STRUCTURAL CHANGES IN UNITED STATES COTTON SUPPLY

A Thesis

by

DONNA MARIE MITCHELL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2009

Major Subject: Agricultural Economics

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Approved by:

Chair of Committee,	John Robinson
Committee Members,	Stephen Fuller
	Gary Wingenbach
Head of Department,	John Nichols

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ABSTRACT

Structural Changes in United States Cotton Supply. (August 2009)

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Chair of Advisory Committee: Dr. John Robinson

Agricultural supply represents the quantity supplied for a given price of a commodity. The supply function is an algebraic representation that shows, in this case, how much yield and acreage output changes from variations in prices and various inputs. Estimating supply functions is an important economic research topic. However, publications on this topic involving applications to agricultural crops are not plentiful, particularly for cotton. This paper focuses on the estimation of cotton supply functions and elasticities within the United States cotton industry. U.S. cotton yields appear to have been dramatically increased in recent years from newer varieties, boll weevil eradication, weather, and other technological improvements. Changes in both productivity and input cost suggest likely changes in supply relationships. Seventeen cotton producing states were divided into homogenous regions. A two equation model was used to estimate the supply functions and elasticities for each region. The results were mixed, depending on the region. There was difficulty in finding good model fits likely due to complexities of biological responses as well as policy distortions. The parameter results suggest that the major determinates of yield were weather and technology. The major determinates of estimating acreage was production in the previous year and policy variables. The overall purpose of this paper was to estimate cotton supply elasticities, which tended to be inelastic across the United States.

DEDICATION

Words cannot express the gratitude due to the most important person in my life, my father. Without his never-ending support, encouragement, and love, I could not have accomplished this monumental task. He has accompanied me on this journey and has been there to celebrate my successes and learn from my failures. His guidance and inspiration have made me strive to be better.

ACKNOWLEDGEMENTS

The accomplishment of this work could not have been done without the influence and support of my giants. I am blessed to have had the opportunity to work with such great intellects. I would like to thank my committee chair, Dr. John Robinson, for his incredible support and patience. He has made this a life changing experience that I will utilize and cherish forever. I would also like express my gratitude to Dr. Stephen Fuller and Dr. Gary Wingenbach for allowing me to have them on my committee, and a special thanks to Dr. James Richardson, Caroline Gleaton, and Vicki Heard for their assistance. I would also like to thank Dr. Jeff Johnson, who has had a big influence on my educational pursuits. He has been a great mentor and friend, and without his persistent encouragement, I would not have reached this milestone.

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CHAPTER I

INTRODUCTION

Supply and demand are the most fundamental elements of economics. Demand represents the quantity of a good for which consumers are willing to pay the prevailing market price, and supply represents the quantity that firms are willing to provide at that price. The Law of Supply states that the amount of a good available for purchase is represented as an upward sloping curve, meaning the higher the price of the good, the higher the quantity supplied. The industry supply function is an aggregation of the supply curves for the individual firm, which, in turn, reflects the positively sloped portion of the firm's marginal cost curve (Nicholson 2005). The supply function is an algebraic representation that shows, in this case, how much cotton yield and acreage would change given changes in cotton prices, conditioned on various other inputs.

Estimating supply functions is an important economic research topic. However, publications on this topic are not plentiful, particularly for cotton production. This thesis focuses on the estimation of cotton supply functions and own-price elasticities. For cotton production, changing energy prices and technology adoption will influence production costs and could potentially affect each firm's marginal cost relationship. The marginal cost curve will shift outward for more expensive inputs, and will shift inward for less expensive inputs. This can potentially shift the industry supply function inward

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This thesis follows the style of the *American Journal of Agricultural Economics*.

or outward. Supply relationships can also shift from changes in productivity, i.e., the production function. U.S. cotton yields appear to have dramatically increased in recent years from newer varieties, boll weevil eradication, weather, and other technological improvements.

The U.S. is the second-largest producer of cotton in the world and, in recent years, has produced about 20 percent of the world's annual supply (USDA ERS 1996b). Cotton in the United States is grown in seventeen states including Alabama, Arizona, Arkansas, California, Florida, Georgia, Kansas, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. Figure 1 below shows U.S. cotton production from 1980 to 2008 has an apparent upward trend. In 1980, production was at 11,017 thousand bales and peaked at 23,259 thousand bales in 2005. The 2008 crop decreased in production to 12,589 thousand bales.

This project will facilitate research by involving elasticities and applying them to policy analysis or transportation/logistics modeling. Academics, government officials, and the cotton industry should be interested in the findings of this project.

For the purposes of this research, a two equation model will be used to estimate cotton yield and acreage. To begin to estimate cotton supply, regions in the United States must be identified by homogeneity. The regions will be grouped by location, weather, substitute crops, and average yield characteristics.

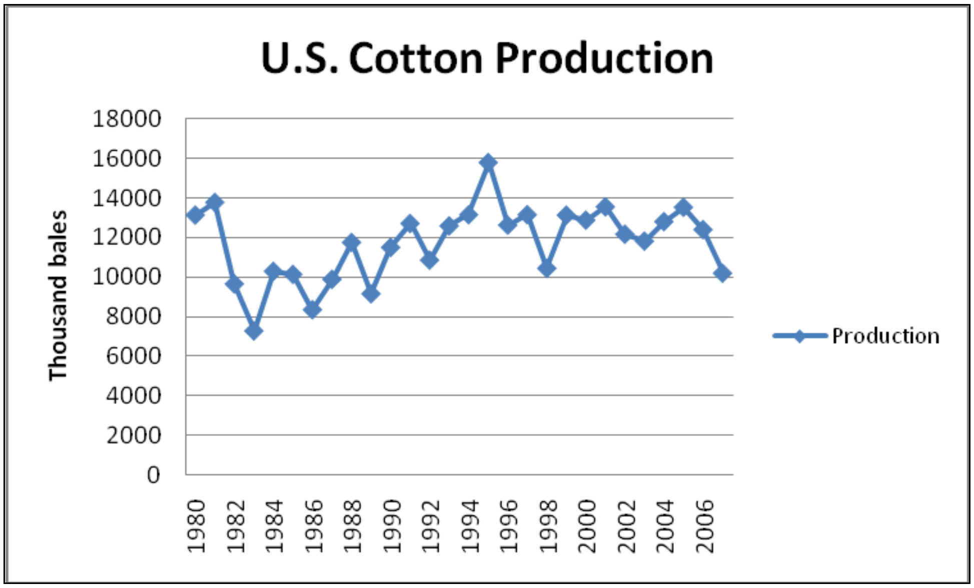

Figure 1. United States cotton production, 1980-2007
Source: NASS 1980-2007

Second, the process involves estimating the supply functions for each region. The supply equation will be estimated as a two equation model where a.) yield per acre is a function of lagged cotton prices, lagged yield, boll weevil eradication, cotton variety, weather, trend, and net expenses and b.) harvested acres are represented as a function of lagged cotton prices, lagged acres, policy variables, lagged price of competing crops, specifically corn, soybeans, and peanuts, and net expenses, and boll weevil eradication.

Third, the short-run elasticities will be estimated for each region of the United States. After these results have been reported, a thorough economic analysis evaluation will be conducted in Chapter IV, followed by a statistical validation of the results in Chapter V.

CHAPTER II

LITERATURE REVIEW

The purpose of this chapter is to present studies that relate specifically to the formulation of supply functions and elasticities. Due to the many complex issues related to the estimation of supply functions, this chapter is divided into two sections that focus on 1.) the problems and challenges associated with supply estimations and 2.) the specifications used to estimate the supply functions.

Problems and Challenges of Estimating Agricultural Supply Functions

In his paper *Conceptualizing the Supply Relation in Agriculture*, Cochrane (1955) addressed the problems associated with estimating supply. He suggested that there is a lack of papers on this subject as well as the quality of the research because those involved in agricultural economics research are only concerned with profit maximization of the firm and the conceptual definition of the supply function. Cochrane said that the precision required for estimating supply is a difficult pursuit. He gave examples of the range in elasticities for different commodities: Robert Walsh estimated an elasticity of .25 for cotton in the 1940's, and Cochrane gave his own relative supply elasticity for cotton to be between 0.2 and 0.3. These findings mean that a one percent increase in the price of cotton would be expected to result in a 0.2 to 0.3 percent increase in the quantity of cotton supplied.

John Black (1924) pointed out the statistical problems of changing prices and output associated with estimating elasticities. Black said one of the problems that causes changes in output can be associated with the impact of independent variables such as pest management, wages, prices, and an increase in technology of competing crops, and strange weather patterns that may or may not be able to be statistically measured. Another problem mentioned by the author was the price response of farmers. The statistical price used should reflect the perception of farmers. Farmers may mistake prices as being high, but might actually be low for the volume of production.

Nerlove and Addison (1958) explained that there are many methods to estimating future prices. They suggested that farmers are constantly revising their expectations of price based on their errors in previous estimates and react to their expectation of what futures prices may be, not what they were.

Gardner (1976) also addressed the selection of prices used in supply analysis. He cited three problems associated with using futures prices. The first problem is the futures price reflects the speculation from the producers that only buy futures contracts, as well as non-farm speculators. The second problem of using futures contracts was in knowing what futures contract was the most important, and the third problem was the date used on the futures contract. The author found the solution to the first problem through rational expectations, implying that there should be no reason for differentiating the price expectations between farmer and speculators or between farmers who purchase future's contracts versus those who don't. The second problem could be avoided by ensuring that the future's contract pertains to the new crop, but the third problem had a difficult solution because it was unclear at what point producers make their planting decisions.

Innovations to Agricultural Supply Specifications

Another important issue involves the choice of independent variables in the supply regressions. The agricultural production economics literature shows a progression of developments in specifying and estimating supply relationships. For example, Brennan (1958) estimated supply functions for single commodities by using average U.S. prices, acreage, and suggested using a new approach by including the prices of inputs and competing crops. Brennan recommended estimating a supply function for different regions that include homogeneity in crop production, technology and climate. Brennan suggested creating ten U.S. regions for estimating cotton supply, but used three in his example. In Brennan's model, he divided the U.S. into three regions: the Southeast (which inlcudes North Carolina, South Carolina, Georgia, Alabama, and Florida), Mississippi Delta (which includes Louisiana, Arkansas, Mississippi, Tennessee and Missouri), and the Southwest (which includes Texas, Oklahoma, California, Arizona, and New Mexico). His cotton response function estimated acreage as a function of the expected price of cotton, the expected prices of substitute crops, and trend.

Grilitches (1960) used a distributed lag model to estimate supply effects on three models: all U.S. farm output, all crops, and livestock and livestock products. The author used an index for output, price indexes, a weather index and a trend variable for U.S. farm output (all expressed in log form except for trend). His short-run supply elasticity for crops was 0.1 and his long-run supply elastitcity for crops was 0.15.

Guise (1969) analysed the effect of technological change, weather and other factors on wheat yield and attempted to separate weather and technology effects while estimating yield. Guise modeled wheat yield in New Zealand as a function of labor inputs, capital, land fertility, fertilizer inputs, disease, and weather effects.

Duffy, Richardson, and Wohlgenant (1987) estimated supply elasticities for cotton, with particular attention paid to the specification of policy variables. They suggest two approaches to presenting policy variables by 1.) grouping the variables by the year of their occurrence and then performing separate regressions by group, and 2.) an aggregated approach that involves integrating farm programs with market price into a single supply inducing price.

The first approach allows the changes in policy to be reflected in the parameters; however, the farm programs change rapidly, so that presents a short window for analysis. The second approach is more widely used. Their paper calculated a support price by looking at, loan rates, deficiency payments, desired acreage, allotments and acreage reductions. The authors defined four cotton producing regions across the United States. The Southeast contains Alabama, Georgia, North Carolina, South Carolina, Virginia, and Florida, the Delta contains Arkansas, Louisiana, Missouri, Mississippi, and Tennessee, the Southern Plains contains New Mexico, Oklahoma, and Texas, and the Southwest contains Arizona, and California. They specified planted acreage as a function of lagged planted acreage, a regional supply-inducing price, a supply-inducing price of a competing enterprise, a diversion payment for cotton, and trend.

Structural change in agricultural markets is a reasonable thing to study given the changes in technology, farm policy, and globalization. For example, White and Shideed (1991) used the Nerlove partial adjustment hypothesis to estimate structural changes in corn acreage. They hypothesized lagged acreage, expected corn price, expected price of competing crops, government program provisions, and technological change to affect planted corn acreage. They used lagged market price of corn to account for corn prices and also used a trend variable to account for technological advances. The government programs included the effective support price, the effective diversion payment, and used a dummy variable for the implemation of the 1983 Payment-In-Kind (PIK) program. Corn acreage was estimated using an OLS model, and two flexible least squares models. The OLS long-run elasticity results show a 0.249 for lagged corn acreage, 0.041 for the corn loan rate, -0.111 for the government programs and -0.031 for lagged soybean prices. The authors report that the OLS short run elasticity estimates are at the lower end of the estimated elasticities compared to the the flexible least squares models and the OLS long run elasticity estimates are at the upper end of the estimated elasticites compared to the flexible least squared models. The previous articles cited in this section have built to the White/Shideed model, which will be closley mirrored in this project.

CHAPTER III

METHODOLOGY

This chapter will focus on the procedures used to develop this research starting with the formulation of five homogenous cotton growing regions, and an in-depth look at the data used for the independent parameters in the regressions. This is followed by a discussion of expected results. Chapter IV will discuss the results and the regression diagnostics.

Regional Development

To estimate U.S. cotton supply functions, homogeneous regions must be identified within the United States based on cotton production, cotton prices, competing crops such as corn, and available resources. The primary focus of this project required regional estimates based on the seventeen cotton producing states previously listed.

The USDA has created Farm Resource Regions (USDA ERS 2006) for the United States that are based on four resources: 1.) the old Farm Production Regions, which divided the U.S. into ten regions that follow state boundary lines, 2.) a cluster analysis of farm statistics that show the major commodities that are being produced in various geographical locations regardless of state lines based on climate, soil, and water availability, 3.) USDA's Land Resource Regions classification that divides the U.S. into geographic locations based on soil, climate and water similar to the cluster analysis, and 4.) National Agricultural Statistics Service crop reporting districts.

The current USDA Farm Resource Regions (USDA ERS 2006) for the United States consist of nine regions called the Basin and Range, the Northern Great Plains, the

Heartland, the Northern Crescent, the Fruitful Rim, the Prairie Gateway, the Mississippi Portal, the Southern Seaboard, and the Eastern Uplands (Figure 2). The Basin and Range includes parts of California, Arizona, and New Mexico. The Fruitful Rim includes parts of California, Arizona, Texas, the entire state of Florida, Georgia, and South Carolina. The Prairie Gateway includes part of New Mexico, Texas, and the entire state of Oklahoma. The Mississippi Portal includes parts of Louisiana, Mississippi, Arkansas, and Tennessee. The Southern Seaboard includes parts of Texas, Louisiana, Arkansas, Mississippi, Alabama, Georgia, South Carolina, and North Carolina. The Eastern Uplands includes parts of Oklahoma, Arkansas, Missouri, Alabama, Georgia, Tennessee, and North Carolina. The Heartland includes most of Missouri. The difficulty with using USDA's current Farm Resource Regions is that their multi-state configuration do not allow for easy matching with state-level data on prices, production, and other variables.

