U.S. COTTON ACREAGE RESPONSE DUE TO SUBSIDIZED CROP INSURANCE

by

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A Thesis Submitted to the Faculty of the

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

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ACKNOWLEDGEMENTS

This research would not have been successful without the help and support of many people. Firstly, I would like to express my deepest gratitude to my adviser, Professor Russell Tronstad, for his patience, guidance and support.

I also would like to thank the members of my thesis committee: Professor George Frisvold and Professor Sateesh Ardhyula for their encouragement and suggestions on the empirical component of my study.

I am very thankful to - Professor Alan Ker, for his insightful comments and suggestions, Kyle Emerick and Paulo Tanimoto for sharing their programming skills. Also, special thanks to my sponsor, the Fulbright-Philippine Agriculture Scholarhip Program (FPASP), PAEF staff members and Joanne Lagasse-Long, for the advice, encouragement and unending support.

Special thanks goes to my AREC staff, classmates and my AZ family (Kyle, Jose, Paulo and Pinar) for making graduate life such an extraordinary experience. Last but not the least, I would like to acknowledge my beloved family, the source of my strength, for the endless love, support and understanding.

DEDICATION

To my family

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ABSTRACT

U.S. farm policy has undergone a series of premium subsidy increases since 1994 to make crop insurance more affordable to farmers. Previous research shows that subsidized crop insurance may cause farmers to shift or expand production to take advantage of crop insurance subsidies. This study models the acreage response of U.S. cotton to subsidized crop insurance using simultaneous insurance participation and acreage response equations. Results of panel data analyses from 1995 to 2005 suggest that increasing benefits from insurance, such as the per unit subsidy of production, encourages participation and thereby encourages cotton production. In addition, counties with very poor yields are relatively more responsive in terms of insurance participation and acreage to changes in price expectations. Empirical evidence implies that crop insurance policies may be shifting the regional comparative advantage of production from high yield and quality acres to low yield and low quality areas, resulting in economic inefficiencies.

CHAPTER 1

THESIS INTRODUCTION

Technological advances, market conditions, and government programs are a few of the many factors that affect cotton production[1]. According to the USDA Agricultural Outlook 2000, there are four major policy eras in U.S. agriculture. In 1785 to 1890, farm policies focused on land distribution. Coinciding with the first era is a period from 1830 to 1914 where the government emphasized improving farm productivity through research and eduction. The third era (1870 to 1933) marks policies that helped farmers to be more competitive. This was done by providing economic information and marketing assistance to farmers. Finally, the fourth period focused on farm income support programs through direct government intervention. Under the fourth period, Congress formed the Federal Crop Insurance Corporation (FCIC) in 1938 with the objective to protect farm income from crop failure and price decreases and protect consumers from food shortage and high prices. Originally, insurance was only provided for cotton and wheat and characterized by a very low participation among farmers. In 1980, the Federal Crop Insurance Act was passed which marked the birth of the current federal crop insurance program.

[1]There are two kinds of cotton produced in the U.S. namely – Upland cotton and Extra Long Staple (Amercian Pima). Because ELS is a very small fraction of total production, 'cotton' refers to only 'upland cotton' in this thesis.

In recent years, the crop insurance program has gone through several reforms in terms of policies and procedures. These changes are theorized to influence farmers' cropping decision since farmers get more and better options to manage both production and price risks. Based on USDA-RMA statistics, there was an additional 10 million insured acres of cotton from 1994 to 1995. This is undoubtedly due to changes in the crop insurance program during that period. The Crop Insurance Act of 1994 brought a major change to the crop insurance program through 'catastrophic' (CAT) protection, for a low sign-up fee. Through the Act, the government paid the entire premium for yield coverage of up to 50%.

Higher coverage levels were also introduced whereby producers pay some of the premium, but total subsidy dollars per acre still increase with higher coverage levels. Insurance participation in terms of the total number of acres insured, rose to about 94% in 1995 as compared to only 42% insurance participation in the prior year.

The effect of crop insurance reform on farmers' cropping decisions has been an important debate for many years. Many studies have been done to determine how changes in crop insurance affect crop production – in terms of crop yield, input usage and acreage. Because the probability of yield falling below 50 percent of an established yield varies by region and crops, the impact of crop insurance reform is not expected to be equal across the cotton belt. To the extent that crop insurance affects farmers' cropping decisions, it is important to study how changes in crop insurance subsidies cause farmers to alter their plantings by putting more land into crop production or by shifting to another crop. This has important policy implications.

The primary objective of this study is to evaluate the impacts of crop insurance program for cotton in the United States. Specifically, this study aims to quantify cotton acreage response to subsidized crop insurance and draw possible policy implications based on the results.

1.1 Cotton

The United States is the largest exporter and second largest producer of cotton in the world. Cotton, one of the major U.S. crops, is produced mainly in the 17 states of Alabama, Arizona, Arkansas, California, Florida, Georgia, Kansas, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Two kinds of cotton are produced in the U.S. – Upland (most commonly grown) and extra-long staple (ELS) or Pima cotton. About 98 percent of the cotton grown is Upland and ELS is grown mostly in California, Arizona and Texas. Planting begins as early as February and ends as late as June depending on geographic location. The crop duration of this annual crop ranges from aroud 150 days to over 200 days.

1.1.1 Cotton Acreage

Cotton acreage varied widely from 1965 to 2006. Various government programs that either promote or discourage cotton production played an important role in the annual acreage variations. Cotton plantings were at their lowest level in 1983 covering only around 7.9 M acres. It was a notable drop of about 45 percent from 1981. This was due to the Payment in Kind (PIK) production control regimes that the government promoted in an attempt to avoid excess supplies and raise prices.

Cotton acreage increased in latter years with some fluctuations and reached its peak in 1995 with about 16.7 M acres. The second highest cotton acreage was recorded in 2001 with about 15.5 M acres. Figure 1.1 shows the variations in U.S. cotton acreage from 1965 to 2006. The major policies will be discussed in the next section of this chapter.

The cotton-belt can be divided into four regions namely – Delta, Southeast, Southwest and West regions. Based on Figure 1.2, the Southwest region constitutes about 43% of the total cotton acreage from 1995 to 2005 while the Delta, Southeast and West shares average 27%, 23% and 7%, respectively. However, cotton production is highest from the Delta, averaging about 6 million bales from 1995 to 2005. In the Southwest, production doubled from 4.6 million bales in 1995 to about 8.9 million bales in 2005 (See Figure 1.3).

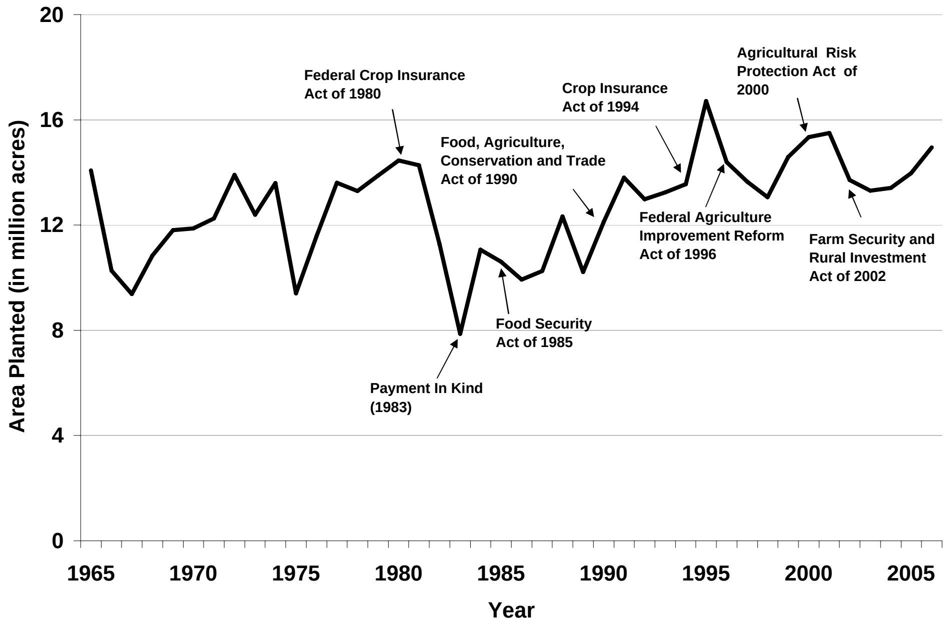

Figure 1.1: Cotton Acreage and Government Policies, 1965-2005

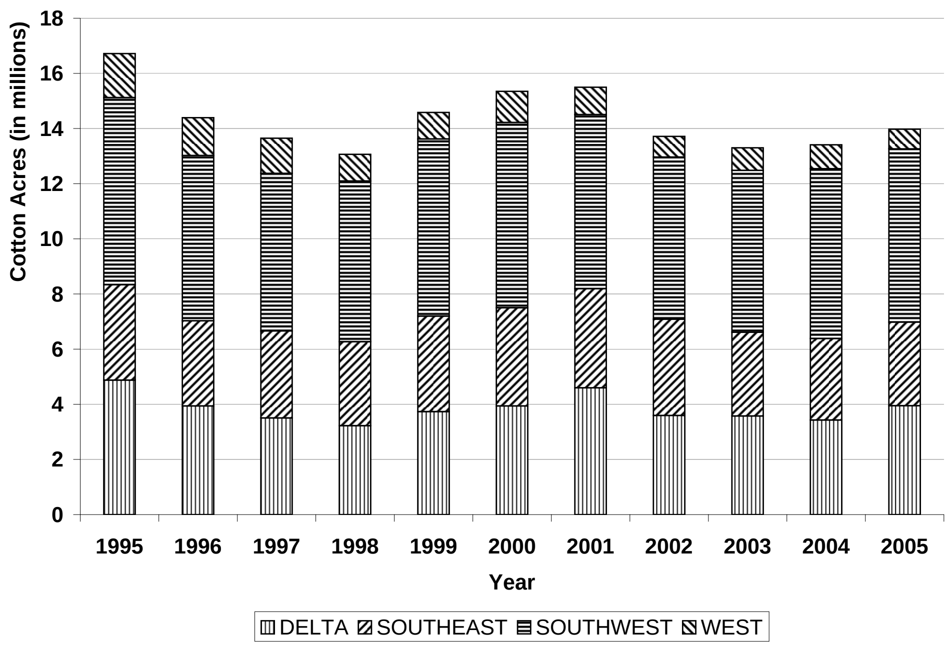

Figure 1.2: Total Cotton Acres by Region, 1995-2005

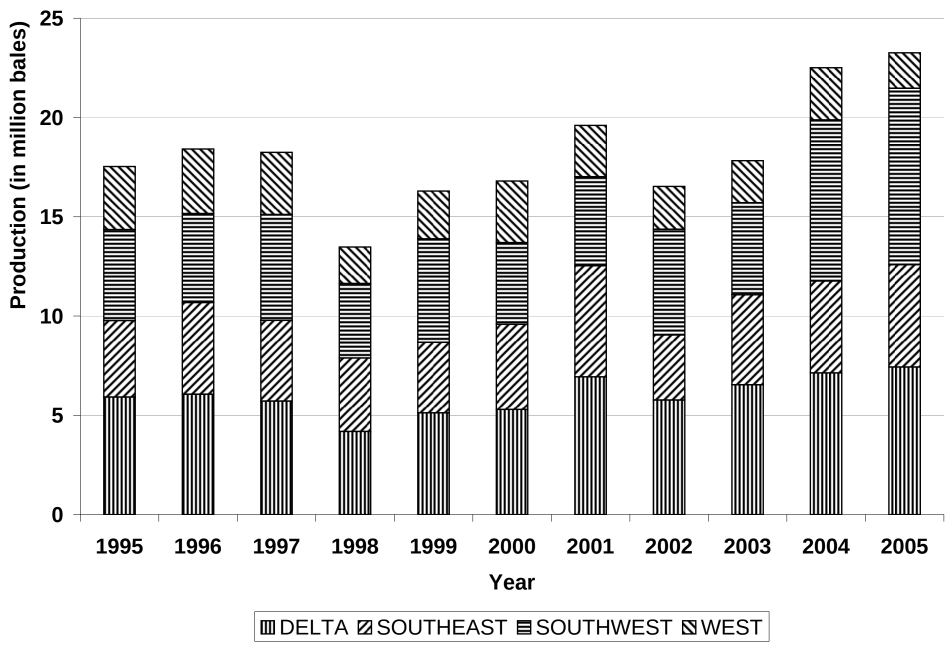

Figure 1.3: Total Cotton Production by Region, 1995-2005

1.1.2 Factors Affecting Cotton Production

Many factors such as the introduction of genetically modified cotton, price support programs, and changes in the world market contributed to the expansion of cotton production. Transgenic cotton revolutionized cotton production. Prior to the introduction of Bt cotton in 1996, cotton producers in many regions received lower yields due to cotton bollworms and tobacco budworms. The rapid spread of the insect-tolerant cotton due to less production risk may have played an important factor in farmers' production decisions[2].

