EVALUATING CROP AND REVENUE INSURANCE PRODUCTS
AS RISK MANAGEMENT TOOLS FOR TEXAS COTTON PRODUCERS

by

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A THESIS

IN

AGRICULTURAL AND APPLIED ECONOMICS

Submitted to the Graduate Faculty
of Texas Tech University in
Partial Fulfillment of
the Requirements for
the Degree of

MASTER OF SCIENCE

Approved

August, 2000

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ACKNOWLEDGMENTS

I have always been one to set goals and work myself to death trying to achieve them. However, there are always times that I feel too tired or frustrated to go on, and I need a little push to keep going. The writing of this thesis was no different. I would like to take time to thank a few of the many individuals who have helped give me that little push when I needed it.

First, I would like to thank my committee members: Dr. Sukant Misra, Dr. Octavio Ramirez, and Dr. Jackie Smith. Their contributions and guidance have helped far more than I could ever express. Dr. Misra could always tell when I was not giving 100 percent, and he would give me that little push I needed. I also know that he pushed himself as hard or harder than I did when time was running out and I needed to finish. I will always appreciate the fact that he understood that I needed to finish as soon as possible in order to start work to support my young family. I will also appreciate the countless hours that Dr. Ramirez spent with me, working until we were (or at least he was!) satisfied with the results. I would also like to thank the entire faculty, staff, and graduate student body of the Department of Agricultural and Applied Economics at Texas Tech University for helping me by being such wonderful teachers, partners, and, best of all, friends.

I would like to thank my parents, Sam and Donna Field, for giving me that push that I needed through elementary, junior high, and high school. Through their example, I

learned how to set goals and strive to achieve them. I know that none of this would have been possible without their support and the solid foundation they created to build upon.

I want to express my appreciation to Randy and Amy Weaver, my father-in-law and mother-in-law, for accepting me into their family and supporting me every step of the way throughout my two years in graduate school. Whenever I felt downtrodden, they were there to give me an emotional push to keep me going.

I want all of my family and friends to know how much their love and support has meant to me, not only the past two years, but throughout my whole life. I wish that I was able to give back to them half of what they have done for me. It is very easy to succeed when one has so many helping hands whenever one stumbles.

Perhaps my greatest cheerleader and best supporter, my wife, Sara, has been with me every step of the way for the past two years. She has been the one who has given me the biggest pushes when I have needed them. I could not have done this without her love, support, and her unselfishness to let me pursue my goals while she supported us. Sara has helped me through some of the toughest times I have had to face, and I am eternally grateful for that.

A new blessing has recently arrived in my life. In the middle of my graduate school stint, my son, Conner, was born. I did not think I was ready to be a father at the time, but now, I cannot imagine my life without him. My priorities have changed significantly since Conner arrived. One thing Conner has taught me, besides patience, is that we both have a lot to learn in the years ahead!

Finally, and most importantly, I would like to thank God, without whom none of this would be possible. I want to thank Him for surrounding me with such wonderful people and for the many blessings he has bestowed upon my family, my friends, and me.

I would like to dedicate this thesis to my wife, Sara, my son, Conner, and my future sons and/or daughters. I hope that when Sara looks at this, she can see just a small part of what I can accomplish when I have her behind me, and I hope that Conner and his brothers and/or sisters will be able to pursue their goals as I have.

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ABSTRACT

Information on the efficacy of various crop and revenue insurance products on Texas cotton producers is not currently available. It is not known why Texas cotton producers purchase so little insurance above catastrophic levels. It could be that the current insurance products are not meeting the needs of cotton producers, or it could be that producers are simply unwilling to pay insurance premiums. In order to better understand the different crop insurance policies, the effects of multiple-peril crop insurance and crop revenue coverage on the net returns of the producer needed to be analyzed. The general objective of this study was to develop an empirical means and illustrate its application in evaluating the cost effectiveness of various crop and revenue insurance products as risk management tools for cotton producers in selected regions of Texas.

The current study utilized the procedure developed by Ramirez (1997) and expanded by Ramirez (1999) to estimate and simulate cotton yield and price distributions. The simulated yield and price series obtained from these procedures were used to develop an empirical procedure to analyze the cost effectiveness of alternative crop insurance products in terms of increasing producer net returns and minimizing variation in net returns. This procedure was then illustrated using a regional level analysis to represent an overall comparison of crop and revenue insurance products and a farm level analysis to compare crop and revenue insurance products for an individual producer.

The results from the estimation of cotton yield distributions indicate that dryland cotton yields in the Northern High Plains, Southern High Plains, and the Northern Low Plains are non-normally distributed, while irrigated yields from the same regions appear to follow a normal distribution. The estimation of cotton prices indicated cotton prices in Texas have been linearly declining in real terms by about one cent every five years.

Results from the regional level analysis indicate that CAT was the overwhelmingly preferred MPCl option for all scenarios. The ranking of the other MPCl options was consistently 50/100, 60/100, and 75/100 in all scenarios. The CRC options always ranked 50, 60, and 75 percent, respectively, with the exception of one scenario in the stochastic dominance analysis. A wide range of subsidies was calculated from the confidence premiums for the non-dominant insurance options. These confidence premiums represent the amount it would take a producer to become indifferent between a dominant scenario and a dominated scenario. Results from the calculation of confidence premiums indicated that premiums for buy-up insurance were too high.

The current study succeeded in demonstrating that farm level data may be used to develop a procedure that allows one to compare the efficacy of various crop and revenue insurance products in terms of increasing producer net returns. This is also the first study that attempts to compare crop and revenue insurance products for the state of Texas. The current study has created a foundation for future studies to build upon. It is possible for the empirical procedure developed in this study to be incorporated into a decision-making tool for producers.

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CHAPTER I

INTRODUCTION

Cotton production contributed an average of \$5.27 billion per year to the United States economy from 1988 through 1994 (National Agricultural Statistics Service [NASS], 1999). More than 14.5 million acres of cotton were planted in the U.S. in 1999. In the same year, more than 13 million acres were harvested, producing more than 16 million bales of cotton. Texas accounted for about 42 percent of planted acres, about 39 percent of harvested acres, and over 31 percent of total cotton production in 1999 (Texas Agricultural Statistics Service [TASS], 2000).

Cotton production, like any other agricultural enterprise, is inherently risky. Cotton producers are subject to unpredictable, random shocks, such as adverse weather, pest infestations, and other natural disasters, such as drought and flooding. Supply uncertainties, coupled with inelastic demand for many agricultural products, lead to price movements that are generally more volatile for farm products than those commonly experienced in other sectors of the economy (Goodwin and Smith, 1995). In the past, producers have relied on the federal government for protection from price and yield variability. This protection came in the form of a federal crop insurance program, ad hoc disaster payments, and deficiency payments. Deficiency payments were made when the price level of the commodity fell below the target price set by the federal government. The target price acted as a floor price, guaranteeing a level of returns per unit of a commodity. Producer income variability was reduced with deficiency payments because

payments were made when national average prices for program crops were low. However, significant changes have occurred in U.S. farm policies. The most recent of which are embedded in the Federal Agricultural Improvement and Reform (FAIR) Act of 1996. The elimination of deficiency payment provisions by the 1996 FAIR Act has affected expected returns and the income variability faced by producers (Skees et al., 1998). The lack of deficiency payments to compensate for commodity price variability, coupled with the flexibility of producers to switch crops from year to year, have increased revenue risks for producers. Although the federal government has attempted to reduce its role in providing price and income support, there has been an increasing emphasis on crop and revenue insurance (Skees et al., 1998). Pressure for reform of crop insurance products resulted because of low participation, poor actuarial performance, and the existence of ad hoc disaster payments (Skees et al., 1998). These issues were addressed by the Crop Insurance Reform Act of 1994, which prohibits ad hoc crop disaster programs, unless the funds are appropriated from other agricultural programs. The 1994 act also directed the Federal Crop Insurance Corporation (FCIC) to develop a pilot crop insurance program to provide farmers with coverage against reduced income as a result of reduced yields and/or prices (Miller et al., 2000). Although the movement of agricultural policy in the United States toward less government involvement has left producers exposed to higher levels of production and marketing risk, there are many risk management practices that are available to producers to help substitute for the government programs. Among these practices are: forward contracting, hedging with

futures and options, and crop insurance. Given the focus of this study, the following section provides a brief overview of the crop insurance products for cotton.

Crop Insurance for Cotton

Federal crop insurance was first created when Congress enacted the 1938 Crop Insurance Act, which established the Federal Crop Insurance Corporation as a means of providing all-risk or multiple-peril crop insurance to farmers (Goodwin and Smith, 1995).

The purpose of this insurance was to provide producers with some protection against economic difficulties caused by adverse growing conditions that resulted in crop losses. Private insurance companies offered insurance against fire and hail, but did not provide general coverage for losses from perils such as drought, flood, and pest infestations (Goodwin and Smith, 1995). The Federal Crop Insurance Act was amended in 1980 to allow expansion to several crops that were previously uninsurable under the original Crop Insurance Act. Several new crop insurance products were developed by FCIC for these crops. The products examined here are the ones currently utilized for cotton.

Crop insurance for cotton can be split into two categories: yield guarantee products and revenue guarantee products (FCIC, 1997). The yield guarantee product used in cotton insurance can be classified as an individual yield model. In this model, the current individual yield for the insured year is compared to the expected individual yield, which is based on the historic average of the insured crop's yield from previous years. The insured's yield is guaranteed to meet or exceed a certain percentage of the insured's individual average production history (APH). The production guarantee is calculated by

multiplying the individual expected yield (APH) by the coverage level, multiplied by the number of acres. The liability is the dollar amount the insurance company will pay the insured individual if the yield is zero. It is calculated by multiplying the total guarantee by the indemnity price, and then by the insured's share in the insured acres (i.e., 100% = 1.00, 90% = 0.90, etc.). The indemnity price is a percentage of the maximum FCIC price chosen by the producer. The APH of each individual is compared to yield spans to determine the appropriate premium rate for the insured individual. The perils insured in this particular model are not typical insurance perils because they represent yield limiting events, such as drought, that have extended duration with no defined beginning (FCIC, 1997). Typical uninsured perils are intentional acts of the insured that reduce yield, such as neglect, mismanagement, and poor farming practices. Once a producer decides to insure his or her cotton, all of the cotton acreage in the county of which the insured individual has a share must be covered. Indemnities are paid when the producer's actual production falls short of the guarantee for an insured unit. Indemnities are calculated by multiplying the difference of the guarantee and the actual yield by the indemnity price.

The revenue guarantee product used in crop insurance for cotton can be classified as a replacement coverage model. In this model, the guarantee is that the individual's revenue will meet or exceed a certain percentage of the final revenue. The final revenue is the individual's average historic yield multiplied by the higher of the harvest-time futures price in the commodity market before the risk period begins, or the actual market price discovered at the end of the risk period (FCIC, 1997). The liability is the final revenue multiplied by the coverage level chosen by the producer. Premium rates are

based on historic yield averages distributed by yield spans, plus a rate for variability, also known as a premium load. Perils included in this model are similar to the ones in the individual yield model. However, the replacement coverage model includes price movement. The crop coverage requirements are the same as the individual yield model. Indemnities are calculated by taking the difference of the guaranteed revenue and the harvested revenue. Harvest revenue is the harvested and appraised yield, reduced for low quality, multiplied by the harvest-time price discovered in the commodity market at the end of the risk period (FCIC, 1997).

Crop Hail and Fire Insurance

Crop hail and fire insurance provides protection against hail and fire damage up to an actual cash value of the crop on an acre by acre basis. Crop hail and fire insurance is available through private insurance companies, and is not subsidized by the federal government. Producers may opt for a step ladder or escalator approach for insuring their crop. The step ladder option allows the producer to insure the actual value of the crop by increasing coverage as the growing season progresses. Deductibles range from a basic 10 percent to 50 percent, depending on the level of coverage. The premium rates for the step ladder approach are determined by the loss ratio for each county, and are measured in a per hundred dollar value. The escalator approach allows an early appraisal and is beneficial if an early loss occurs. The historical loss ratio for the escalator approach is high, and many private insurance companies are not offering this option. Producers can obtain crop hail and fire insurance on a stand-alone basis. This results in lower premiums

because the producer partially self-insures the crop. Crop hail and fire insurance is a natural component of multiple peril crop insurance and can be purchased separately, or in conjunction with multiple peril crop insurance.

Multiple-Peril Crop Insurance

Multiple Peril Crop Insurance (MPCI) is one of the oldest forms of crop insurance. It is a broad-based crop insurance program that is regulated and subsidized through the Federal Crop Insurance Corporation (FCIC) of the United States Department of Agriculture (USDA). MPCI is a yield guarantee product that utilizes the individual yield model. MPCI covers unavoidable production losses caused by drought, excessive moisture, hail, wind, frost/freeze, tornado, lightning, flood, insect infestation, plant disease, excessive temperature during pollination, wild-life damage, fire, and earthquake. However, MPCI does not cover losses occurring from poor farming practices, low commodity prices, theft, and/or specified perils that are excluded in some policies (Iowa State University Extension, 1997). Two decisions that determine the amount of protection obtained from MPCI are: (1) level of yield coverage chosen, and (2) level of price coverage chosen. The yield coverage level varies in five percent increments from 50 percent to 75 percent of actual production history (APH). APH is an average of the producer's yield on the insured crop for four to ten years. If four consecutive years of yields cannot be proven, T yields are substituted for the missing years. T yields are computed as a percentage of the Farm Service Agency (FSA) established yield for that crop (Iowa State University Extension, 1997). The coverage price level can be selected

between 55 percent and 100 percent of the base price. The base price is annually set by the FCIC based on expectations of the market price, supply and demand factors.

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 the following way:

$$\text{Producer premium} = (APH) * (\text{Coverage level}) * (\text{Base price}) * (\text{Indemnity price election}) * (\text{Premium rate}) * (\text{Subsidy factor}) * (\text{Acres}) * (\text{Option factor})$$

where *APH* is actual crop yield production history, *Coverage level* is the level of insurance protection chosen by the producer, *Indemnity price election* is the price level chosen by the producer, *Premium rate* is from the FCIC actuarial table for the producer's county, *Subsidy factor* is determined by the level of coverage, *Acres* is the number of acres insured, and *Option factor* is equal to 0.9 if the basic unit option is chosen, or 1.0 if hail and fire exclusion are chosen. FCIC provides a subsidy, which varies from 100 percent for basic catastrophic coverage to about 23 percent or less for the highest coverage levels.

Indemnity payments are made only if the producer's actual realized yield, adjusted for quality, is less than the yield guarantee. Indemnity payments are calculated as:

$$\text{Indemnity payment} = [(\text{Yield guarantee} - \text{Actual yield}) * (\text{Base price}) * (\text{Price election})] * \text{Acres}$$

where *Yield guarantee* is the yield coverage chosen, *Actual yield* is the actual yield of the producer, *Base price* is the base price set by the FCIC, *Price election* is the price level chosen by the producer, and *Acres* is the number of acres insured (Iowa State University

Extension, 1997). Indemnity payments are taxable income. However, they may be reported in the tax year following harvest if that is normally when the crop is sold.

Catastrophic Coverage

Catastrophic (CAT) coverage is the most inexpensive, minimal level multiple peril crop insurance policy that can be obtained. The policy is 100 percent subsidized by FCIC and is available for a \$60 processing fee per crop per county, with a limit of \$200 per farm per county. CAT is a 50/55 policy which has a yield coverage of 50 percent and a price election of 55 percent.

Late and Prevented Planting

Late planting and prevented planting are automatic features of MPCI, but may be excluded in exchange for reduced premiums. Premiums do not change for acres that are planted late. The late planting period consists of 25 days after the deadline set by USDA. If the producer plants within the first ten days of the late planting period, a one percent reduction per day in production guarantee is incurred. If planting occurs within the next fifteen days, a penalty of two percent per day is incurred. After the 25 day late planting period, the insured crops are covered at 50 percent of the original production guarantee. In the case of prevented planting, MPCI guarantees 50 percent of the original yield coverage. However, no other crops, with the exception of forage crops for hay and grazing, can be planted on those acres. If the producer decides to plant a substitute crop, only 25 percent of the original crop guarantee is received. The option to replant for

cotton is not included in MPCI. No coverage is received if CAT coverage was purchased, or late and prevented planting options were excluded.

Crop Revenue Coverage

Crop revenue coverage (CRC) is a revenue guarantee product that is an example of the replacement coverage model discussed earlier. CRC offers two coverage components to farmers. The first component offers a revenue guarantee based on spring-time futures quotes on the harvest-time contract and producers' expected yields (APH). The producer chooses a coverage level between 50 and 75 percent of his or her guaranteed revenue. The guaranteed revenue is calculated by multiplying the producer's APH by the CRC base price. The CRC base price is equal to 95 percent of the average of December futures contract between January 15 and February 14. If the producer's actual revenue falls below the guarantee, he or she is eligible for a "revenue indemnity" (Skees et al., 1998). The second component offers "replacement coverage," which allows coverage to increase during the growing season if futures prices increase. For example, if a farmer has a short crop and the harvest price is higher than the pre-harvest estimation, the farmer receives an indemnity based on the higher harvest price. The producer receives the higher of the "revenue indemnity" or "replacement coverage indemnity" (Skees et al., 1998). CRC originally encompassed all counties in Nebraska and Iowa for corn and soybeans in 1996. Since then, CRC has been expanded to encompass virtually all U.S. planted acreage in corn, soybeans, wheat, and cotton, except in the Northeast (Skees et al., 1998).

Premium rate calculations for CRC are fairly complicated. Premium rates are set on the yield risk for the crop, revenue risk for the producer, and a load for the price risk component. These risk components are added together, and a subsidy is subtracted to obtain the producer paid premium. An example of a CRC premium calculation worksheet for the 2000 crop year is shown in Figure 1.1. CRC premium rates are higher than MPCI rates because of the “replacement coverage” component of the policy. Also, FCIC subsidizes only the yield risk portion of CRC coverage. For cotton, premium rates tend to average up to 40 percent higher than MPCI rates. In 1997, CRC tended to account for less than 30 percent of the federally insured crop acreage (Skees et al., 1998).