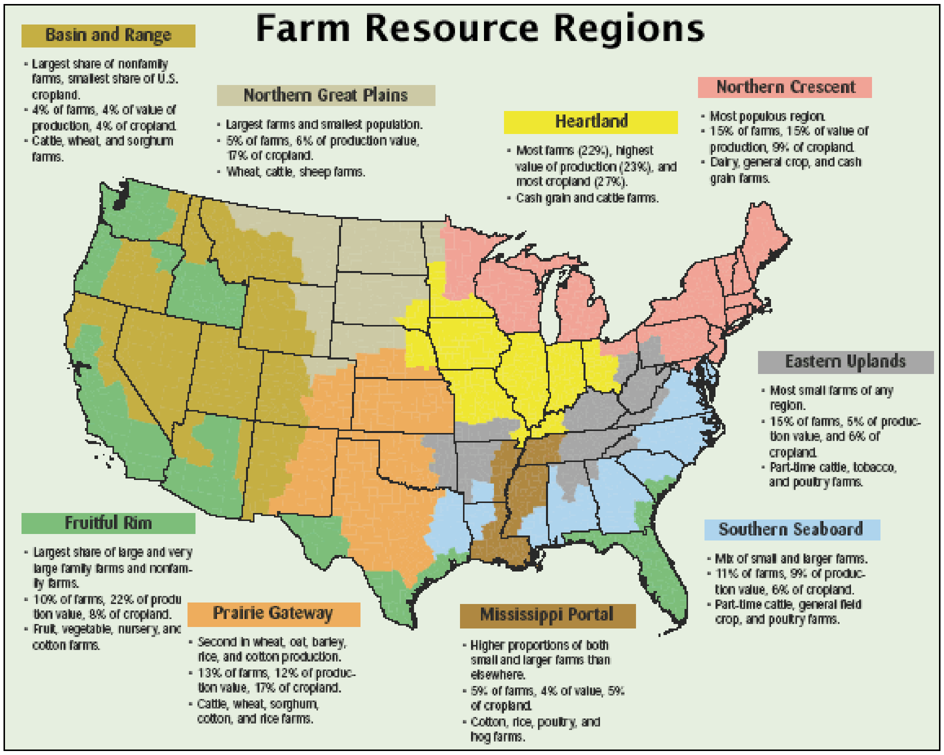

Figure 2. USDA farm resource regions
Source: USDA ERS 2006

The USDA had a prior classification system from 1995. Figure 3 below shows the USDA's older version of the Farm Production Regions (USDA ERS 2006). This map consists of regions that are made of states that follow boundary lines. I adapted this classification to identify five cotton producing regions.

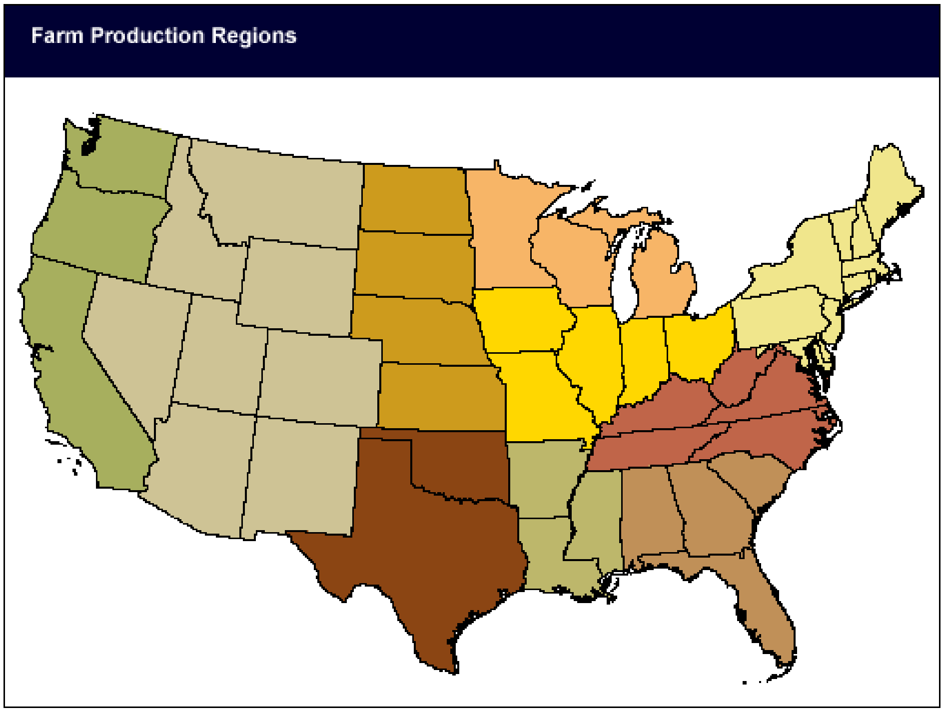

Figure 3. USDA farm production regions
Source: USDA ERS 2006

Prior to 1995, the USDA grouped Regions by commodities (Figure 4). These regions were formed based on production techniques and available resources. Since this paper focuses on cotton, the USDA's Cotton Production Regions were used. The USDA's Southwest region included Arizona and California. The Southern Plains region included Oklahoma, and Texas. The Delta region included Arkansas, Louisiana, Mississippi, Missouri and Tennessee, and the Southeast region included Alabama, Georgia, North Carolina, and South Carolina (USDA ERS 2007).

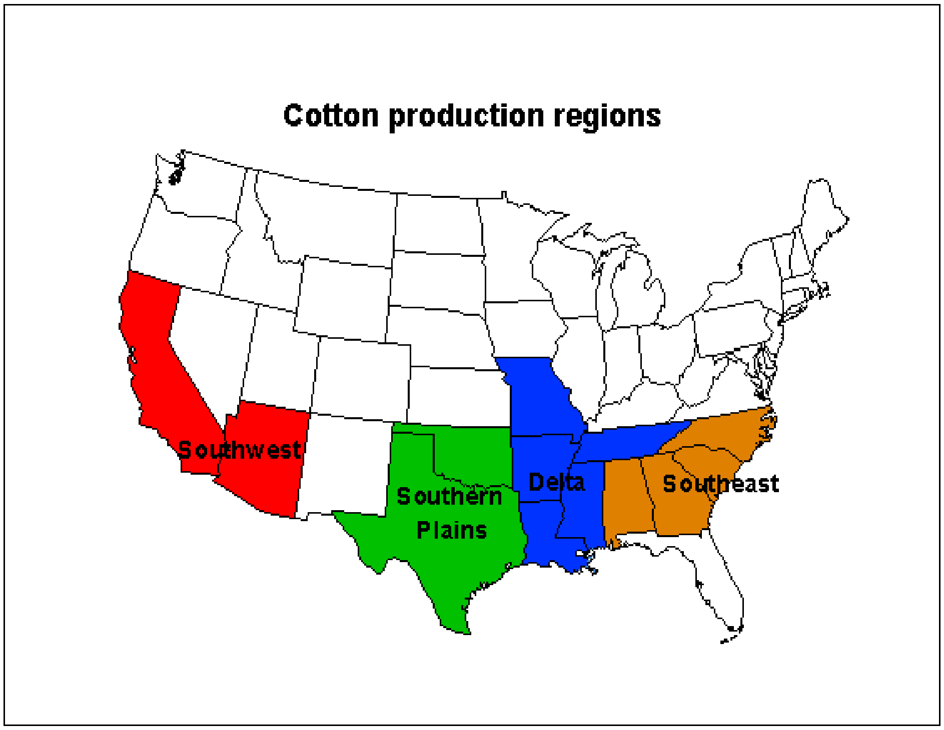

Figure 4. USDA cotton production regions
Source: USDA ERS 2007

This paper has defined five regions for the United States that combine the new and old USDA farm production regions (Figure 5). Region One includes North Carolina, Tennessee, and Virginia. Region Two includes Alabama, Florida, Georgia, and South Carolina. Region Three includes Arkansas, Louisiana, Mississippi, and Missouri. Region Four includes Kansas, Oklahoma, and Texas. Region Five includes Arizona, California, and New Mexico. These regional specifications were chosen for this paper because they appeared to better delineate different cotton production systems.

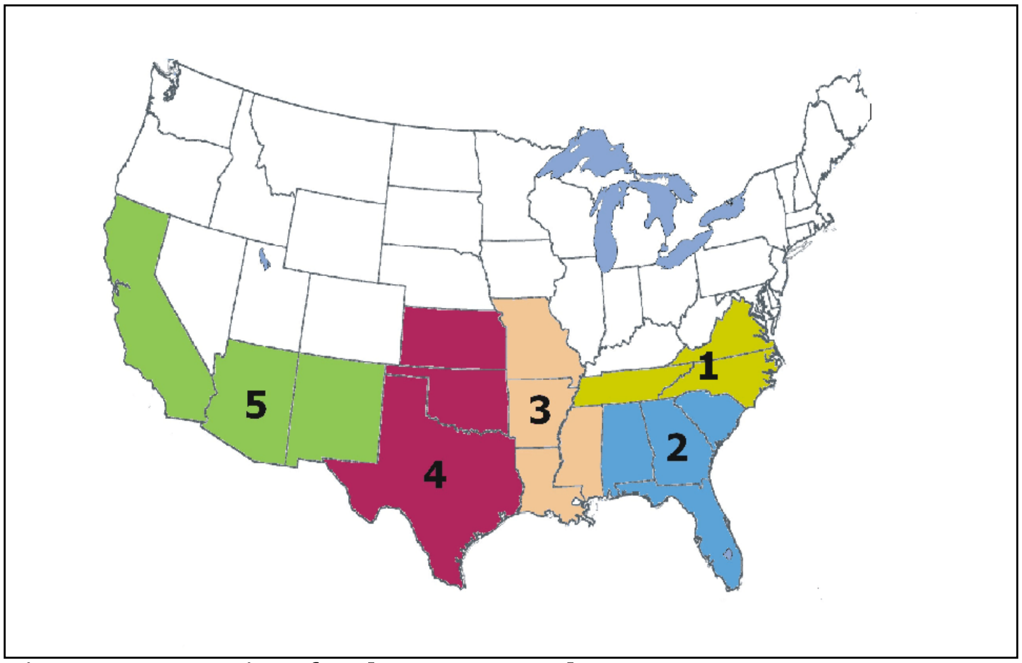

Figure 5. U.S. regions for the present study

Function Estimation and Data Development

A two equation model was used to econometrically estimate United States cotton supply for the five U.S. regions established above. Equations One and Two are estimated separately using ordinary least squares and are defined as the following linear specifications:

(1) $Yield_{t,r} = b_0 + b_1 PriceCotton_{t-1} + b_2 Yield_{t-1} + b_3 Weather_t + b_4\ Trend_t + b_5 BWE_t + b_6 Variety_t + b_7 NetExpenses_{t-1}$

(2) $Acres_{t,r} = b_0 + b_1 PriceCotton_{t-1} + b_2 Acres_{t-1} + b_3 Policy_t + \mathrm{b}_4 PriceCompetingCrops_{\mathrm{t-1}} + b_5 NetExpenses_{t-1} + b_6 Trend_t + b_7 BWE_t + b_8 PIK_t$

where

- b_i are the standard Beta OLS parameter estimates

- *Yield* is regional average cotton yield (in pounds) per acre, either in year *t* or lagged one season (*t-1*)
- $PriceCotton_{t-1}$ is regional season average price of cotton lagged one season (*t-1*)
- $Weather_t$ is a variable capturing important cotton growing weather conditions
- $Trend_t$ is a variable reflecting the linear trend of the dependent variable
- BWE_t is a 0/1 dummy variable indicating implementation of regional boll weevil eradication by year *t*
- $Variety_t$ indicates the adoption of new, productive cotton varieties by percentage used
- $Acres_r$ is harvested acres of cotton (in thousands of acres) for region *r* in either year *t* or lagged one season (*t-1*)
- $Policy_t$ is a 0/1 dummy variable indicating the year of implementation of farm bills between 1980 and 2002
- $PriceCompetingCrops_{t-1}$ is the regional season average price of major competing crops lagged one season (*t-1*)
- $NetExpenses_{t-1}$ reflects total variable costs per acre of regional cotton production lagged one year (*t-1*)
- PIK_t is another 0/1 dummy variable indicating the year of implementation of the Payment in Kind program.

Regional cotton yield (Equation 1) was estimated as a function of a lagged price of cotton, lagged yield, weather variables, trend, boll weevil eradication and cottonseed variety.

NASS estimates of regional yield and cotton price were used from 1979 to 2006 to represent lagged yield and the lagged price of cotton in both equations (USDA NASS 1979-2007). Following Nerlove and Addison (1958), I am therefore assuming that cotton growers formulated their price expectations based on their most recent prior experience. The data for cotton yield and price were obtained by averaging the yield and price data from NASS for the states included in each respective region.

Weather is obviously an important variable determining for crop yield and production. For cotton, the key weather influences are soil moisture and temperatures at particular points in the planting and growing season. To explain variations in yield, I would ideally collect representative data on soil moisture at planting and various plant growth stages across the region. However, such data are not available in an aggregate study. In this paper I approximated regional weather effects by simply indicating the occurrence of the El Niño/La Niña phenomenon. ENSO (El Niño/Southern Oscillation) represents abnormal changes in the atmosphere due to oceanic events causing subsurface temperatures to change resulting in effects in weather patterns throughout the world, redistributing rain, causing floods, and droughts. The Southern Oscillation refers to an oscillation of subsurface temperatures. El Niño and La Niña are two extreme phases of the ENSO climate cycle (NOAA 2001). El Niño occurs when there is an irregular warming of subsurface temperatures from Peru to Ecuador to the Pacific. Past El Niño occurrences were recorded in 1951, 1953, 1957-1958, 1965, 1969, 1972-1973, 1976, 1982-1983, 1986-1987, 1991-1992, 1994 and 1997 (Thomas 2000).

The effects of El Niño results in less rain and mild conditions across the Northern United States and causes an increase in rain across the Southern part of the United States (Pena 2008). La Niña represents a cooling of subsurface temperatures and was recorded in 1950, 1954, 1964, 1970, 1973, 1975, 1988, and 1995 (NOAA 2001). La Niña causes warmer conditions and less rain across the Southern United States and more rainy conditions across the Northern United States (Pena 2008). I expect that El Niño conditions would generally result in more moisture and higher cotton yields in the relatively drier regions such as Region Four (Texas, Oklahoma, and Kansas). I would also expect La Niña years to result in more drought conditions and lower yields, *ceteris paribus*.

Figures 6, 7, and 8 show the precipitation effects of strong El Niño events from 1895 to 1997 from January to March, March to May and April to June. Figure 6 shows that from January to March, the Southwest becomes somewhat wet to wet and parts of the Northwest and Northeast become dry to very dry during El Niño events. Figure 7 shows that from March to May, the Southwest becomes very wet, and the North and Southeast becomes dry to very dry. Figure 8 shows that during strong El Niño events, the North and Southwest become wet to very wet and much of the North and Southeast become normal with some areas of the Northeast experiencing dry to very dry precipitation.