Several government programs, farm policies and price support programs were believed to have impacted farm-level decision-making. The Boll Weevill Eradication Program was also believed to have contributed to increases in cotton acreage, especially in the late 1990s[3]. Also, U.S. agriculture experienced major changes upon enactment of the Federal Agriculture Improvement Reform (FAIR) Act of 1996, known as 'freedom to plant act' which removed Acreage Reduction Program (ARP) planting restrictions that had been in existence for many years. Under the 1996 Act, market price support and income support programs were replaced by 'Agricultural Market Transition Act' (AMTA) payments and marketing loan programs. Unlike the old price and income support program, AMTA payments are fixed payments independent of the market condition and based on a farmer's historical level of base

[2] See Frisvold et al. (2006) for a detailed discussion of the Bt cotton adoption impacts on production, price and trade.

[3] See Goodhue and Dumas (1999) for the effects of Boll Weevil Eradication Program on Cotton Acreage

yield and acreage. It has been the topic of many debates that this fixed payment is not completely decoupled from markets and it may have caused distortionary effects in the market.

In 2002, a new farm bill known as the Farm Security and Rural Investment (FSRI) Act was signed to replace the fixed payments agreed to in 1996 Farm Bill. Under this new farm bill, Counter-cyclical payments (CCP) were added for eligible producers to bolster income if prices fall below target price levels. Direct payments are based on a farm's base acreage and payment yield. The direct payment rate for cotton is about $0.0667/lb of base production. The CCP gives support to producers in the event of low prices. The target price for cotton is about $0.724/lb. If the U.S. average farm price is $0.60/lb, the CCP would equal 0.724 - (0.0667 + 0.60).

U.S. cotton was eligible for special programs such as 'market gains,' posted county price or Loan Deficiency Payments (LDP) and Step 2 payments to keep its competitiveness on the world market. The Step 2 program became controversial when a formal complaint was made to the World Trade Organization (WTO) by Brazil alleging this program to deflate the world price for cotton. Step 2 payments are direct subsidies paid to exporters and domestic mills at a payment rate equal to the difference between the US-Northern Europe price and the Northern Europe price during the last four weeks. This payment assured a cheaper cost to domestic buyers of US cotton stimulating demand. This increase in demand was also argued to encourage production and exports which were believed to cause trade distortion and depress the world price for cotton. In compliance with the WTO, the Step 2 program was terminated effective August 2006.

Aside from these farm policies, it is also suspected that the provision of high subsidies for cotton crop insurance influence farmers' planting decisions in terms of what crop to produce and how much land to allocate to a given crop.

1.2 Overview of Crop Insurance

Crop insurance acts as a safety net for cotton farmers from crop losses due to drought, pest infestation, disease or other natural causes that can drastically reduce yield, quality and market loss as well. Cotton producers can buy insurance under the federal crop insurance program at a subsidized rate. There are three types of insurance for cotton namely, yield, revenue and group risk plan (GRP). The traditional federal crop insurance product is the MPCI or known as the Actual Production History Program (APHP). This product is offered to protect farmers against yield losses due to natural occurrences. In the case of revenue insurance, various insurance products such as Crop Revenue Coverage (CRC), Income Protection (IP), and Revenue Assurance (RA) were developed to provide protection against price and yield losses. Finally, GRP is another insurance product that protects farmers by paying an indemnity when NASS county yield falls below a yield guarantee. Crop insurance can be purchased at different levels of protection. The lowest level of protection is the catastrophic (CAT) coverage with the entire premium paid by the government. Under CAT, farmers pay an administrative fee and are guaranteed an indemnity payment of 55 percent of the established price on yields below 50 percent. Coverage levels greater than CAT is called Buy Up insurance. For Buy Up, yield protection levels range from 50 to 85 percent and the price election ranges from 60% to 100%.

Crop insurance was first authorized in the 1930s and implemented by the Federal Crop Insurance Corporation (FCIC). In the 1980s, the Federal Crop Insurance Act expanded the program and provided a 30 percent premium subsidy at the 65% coverage level. However, Congress was not satisfied with the level of coverage and authorized ad hoc disaster payments in 1988, 1989 and 1992 to provide relief to farmers in need.

The Federal Crop Insurance Reform Act of 1994 mandated farmers to obtain CAT to be eligible for disaster payments. The Act of 1994 brought the introduction of CAT with a sign-up fee of no more than $100 for each crop insured. The premium subsidy also increased to 42 percent upon enactment for the 65 percent coverage level. In effect, cotton acreage under insurance increased from 5.8 million acres to 15.8 million acres from 1994 to 1995. However, most of the insured acreage in 1995 was under CAT while only about 30% of the total acreage insured was at Buy Up levels.

Cotton, a highly subsidized crop, has received about 11.6% of the total USDA subsidies from 1995 to 2005. As shown in Table 1.1, subsidies for cotton increased

Table 1.1: Total USDA Subsidies for Cotton, 1995-2005

Year	Total USDA Subsidies (in million $)	Cotton Subsidies (in million $)	Cotton Share (in %)
1995	7,242	30	0.41
1996	7,274	647	8.90
1997	7,455	595	7.98
1998	12,358	1,163	9.41
1999	21,572	1,721	7.98
2000	23,391	1,850	7.91
2001	22,441	3,033	13.52
2002	12,949	2,389	18.45
2003	16,438	2,697	16.41
2004	12,533	1,654	13.20
2005	21,057	3,331	15.82
Total	164,710	19,110	11.60

Source: RMA, USDA

by more than $600 million from 1995 to 1996 while total USDA subsidies did not change much. From 1995 to 1997, cotton prices were relatively high. The Federal Agricultural Improvement Reform (FAIR) Act of 1996 provided farmers complete flexibility by allowing them to receive government payments independent of farm price and acreage. For the first time in several decades, Acreage Reduction Program (ARP) Payments were removed so that producers did not have to plant a crop under ARP constraints to receive subsidy payments.

The most recent policy implemented was the Agricultural Risk Protection Act (ARPA) of 2000 which significantly increased premium subsidy rates across the board to help farmers get a higher level of crop insurance protection. Cotton producers received additional premium subsidies amounting to about $1.183 billion from

Table 1.2: Premium Subsidies Under ARPA 2000

Coverage level	Old Law APH	Old Law CRC	New Law Both APH and CRC
CAT	100%	100%	100%
50	55%	42%	67%
65	42%	32%	59%
70	32%	25%	59%
75	24%	18%	55%
85	13%	10%	38%

Source: See Jose (2001)

2000 to 2001, the year when ARPA took effect. Under this farm bill, farmers pay less premium costs compared to the same coverage level under the old law, hence, making crop insurance more affordable to them. In 2001, about 14.68 million cotton acres were insured, which is the largest net acreage ever insured for cotton.

Cotton producers experienced several major changes in U.S. agricultural policy. Figure 1.1 shows cotton acreage from 1965 to 2005 and the correspoding U.S. farm policies implemented during that period. Farm policies that increase farmers benefit from insurance may have contributed to the increase in cotton acreage, especially in mid-1990s and early 2000.

My thesis constitutes four remaining chapters. Previous work discussing how farmer's cropping decisions are influenced by subsidized crop insurance is presented in Chapter 2. Chapter 3 provide information about the econometric models and data used. Chapter 4 contains the results of my empirical work from the fixed effects and random effects model with elasticity estimates. The final portion, Chapter 5, provides conclusions and possible implications of the empirical results.

CHAPTER 2

Literature Review

In recent years, impact studies of farm programs on farmer's crop production decisions have recieved considerable attention. A large body of literature deals with government program impacts on – production (Hennessy, 1998), prices (Young et al., 2001) and returns (Gray et al., 2004). Agricultural economists also emphasize the potential effect of farm programs such as crop insurance on chemical input use (Horowitz and Lichtenberg, 1993; Ramaswami, 1993; Babcock and Hennessy, 1996; Smith and Goodwin, 1996; Wu, 1999; Goodwin et al., 2004) which often indicates the moral hazard problem that these 'income-enhancing' farm programs could bring to farmers. Studies on the envionmental implications of crop insurance have also been given attention (Innes and Ardila, 1994; Wu, 1999; Deal, 2004.).

Acreage response due to farm programs, particularly farm subsidized crop insurance, which is the focus of my study, has been an important topic among researchers (Duffy et al., 1987; Keeton and Skees, 1999.; Wu, 1999; Vandeveer and Young, 2001.; Wu and Adams, 2001; Barnett et al., 2002.; Goodwin et al., 2004; Deal, 2004.). Most of these acreage or supply respose studies focus on corn, soybean, wheat or crop mix. Only a few address the impacts of subsidized crop insurance for cotton. Furthermore, most studies focused on one or two farm regions, except Duffy et al. (1987)

who estimated cotton acreage response on four distinct production regions in the U.S. Furthermore, the ability for producers to respond to crop insurance subsidies was rather limited until the 1996 FAIR Act.

2.1 Crop Insurance Participation

Crop insurance has been given tremendous attention not only by politicians but also by agricultural economists. Knight and Coble (1997) outlined econometric studies examining issues related to the Multiple Peril Crop Insurance program since the 1980s. They divided the studies into two groups – studies that use aggregate data (mostly at the county-level) and farm-level data to examine the factors affecting MPCI participation. They offered direction for future research and considered studies on acreage effects of MPCI and other insurance programs as important areas for future research.

In any crop insurance assessment study, determining the factors that influence a farmer's demand for crop insurance is important. Goodwin (1993) estimated the factors affecting demand for multiple peril crop insurance (MPCI) for Iowa corn farmers from 1985 to 1990 using panel data at the county-level. He compared two approaches of capturing insurance participation. As an alternative approach to the conventional method of measuring insurance participation (proportion of planted acres insured), Goodwin introduced liability per acre in his second equation as a measure of insurance participation. He argued that the liability demand approach is a better measure for insurance participation since the insured could change his participation without changing the acreage insured such as changing coverage level or cancelling coverage. The explanatory variables in the model included premium rates, premium per acre, lagged yield, loss ratio, percent livestock sales and farm/farmer characteristic variables. Loss-risk was used to represent the effects of premium changes on the demand for insurance. He estimated demand elasticities of -0.32 in the acreage equation and -0.73 in liability equation which confirms the expectation that the liability equation is more price elastic. Another interesting result is that counties with low loss-risks (loss ratio is less than that of state average) have more elastic demands for crop insurance than counties with high loss-risks, suggesting that raising premium rates for all producers would cause adverse selection and may raise the industry loss ratio.

Using panel data at the farm-level from 1977 to 1990, Coble et al. (1996) estimated MPCI demand for wheat in Kansas. They used a one-way, random effects binomial probit model to estimate discrete choice participation. Expected returns to insurance (expected indemnity minus producer premium) and its variance, expected market returns (expected market price multiplied by yield minus cost of production) and its variance, farm net worth, percent equity, a crop diversification index, wheat acres, acreage planted, regional dummies and preseason rainfall to capture intertemporal adverse selection were regressors for their probit analysis. Results showed that producers with high expected returns to insurance and market return risk are more likely to increase insurance participation while high farm net worth decreases insurance participation which is consistent with the theory of decreasing absolute risk aversion. Also, their results showed that producers receiving small but frequent indemnities are more likely to purchase insurance than producers who receive large indemnities but infrequently. The estimated elasticity of participation to premiums is -0.65.

