 |
| -1.438E-8 | 60/100 | 0 | 4 | 1 | 118.5 |
| -6.450E-9 | 65/100 | 0 | 4 | 2 | 68.5 |
| -4.187E-9 | 70/100 | 0 | 4 | 2 | 68.5 |
| ***-3.631E-9*** | ***75/100*** | ***0*** | ***4*** | ***3*** | ***18.5*** |

1) One forward contract was assumed to be equal to 50,000 lbs. In practice, forward contracting is available in 25,000 lbs. units. Futures and options contracts are in 50,000 lbs. units.

Table 4. Best Mix of Marketing Strategies and Optimal Insurance Options for Risk Averse Preferences with Risk Aversion Coefficient of 0.01 under the Expected Utility Model and Different Futures Price Levels

| Expected utility | Insurance coverage level | Number of futures contracts | Number of forward contracts | Number of put options | Cash sale (1000 lbs.) | Futures price level ($/lb) |
|---|---|---|---|---|---|---|
| -0.110261 | 50/60 | 0 | 0 | 0 | 368.5 | 0.65 |
| -0.109919 | 50/60 | 0 | 0 | 3 | 218.5 | 0.66 |
| -0.108771 | 50/60 | 0 | 0 | 6 | 68.5 | 0.67 |
| -0.107105 | 50/60 | 0 | 0 | 7 | 18.5 | 0.68 |
| -0.105348 | 50/60 | 0 | 0 | 7 | 18.5 | 0.69 |
| -0.103304 | 50/60 | 0 | 2 | 5 | 18.5 | 0.70 |
| -0.100716 | 50/60 | 0 | 4 | 3 | 18.5 | 0.71 |
| -0.097913 | 50/60 | 0 | 5 | 2 | 18.5 | 0.72 |
| -0.094986 | 50/60 | 0 | 5 | 2 | 18.5 | 0.73 |
| -0.092061 | 50/60 | 1 | 5 | 1 | 18.5 | 0.74 |
| -0.088946 | 50/60 | 2 | 5 | 0 | 18.5 | 0.75 |

Table 5. Best Mix of Marketing Strategies and Optimal Insurance Options for Risk Averse Preferences with Risk Aversion Coefficient of 0.03 under the Expected Utility Model and Different Futures Price Levels.

| Expected utility | Insurance coverage level | Number of futures contracts | Number of forward contracts | Number of put options | Cash sale (1000 lbs.) | Futures price level ($/lb) |
|---|---|---|---|---|---|---|
| -0.002766 | 50/60 | 0 | 0 | 0 | 368.5 | 0.62 |
| -0.002759 | 50/60 | 0 | 0 | 1 | 318.5 | 0.63 |
| -0.002729 | 50/60 | 0 | 0 | 2 | 268.5 | 0.64 |
| -0.002677 | 50/60 | 0 | 0 | 3 | 218.5 | 0.65 |
| -0.002608 | 50/60 | 0 | 0 | 4 | 168.5 | 0.66 |
| -0.002523 | 50/60 | 0 | 0 | 5 | 118.5 | 0.67 |
| -0.002428 | 50/60 | 0 | 0 | 6 | 68.5 | 0.68 |
| -0.002327 | 50/60 | 0 | 0 | 7 | 18.5 | 0.69 |
| -0.002223 | 50/60 | 0 | 0 | 7 | 18.5 | 0.70 |
| -0.002117 | 50/60 | 0 | 1 | 6 | 18.5 | 0.71 |
| -0.001974 | 65/100 | 0 | 4 | 3 | 18.5 | 0.72 |
| -0.001825 | 65/100 | 0 | 4 | 3 | 18.5 | 0.73 |
| -0.001678 | 65/100 | 0 | 4 | 3 | 18.5 | 0.74 |
| -0.001539 | 65/100 | 0 | 4 | 3 | 18.5 | 0.75 |

Table 6. Best Mix of Marketing Strategies and Optimal Insurance Options for Risk Averse Preferences with Risk Aversion Coefficient of 0.1 under the Expected Utility Model and Different Futures Price Levels.

| Expected utility | Insurance coverage level | Number of futures contracts | Number of forward contracts | Number of put options | Cash sale (1000 lbs.) | Futures price level ($/lb) |
|---|---|---|---|---|---|---|
| -7.975E-8 | 75/100 | 0 | 2 | 2 | 168.5 | 0.60 |
| -6.944E-8 | 75/100 | 0 | 2 | 2 | 168.5 | 0.61 |
| -6.058E-8 | 75/100 | 0 | 2 | 2 | 168.5 | 0.62 |
| -5.170E-8 | 75/100 | 0 | 2 | 3 | 118.5 | 0.62 |
| -4.346E-8 | 75/100 | 0 | 2 | 3 | 118.5 | 0.63 |
| -3.626E-8 | 75/100 | 0 | 3 | 2 | 118.5 | 0.64 |
| -2.986E-8 | 75/100 | 0 | 3 | 2 | 118.5 | 0.65 |
| -2.986E-8 | 75/100 | 0 | 3 | 2 | 118.5 | 0.66 |
| -2.454E-8 | 75/100 | 0 | 3 | 2 | 118.5 | 0.67 |
| -2.001E-8 | 75/100 | 0 | 3 | 3 | 68.5 | 0.68 |
| -1.620E-8 | 75/100 | 0 | 3 | 3 | 68.5 | 0.69 |
| -1.307E-8 | 75/100 | 0 | 3 | 3 | 68.5 | 0.70 |
| -1.037E-8 | 75/100 | 0 | 4 | 3 | 18.5 | 0.71 |
| -8.150E-9 | 75/100 | 0 | 4 | 3 | 18.5 | 0.72 |
| -6.354E-9 | 75/100 | 0 | 4 | 3 | 18.5 | 0.73 |
| -4.881E-9 | 75/100 | 0 | 4 | 3 | 18.5 | 0.74 |
| -3.693E-9 | 75/100 | 0 | 4 | 3 | 18.5 | 0.75 |