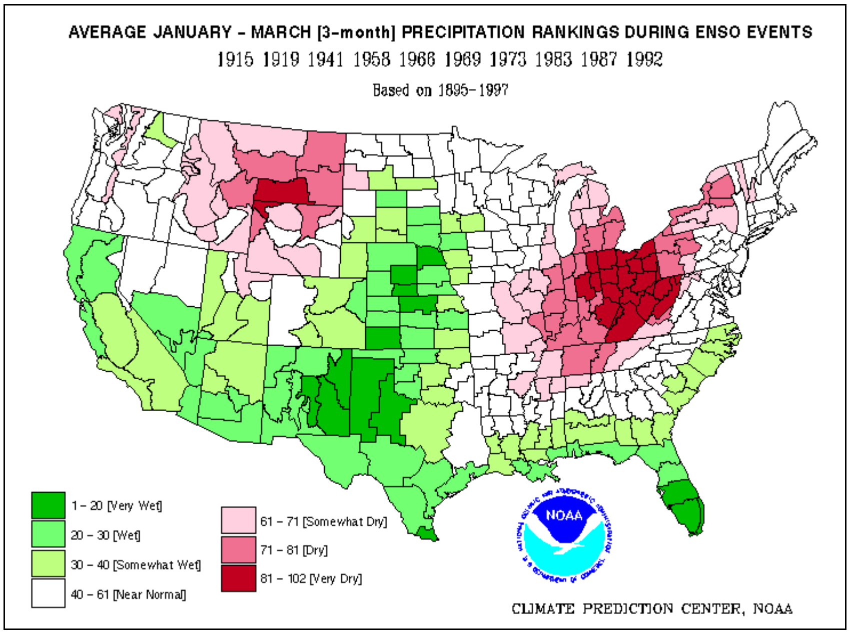

Figure 6. January to March precipitation during ENSO events, 1895-1997

Source: National Weather Service 2008

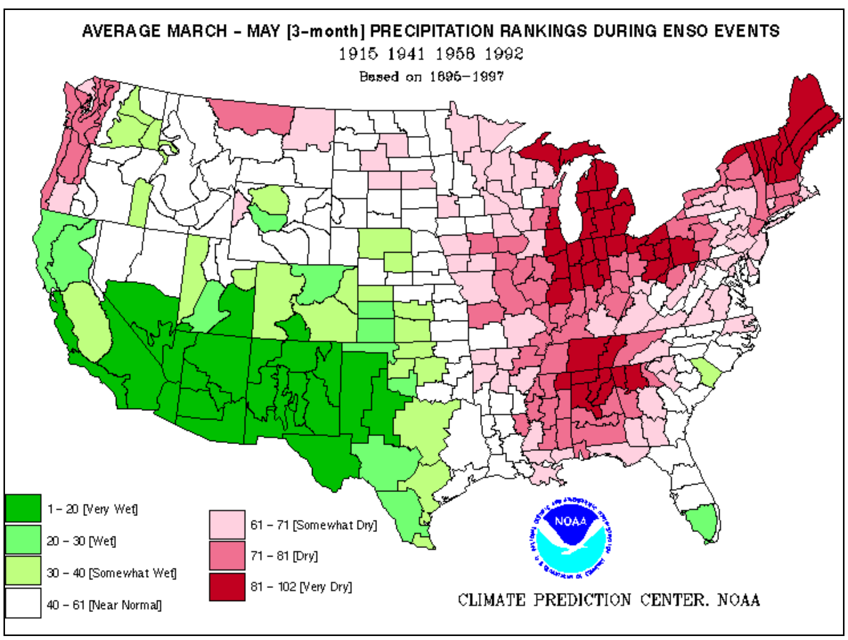

Figure 7. March to May precipitation during ENSO events, 1895-1997

Source: National Weather Service 2008

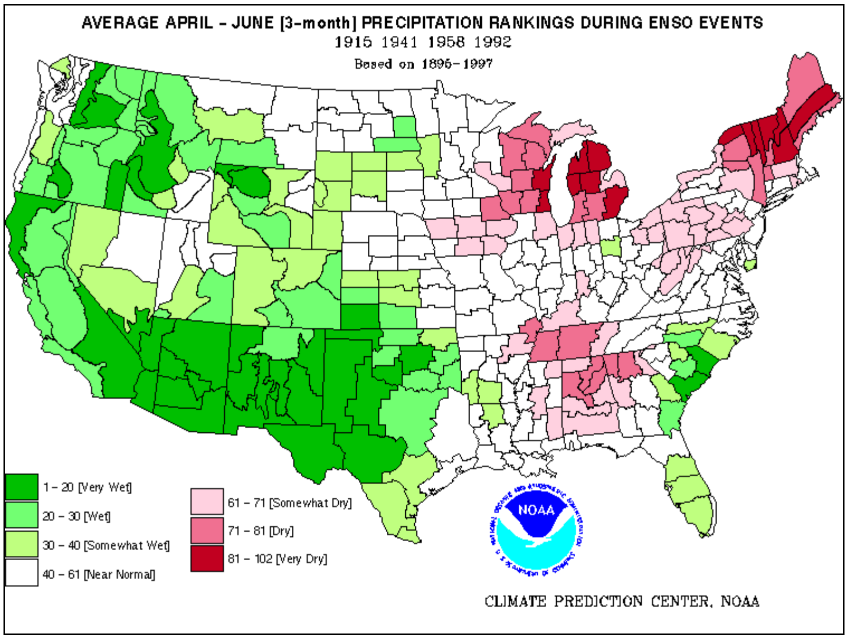

Figure 8. April to June precipitation during ENSO events, 1895-1997
Source: National Weather Service 2008

This study also looked at an alternative method of accounting for weather effects on cotton yield by using cumulative monthly precipitation in inches. Previous research has employed rainfall and temperature data series from weather stations to represent the wider region. Precipitation data were obtained from historical data (Weather Underground, 1980-2007). I needed to determine which counties produced the most cotton so that weather station data from Weather Underground could be found to correspond with temperatures in that region. To do this, I used National Cotton Council (2007) estimates of county production by state in planted acres, harvested acres, yield, and bales.

In Region One (North Carolina, Tennessee, and Virginia), data from Raleigh, North Carolina was used to represent precipitation data in this region. In Region Two

(Alabama, Florida, Georgia, and South Carolina), historical precipitation data from Huntsville, Alabama were averaged with data from Pensacola, Florida, and Columbia, South Carolina from 1980 to 2007. Pensacola is in Escambia County, the third highest cotton producing county in Florida. No other weather station data were available for the cities within the cotton producing counties in Florida. The Albany, Georgia precipitation data would be used to represent the weather in Georgia cotton production, but no data later than 1996 were available, so Georgia weather was not included in this time series data set. Columbia, South Carolina is located in Richland County, which is not a top cotton producing county in South Carolina, but is adjacent to a county that does produce some cotton. Weather station data from Columbia was used because no other city within the top producing counties could be found.

In Region Three (Arkansas, Louisiana, Mississippi, and Missouri), the only historical weather available was in Jonesboro, Arkansas which is located in the second highest producing county in Arkansas. These data could not be used because the data do not go back any further than 1996. There was no historical weather data for any cities located in the top counties in Louisiana. The closest weather station data available was located in Vicksburg, Mississippi and lacks data preceding 1996. Precipitation data for Greenwood, Mississippi were used for this time series.

In Region Four (Texas, Oklahoma, and Kansas), precipitation data were taken from Lubbock, Texas to represent the entire Region. In Region Five (Arizona, California, and New Mexico), precipitation data were averaged from Fresno, Bakersfield, and Stockton California. The San Joaquin Valley produces the bulk of

California’s cotton. Fresno is located in Fresno County and is the second highest producing county in California. Bakersfield is located in Kern County, the third highest cotton producing county, and Stockton is located in San Joaquin County, but is not a top ten producing county.

The initial stages of specifying the regression included only the month of June to represent a precipitation variable. The months of May and July were later added to account for the effects of weather on planting/stand establishment (in May) or on crop development and yield potential (in July).

Boll weevil eradication (BWE) is likely to have a large effect on the yield regression. Since 1983, the boll weevil has been functionally eradicated from 12.5 million acres in Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Kansas, California, and Arizona. The eradication program is ongoing in 3.5 million acres of planted cotton in parts of Tennessee, Mississippi, Missouri, Arkansas, Louisiana, Oklahoma, Texas and New Mexico. A dummy variable was used to represent the effect of the eradication on yield and acreage. In Region One, boll weevil eradication in North Carolina began in 1983 and was completed in 1987. Eradication began in parts of Tennessee in 1994, 1998, and 2000 and 1977 in Virginia. The indicator variable used in the regression changed at 1983. In Region Two, Alabama, Florida, and Georgia started the eradication program in 1987. South Carolina began eradicating in 1983, so the year indicated by a “1” value began with 1987. In Region Three, Louisiana and parts of Arkansas, and Mississippi began the eradication program in 1997, while Missouri started the eradication program in 2001. The “1” value for this indicator variable started in 1997. In Region Four, parts of Texas began eradicating in 1994, 1998 in Oklahoma and was completely eradicated by 2005, so the “1” dummy variable in this regression started in 1994. In Region Five, California began eradicating in 1983, Arizona began in 1985, and New Mexico began in 1988. The “1” dummy variable used in this regression started in 1983 (El-Lissy and Grefenstette 2005).

The BWE variable indicates a year averaged between the states in each region for areas that have begun the eradication program. In addition to this version, lagging the BWE variable by four years was also tried to ensure that the program had time to take effect.

The effect of cottonseed varieties were also used to estimate yield with data collected from the USDA Agricultural Marketing Service (AMS) *Cotton Varieties Planted* publications (1999-2008). The time series data used in this project’s regressions include the percentages of newer varieties that contributed to recent increases in yield. The AMS has four growth areas: the Southeast (Alabama, Florida, Georgia, North Carolina, South Carolina, and Virginia), South Central (Arkansas, Louisiana, Mississippi, Missouri, and Tennessee), Southwest (Texas, Oklahoma, and Kansas) and the West (Arizona, California, and New Mexico).

Region One and Region Two use the AMS data from the Southeast. The most popular variety from these regions that has made a significant impact on yield is the Deltapine Boll Guard/Round-up Ready strains. The Deltapine varieties used for these regressions started in 2003 with an adoption rate of 22.89 percent. In 2004, Deltapine varieties more than doubled to 48.82 percent, 61.54 percent in 2005, and 74.61 percent in 2006. AMS data were lacking for 2007, so the average of the 2006 and 2008 years was used to get a percentage for 2007. The 2008 percentage was 62.33, and after averaging, 2007 had a percentage of 68.47.

The AMS data for the South Central was used to calculate the percentages of new variety adoption in Region 3. The Deltapine Boll Guard/ Round-up Ready, B/RR varieties were most used in this region. In 1999, the Deltapine percentage used was 3.44 percent, 21.5 percent in 2000, 16.86 in 2001, 17.17 in 2002, 22.04 in 2003, 40.65 in 2004, 50.2 percent in 2005, and 63.47 in 2006. Again, because of the data lacking in 2007, the percentages for 2006 and 2008 were averaged. In 2008, the percentage used was 43.71, which gave a 2007 percentage of 53.59.

The AMS Southwest region was used in Region Four to determine the effect of the popular Fibermax strain. AMS has variety data for Fibermax starting in 2001 with a percentage use of 6.56, 10.32 in 2002, 19.96 in 2003, 30.76 in 2004, 37.27 in 2005, 40.04 in 2006, and 42.605 in 2007. The percentage of use in 2007 was determined by averaging the 2008 percentage of 45.17 and the 2006 percentage. The AMS west growth region is used in Region Five. The variety captured in the regression for this region is Deltapine Boll Guard/ Round-up Ready. In 2000, the percentage used is 3.41, 4.21 in 2001, 6.18 in 2002, 16.83 in 2003, 20.75 in 2004, 22.72 in 2005, 16.3 in 2006, 27.465 in 2007 (after averaging 2006 and the 2008 percentage of 38.63) (USDA AMS, 1999-2008).

The USDA's Historic and Old Format Production Regional Cost and Return Data contain cotton farm budgets from 1975 to 1996. The cash expenses from the budget sheet were used to represent my $NetExpenses_{t-1}$ variable for the regressions. The cash expenses include seed, fertilizer, chemicals, custom operations, fuel, lube and electricity, repairs, hired labor, ginning, and other variable expenses calculated from 1979 to 1996 (USDA ERS 2008). Years 1997 to 2007 were forecasted numbers. Region One and Region Two regressions contain cash expense data from the Southeast. The regression for Region Three contains cash expense data from the USDA Delta region and Region Four contains cash expense data from the USDA Southern Plains region. The regression for Region Five contains cash expense data from The USDA Southwest region. Net expenses are used in both yield and acreage regressions.

Once the initial regressions were run, variations to the data were made to explore alternatives. Net expenses used in the regressions are lagged under the assumption that producers would plant cotton in the current year based on the expenses used in the previous planting season. Unlagging net expenses would mean that producers plant the current year's cotton based on the expected costs of planting in the current season. Unlagging net expenses was tried in each of the yield and acreage regressions and the regression results did not change much compared to the original regressions, so lagged net expenses were used in the final regressions.

Harvested acres (Equation 2) was estimated as a function of lagged price of cotton, lagged acres, policy variables, lagged prices of competing crops and lagged net expenses. Data for the lagged price of cotton, lagged acres, lagged price of corn and lagged price of soybeans were taken from NASS Quickstats for the years 1979 to 2006

(USDA NASS 1979-2007). Again, the data for acres and price were averaged for the individual states in each region.

The policy variables were dummy variables indicating the years following the implementation of the 1981, 1985, 1990, 1996, and 2002 farm bills. The 1981 farm bill, also titled “The Agriculture and Food Act of 1981” covered topics of the loan program, price supports, and specific changes regarding cotton. The 1981 farm bill specified that the loan rates for cotton would be determined as specified by the 1977 farm bill. It also continued the use of target price and deficiency payments which had to be the higher of the minimum level plus additional production costs or 120 percent of the loan. This farm bill featured an acreage limitation to reduce planted acres of cotton (Johnson, et al. 1982).

The Food Security Act of 1985 set the target price of cotton at $0.729 per pound. The minimum nonrecourse loan rate was set at $0.55 per pound. A marketing loan was instituted when the world price of cotton was below the loan price. Producers could either repay their loans at the loan rate level or at the market price of cotton. The act allowed farmers to still receive deficiency payments (Glaser 1986). In short this legislation solidified the role of farm program payments in supporting cotton prices and incomes, and likely reinforced non-market incentives to produce cotton on base acres.

The Food, Agriculture, Conservation and Trade (FACT) Act of 1990 continued the basic orientation of the previous legislation, although it limited payments slightly for budget reasons. The 1990 legislation set a loan rate at 85 percent of a five year moving average, mandated marketing loans for cotton and as well as a minimum loan rate. The target price for cotton was set at $0.729 per pound. The Acreage Reduction Program was instituted with a maximum of 25 percent of cotton crops that could be reduced. Producers could receive loans from the government, keeping their crop as collateral. The loan rate for cotton was set at 85 percent of the Olympic average of spot prices with a minimum of $0.50 per pound. This bill also instituted the Conservation Reserve Program (CRP), which took out some highly erodible cotton land (USDA ERS 1996).

The Federal Agriculture Improvement and Reform Act (FAIR) of 1996 was notable in giving producers almost total flexibility in their planting decisions, while it limited government payments. The increased flexibility allowed farmers to plant 100 percent of their total contract acreage to any crop. The bill also eliminated acreage reduction programs. The bill kept the nonrecourse and marketing loans. The loan rate was set again at 85 percent of the Olympic average with a minimum of $0.5192 per pound (USDA ERS 1996a).