Another study on wheat was done by Smith and Baquet (1996). Using Heckman's two-stage estimation procedure, they modeled a Montana wheat farmer's participation and coverage-level decisions separately. The study segmented the sample further according to expected returns of the wheat farmers. The study estimated three models – wheat farmers with negative expected return, wheat farmers with positive expected returns, and a full sample. They included a measure of yield variabliltiy, premium rate, standard deviation of wheat yield, income from dry land farming, level of education of the farmer, average yield, and dummy variables indicating debt and receipt of disaster relief. Results show that a farmer's expectation about yield variability determines participation instead of the actual yield variability which is being measured by the standard deviation of wheat yield. Estimates for yield variability were found to positively influence insurance participation decisions and choice of coverage level in the full sample and the two other segments. Also, Smith and Baquet found that farmers with negative expected returns are more risk averse since they tend to buy higher coverage levels when their yields are more variable. On the contrary, those with positive expected returns buy a lower coverage level when yields are more variable. As for the premium, they found that changes in the premium rate do not affect crop insurance participation decisions but reduce coverage levels. On the average, price elasticities obtained by Smith and Baquet (1996) lie within the range of price elasticities, -0.2 to -0.9, reported in other studies. Their results show that as yield variablity (standard deviation of wheat yield) increases, the price elasticity of demand for farmers with negative expected returns tend to be more price responsive while farmers with positive expected returns become less responsive to price.

2.2 Crop Insurance Participation and Acreage Response

The U.S. crop insurance program underwent several changes since the early 1980s in an effort by the government to improve crop insurance participation as well as the program's actuarial soundness. Concerns about the potential production-distorting effects of the program due to heavy subsidies has been an important topic among researchers.

Only a few studies address the effect of US federal crop insurance programs on planted acreage and these studies provide contradicting results about the size of the effect. Keeton and Skees (1999) studied acreage shifts of the 6 major U.S. crops for the periods of 1978 to 1982 and 1988 to 1992 using an ordinary least squares method. Their findings showed that the crop insurance program has created incentives for farmers to plant more acres, especially in more risky areas. Their estimates showed that the proposed crop insurance subsidies in the 1980s led to about 50 million additional cropland acres in the US. However, most of these additional acres were under the Conservation Reserve Program (CRP).

A national policy simulation model using POLYSYS-ERS was used by Young et al. (2001) to show the market impacts across the seven regions for the eight largest commodities in the U.S. Based on the simulation, results suggest an additional 960,000 acres from the combined effect of all crop insurance. Wheat and cotton accounted for about 75% of the total increase.

Similarly, a recent study by Goodwin et al. (2004) suggests that expansion in crop insurance programs have not brought large increases in planted acreage but have resulted in small planted acreage responses, especially for barley. Using a pooled cross-sectional time series model, acreage response, insurance participation, input usage and CRP participation were jointly evaluated in the Heartland region for corn and soybeans and in the Northern Great Plains for wheat and barley from 1985 to 1993. The elasticity of acreage response to changes in insurance participation (as measured by a ratio of total liabiliy and total possible liability) for corn, soybeans and barley were 0.014, 0.0025, and 0.19 respectively. Results of policy simulations suggest that large premium decreases (30%) caused planted acreage to increase by about 1.1% for barley and only about 0.28% to 0.49% for corn.

Most of these acreage response studies focused on crops other than cotton until recently, an unpublished report by Barnett et al. (2002), examined the impacts of the cotton crop insurance program on cotton planted acreage in Mississippi over the period 1996 to 2000. Using a single equation, they modelled cotton acreage as a function of expected net returns per acre (expected net market returns plus expected net returns to insurance) for cotton and soybeans, a major competing crop in Mississippi. Based on their estimates, results showed that on the average, a 1% increase in expected net returns to insurance would increase cotton acreage by 0.036% while the effect of a 1% increase in expected net market returns for cotton would increase cotton acreage by 0.222%. This suggests that expected market returns has a more substantial contribution to cotton acreage as compared to that of expected returns to insurance.

Most recently, in an unpublished PhD dissertation by Deal (2004), he attempted to examine the relationship between subsidized crop insurance and soil erosion. In one of the chapters, Deal (2004) modeled the impact of crop insurance on cotton acreage and input usage in Southern Seaboard, Mississippi Portal and Prairie Gateway regions in two time periods - 1990 to 1995 and 1996 to 2000. Similar to Goodwin et al. (2004), he used the instrumental variable technique in the context of GMM to jointly estimate the proposed five structural equations. He also measured crop insurance participation as the ratio between total liability and total possible liability. Regression results implied a negative and significant relationship between crop insurance participation and cotton acreage in 1990 to 1995 in Mississippi Portal but a positive and significant relationship in the two regions for the period 1996-2000. On the average, calculated elasticities of cotton acreage response on changes in insurance particpation, ranging from -0.104 to 0.099, were mostly inelastic. Based on policy simulations, significant reductions in premium changes insurance participation significantly but does not translate to large changes in cotton acreage.

To summarize results of some studies mentioned in this chapter, I present the summary of econometric results in Table 2.1[1].

[1]For a more comprehensive summary of MPCI literature since 1980, refer to Knight and Coble (1997)

Table 2.1: Literaure Review: Summary of Econometric Results

			Significant Variables		
Author	Data/Model	Dependent Variable	Positive	Negative	Insignificant
Goodwin	Iowa, Corn	*Demand for insurance*	Premium*Loss risk	Premium/acre	Premium*1989
1993	County-level	Liability/acre	% Rented acres	Lagged yield	% Full-time farmers
(AJAE)	1985-1990	Insured acres	% Corporations		% Non-irrigated acres
	NT=594		Land value/acre		% Livestock sales
	Fixed effects		Farm size		
			Lagged yield*1989		
Coble et al.,	Kansas, Wheat	*MPCI Decision*	Exp. RI	Var. RI	% Equity
1996	Farm-level	1 - purchase	Var. MR	Exp. MR	Crop diversification
(AJAE)	1977-1990	0 - not purchase	Wheat acres	Farm net worth	Preseason rainfall
	NT=4956		Year1989	Region2	Year1988
	Random effects probit		Year1990	Region3	
Smith, Baquet	Montana, Wheat	*MPCI Decision*	Yield var. rating	Avg yield	Premium
1996	Farm-level	1 - purchase	Disaster relief (D)		Stdev. yield
(AJAE)	1990	0 - not purchase	Debt (D)		Prem*Stdev. yield
	N=370		Education		Income (dryland)
	Heckman 2-stage	*MPCI Liability*	Yield var. rating	Premium	Stdev. yield
			Debt (D)		Prem*Stdev. yield
			Education		Income (dryland)
			Mills ratio		Disaster relief (D)

Table 2.1 (Continued): Literaure Review: Summary of Econometric Results

Author	Data/Model	Dependent Variable	Significant Variables: Positive	Significant Variables: Negative	Insignificant
Keeton,Skees 1999 (MS thesis)	US, 6 crops District-level 1978-1982 1988-1999 285 districts OLS	Δ Cropland use	Δ Subsidies Δ Participation Δ Base acres	Δ Premium Lagged yield	Δ Exp. revenue Δ Disaster payment
Barnett et al. 2002 (Technical Report)	Mississippi, Cotton County-level 1985-1993 NT=114 Fixed effects	Cotton acreage	Net returns per acre (cotton)	Net returns per acre(soybean)	
Goodwin et al. 2004[a] (AJAE)	Corn Belt Corn/Soybean 1985-1993 NT=4042 IV technique	Insurance participation for corn (INSPART)	Premium*Loss ratio Livestock sales Yield CV Loss ratio Corn acres	Premium Fertilizer County acres	Dummy 1988
	GMM	Corn Acreage	Lagged corn acres Soybean acres Corn INSPART Soil T-factor County acres	CRP Enrollment	Corn price Soil K-factor Diverted corn base

[a] Six structural model was estimated. Only results from insurance participartion for corn and corn acreage are given in this Table. See Goodwin et al. (2004) for detailed results.

Table 2.1 (Continued): Literaure Review: Summary of Econometric Results

Author	Data/Model	Dependent Variable	Significant Variables: Positive	Significant Variables: Negative	Insignificant
Deal	Region 1[b]	Insurance participation	*1990-95*		
2004[a]	Cotton/Soybean	for cotton (INSPART)	Premium*Loss ratio	Premium	Loss ratio
(PhD thesis)	County-level		Yield CV	Lagged income	Soybean acres
	1990-1995		County acres		Soil erosion
	1996-2000		Livestock sales		Land capability
	IV technique				Fertilizer
	GMM		*1996-2000*		
			Premium	Lagged income	Premium*Loss ratio
			Yield CV	Soil erosion	Soybean acres
			Loss ratio		Livestock sales
			County acres		Land capability
			Fertilizer		
			Disaster payments		
	Region 2[c]	Insurance participation	*1990-95*		
	Cotton/Sorghum	for cotton (INSPART)	Premium*Loss ratio	Premium	Lagged income
	County-level		Yield CV	Loss ratio	Livestock sales
	1990-1995		County acres	Soil erosion	
	1996-2000		Sorghum acres	Fertilizer	
	IV technique		Land capability		
	GMM		*1996-2000*		
			Premium*Loss ratio	Loss ratio	Premium
			Land capability	Yield CV	Sorghum acres
				Soil erosion	County acres
				Fertilizer	Lagged income
					Livestock sales
					Disaster payments

[a] Five structural model was estimated. Only results from insurance participation and cotton acreage are presented in this Table. See Deal (2004) for detailed results.
[b] Region 1 is composed of the Mississippi region and Southern Seaboard
[c] Region 2 corresponds to the Gateway Prairie

The literature on crop insurance focused mainly on crop-mix or other major crops such as wheat, corn and soybeans. Literature on cotton is fairly limited and mostly centers on the the Mississippi region. In addition to that, these studies failed to incorporate the effect of Bt cotton, which is known to be a major technology shifter for some regions and influence a farmer's decision making in terms of how much land to plant and how much land to insure. In the next chapter, I will describe my data and present my theoretical and empirical model.

Table 2.1 (Continued): Literaure Review: Summary of Econometric Results

			Significant Variables		
Author	Data/Model	Dependent Variable	Positive	Negative	Insignificant
Deal	Region1	Cotton Acreage	*1990-95*		
2004	Cotton/Soybean		Lagged acres	INSPART	Soil erosion
(PhD thesis)	County-level		County acres		
	1990-1995		Land capability		
	1996-2000		*1996-2000*		
	IV technique		Lagged acres		County acres
	GMM		INSPART		Land capability
					Soil erosion
	Region2	Cotton acreage	*1990-95*		
	Cotton/Sorghum		Lagged acres	Soil erosion	INSPART
	County-level				Land capability
	1990-1995				County acres
	1996-2000		*1996-2000*		
	IV technique		Lagged acres	Soil erosion	County acres
	GMM		INSPART		Land capability

CHAPTER 3

Empirical Models and Data

To address the question whether crop insurance has encouraged additional cotton acreage or not, I utilized an unbalanced panel of 4,637 pooled annual county-level observations. It is unbalanced in the sense that the number of counties varies over time. Creating a complete panel from an unbalanced panel data for the purpose of computational simplification is not recommended since it may result on large efficiency loss (Baltagi and Chang, 2000).

Several benefits and limitations of using panel data were enumerated by Hsiao (2003) and Baltagi (2005). With panel data, researchers are able to analyze a more informative data due to increased data variability. In addition, panel data increases the degrees of freedom and exhibit less collinearty among explanatory variables thereby improving efficiency in estimation. Most importantly, panel data controls for individual heterogeneity and allows better analysis of dynamic adjustment unlike time-series data and cross sectional data.

If one or more of the basic assumptions of the classical linear regression are violated, OLS may produce estimates with undesirable characteristics. OLS on panel data may produce biased and/or inefficient estimates depending on the assumptions of the correlation between the individual effects, μ_i, and the explanatory variables.

A special feature of the panel data model is its ability to control for μ_i that is time invariant. The basic framework for regression using panel data is given below (Baltagi 2005):

$$y_{it} = \alpha + \mathbf{x}'_{it}\boldsymbol{\beta} + \upsilon_{it} \tag{3.1}$$

$$\upsilon_{it} = \mu_i + \nu_{it} \tag{3.2}$$

where μ and ν denote the unobservable individual effects and the remainder disturbance, respectively. The subscripts i and t correspond to the particular ith cross section and tth time period. If μ_i is assumed to be correlated with the explanatory variables then a 'fixed effects' specification is recommended. On the other hand, if μ_i is not correlated with the explanatory variables then a 'random effects' is the preferred specification.