General Problem

Whether or not current crop insurance products meet the needs of producers is currently unknown. Participation of Texas cotton producers in crop insurance programs may seem to be high relative to other crops and states, but participation rates above catastrophic levels account for only 45% of total insurable acres for cotton in Texas (Stokes, 1999). This low participation rate exposes cotton producers to higher levels of financial risks. This increased exposure to risk, in turn, can have serious implications for the agricultural sector, as well as the local economies involved. A study by Leatham et

CROP REVENUE COVERAGE PREMIUM CALCULATION WORKSHEET			
<p>Unit: _____ Date: _____ State: _____</p> <p>County: _____ Crop: _____</p> <p>TWP: _____ RGE: _____ Section: _____</p> <p>Type: _____ Practice: _____ R-span: _____</p> <p>A) Approved Yield: _____</p> <p>B) Coverage Level: _____</p> <p>C) MPCl Base Premium Rate: _____</p> <p>D) Base Price: _____</p> <p>E) CRC Rate Factor: _____</p> <p>F) Low Price Factor: _____</p> <p>G) High Price Factor: _____</p> <p>H) Estimated Acres: _____</p> <p>I) Share: _____</p> <p>J) High Risk Map Area Adjustment Factor: _____</p> <p>K) Rate Class Option Factor: _____</p> <p>L) CRC Option Factor: _____</p> <p>M) MPCl Market Price Election _____</p> <p>N) Producer Subsidy Percentage: 85%=0.130 65%=0.417 80%=0.173 60%=0.378 75%=0.235 55%=0.461 70%=0.319 50%=0.550</p> <p>O) Yield Adjustment Surcharge: _____</p> <p>P) CRC Enterprise Option Factor: _____ <i>The Option Factor "L" must always contain a form of the Basic Unit Discount (BUD) when selecting the enterprise unit option.</i></p> <p><u>PART 1 - YIELD RISK</u> $(A \times B \times C \times D)$ (Round A x B to one decimal and final product to two decimals)</p> <p><u>PART 2 - REVENUE RISK</u> $(A \times B \times E \times F)$ (Round A x B to one decimal and final product to two decimals)</p> <p><u>PART 3 - PRICE RISK</u> $(A \times B \times C \times G)$ (Round A x B to one decimal and final product to two decimals)</p> <p><u>PART 4 - SUBTOTAL</u> $(PART 1 + PART 2 + PART 3)$ (Rounding: Two decimals)</p> <p><u>PART 5 - RISK PREMIUM</u> $(PART 4 \times H \times I \times J \times K \times L \times O \times P)$ (Rounding: Zero decimals*)</p> <p><u>PART 6 - SUBSIDY</u> $(A \times B \times C \times M \times H \times I \times J \times K \times L \times N \times O \times P)$ (Rounding: Zero decimals*)</p> <p><u>PART 7 - PRODUCER PAID PREMIUM</u> $(PART 5 - PART 6)$ (Rounding: Zero decimals*)</p> <p>* NOTE: Round to two decimals for one acre quotes</p>	<p>Unit: _____ Date: _____ State: _____</p> <p>County: _____ Crop: _____</p> <p>TWP: _____ RGE: _____ Section: _____</p> <p>Type: _____ Practice: _____ R-span: _____</p> <p>A) Approved Yield: _____</p> <p>B) Coverage Level: _____</p> <p>C) MPCl Base Premium Rate: _____</p> <p>D) Base Price: _____</p> <p>E) CRC Rate Factor: _____</p> <p>F) Low Price Factor: _____</p> <p>G) High Price Factor: _____</p> <p>H) Estimated Acres: _____</p> <p>I) Share: _____</p> <p>J) High Risk Map Area Adjustment Factor: _____</p> <p>K) Rate Class Option Factor: _____</p> <p>L) CRC Option Factor: _____</p> <p>M) MPCl Market Price Election _____</p> <p>N) Producer Subsidy Percentage: 85%=0.130 65%=0.417 80%=0.173 60%=0.378 75%=0.235 55%=0.461 70%=0.319 50%=0.550</p> <p>O) Yield Adjustment Surcharge: _____</p> <p>P) CRC Enterprise Option Factor: _____ <i>The Option Factor "L" must always contain a form of the Basic Unit Discount (BUD) when selecting the enterprise unit option.</i></p> <p><u>PART 1 - YIELD RISK</u> $(A \times B \times C \times D)$ (Round A x B to one decimal and final product to two decimals)</p> <p><u>PART 2 - REVENUE RISK</u> $(A \times B \times E \times F)$ (Round A x B to one decimal and final product to two decimals)</p> <p><u>PART 3 - PRICE RISK</u> $(A \times B \times C \times G)$ (Round A x B to one decimal and final product to two decimals)</p> <p><u>PART 4 - SUBTOTAL</u> $(PART 1 + PART 2 + PART 3)$ (Rounding: Two decimals)</p> <p><u>PART 5 - RISK PREMIUM</u> $(PART 4 \times H \times I \times J \times K \times L \times O \times P)$ (Rounding: Zero decimals*)</p> <p><u>PART 6 - SUBSIDY</u> $(A \times B \times C \times M \times H \times I \times J \times K \times L \times N \times O \times P)$ (Rounding: Zero decimals*)</p> <p><u>PART 7 - PRODUCER PAID PREMIUM</u> $(PART 5 - PART 6)$ (Rounding: Zero decimals*)</p> <p>* NOTE: Round to two decimals for one acre quotes</p>		

THIS WORKSHEET IS INTENDED TO ASSIST IN ESTIMATING PRODUCER PREMIUM ONLY.

CRC - PG2000 (Ed. 6/17/99)

Figure 1.1. CRC Premium Calculation Worksheet

al. (1997) indicated that crop insurance indemnities paid to farmers in North Dakota resulted in an annual average increase (preservation) in business sales, personal income, and Gross State Product of \$211 million, \$94 million, and \$104 million, respectively.

Low participation rates could arise from problems with existing crop insurance products. One problem with the current crop insurance design could be that available crop and revenue insurance products are not cost effective. A producer must pay a premium in order to be insured against low yield and, in the case of CRC, low market prices. In years with lower than average yields and/or prices, the insurance product will pay the producer an indemnity payment. This indemnity payment is designed to reduce income variability faced by the producer. In years with higher than average yields and/or prices, the insurance product will not pay the producer an indemnity payment. A crop insurance product may be considered cost effective if the producer's income variability is reduced and/or the producer's probability of declining net returns is reduced over a planning horizon. A producer may also consider a crop insurance product cost effective if the amount of indemnity payments received over a planning horizon meets or exceeds the amount the producer has paid for insurance premiums over the same planning horizon.

A persisting problem with current crop insurance products is the calculation of the actual production history (APH). APH is determined by the average of the past four to ten years of actual production history of the producer. However, if those years happen to include a long, multi-year drought, the producer's APH becomes very low. This leads to higher than normal premium rates. A low APH also indicates that production must be

very low in order for the producer to qualify for indemnities, especially at the 50 percent coverage level. Agricultural lenders' influence on producers could also be a problem concerning crop insurance. Knight et al. (1989) found that lenders can directly or indirectly influence production decisions. Lenders may be requiring farmers to purchase certain crop insurance policies in order to be approved for loans. If a lender does not have a clear understanding of which crop insurance policy would best benefit his or her customer, he or she may be encouraging the purchase of the wrong policy, possibly leading to a decline in net worth and increasing the chance of default on loans.

Adverse selection and moral hazard are two additional problems inherent to crop insurance. Adverse selection occurs when insurance premium rates are calculated by using an average, instead of individual, yield. This practice tends to overcharge low-risk agents and undercharge high-risk agents. This, in turn, leads to a skewed participation rate toward the high-risk agents, increasing the risk of the insurance pool and increasing indemnity payments. Current crop insurance products reduce the likelihood of adverse selection. However, if a producer does not have adequate yield histories, T values are used in determining his or her APH. These T values represent an average, and if enough producers in the area have to rely on T yields, adverse selection could occur. Moral hazard results from the intentional behavior of the insured to reduce production and receive indemnity payments. This leads to higher premium rates as a result of increased indemnity payments. Although current crop insurance policies are devised to reduce moral hazard, it is difficult and expensive to monitor the behavior of insured producers.

Specific Problem

The reason Texas cotton producers purchase so little insurance above catastrophic levels is not known. It could be that the available insurance products are not cost effective, or it could simply be producers are unwilling to pay insurance premiums. Price and yield distributions for Texas cotton producers are not currently available. The true variability of producer level yield for cotton in Texas needs to be known in order for actuarially fair premiums to be calculated. Information on the efficacy of various crop and revenue insurance products on Texas cotton producers is not currently available. In order to better understand the different crop insurance policies, the effects of crop hail and fire insurance, multiple-peril crop insurance, and crop revenue coverage on the ending net worth of the producer needs to be analyzed. If a crop insurance policy helps increase the ending net worth of the producer, it should be continued. If a crop insurance policy can be purchased that helps decrease income variability at a reasonable price, producers should look favorably on that policy. However, if the existing crop insurance models are not cost effective, there might be a need to develop new products given the yield and price variability of cotton.

A clear understanding on the efficacy of various crop and revenue insurance products and the development of empirical tools to assess the cost effectiveness of alternative insurance products should be beneficial to producers, lenders, and agricultural policy makers. Information from this study should be beneficial to producers making crop insurance purchase decisions. The producer could determine which policy would best fit his or her cotton production situation. Agricultural lenders could also benefit

from this information. If the lender can influence the producer to purchase the type of crop insurance best suited for his or her operation, the chance of default on an operation loan would be decreased, benefitting both the lender and producer. Agricultural policy makers could use the information found in this study to determine whether or not the current crop insurance programs need to be revised or updated.

Objectives

The general objective of this study was to develop an empirical means and illustrate its application in evaluating the cost effectiveness of various crop and revenue insurance products as risk management tools for cotton producers in selected regions of Texas. The specific objectives that were addressed to achieve the general objective were:

1. Estimate price and yield probability distributions for cotton in Texas.
2. Develop an empirical procedure to analyze the cost effectiveness of alternative crop insurance products in terms of increasing producer net returns and minimizing variation in net returns.
3. Conduct a regional and a farm level analysis, by employing the procedure described above, to analyze the efficacy of various crop insurance products on Texas cotton producers.

CHAPTER II

LITERATURE REVIEW

Studies on crop insurance for cotton are scarce, but a review of previous research on crop insurance contributed to the formulation of the researchable problem and objectives, provided important conceptual insights, and offered ideas and direction for identifying appropriate methods and procedures to accomplish the objectives of the current study. Literature that is relevant to this study are divided into the following categories: crop insurance for cotton, crop insurance for other crops, and other procedural studies. The first section reviews literature on crop insurance specifically for cotton. This is followed by a review of research on crop insurance for crops other than cotton. The third section on procedural studies examines methods and procedures used by previous studies, which provided important procedural insight for this study.

Crop Insurance for Cotton

Empirical studies related to crop insurance for cotton have been scarce. Studies that have been conducted focus on the efficacy of crop and revenue insurance products as risk management tools and determining whether risk management tools serve as a substitute for government support. There have been no studies that analyze crop insurance for cotton in Texas.

A study on the efficacy of various crop and revenue insurance products as risk management tools within a typical Mid-South farming context was conducted by

Spurlock et al. (1998). The study investigated different levels of Actual Production History Program (APHP, also known as MPCl) and CRC coverage to determine why crop insurance participation levels in the Mid-South were so low. A whole-farm financial simulation model was used to estimate probability distributions of ending net worth for APHP and CRC insurance with different levels of coverage, as well as the case of no insurance. The study developed and used an Excel spreadsheet that produces annual financial information with input data such as acres of each crop, cost of production, government program benefits, and crop prices and yields. A representative farm was chosen in the Delta area of Mississippi, and cost of production data for four enterprises (irrigated and non-irrigated cotton, irrigated and non-irrigated soybeans) were obtained from 1997 Mississippi State University Planning Budget for Cotton and Soybeans. Crop yield and price probability distributions were estimated using actual farm-level data collected by the Federal Crop Insurance Corporation (FCIC) for 1986-95. A larger sample of farm-level yields was derived using regression models and ordinary least squares assumptions. Probability density functions of cotton and soybean prices were estimated, and the correlation matrix for cotton and soybean prices was calculated. The whole-farm financial simulation model examined different coverage scenarios for both APHP and CRC.

The results from the APHP scenarios showed the mean net worth for the CAT (50/60) coverage to be higher than all other coverage levels for all crop combinations studied. The standard deviation of ending net worth also decreased as the coverage increased, with only one exception. The probability of a negative net worth increased

with the level of coverage in two of the three crop combinations, but decreased slightly in the case of only insuring soybeans. The results from the CRC scenarios analyzed by Spurlock et al. (1998) indicated the net worth for the 50 percent revenue coverage was the highest of the three insurance scenarios. However, the highest ending net worth for all three crop combinations resulted when no insurance product was purchased. The standard deviation of ending net worth decreased as the coverage increased, except for when only soybeans were insured. The probability of a negative net worth increased with the level of revenue coverage in the first two cases, but held fairly constant in the case of only insuring soybeans.

Spurlock et al.'s (1998) results imply that economically rational farmers should not purchase AHP insurance above the CAT level, and should not purchase CRC insurance at all. Should this model hold, the following conclusions would seem to hold for the Mid-South: (1) current AHP premiums overestimate the actual yield risk exposure, (2) CRC will not be attractive, (3) by requiring purchases of buy-up insurance, lenders may increase, rather than decrease, the potential risk of default on long-term loans.

The study by Spurlock et al. (1998) served as a good starting point for the current research. The problem and objectives of the study are similar to the ones faced by and being addressed in the current research. The use of a whole-farm financial model is particularly interesting, and was considered while determining the methods and procedures of the current study. The division of the crops into different practices (i.e., irrigated and non-irrigated) is important when estimating participation. However, the use

of ordinary least squares regression to inflate the number of observations is questionable. The current study attempted to avoid this by acquiring a sufficient number of farm-level observations. The results of the current study are compared and contrasted to the results in the Spurlock et al. (1998) study.

Wojciechowski et al. (1999) attempted to determine if risk management practices, such as crop insurance, forward contracts, and futures and options markets can be successfully used as substitutes for government support. The specific objectives were to examine the potential use of alternative marketing strategies for improving the profitability of cotton production and to analyze the linkage between yield and price risk by developing alternative marketing strategies which depend upon yield management strategies.

Four marketing strategies for a cotton producer were designated. These were: (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. An optimal level of multi-peril crop insurance (MPCI) was also evaluated. A decision rule, consisting of two alternative models, was developed for choosing the best marketing strategies and insurance alternatives. The first model, expected utility model, allows the decision maker to choose a combination of market strategies and insurance levels that maximizes expected utility. The second model uses chance constrained linear programming to find the optimal combination of market strategies and insurance levels. Both models utilize price and yield distributions that were estimated from historical data.

In the expected utility model by Wojciechowski et al. (1999), the optimal strategy utilized forward contracting and cash sale at harvest. Crop insurance levels increased with higher risk aversion coefficients. With the chance constrained linear programming model, the optimal level of insurance was 50/60, and the optimal marketing strategy involved futures contracts, forward contracts, and cash sales at the 95% confidence level. At the 99% confidence level, the optimal level of insurance was 65/100, and the optimal marketing strategy involved futures contracts, forward contracts, put options, and cash sales.

According to Wojciechowski et al. (1999), two practical implications resulting from the research are: (1) a marketing strategy, or a combination of strategies, can be substituted for government programs, and (2) crop yield insurance can complement marketing tools in providing producers with better revenue protection .

The study by Wojciechowski et al. (1999) is relevant to the current study because the problem is similar to the one faced by the current research. Procedurally, the study by Wojciechowski et al. (1999) is comparable to the current study because Wojciechowski et al. (1999) used county level data to regress an annual trend with dummy variables for different counties in the estimation of cotton yield distributions. The current study differs in the fact that county and farm level data were used in the estimation of cotton yield distributions with dummy variables for different regions.

The studies presented in this section provided a foundation for the current research. The problems and objectives were similar to the ones presented in this investigation, and the results were compared and contrasted to the results provided by the

current study. They are relevant to the current research because they provided a background on research performed on crop insurance for cotton. However, studies on crop insurance for cotton are scarce, especially for Texas. The current research has attempted to add to the existing knowledge base on crop insurance for cotton, and expands it to include Texas.

Crop Insurance for Other Crops

A study conducted by Baldwin et al. (1998) compared historical net returns over costs and cash flow obligations from combinations of pre-harvest sales and insurance products (CRC and MPCCI) to those from harvest cash sales for corn and soybeans. A sub-objective was to see how differences in farm financial structures would alter outcomes using: (1) an owner-operator, (2) a recent-buyer/cash renter, and (3) cash renter.

Model farms were selected in Iowa, Kansas, and Ohio. The simulation contained decision rules derived by 1997 and 1998 studies by Wisner et al., a combination of hedging (forward contracting) and options. These techniques, combined with crop insurance, were applied to historical price and yield data for the model farms from 1985 to 1997.

Baldwin et al. (1998) found that crop insurance benefits were insufficient to maintain a positive net income, but modestly reduced financial stresses. For all years, the mean net incomes with both insurances were less than mean net incomes of the cash harvest strategy. A combination of MPCCI and pre-harvest pricing strategies outperformed the combination of CRC and pre-harvest pricing strategies for both corn and soybeans.

Baldwin et al. (1998) tested differences in farm structure for net returns over total economic costs and net returns over cash flow. For the cash renter, the best alternative was to use pre-harvest pricing strategies in combination with MPCCI to cover total economic costs. No combination of pre-harvest pricing strategies and insurance could be found in order for the buyer-renter and owner to cover total economic costs. In order to cover cash flow, the best option for the cash renter was pre-harvest pricing strategies without insurance. The best alternative for the buyer-renter and the owner was pre-harvest pricing strategies with MPCCI.

The findings by Baldwin et al. (1998) offer some support that crop insurance may have a role in boosting the confidence level of farmers who are reluctant to price grain before harvest. They also suggested that opportunities exist for additional empirical work on the behavior of forward pricing tools and options markets.

The study by Baldwin et al. (1998) is relevant to the current study because it provided evidence that crop insurance can help reduce income variability. The problem faced by Baldwin et al.'s 1998 study was similar to the one faced by the current study. The analysis of different farm structures can be applied to the current research when it seeks to determine if current crop insurance alternatives can help cover cash flow needs.

Smith and Baquet (1996) conducted a study on the demand for MPCCI from Montana wheat farmers. Their study examined the determinants of both the participation decision and the level of coverage selected by farms that purchased MPCCI utilizing Heckman two-stage estimations procedures.

Smith and Baquet (1996) found that it is the farm operator's subjective concern about variability, not actual yield variability, that determines participation. They also found that premium rates do not have a significant effect on participation, but do have a significant impact on coverage level choices. Results also implied that as yield variability increases, farmers with negative expected returns become more price responsive in their coverage level decisions while farmers with positive expected returns become less price responsive. Concerns about debt repayment and the avoidance of farm failure seemed to play an important role in the farm's crop insurance decision. It was also shown that there was a negative relationship between the probability of MPCCI participation and average yields, indicating that the structure of the MPCCI program has resulted in adverse selection. The two-stage model was also proven to be superior to a one-stage model.

This study is relevant to the current study because it investigates the demand for MPCCI by Montana wheat farmers, which represents a problem that is similar to the one faced by the current study. The use of a two-stage model is intriguing, and provides useful procedural insight for the current study. The only drawback to the study by Smith and Baquet (1996) was that it only analyzed MPCCI insurance. The need to analyze other forms of crop insurance still exists.