The Farm Security and Rural Investment Act of 2002 reinstituted some of the risk buffering aspects of the 1985 farm program. Under the 2002 legislation, cotton producers were allowed to receive direct payments at a rate of $0.0667 per pound. Counter cyclical payments were reinstituted and were made when the effective price was lower than the target price. The target price for cotton was $0.724 per pound. The 2002 farm bill continued the planting flexibility rules of the 1996 farm bill and the marketing loan was extended with a loan rate of $0.52 per pound. The Conservation Reserve Program, Wetlands Reserve Program, and the Environmental Quality Incentives Program were extended (Young 2008).

In 1983, the Payment-in-Kind, or PIK, program was a one time, voluntary acreage reduction program that paid farmers to reduce their production in grain, cotton, and rice, which caused a reduction of 49 million crop acres. This program is represented as a 0,1 dummy variable (USDA ERS 1984).

Hypothesis Testing

Before the regressions were estimated, hypotheses were posited about the signs of the independent variable coefficients. In the yield regressions, the lagged price of cotton, lagged yield, trend, boll weevil eradication, and cottonseed variety are expected to have positive coefficients. Trend, BWE, and variety should be positive because these variables show advancement in technology. Pest eradication, captured by the BWE variable, would increase yield and therefore have a positive beta coefficient. The genetically modified cottonseed varieties would also create a positive beta coefficient. Lagged net expenses are expected to have a negative coefficient since higher priced inputs would be used less, thus reducing yield. May, June, and July precipitation variables are expected to have positive coefficients. El Niño should have a positive coefficient because it creates wet and rainy conditions across the Southern part of the U.S. and La Niña should have a negative coefficient because it creates drought-like conditions across the Southern part of the U.S. Specifically, for the Southwest Region we expect a positive sign for El Niño and a negative sign for La Niña.

In the acreage regression, the lagged price of cotton, lagged acres, trend, and boll weevil eradication are expected to have positive coefficients for the reasons mentioned above. The lagged price of corn, lagged price of soybeans, lagged price of peanuts, and lagged net expenses should have negative coefficients, the former three being substitutes for cotton in various regions. The five farm bills and the PIK dummy variable should have either positive or negative effects depending on the region. For example, the cotton acreage in Texas is fairly fixed and would not be expected to vary much with previous changes in farm bills. However, farm legislation that allowed more planting flexibility, e.g., the 1996 legislation and thereafter, would be expected to have a negative impact on cotton acres in regions than can feasibly grow alternative crops, since there have been periodic spikes in grain and oilseed prices since the mid 1990's.

The variables used in the yield regressions may be separated into two groups. El Niño and La Niña are expected to capture the same effects as the May, June, and July precipitation variables, and trend is expected to capture similar effects as the boll weevil eradication variable and varietal impacts.

CHAPTER IV

RESULTS AND ANALYSIS

This chapter will focus on the results of the regressions described in Chapter III. This chapter will be divided into three main parts: 1.) summary statistics and graphs that describe the independent variables in each region, 2.) regression analyses that contains partial correlations, regression and parameter results, and regional analyses where the yield and acreage regressions of each region will be analyzed separately and 3.) a section dedicated to the estimation of elasticities.

Descriptive Statistics

This section provides basic statistical information regarding the data. Included in this section are the summary statistics and the graphs of the independent variables for yield and acreage in each region.

Tables 1 and 2 below show the summary statistics for yield and acreage. The summary statistics show the mean, minimum, median and maximum values for each variable as well as the standard deviations and the confidence intervals. Looking at Table 1, the mean yield in Region Four is much lower than other regions. California produces an average yield double that of Region Four. The other regions are close in mean yield output and rank. The difference between Region Four and Region Five is that Texas (Region Four) has more dryland cotton production than any other state, whereas California (Region Five) is strictly irrigated. The minimum, median, and maximum statistics give results that correspond to the mean. Regions One, Two, and

Three are quite similar. Region Four has the smallest statistics, while Region Five has the highest values. Each region shows about the same variability between the highs and lows. In Table 2, the acreage results show that the mean for Region Four dominates the other regions in acreage significantly. The minimum, median, and maximum is about the same for Regions One, Two, and Five. Region Three is less than the results for Region Five, but is much larger compared to the other regions. The statistical summaries are significantly larger in Region Four.

Table 1. Cotton Yield (Lbs per Acre) Summary Statistics

	Region 1	Region 2	Region 3	Region 4	Region 5
Mean	626.298	620.598	728.893	418.518	1058.250
StDev	141.770	112.624	148.300	137.844	125.990
95 % LCI	562.842	570.188	662.514	356.819	1001.858
95 % UCI	689.753	671.008	795.271	480.216	1114.642
Min	349.000	397.000	391.250	203.500	860.333
Median	605.833	609.750	706.250	412.333	1031.500
Max	918.667	797.500	1014.750	766.333	1390.667

Table 2. Cotton Acreage (Thousand Acres) Summary Statistics

	Region 1	Region 2	Region 3	Region 4	Region 5
Mean	1001.464	1472.021	2898.964	4879.668	1300.64
StDev	485.423	747.626	599.365	730.99957	472.90
95 % LCI	784.191	1137.388	2630.691	4531.0382	1088.98
95 % UCI	1218.737	1806.655	3167.237	5228.2978	1512.31
Min	274.400	411.000	1468.000	3436.5	401.00
Median	1071.850	1450.250	2934.000	4908	1344.50
Max	1684.000	2519.000	4058.000	6067.6	2235.00

Figures 9, 10, 11, 12 and 13 show the actual yield amounts from 1980 to 2007 used in the regressions. Yield in Region One has an increasing, upward trend. Region Two, and Three have very flat trends. Regions Four and Five have slightly increasing trends in yield. Region One has an increasing upward trend in acreage. In Region Two, there is an increasing trend in yield until around 1995, and then it begins to flatten out. Region Three and Region Four have very flat trends and Region Five has a decreasing trend in yield. Due to technological advances like pest eradication, yield is expected to have increased over time. Yield does increase over time in Regions One, Three, Four, and Five. Region Two is very flat.

Figures 14, 15, 16, 17 and 18 show the actual acreage from 1980 to 2007. Region One acreage has an increasing trend. Region Two acreage increased until 1995 and then became relatively flat. Acreage in Region Three was increasing slightly until 1995 and then started to decline. Region Four acreage was around seven million acres and then decreased to around five million acres in 1982, where it remained relatively flat. Region Five acreage has a steadily decreasing trend. Acreage doesn’t change in Regions Three and Four because these regions always plants cotton for reasons of tradition, capital constraints, and (in the special case of Region Four) lack of feasible crop substitutes. Region Five is losing acreage production due to water constraints and substitutions to other horticultural crops. Also shown in the figures are the predicted values from the regressions. These will be referred to later in this chapter.