To estimate the effect of crop insurance participation on cotton acreage, a two equation system approach is proposed. This takes into consideration the simultaneous nature of the decision process - how much land to allocate in cotton production and how much land to insure, an approach suggested by Goodwin et al. (2004). The variable definition and model specification is given below. Following Baltagi's notation, the simultaneous equation model can be written as ,

$$\boldsymbol{\Gamma}\mathbf{y}_{it} + \boldsymbol{\Lambda}\mathbf{x}_{\boldsymbol{it}} = \boldsymbol{\upsilon}_{\boldsymbol{it}} \tag{3.3}$$

where $\mathbf{\Gamma}$ is an $M \times M$ matrix of coefficient of endogenous variables, $\mathbf{\Lambda}$ is an $M \times K$ matrix of coefficient of predetermined variables. M is the number of structural equations in the model and K is the number of predetermined variables. $\mathbf{y_{it}}$, $\mathbf{x_{it}}$ and $\boldsymbol{\upsilon_{it}}$ are column vectors with dimensions M, K and M, respectively. $\boldsymbol{\upsilon_{it}}$ denotes the error component structure. For example, for the equation j, $\boldsymbol{\upsilon_{itj}} = \boldsymbol{\mu_{ij}} + \boldsymbol{\nu_{itj}}$ which is similar to Equation (3.2).

This can also be written in a stacked structural form as,

$$\mathbf{y} = \mathbf{Z}\boldsymbol{\delta} + \boldsymbol{\upsilon} \tag{3.4}$$

where $\boldsymbol{y'} = [\boldsymbol{y'_1}, \boldsymbol{y'_2}]$, $\boldsymbol{Z} = diag[\boldsymbol{Z_j}]$, $\boldsymbol{\delta'} = [\boldsymbol{\delta'_1}, \boldsymbol{\delta'_2}]$ and $\boldsymbol{\upsilon'} = [\boldsymbol{\upsilon'_1}, \boldsymbol{\upsilon'_2}]$.

Due to simultaneity bias, OLS will produce biased and inconsistent estimates because of the correlation between the error and the endogenous variables on the right-hand side of the equation. Taking into consideration the panel structure and simultaneity of the equations, I propose the application of fixed and random effects modelling procedures. The estimation procedure used follows the steps suggested by Cornwell et al. (1992) for the fixed effects standard linear simultaneous equation model. He shows that the traditional maximum likelihood estimates (MLE) of the structural parameters is equivalent to the MLE of the system after a within transformation. On the other hand, for the random effects model, I propose the error component specification for simultaneous equations with incomplete panels by Baltagi and Chang (2000) using error component three stage least squares (EC3SLS).

Following Baltagi's EC3SLS which accounts for random error component structure of an unbalanced panel, I computed $\boldsymbol{\delta}$ as,

$$\hat{\boldsymbol{\delta}}_{EC3SLS} = (\mathbf{Z}^{*\prime}\mathbf{P}_{\mathbf{x}^*}\mathbf{Z}^*)^{-1}\mathbf{Z}^{*\prime}\mathbf{P}_{\mathbf{x}^*}\mathbf{y}^* \tag{3.5}$$

where $\boldsymbol{Z}^* = \boldsymbol{\Sigma}^{-1/2}\boldsymbol{Z}$, $\boldsymbol{y}^* = \boldsymbol{Z}^*\boldsymbol{\delta} + \boldsymbol{u}^*$, $\boldsymbol{u}^* = \boldsymbol{\Sigma}^{-1/2}\boldsymbol{u}$, $\boldsymbol{P}_{\boldsymbol{x}}^* = \boldsymbol{X}^*(\boldsymbol{X}^{*\prime}\boldsymbol{X}^*)^{-1}\boldsymbol{X}^{*\prime}$, $\boldsymbol{X}^* = \boldsymbol{\Sigma}^{-1/2}\boldsymbol{X}$ and $\boldsymbol{X}$ is the instrument matrix. The $\hat{\boldsymbol{\delta}}_{\boldsymbol{EC3SLS}}$ can also be expressed as,

$$\hat{\boldsymbol{\delta}}_{EC3SLS} = [\mathbf{Z}'\boldsymbol{\Sigma}^{-1}\mathbf{X}(\mathbf{X}'\boldsymbol{\Sigma}^{-1}\mathbf{X})^{-1}\mathbf{X}'\boldsymbol{\Sigma}^{-1}\mathbf{Z}]^{-1}\mathbf{Z}'\boldsymbol{\Sigma}^{-1}\mathbf{X}(\mathbf{X}'\boldsymbol{\Sigma}^{-1}\mathbf{X})^{-1}\mathbf{X}'\boldsymbol{\Sigma}^{-1}\mathbf{y} \tag{3.6}$$

where $\boldsymbol{\Sigma}$ is the variance-covariance matrix between the error terms and calculated using the residuals of a 2SLS procedure. The EC3SLS estimator was derived by Baltagi (1981) and is known to perform better than 2SLS and 3SLS in estimating structural parameters of a simultaneous equation model with error components[1].

Choosing between fixed effects or random effects depends on the correlation between the cross-sectional error and explanatory variables. If there is correlation between μ_i and $\boldsymbol{X_i t}$ then the fixed effects model is appropriate. Otherwise, the error components estimation procedure should be used. To test the correct specification I applied Hausman test under $Ho : E(\mu_i|\boldsymbol{X}_{it} = 0)$. Under Ho, random effects is

[1]See Baltagi (1981) and Baltagi and Chang (2000) for detailed discussion on EC3SLS.

BLUE, consistent and asymptotically efficient. If Ho is rejected then fixed effects is the correct specification because random effects is not consistent and inefficient. This also implies that the unobserved individual effects that are time invariant are correlated with the explanatory variables.

The Hausman test is given by:

$$Hausman = (\hat{\boldsymbol{\beta}}_{\mathbf{FE}} - \hat{\boldsymbol{\beta}}_{\mathbf{RE}})'(\boldsymbol{\Sigma}_{\mathbf{FE}} - \boldsymbol{\Sigma}_{\mathbf{RE}})^{-1}(\hat{\boldsymbol{\beta}}_{\mathbf{FE}} - \hat{\boldsymbol{\beta}}_{\mathbf{RE}}) \tag{3.7}$$

with $\boldsymbol{\chi^2_K}$ distribution where K denotes degrees of freedom which is equal to the number of predetermined variables. $\hat{\boldsymbol{\beta}}_{\boldsymbol{FE}}$ and $\hat{\boldsymbol{\beta}}_{\boldsymbol{RE}}$ correspond to the parameter estimates of fixed effects and random effects while $\boldsymbol{\Sigma}_{\boldsymbol{FE}}$ and $\boldsymbol{\Sigma}_{\boldsymbol{RE}}$ represent the parameter covariance matrices of fixed effects and random effects.

3.1 Data

My data focused on 577 counties from the cotton-producing states in the US from 1995 to 2005.[2] Data were obtained from various sources - insurance contract data were collected from the Risk Management Agency (RMA)[3] summary of business report while acreage planted, state prices and yield data were collected from the National Agricultural Statistics Service (NASS). To avoid disclosure of individual operations, it is not possible for NASS to publish information for all counties. Only

[2] All cotton-producing states are included except for Kansas
[3] RMA was established by FAIR Act of 1996 to supervise and administer the FCIC activities

counties that meet the minimum acres for publication are considered in the NASS data. A frequent problem observed is that total acres in some counties reported by NASS are less than the insured acres reported by RMA. This discrepancy may be due to sampling errors since NASS uses sample surveys to collect information from farm cooperators to establish county-level data. RMA can report small acreage values for a county due to the Freedom of Information Act. Also, the prevented planting provision in insurance policies contributes to this gap. Prevented planting can occur when there is a shortage in irrigation water due to drought, excess moisture to plant or other natural causes that may prevent planting during the planting window for a region. The producer may opt not to plant the insured crop and file for a prevented planting payment. Land under prevented planting is counted under insured acreage but not as planted acreage.[4]

Data on Bt cotton were obtained from the Mississippi State University archive of Beltwide Cotton Crop Loss data. The data is available at the state level and for some regions of a state. Due to difficulties in merging counties, state-level adoption rate for Bt are used in this study. Other data such as futures prices, average world price for cotton and deficiency payments were taken from Agricultural Marketing Service (AMS). Prices and other economic variables were deflated uzing the CPI for all goods and are in 2007 dollars.

As mentioned earlier in this chapter, a systems equation approach is proposed.

[4]Prevented planting is only provided to some crops including cotton and ELS cotton.

The two equation system proposed is:

$$\begin{aligned} INSURANCE_{it} = \alpha + \beta_1 ACRES_{it} + \beta_2 SUBSIDYPERLB_{it-1} + \beta_3 ROR_{it-1} + \\ \beta_4 EXPPRICE_{it} + \beta_5 LAGYLD_{it} + \beta_6 EXPPRICE_{it} * LAGYLD_{it} + \\ \beta_7 YLDVAR_{it} + \beta_8 BT_{it} + \beta_9 D1 + \beta_{10} D2 \end{aligned} \tag{3.8}$$

$$\begin{aligned} ACRES_{it} = \gamma + \delta_1 INSURANCE_{it} + \delta_2 EXPPRICE_{it} + \delta_3 LAGYLD_{it} + \\ \delta_4 EXPPRICE_{it} * LAGYLD_{it} + \delta_5 YLDVAR_{it} + \\ \delta_6 BT_{it} + \delta_7 PICC_{it} + \delta_8 D1 + \delta_9 D2 \end{aligned} \tag{3.9}$$

where $ACRES_{it}$ is the acreage of cotton planted in county i for year t divided by total cropland acres in the county, $INSURANCE_{it}$ is the insurance participation in county i for year t, $EXPPRICE_{it}$ is the expected price for cotton in county i for year t, $LAGYLD_{it}$ is the lagged yield in county i for year t, $EXPPRICE_{it} * LAGYLD_{it}$ is the interaction between $EXPPRICE_{it}$ and $LAGYLD_{it}$, $YLDVAR_{it}$ is the yield variability in county i for year t, BT_{it} is the Bt adoption rate of the state, $SUBSIDYPERLB_{it}$ is the expected premium subsidy in \$ per lb of production in county i for year t, ROR_{it-1} is the rate of returns to insurance measured as the proportion between total indemnity and producers premium (net premium plus sign up fee) in county i for year t, $PICC_{it}$ is the price index for competing crops in county i for year t, and lastly, $D1$ and $D2$ are period dummies for 2000 to 2001 and

2002 to 2005, respectively.

In order for the systems of equation to be identified, valid instruments are used for the insurance participation and cotton acreage equation. $SUBSIDYPERLB$ and ROR are used as instruments for the insurance participation equation while $PICC$ is used as an instrument in the acreage equation. These instruments are valid in the sense that there is no reason to believe that acreage planted for cotton is directly influenced by $SUBSIDYPERLB$ and ROR and on the other hand insurance participation is not directly influenced by $PICC$. The variables used in the model are described in Tables 3.1 and 3.2 and descriptive statistics are summarized in Table 3.3.