Wang et al. (1998) conducted a study designed to investigate the relative performance of individual-yield (IYCI) and area-yield (AYCI) crop insurance programs. The analysis was conducted in a portfolio setting where the producer may use a variety of risk management tools including futures, options, and crop insurance. However, only participation rates for crop insurance were analyzed.

The model contains two periods: a planting period when the level of each risk management tool is set by the farmer, and a harvest period when prices and yields are realized and profit is calculated. The model contains a price vector consisting of cash and futures prices for corn in the harvest period, a random yield vector consisting of the individual's farm corn yield and corn yield index, which is used to trigger crop insurance indemnities, and a variable representing the portfolio of risk management tools that maximizes the expected utility of per acre profits in the planting period. A joint distribution of cash and futures prices at harvest was calibrated by estimating a bivariate ARCH model with a seasonal component for cash and futures prices. Individual farm yield distributions were derived from the county yield distribution by making scale adjustments. Correlation between the simulated price and county yield distributions is imposed using the normal transformation procedure described by Taylor (1994). This method was also used to impose a representative degree of correlation between the simulated individual and county yield distributions for investigating crop insurance based on area yield. The remaining model parameters were selected to be representative of those faced by farmers in southwest Iowa during the 1994-95 crop year.

Farmer participation and welfare (measured in willingness-to-pay) was compared by Wang et al. (1998) for the cases where the farmer uses IYCI and AYCI. In most situations studied, IYCI was preferred to AYCI. AYCI was preferred to IYCI only when the trigger restrictions were relaxed and when a 35% premium loading factor was added to IYCI.

This study is relevant to the current study because it shows that producers prefer IYCI to AYCI. This is important because the calculation of a producer's APH is determined by his or her individual yield history, comparable to IYCI. However, if there are missing years from a producer's individual yield history, a T-value is substituted, making the policy comparable to AYCI. The measurement of farmer participation and welfare is also relevant to the current study.

A study conducted by Leatham et al. (1987) looked at the relationship between farmers and lenders and the effect of that relationship on crop insurance purchase decisions. A six-year, whole-farm simulation was used to generate farm income and probability distributions under alternative yield variabilities. A historical correlation matrix was used to capture the correlation between yields and prices. Cash flow deficits were allowed to be covered by: (a) a loan could be taken out secured by crops held for sale in the next tax year, (b) a mortgage on farmland and intermediate assets, or (c) sale of farmland. The producer could borrow up to a pre-specified level of debt-to-assets ratio. If the combination of all these options could not remove the deficit, the farm would be declared insolvent and foreclosure initiated. Net present value (NPV) distributions for the farmer and lender were developed and used to determine the level of risk aversion. Comparisons were drawn between the preferences of the lender and the farm operator. The farm lender was assumed to be the farmer's sole source of borrowed funds other than CCC loans. The probability distribution of returns to loans was estimated using loan payments results from the farm simulation.

A representative farm was simulated with and without the use of wheat crop insurance. The policy used was the highest yield protection and medium price option. The representative farm was also simulated using alternative insurance loss ratios. Results showed, from the lender's perspective, that crop insurance use was preferred to no use at all loss ratios. The mean NPV was greater and the standard deviation was lower when crop insurance was used at all loss ratios. Results also showed that crop insurance always decreased the farmer's standard deviation of NPV.

Leatham et al. (1987) stated there are two implications of this study. First, it appears the design of crop insurance at the time favored farmers who had higher variability relative to other farmers in the area. Second, lenders seemed to prefer their clients to use crop insurance, and that a small interest rate premium will help cause this shift. However, if a farmer chooses not to use crop insurance, for whatever reason, higher returns to lenders would be accompanied by an increase in the likelihood of loan default.

The use of a whole-farm simulation model to estimate net worth distributions was considered to help meet the objectives of the current study. Also, the use of a price-yield correlation matrix was helpful when estimating price and yield distributions. The study shows that risk preferences play a part in the determination of the use of crop insurance, and that the design of the current crop insurance model lends itself to adverse selection. The use of only one coverage level in this study is questionable, as the effects of different coverage levels was not investigated. The current research analyzed the effects of many different coverage levels.

The studies presented in this section provided evidence that crop insurance is a viable risk management tool that warrants further study. The researchable problems in these studies were similar to the problem faced in the current study. Information about farmer participation and welfare can be helpful if the current study seeks to develop new crop insurance alternatives through sensitivity analysis. Also, the results were compared with those from the current investigation.

Other Procedural Studies

Although there are many studies that focus on crop insurance for crops, it is important to review procedural studies that may contribute to the current study. Of particular concern are the estimations of price and yield distributions, as well as simulation methods that were developed to estimate ending net return distributions.

The use of “The Agricultural Risk Management Simulator” (ARMS) is discussed in an article by King et al. (1987). ARMS is a microcomputer program designed to help users evaluate strategies for managing yield and price risk in crop farming operations. Choices regarding crop mix, the purchase of MPCI, and the use of forward contracting define risk management strategies. The net cash flow probability distribution for each strategy considered is determined by probabilistic budgeting. King et al. (1987) note that flexibility with regard to both sources of probabilistic information and the form of yield and price probability distributions is an important feature of the program. Although this simulator may be outdated, it provided procedural insight for the development of a financial simulator in the current study.

Since price and yield distributions may be correlated and non-normally distributed, Ramirez et al. (1994) developed a method using the inverse hyperbolic sine transformation for estimating non-normal distributions of crop yields and prices over time. In this study, an inverse hyperbolic sine transformation into normality was estimated for wheat, corn, and soybean yields in the U.S. Ramirez et al. (1994) found that soybean and wheat yields seemed to follow a normal distribution, while corn yields were not normally distributed. The resulting parameter estimates were then used to simulate crop yields. Ramirez et al. (1994) indicate several desirable characteristics of this method. First, the interdependence between random variables is an explicit part of the density function because the inverse hyperbolic transformation to normality has an explicit interaction term (the transformed variance matrix). Secondly, normality is a special case of the transformation, and it is possible to test directly for normality using the parameter estimates. Also, the complete distribution function is known, allowing the interaction terms and transformation parameters to be estimated simultaneously. Finally, this formulation allows for the joint estimation of the trend parameters.

Ramirez (1997) extended the model by reparameterizing the inverse hyperbolic sine transformation to develop a multivariate, nonnormal density function that contains parameters that can accurately and separately account for skewness, kurtosis, heteroscedasticity, and the correlation among the random variables of interest. Ramirez (1997) applied this model to corn, soybean, and wheat yields in the Corn Belt. He found that while corn and soybean yields appeared to be skewed and kurtotic, wheat yields appeared normal, but heteroscedastic. Ramirez (1997) detected a strong positive

correlation between corn and soybean yields. Crop yields were then simulated using the parameter estimates. The simulation outcomes were observed to be highly consistent with the attributes of the original data

By using a transformation of the dependent and independent variables through the error term, Ramirez (1999) further developed his model to account for autocorrelation. Ramirez (1999) explains that two key advantages of his proposed estimator over all other partially adaptive estimators available is that it can be used in a multiple equation setup, and it can also account for heteroscedasticity and autocorrelation in the error term, further increasing estimating efficiency.

The studies by Ramirez et al. (1994) and Ramirez (1997 and 1999) contributed to the current study by developing the models that were used to estimate price and yield distributions. The crop yield simulation procedures described by Ramirez (1994 and 1997) were also utilized to simulate prices and yields in the current study.

The studies presented in this section provided a foundation for the methods and procedures that were utilized in the current study. The estimation of price and yield distributions were determined using the model developed by Ramirez (1999). The current study also utilized a financial simulation conceptually similar to the ones described by Spurlock et al. (1998) and King et al. (1987) to estimate net return distributions.

CHAPTER III

CONCEPTUAL FRAMEWORK

This chapter focuses on the conceptual analysis of the production decisions for Texas cotton producers in terms of determining which crop insurance product and which coverage level they need to purchase. The conceptual framework is organized into three sections. The first section analyzes production decisions under certainty. The second section focuses on production decisions under uncertainty and analyzes the relevance of risk management tools, such as crop insurance, at the farm level. The last section analyzes the expected utility model and its application to cotton production decisions in risky situations.

Production Under Certainty

The most common model used when analyzing production decisions is the neoclassical theory of the firm, assuming profit maximization. Producers are assumed to produce the quantity of output, in this case, cotton, that will achieve the highest level of profit compared to all other levels of production. Under the profit maximization scenario, it is also assumed that cotton producers are price takers, that is, an extra pound of cotton can be sold without affecting the price level.

When it is assumed that the producer knows with certainty his or her yield levels, cost curves can be derived. In this conceptual analysis, it is assumed that the production decisions are made in the short run, since crop insurance is purchased from year to year.

Figure 3.1 shows the cotton producer's profit maximization decision under certainty.

Average costs (AC) are the total costs per pound of cotton. Average variable costs (AVC) are the variable costs per pound of cotton. Variable costs are costs of those inputs that can be varied in order to change the farm's output level.

Figure 3.1. Profit Maximization Decision for a Cotton Producer under Certainty.

The price level, assumed to be known and non-varying in the short run, is given by P^* . The demand curve faced by the cotton producer, therefore, is a horizontal line through P^* . Marginal revenue (MR) is the additional amount of revenue earned from selling one more pound of cotton. Since the cotton producer is a price-taker, $P^* = MR$. Since the producer's goal is profit maximization, he or she will produce where $MC = MR$. Thus, C^* is the profit maximizing level of cotton produced. Since the price level is

known with certainty and is non-varying, very little risk is involved in this scenario. Also, the level of production is known with certainty and non-varying. Thus, risk management tools, such as crop insurance, are not important under the scenario of production with certainty.

Production Under Uncertainty

Although cotton producers operate under some certainty, price and yield levels at the end of the planning horizon are not known, forcing the producer to make decisions under uncertainty. Some discussion of what occurs when actual price and yield levels vary from expected price and yield levels would be beneficial.

Cotton producers do not know the harvest price of cotton during planting and the growing season with certainty. Producers have expectations, but they do not have complete control over outcomes. Cotton prices are subject to variations due to various, uncontrollable factors. Therefore, the planting decision that the cotton producer makes on the basis of price expectations may result in unexpected consequences. For example, suppose that the cotton producer expected a market price equal to P^0 , and thus had decided on a profit maximizing level of output represented by C^0 in Figure 3.2. If the actual realized price (P') is above the expected price, then $MR > MC$ at the C^0 level of production. This will cause the producer to earn less than what could have been earned if more acreage had been planted. Conversely, if the actual realized price (P'') is below the expected price, then $MR < MC$ at C^0 , and the producer will be producing inefficiently because he or she could have increased profit by producing at C'' . If the actual realized

Figure 3.2. Profit Maximization Decision for a Cotton Producer under Uncertain Price Levels.

price falls below the average cost curve, the producer will in fact be losing money. Thus, risk management tools, such as crop insurance, that protect a producer from negative price movement may be beneficial in this case.

The previous analysis implicitly assumes that the producer knew his or her yield levels with certainty. However, yield levels are also subject to variations due primarily to weather, disease, and insect problems. If the producer uses an average or estimated yield, then estimated cost curves can be derived, as depicted in Figure 3.3. For the sake of simplicity, only the marginal cost curve is depicted in this analysis. For this discussion, it is also assumed that the price level is known with certainty, P^* . At this price level, the profit maximizing production decision is at C^0 . A yield that is lower than the expected yield will cause the marginal cost curve to shift up to MC' . Production at C^0 is not

Figure 3.3. Profit Maximization Decision for a Cotton Producer under Uncertain Yield Levels.

optimal, since $MC > MR$. More profit could have been obtained if less cotton acreage had been planted. If actual yields are higher than expected, the result is a downward shift in the marginal cost curve to MC^2 . Production at C^0 is again not optimal because $MR > MC$. Higher profits could be realized if the producer had chosen to produce at C^2 . Therefore, crop insurance products, such as MPCl, can be utilized to help protect the producer from unanticipated negative yield variability.

The previous two discussions have accounted for price and yield variations individually. However, when both factors are analyzed together, it can be seen that contemporaneous price and yield uncertainties further complicate the efficiency of the production decision, as illustrated in Figure 3.4. The production decision, C^0 , results from the expected price P^0 and expected marginal cost MC^0 . As before, lower than

Figure 3.4. Profit Maximization Decision for a Cotton Producer under Uncertain Price and Yield Levels.

expected yields cause the marginal cost curve to shift up to MC^1 , where $MC > MR$ at C^0 . Production is sub-optimal, since production costs are not fully covered and higher profits could be realized if less cotton acreage was planted. At higher price levels (P^1), some of the lost profits due to low yields are offset by increases in price. Depending on the magnitudes of the price increase and the yield decrease, production inefficiency could be completely offset. At lower price levels (P^2), production becomes very inefficient, as lost profits increase from the original price level. The combination of lower than expected yields and lower than expected prices presents the “worst case scenario.” Crop insurance products, such as MPCl or CRC, could be utilized to protect producers from negative changes in prices and/or yields.

If actual yields are higher than expected, the result is a downward shift in the marginal cost curve to MC^2 . Production at C^0 is again sub-optimal because $MR > MC$.

The new profit maximizing production level should be at C^2 . Price changes again complicate the production decision. At higher price levels (P'), production becomes very inefficient, as more potential profits are not realized. Although the producer is acquiring a much higher revenue than the original scenario, the producer is still not operating at the profit maximizing level of production. Lower price levels (P'') tend to offset the increase in yields, and, depending on the magnitude of the price decrease and the yield increase, may offset the increase in revenue altogether.

The previous sections have illustrated that cotton production decisions under certainty are fairly “straight-forward,” but when yield and price variabilities are introduced, cotton production decisions become more difficult, and the impacts of those decisions have large implications for the producers. The potential for loss increases dramatically with the introduction of price and yield variability. Crop insurance products may help compensate the income of producers who experience lower than expected prices, low yields, or both.

Expected Utility Model

Expected utility maximization is the theoretical framework under which production decisions under uncertainty are usually examined. Under the axioms developed by Von Neumann and Morgenstern, a producer facing i possible outcomes will act to maximize expected utility, which is given by:

$$\sum_{i=1}^{i=n} \pi_i u(x_i)$$

where π_i represents the probability of the i^{th} outcome, x_i represents the expected outcome, and $u(x_i)$ is a utility function. Thus, cotton producers maximize a weighted-average type utility function where the weights are given by probabilities of alternative event outcomes. The attitudes held by producers toward risk will affect the decisions they make. Risk attitudes may be categorized in three ways: (1) risk loving, (2) risk neutral, and (3) risk averse. A risk loving individual is one who prefers the risky prospect to the expected value of the prospect, given by:

$$E[u(x_i)] > U[E(x_i)].$$

A risk neutral individual is one that is indifferent between the expected value of the prospect and the prospect itself:

$$E[u(x_i)] \approx U[E(x_i)].$$

A risk averse individual is one who prefers the expected value of a risky prospect to the prospect itself:

$$U[E(x_i)] > E[u(x_i)].$$

This conceptual analysis assumes cotton producers are risk averse individuals, since a producer who is not risk averse will not be willing to pay a risk premium, and, hence, will not participate in a crop insurance program. Therefore, the properties of risk averse utility functions will be further discussed. The fact that a risk averse individual prefers the expected value of a risky prospect to the prospect itself implies that the individual's utility function is strictly concave. This is also explained using certainty equivalence and risk premiums. The certainty equivalent of a risky choice, $CE(x_i)$, is the amount $CE(x)$ such that the decision maker is indifferent between receiving $CE(x_i)$ with

certainty or incurring the risky prospect. A risk premium, $RP(x_i)$, is the amount a decision maker is willing to pay in order to not take the risky prospect. It is the difference between the expected value of the risky prospect and the certainty equivalence:

$$RP(x_i) = E(x_i) - CE(x_i).$$

Figure 3.5 graphically illustrates how the utilities of two outcomes, $G(\pi)$ and $L(\pi)$, are determined. The expected value of the outcome, $E(\pi)$, is defined as

$[P(L)*L(\pi)] + [P(G)*G(\pi)]$, where $P(L)$ is the probability of $L(\pi)$ occurring and $P(G)$ is

the probability of $G(\pi)$ occurring. The certainty equivalence is given by $CE(\pi)$. Figure

3.5 also illustrates the fact that the expected value of a risky prospect (i.e., cotton

production), $U[E(\pi)]$, is preferred to the prospect itself, $E[U(\pi)]$. When applied to the

issue of crop insurance, it is evident that risk averse producers should be willing to pay a

Figure 3.5. Expected Utility Model for a Risk Averse Cotton Producer.

positive risk premium to avoid a risky prospect, since $E(x_i) - CE(x_i) > 0$. That risk premium would be the difference in the expected value of the crop insurance product and the expected value of cotton production. However, if the insurance premium charged is higher than the producer's risk premium, he or she will not participate. Thus, higher than actuarially fair premiums will result in non-participation.

CHAPTER IV

METHODS AND PROCEDURES

The general objective of this study was to develop an empirical means and illustrate its application in evaluating the cost effectiveness of various crop and revenue insurance products as risk management tools for Texas cotton producers. Specifically, this analysis has attempted to: (1) estimate price and yield probability distributions for cotton in Texas, (2) develop an empirical procedure to analyze the cost effectiveness of alternative crop insurance products in terms of increasing producer net returns and minimizing variation in net returns, and (3) conduct a regional and a farm level analysis, by employing the procedure described above, to analyze the efficacy of various crop insurance products on Texas cotton producers. The first section of the methods and procedures discusses the estimation of price and yield distributions. The second section describes the empirical procedures developed to compare different crop and revenue insurance products. The development of regional and farm level analyses are examined in the third section to analyze the efficacy of various crop insurance products on Texas cotton producers. The final section explores data considerations.

Estimation of Price and Yield Distributions

The conceptual framework established that price and yield levels are not fixed, but variable. In order to study the cost effectiveness of crop and revenue insurance products and their impacts on net worth, yield and price distributions needed to be first understood.

Pooled yield data was analyzed to estimate yield distributions at the farm level. Because of the limited number of years of farm level data available, this alone may not be enough to precisely quantify the trend and other critical features of the yield distributions.

Therefore, aggregate time series yield data was used to assist in the estimation of the yield distribution and its changes through time. The two sets of data were used to estimate different yield variability measures at the farm and county levels. A multivariate parametric model, developed by Ramirez (1997) and expanded by Ramirez (1999), was used to estimate the yield and price distributions. This approach utilizes a multivariate, nonnormal density function that can accurately and separately account for skewness, kurtosis, heteroscedasticity, and the correlation among the random variables of interest, irrigated and dryland cotton yields, in this case.