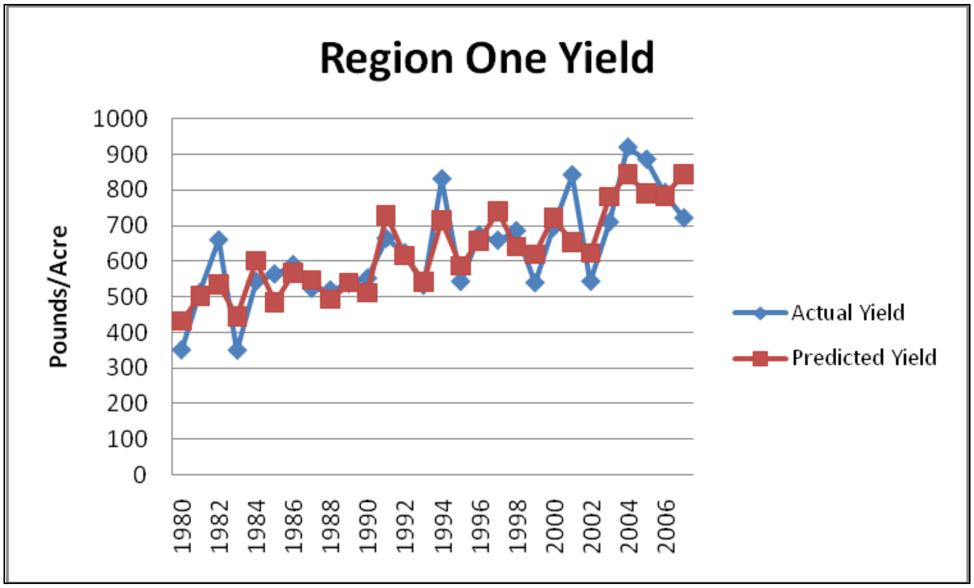

Figure 9. Region one yield: actual vs. predicted
Source: NASS 1980-2007

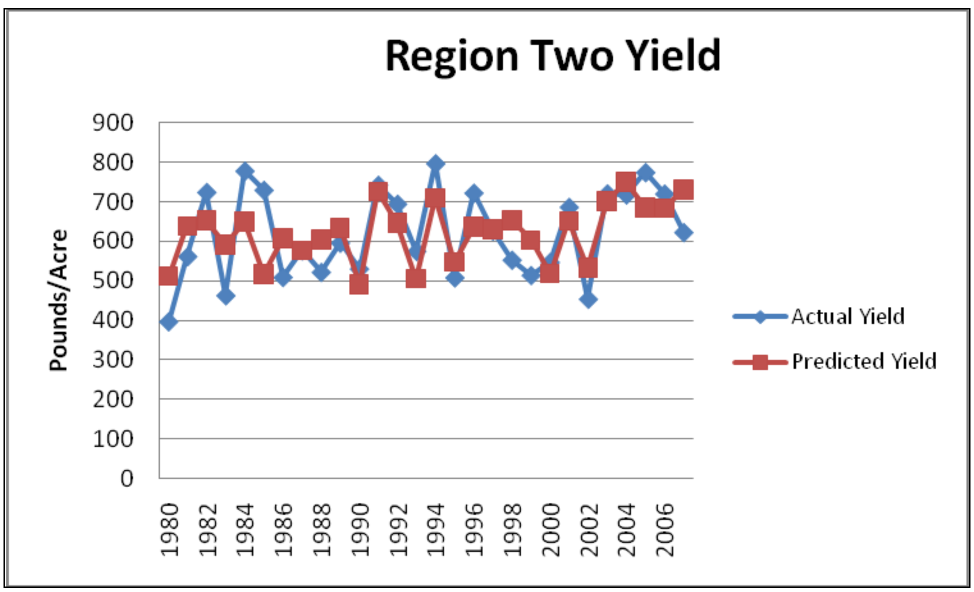

Figure 10. Region two yield: actual vs. predicted
Source: NASS 1980-2007

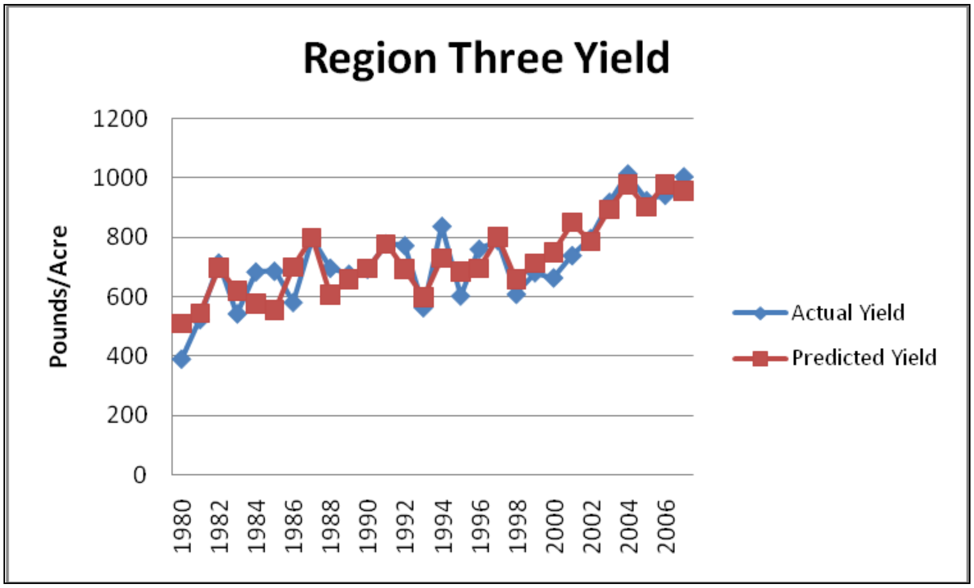

Figure 11. Region three yield: actual vs. predicted
Source: NASS 1980-2007

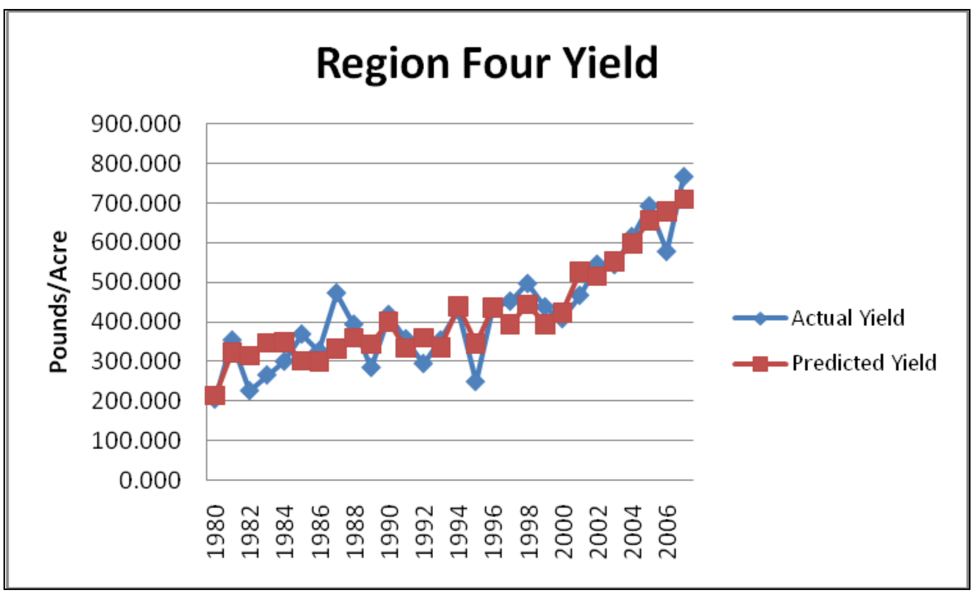

Figure 12. Region four yield: actual vs. predicted
Source: NASS 1980-2007

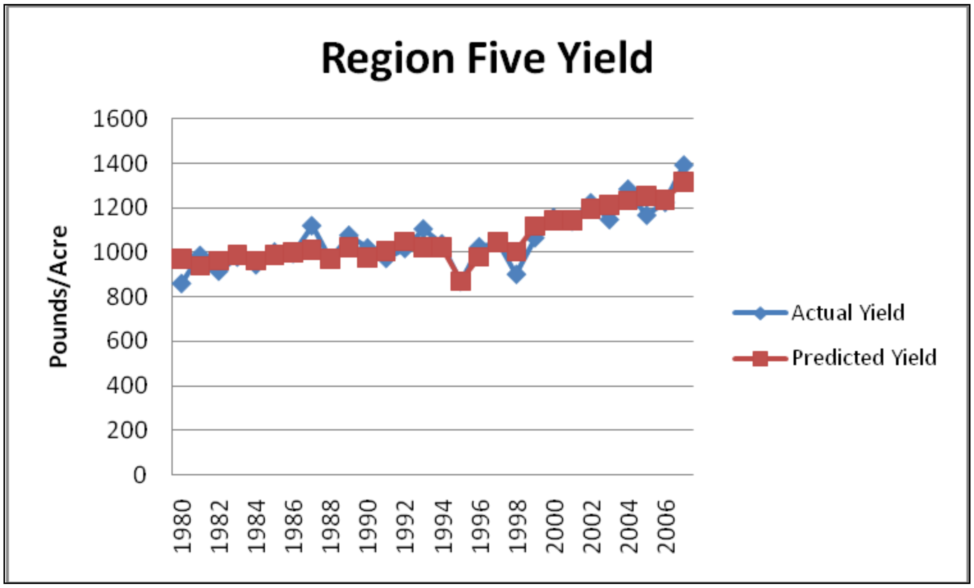

Figure 13. Region five yield: actual vs. predicted
Source: NASS 1980-2007

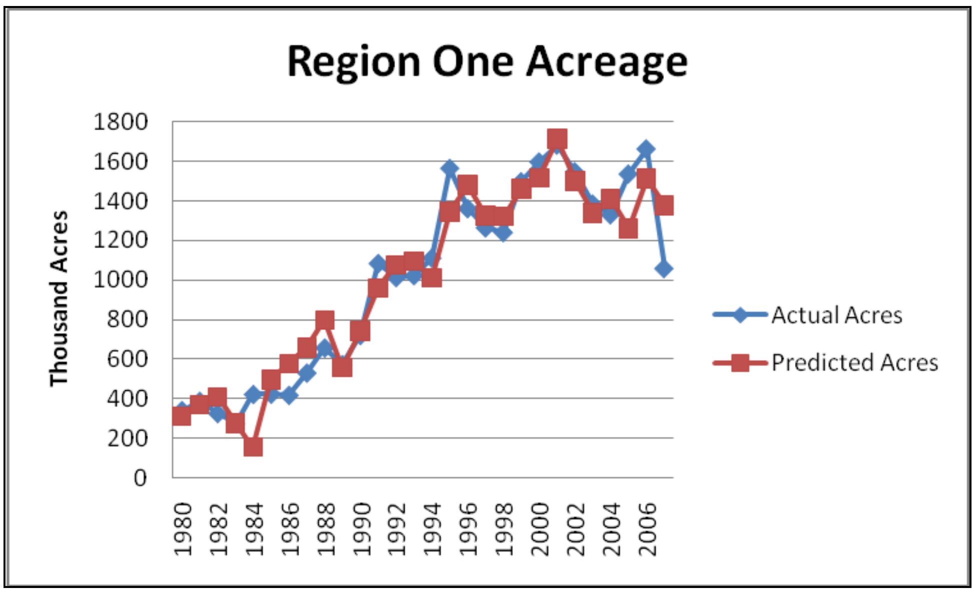

Figure 14. Region one acreage: actual vs. predicted
Source: NASS 1980-2007

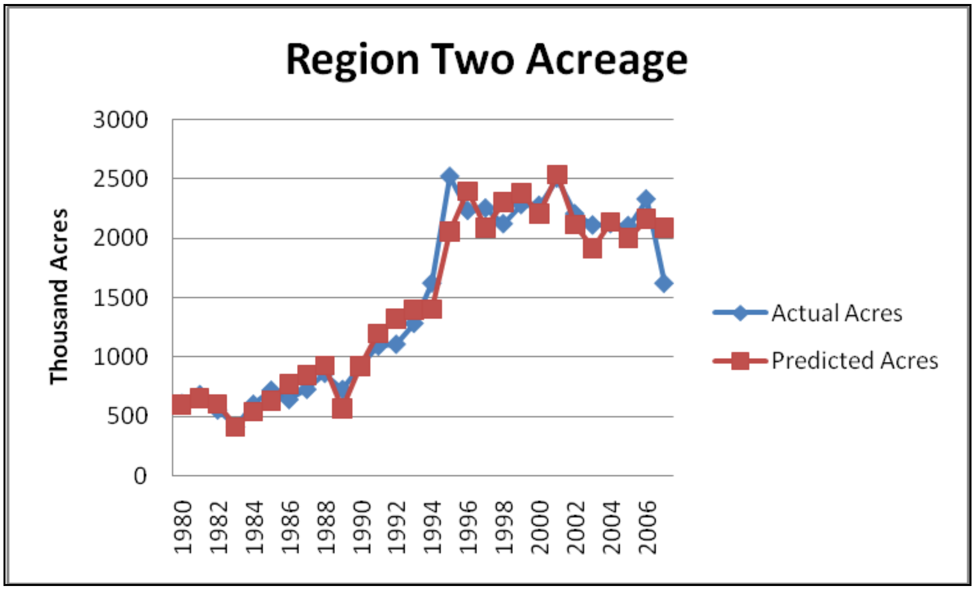

Figure 15. Region two acreage: actual vs. predicted
Source: NASS 1980-2007

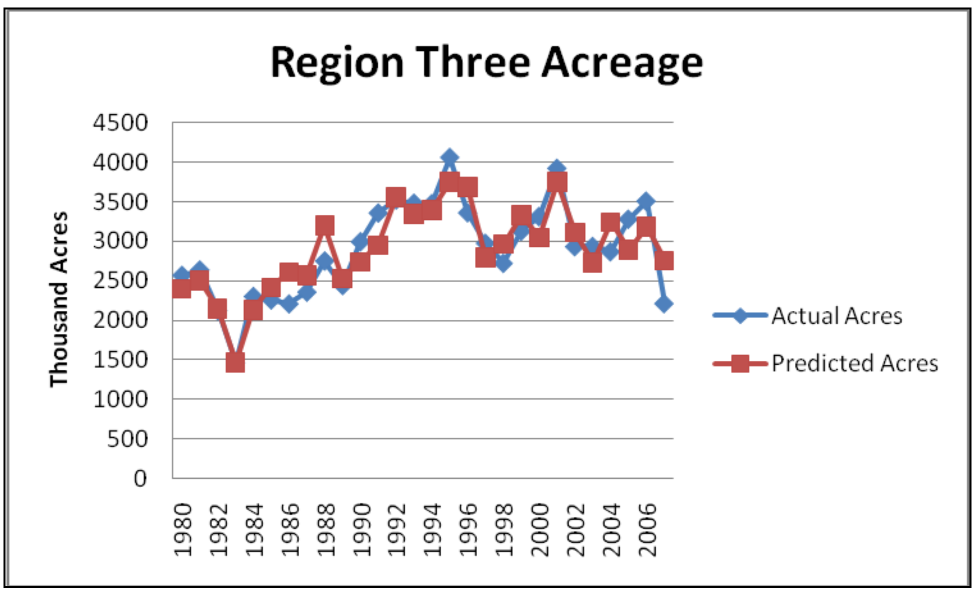

Figure 16. Region three acreage: actual vs. predicted
Source: NASS 1980-2007

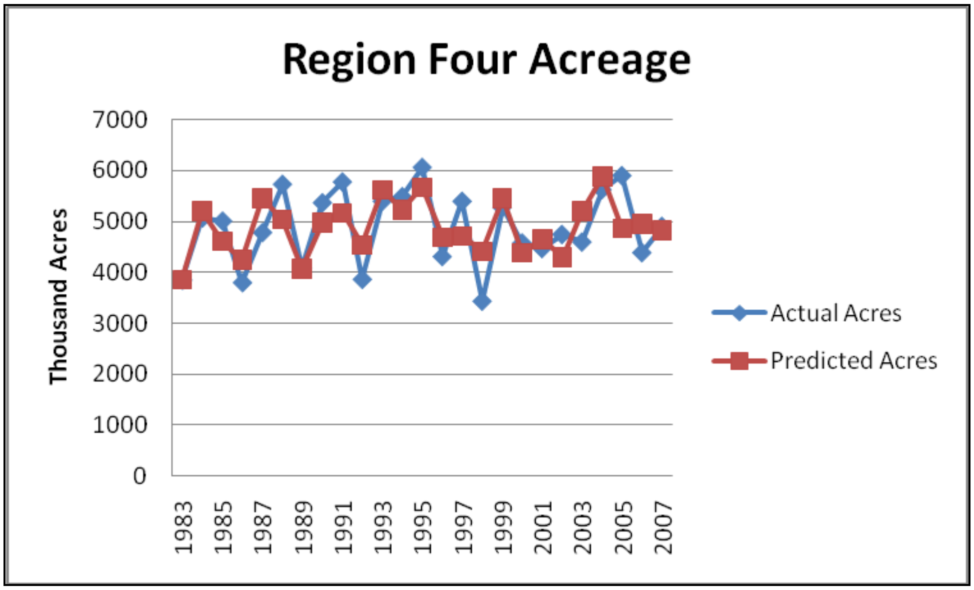

Figure 17. Region four acreage: actual vs. predicted
Source: NASS 1980-2007

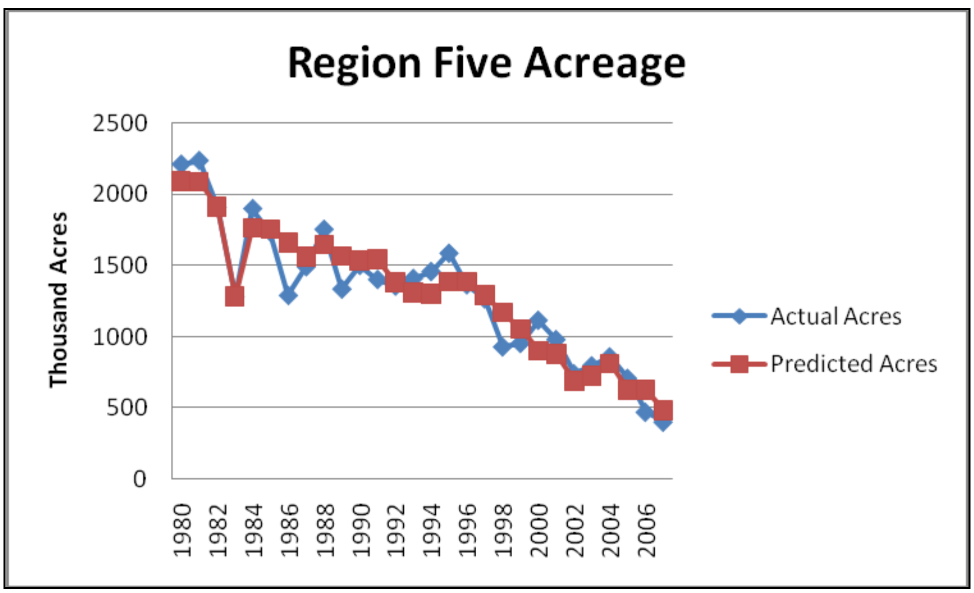

Figure 2. Region five acreage: actual vs. predicted
Source: NASS 1980-2007

Regression Analysis

This section will focus on the partial correlations on the yield and acreage regressions, the regression results comparing the F-tests, R^2 and adjusted R^2 (Rbar^2) parameter results that show the betas, p-values and t-tests, and an analysis of the results in each of the yield and acreage regressions.

Partial Correlation

The partial correlation values give results between -1 and +1 that show the singular effect that each independent variable has on the dependent variable. A zero partial correlation means that there is no linear relationship between the independent variable and the dependent variable, which would imply that the independent variable has no direct impact on the independent variable and probably should be (or has been) removed from the regression. A number close to -1 means that there is a strong negative correlation between the variables, and a number close to +1 means that there is strong positive correlation between the variables (Pindyck and Rubinfeld 1991). The partial correlations are displayed in Table 3 below. Lagged cotton price, El Niño, and BWE are positively correlated with yield in Regions One, Two, and Region Three. They are negatively correlated with yield in Regions Four and Five. Lagged yield is negatively correlated to yield in all regions, suggesting that yields tend to vary from year to year. El Niño is positively correlated with yield in all regions except for Region For and Five. La Niña and lagged peanut prices were removed from all of the regressions, so the partial correlation values are zero. BWE is negatively correlated with yield in Regions One and Two. Trend and variety are positively correlated in all regions except for trend in Region Four, where it was excluded from the regression. The May weather variable was only included in Regions Four and Five and is negatively correlated with yield in both. The June weather variable was included in Regions Three, Four, and Five and is positively correlated with yield in Region Three and negatively correlated with yield in Regions Four and Five. July weather is negatively correlated with yield in Regions Three, Four, and Five. Lagged net expenses is positively correlated with yield in Regions Two, and Four, and negatively correlated with yield in Regions One, Three, and Five.

By looking at Table 3, we can say that in Region One that El Niño and trend have strong impacts on yield. Lagged yield, variety, and July weather have somewhat strong impacts on yield, and lagged cotton price, BWE, and lagged net expenses have a weak influence on Region One. Region Two yields are influenced by El Niño and July weather. Lagged cotton price, lagged yield, trend, and variety have somewhat of an impact on Region Two, while lagged net expenses has a very weak impact. Region Three is strongly influenced by El Niño, trend, and lagged net expenses, somewhat influenced by BWE, variety, and July weather, and weakly influenced by lagged cotton price and lagged yield. Region Four is strongly influenced by variety and June weather, somewhat influenced by lagged net expenses, and weakly influenced by lagged cotton price, lagged yield, El Niño, BWE, and July weather. Region Five is strongly influenced by variety, somewhat influenced by lagged cotton price, lagged yield, and trend, and weakly influenced by El Niño, May, June, and July weather, and lagged net expenses. Later in this chapter we review the significant variables in each of the regressions. If the results of the partial correlations are compared to the significant variables, we see that they are almost exactly the same.

Table 3. Partial Correlations for the Yield Regressions

	Region 1	Region2	Region 3	Region 4	Region 5
Cotton Price$_{t-1}$	0.057	0.370	0.186	-0.174	-0.269
Yield$_{t-1}$	-0.371	-0.310	-0.146	-0.064	-0.216
El Nino	0.469	0.480	0.587	-0.122	-0.025
La Nina	0.000	0.000	0.000	0.000	0.000
Peanut Prices$_{t-1}$	0.000	0.000	0.000	0.000	0.000
Trend	0.466	0.217	0.525	0.000	0.208
BWE	-0.058	-0.234	0.301	0.133	0.000
Variety	0.304	0.321	0.295	0.598	0.470
May	0.000	0.000	0.000	0.000	-0.186
June	0.000	0.000	0.288	-0.406	-0.147
July	0.341	0.435	-0.245	-0.104	-0.023
Net Expenses$_{t-1}$	-0.084	0.068	-0.447	0.210	-0.014

Note: BWE represents Boll Weevil Eradication. These results are referring to Equation 1.

Table 4 below shows the partial correlations for the acreage regressions in each of the five regions. The lagged price of cotton is positively correlated with acreage in all regions. Lagged acres are positively correlated with acres in Regions, Two, Four, and Five and negatively correlated in Regions One and Three. The 1981, 1985, and 1990 farm bills were excluded from the regressions and therefore have a zero correlation. The 2002 farm bill was only included in Region Three and is negatively correlated with acreage. The 1996 farm bill is positively correlated with acreage in all regions except for Regions Three and Four. The lagged price of corn is negatively correlated with acreage in all regions. The lagged price of soybeans is positively correlated with acreage in all regions except for Region Two. Region Five does not produce soybeans and therefore has a zero correlation. The lagged price of peanuts is only included in Region Two and is positively correlated. Lagged net expenses is positively correlated in Region Three, and excluded from Region Five. Trend is positively correlated in Regions One, Two, and Four and is negatively correlated in Regions Three and Five. PIK is negatively correlated with acreage in all regions and BWE is positively correlated with acreage in Regions One, Three, and Five.