Based on past literature, crop insurance participation is measured in different ways. The conventional way of measuring crop insurance participation is simply given by the ratio of insured acres and total acres planted while in a binary probit model using survey data, crop participation will have a value of 1 when insurance is purchased and 0 otherwise. Goodwin (1993) proposed an alternative way of measuring crop insurance participation considering changes in buy-up levels. Following the measure of crop insurance participation by Goodwin et al. (2004), crop participation is the ratio of total liability to total possible liability in a county for a specific year. Goodwin et al. (2004) point out that one can increase insurance participation without increasing acres insured but by merely increasing the coverage level which is reflected by total liability. Similarly, I constructed the total possible

Table 3.1: Variable Description and Expected Signs for Insurance Equation

Variables	Variable Description	Source of Data	Expected Signs
Dependent variable			
INSURANCE	Insurance participation measured as total liability over total possible liability	RMA/NASS	
Independent variables			
ACRES	Total acres planted for cotton over county's total cropland acres	NASS/Ag. Census	+
SUBSIDYPERLB	Subsidy per lb production measured by total subsidy over 5-year moving average yield	RMA/NASS	+
ROR	Rate of return from insurance measured as total indemnity over producer's premium	RMA	+
EXPPRICE	Expected price for cotton ($/lb)	NASS/AMS/RMA	+
LAGYLD	Lagged yield (lb/acre)	NASS	+
EXPPRICE*LAGYLD	Interaction between EXPPRICE and LAGYLD multiplied by lagged yield ($/acre)	NASS/AMS/RMA	-
YLDVAR	Yield variability measured by moving coefficient of variation	NASS	+
BT	Bt cotton adoption rate	CIL	-
D1	Dummy for years 2000 to 2001		
D2	Dummy for years 2002 to 2005		

Table 3.2: Variable Description and Expected Signs for Cotton Acreage Equation

Variables	Variable Description	Source of Data	Expected Signs
Dependent variable			
ACRES	Total acres planted for cotton over county's total cropland acres	NASS/Ag. Census	
Independent variables			
INSURANCE	Insurance participation measured as total liability over total possible liability	RMA/NASS	+
EXPPRICE	Expected price for cotton ($/lb)	RMA/AMS/NASS	+
LAGYLD	Lagged yield (lb/acre)	NASS	+
EXPPRICE*LAGYLD	Interaction between EXPPRICE and LAGYLD multiplied by lagged yield ($/acre)	NASS/AMS/RMA	-
YLDVAR	Yield variability measured by moving coefficient of variation	NASS	-
BT	Bt cotton adoption rate	CIL	+
PICC	Expected price index of the major 3 competing crops (corn, soybean and wheat)	NASS	-
D1	Dummy for years 2000 to 2001		
D2	Dummy for years 2002 to 2005		

Table 3.3: Summary Statistics

Variables	Delta (21.2%)	Southeast (43.6%)	Southwest (28.9%)	West (6.2%)	U.S. (4637)
Dependent variables					
INSURANCE	0.545	0.725	0.784	0.482	0.689
	(0.291)	(0.281)	(0.318)	(0.239)	(0.309)
ACRES	0.214	0.240	0.173	0.121	0.208
	(0.153)	(0.176)	(0.185)	(0.128)	(0.175)
Independent variables					
SUBSIDYPERLB	0.021	0.029	0.044	0.012	0.031
	(0.009)	(0.014)	(0.023)	(0.009)	(0.019)
ROR	2.350	2.429	2.361	2.333	2.387
	(9.300)	(4.891)	(2.586)	(6.116)	(5.748)
EXPPRICE	0.743	0.770	0.703	0.796	0.747
	(0.117)	(0.124)	(0.112)	(0.130)	(0.123)
LAGYLD	732	618	472	1,072	628
	(168)	(169)	(236)	(304)	(249)
EXPPRICE*LAGYLD	537	474	326	845	468
	(121)	(142)	(160)	(253)	(197)
YLDVAR	0.182	0.236	0.280	0.159	0.232
	(0.066)	(0.098)	(0.116)	(0.100)	(0.106)
BT	0.588	0.552	0.148	0.246	0.424
	(0.291)	(0.247)	(0.102)	(0.276)	(0.298)
PICC	0.958	0.954	0.977	0.861	0.956
	(0.213)	(0.215)	(0.207)	(0.302)	(0.220)
D1	0.098	0.102	0.101	0.108	0.101
	(0.298)	(0.312)	(0.301)	(0.310)	(0.302)
D2	0.386	0.376	0.405	0.385	0.387
	(0.487)	(0.484)	(0.491)	(0.488)	(0.487)
Other descriptors					
Planted	37,061	15,544	44,925	34,151	29,761
	(34,483)	(15,108)	(68,515)	(52,576)	(45,984)
Insured acres	31,544	14,329	43,704	27,492	27,292
	(34,483)	(14,348)	(67,319)	(43,573)	(43,861)

Sample standard errors in parentheses

liability or maximum liability by multiplying the 5-year historical yield for county by price election for a given year and 75% for years before 2000 and 85% for years 2002 to 2005. The crop insurance program increased the maximum coverage level from 75% to 85% for 2000 and subsequent years. A high ratio of total liability to total possible liability implies a high crop insurance participation.

The sample can also be segmented by region. Insurance participation averages about 0.689 and varies by region. The Southwest region has the highest average insurance participation while the West region has the lowest insurance participation. It is important to point out that mean yield and $EXPPRICE * LAGYLD$ for the Southwest region are lowest too. Moreover, yield variability is highest in the Southwest which may imply that cotton production is relatively riskier in the Southwest region. The West region is characterized by a relatively lower insurance participation but with high $EXPPRICE * LAGYLD$ and yield and low yield variability. This signifies a high and relatively more stable yield, due largely to irrigated production in the West.

The Southeast, Southwest, Delta and West regions constitute 43.6%, 28.9%, 21.2% and 6.2% of the total observations in my analysis, respectively. Similarly, $ACRES$ is highest for the Southeast region which is also slightly higher than the total average while the West region has the lowest average $ACRES$. However, in terms of the absolute average of cotton acreage, the Southeast region has the smallest value (15,544 acres) while Southwest region has the largest (44,925 acres).

This is because counties in the Southeast are generally smaller than counties in the Southwest and West regions. $ACRES$ has a mean of 20.8% and ranges from 0.1% to 98.1%.

On the choice of explanatory variables, I included variables to capture the influences of market incentives, government incentives and technology on farmer's decision making. Market incentives are captured by the $EXPPRICE$, $LAGYLD$ and the interaction of $EXPPRICE$ and $LAGYLD$ which is $EXPPRICE * LAGYLD$. Expected price is calculated using the December futures price in February plus the 'November state basis' to incorporate state level supply and demand conditions, transportation costs, handling and storage cost, etc. during the marketing year. Also, the expected LDP is incorporated to capture the effect of government price support programs. The December futures price in February is chosen because it is the month when cotton producers plan or make decisions for the upcoming cropping year (i.e. avail/renew insurance policies, decide how much land to allocate, buying inputs, etc.). The basis used in calculation is the difference between the lagged local cash price (i.e. state price) of cotton and the average of December futures price in the last 12 weeks the contract traded(lagged). The average of December futures price in the last quarter (lagged) is used to calculate the basis because this is the most recent basis information available and it correponds to the nearest futures price at the time when a large precentage of cotton is marketed. U.S. cotton producers are also eligible to receive marketing loan benefits through direct loan deficiency payments (LDP). An LDP rate is given when the adjusted world price (AWP)falls below \$0.52/lb. When the AWP falls below 52 ¢/lb and the producer sells cotton or places it in the loan program then an LDP payment or 'market gain' occurs to the producer. Expected LDP is contructed given the conditions below:

$$E(BasisLDP) = AWPlq(lagged) - DECfutureslq(lagged) \tag{3.10}$$

$$AvMktPrice = DECfutures + E(BasisLDP) \tag{3.11}$$

$$ExpectedLDP = \begin{cases} 52 - AvMktPrice & \text{if } AvMktPrice < 52 \\ 0 & \text{otherwise} \end{cases}$$

where $AvMktPrice$ is the average market price while $AWPlq$ and $DECfutureslq$ are the AWP and December futures in the last quarter of the year, respectively. Creating an expected net farm price is quite challenging because of price support programs from the federal government. Price estimates used in this study may not be perfect but are comparable to actual prices and deficiency payments received by farmers at the state-level. The $EXPPRICE$ has a mean of \$0.747/lb.

The interaction of $EXPPRICE$ and $LAGYLD$ is given by $EXPPRICE * LAGYLD$. It is expected that counties with high yield insure less when expected price increases and increase insurance participation when expected price goes down. Similarly, counties with high yields are expected to have less acreage response when price goes up while counties with very low yield are expected to be more responsive to price changes.

Yield greatly varies among counties. The minimum yield observed in the sample is 55 lbs/acre in Scheiler county, Texas in 2001 while the highest is 1800 lb/acre in Riverside, California in 2005. To capture yield risk differences among counties, I included a measure of variability in yield, $YVAR$. The $YLDVAR$ variable is calculated using the moving coefficient of variation defined as the ratio of the moving standard deviation to the moving mean. Having an unbalanced panel made construction of this varible difficult. To avoid losing a large number of observations, counties that have at least one year historical yield information from 1985 to the county's initial year of cotton production are considered in my sample. Also, note that for some cotton-producing counties, the initial year in the sample period is later than 1995. $YLDVAR$ reflects a county's yield risk. Mean $YLDVAR$ is about 0.232. It is expected that a high yield variability would affect both production and insurance particpation decision of farmers. Counties facing high yield risk reflected by high variations in yield may cause farmers to increase insurance participation and plant less cotton.

Benefits from insurance is proxied by the variable ROR. This is calculated as the proportion of indemnity to producer premium. Producer premium is calculated as the sum of net premium and total administrative fee paid by the county. I expect ROR to be positively associated with insurance participation. This variable is also used as an instrument for the insurance equation. ROR greatly varies by region and has a mean of 2.387 which means that the benefit derived from insurance is over twice as much as the producers' cost to insurance on the average and across all counties. However, this does not imply that all producers would expect this rate of return from crop insurance.

To estimate the effect of differences in the subsidy per lb of production received by counties, I included the $SUBSIDYPERLB$ variable which is constructed as total subsidies received by the county divided by the 5-year moving average yield. A positive association between $SUBSIDYPERLB$ and $INSURANCE$ is expected.

To capture the effect of technology, I included the Bt cotton adoption rate as an explanatory variable. The introduction of Bt cotton has played an important role in the decision-making of cotton producer and I expect that an increase in adoption rate of Bt cotton causes farmers to plant more cotton. Before the introduction of Bt cotton, farmers could lose much of their cotton to bollworms but after the introduction of this technology, farmers were able to control many of these pests. On the other hand, the effect of Bt cotton adoption rate on insurance participation is expected to be negative since Bt cotton makes cotton production less risky. The Bt cotton adoption rate is highest for the Delta region (58.8%) and lowest in the Southwest (14.8%).

The effect of competing crops on cotton acreage is also considered. Choosing which crops to include is challenging because major competing crops of cotton vary by region. In this study, I only considered wheat, corn and soybeans as the major competing crops for all counties. The expected price for each crop is constructed using a futures price or loan rate and state basis which is the difference between the US average and state price in the previous year. To compare these prices, I constructed a price index for these major crops using a Laspeyres index with 1996 as the base year. For example, the price index for wheat is computed as shown below.

$$Priceindex_w = \left(\frac{P_{w,t}}{P_{w,1996}}\right) * \left(\frac{acres_w}{acres_w + acres_s + acres_c}\right) \tag{3.12}$$

The computed price indices of the competing crops are added to get $PICC$. Note that prices used in the computation are state-level while acres are measured at the county-level. Using this measure, more weight is given to the major competing crop in a county. $PICC$ has a mean of 0.956. I expect that a high $PICC$ would decrease the planted acreage for cotton. This variable is also used as an instrument for the acreage equation.

Price risk is not included in the model because the prices used are at state-level. Risk faced by farmers due to price fluctuations is generally low because of government price support programs. Deficiency payments are triggered when market price falls below \$0.52/lb. These payments cause farmers to receive relatively higher prices when cotton price is low. In effect, price variation or price risk becomes lower due to price support programs. Table 3.4 compares the average market price for cotton and average net price after subsidy.

Table 3.4: Average Cotton Market Price, 1995-2005

	Market Price			Net Price After Subsidy		
State	Average	Stdev	CV	Average	Stdev	CV
Alabama	0.539	0.139	0.259	0.581	0.125	0.215
Arizona	0.530	0.141	0.266	0.570	0.141	0.248
Arkansas	0.544	0.141	0.259	0.588	0.126	0.214
California	0.630	0.127	0.201	0.671	0.123	0.183
Florida	0.546	0.144	0.264	0.587	0.138	0.234
Georgia	0.550	0.139	0.253	0.592	0.125	0.212
Louisiana	0.526	0.132	0.250	0.567	0.122	0.215
Mississippi	0.528	0.139	0.264	0.568	0.128	0.225
Missouri	0.547	0.138	0.252	0.584	0.119	0.204
New Mexico	0.565	0.130	0.229	0.601	0.129	0.214
North Carolina	0.554	0.145	0.263	0.595	0.128	0.216
Oklahoma	0.500	0.129	0.257	0.535	0.120	0.225
South Carolina	0.561	0.153	0.273	0.598	0.133	0.223
Tennessee	0.526	0.135	0.257	0.568	0.125	0.219
Texas	0.505	0.135	0.267	0.545	0.125	0.230
Virginia	0.553	0.151	0.274	0.592	0.124	0.210

CHAPTER 4

Empirical Results

This section presents insurance participation for US cotton. Total acres devoted to cotton production decreased from 1995 to 1998 and slowly increased from 1998 to 2001 and then decline in 2002. Total number of insured cotton acreage followed the trend of cotton acreage as shown in Figure 4.1. It is important to point out that in 1995, the year when insured to planted acreage was the highest in the sample period, about 57% of the insured acreage was under CAT while only 43% under BUP.