Ramirez (1999) proposes a reparameterized model that can also model autocorrelation in each of the variables under analysis. Cotton prices were expected to be heteroscedastic and autocorrelated in this case. In Ramirez's (1999) models:

$$E[Y_j] = F(B_j, X_j) \quad (4.1)$$

$$V[Y_j] = G(\Sigma_j, Z_j)f(\Theta_j, \mu_j), \quad (4.2)$$

where $f(\Theta_j, \mu_j)$ is an exponential function of Θ_j and μ_j (the parameters that control the degree of non-normality in the probability distribution), Y_j is a vector of yield or price data, and X_j is a matrix containing the original data on the explanatory variables described below. Equation (4.1) states that the expected value of cotton yields is a linear function of the independent variables and slope coefficients, as in the standard linear regression model estimated by ordinary least squares (OLS). Equation (4.2) states that the variance

of yields is proportional to the square of the parameter or parametric function σ_j . If the value of Θ_j is not equal to zero, Y_j has a kurtotic probability density function (pdf). If the value of μ_j is greater than zero, Y_j has a skewed pdf. The sign of μ_j determines whether the pdf is skewed to the left or right.

The first step in the estimation of cotton yield distributions was to determine which variables would be included in the models. The thirteen counties included in the study were combined into three groups based on geographical location: (1) the Southern High Plains, (2) the Northern High Plains, and (3) the Northern Low Plains. Two separate models were estimated for irrigated and dryland cotton yields. In these models, the mean and variance of each yield distribution were estimated independently of each other, and of the distribution's skewness and kurtosis parameters, by the functions $F(B_j, X_j)$ and $G(\Sigma_j, Z_j)$. B_j and Σ_j were parameter vectors, and X_j and Z_j were matrices of exogenous variables believed to affect the mean and variance of each distribution. For these models, $j = D$ and I for dryland and irrigated yield distributions, respectively. The mean function, $F(B_j, X_j)$, was specified as a third-degree polynomial function of time:

$$F(B_j, X_j) = B_j X_j = B_{00} + B_{01}NHP + B_{02}NLP + B_{10}T + B_{11}(T.*NHP) \quad (4.3) \\ + B_{12}(T.*NLP) + B_2 T^2 + B_3 T^3 + B_4 AC + B_5 AF$$

where T was a simple time-trend variable starting at one in 1970, $NHP = 1$ if the yield observation comes from a farm or county in the Northern High Plains region and zero otherwise, $NLP = 1$ if the observation comes from a farm or county in the Northern High Plains region and zero otherwise, AF = acres planted on the farm in deviations from the mean in the case of a farm-level yield observation and zero otherwise, AC = acres planted

in the county in deviations from the mean in the case of a county-level yield observation and zero otherwise, and “.” is an element-by-element vector multiplication. Equation (4.3) assumes that average farm and county level yields are the same for a given region, but average yields may vary across regions.

The variance function was specified as:

$$G(\sum_j, Z_j) = \sum_j Z_j = \sigma_{00} + \sigma_{01}NHP + \sigma_{02}NLP + \sigma_{0L}CL + \sigma_{10}T + \sigma_{11}(T.*NHP) \quad (4.4) \\ + \sigma_{12}(T.*NLP) + \sigma_{1L}(T.*CL) + \sigma_2 T^2 + \sigma_3 AC + \sigma_4 AF$$

where $CL = 1$ for county-level observations and zero otherwise. This model allowed for different yield variances across regions and levels (farm vs. county). It also allowed for the yield variances to change differently through time, according to region and level. The acres planted at the farm and county levels were believed to affect yield variability as well.

Separate irrigated and dryland yield models were first estimated by maximizing the following univariate log likelihood function:

$$LL_j = \sum_{i=1}^n G_{ji} - \frac{1}{2} \sum_{i=1}^n H_{ji} \quad (4.5)$$

where:

$$G_{ji} = F(\Theta_j, \mu_j) / [(\text{sign } \mu_j) \sum_{ji} Z_j (1 + R_{ji}^2)^{1/2}]; \\ H_{ji} = \Theta_j^{-1} \ln[R_{ji} (1 + R_{ji}^2)^{1/2}] - \mu_j; \\ R_{ji} = [\Theta_j F(\Theta_j, \mu_j) / (\text{sign } \mu_j) (\sum_{ji} Z_j)] (Y_{ji} - X_{ji} \beta_j + \sum_{ji} Z_j / \Theta_j) \\ F(\Theta_j, \mu_j) = [e(0.5\Theta_j^2)] [e(\Theta_j \mu_j) - e(-\Theta_j \mu_j)] / 2;$$

$j = D$ or I for dryland or irrigated cotton, respectively, Y_{ji} represents the vectors of dryland and irrigated cotton yields, and $X_{ji} \beta_j$ and $\sum_{ji} Z_j$ are the functions described above. Once

the full univariate models were estimated, suspect variables were dropped or combined until the final restricted models were obtained. Likelihood ratio tests were conducted between each step and between the first and final steps to insure that statistically significant variables were not excluded from the final restricted models. After the dryland and irrigated yield models were estimated separately, they were combined into a single model in order to estimate the covariance between irrigated and dryland yields. The parameters of the joint irrigated and dryland yield distribution were estimated by maximizing the following concentrated log-likelihood function:

$$BLL = \left\{ \sum_{i=1}^n \sum_{j=I,D} [\ln(G_{ji})] - 0.5 \sum_{i=1}^{690} \sum_{j=I,D} [\{H_{ji} * (\Sigma^{-1})\} .* H_{ji}] - \sum_{i=691}^n \sum_{j=I,D} H_{ji}^2 - \left[\frac{n_2}{2} \right] \ln |\Sigma_2| \right\} \quad (4.6)$$

where BLL is the value of the bivariate log-likelihood function, $j = D$ for dryland cotton and $j = I$ for irrigated cotton, G_{ji} and H_{ji} are as defined in equation (4.5), Σ is the irrigated-dryland correlation matrix, “*” indicates a matrix multiplication, while “.*” indicates an element by element matrix multiplication, n_2 is the number of observations ($i = 1, \dots, 690$) that contain coupled, county level irrigated and dryland yields, and Σ_2 is an $m \times m$ matrix with diagonal elements equal to one and a pair of non-zero, non-diagonal elements, $\sigma_{12} = \sigma_{21}$, to represent the correlation coefficient between Y_I and Y_D . The coupled data is used to estimate the correlation between dryland and irrigated yields. It contains observations for years in which both dryland and irrigated yields were available for a county in a given year. Since this type of data were not available at the farm level, it was assumed that the correlation coefficient at the farm level is the same as that at the county level. The concentrated bivariate log-likelihood function links the irrigated yield data and the

dryland yield data through the cross-error-term correlation matrix Σ . The yield distributions, estimated by maximizing equation (4.6), account for any potential non-normality (kurtosis and/or right or left skewness), heteroscedasticity, and for the correlation among dryland and irrigated cotton yields (σ_{12}).

The procedure for estimating the cotton price model was similar to the one used to estimate the dryland and irrigated cotton yield models, except that it is also designed to account for autocorrelation. The mean function of the price model was:

$$F(X_{CP}B_{CP}) = B_0 + B_1T + B_2T^2 \quad (4.7)$$

and the variance function of the price model was:

$$G(\Sigma_{CP}Z_{CP}) = \sigma_0 + \sigma_1T + \sigma_2T^2 \quad (4.8)$$

where $T = 1, \dots, 65$, depending on the year that the observation was taken ($1 = 1934$, $65 = 1998$). The price model was estimated by maximizing the likelihood function in equation (4.5) where, to account for autocorrelation, Y_{CP} is replaced by $Y_{CP}^* = PY_{CP}$ and X_{CP} is replaced by $X_{CP}^* = PX_{CP}$, Y_{CP} being the vector of original price data, and the X_{CP} matrix contains the original data on the explanatory variables (time) believed to affect the mean of the price distribution. In the case of first-order autocorrelation, the element on the first row and column of P is $(1-\rho_j^2)^{1/2}$, where ρ_j is the correlation coefficient between any two consecutive error terms. The rest of the elements in the principal diagonal of P are ones. All elements immediately below the principal diagonal are equal to $-\rho_j$ and the remaining elements of P are zero.

Once the parameters for the price and joint yield distributions were estimated, they were used to simulate any number of draws from the estimated distribution of cotton

prices and joint distribution of cotton yields. This simulation technique, developed by Ramirez (1997), incorporated, if and when appropriate, a time-trend process and other factors affecting mean yield and price through time and space, as well as heteroscedasticity, autocorrelation, right or left skewness, kurtosis, and takes into account correlation between dryland and irrigated cotton yields.

Simulation of Cotton Yields and Prices

For this study, a 15,000 by 2 matrix (V) of standard normal random variables was multiplied by the Cholesky decomposition of Σ . If cotton yields were found to be non-normally distributed, they would be simulated for the years 1995 - 2009 using the following formula:

$$Y_{jit} = \frac{\left[\frac{\Sigma_j Z_{jt}}{F(\Theta_j, \mu_j)} \right] (e^{\Theta_j V_{jt}} - e^{-\Theta_j V_{jt}})}{2} - \Sigma_j Z_{jt} + B_j X_{jt} \quad (4.9)$$

where $t = 25$ for the year 1995, $j = I$ or D for irrigated or dryland cotton, respectively, $F(\Theta_j, \mu_j)$ is as defined after equation (6), Θ_j is the kurtosis parameter estimate, μ_j is the skewness parameter estimate, and V_{jt} is the i th element of the column of V that corresponds to either dryland or irrigated cotton. $\Sigma_j Z_{jt}$ and $B_j X_{jt}$ vary according to equation (4.3) as cotton yields are simulated for different regions. For example, for the Northern High Plains, $B_j X_{jt} = B_{00} + B_{01} + B_{10}T + B_{11}T + B_2T^2 + B_3T^3$ and $\Sigma_j Z_{jt} = \sigma_{00} + \sigma_{01} + \sigma_{10}T + \sigma_{11}T + \sigma_2T^2$ where $T = 25$ for the year 1995. If cotton yields were estimated to be normally distributed, the simulation involved the simple formula:

$$Y_{jit} = \left(\sum_j Z_{jt} \right) * V_{ji} + B_j X_{jt} \quad (4.10)$$

where $t = 25$ for the year 1995 and V_{ji} is the i th element of the column of V that corresponds to either dryland or irrigated cotton. As in the non-normally distributed cotton yield simulation, $\sum_j Z_{jt}$ and $B_j X_{jt}$ vary according to equation (4.3) as cotton yields are simulated for different regions. Prices were simulated using the following formula:

$$CP_{F(T+t)} = \sum_{CP} Z_{CP(T+t)} * Z + \left\{ X_{CP(T+t)} B_{CP} + \left[\rho_{CP}^t (Y_{CP(T)} - X_{CP(T)} B_{CP}) \right] \right\} \quad (4.11)$$

where F stands for a forecast, T is the final year included in the data set ($T = 64$ for 1998), and t is the number of years forecasted beyond the data set ($t = 2, \dots, 11$ for 2000 - 2009). This simulation model allows for autocorrelation in the forecasted price distributions by multiplying the error term of the final observation ($Y_{CP(T)} - X_{CP(T)} B_{CPe}$) by the error term correlation coefficient (ρ_{CP}) raised to the power of t . Simulation models that do not account for autocorrelation simulate the mean of the price distributions at the long-term mean trend. If the last price in the data set does not fall near the long-term mean trend, the autocorrelated simulation model helps smooth the transition back to the long-term trend, as seen in Figure 4.1.

Development of Empirical Procedure

The simulated yield and price series obtained from the procedures described in the previous section were used to develop an empirical procedure to analyze the cost effectiveness of alternative crop insurance products in terms of increasing producer net

Figure 4.1. Long Term Mean Trend versus Autocorrelated Forecasted Prices

returns and minimizing variation in net returns. In order to be able to compare different crop and revenue insurance products, net returns per planted acre needed to be estimated over a planning horizon. The first step in developing the procedure was to calculate total revenue distributions. This was done by multiplying the simulated yields by the simulated prices. For example, if the simulation procedures described in the previous section resulted in n random draws each from the yield and price distributions, the total revenue distribution was calculated by the following equation:

$$TR = SY.*SP \quad (4.11)$$

where TR represents an $n \times T$ matrix containing n total revenues per planted acre from T time periods (T is the total number of years included in the planning horizon), SY is an $n \times T$ matrix of simulated yields containing n random draws from the estimated yield distribution for T time periods, and SP is an $n \times T$ matrix of simulated prices containing n random draws from the estimated price distribution for T time periods. Net revenues were then calculated by subtracting production costs from and adding cottonseed revenues to the total revenues. Continuing with the given example, net revenues were calculated by:

$$NR = TR - PC + SR \quad (4.12)$$

where NR is an $n \times T$ matrix containing n net revenues per planted acre from T time periods, PC is an $n \times 1$ vector containing the production cost per planted acre less insurance and returns to management, and SR is an $n \times T$ matrix containing the seed revenues per planted acre associated with the n simulated yields for T time periods. The final step in estimating net returns was to subtract insurance premiums and add indemnity

payments, when applicable, to the net revenues to obtain net returns per planted acre.

Again, continuing with the given example, net returns were calculated by:

$$NRet = NR - IC + IR \quad (4.13)$$

where NRet is an $n \times T$ matrix containing n net returns per planted acre for T time periods, IC is an $n \times T$ matrix containing the cost of insurance premiums for T time periods, and IR is an $n \times T$ matrix containing revenues from insurance indemnity payments paid for T time periods.

Insurance premiums were calculated using an estimated APH, estimated base price, and premium rates obtained from actuarial tables produced by FCIC. The estimated APH was calculated as a moving average of the previous five years' yields. For example, the estimated APH was calculated by:

$$APH_{it} = [SY_{i(t-5)} + SY_{i(t-4)} + SY_{i(t-3)} + SY_{i(t-2)} + SY_{i(t-1)}]/5 \quad (4.14)$$

where APH_{it} is the i th ($i = 1, \dots, n$) APH calculated in time period t . If t is the first year of T time periods, n random draws would be needed for the previous five years in order to calculate the APH for time t , resulting in $T+5$ total years that would need to be simulated for the procedure.

The base prices were estimated by a distributed lag model, which was corrected for autocorrelation using the first-order autoregressive process, or AR(1). The final estimated model was:

$$BP_t = 0.1134 + 0.2093*P_{t-1} + 0.2751*P_{t-2} + 0.2449*P_{t-3} \quad (4.15)$$

(0.0628) (0.0960) (0.0921) (0.0955) $R^2 = 0.8799$

where BP_t is the base price in time t , P_{t-1} is the market price observed in time $t-1$, etc.

Base prices were estimated for each of the ten years in the planning horizon (2000 - 2009) and were assumed to be the same for both MPCCI and CRC insurance products.

The premium rates are dependent upon the APH and coverage level chosen.

Indemnity payments were calculated for each iteration (i) of each time period (t). If the insurance product was an MPCCI product, the indemnity payment was calculated as:

$$IR_{it} = [(APH_{it} * CL) - SY_{it}] * BP_t * PE \quad (4.16)$$

where IR is the i th element in the year t , CL is the yield coverage election chosen, and PE is the price election chosen. The indemnity was only calculated when the actual yield fell below the guaranteed yield, or when $SY_{it} < (APH_{it} * CL)$. Otherwise, IR_{it} was equal to zero. If the insurance product was a CRC product, the indemnity payment was calculated as:

$$IR_{it} = \{[APH_{it} * \text{Max}(BP_t, SP_{it})] * CL\} - (SY_{it} * SP_{it}) \quad (4.17)$$

only if the actual revenue fell below the guaranteed level, or when $(SY_{it} * SP_{it}) < \{[APH_{it} * \text{Max}(BP_t, SP_{it})] * CL\}$. Otherwise, IR_{it} was set to zero. Simulated net returns under different crop and revenue insurance products were used to analyze the efficacy of the insurance products on cotton producers. Statistical measures used to compare insurance products in the regional and farm level analyses were mean net returns, standard deviations, coefficients of variation, probability of receiving an indemnity payment, premiums paid and indemnity payments received over a ten-year planning horizon, and the difference in premiums and indemnities. A third-degree stochastic dominance

analysis was also used to compare crop insurance products and calculate confidence premiums in absolute values and as a percentage of the mean.

Regional and Farm Level Analyses

The empirical procedure developed in the previous section was employed to assess the efficacy of various crop insurance products on Texas cotton producers at the regional level and for a representative farm. The regional level analysis attempted to compare four different MPCl products (CAT, 50/100, 60/100, and 75/100) and three different CRC products (50, 60, 75), as well as the case of no insurance to determine which, if any, of the seven crop insurance alternatives were beneficial. This study was conducted over three regions: the Southern High Plains, the Northern High Plains, and the Northern Low Plains. The farm level analysis incorporated data from a sample farm into the procedure developed in the previous section to determine which, if any, of the same seven crop insurance alternatives were cost-effective for the sample farm. The sample farm was an irrigated cotton farm located in the Northern High Plains. Both studies were conducted assuming a ten-year planning horizon.

For the regional level analysis, the dryland and irrigated cotton yields were simulated by incorporating the mean and variance parameter estimates derived in the estimation of cotton yield distributions into equation (4.9) if yields were non-normally distributed or equation (4.10) if yields were non-normally distributed. Irrigated cotton yields were also simulated for the farm level analysis by using equation (4.9) or (4.10). However, this simulation utilized the mean calculated from a five-year average of yields

from the sample farm and the variance estimated for the region in which the farm was located. The regional level analysis used the cotton prices simulated from the estimated cotton price distribution. Prices for the farm level analysis were simulated in the same manner as the regional level analysis, except the mean utilized was the average of the prices received by the sample farm. Production costs for the regional level analysis were derived from the Texas Agricultural Extension Service's (TAEX) crop budgets for each region (TAEX, 2000), while the farm level analysis utilized actual production cost data from the sample farm. Cottonseed production for both the regional and farm level analyses were calculated assuming the same ratio of seed to lint (in pounds) as the TAEX budgets, and cottonseed revenues were assumed to be a three-year average of the TAEX budgets. Production costs and cottonseed revenues were held constant over the planning horizon for both analyses.

Actuarial tables containing insurance premium rates were obtained for each county included in the study. Regional level rates were obtained by averaging the rates from all counties included in their respective regions. For example, rates for the Southern High Plains were obtained by averaging the rates from Cochran, Crosby, Dawson, Hockley, Lamb, and Martin counties. For the farm level analysis, premium rates were obtained from the actuarial table for the county in which the farm was located. Premium rates were held constant across the planning horizon for both analyses. Insurance premiums for both analyses were calculated for MPCI at the CAT, 50/100, 60/100, and 75/100 levels and for CRC at the 50, 60, and 75 levels of coverage. Indemnity payments were calculated for both analyses using the criteria described in the previous section.

Data Considerations

This analysis utilized two types of data: price data and yield data. The price data and the historical yield data were seasonal time-series data. The producer yield data was a five- to ten-year set of cross-sectional data. The price data consisted of cotton prices received by the producer at the time of harvest. The yield data were actual realized yields at harvest. Other data that were utilized in this analysis include production cost data for the regional level analysis and financial information for the farm level analysis.