Reviewing Table 4, we see that acreage in Region One is strongly influenced by lagged cotton price and lagged yield, somewhat influenced by lagged price of corn, and PIK, and weakly influenced by the 1996 farm bill, lagged price of soybeans, lagged net expenses, and BWE. Region Two is strongly influenced by the lagged price of cotton, lagged acres, and trend, and somewhat influenced by the lagged price of soybeans, lagged price of peanuts, lagged net expenses, and BWE, and weakly influenced by the 1996 farm bill, lagged price of corn and PIK. Region Three appears to be strongly influenced by lagged cotton price, the 1996 farm bill, the 2002 farm bill, the lagged price of corn, lagged net expenses, and PIK, and somewhat influenced by trend and BWE, and weakly influenced by lagged acres and lagged soybeans. Region Four is strongly influenced by lagged acres, the 1996 farm bill, and the lagged price of corn, somewhat influenced by lagged price of cotton, the 1985 farm bill, PIK, and BWE, and weakly influenced by the lagged price of soybeans and lagged net expenses. Region Five appears to be strongly influenced by trend and PIK, somewhat influenced by lagged price of cotton and lagged acreage, and weakly influenced by the 1996 farm bill, lagged price of corn, and BWE. Again, the partial correlations almost always match up with the significant variables in each of the regressions shown in the parameter results later in this chapter.

Table 4. Partial Correlations for the Acreage Regressions

	Region 1	Region2	Region 3	Region 4	Region 5
Price Cotton$_{t-1}$	0.542	0.619	0.419	0.292	0.380
Acres$_{t-1}$	0.783	0.561	-0.012	-0.498	0.214
1981 Farm Bill	0.000	0.000	0.000	0.000	0.000
1985 Farm Bill	0.000	0.000	0.000	-0.348	0.000
1990 Farm Bill	0.000	0.000	0.000	0.000	0.000
1996 Farm Bill	0.023	0.049	-0.511	-0.533	0.079
2002 Farm Bill	0.000	0.000	-0.476	0.000	0.000
Price Corn$_{t-1}$	-0.355	-0.111	-0.488	-0.429	-0.059
Price Soybeans$_{t-1}$	-0.105	-0.285	0.095	0.181	0.000
Price Peanuts$_{t-1}$	0.000	0.233	0.000	0.000	0.000
Net Expenses$_{t-1}$	0.169	-0.342	0.469	-0.128	0.000
Trend	0.000	0.482	-0.345	0.000	-0.642
PIK	-0.269	-0.157	-0.612	-0.301	-0.575
BWE	0.039	-0.301	0.257	0.232	0.027

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication. These results are referring to Equation 2.

Regression Results

The purpose of the Ordinary Least Squares method is to find the best fitting line through the data. The best fitting line will be determined through various measures of fit. The best measures of fit can be determined by estimating the coefficient of determination, or R^2. The R^2 is a goodness of fit measure that is number between zero and one, with zero indicating no fit, and a one with a perfect fit. The number of independent variables can raise the R^2. However, the use of the Rbar^2 can also be used, which compensates for the effect of added regressors. The addition of independent variables may either raise or lower the value. This paper also looks at the F-tests in Table 5. The F-test is used to test the significance of the R^2. It tests the hypothesis that none of the independent variables help to explain the variation of the dependent variables (Pindyck and Rubinfeld 1991; Mirer 1995).

Table 5 below shows the regression results for yield and acres in each of the five regions. Comparing the results for each region, we see that the R^2 for yield in each of the regions varies from 0.430 to 0.823. The results for acreage range from 0.196 to 0.944. Regions Four and Five have the best results for yield with R^2 values of 0.823, and 0.816. Regions One and Three have R^2 values of 0.711 and 0.778 and. Region Two has an R^2 of 0.430, a very poor number. The statistical results for yield are somewhat disappointing, because the goodness of fit measures are low. The low R^2 value for Region 2 yield implies that a majority of the variability in yield is not being explained by my model. The acreage results are greatly different than the yield results and are more statistically pleasing. Regions One, Two, and Five have very good results with R^2 values of 0.925, 0.929, 0.946, and 0.913. Regions Three, and Four, however, have shown poor acreage results with R^2 values of 0.798, and 0.510.

Table 5. Yield and Acreage Regression Results

	F-Test	R^2	$Rbar^2$
Region 1:			
Yield	5.850	0.711	0.590
Acres	29.278	0.925	0.893
Region 2:			
Yield	1.793	0.430	0.190
Acres	29.538	0.946	0.914
Region 3:			
Yield	7.009	0.778	0.667
Acres	6.703	0.798	0.679
Region 4:			
Yield	11.072	0.823	0.749
Acres	1.733	0.510	0.216
Region 5:			
Yield	8.888	0.816	0.724
Acres	29.572	0.912	0.881

Parameter Results

This subsection will review the betas, t-tests, and p-values for the yield and acreage regressions in each region.

The beta coefficient shows how much the dependent variable will change (in pounds per acre for yield, or thousand acres for acreage) for a one unit change in an independent variable, when all other independent variables are constant. The t-test measures the size of the error term for the null hypothesis in relation to the standard error. If the t-test is 3.31, then the error implied by the null hypothesis is 3.31 times as large as the standard error. Large values of the t-test are unlikely to occur if the null hypothesis is true. The t-test is shown below:

(3) $$t = \frac{\hat{\beta}_j}{s(\hat{\beta}_j)}.$$

The p-value represents the probability that the "t" statistic would be as large or larger than it actually is if the null hypothesis was true, or the largest significance level that would still calculate the test and fail to reject the null hypothesis. A low p-value raises concern against the null hypothesis because it indicates that the t statistic unlikely to be large (Mirer 1995).

Table 6 below shows the parameter results for the beta, t-test, and p-value results for each variable in each region in the yield regression (Equation 1). There were no observations of lagged cotton price or lagged yield being significant. Lagged net expenses were significant in one region. El Niño was significant in three regions. La Niña and lagged peanut prices were excluded from all regressions; therefore there were no observations of significance. Trend and variety were significant in two regions, and BWE was not significant in any of the regions. May and June precipitation were not significant in any regions. Table 7 shows the parameter results for the acreage regression (Equation 2). Lagged cotton price, the 1996 farm bill, trend, and PIK were significant in two regions. Lagged acreage was significant in three regions. The 1981, and 1990 farm bills were excluded from all regressions, therefore there were no observations of significance. The 1985 farm bill, lagged price of soybeans, lagged peanut prices, and BWE were not significant in any regions. The 2002 farm bill, lagged price of corn, and lagged net expenses were only significant in one region. The bolded variable coefficients are significantly different from zero.

Table 6. Parameter Results for the Yield Regressions

	Intercept	Cotton Price $_{t-1}$	Yield $_{t-1}$	El Niño	La Niña	Peanut Prices $_{t-1}$	Trend	BWE	Variety	May Weather	June Weather	July Weather	Net Expenses $_{t-1}$
Region 1:													
Beta	633.34	52.58	-0.35	**100.69**	0.00	0.00	**17.73**	-19.51	1.64	0.00	0.00	13.93	-0.62
T-Test	1.47	0.25	-1.74	2.32	0.00	0.00	2.29	-0.25	1.39	0.00	0.00	1.58	-0.37
P-Value	0.16	0.81	0.10	0.03	1.00	1.00	0.03	0.80	0.18	1.00	1.00	0.13	0.72
Region 2:													
Beta	206.13	382.61	-0.29	**119.03**	0.00	0.00	8.29	-95.69	1.95	0.00	0.00	**17.84**	0.57
T-Test	0.41	1.74	-1.42	2.39	0.00	0.00	0.97	-1.05	1.48	0.00	0.00	2.10	0.30
P-Value	0.69	0.10	0.17	0.03	1.00	1.00	0.35	0.31	0.16	1.00	1.00	0.05	0.77
Region 3:													
Beta	**1255.07**	179.39	-0.12	**123.61**	0.00	0.00	**43.63**	110.94	2.54	0.00	7.07	-8.15	**-3.86**
T-Test	3.19	0.80	-0.63	3.07	0.00	0.00	2.62	1.34	1.31	0.00	1.28	-1.07	-2.12
P-Value	0.01	0.43	0.54	0.01	1.00	0.00	0.02	0.20	0.21	1.00	0.22	0.30	0.05
Region 4:													
Beta	364.89	-124.24	-0.07	-17.42	0.00	0.00	0.00	34.66	**5.55**	0.00	-185.05	-3.87	0.87
T-Test	1.98	-0.77	-0.28	-0.54	0.00	0.00	0.00	0.58	3.26	0.00	-1.93	-0.45	0.94
P-Value	0.06	0.45	0.78	0.60	1.00	0.00	1.00	0.57	0.00	1.00	0.07	0.65	0.36
Region 5:													
Beta	**1315.76**	-235.65	-0.20	-3.46	0.00	0.00	8.24	0.00	**6.39**	-15.21	-37.87	-1.58	-0.06
T-Test	2.94	-1.19	-0.94	-0.11	0.00	0.00	0.90	0.00	2.26	-0.80	-0.63	-0.10	-0.06
P-Value	0.01	0.25	0.36	0.92	1.00	0.00	0.38	1.00	0.04	0.43	0.54	0.92	0.95

Note: BWE represents Boll Weevil Eradication. These results are referring to Equation 1.

Table 7. Parameter Results for the Acreage Regressions

	Intercept	Cotton Price$_{t-1}$	Acres $_{t-1}$	1981 Farm Bill	1985 Farm Bill	1990 Farm Bill	1996 Farm Bill	2002 Farm Bill	Price Corn$_{t-1}$	Price Soybeans $_{t-1}$	Peanut Prices$_{t-1}$	Net Expenses $_{t-1}$	Trend	PIK	BWE
Region 1:															
Beta	-156.04	**1116.12**	**0.84**	0.00	0.00	0.00	9.07	0.00	-252.35	-31.32	0.00	1.76	0.00	-220.56	23.34
T-Test	-0.23	2.81	5.49	0.00	0.00	0.00	0.10	0.00	-1.65	-0.46	0.00	0.75	0.00	-1.22	0.17
P-Value	0.82	0.01	0.00	1.00	1.00	1.00	0.92	1.00	0.11	0.65	1.00	0.46	1.00	0.24	0.87
Region 2:															
Beta	1277.65	**2161.34**	**0.62**	0.00	0.00	0.00	34.90	0.00	-107.02	-132.59	1933.98	-6.99	**65.65**	-168.51	-377.33
T-Test	1.11	3.25	2.80	0.00	0.00	0.00	0.20	0.00	-0.46	-1.23	0.99	-1.50	2.27	-0.65	-1.30
P-Value	0.28	0.00	0.01	1.00	1.00	1.00	0.84	1.00	0.65	0.24	0.34	0.15	0.04	0.52	0.21
Region 3:															
Beta	-2288.23	2007.36	-0.01	0.00	0.00	0.00	**-841.85**	**-1446.44**	**-721.07**	60.60	0.00	**24.22**	-140.74	**-1407.34**	382.48
T-Test	-1.27	1.90	-0.05	0.00	0.00	0.00	-2.45	-2.23	-2.30	0.39	0.00	2.19	-1.51	-3.19	1.10
P-Value	0.22	0.07	0.96	1.00	1.00	1.00	0.03	0.04	0.03	0.70	0.00	0.04	0.15	0.01	0.29
Region 4:															
Beta	**8524.61**	2048.72	**-0.44**	0.00	-658.74	0.000	**-999.31**	0.000	-1028.44	168.24	0.00	-4.118	0.00	-945.64	581.80
T-Test	3.90	1.19	-2.222	0.00	-1.43	0.000	-2.44	0.000	-1.842	0.711	0.00	-0.500	0.00	-1.22	0.92
P-Value	0.00	0.26	0.042	0.00	0.17	1.000	0.03	1.000	0.085	0.488	0.00	0.624	1.00	0.241	0.37
Region 5:															
Beta	**1237.88**	907.70	0.16	0.00	0.00	0.00	30.23	0.00	-30.27	0.00	0.00	0.00	**-43.01**	**-556.56**	18.06
T-Test	3.00	1.83	0.98	0.00	0.00	0.00	0.36	0.00	-0.26	0.00	0.00	0.00	-3.74	-3.15	0.12
P-Value	0.01	0.08	0.34	1.00	1.00	1.00	0.73	1.00	0.79	0.00	0.00	1.00	0.00	0.01	0.90

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication. These results are referring to Equation 2.

Region 1-Yield Analysis

This regression excluded La Niña, June and May weather variables, and lagged peanut prices. Lagged peanut prices were distorted by the peanut provisions in the farm bill and did not truly reflect market forces. This could be an explanation of the large values for the peanut coefficients and were excluded from the regressions. The significant parameter estimates were El Niño and trend (Table 6). Trend is likely capturing technology improvements and El Niño and July precipitation variable were working together to capture weather. The original hypothesis was that lagged price of cotton, lagged yield, and BWE variables, and variety would be positive. In this regression, the coefficient on lagged yield was significant and negative. Lagged yield is hypothesized to be negative because of fluctuations in yield output from year to year. The coefficient on BWE was the wrong sign from prior expectations, and was not significantly different from zero (Table 6). This suggests that other factors have had more influence on yields (reflected in the weather and trend variables).

Region 1: Acreage Analysis

This regression omitted dummy variables for the 1981, 1985, 1990, and 2002 farm bills. The inclusion of so many dummy variables measuring similar impacts caused poor regression results. Therefore, only the 1996 farm bill dummy variable was included because it represented a major policy change regarding planting flexibility. Lagged peanut prices were also left out of this regression for the reason previously stated. Trend was also removed from the regression because of its interaction with lagged acreage. Lagged cotton price and lagged acres were significant (Table 7). All variables had the expected results except for lagged net expenses, but it was not significantly different from zero.

Region 2: Yield Analysis

As in Region 1, the La Niña parameter was excluded from the Region 2 yield regression, as was lagged peanut prices and the May and June precipitation variables. El Niño and July precipitation were the significant parameter estimates (Table 6). Both the BWE coefficient and the lagged yield coefficient were negative and not significantly different from zero.

Region 2: Acreage Analysis

The 1981, 1985, 1990, and 2002 farm bills were excluded from this regression. Peanut prices were included in this regression because peanuts have more of an impact in the states included in this region compared to Region One. The lagged cotton price, lagged acres, and the trend coefficients were positive and significant (Table 7). The policy effects from the farm bills in this Region had more impacts on the increased flexibility of expanding more acres devoted to peanuts into cotton. This switch to cotton acres was captured by the trend variable. BWE had a negative coefficient, although not significant, and did not match our initial assumptions that it would increase acreage. Tribble, McIntosh, and Wetzstein (1999) have also documented a positive acreage response for Georgia, located in this region. This is likely due to the time frame of our analysis. With the planting flexibility that was granted with the 1996 farm bill, these regions increased cotton production (Figure 15), but boll weevils were eradicated from these regions in the early nineties (El-Lissy and Grefenstette 2005). Thus, BWE had less impact on increased production which might have reflected the insignificant beta coefficient.