High participation under CAT is associated with the 1994 Farm Bill which made CAT mandatory to farmers. In 1996, this requirement was removed and in effect a decline in the total insured acreage was observed. A series of subsidy increases followed to encourage insurance participation and in effect, insured acreage increased, especially at the BUP level. A shift from CAT to BUP levels is observed. In 2001, about 76% of the insured acreage is under BUP while CAT only comprised 24% of the total acreage insured. From 2000 to 2002, about 56% of the insured acreage was at the 65% coverage level or greater. Figures 4.2 and 4.3 show the acres and percentage of insured acres under different coverage levels.

The weighted average coverage level purchased in the US show that in 1995 to

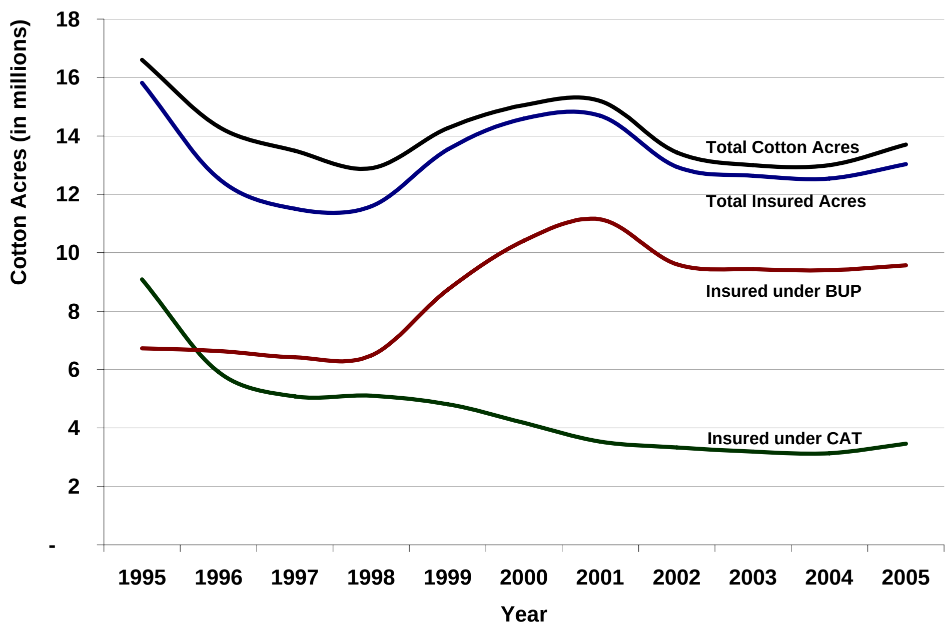

Figure 4.1: Cotton Acreage and Insured Acreage, 1995-2005

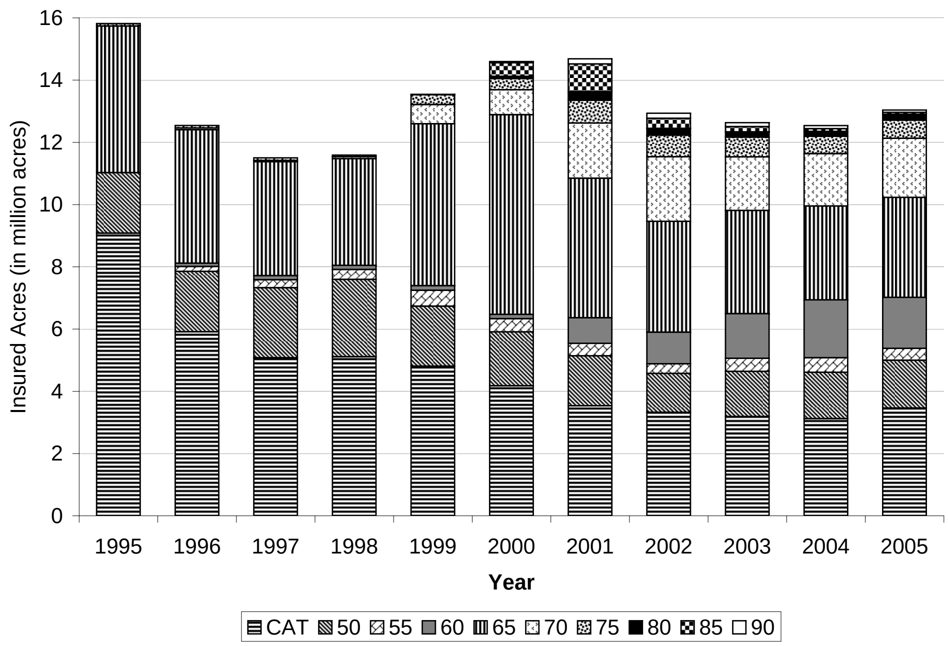

Figure 4.2: Insured Acreage by Coverage Levels, 1995-2005

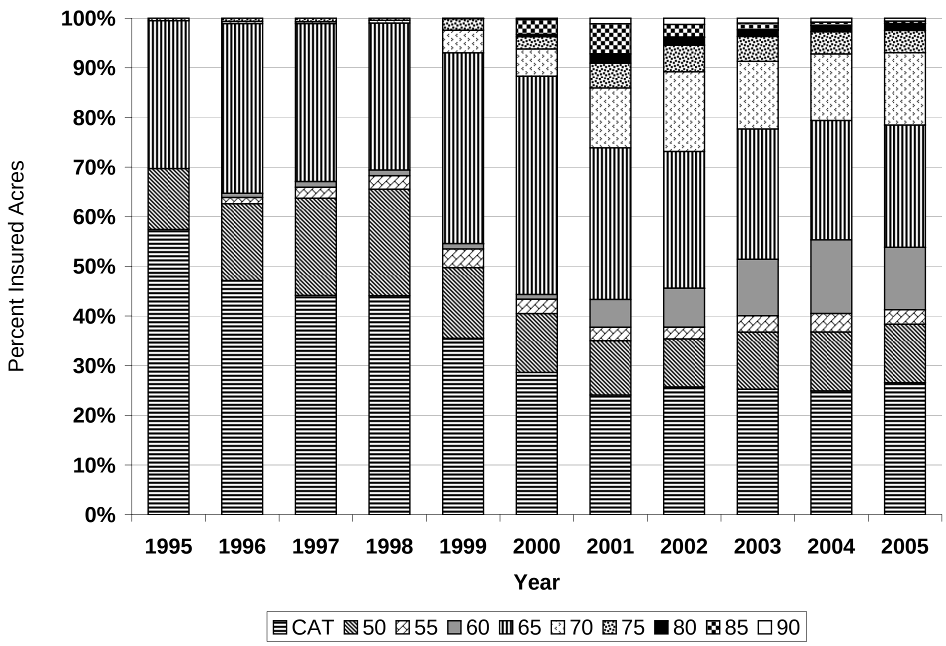

Figure 4.3: Percentage of Insured Acres under Different Coverage Levels, 1995-2005

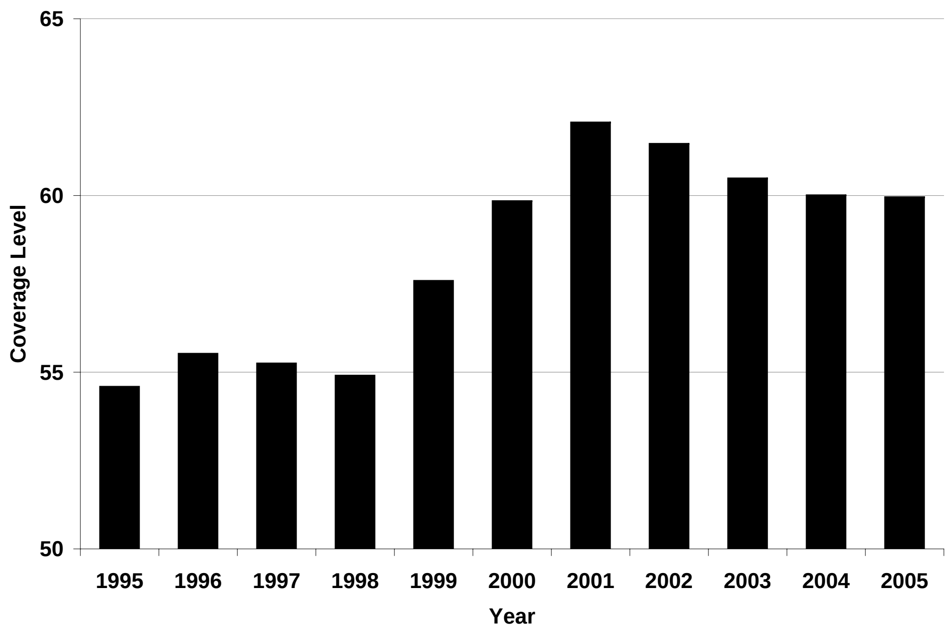

Figure 4.4: Weighted Average Insured Coverage Level for U.S. Cotton, 1995-2005

1998, the coverage level was just around 55% (Figure 4.4). The weighted average coverage level computed in this study is a combination of yield insurance and revenue insurance. The highest coverage level offered to farmers was increased from 75% to as high as 85%. In some counties, GRIP is offered with various coverage levels from 65% to 90%. The weighted average coverage level was recorded in 2001, with about 62% coverage level. This is the same year when the ARPA took effect and premium subsidy rates were increased across the board.

In measuring insurance participation, I used the ratio of total liability to to-

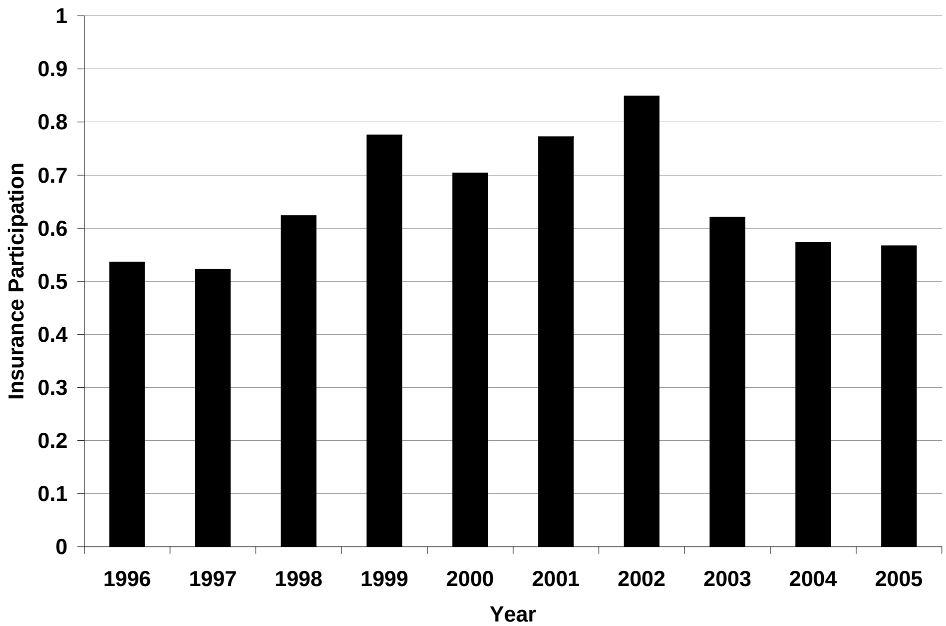

Figure 4.5: Crop Insurance Participation for U.S. Cotton, 1996-2005

tal potential liability in a county. This measure is believed to be superior to the traditional measure which is the proportion of insured acreage to the total cotton acres because it captures differences in coverage levels. A higher total liability is associated with higher insurance participation. Insurance participation during the sample period is presented in the Figure 4.5.