Price data were collected from the National Agricultural Statistics Service (NASS). The state-level data consisted of annual price data from 1934 to 1998, and were used to estimate the price distribution faced by Texas cotton producers. Producer yield data were collected from the Texas Agricultural Extension Service (Fincham, 1999). The yield data included five to ten years of producers' yield history. The data included the number of acres planted, the actual realized yield in pounds per planted acre, the location of the farm, and the farming practice (i.e., irrigated or non-irrigated). This study acquired data for producers from thirteen counties in three different regions. The three regions in this study, illustrated in Figure 4.2, are: (1) Northern High Plains, (2) Southern High Plains, and (3) Northern Low Plains. In this analysis, only data that contained the true, actual realized yields were utilized; T values were not included in the data for this analysis. The exclusion of T values resulted in a true estimation of yield variability.

Region	Outside of Study Area	Southern High Plains
	Northern High Plains	Northern Low Plains

Figure 4.2. Study Area Regions

Historical yield data were used to estimate yield variability through time. County yield data from 1970 to 1998 were collected from the Texas Agricultural Statistics Service (TASS, 1970-98).

Production cost data was obtained by using a three-year average from the Texas Agricultural Extension Service crop budgets (TAEX, 2000). Insurance costs included in these budgets were subtracted and returns to management were not included. Actuarial tables used in the calculation of insurance premiums were collected from USDA's Risk Management Agency (FCIC-RMA, 2000). Historical base prices from 1988 to 1998 were obtained from a private insurance company, and were used in the distributed lag model to estimate a model for simulating base prices utilized in the calculation of insurance premiums. Financial information for the representative farm was collected from the Standardized Performance Analysis (SPA) project from Texas Tech University (Clark et al., 1998).

CHAPTER V

RESULTS

The results presented in this section are obtained from the methods and procedures used to complete the objectives of the study. This chapter is divided into three sections. The first section presents the results obtained from the estimation of cotton yield and price distributions. Results from the regional level analysis are included in the second section. The final section explores the results obtained from the farm level analysis.

Cotton Yield and Price Distributions

Cotton Yield Distributions

Definitions and results for the maximum likelihood parameter estimates for the full dryland and irrigated cotton yield probability distribution functions and the final restricted models are presented in Tables 5.1 and 5.2. The statistical significance of each individual parameter was evaluated through likelihood ratio tests. Likelihood ratio tests were also performed between the final restricted models and the respective full models. All parameters in the final restricted models were statistically significant at the 95 percent level.

The final model for irrigated cotton yields implies distinct yield distributions for the Southern High Plains and Northern Low Plains of Texas. The yield distribution for the Northern High Plains is almost identical to that of the Southern High Plains, with the

Table 5.2. Cotton Yield Estimation Results

	Irrigated		Dryland	
	Full Model	Rest. Model	Full Model	Rest. Model
MLV	-5.70580	-5.71079	-5.49435	-5.49883
LR		7.02592		8.27008
θ	0.18862	-	-0.05075	0.26311
μ	-1.10935	-	30	20
INT	426.90009	394.27063	269.56283	265.37086
NLP	100.05629	91.87648	105.87250	51.48484
NHP	-8.80380	-	-27.86968	-
T	-19.38895	-7.72643	-18.36331	-16.22325
T*NLP	-8.70291	-7.42525	-2.55677	-
T*NHP	-0.62327	-	1.80496	-
T ²	1.48005	0.5814	1.96192	1.76196
T ³	-1.85455	-	0.28619	-0.04596
AC	-0.02571	-	0.35957	0.27472
AF	-0.10319	-	0.08422	-
σ_{INT}	86.64383	230.69855	167.61836	185.33233
σ_{NLP}	-9.14105	-47.09278	39.25158	-
σ_{NHP}	-2.67670	-	-46.65995	-51.5959
σ_{CL}	-57.47816	-112.08922	-49.23212	-49.55682
σ_T	-1.85269	-	2.36708	-
σ_{T*NLP}	-0.04747	-	-3.14886	-1.1149
σ_{T*NHP}	0.53166	1.82429	1.76656	1.91462
σ_{T*CL}	1.86455	1.85417	0.25493	-
σ_{T^2}	0.00521	-0.01488	-0.05951	-
σ_{AC}	-0.04886	-0.21373	0.02337	-
σ_{AF}	-0.00792	-	-0.10290	-0.13655

exception of the variance trend. The model shows that irrigated cotton yield distributions are normal, and exhibit different variances at the farm and county level. Figure 5.1 illustrates the predicted mean trends for cotton yields. The mean irrigated cotton yield for the Northern and Southern High Plains of Texas was estimated at 387 pounds per planted acre in 1970, while the mean yield for the Northern Low Plains was about 84 pounds per acre higher in the same year. Irrigated cotton yields for the Northern and Southern High Plains were found to be lower (approximately 369 pounds per acre) in the middle-to-late 1970's but increased to approximately 586 pounds per planted acre by 1995. For the Northern Low Plains, it was predicted that average irrigated cotton yields were at about 388 pounds per acre in the early 1980's and increased to approximately 485 pounds per acre by 1995. Summary statistics for the 1995 simulated yield distribution are presented in Table 5.3.

Table 5.3. Summary Statistics for 1995 Simulated Cotton Yields

	Irrigated			Dryland		
	<u>SHP</u>	<u>NHP</u>	<u>NLP</u>	<u>SHP</u>	<u>NHP</u>	<u>NLP</u>
Mean	587.735	587.5	486.087	228.115	228.114	279.402
St. Dev.	265.7	218.688	172.012	189.157	188.929	159.379
Kurt.	0.00638	0.00638	0.00638	1.39121	1.39121	1.39121
Skew.	0.00627	0.00627	0.00627	0.84441	0.84441	0.84441

Figure 5.2 suggests that the absolute county level yield variability was initially the same for the Northern and Southern High Plains. However, the standard deviation for the Northern Low Plains was initially 47 pounds per acre less than that of the other two regions. Although the yield variability of the Northern High Plains increased at a greater

Figure 5.1. Predicted Mean Trends for Cotton Yields

Figure 5.2. Absolute and Relative Yield Variability in Cotton Yields

rate than that of the other regions, the results indicate that the yield variability for all three regions have increased at a decreasing rate over time in absolute (standard deviation) terms. By 1995, the yield variability of the Northern High Plains had increased to approximately 204 pounds per acre, while the yield variability had increased to about 157 pounds per acre in the Southern High Plains and about 110 pounds in the Northern Low Plains.

Figure 5.2 compares the absolute yield variability (standard deviation) with the relative yield variability (coefficient of variation) of irrigated cotton yields. The results indicate that while the absolute yield variability has increased consistently from 1970 to 1998, the relative yield variability acted much differently. Initially, the relative yield variability appeared to be the same for the Northern and Southern High Plains, while the relative yield variability for the Northern Low Plains was about 15% lower. It appears that the relative yield variability for the Southern High Plains increased to about 36% in the late 1970's and then decreased to about 24% by 1998. The relative yield variability for the Northern High Plains followed a similar trend, increasing to about 42% in the early 1980's before decreasing to approximately 32% by 1998. According to the results for the Northern Low Plains, the relative yield variability increased until the mid 1980's, where it leveled off at about 25% before decreasing slightly to about 21% in 1998.

Figure 5.3 compares absolute farm level yield variability with absolute county level yield variability from 1989 to 1998. The analysis suggests that the county level standard deviation for irrigated cotton were about 75 pounds per acre less than the farm level standard deviation for each region in 1989. The farm level yield variability appears

Figure 5.3. Farm and County Level Standard Deviation Trends

to be decreasing slightly in the Southern High Plains and Northern Low Plains and increasing slightly in the Northern High Plains, while the county level yield variability appears to be increasing slightly in each region through time.

The model also attempted to determine the impact of planted acres on irrigated cotton yield means and variabilities at the farm and county levels. Results indicate that as planted acres at the county level increase (in standard deviations from the mean), the variability in irrigated cotton yields decreases. This could be due to the fact that counties that plant high amounts of cotton acreage are better suited for cotton production than those counties that have small amounts of planted cotton acreage.

The dryland cotton model revealed distinct yield distributions for all three regions studied, which were kurtotic and right skewed and indicated different variances at the farm and county level. The dryland cotton yields averaged about 250 pounds per acre in the Northern and Southern High Plains in 1970. In the same year, dryland cotton yields were estimated to be approximately 51 pounds per acre higher in the Northern Low Plains. Results further indicate that dryland cotton yields decreased to about 222 pounds per acre for the Northern and Southern High Plains and 273 pounds per acre for the Northern Low Plains in the mid 1970's, before increasing to a maximum around 1989 of about 278 pounds per acre and 329 pounds per acre, respectively. From 1990 to 1995, dryland cotton yields declined to approximately 227 pounds per acre in the Northern and Southern High Plains and approximately 278 pounds per acre in the Northern Low Plains. The downward trend in dryland yields in the 1990's (Figure 5.1) may be due to the fact that producers suffered severe weather related yield losses in the mid-to-late

1990's. It seems that the time trend estimated by this model may be modeling cyclical weather patterns and that the true underlying long-term trend for dryland cotton yields is relatively flat, and hovering around 250 pounds per acre in the Northern and Southern High Plains and about 300 pounds per acre in the Northern Low Plains. For these reasons, cotton yields were simulated for the regional level analysis using the 1995 yield distributions.

As evident in Figure 5.2, the absolute county level dryland cotton yield variability was initially the same (approximately 135 pounds per planted acre) in the Southern High Plains and Northern Low Plains, but the yield variability for the Northern High Plains was approximately 52 pounds per acre less. The yield variability has remained constant through time for the Southern High Plains, appeared to have decreased through time for the Northern Low Plains to about 103 pounds per acre in 1998, and has increased through time for the Northern High Plains to around 140 pounds per acre.

Figure 5.2 also illustrates the relative yield variability of dryland cotton yields. The coefficient of variation trend for the Southern High Plains and Northern Low Plains follow a similar pattern; increased until the mid 1970's, then decreased until around 1990, and increased significantly in the mid-to-late 1990's. The coefficient of variation trend for dryland cotton yields in the Northern High Plains increased until the mid-to-late 1970's, leveled off until the late 1980's, and increased significantly during the 1990's. It seems that the coefficient of variation for dryland cotton yields is inversely related to the long term yield trend. This could again be due to cyclical weather patterns. In periods of bad weather, relative yield variabilities may increase, while average yields decrease.

Likewise, in periods of good weather, relative yield variabilities may decrease, while average yields may increase.

A comparison of the county level absolute yield variability to farm level yield variability reveals that for all three regions, the farm level standard deviation was about 50 pounds per acre more than the county level yield variability (Figure 5.3). This is because farm and county level yield variabilities were found to be changing the same way through time.

As with irrigated cotton yields, the impact of planted acres on dryland cotton yield means and variabilities were estimated at both the farm and county levels. Results indicate that as dryland planted cotton acreage increased (in standard deviations from the mean) at the county level, the mean yield of dryland cotton increased. It was also found that with an increase in planted acres at the farm level (in standard deviations from the mean), yield variability decreased.

Cotton Price Distribution

Definitions and results for the final model for the cotton price distribution are presented in Tables 5.4 and 5.5, respectively. Results indicate that cotton prices follow a normal distribution. All parameters were statistically significant at the 95 percent level. The model estimates that the mean price in 1934 was around 70 cents per pound (in 1998 dollars). The long-term trend indicates that mean cotton prices have decreased in real terms about one cent per pound every five years. The price variability was estimated at about 12 cents per pound in 1934, but decreasing slightly through time. The non-linear

Table 5.4. Definition of Variable Names for
Cotton Price Estimation

Variable Name	Definition
θ	Kurtosis parameter
μ	Skewness parameter
ρ	Autocorrelation coefficient
CP	Cotton price variable
T	Time trend variable
T2	Time trend variable squared
σ	Variance of yield distribution

Table 5.5. Cotton Price Estimation Results

	Full Model	Rest. Model
MLV	-1.76864	-1.84348
LR		9.87835
θ	0.01570	-
μ	0.88550	-
ρ	0.40500	0.44311
CP	0.68320	0.704328
T	-0.00060	-0.002203
T2	0.00000	-
σ_{CP}	0.00170	0.11797
σ_T	0.00000	-0.000666
σ_{T2}	0.00000	-

terms for the mean and variance trends included in the first model were not statistically significant. A first-order autocorrelation coefficient (ρ), which is the correlation coefficient between errors in time t and errors in time $t-1$, was also estimated to be about 0.44. Prices were simulated for the years 2000 through 2009 using the price distribution that the model predicted for each year.

Regional Level Analysis

Net returns were obtained from the empirical procedure developed in the Methods and Procedures chapter for four different MPCl products (CAT, 50/100, 60/100, and 75/100), three CRC products (50, 60, and 75), as well as the case of no insurance for the three regions under study. Tables 5.6, 5.7, and 5.8 contain the summary statistics for the Southern High Plains, the Northern High Plains, and the Northern Low Plains, respectively. This section evaluates the results from the regional level analysis in terms of mean net returns, standard deviations, coefficients of variation, the probability of receiving an indemnity payment, premiums paid and indemnities received over a ten-year planning horizon, and the difference in premiums and indemnities. These summary statistics were chosen to allow comparison of crop insurance products in different manners. For example, one producer may compare crop insurance products strictly based on mean net returns, whereas another producer may look at the standard deviation of mean net returns or the coefficient of variation to determine the effect different crop insurance products have on the yield variability. Third degree stochastic dominance results are also analyzed for the regional level analysis.

Table 5.6. Crop and Revenue Insurance Product Comparisons for the Southern High Plains

	Irrigated							
	No Insurance	MPCI				CRC		
		CAT (50/55)	50/100	60/100	75/100	50	60	75
Mean	-83.39	-80.57	-84.32	-86.47	-97.19	-86.53	-89.77	-104.34
St. Dev.	45.95	44.93	43.96	43.05	41.24	43.39	42.11	39.33
CV	55.10	55.77	52.13	49.79	42.43	50.14	46.91	37.69
P(Indem)	-	0.10	0.10	0.15	0.26	0.09	0.15	0.25
Sum Prem.	-	0.90	55.46	110.41	295.31	82.23	152.85	385.95
Sum Indem.	-	26.24	47.71	83.83	173.91	53.89	95.01	196.93
Indem-Prem.	-	25.34	-7.74	-26.58	-121.39	-28.34	-57.84	-189.01

	Dryland							
	No Insurance	MPCI				CRC		
		CAT (50/55)	50/100	60/100	75/100	50	60	75
Mean	-125.85	-119.27	-121.48	-124.92	-141.44	-123.22	-127.60	-147.08
St. Dev.	37.02	36.69	36.63	36.98	36.58	36.54	36.83	36.11
CV	29.42	30.76	30.15	29.60	25.86	29.65	28.86	24.55
P(Indem)	-	0.30	0.30	0.35	0.43	0.29	0.35	0.42
Sum Prem.	-	0.90	69.05	138.60	355.44	95.82	178.13	429.32
Sum Indem.	-	59.45	108.08	147.14	217.40	119.17	162.50	240.37
Indem-Prem.	-	58.55	19.99	8.54	-138.04	23.35	-15.63	-188.94

Table 5.7. Crop and Revenue Insurance Product Comparisons for the Northern High Plains

	Irrigated							
	No Insurance	MPCI				CRC		
		CAT (50/55)	50/100	60/100	75/100	50	60	75
Mean	-79.29	-73.96	-76.98	-78.92	-91.94	-78.81	-81.60	-97.75
St. Dev.	54.60	52.98	51.60	50.61	48.82	50.74	49.21	45.88
CV	68.86	71.63	67.03	64.13	53.10	64.38	60.31	46.94
P(Indem)	-	0.14	0.14	0.20	0.30	0.14	0.19	0.29
Sum Prem.	-	0.90	67.05	134.27	359.51	94.74	176.50	444.67
Sum Indem.	-	48.58	88.34	138.54	248.57	98.78	155.24	278.48
Indem-Prem.	-	47.68	21.28	4.28	-110.94	4.04	-21.27	-166.19

	Dryland							
	No Insurance	MPCI				CRC		
		CAT (50/55)	50/100	60/100	75/100	50	60	75
Mean	-100.53	-93.93	-94.78	-96.85	-109.97	-96.12	-98.99	-114.83
St. Dev.	37.05	36.73	36.58	36.83	36.80	36.48	36.67	36.36
CV	36.85	39.10	38.59	38.03	33.46	37.95	37.04	31.66
P(Indem)	-	0.30	0.30	0.35	0.43	0.29	0.35	0.42
Sum Prem.	-	0.90	57.08	114.51	301.26	80.30	149.30	368.22
Sum Indem.	-	59.57	108.31	147.41	217.71	119.41	162.78	240.73
Indem-Prem.	-	58.67	51.23	32.90	-83.55	39.11	13.47	-127.50

Table 5.8. Crop and Revenue Insurance Product Comparisons for the Northern Low Plains

	Irrigated							
	No Insurance	MPCI				CRC		
		CAT (50/55)	50/100	60/100	75/100	50	60	75
Mean	-163.82	-161.92	-164.92	-166.62	-174.58	-165.96	-167.97	-177.10
St. Dev.	36.34	35.62	35.07	34.49	33.60	34.56	33.61	31.60
CV	22.18	22.00	21.27	20.70	19.24	20.82	20.01	17.84
P(Indem)	-	0.09	0.09	0.14	0.25	0.08	0.13	0.24
Sum Prem.	-	0.90	42.03	84.04	224.55	56.54	105.82	268.02
Sum Indem.	-	17.99	32.71	59.75	129.91	37.14	68.00	147.59
Indem-Prem.	-	17.09	-9.32	-24.29	-94.64	-19.40	-37.82	-120.43

	Dryland							
	No Insurance	MPCI				CRC		
		CAT (50/55)	50/100	60/100	75/100	50	60	75
Mean	19.45	22.84	21.69	21.21	14.92	20.51	19.35	10.69
St. Dev.	32.58	32.24	31.98	31.99	32.12	31.86	31.80	31.73
CV	167.48	141.13	147.47	150.86	215.32	155.29	164.37	296.84
P(Indem)	-	0.19	0.19	0.26	0.37	0.19	0.25	0.35
Sum Prem.	-	0.90	36.54	73.21	195.93	54.19	101.05	253.62
Sum Indem.	-	31.09	56.53	88.99	155.98	63.23	99.41	174.42
Indem-Prem.	-	30.19	19.99	15.78	-39.95	9.04	-1.64	-79.20

Mean Net Returns

Net returns for dryland and irrigated cotton were averaged across a ten year planning horizon (2000 - 2009). The mean was calculated from 15,000 repetitions for each level of MPCl and CRC, for each region, in order to compare different crop and revenue insurance products and rank them from highest to lowest mean net return.

For irrigated cotton in the Southern High Plains, the only MPCl insurance product that is preferable to no insurance when comparing mean net returns is CAT (50/55) (Table 5.6). The scenario where no insurance is purchased returned the next highest mean net return, followed by the scenarios involving 50/100, 60/100, and 75/100 coverage levels, respectively. None of the CRC insurance products returned net returns above that of the scenario with no insurance. The ranking of CRC scenarios in terms of net returns was: no insurance, 50 percent, 60 percent, and 75 percent (Table 5.6).