Region Three: Yield Analysis

La Niña and May weather were excluded from the yield regression in Region Three. Because this is the Delta region, it was hypothesized that June and July weather would both have impacts on weather, thus creating higher yields due to the summer rain. El Niño, trend, and lagged net expenses have significant coefficients with the expected signs (Table 6). The coefficient for lagged net expenses was significant presumably because it captured the technology effects that were not reflected in the trend variable. That is, lagged net expenses possibly reflected increasing costs arise associated with new advances in technology like new pesticides and genetically modified cultivars. Lagged yield and July weather had small negative coefficients.

Region Three: Acres Analysis

In this region, the acreage regression excluded the variables for the 1981, 1985 and 1990 bills. The 1996 and 2002 farm bills, lagged price of corn, lagged net expenses, and PIK were all significant (Table 7). The 1996 and 2002 farm bills, lagged price of corn, and PIK all have negative coefficients. Lagged net expenses, which was hypothesized to be negative, had a positive coefficient. Again, lagged net expenses was significant and positive because of its interaction with trend. The 1996 farm bill gave producers planting flexibility and the 2002 farm bill brought back counter cyclical payments. These coefficients are negative because prior to 1996, producers planted corn and after the 1996 farm bill, farmers planted more cotton. Lagged cotton prices then decreased, causing the shift back to corn production and the 2002 bill caused another shift back to cotton.

Region 4: Yield Analysis

In this regression, the La Niña, trend, and May weather variables were excluded. Variety was the only significant variable. The lagged price of cotton, lagged yield, El Niño, and the June and July weather variables had negative coefficients while lagged net expenses was small and positive (Table 6). Although strong positive effects for variety were expected, the other results were not expected in this region. This could have resulted from the highly variable nature of yield and production in Texas and variety could be measuring the same effects as trend, BWE, and weather.

Region 4: Acres Analysis

The 1981, 1990, and 2002 policy variables were excluded from the Region Four acreage regression. Figure 16 shows a very dramatic decrease in acreage in 1981 that was interfering with our linear model. The regression in this region only included data from 1983 to 2007 to remove any effect that the extreme decrease in acreage during that time would have. Lagged acres and the 1996 farm bill were significant (Table 7). All coefficients had the expected signs except for the lagged price of soybeans, which was positive possibly because of the increasing demand of oilseeds. Soybeans do not compete in this region for cotton acreage, but the increase in soybean oil would cause demand in cottonseed to increase, therefore causing cottonseed prices to increase, creating a positive effect in the regression.

Region 5: Yield Analysis

La Niña and BWE were removed from this regression. BWE was excluded because there was very little eradication needed for the cotton producing regions of California and Arizona. The weather variables were not significant in this region because this region is heavily irrigated and weather is a minor factor in cotton production. Lagged yield and the lagged price of cotton had negative coefficients (Table 6).

Region 5: Acres

In this regression all farm bills except for the 1996 bill were excluded along with lagged net expenses. This resulted in the trend and PIK variables to be significant and to have negative coefficients (Table 7). This region is shifting its production from cotton to horticultural crops. Trend has been declining because of the lack of water availability as cotton had to compete with other crops. The other variables had the expected signs.

Elasticity Estimation

The supply elasticity is the degree to which quantity supplied reacts to changes in price. Short-run elasticities will be estimated for each region. The short run elasticity is estimated by aggregating the elasticity at the mean for cotton price for yield and acreage in each region (Richardson 2008).

Table 8 shows the short-run supply elasticity results for yield and acreage in each of the five regions. The elasticity of supply demonstrates how the proportional changes in price relate to proportional changes in output. The short-run elasticity of supply is calculated as follows:

(4) $$e_{s,p} = \frac{\partial Q_s}{\partial P} \cdot \frac{P}{Q_s}\,.$$

The numerator can be understood as the percentage change in quantity supplied and the denominator can be read as the percentage change in price. An elastic good has a price elasticity that is greater than one. An inelastic good has a price elasticity less than one and a good that is unitary elastic is equal to one. A high elasticity indicates that a small change in price will result in a large change in quantity supplied and an inelastic price elasticity indicates that it takes large price changes to create a change in output (Nicholson 2005).

Table 8 shows the yield elasticity results for each Region. They are 0.047, 0.360, 0.141, -0.190, -0.140, respectively. For example, Region One has an elasticity of 0.047, so we can say that a one percent increase in last year's price will cause a 0.047 percent increase in cotton price. There is a large range of results for yield. The elasticities in Regions Four and Five were negative, which was unusual, especially for Region Four. The results for acreage also had a wide range. The elasticity results for acreage in each of the Regions were 0.650, 0.858, 0.396, 0.218, and 0.431. Aggregating the yield and acreage elasticities gives the total elasticity of supply for each region. The total elasticity of supply results were 0.697, 1.128, 0.537, 0.028, and 0.291. We would expect the Southeast regions to be more elastic because cotton competes with other crops in these regions. If the price of cotton were to increase, it is likely that producers in the Southeast would be more inclined to rotate their crops to cotton production. The

Southern Plains (Region 4) is very inelastic because producers in these Regions will continue to plant cotton, regardless of outside influence. The elasticity results in the Delta (Region Three) are in between the Southeast and the Southern Plains, because they are not totally restricted to cotton production.

Table 8. Cotton Elasticity of Supply Results

Region	Yield Elasticity	Acreage Elasticity	Total Elasticity of Supply	FAPRI Elasticity
Region 1	0.049	0.650	0.699	0.076
Region 2	0.360	0.858	1.128	0.076
Region 3	0.141	0.396	0.537	0.131
Region 4	-0.190	0.218	0.028	0.459
Region 5	-0.14	0.431	0.291	0.670

Source: FAPRI 2009

The Food and Agricultural Policy Research Institute (FAPRI) has a matrix of elasticities for net returns projected for 2008 to 2017 for ten commodities. Their elasticities are done regionally for the Corn Belt, Central Plains, Delta, Far West, the Lake States, the North East, Northern Plains, Southeast, and Southern Plains. The FAPRI elasticitiy for the Southeast will be compared to Regions One and Two. The FAPRI Delta region will be compared to Region Three, the Southern Plains region will be compared to Region Four, and the Southeast region will be compared to Region Five (FAPRI 2009). Comparing the elasticity results in this paper to the FAPRI elasticities in Table 8 shows very different results. The elasticity results from this study in Region Two show elastic elasticities. Region One is very close to becoming elastic. Regions Three, Four, and Five are inelastic. The FAPRI results are highly inelastic.

Duffy, Richardson, and Wohlgenant (1987) estimated a sample mean and a 1981 elasticity for short-run elasticities for cotton in four regions labeled the Southeast (Alabama, Georgia, North Carolina, South Carolina, Virginia, and Florida), the Delta (Arkansas, Louisiana, Missouri, Mississippi, and Tennessee), the Southern Plains (New Mexico, Oklahoma, and Texas), and the Southwest (Arizona, and California). The Southeast had a short-run elasticitiy of 0.273 for the sample and a 0.529 elasticity for 1981. The Delta had a short-run elasticity for the sample of 0.116 and a 0.130 for 1981. The Southern Plains had an elasticity of 0.425 for the sample and 0.331 for 1981 and the Southwest had an elasticity of 0.672 for the sample and 0.331 for 1981. Nerlove (1956) estimated an elasticity of supply for cotton acreage for the United States to be 0.67. Shumway, Saez, and Gottret (1988) estimated an elasticity of supply for Texas cotton acreage to be 0.25. Pan el al. (2006) has calculated cotton acreage elasticities for the Delta, the Southeast, Southwest irrigated, Southwest dryland, and the West. Their elasticity results for the short-run are 0.18, 0.16, 0.31, 0.37, and 0.42, respectively.

CHAPTER V

ECONOMETRIC DIAGNOSTICS AND VALIDATION

This research has been verified to ensure that the regressions have been correctly estimated. The independent variables included in the regressions are consistent with the methodology of previous research (as explained in the literature review) and the results from this study seem to correctly replicate real world situations. The results were reported and analyzed in the previous chapter. This chapter will focus on the regression diagnostics and model validations.

Regression Diagnostics

This section will focus on the validation of the results by a review of other regional specifications not using in the regressions, comparing the actual yield and acreage to the predicted acreage, and the regression diagnostics by comparing the restricted to the unrestricted form of the models.

Other Regional Specifications

This subsection focuses on different versions of the regressions that were tested to ensure that the regressions were the best that could have been estimated. An alternative estimate of the Region One regressions was conducted by omitting Tennessee. The assumption here was that the remaining states of North Carolina and Virginia would be more homogenous. Region One includes North Carolina, Tennessee and Virginia. Although Tennessee is in Region One, some of its cotton production lies in an area close to the Delta (Region Three). Tennessee was removed from Region One and the regression results for yield were statistically worse and the acreage results were about the same. Because the results of the yield regression were not improved, the original grouping of Region One with North Carolina, Tennessee, and Virginia will be used.

A second alternative involved combining the two southeastern regions (Regions One and Two). Some of the results in Regions One and Two were different than expected. Since Regions One and Two involve Southeastern states, they were combined to determine if better results were possible. The yield regression had an F-test of 4.855, an R^2 of 0.672, and an $Rbar^2$ of 0.533. Lagged yield, El Niño, and July weather were significant. The acreage regression had an F-test of 32.203, an R^2 of 0.931, and $Rbar^2$ of 0.902. Lagged cotton price and lagged acres were significant. The results of combining the regions were on par with the results from Region One. Combining these two regions did not lead to improved fit or more expected parameter estimates. Apparently, cotton production within these two regions is not homogenous enough to gain statistically from the greater number of combined observations.

Actual Yield and Acreage vs. Predicted Yield and Acreage

Earlier in this Chapter, the actual values of yield and acreage were represented in a figure. Also included in the figures are the predicted values of each variable. The line graphs were used to compare how well the regressions fit the original data. The blue line represents the actual yield and acres, and the pink line represents the predicted yield and acres. Figures 9 through 18 above show that the predicted values from each of the yield regressions fit the actual values extremely well, with little variability between the two. There were no periods of time within the data series that the model fails to account for, which is reassuring.

Restricted/Unrestricted Model Comparisons

Another tool in determining the fit of the OLS regression line besides using the R^2, is to compare the restricted form of the model with the unrestricted form. The sum of squared residuals (SSR) measures the overall fit of the regressions. If the restricted form of the model is closely similar to the unrestricted form of the model, then the restrictions are very much the same as reality, and conversely, if the restricted is unlike the unrestricted model, then the restricted form of the model is not capturing reality. The SSR of the restricted model is usually always greater than the SSR of the unrestricted model because the SSR of the unrestricted models uses all variables to help achieve the smallest SSR possible. The restricted form has fewer variables, which tends to make the SSR a higher value. If the null hypothesis is false, the SSR of the restricted model will be higher than then SSR of the unrestricted model because the regression most likely includes variables that are not correct. The unrestricted and restricted models are analyzed by comparing the F-tests, R^2 and Rbar^2. The equation for the F-Test is shown below:

$$F = \frac{(SSR_r - SSR_u)/r}{SSR_u/(n-k-1)}. \tag{5}$$

The number of restrictions will be denoted by “r”, the number of observations are denoted by “n”, “k” represents the number of regressors in the unrestricted form, and “n-k-1” represents the degrees of freedom (Pindyck and Rubinfeld 1991; Mirer 1995)

Table 9 below displays the results for the restricted and unrestricted model for the yield regressions in each of the five regions. It appears that in each of the Regions, the restricted model matches very closely to the unrestricted model.

Table 9. A Comparison of the Restricted and Unrestricted Model for Yield

Restricted Model	Results	Unrestricted Model	Results
Region 1			
F-test:	5.850	F-Test:	3.322
R^2:	0.711	R^2:	0.727
Rbar^2	0.590	Rbar^2	0.508
Region 2			
F-Test	1.793	F-Test	1.793
R^2	0.430	R^2	0.589
Rbar^2	0.190	Rbar^2	0.261
Region 3			
F-Test	7.009	F-Test	5.246
R^2	0.778	R^2	0.783
Rbar^2	0.667	Rbar^2	0.634
Region 4			
F-Test	11.072	F-Test	10.018
R^2	0.823	R^2	0.873
Rbar^2	0.749	Rbar^2	0.786
Region 5			
F-Test	8.888	F-Test	8.449
R^2	0.816	R^2	0.853
Rbar^2	0.724	Rbar^2	0.752

Table 10 below shows the results for the restricted and unrestricted model for acreage in all five regions. In all of the Regions except for Regions One and Four, the results of the restricted model match very closely with the unrestricted model. In Region One, the F-test, is larger in the restricted model, but the R^2 and Rbar^2 are much lower than in the unrestricted model. In Region Four, the F-Test R^2 and $Rbar^2$ are close to the unrestricted model, even though the R^2 is low in both. This would suggest that acreage in Region Four have a poor fits. Region Four might have poor results because Texas acreage doesn't very much due to economic variables and it is more fixed due to natural and capital constraints.

Table 10. A Comparison of the Restricted and Unrestricted Model for Acreage

Restricted Model	Results	Unrestricted Model	Results
Region One			
F-Test:	29.278	F-Test:	18.399
R^2:	0.925	R^2:	0.952
$Rbar^2$	0.893	$Rbar^2$	0.900
Region Two			
F-Test	29.538	F-Test	17.766
R^2	0.946	R^2	0.950
$Rbar^2$	0.914	$Rbar^2$	0.897
Region Three			
F-Test	6.703	F-Test	6.742
R^2	0.798	R^2	0.862
$Rbar^2$	0.679	$Rbar^2$	0.734
Region Four			
F-Test	1.733	F-Test	1.340
R^2	0.510	R^2	0.573
$Rbar^2$	0.216	$Rbar^2$	0.145
Region Five			
F-Test	29.572	F-Test	29.999
R^2	0.912	R^2	0.960
$Rbar^2$	0.881	$Rbar^2$	0.928

Model Validation

This subsection will focus on model validations by testing for serial correlation, multicolinearity, and heteroskedasticity.

Serial Correlation

Autocorrelation, or serial correlation, occurs when the errors in one time period are correlated with errors in the next time period. Autocorrelation does not affect the unbiasedness of the OLS regressions, but it will cause the test statistics to be exaggerated. The Durbin-Watson test is a statistical test for autocorrelation and is measured by the test statistic as shown below.

$$DW = \frac{\sum_{t=2}^{n}(\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=1}^{n}\hat{u}_t^2}. \tag{6}$$

When the Durbin-Watson is equal to two, there no is no serial correlation. The DW values below two exhibit signs of positive correlation, and DW values above two exhibit signs of negative serial correlation (Pindyck and Rubinfeld 1991; Mirer 1995). The test statistics for each regression are shown in Table 11.

Table 11. Durbin-Watson Test Statistics

Region 1:	
Yield	2.362
Acres	2.152
Region 2:	
Yield	1.987
Acres	1.842
Region 3:	
Yield	2.120
Acres	1.966
Region 4:	
Yield	1.845
Acres	2.769
Region 5:	
Yield	2.070
Acres	1.503

Each of the regressions was checked for serial correlation using STATA (Statcorp 1996-2009). The null hypothesis was no serial correlation. We failed to reject the null hypothesis in Region One and acres, Region Two yield and acres, Region Three yield and acres, Region Four yield, and Region Five yield. We rejected the null hypothesis in Region One yield and Region Four and Region Five acres, implying this exhibits signs of serial correlation.