Based on Figure 4.5, crop insurance participation was at its peak in 2001, the year when ARPA took effect. This graph is similar to what I have presented in Figure 4.1. During the same year, the share of cotton on the total cropland area

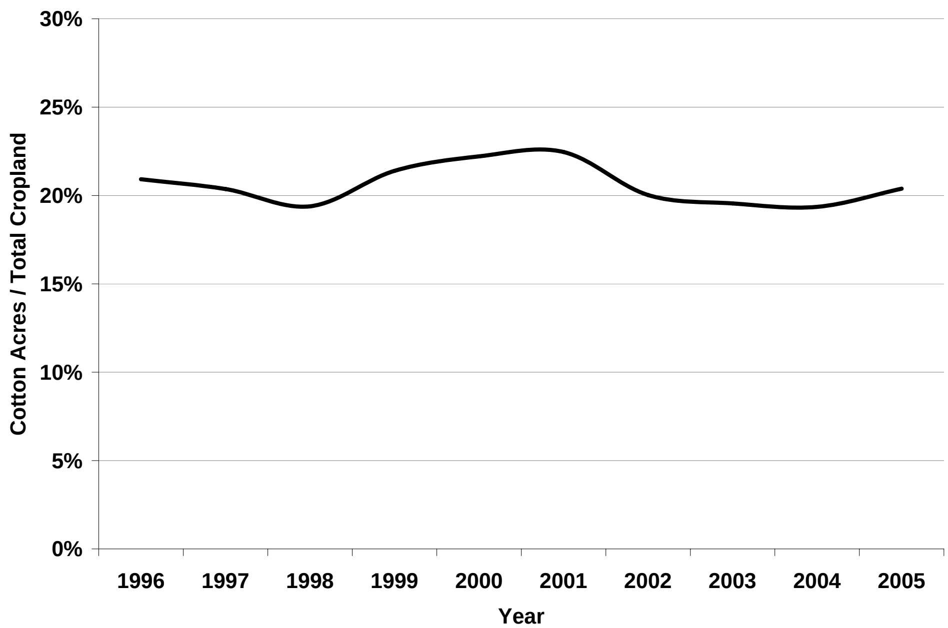

Figure 4.6: Share of Cotton Acres on Total Cropland Area in the US, 1996-2005

was as much as 22.5%. Figure 4.6 shows the proportion of cropland acres planted to cotton. This is the dependent variable used in Equation 3.9. This gives the share of cotton acres on the total cropland area in size for different counties. I normalized cotton acres using total cropland area because of the large variations in countysize. The value for cropland acres in a county is constant at the 2002 Ag. Census level.

4.1 Fixed Effects and Random Effects Model

To address my empirical focus which is to determine the effect of subsidized crop insurance program on US cotton acreage, I followed the framework used by Goodwin et al. (2004) by considering the simultaneity nature of the problem. The equations are estimated simultaneously because acreage decisions and crop insurance program participation decisions are made at the same time. Estimating the model simultaneously provides gains in efficiency because of the correlation between errors of the equations. Unlike Goodwin et al. (2004), I considered the panel structure of my data and applied fixed effects and random effects specification. I then tried to compare the fixed effects and random effects using Hausman test for model specification in Equation 3.7.

However, Hausman test is not well defined because the difference in the covariance matrix ($cov_{FE} - cov_{RE}$) is not positive definite. A non positive definite covariance matrix may imply that there is no obvious efficiency gains in the random effects model. Also, based on the results, the variance of the parameter estimates seem to be higher for the random than the fixed effects model. Also, it can be argued that μ_i is correlated with the explanatory variables. For example, the location of the county, size of county, and land quality can be argued to be correlated with the regressors. Therefore, correlation between μ_i and the explanatory variables is assumed. Another reason for choosing the fixed effects model is that the counties observed are not randomly sampled but more or less exhaust the population. The results of estimating the parameters in(3.8) and (3.9) are given in Table 4.1. Only the fixed effects results are discussed in this section.

4.1.1 Insurance Participation

Valid instruments used for the insurance equation are $SUBSIDYPERLB$ and ROR. The estimate on the rate of returns variable in the insurance equation shows a strong and positive association between rate of returns and crop insurance participation. A high rate of return to insurance suggests a large benefit as shown by a high ratio between the total indemnity received and total cost of insurance paid by the county.

Similarly, the coefficient on $SUBSIDYPERLB$ is highly significant and positive. If subsidy per lb of production increases then insurance participation also increases. Generally, counties that receive higher subsidy per lb of production are counties where production risk is high and yields are low. Because subsidy rates are structured as a percentage of total premium, it is likely to favor counties in high risk regions (low yield). Keeton and Skees (1999) suggested targeting a per unit of production subsidy so that subsidies will no longer favor high risk regions at a cost to low-risk regions.

The effect of yield variability on insurance participation is also highly significant and positive. This is not surprising because a high yield variability implies an unstable yield. This implies that when there is high yield variation in the county

Table 4.1: Fixed Effects and Random Effects Results

	Dependent Variable			
	Fixed Effects		Random Effects	
Independent Variable	INSURANCE	ACRES	INSURANCE	ACRES
Intercept	0.0181	-0.0017	-0.1305	0.0955*
	(0.0102)	(0.0018)	(0.2084)	(0.0381)
EXPPRICE	0.1957	0.0479*	0.1202	0.0184
	(0.1328)	(0.0220)	(0.1401)	(0.0406)
LAGYLD	-0.0001	0.0001**	-0.00001	0.00004
	(0.0002)	(<0.0001)	(0.0002)	(<0.0001)
EXPPRICE*LAGYLD	-0.0005**	-0.0001	-0.0006**	0.00004
	(0.0002)	(<0.0001)	(0.0002)	(<0.0001)
YLDVAR	0.3275**	-0.0479**	0.6435**	-0.1352**
	(0.0695)	(0.0101)	(0.1229)	(0.0235)
BT	0.2926**	-0.0220**	0.1413**	0.0168
	(0.0254)	(0.0074)	(0.0347)	(0.0117)
D1	-0.0734*	0.0226**	-0.0918*	0.0216**
	(0.0339)	(0.0027)	(0.0376)	(0.0055)
D2	-0.0086	-0.0075*	0.0059	-0.0091
	(0.0214)	(0.0032)	(0.0299)	(0.0068)
SUBSIDYPERLB	0.6364*		0.2187	
	(0.2835)		(0.5426)	
ROR	0.0042**		0.0039**	
	(0.0008)		(0.0008)	
ACRES	3.6750**		4.4467**	
	(1.2135)		(1.4038)	
PICC		-0.0154**		0.0028
		(0.0045)		(0.0090)
INSURANCE		0.0599**		0.0864*
		(0.0218)		(0.0371)
Number of observations	4,637			

Asterisks indicate statistical significance at the 5%(*) and 1%(**) levels. Standard errors in parentheses.

insurance participation also tends to be high. This is supported by Table 3.3 which shows that the region with the highest mean yield variability (Southwest region) also has the highest mean level of insurance participation. However, insurance participation is lowest for the West which has the lowest mean for yield variations.

The effects of $EXPPRICE$, $LAGYLD$ and the interaction term, $EXPPRICE*LAGYLD$, on insurance participation are also included in the model. Based on the marginal effects of expected price, an increase (decrease) in price expectation causes a decrease (increase) in insurance participation for counties with relatively high yield expectations. On the other hand, the correlation between expected price and insurance participation is positive for counties with very low yield but not significant for a 95% confidence interval. This finding is a very interesting and has important policy implications. This will be discussed in the last section of this chapter.

Lastly, a positive correlation between Bt cotton adoption rate and insurance participation may imply that counties with a high rate of Bt cotton adoption insure more of their land. This result is surprising because I expect that high Bt cotton adoption rates will decrease insurance participation because this technology reduces risk in cotton production. However, it is imporatant to note that adoption of Bt cotton is relatively more expensive than using traditional cotton varieties. This means that counties with high Bt cotton adoption rate have a relatively higher investment than counties with low adoption rate. Therefore it makes sense for counties with a high investment on cotton to purchase more insurance to protect their investment in production.

4.1.2 Acreage Response

For the $ACRES$ equation, the instrument that I used is the price index for competing crops. The major competing crops considered are corn, soybeans and wheat. The estmate for $PICC$ is highly significant and negative. An increase in price expectation for these competing crops causes a decrease in cotton plantings. However, the effect of $PICC$ on cotton acres is inelastic.

The effect of $YLDVAR$ on cotton acreage is negative and highly significant. This simply means that counties with high yield variation tend to plant less cotton compared to counties with relatively stable yield. High yield variation is also common in dry land counties.

Similar to the results in the previous section, in counties with reltively high yields, an increase in price expectation causes a reduction in cotton acreage or a decrease in price expectation triggers more cotton planting. However, for counties with extremely low yields, the marginal effect of the price expectation on cotton acres is positive. Policy implications of this result are given in the next section.

The effect of Bt cotton adoption on cotton planting has a counterintuitive sign. It has been speculated that the introduction of this risk reducing technology expanded cotton production in some counties. However, based on my results, adoption of

Bt cotton decreases cotton plantings. In the aggregate, increased yields from Bt cotton have decreased the need for more acreage to meet U.S. and export demands. However, one limitation in my model is that the data available for Bt cotton adoption rate is at state-level.

Compared to the 1995 to 1999 period, results show that cotton acreage from 2000 to 2001 is significantly higher but insurance participation is lower. However, cotton acreage from 2002 to 2005 was significantly lower than for 1995 to 1999.

The main focus of my research is to determine the effect of insurance on cotton acreage. Based on my results, cotton acres and insurance participation are positively correlated and highly significant. An increase in cotton acres in a county also means an increase in insurance participation because there will be more land to insure. In contrast, a decrease in cotton acres in a county means reduction in insurance participation because there will be less land to insure. On the other hand, the effect of insurance participation on cotton acreage is positive and significant. Similar to what other studies have found, the effect of insurance is positive and inelastic. Results from random effects also verify the positive and inelastic effect of insurance on acreage. Elasticity of acreage with respect to insurance participation at data means is about 0.198 while the calculated elasticity of acreage with respect to subsidy per unit production is 0.0218. Elasticities found by other studies for other crops were 0.014, 0.0025 and 0.19 for corn, soybean, barley (Goodwin et al. 2004) and 0.099 for cotton in Mississippi portal and Southern Seaboard (Deal 2004).

The fixed effects estimates of the reduced form are given in Appendix B. Based on the results, the subsidy per unit of production positively affects cotton acreage. Increasing $SUBSIDYPERLB$ by \$1/lb would result to an increase in $ACRES$ by 4.8%. However, the effect is not statistically significant at data means. The effect of subsidy per unit of production on acres is also computed by region and results show that the effect of $SUBSIDYPERLB$ on $ACRES$ is positive for the Delta (0.293), West (1.398) and Southwest (0.155) regions. The effect is only significant for Southeast and Southwest regions. However, the estimate for the Southeast region is -0.217, which seems counterintuitive. The explanation of the negative effect of $SUBSIDYPERLB$ on acres for the Southeast region may be attributed to the county-level effects of Bt adoption which are not captured by this study and the larger yield impacts of Bt in the Southeast than other regions. Bt adoption in the Southeast probably caused production to become much less risky for the Southeast than other regions. In effect, decreasing $SUBSIDYPERLB$ for the Southeast likely increased $ACRES$ because of improved cotton production in the region. Controlling for this effect is difficult since BT adoption is only observed at the state level and thus insufficient variation in BT adoption makes controlling for its effect challenging. A contribution of future studies would be to more precisely measure BT adoption by counties in order to more accurately control for the effects of Bt technology on cotton acreage.

I also modelled insurance participation and cotton acreage by segmenting it into the four regions. The parameter estimates of insurance participation on cotton acreage for these regions were positive and significant except for Delta and West regions. The computed elastcities at data means for Southeast and Southwest regions are 0.26 and 0.38, respectively.

4.2 Marginal Effects of Expected Price and Yield

Generally, counties that exhibit high cotton yields are those that are irrigated and it can be argued that production risk is relatively lower for counties with high cotton yield. Prices are also high for counties that are irrigated because of better cotton quality. On the other hand, dryland or counties with limited rainfall can be characterized with relatively low yields and high production risk. Prices are also generally lower, due in part to lower quality cotton, as evidenced by lower average state prices.