For dryland cotton in the Southern High Plains, CAT once again was found to be most preferable among the MPCl crop insurance options. However, unlike irrigated cotton, the second best option was 50/100, followed by 60/100, no insurance, and 75/100, respectively. For CRC insurance options, the 50 percent coverage level returned the highest mean net return, followed by no insurance, 60 percent, and 75 percent, respectively.

According to Table 5.7, the same rankings were present for irrigated cotton in the Northern High Plains as were present for dryland cotton in the Southern High Plains (i.e., for MPCl: CAT, 50/100, 60/100, no insurance, and 75/100 and for CRC: 50, no insurance, 60 and 75). For dryland cotton in the Northern High Plains, CAT once again

returns the highest mean net return (Table 5.7), followed by 50/100, 60/100, no insurance, and 75/100. The 50 percent option was the highest ranked CRC option for dryland cotton in the Northern High Plains. The 60 percent scenario was next highest, followed by the no insurance and 75 percent options.

The results for irrigated cotton in the Northern Low Plains indicated that the insurance products in that region followed the same ranking as that of irrigated cotton in the Southern High Plains, which was CAT, no insurance, 50/100, 60/100, and 75/100 for MPCl and no insurance, 50, 60 and 75 for CRC (Table 5.8). The same rankings were present for dryland cotton in the Northern Low Plains as were reported for irrigated cotton in the Northern High Plains. CAT was the most preferred MPCl option, followed by 50/100, 60/100, no insurance, and 75/100, and the 50 percent option was the most preferred CRC option, followed by no insurance, 60 percent, and 75 percent (Table 5.8).

These results indicate that CAT was the overwhelmingly preferred MPCl option for all scenarios. The ranking of the other MPCl options was consistently 50/100, 60/100, and 75/100 in all scenarios. However, if no insurance is considered as an option, it is interesting to note that for irrigated cotton, no insurance was the second preferred option after CAT for irrigated cotton in the Southern High Plains and the Northern Low Plains. For the Northern High Plains, however, the 50/100 and 60/100 options were ranked above the no insurance option. It is also interesting to note that in all scenarios, the no insurance scenario ranked behind the CAT option and ahead of the 75/100 option. The CRC options always ranked 50, 60, and 75 percent, respectively. Again, it should be noted that for irrigated cotton, the no insurance option fared better than any of the CRC

options, except for the Northern High Plains, where the 50 percent option was preferred to no insurance. In the case of dryland cotton, 50 percent CRC coverage ranked higher than no insurance for both the Southern High Plains and Northern Low Plains. In the Northern High Plains, both 50 and 60 percent CRC coverage levels fared better than the no insurance option. It should, however, be noted that, in all scenarios considered, the no insurance option ranked above the 75 percent CRC coverage level.

Standard Deviation

The standard deviation of net returns was also calculated from 15,000 repetitions for each level of MPCl and CRC, for each region in order to compare the variability in net returns for different crop and revenue insurance products. Comparing standard deviations of net returns from the MPCl insurance products for irrigated cotton in the Southern High Plains indicated that the 75/100 coverage level appeared to reduce the variability in yields the most, followed by the 60/100, 50/100, CAT, and no insurance scenarios, respectively (Table 5.6). For CRC insurance products, the 75 percent coverage level reduced absolute net return variability the most, followed by the 60 percent, 50 percent, and no insurance scenarios, respectively. The absolute net return variability from insurance products for irrigated cotton in the other two regions followed the same pattern (Tables 5.7 and 5.8).

For dryland cotton in the Southern High Plains (Table 5.6), the standard deviation of net returns for MPCl insurance products generally decreased as the coverage level increased, with the exception of the 60/100 option. Although the standard deviation of

net returns associated with the 60/100 option was lower than the scenario with no insurance and higher than the 75/100 option, as expected, it was marginally higher than the CAT and 50/100 levels. Similarly, the 60 percent coverage level had the highest standard deviation of all CRC insurance options, followed by the 50 percent and 75 percent coverage levels.

All MPCl options for dryland cotton in the Northern High Plains had lower standard deviations of net returns than the no insurance option (Table 5.7). The 50/100 option had the lowest standard deviation, followed by CAT, 75/100, and 60/100. However, the difference between the smallest and largest standard deviation of net returns was only about 0.25. The standard deviations of net returns for all CRC options were also below the no insurance option. The lowest standard deviation was associated with the 75 percent level, followed by the 50 and 60 percent levels. Once again, the difference between the smallest and largest standard deviation was very small.

In the case of MPCl options for dryland cotton in the Northern Low Plains, the 50/100 and 60/100 options had the lowest standard deviation of net returns, followed by the 75/100 and CAT option (Table 5.8). However, the difference between the lowest and highest standard deviation was only about 0.26. All MPCl and CRC insurance options for irrigated cotton in the Northern Low Plains had lower standard deviations of net returns than the no insurance option. The 75 percent coverage level had the lowest standard deviation, followed by the 60 and 50 percent levels.

In all irrigated cotton scenarios, the standard deviation of net returns decreased as the coverage level increased for both MPCl and CRC insurance products. All insurance

options had lower standard deviations than the case of no insurance for all dryland cotton scenarios. CAT and 50/100 seemed to reduce the standard deviation of net returns, respectively, but the 60/100 level and, in some cases the 75/100 level, resulted in a higher standard deviation than the CAT and 50/100 levels. This may be due to the fact that the insurance rates for these options (60/100 and 75/100) are overrated for dryland cotton in some regions, resulting in higher premiums and, thus, a greater fluctuation of net returns. All CRC options resulted in lower standard deviations than the case of no insurance. However, in two out of three regions, the 60 percent level had the highest standard deviation of all CRC options. This may once again be caused by overrating of this option.

Coefficient of Variation

The coefficient of variation, or relative variability, is calculated by expressing the standard deviation as a percent of the mean net return. The relative variability in net returns for irrigated cotton in the Southern High Plains (Table 5.6) decreased as MPCl insurance levels increased, with the exception of CAT. The CAT coverage level actually had a higher coefficient of variation than the no insurance scenario. For CRC, the relative variability decreased as the coverage level increased. MPCl insurance options for dryland cotton in the Southern High Plains indicated that the 75/100 level returned the lowest coefficient of variation, followed by the no insurance, 60/100, 50/100, and CAT scenarios, respectively (Table 5.6). The lowest coefficient of variation for CRC options

was returned by the 75 percent option, followed by the 60 percent, no insurance, and 50 percent coverage levels, respectively.

The same ranking of insurance options was found for irrigated cotton in the Northern High Plains (Table 5.7) as was present for irrigated cotton in the Southern High Plains, which was, from lowest to highest: 75/100, 60/100, 50/100, no insurance, and CAT for MPCl and 75, 60, 50, and no insurance for CRC. Dryland cotton insurance products in the Northern High Plains (Table 5.7) followed a very similar ranking as that of dryland cotton in the Southern High Plains, except that the CRC 60 option ranked behind the no insurance option and ahead of the 50 percent option.

For irrigated cotton in the Northern Low Plains (Table 5.8), the coefficient of variation for all coverage levels of MPCl and CRC were lower than the scenario for no insurance, and the relative variability decreased as coverage levels increased for both MPCl and CRC insurance products. The coefficient of variation for dryland cotton in the Northern Low Plains (Table 5.8) actually increased as the coverage level increased for MPCl, and the coefficient of variation for the 75/100 level was higher than that of the scenario for no insurance. Likewise, the coefficient of variation for CRC options increased as the coverage level increased, and the coefficient of variation for the 75 percent level was higher than the case of no insurance.

Overall, MPCl and CRC insurance products seem to be reducing the relative variability in net returns when compared to the case of no insurance. However, in a few cases, the coefficient of variation for a particular option is higher than that of no insurance. Since the coefficient of variation is a measurement of the standard deviation

as a percent of the mean, relative movements in the mean and standard deviation can affect the coefficient of variation. The coefficient of variation is directly related to the standard deviation and inversely related to the mean. For example, a decrease in the standard deviation will result in a lower coefficient of variation, if the mean is held constant, while a decrease in the mean can result in a higher coefficient of variation, if the standard deviation is held constant. Therefore, the movement of the coefficient of variation is determined by the relative magnitudes of the movements of the mean and standard deviation. This is evident in the analysis of the coefficients of variations, and may explain why some insurance options have a greater coefficient of variation relative to other options.

Probability of Receiving an Indemnity Payment

The probability of receiving an indemnity payment in a given year was also calculated from 15,000 repetitions for each level of MPCl and CRC. For both practices in all regions, the probability of receiving an indemnity payment for the CAT option was equal to that of the 50/100 level (Tables 5.6, 5.7, and 5.8). This is explained by the fact that MPCl insurance products pay indemnities based on the yield coverage level and both options contain the 50 percent yield protection. As one might expect, the probability of receiving an indemnity payment increased as coverage levels increased for both MPCl and CRC insurance options.

For irrigated cotton, the probability of receiving an indemnity payment ranged from nine percent to fourteen percent for CAT and 50/100 options and 25 to 30 percent

for the 75/100 option across regions. CRC probabilities ranged from eight to fourteen percent for the 50 percent option and 24 to 29 percent for the 75 percent option. Dryland probabilities for MPCl ranged from 19 to 30 percent for the CAT and 50/100 options across regions, while the 75/100 probabilities ranged from 37 to 43 percent. The CRC probabilities for dryland cotton ranged from 19 to 29 percent for the 50 percent option and 35 to 42 percent for the 75 percent option across all regions.

Premiums Paid and Indemnities Received

Insurance premiums and indemnities were summed across a ten year horizon to determine if the cost of the premiums were offset by the receipt of indemnity payments. Once again, the mean cost of premiums and mean level of indemnity payments received were calculated from 15,000 iterations. The CAT premium was \$0.90 in all regions (Tables 5.6, 5.7, and 5.8) because CAT is available for a \$60 fee per crop, per county. The average farm size of 582 acres from Texas Agricultural Statistics (1998) was used for the calculation of the CAT premium. For both practices in all regions, premiums paid and indemnities received increased as coverage levels increased for MPCl and CRC insurance products.

Premium-Indemnity Difference

To determine if the cost of insurance premiums was offset by the receipt of indemnity payments, the amount of premiums paid was subtracted from the amount of indemnities received. CAT was the only MPCl insurance option for irrigated cotton in

the Southern High Plains where the mean sum of indemnity payments received exceeded the mean sum of premiums paid (Table 5.6). The other MPCCI coverage levels resulted in a premium-indemnity deficit. In other words, the indemnity payments received were less than the insurance premiums paid. As the coverage level increased for MPCCI buy-up options, the premium-indemnity deficit increased. All options of CRC resulted in a premium-indemnity deficit. Like MPCCI, the deficit increased as the coverage level increased for CRC. Similar results were achieved for irrigated cotton in the Northern Low Plains.

Three of the four MPCCI insurance products studied for dryland cotton in the Southern High Plains (Table 5.6) resulted in a premium-indemnity surplus. In other words, the mean sum of indemnity payments received was greater than the mean sum of premiums paid. The CAT option returned the greatest premium-indemnity surplus, followed by 50/100 and 60/100. The 75/100 coverage level resulted in a premium-indemnity deficit. For CRC options, the 50 percent coverage level returned a premium-indemnity surplus, while the 60 and 75 percent levels both returned a deficit.

Similar results were found when comparing crop insurance options for irrigated cotton in the Northern High Plains (Table 5.7) as were found for dryland cotton in the Southern High Plains. Results for dryland cotton in the Northern High Plains indicate the CAT, 50/100, and 60/100 options all returned a premium-indemnity surplus, while the 75/100 option returned a deficit (Table 5.7). For CRC, the 50 and 60 percent levels returned a surplus, while the 75 percent level returned a deficit.

Irrigated cotton in the Northern Low Plains (Table 5.8) returned similar results to irrigated cotton in the Southern High Plains. Only CAT had a premium indemnity surplus, while the premium-indemnity deficit increased as the coverage level increased for the other MPCl options, as well as the CRC options. Dryland cotton for the Northern Low Plains (Table 5.8) returned similar results to dryland cotton in the Southern High Plains and irrigated cotton in the Northern High Plains. CAT, 50/100, and 60/100 all returned premium indemnity surpluses, while the 75/100 option returned a deficit. For CRC, the 50 percent option returned a surplus, while the other two CRC options both returned deficits.

CAT was the only insurance option that returned a premium-indemnity surplus for all of the scenarios studied. In all but two scenarios, the 50/100 and 60/100 options also returned a surplus. The 75/100 option returned a premium-indemnity deficit for all scenarios studied. The 50 percent CRC option returned a surplus in four out of the six scenarios, while the 60 percent option returned a surplus in only one scenario. The 75 percent option returned a deficit in all of the scenarios studied. The surplus declined and/or the deficit increased as the coverage level increased in all scenarios for both MPCl and CRC.

Stochastic Dominance

Different insurance products were also compared using third degree stochastic dominance criterion. As part of the stochastic dominance analysis, confidence premiums were calculated using the method developed by Mjelde and Cochran (1988) in absolute

amounts, and as a percent of the premiums paid. The absolute amount reflects the sum of money a producer could be paid to move from the dominant scenario to a dominated scenario. The absolute amount was then calculated as a percent of the premium associated with the respective dominated scenario. This was done in order to determine how much of a premium subsidy it would take in order to make a producer indifferent between a dominated scenario and the dominant scenario. Tables A.1 through A.12 report the results from the stochastic dominance analyses for MPCCI and CRC insurance options, for both irrigated and dryland cotton in all three regions. Since this study assumes a risk averse producer, only the risk averse rankings will be discussed.

Results from the stochastic dominance analysis indicate that the CAT (50/55) option was the most preferred MPCCI option. The ranking of the other MPCCI options was consistently 50/100, 60/100, and 75/100 in all scenarios. However, if no insurance was considered an option, no insurance was the second preferred option for irrigated cotton in the Southern High Plains. For all other scenarios, however, the 50/100 and 60/100 options ranked above the no insurance option. It is also important to note that the no insurance option ranked behind CAT and ahead of the 75/100 in all scenarios. These rankings are identical to the ones found when comparing crop insurance products in terms of mean net returns, with the exception of irrigated cotton in the Northern Low Plains.

The CRC options were ranked 50 percent, 60 percent, and 75 percent in all scenarios except for irrigated cotton in the Northern Low Plains, where the ranking was 60 percent, 50 percent, no insurance, and 75 percent. Again, it is important to note that for irrigated cotton, no insurance was the preferred option in the Southern High Plains,

while the 50 percent option was the preferred option in the Northern High Plains, and the 60 and 50 percent options were preferred ahead of the no insurance option in the Northern Low Plains.

In the case of dryland cotton, the 50 percent option was ranked higher than no insurance in the Southern High Plains and Northern Low Plains. In the Northern High Plains, both the 50 and 60 percent options fared better than the no insurance option. However, it should be noted that the no insurance option was ranked ahead of the 75 percent option in all of the CRC scenarios. Again, these rankings are identical to the ones found when comparing crop insurance products in terms of mean net returns, with the exception of irrigated cotton in the Northern Low Plains. The reason that the stochastic dominance rankings for MPCl and CRC options for irrigated cotton in the Northern High Plains differ from the mean net returns ranking could be due to the fact that the stochastic dominance analysis takes into account the variability in net returns. Unlike the other scenarios, the yield variability for irrigated cotton in the Northern Low Plains was significantly reduced as the insurance coverage level increased. The added benefit of reduced net return variability could offset the loss in net returns, thus, changing the ranking.

Stochastic dominance results for irrigated cotton in the Southern High Plains (Table A.1), indicate that CAT was the most preferred MPCl option, followed by the no insurance, 50/100, 60/100, and 75/100 options, respectively. The absolute amount of the confidence premium for the no insurance option was \$3.12, implying that if the producer is paid \$3.12 per acre, then he or she will be indifferent between the no insurance and

CAT options. The absolute amounts of the confidence premiums for the 50/100, 60/100, and 75/100 options are \$3.48, \$5.42, and \$15.69, respectively. The confidence premiums expressed in percentage of premiums paid are 62.76 percent, 49.05 percent, and 53.14 percent, respectively. In other words, premiums for the 50/100, 60/100, and 75/100 MPCl options need to be subsidized by about 63, 49, and 53 percent, respectively, to make a producer indifferent between the dominant scenario (CAT) and each of the dominated scenarios. The reason that the subsidy level for the 60/100 option is less than the 50/100 and 75/100 options may be because the premium rates for the 60/100 option are less overrated than the other options. No insurance was the preferred option when comparing CRC options, followed by the 50, 60, and 75 percent options (Table A.2). According to the confidence premium findings, the 50, 60, and 75 percent option premiums have to be subsidized by about 28, 34, and 50 percent, respectively, to make a producer indifferent between the dominant scenario (no insurance) and each of the dominated scenarios.

For dryland cotton in the Southern High Plains (Table A.3), CAT was the preferred MPCl option, and the confidence premium results indicate that the 50/100, 60/100, and 75/100 levels have to be subsidized by about 22, 38, and 50 percent, respectively to make a producer indifferent between CAT and each of the dominated insurance products. The 50 percent option was the preferred CRC option for dryland cotton in the Southern High Plains (Table A.4) and the confidence premium results indicate that the 60 and 75 percent levels have to be subsidized by about 25 and 45

percent, respectively, to make a producer indifferent between the CRC 50 option and each of the dominated insurance products

MPCI confidence premium findings for irrigated cotton in the Northern High Plains (Table A.5) imply that a producer would become indifferent between the dominant scenario (CAT) and each of the dominated scenarios if the 50/100, 60/100, and 75/100 levels were subsidized by about 38, 31, and 46 percent, respectively. CRC confidence premium results for irrigated cotton in the Northern High Plains (Table A.6) indicate that the 60 and 75 percent options had to be subsidized by about 13 and 39 percent, respectively in order to make a producer indifferent between the dominant scenario (50 percent) and each of the dominated options. MPCI products for dryland cotton in the Northern High Plains (Table A.7) followed the same ranking as that of irrigated cotton, and confidence premium results show that the 50/100, 60/100, and 75/100 options need to be subsidized by nine, 28, and 47 percent, respectively. Confidence premium findings for dryland cotton in the Northern High Plains (Table A.8) indicate that the 60 percent level needs to be subsidized by about 22 percent, while the 75 percent option needs a 45 percent subsidy.

Confidence premium results for irrigated cotton in the Northern Low Plains (Table A.9) indicate that the 50/100, 60/100, and 75/100 coverage levels need to be subsidized by about 58, 36, and 47 percent, respectively, to make a producer indifferent from the dominant option (CAT) and each of the dominated options. Results for CRC options for irrigated cotton in the Northern Low Plains (Table A.10) suggest about a 1.5 and 19 percent subsidy for the 50 and 75 percent options, respectively, to make a

producer indifferent from the dominant option (60 percent) and each of the dominated options. MPCCI confidence premium results for dryland cotton in the Northern Low Plains (Table A.11) suggest a 34, 25, and 42 percent subsidy for the 50/100, 60/100, and 75/100 options, respectively. Subsidies of about 12 and 40 percent for the 60 and 75 percent CRC levels would be needed to make a producer indifferent from the dominant option (50 percent) and each of the dominated options.