Table 7. Chance Constrained Linear Programming Results for 1997 Cotton Data and 95% Confidence Level

| Expected revenue[1] | Insurance coverage level | Number of futures contracts | Number of forward contracts | Number of put options | Cash sale (1000 lbs.) |
|---|---|---|---|---|---|
| 258.542 | 00/00 | 2 | 5 | 0 | 18.5 |
| ***258.690*** | ***50/60*** | ***2*** | ***5*** | ***0*** | ***18.5*** |
| 255.008 | 50/100 | 2 | 5 | 0 | 18.5 |
| 253.351 | 55/100 | 2 | 5 | 0 | 18.5 |
| 251.378 | 60/100 | 2 | 5 | 0 | 18.5 |
| 250.334 | 65/100 | 2 | 5 | 0 | 18.5 |
| 246.265 | 70/100 | 2 | 5 | 0 | 18.5 |
| 240.273 | 75/100 | 2 | 5 | 0 | 18.5 |

1) Expected revenue from 500 acres of cotton in thousands dollars.

Table 8. Chance Constrained Linear Programming Results for 1997 Cotton Data at 99% Confidence Level.

| Expected Revenue[1] | Insurance coverage level | Number of futures contracts | Number of forward contracts | Number of put options | Cash sale (1000 lbs.) |
|---|---|---|---|---|---|
| ns | 0/0 | ns | ns | ns | ns |
| ns | 50/60 | ns | ns | ns | ns |
| ns | 50/100 | ns | ns | ns | ns |
| ns | 55/100 | ns | ns | ns | ns |
| 247.844 | 60/100 | 0 | 4 | 2 | 68.5 |
| 249.992 | 65/100 | 1 | 5 | 1 | 18.5 |
| 246.265 | 70/100 | 2 | 5 | 0 | 18.5 |
| 240.273 | 75/100 | 2 | 5 | 0 | 18.5 |

1) Expected revenue from 500 acres of cotton in thousands dollars.
ns - no solution found.

Table 9. Chance Constrained Linear Programming Results for 1997 Cotton Data at 95% Confidence Level and Different Level of Futures Prices.

| Expected revenue[1] | Insurance coverage level | Number of futures contracts | Number of forward contracts | Number of put options | Cash sale (1000 lbs.) | Level of futures price ($/lb) |
|---|---|---|---|---|---|---|
| 238.587 | 50/60 | 0 | 0 | 1 | 318.5 | 0.65 |
| 238.762 | 50/60 | 0 | 0 | 1 | 318.5 | 0.66 |
| 238.959 | 50/60 | 0 | 0 | 1 | 318.5 | 0.67 |
| 240.192 | 50/60 | 0 | 0 | 7 | 18.5 | 0.68 |
| 241.741 | 50/60 | 0 | 0 | 7 | 18.5 | 0.69 |
| 243.450 | 50/60 | 0 | 0 | 7 | 18.5 | 0.70 |
| 245.474 | 50/60 | 0 | 4 | 3 | 18.5 | 0.71 |
| 248.480 | 50/60 | 0 | 5 | 2 | 18.5 | 0.72 |
| 251.616 | 50/60 | 0 | 6 | 1 | 18.5 | 0.73 |
| 255.041 | 50/60 | 1 | 6 | 0 | 18.5 | 0.74 |
| 258.512 | 50/60 | 2 | 5 | 0 | 18.5 | 0.75 |

1) Expected revenue form 500 acres of cotton in thousands dollars.

Table 10. Chance Constrained Linear Programming Results for 1997 Cotton Data and at 99% Confidence Level and Different Level of Futures Prices

| Expected revenue[1] | Insurance coverage level | Number of futures contracts | Number of forward contracts | Number of put options | Cash sale (1000 lbs.) | Level of futures price ($/lb) |
|---|---|---|---|---|---|---|
| 219.164 | 75/100 | 0 | 2 | 4 | 68.5 | 0.66 |
| 225.928 | 70/100 | 0 | 2 | 4 | 68.5 | 0.67 |
| 229.208 | 70/100 | 0 | 0 | 7 | 18.5 | 0.68 |
| 230.596 | 70/100 | 0 | 0 | 7 | 18.5 | 0.69 |
| 234.006 | 65/100 | 0 | 3 | 2 | 118.5 | 0.70 |
| 236.814 | 65/100 | 0 | 3 | 3 | 68.5 | 0.71 |
| 240.464 | 65/100 | 0 | 4 | 3 | 18.5 | 0.72 |
| 243.628 | 65/100 | 0 | 5 | 2 | 18.5 | 0.73 |
| 246.642 | 65/100 | 0 | 5 | 2 | 18.5 | 0.74 |
| 250.031 | 65/100 | 1 | 5 | 1 | 18.5 | 0.75 |

1) Expected revenue form 500 acres of cotton in thousands dollars.
ns - no feasible solution found.