Based on the parameter estimates and standard errors of the reduced form, the marginal effects of $EXPPRICE$ on insurance participation (Figure 4.7), results suggest that an increase in price expectation causes a decline in insurance participation among counties with relatively higher yields. Because yield and prices are already high in these counties, it is expected that crop insurance participation will decline if price increases because production in these counties will be most likely above the insurance gurantee. However, a decrease in price expectation may cause counties with very high yields to insure more because these counties will be more

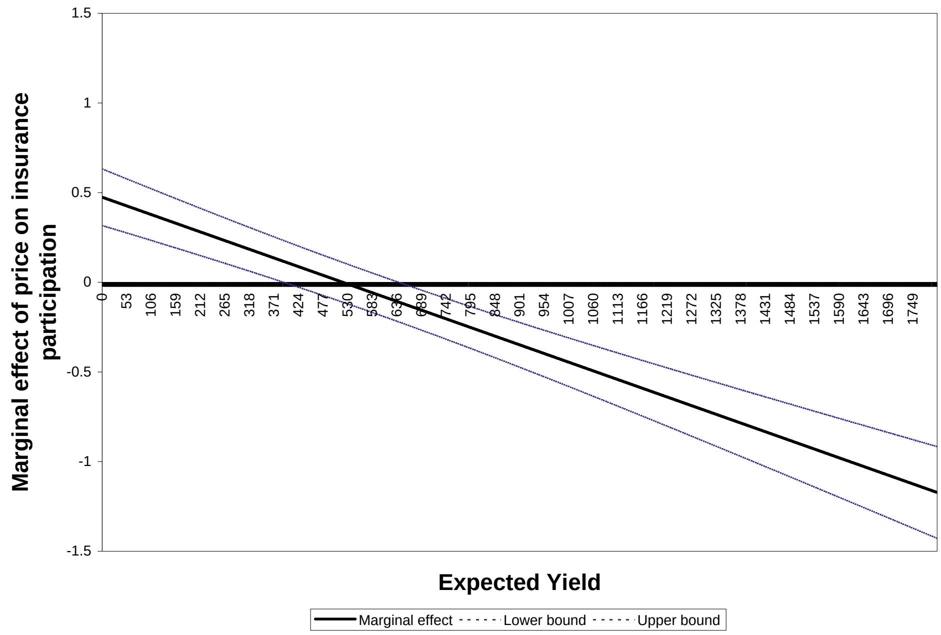

Figure 4.7: Marginal Effects of Expected Price on Insurance Participation Given Yield Expectation

likely to benefit from insurance, especially when revenues in recent years are high. On the otherhand, counties with extremely low yields behave differently. The association between price expectation and insurance participation is positive which may be due to relatively higher production risk in counties with very low yields.

The marginal effect of $EXPPRICE$ on cotton acreage is given in Figure 4.8. The direction of the effect is similar to Figure 4.7 where in the marginal impact of price is decreasing in yield. This means that an increase in the expected price has a smaller impact on acreage when yield is very high and there is more acreage response from counties with extremely low yields. This may indicate that counties with extremely high yields are those that are irrigated and because of limited water supply for agriculture, these counties are not able to respond as much as counties with dryland agriculture. Another intuition is that since yield is very high in these counties, it can be argued that the land quality being used is also high. An increrase in acreage response due to changes in price expectation may suggest bringing less productive land into cotton production. Therefore, when yields are very high, an increase in price results in a smaller impact on acreage because the options for putting more land into production are limited.

Graphs for the marginal effects of yield on insurance participation and cotton acreage is given in the Appendix. Note that the marginal effects are calculted using the parameter estimates and standard errors of the reduced form in Appendix A.1.

To compare my econometric results to previous literature, I then summarized my empirical results in Table 4.2. In the next chapter, important implications of the result and conclusions. Also, I include limitations of my thesis and recommendations for future work.

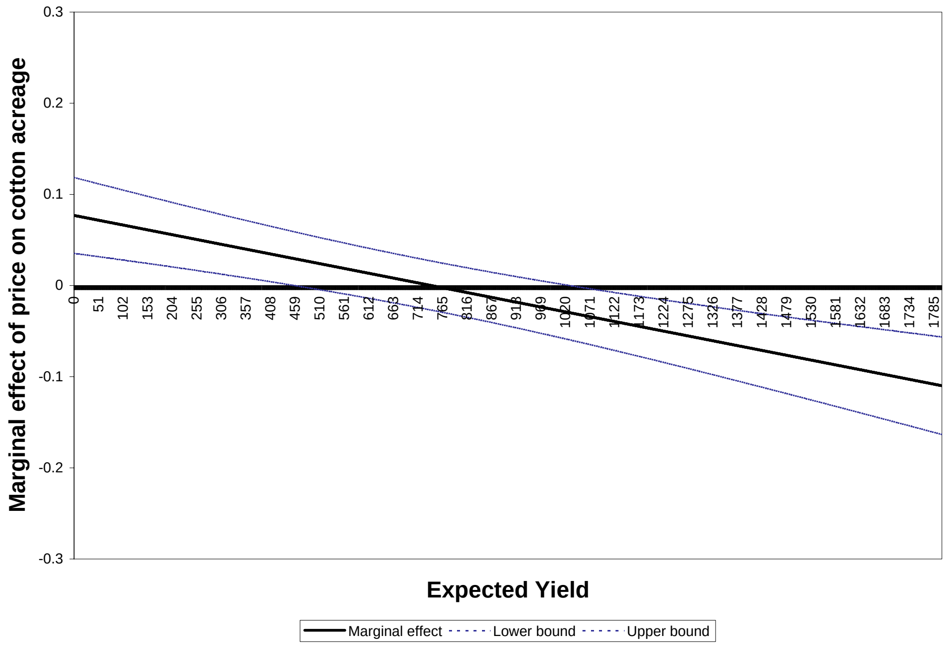

Figure 4.8: Marginal Effects of Expected Price on Cotton Acreage Given Yield Expectation

Table 4.2: Summary of Econometric Results

		Significant Variables		
Data/Model	Dependent Variable	Positive	Negative	Insignificant
US	Insurance Participation	ACRES	EXPPRICE*	LAGYLD
Cotton	(INSPART)	YVAR	LAGYLD	D2
County-level		BT	D1	EXPPRICE
1995-2005		SUBSIDYPERLB		
NT=4637		ROR		
Fixed Effects				
Simultaneous				
	Cotton Acreage	INSPART	YVAR	EXPPRICE*
		LAGYLD	BT	LAGYLD
		EXPPRICE	PICC	
		D1	D2	

CHAPTER 5

Conclusions and Implications

In this thesis, I examined crop insurance participation for cotton and its effect on cotton acreage. Unlike other studies, I expanded my work by not limiting my analysis to one or two regions but through inclusion of all cotton-producing counties in the U.S. with data for the period 1995 to 2005. ARP restrictions were removed in 1996, allowing producers to respond to crop insurance incentives more than previously. Using simultaneous equations, I estimated crop insurance participation and cotton acreage responses using fixed effects and random effects panel models. Results from estimation have important policy implications.

An important finding is that counties with extremely low yields, usually those in dry land/rainfed region, have more response to insurance participation as the price expectation goes up as compared to those with very high yields. Moreover, counties with extremely low yields respond more to changes in price than counties with relatively high yields. An important policy implication is that increasing government price support programs are more likely to benefit counties with relatively higher production risk. If this finding is correct then increasing government price support will lead to increased insurance participation and cotton production in relatively riskier counties, therefore encouraging inefficient production.

Another important issue addressed by this study is the perspective that insurance programs affect acreage decisions. There has been increasing concern about the production-inducing effect, especially in riskier areas or growing riskier crops, of crop insurance programs. Based on Goodwin et al. (2004), elasticities of acreage response on changes in insurance participation at data means for corn, soybean and barley are 0.014, 0.0025 and 0.19, respectively. In the Mississippi portal and Southern Seaboard, Deal (2004) also found inelastic response of about -0.104 in 1990 to 1995 and 0.099 in 1996 to 2000. Findings of this study also support literature that claimed a positive but marginal effect of insurance participation on crop acreage. Specifically, results show that on the average, a 1% increase in insurance participation causes an increase in cotton acreage of 0.198%. Other studies that claimed large acreage expansion due to US subsidized crop insurance program is not supported by this thesis.

5.1 Limitations and Recommendation for Future Work

The limitations of this thesis serve as an avenue for future reasearch. I have focused on county-level responses in terms of acreage decisions and insurance participation for cotton. Having farm-level data would be more ideal to adequately capture acreage response because an aggregate data masks the behaviorial differences among cotton producers in one county.

Another important criticism mentioned by Goodwin (2004) is that insurance data are only available for farms that purchase insurance. Premium rates used only represents the rates of insured farms in a county. If nonbuyers face higher premium rates then the rates used in the study may have minimized the actual rates.

The introduction of more data is also necessary. Several factors that influence insurance participation and cotton acreage were not included in the model due to their unavailability. Data on price election and prevented planting at the county-level can be useful. Also, a county-level data on Bt cotton adoption is needed to adequately address the impact of this technology to farmers' planting decisions.

The adverse selection problem of crop insurance program remains an important topic for future research. Studies on whether the crop insurance program gives more incentives to counties with riskier crop production are recommended.

APPENDIX A

Reduced Form Estimates

Table A.1: Fixed Effects Estimates of the Reduced Form

	Dependent Variable	
Independent Variable	INSURANCE	ACRES
Intercept	0.0153*	-0.0007
	(0.0077)	(0.0020)
EXPPRICE	0.4739**	0.0769**
	(0.0805)	(0.0212)
LAGYLD	0.0003**	0.0001**
	(0.0001)	(0.00002)
EXPPRICE*LAGYLD	-0.0009**	-0.0001**
	(0.0001)	(0.00002)
YLDVAR	0.1938**	-0.0363**
	(0.0340)	(0.0108)
BT	0.2721**	-0.0059
	(0.0202)	(0.0045)
D1	0.0127	0.0233**
	(0.0127)	(0.0031)
D2	-0.0462**	-0.0102**
	(0.0139)	(0.0035)
SUBSIDYPERLB	0.8223**	0.0485
	(0.2763)	(0.0348)
ROR	0.0053**	0.0003
	(0.0002)	(0.0002)
PICC	-0.0689**	-0.0203**
	(0.0042)	(0.0042)

Asterisks indicate statistical significance at the 5%(*) and 1%(**) levels. Standard errors in parentheses.

APPENDIX B

Marginal Effects of Yield

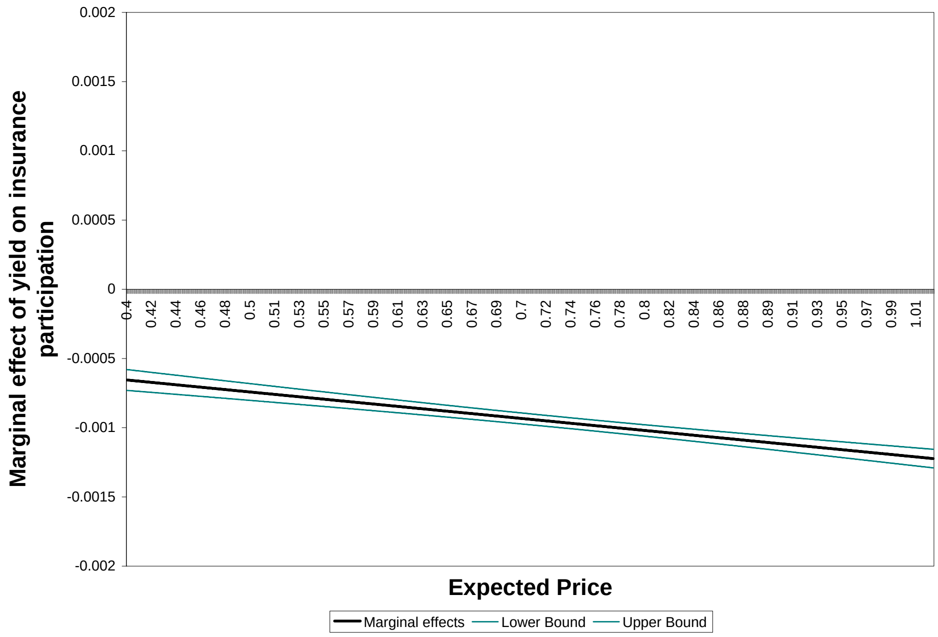

Figure B.1: Marginal Effects of Expected Yield on Insurance Participation Given Price Expectation

Figure B.2: Marginal Effects of Expected Yield on Cotton Acreage Given Price Expectation

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