For irrigated cotton, premium confidence results indicate the amount of subsidy a producer would have to receive to become indifferent between the dominant scenario and the dominated scenario ranged from 38 to 63 percent for the 50/100 option. Subsidy levels for the 60/100 and 75/100 options ranged from 31 to 49 percent and 46 to 53 percent, respectively. For CRC options, the 50 percent option only required a subsidy in two scenarios. A 1.5 percent subsidy was required when the dominant option was the 60 percent option, and a 28 percent subsidy was required when no insurance was the dominant option. Subsidies ranged between 13 and 34 percent and 19 and 50 percent for the 60 and 75 percent options, respectively.

Premium confidence findings for dryland cotton suggest a range of subsidies from nine to 34 percent to make a producer indifferent between the dominant option (CAT) and the 50/100 coverage level. For the 60/100 and 75/100 options, the subsidies ranged from 25 to 38 percent and 42 to 50 percent, respectively. CRC options for dryland cotton required a range of subsidies from 12 to 25 percent for the 60 percent option and 40 to 45 percent for the 75 percent options. Confidence premiums seemed to vary considerably

across regions and production practices, perhaps indicating that premium rates are being miscalculated by varying amounts across regions for irrigated and dryland cotton.

Farm Level Analysis

Summary statistics were calculated for the farm level analysis in the same manner as the regional level analysis. The results for the farm level analysis are presented in Table 5.9. When analyzing mean net returns for the base farm, the CAT option was the only MPCCI option that resulted in a higher net return than the case of no insurance. The 50/100, 60/100 and 75/100 options followed the case of no insurance, respectively. None of the CRC options resulted in higher mean net returns than the case of no insurance. The CRC options were ranked 50, 60, and 75 percent, from highest to lowest mean net return. All MPCCI and CRC options had a lower standard deviation than the scenario with no insurance. The standard deviation decreased as the coverage level increased. The opposite trend was present in the coefficient of variation, as it increased as coverage

Table 5.9. Crop and Revenue Insurance Product Comparisons for the Base Farm

	No Insurance	MPCCI				CRC		
		CAT (50/55)	50/100	60/100	75/100	50	60	75
Mean	180.81	181.92	173.21	167.19	146.70	169.06	160.95	133.81
St. Dev.	64.99	64.95	64.33	63.78	62.14	63.79	62.89	60.39
CV	35.95	35.70	37.14	38.15	42.36	37.73	39.07	45.13
P(Indem)	-	0.06	0.06	0.12	0.26	0.05	0.10	0.22
Sum Prem	-	0.72	86.59	173.79	465.73	130.13	243.33	612.40
Sum Indem	-	10.45	19.00	52.71	162.33	23.51	62.62	186.06
Indem-Prem	-	9.73	-67.59	-121.08	-303.40	-106.63	-180.71	-426.34

levels increased for both MPCl and CRC. This trend is probably due to the fact that as the coverage level increased across scenarios, the mean net returns were decreasing at a larger magnitude than the standard deviation of net returns were decreasing. The probability of receiving an indemnity payment, the mean sum of premiums paid, and the mean sum of indemnities received all increased as the coverage level increased for both MPCl and CRC insurance products. CAT was the only MPCl insurance product that resulted in a premium-indemnity surplus. The other three MPCl options resulted in deficits, increasing as the coverage level increased. All CRC insurance options returned a premium-indemnity deficit, with the deficit increasing as the coverage level increased.

The stochastic dominance analysis of the base farm indicates that CAT was the most preferred MPCl option (Table A.13). The no insurance option was the second best option, followed by the 50/100, 60/100, and 75/100 levels. Confidence premium results indicate that the 50/100, 60/100, and 75/100 levels need to be subsidized by about 97, 82, and 72 percent, respectively, to make each of the dominated scenarios as attractive as the dominant scenario. For CRC, the ranking indicated that having no insurance was most preferable (Table A.14). The 50, 60, and 75 percent levels ranked respectively behind the no insurance option. Confidence premium findings suggested subsidies of 86, 77, and 73 percent, respectively, to make a producer indifferent between the dominant scenario (no insurance) and each of the dominated scenarios.

The confidence premiums were a high percentage of the premium. This may be due to the fact that the base farm included in the farm level analysis was able to generate

high net returns, and insurance would be needed only in the case of a disaster; hence, the lack of need for buy-up insurance products.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Overview

Information on the efficacy of various crop and revenue insurance products on Texas cotton producers is not currently available. It is not known why Texas cotton producers purchase so little insurance above catastrophic levels. It could be that the current insurance products are not meeting the needs of cotton producers, or it could be that producers are simply unwilling to pay insurance premiums. In order to better understand the different crop insurance policies, the effects of multiple-peril crop insurance and crop revenue coverage on the net returns of the producer needed to be analyzed. The general objective of this study was to develop an empirical means and illustrate its application in evaluating the cost effectiveness of various crop and revenue insurance products as risk management tools for cotton producers in selected regions of Texas.

A multivariate parametric model, developed by Ramirez (1997) and expanded by Ramirez (1999), was used to estimate the yield and price distributions. This approach utilizes a multivariate, nonnormal density function that can accurately and separately account for skewness, kurtosis, heteroscedasticity, and the correlation among the random variables of interest, irrigated and dryland cotton yields, in this case. When estimating cotton price distributions, Ramirez's procedure (1999) was also used to correct for autocorrelation. Once the parameters for the price and joint yield distributions were

estimated, they were used to simulate any number of draws from the estimated distribution of cotton prices and joint distribution of cotton yields. This simulation technique, developed by Ramirez (1997), incorporated, if and when appropriate, a time-trend process and other factors affecting mean yield and price through time and space, as well as heteroscedasticity, autocorrelation, right or left skewness, kurtosis, and accounted correlation between dryland and irrigated cotton yields.

The simulated yield and price series obtained from these procedures were used to develop an empirical procedure to analyze the cost effectiveness of alternative crop insurance products in terms of increasing producer net returns and minimizing variation in net returns. In order to be able to compare different crop and revenue insurance products, net returns per planted acre needed to be estimated over a planning horizon. The first step in developing the procedure was to calculate total revenue distributions. This was done by multiplying the simulated yields by the simulated prices. Net revenues were then calculated by subtracting production costs from and adding cottonseed revenues to the total revenues. The final step in estimating net returns was to subtract insurance premiums and add indemnity payments, when applicable, to the net revenues to obtain net returns per planted acre. Summary statistics, such as net returns, absolute and relative yield variabilities, probabilities of receiving an indemnity, premiums paid, and indemnities received were calculated for various options of crop and revenue insurance. Stochastic dominance efficiency criterion was also employed to determine how insurance products may be ranked with risk aversion.

This procedure was then illustrated using a regional level analysis to represent an overall comparison of crop and revenue insurance products. The regions included in the current study were the Southern High Plains, Northern High Plains, and Northern Low Plains. A farm level analysis was also used to illustrate how the procedure may be used to compare crop and revenue insurance products for an individual producer. The base farm used in the farm level analysis was an irrigated cotton farm from the Northern High Plains.

Summary of Results

The results from the estimation of cotton yield distributions indicate that dryland cotton yields in the Northern High Plains, Southern High Plains, and the Northern Low Plains are non-normally distributed, while irrigated yields from the same regions appear to follow a normal distribution. This information could be very useful to policy makers because actuarially fair premiums are more likely to be calculated if the true variability of yield for cotton is known.

The predicted mean yield for irrigated cotton in the Northern and Southern High Plains was approximately 588 pounds per planted acre in 1995, while the predicted mean for the Northern Low Plains was about 486 pounds per planted acre. The standard deviations of irrigated cotton in the Southern High Plains, Northern High Plains, and Northern Low Plains were about 266, 219, and 172 pounds per planted acre, respectively. Estimated dryland cotton means in 1995 were: 228 pounds per planted acre for the Northern and Southern High Plains and 279 pounds per planted acre for the Northern

Low Plains. The standard deviations for dryland cotton was 189 pounds per planted acre for the Northern and Southern High Plains and 159 pounds per planted acre for the Northern Low Plains.

Results indicate dryland cotton yields have decreased and increased in a cyclical pattern over the last 30 years. Of particular concern is the sharp decline in yields in the mid-to-late 1990's. Low dryland cotton yields were recorded for at least three years from 1990 to 1998. The poor yields in the late 1990's are probably responsible for the decline in the long-term trend. Thus, the estimation of dryland cotton yields may have modeled cyclical weather patterns, indicating that dryland cotton yields have remained relatively stable over the past 30 years. Results further indicate that irrigated cotton yields have been increasing since the late 1970's or early 1980's. This increase in yields may be due to the adoption of new irrigation technologies, such as LEPA (Low Energy Precision Application).

The mean yields for each region were assumed to be the same at the farm and county levels, but different yield variabilities were estimated for each level. The analysis suggests that the county level standard deviation for irrigated cotton were about 75 pounds per acre less than the farm level standard deviation for each region in 1989. The farm level yield variability for irrigated cotton appears to be decreasing slightly in the Southern High Plains and Northern Low Plains and increasing slightly in the Northern High Plains, while the county level yield variability appears to be increasing slightly in each region through time. For dryland cotton, the results indicate that for all three regions, the farm level yield variability was about 50 pounds per acre more than the

county level yield variability. This is because farm and county level yield variabilities were found to be changing the same way through time.

The estimation of cotton prices indicated cotton prices in Texas have been linearly declining in real terms by about one cent every five years. Cotton prices were found to be autocorrelated. Prices were simulated for the years 2000 through 2009 accounting for autocorrelation and using the price distribution the model predicted for each year.

When comparing mean net returns, the results from the regional level analysis indicate that CAT was the overwhelmingly preferred MPCl option for all scenarios. The ranking of the other MPCl options was consistently 50/100, 60/100, and 75/100 in all scenarios. However, if no insurance is considered as an option, it is interesting to note that for irrigated cotton, no insurance was the second preferred option after CAT for irrigated cotton in the Southern High Plains and the Northern Low Plains. For the Northern High Plains, however, the 50/100 options and 60/100 options were ranked above the no insurance option. It is also interesting to note that in all scenarios, the no insurance scenario ranked behind the CAT option and ahead of the 75/100 option. The CRC options always ranked 50, 60, and 75 percent, respectively. Again, it should be noted that for irrigated cotton, the no insurance option fared better than any of the CRC options, except for the Northern High Plains, where the 50 percent option was preferred to no insurance. In the case of dryland cotton, 50 percent CRC coverage ranked higher than no insurance for both the Southern High Plains and Northern Low Plains. In the Northern High Plains, both 50 and 60 percent CRC coverage levels fared better than the

no insurance option. It should, however, be noted that, in all scenarios considered, the no insurance option ranked above the 75 percent CRC coverage level.

In all irrigated cotton scenarios, the standard deviation of net returns decreased as the coverage level increased for both MPCl and CRC insurance products. All insurance options had lower standard deviations than the case of no insurance for all dryland cotton scenarios. CAT and 50/100 seemed to reduce the standard deviation of net returns, respectively, but the 60/100 level and, in some cases the 75/100 level, resulted in a higher standard deviation than the CAT and 50/100 levels. This may be due to the fact that the insurance rates for these options (60/100 and 75/100) are overrated for dryland cotton in some regions, resulting in higher premiums and, thus, a greater fluctuation of net returns. All CRC options resulted in lower standard deviations than the case of no insurance. However, in two out of three regions, the 60 percent level had the highest standard deviation of all CRC options. This may once again be caused by overrating of this option. Overall, MPCl and CRC insurance products seem to be reducing the relative variability in net returns when compared to the case of no insurance. However, in a few cases, the coefficient of variation for a particular option was found to be higher than that of no insurance. Since the coefficient of variation is a measurement of the standard deviation as a percent of the mean, relative movements in the mean and standard deviation can affect the coefficient of variation.

The probability of receiving an indemnity payment in a given year was also calculated for each level of MPCl and CRC. For both practices in all regions, the probability of receiving an indemnity payment for the CAT option was equal to that of the

50/100 level. This is explained by the fact that MPCCI insurance products pay indemnities based on the yield coverage level and both options contain the 50 percent yield protection. As one might expect, the probability of receiving an indemnity payment increased as coverage levels increased for both MPCCI and CRC insurance options.

Insurance premiums and indemnities were summed across a ten year horizon to determine if the cost of the premiums were offset by the receipt of indemnity payments. The CAT premium was \$0.90 in all regions. For both irrigated and dryland cotton in all regions, the mean sum of insurance premiums and the mean sum of indemnities received both increased as coverage levels increased for MPCCI and CRC insurance products. To determine if the cost of insurance premiums was offset by the receipt of indemnity payments, the amount of premiums paid was subtracted from the amount of indemnities received. CAT was the only insurance option that returned a premium-indemnity surplus for all of the scenarios studied. In all but two scenarios, the 50/100 and 60/100 options also returned a surplus. The 75/100 option returned a premium-indemnity deficit for all scenarios studied. The 50 percent CRC option returned a surplus in four out of the six scenarios, while the 60 percent option returned a surplus in only one scenario. The 75 percent option returned a deficit in all of the scenarios studied. The surplus declined and/or the deficit increased as the coverage level increased in all scenarios for both MPCCI and CRC.

Results from the stochastic dominance analysis indicated that the rankings of insurance products are identical to the ones found when comparing crop insurance products in terms of mean net returns, with the exception of irrigated cotton in the

Northern Low Plains. Results indicate that the CAT (50/55) option was the most preferred MPCl option. CAT ranked ahead of all MPCl options, as well as the case of no insurance, in all scenarios studied. This finding was consistent with Skees et al. (1998), who found that CAT increased the ending net worth of a representative farm in the Delta area of Mississippi. The ranking of the other MPCl options was consistently 50/100, 60/100, and 75/100 in all scenarios. However, if no insurance was considered an option, it is interesting to note that for irrigated cotton in the Southern High Plains, no insurance was the second preferred option. For all other scenarios, however, the 50/100 and 60/100 options ranked above the no insurance option. It is also important to note that the no insurance option ranked behind CAT and ahead of the 75/100 in all scenarios. The CRC options were ranked 50 percent, 60 percent, and 75 percent in all scenarios except irrigated cotton in the Northern Low Plains, where the ranking was 60 percent, 50 percent, no insurance, and 75 percent. Again, it is important to note that for irrigated cotton, no insurance was the preferred option in the Southern High Plains, while the 50 percent option was the preferred option in the Northern High Plains, and the 60 and 50 percent options were preferred ahead of the no insurance option in the Northern Low Plains. In the case of dryland cotton, the 50 percent option was ranked higher than no insurance in the Southern High Plains and Northern Low Plains. In the Northern High Plains, both the 50 and 60 percent options fared better than the no insurance option. However, it should be noted that the no insurance option was ranked ahead of the 75 percent option in all of the CRC scenarios.

For irrigated cotton, premium confidence results indicate the amount of subsidy a producer would have to receive to become indifferent between the dominant scenario and the dominated scenario ranged from 38 to 63 percent for the 50/100 option. Subsidy levels for the 60/100 and 75/100 options ranged from 31 to 49 percent and 46 to 53 percent, respectively. For CRC options, the 50 percent option only required a subsidy in two scenarios. A 1.5 percent subsidy was required when the dominant option was the 60 percent option, and a 28 percent subsidy was required when no insurance was the dominant option. Subsidies ranged between 13 and 34 percent and 19 and 50 percent for the 60 and 75 percent options, respectively.

Premium confidence findings for dryland cotton suggest a range of subsidies from nine to 34 percent to make a producer indifferent between the dominant option (CAT) and the 50/100 coverage level. For the 60/100 and 75/100 options, the subsidies ranged from 25 to 38 percent and 42 to 50 percent, respectively. CRC options for dryland cotton required a range of subsidies from 12 to 25 percent for the 60 percent option and 40 to 45 percent for the 75 percent options. For the farm level analysis, CAT was the only MPCCI option that was preferred to no insurance. None of the CRC options ranked ahead of the no insurance option. Confidence premiums calculated for dominated insurance scenarios were a significant part of the premium paid, ranging from 97 to 72 percent for the MPCCI 50/100 and 75/100 options, respectively, and from 86 to 73 percent for the CRC 50 and 75 options, respectively. This indicates that a high subsidy of premiums would have to be included for the base farm to purchase buy-up insurance options.

Conclusions

The current study attempted to compare crop and revenue insurance products for selected regions in Texas using farm level data. This study succeeded in demonstrating that farm level data may be used to develop a procedure that allows one to compare the efficacy of various crop and revenue insurance products in terms of increasing producer net returns. This is also the first study that attempts to compare crop and revenue insurance products for the state of Texas.

If cotton yield distributions are estimated without accounting for non-normality, net returns are likely to be miscalculated. An important aspect of this study is the fact that cotton yield and price distributions were estimated using a procedure that can accurately and separately account for skewness, kurtosis, heteroscedasticity, and the correlation among the random variables of interest. In the current study, dryland cotton yields were found to be right-skewed and kurtotic. If one assumes a normal distribution, it is likely that the probability of low to moderately low yields would be underestimated, while the probability of moderately high to high yields would be overestimated (Ramirez et al., 2000). Also, extremely high yields are likely to be underestimated by a normal model, in this case. For example, if the probability of low cotton yields is being underestimated, certain crop and revenue insurance products may not appear efficient because they are not being triggered by low yields. Also, the empirical procedure developed in this study may be biased due to the miscalculation of net returns through the assumption of normality. Thus, when comparing various crop and revenue insurance

products, it is important to accurately estimate the true variability that producers are facing.

Premium rates appear to be too high for most buy-up insurance products. The overwhelmingly preferred MPCCI insurance option was the CAT option. CAT is 100 percent subsidized by the federal government and is available for only a \$60 fee per crop, per county. This makes CAT a very inexpensive insurance option, and helps insure producers against disasters, hence “catastrophic” coverage. Even when the procedure was applied to a base farm that was able to maintain relatively high net returns, CAT was still the most preferred option. This result may indicate that all producers, regardless of mean net returns, could benefit from the purchase of CAT insurance in the long run.

A crop insurance product can be considered cost effective if the indemnities received from the insurance product are greater than or equal to the premiums paid. In all scenarios, the CAT option was considered cost effective. This is due to the fact that the per acre cost for CAT coverage is very small. Therefore, if an indemnity payment is given for just one out of the ten years in the planning horizon, the CAT option has paid for itself. The 50/100 option was considered cost effective in all but a few of the scenarios studied. The 60/100 coverage level was considered cost-effective in about half of the scenarios studied. The 75/100 coverage level was never found to be cost effective. CRC 50 was considered to be cost-effective in most cases, CRC 60 was cost-effective in only two scenarios, and CRC 75 was never found to be cost effective. These results confirm that premium rates for many crop insurance alternatives are too high.

One reason that insurance premiums appear to be too high for higher levels of insurance could be adverse selection. Adverse selection results from a skewed participation rate toward the high-risk producers. In other words, the only participants in high levels of buy-up insurance at the current premium rates are those most likely to suffer a loss. Adverse selection increases the risk of the insurance pool and increases indemnity payments. In order to offset increasing indemnity payments, FCIC must increase premium rates. Thus, insurance products that suffer from adverse selection tend to overcharge low-risk producers and undercharge high-risk producers. At the high premium rates, low-risk producers will not participate, leaving only high-risk producers in the insurance pool, further increasing premium rates.

A rational producer will not purchase an insurance option that is going to significantly reduce his or her net returns if the product does not significantly reduce the variability of net returns faced by the producer. High insurance premium rates for producers may result in non-participation in these insurance programs, exposing producers to higher levels of financial risk. This also has some implications for the intervention of the federal government in terms of disaster payments and emergency assistance programs. If producers are not participating in crop insurance programs, then the federal government is spending more on disaster payments and emergency assistance programs. Thus, actuarially fair premiums should not only result in increased producer participation, but may also minimize government expenditures.

If premium rates were subsidized by the amounts calculated in this study, all crop insurance options could be considered cost-effective. Subsidies could also minimize the

amount of adverse selection at the higher levels of buy-up insurance because more producers would be likely to participate. Thus, lowering the overall risk of the insurance pool. It would be interesting to determine if crop insurance subsidies would cost more to the federal government than what it is currently costing for disaster payments and emergency assistance programs.

Given the results for the regional level analysis, subsidies seem to vary considerably across regions and production practices, perhaps indicating that premium rates are being miscalculated by varying amounts across regions for irrigated and dryland cotton. This finding has important implications for policy makers. If crop insurance rates are being miscalculated by different amounts across regions and production practices, a flat subsidy increase will not solve the problem. A flat subsidy increase could lead to underestimation of rates in some regions, while premium rates in other regions may continue to be overestimated. An extensive study of current premium rates needs to be undertaken, or the current rating policy needs to be revised in order to solve this problem.

Actuarially unfair premiums could actually result in a higher variability of net returns, while actuarially fair premiums should reduce the variability in net returns. Even if an insurance product is considered cost effective and may actually increase net returns, a risk averse individual may not choose to purchase that option if it increases the net return variability faced by the producer.

Limitations and Implications for Future Research

The model used to estimate cotton yield distributions relied on about ten years of farm level data from 13 counties, as well as county level data. Future studies could include a longer series of farm level data for more counties. Future studies could also expand the current study to include more regions of Texas. It is important to note that the procedure developed in this study is flexible enough to incorporate these changes. Also, the current study could be expanded to include crop and revenue insurance products from different crops. Of course, different price and yield distributions would have to be estimated for the new crops.

Another limitation of the current study was that it did not take into consideration the stochastic nature of producers' net worth or the level of debt faced by the producer. The current study utilized a partial budget analysis with net returns. Alternative crop insurance options may affect net worth differently than net returns. These affects may be further complicated when analyzing different debt structures. Future studies could analyze the effect that different insurance alternatives have on producers' ending net worth while considering different debt structures. However, it is important to note that the empirical procedure developed in this study could be expanded to include financial information relative to net worth and levels of debt.

The base price used for the calculation of insurance premiums and indemnities was estimated using a distributed lag model, where the historical MPCCI base price was regressed against the lagged values of the observed market price. For the purposes of this study, the base price for CRC was assumed to be equal to the base price for MPCCI. In

reality, CRC base prices are a function of the futures price for cotton, thus, the CRC base price probably should be estimated using historical futures data.

The current study did not include the direct comparison of MPCl and CRC insurance products. This was partly due to the assumption made that the base prices were equal. Directly comparing MPCl and CRC insurance products may result in some incorrect conclusions. Future studies may be developed in a manner that would allow for the direct comparison of MPCl and CRC insurance products.

The current study has created a foundation for future studies to build upon. It is possible for the empirical procedure developed in this study to be incorporated into a decision-making tool for producers. A stand-alone or web-based software could be developed that asks the producer for production and financial information, incorporates that information into the procedures developed in the current study, and then recommends the crop or revenue insurance alternative that best suits the individual producer's need.

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APPENDIX
STOCHASTIC DOMINANCE
RESULTS

Table A.1. Stochastic Dominance Results for Irrigated Cotton
in the Southern High Plains (MPCI)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CAT	Most Preferred	1 CAT	Most Preferred
2 NO INS	2nd Most Preferred	2 NO INS	2nd Most Preferred
3 MPCI 50/100	3rd Most Preferred	3 MPCI 50/100	3rd Most Preferred
4 MPCI 60/100	4th Most Preferred	4 MPCI 60/100	4th Most Preferred
5 MPCI 75/100	Least Preferred	5 MPCI 75/100	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Premium
1 CAT	The Most Dominant Distribution		
2 NO INS		3.12	
3 MPCI 50/100		3.48	62.76
4 MPCI 60/100		5.42	49.05
5 MPCI 75/100		15.69	53.14
2 NO INS	The Next Most Dominant Distribution		
3 MPCI 50/100		0.36	6.55
4 MPCI 60/100		2.30	20.82
5 MPCI 75/100		12.57	42.58
3 MPCI 50/100	The Next Most Dominant Distribution		
4 MPCI 60/100		1.94	17.53
5 MPCI 75/100		12.21	41.35
4 MPCI 60/100	The Next Most Dominant Distribution		
5 MPCI 75/100		10.28	34.80

Table A.2. Stochastic Dominance Results for Irrigated Cotton
in the Southern High Plains (CRC)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 NO INS	Most Preferred	1 NO INS	Most Preferred
2 CRC 50	2nd Most Preferred	2 CRC 50	2nd Most Preferred
3 CRC 60	3rd Most Preferred	3 CRC 60	3rd Most Preferred
4 CRC 75	Least Preferred	4 CRC 75	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Premium
1 NO INS	The Most Dominant Distribution		
2 CRC 50		2.33	28.33
3 CRC 60		5.26	34.41
4 CRC 75		19.18	49.70
2 CRC 50	The Next Most Dominant Distribution		
3 CRC 60		2.93	19.17
4 CRC 75		16.85	43.67
3 CRC 60	The Next Most Dominant Distribution		
4 CRC 75		13.92	36.08

Table A.3. Stochastic Dominance Results for Dryland Cotton
in the Southern High Plains (MPCI)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.1)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CAT	Most Preferred	1 CAT	Most Preferred
2 MPCI 50/100	2nd Most Preferred	2 MPCI 50/100	2nd Most Preferred
3 MPCI 60/100	3rd Most Preferred	3 MPCI 60/100	3rd Most Preferred
4 NO INS	4th Most Preferred	4 NO INS	4th Most Preferred
5 MPCI 75/100	Least Preferred	5 MPCI 75/100	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.1)			
		Absolute Amount	Percent of Premium
1 CAT	The Most Dominant Distribution		
2 MPCI 50/100		1.51	21.84
3 MPCI 60/100		5.24	37.78
4 NO INS		6.50	-
5 MPCI 75/100		17.77	49.98
2 MPCI 50/100	The Next Most Dominant Distribution		
3 MPCI 60/100		3.73	26.90
4 NO INS		4.99	-
5 MPCI 75/100		16.26	45.74
3 MPCI 60/100	The Next Most Dominant Distribution		
4 NO INS		1.26	-
5 MPCI 75/100		12.53	35.25
4 NO INS	The Next Most Dominant Distribution		
5 MPCI 75/100		11.27	31.69

Table A.4. Stochastic Dominance Results for Dryland Cotton
in the Southern High Plains (CRC)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.1)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CRC 50	Most Preferred	1 CRC 50	Most Preferred
2 NO INS	2nd Most Preferred	2 NO INS	2nd Most Preferred
3 CRC 60	3rd Most Preferred	3 CRC 60	3rd Most Preferred
4 CRC 75	Least Preferred	4 CRC 75	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.1)			
		Absolute Amount	Percent of Premium
1 CRC 50	The Most Dominant Distribution		
2 NO INS		3.68	-
3 CRC 60		4.53	25.43
4 CRC 75		19.47	45.36
2 NO INS	The Next Most Dominant Distribution		
3 CRC 60		0.85	4.76
4 CRC 75		15.79	36.78
3 CRC 60	The Next Most Dominant Distribution		
4 CRC 75		14.94	34.80

Table A.5. Stochastic Dominance Results for Irrigated Cotton
in the Northern High Plains (MPCI)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CAT	Most Preferred	1 CAT	Most Preferred
2 MPCI 50/100	2nd Most Preferred	2 MPCI 50/100	2nd Most Preferred
3 NO INS	3rd Most Preferred	3 MPCI 60/100	3rd Most Preferred
4 MPCI 60/100	4th Most Preferred	4 NO INS	4th Most Preferred
5 MPCI 75/100	Least Preferred	5 MPCI 75/100	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Premium
1 CAT	The Most Dominant Distribution		
2 MPCI 50/100		2.56	38.13
3 MPCI 60/100		4.20	31.26
4 NO INS		5.92	-
5 MPCI 75/100		16.70	46.44
2 MPCI 50/100	The Next Most Dominant Distribution		
3 MPCI 60/100		1.64	12.22
4 NO INS		3.36	-
5 MPCI 75/100		14.14	39.33
3 MPCI 60/100	The Next Most Dominant Distribution		
4 NO INS		1.72	-
5 MPCI 75/100		12.50	34.76
4 NO INS	The Next Most Dominant Distribution		
5 MPCI 75/100		10.78	29.98

Table A.6. Stochastic Dominance Results for Irrigated Cotton
in the Northern High Plains (CRC)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CRC 50	Most Preferred	1 CRC 50	Most Preferred
2 NO INS	2nd Most Preferred	2 NO INS	2nd Most Preferred
3 CRC 60	3rd Most Preferred	3 CRC 60	3rd Most Preferred
4 CRC 75	Least Preferred	4 CRC 75	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Premium
1 CRC 50	The Most Dominant Distribution		
2 NO INS		1.94	-
3 CRC 60		2.32	13.12
4 CRC 75		17.39	39.11
2 NO INS	The Next Most Dominant Distribution		
3 CRC 60		0.38	2.14
4 CRC 75		15.45	34.75
3 CRC 60	The Next Most Dominant Distribution		
4 CRC 75		15.07	33.90

Table A.7. Stochastic Dominance Results for Dryland Cotton
in the Northern High Plains (MPCI)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.1)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CAT	Most Preferred	1 CAT	Most Preferred
2 MPCI 50/100	2nd Most Preferred	2 MPCI 50/100	2nd Most Preferred
3 MPCI 60/100	3rd Most Preferred	3 MPCI 60/100	3rd Most Preferred
4 NO INS	4th Most Preferred	4 NO INS	4th Most Preferred
5 MPCI 75/100	Least Preferred	5 MPCI 75/100	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.1)			
		Absolute Amount	Percent of Premium
1 CAT	The Most Dominant Distribution		
2 MPCI 50/100		0.52	9.11
3 MPCI 60/100		3.19	27.89
4 NO INS		6.51	-
5 MPCI 75/100		14.19	47.09
2 MPCI 50/100	The Next Most Dominant Distribution		
3 MPCI 60/100		2.67	23.35
4 NO INS		5.99	-
5 MPCI 75/100		13.67	45.37
3 MPCI 60/100	The Next Most Dominant Distribution		
4 NO INS		3.31	-
5 MPCI 75/100		10.99	36.49
4 NO INS	The Next Most Dominant Distribution		
5 MPCI 75/100		7.68	25.50

Table A.8. Stochastic Dominance Results for Dryland Cotton
in the Northern High Plains (CRC)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.1)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CRC 50	Most Preferred	1 CRC 50	Most Preferred
2 CRC 60	2nd Most Preferred	2 CRC 60	2nd Most Preferred
3 NO INS	3rd Most Preferred	3 NO INS	3rd Most Preferred
4 CRC 75	Least Preferred	4 CRC 75	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.1)			
		Absolute Amount	Percent of Premium
1 CRC 50	The Most Dominant Distribution		
2 CRC 60		3.33	22.32
3 NO INS		4.96	-
4 CRC 75		16.45	44.67
2 CRC 60	The Next Most Dominant Distribution		
3 NO INS		1.63	-
4 CRC 75		13.12	35.62
3 NO INS	The Next Most Dominant Distribution		
4 CRC 75		11.49	31.21

Table A.9. Stochastic Dominance Results for Irrigated Cotton
in the Northern Low Plains (MPCI)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.1)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CAT	Most Preferred	1 CAT	Most Preferred
2 NO INS	2nd Most Preferred	2 MPCI 50/100	2nd Most Preferred
3 MPCI 50/100	3rd Most Preferred	3 MPCI 60/100	3rd Most Preferred
4 MPCI 60/100	4th Most Preferred	4 NO INS	4th Most Preferred
5 MPCI 75/100	Least Preferred	5 MPCI 75/100	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.1)			
		Absolute Amount	Percent of Premium
1 CAT	The Most Dominant Distribution		
2 MPCI 50/100		2.10	57.59
3 MPCI 60/100		2.66	36.40
4 NO INS		3.52	-
5 MPCI 75/100		9.11	46.51
2 MPCI 50/100	The Next Most Dominant Distribution		
3 MPCI 60/100		0.56	7.65
4 NO INS		1.41	-
5 MPCI 75/100		7.01	35.77
3 MPCI 60/100	The Next Most Dominant Distribution		
4 NO INS		0.85	-
5 MPCI 75/100		6.45	32.91
4 NO INS	The Next Most Dominant Distribution		
5 MPCI 75/100		5.59	28.55

Table A.10. Stochastic Dominance Results for Irrigated Cotton
in the Northern Low Plains (CRC)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.1)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 NO INS	Most Preferred	1 CRC 60	Most Preferred
2 CRC 50	2nd Most Preferred	2 CRC 50	2nd Most Preferred
3 CRC 60	3rd Most Preferred	3 NO INS	3rd Most Preferred
4 CRC 75	Least Preferred	4 CRC 75	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.1)			
		Absolute Amount	Percent of Premium
1 CRC 60	The Most Dominant Distribution		
2 CRC 50		0.08	1.49
3 NO INS		1.65	-
4 CRC 75		5.13	19.15
2 CRC 50	The Next Most Dominant Distribution		
3 NO INS		1.56	-
4 CRC 75		5.05	18.84
3 NO INS	The Next Most Dominant Distribution		
4 CRC 75		3.48	13.00

Table A.11. Stochastic Dominance Results for Dryland Cotton
in the Northern Low Plains (MPCI)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CAT	Most Preferred	1 CAT	Most Preferred
2 MPCI 50/100	2nd Most Preferred	2 MPCI 50/100	2nd Most Preferred
3 MPCI 60/100	3rd Most Preferred	3 MPCI 60/100	3rd Most Preferred
4 NO INS	4th Most Preferred	4 NO INS	4th Most Preferred
5 MPCI 75/100	Least Preferred	5 MPCI 75/100	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Premium
1 CAT	The Most Dominant Distribution		
2 MPCI 50/100		1.24	34.00
3 MPCI 60/100		1.82	24.80
4 NO INS		3.30	-
5 MPCI 75/100		8.27	42.23
2 MPCI 50/100	The Next Most Dominant Distribution		
3 MPCI 60/100		0.57	7.83
4 NO INS		2.05	-
5 MPCI 75/100		7.03	35.89
3 MPCI 60/100	The Next Most Dominant Distribution		
4 NO INS		1.48	-
5 MPCI 75/100		6.46	32.96
4 NO INS	The Next Most Dominant Distribution		
5 MPCI 75/100		4.98	25.40

Table A.12. Stochastic Dominance Results for Dryland Cotton
in the Northern Low Plains (CRC)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CRC 50	Most Preferred	1 CRC 50	Most Preferred
2 NO INS	2nd Most Preferred	2 NO INS	2nd Most Preferred
3 CRC 60	3rd Most Preferred	3 CRC 60	3rd Most Preferred
4 CRC 75	Least Preferred	4 CRC 75	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Premium
1 CRC 50	The Most Dominant Distribution		
2 NO INS		0.90	-
3 CRC 60		1.26	12.43
4 CRC 75		10.03	39.54
2 NO INS	The Next Most Dominant Distribution		
3 CRC 60		0.35	3.48
4 CRC 75		9.12	35.97
3 CRC 60	The Next Most Dominant Distribution		
4 CRC 75		8.77	34.59

Table A.13. Stochastic Dominance Results for Irrigated Cotton
for the Base Farm (MPCI)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 CAT	Most Preferred	1 CAT	Most Preferred
2 NO INS	2nd Most Preferred	2 NO INS	2nd Most Preferred
3 MPCI 50/100	3rd Most Preferred	3 MPCI 50/100	3rd Most Preferred
4 MPCI 60/100	4th Most Preferred	4 MPCI 60/100	4th Most Preferred
5 MPCI 75/100	Least Preferred	5 MPCI 75/100	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Premium
1 CAT	The Most Dominant Distribution		
2 NO INS		1.07	-
3 MPCI 50/100		8.42	97.22
4 MPCI 60/100		14.18	81.60
5 MPCI 75/100		33.72	72.41
2 NO INS	The Next Most Dominant Distribution		
3 MPCI 50/100		7.35	84.84
4 MPCI 60/100		13.11	75.43
5 MPCI 75/100		32.65	70.11
3 MPCI 50/100	The Next Most Dominant Distribution		
4 MPCI 60/100		5.76	33.16
5 MPCI 75/100		25.30	54.33
4 MPCI 60/100	The Next Most Dominant Distribution		
5 MPCI 75/100		19.54	41.96

Table A.14. Stochastic Dominance Results for Irrigated Cotton
for the Base Farm (CRC)

Risk Neutral Ranking of Probability Distributions (RAC = 0.00)		Ranking of Distributions for Risk Averse Individuals (RAC = 0.01)	
Scenario Name	Level of Preference	Scenario Name	Level of Preference
1 NO INS	Absolutely Preferred	1 NO INS	Absolutely Preferred
2 CRC 50	2nd Most Preferred	2 CRC 50	2nd Most Preferred
3 CRC 60	3rd Most Preferred	3 CRC 60	3rd Most Preferred
4 CRC 75	Least Preferred	4 CRC 75	Least Preferred

Confidence Premiums for Probability Distributions (RAC = 0.01)			
		Absolute Amount	Percent of Dominant Mean
1 NO INS	The Most Dominant Distribution		
2 CRC 50		11.21	86.17
3 CRC 60		18.75	77.07
4 CRC 75		44.62	72.87
2 CRC 50	The Next Most Dominant Distribution		
3 CRC 60		7.54	30.99
4 CRC 75		33.41	54.56
3 CRC 60	The Next Most Dominant Distribution		
4 CRC 75		25.87	42.24

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