The Durbin Watson test statistic after re-estimating the regressions in yield in Region One was transformed to 2.28, acreage in Region Four was transformed to 2.452, and acreage in Region Five was transformed to 1.836. The p-values for testing the Durbin-Watson are shown in Table 12.

Table 12. P-values for Testing Serial Correlation

	Region 1	Region 2	Region 3	Region 4	Region 5
Yield	0.028	0.648	0.421	0.656	0.187
Acreage	0.848	0.637	0.672	0.009	0.096

Table 13 shows the F-test, R^2, and Rbar^2 for yield in Region One and acreage in Regions Four and Five. Before correcting for autocorrelation, yield in Region One had an F-test of 5.850, an R2 of 0.711, and an Rbar2 of 0.590. The results changed to an F-test of 15.54, an R2 of 0.867, and an Rbar2 of 0.811. Before correcting for autocorrelation, acreage in Region Four had an F-test of 4.321, an R^2 of 0.684, and an Rbar^2 of 0.525. The results in Region Four changed to an F-test of 7.68, the R^2 changed to 0.793 and the Rbar^2 was changed to 0.690. The original results of the acreage regression in Region Five had an F-test of 29.865, an R^2 of 0.913, and an Rbar^2 of 0.882. After re-estimating the model, the F-test changed to 21.66, the R^2 changed to 0.884 and the Rbar^2 changed to 0.843. Overall, the re-estimation process did improve the regression statistics.

Table 13. Corrected Acreage Regression Results

	F-Test	R^2	Rbar^2
Region 1:			
Yield	15.54	0.867	0.811
Region 4:			
Acres	9.69	0.853	0.765
Region 5:			
Acres	21.48	0.882	0.841

Since the yield equation in Region One, and the acreage equations in Region Four and Five exhibit signs of serial correlation, the regressions were re-estimated using the Prais-Winsten method. Tables 14 and 15 show the parameters for the new regression results for yield (Equation 1) and acreage (Equation 2). The significant variables in the original yield regression in Region One were El Niño and trend. The significant variables remained the same after correcting for autocorrelation. The elasticity at the mean for yield in region was re-estimated to be -0.072. The significant variables in the original acreage regression in Region Four were lagged acres and the 1996 farm bill. The significant variables after correcting for autocorrelation were the 1985 and 1996 farm bills, and the lagged price of corn. The elasticity at the mean for acreage in Region Four was re-estimated to be 0.146. The significant variables in the original regression estimate in acreage in Region Five were trend and PIK. After correcting for serial correlation, the significant variables were lagged cotton price, trend, and PIK. The elasticity at the mean for acreage in Region Five was re-estimated to be 0.499

Table 14. Parameter Results for Yield After Correcting for Serial Correlation

	Intercept	Cotton Price $_{t-1}$	Yield $_{t-1}$	El Niño	La Niña	Peanut Prices $_{t-1}$	Trend	BWE	Variety	May Weather	June Weather	July Weather	Net Expenses $_{t-1}$
Region 1:													
Beta	**775.25**	-77.88	-0.21	**89.80**	0.00	0.00	**15.76**	-15.17	1.42	0.00	0.00	21.45	-1.13
T-Test	1.89	-0.44	-1.05	2.22	0.00	0.00	2.57	-0.28	1.66	0.00	0.00	2.34	-0.73
P-Value	0.073	0.662	0.307	0.039	1.00	1.00	0.019	0.783	0.113	1.00	1.00	0.476	0.476

Note: BWE represents Boll Weevil Eradication. These results are referring to Equation 1.

Table 15. Parameter Results for Acreage After Correcting for Serial Correlation

	Intercept	Cotton Price$_{t-1}$	Acres $_{t-1}$	1981 Farm Bill	1985 Farm Bill	1990 Farm Bill	1996 Farm Bill	2002 Farm Bill	Price Corn$_{t-1}$	Price Soybeans $_{t-1}$	Net Expenses $_{t-1}$	Trend	PIK	BWE
Region 4:														
Beta	**7791.91**	1373.28	-.18	0.00	**-607.45**	0.00	**-988.16**	0.00	**-1186.66**	297.32	-7.27	0.00	-930.81	730.46
T-Test	4.95	0.95	-0.86	0.00	-1.90	0.00	-3.73	0.00	-2.65	1.52	-1.15	0.00	-1.31	1.71
P-Value	0.000	0.36	0.40	1.00	0.08	1.00	0.00	1.00	0.02	0.15	0.27	1.00	0.21	0.12
Region 5:														
Beta	**1585.13**	**1050.86**	-0.002	0.00	0.00	0.00	39.52	0.00	-59.39	0.00	0.00	**-54.62**	**-585.92**	72.78
T-Test	3.38	2.37	-0.02	0.00	0.00	0.00	0.37	0.00	-0.60	0.00	0.00	-4.52	-4.04	0.44
P-Value	.003	.028	0.99	1.00	1.00	1.00	0.78	1.00	0.56	1.00	1.00	1.00	0.00	0.67

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication. These results are referring to Equation 2.

Multicolinearity

Multicolinearity is a situation where the independent variables in the regression are not only correlated with the dependent variable, but also with other explanatory variables as well. Extra care must be taken when analyzing the regression coefficients if problem colinearity is present. The best way to determine if the regression exhibits signs of multicolinearity is to examine the correlation matrix. The variables in the correlation matrices range from -1 to +1. A value of -1 implies a negative correlation and a value of +1 implies a positive correlation. A correlation matrix can show the strength of the correlation by the actual value. Values at 0.50 or greater indicate a strong correlation, values around 0.30 indicate a moderate correlation and values below 0.20 indicate a weak correlation. The values may indicate relationships between variables, but causal inferences cannot be made. Direction can also be determined by the positive or negative signs (Pindyck and Rubinfeld 1991; Mirer 1995).

The results of the correlation matrices for each Region are shown in Tables 16 through Table 25 below. The bolded values in the correlation matrices indicate their statistical significance.

The significant values in the correlation matrix for the yield regression in Region One (Table 16) show that lagged yield is positively correlated to yield and negatively correlated to lagged cotton price. Trend is positively correlated to yield and lagged yield, and negatively correlated to lagged cotton price. Boll weevil eradication is positively correlated to yield, lagged yield, and trend. Variety is positively correlated to yield, lagged yield, and trend and negatively correlated to the lagged price of peanuts. May weather is positively correlated to the lagged price of peanuts, and July weather is positively correlated to La Niña. Lagged net expenses is positively correlated to yield, lagged yield, trend and BWE. No details will be given for the remaining matrices in Tables 17 through 25.

Table 16. Correlation Matrix for Yield in Region One

	Yield	Cotton Price $_{t-1}$	$Yield_{t-1}$	El Niño	La Niña	Peanut $Prices_{t-1}$	Trend	BWE	Variety	May Weather	June Weather	July Weather	Net Expenses $_{t-1}$
Yield	1	-0.29	**0.44**	-0.07	-0.19	-0.11	**0.72**	**0.49**	**0.58**	-0.23	0.15	**0.40**	**0.61**
Cotton $Price_{t-1}$		1	**-0.52**	0.08	0.22	0.28	**-0.51**	-0.30	**-0.44**	**0.45**	0.00	0.23	-0.35
$Yield_{t-1}$			1	-0.09	0.12	-0.16	**0.75**	**0.54**	**0.59**	-0.12	0.32	0.05	**0.66**
El Niño				1	-0.18	0.29	-0.35	-0.18	-0.28	-0.09	-0.06	-0.12	-0.25
La Niña					1	0.13	-0.07	0.16	-0.12	**0.48**	0.30	0.08	-0.12
Peanut $Prices_{t-1}$						1	-0.14	0.37	**-0.63**	0.13	-0.26	0.08	-0.09
Trend							1	**0.75**	**0.65**	-0.31	0.17	0.21	**0.82**
BWE								1	0.25	-0.21	0.11	0.08	**0.48**
Variety									1	-0.24	0.27	0.15	**0.53**
May Weather										1	0.30	0.23	-0.15
June Weather											1	0.05	0.04
July Weather												1	0.31
Net $Expenses_{t-1}$													1

Note: BWE represents Boll Weevil Eradication.

Table 17. Correlation Matrix for Acreage in Region One

	Acres	Cotton Price $_{t-1}$	Acres $_{t-1}$	1981 Farm Bill	1985 Farm Bill	1990 Farm Bill	1996 Farm Bill	2002 Farm Bill	Price Corn $_{t-1}$	Price Soybeans $_{t-1}$	Price Peanuts $_{t-1}$	Net Expenses $_{t-1}$	Trend	PIK	BWE
Acres	1	-0.33	**0.92**	**-0.55**	**-0.41**	0.21	**0.52**	**0.39**	-0.32	-0.36	0.06	**0.72**	**0.90**	-0.29	**0.76**
Cotton Price $_{t-1}$		1	**-0.43**	0.15	-0.06	0.28	-0.14	**-0.46**	**0.55**	**0.60**	0.28	-0.35	**-0.51**	0.03	-0.30
Acres $_{t-1}$			1	**-0.51**	**-0.43**	0.12	**0.49**	**0.49**	-0.17	-0.27	-0.08	**0.76**	**0.95**	-0.25	**0.73**
1981 Farm Bill				1	-0.19	-0.21	-0.21	-0.19	0.31	0.18	-0.08	-0.28	**-0.51**	**0.47**	**-0.71**
1985 Farm Bill					1	-0.24	-0.24	-0.22	-0.28	-0.08	0.23	-0.25	-0.32	-0.09	0.05
1990 Farm Bill						1	-0.27	-0.24	0.04	-0.02	**0.54**	-0.09	0.00	-0.10	0.30
1996 Farm Bill							1	-0.24	-0.21	-0.32	0.15	0.35	**0.39**	-0.10	0.30
2002 Farm Bill								1	-0.04	0.06	**-0.61**	0.55	**0.66**	-0.09	0.27
Price Corn$_{t-1}$									1	0.83	-0.18	-0.13	-0.27	-0.04	**-0.41**
Price Soybeans$_{t-1}$										1	-0.14	-0.24	-0.27	-0.07	-0.27
Price Peanuts$_{t-1}$											1	-0.09	-0.14	0.02	0.37
Net Expenses$_{t-1}$												1	**0.82**	-0.01	**0.48**
Trend													1	-0.25	**0.75**
PIK														1	-0.33
BWE															1

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication.

Table 18. Correlation Matrix for Yield in Region Two

	Yield	Cotton Price $_{t-1}$	Yield$_{t-1}$	El Niño	La Niña	Peanut Prices $_{t-1}$	Trend	BWE	Variety	May Weather	June Weather	July Weather	Net Expenses $_{t-1}$
Yield	1	0.01	-0.04	0.12	-0.26	-0.05	0.26	0.13	0.35	-0.12	0.36	0.21	0.21
Cotton Price$_{t-1}$		1	-0.23	0.06	0.21	0.37	**-0.47**	-0.24	**-0.38**	0.08	-0.08	-0.21	-0.32
Yield$_{t-1}$			1	0.11	0.17	-0.06	0.30	0.11	0.37	-0.17	0.05	-0.12	**0.39**
El Niño				1	-0.18	0.24	-0.35	-0.18	-0.28	0.20	0.19	-0.17	-0.25
La Niña					1	0.23	-0.07	0.16	-0.12	-0.13	0.01	0.24	-0.12
Peanut Prices$_{t-1}$						1	-0.21	0.31	**-0.68**	0.15	0.07	0.18	-0.16
Trend							1	**0.75**	**0.65**	-0.32	0.08	0.06	**0.82**
BWE								1	0.25	-0.23	0.19	0.26	**0.48**
Variety									1	-0.32	0.05	-0.03	**0.53**
May Weather										1	0.16	-0.11	-0.16
June Weather											1	**0.44**	-0.08
July Weather												1	-0.15
Net Expenses$_{t-1}$													1

Note: BWE represents Boll Weevil Eradication.

Table 19. Correlation Matrix for Acreage in Region Two

	Acres	Price Cotton $_{t-1}$	Acres $_{t-1}$	1981 Farm Bill	1985 Farm Bill	1990 Farm Bill	1996 Farm Bill	2002 Farm Bill	Price Corn $_{t-1}$	Price Soybeans $_{t-1}$	Price Peanuts $_{t-1}$	Net Expenses $_{t-1}$	Trend	PIK	BWE
Acres	1	-0.19	**0.94**	**-0.50**	**-0.44**	0.12	**0.57**	0.37	-0.17	-0.23	-0.02	**0.71**	**0.87**	-0.28	**0.68**
Price Cotton $_{t-1}$		1	-0.32	0.06	-0.04	0.31	-0.17	**-0.41**	**0.58**	**0.57**	0.37	-0.32	**-0.47**	-0.01	-0.24
Acres $_{t-1}$			1	**-0.47**	**-0.43**	-0.01	**0.59**	**0.46**	-0.09	-0.17	-0.16	**0.78**	**0.91**	-0.23	**0.65**
1981 Farm Bill				1	-0.19	-0.21	-0.21	-0.19	0.30	0.18	-0.05	-0.28	**-0.51**	**0.47**	**-0.71**
1985 Farm Bill					1	-0.24	-0.24	-0.22	-0.31	-0.12	0.20	-0.25	-0.32	-0.09	0.05
1990 Farm Bill						1	-0.27	-0.24	0.05	-0.04	**0.53**	-0.09	0.00	-0.10	0.30
1996 Farm Bill							1	-0.24	-0.08	-0.29	0.23	0.35	**0.39**	-0.10	0.30
2002 Farm Bill								1	-0.13	0.10	**-0.73**	**0.55**	**0.66**	-0.09	0.27
Price Corn $_{t-1}$									1	**0.82**	-0.04	-0.13	-0.28	-0.02	-0.36
Price Soybeans $_{t-1}$										1	-0.14	-0.21	-0.22	-0.10	-0.25
Price Peanuts $_{t-1}$											1	-0.16	-0.21	0.00	0.31
Net Expenses $_{t-1}$												1	**0.82**	-0.01	**0.48**
Trend													1	-0.25	**0.75**
PIK														1	-0.33
BWE															1

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication.

Table 20. Correlation Matrix for Yield in Region Three

	Yield	Price Cotton $_{t-1}$	Yield $_{t-1}$	El Niño	La Niña	Trend	BWE	Variety	May Weather	June Weather	July Weather	Net Expenses $_{t-1}$
Yield	1	**-0.46**	**0.55**	-0.01	-0.15	**0.73**	**0.70**	**0.71**	-0.05	-0.03	-0.11	**0.71**
Price Cotton $_{t-1}$		1	**-0.43**	0.08	0.24	**-0.50**	**-0.64**	**-0.56**	0.36	0.28	0.17	**-0.48**
Yield $_{t-1}$			1	-0.24	0.21	**0.70**	**0.60**	**0.69**	-0.15	0.10	0.04	**0.69**
El Niño				1	-0.18	-0.35	-0.37	-0.35	0.14	0.02	-0.02	-0.34
La Niña					1	-0.07	-0.16	-0.15	-0.24	**0.42**	**0.49**	-0.09
Trend						1	**0.75**	**0.75**	-0.09	-0.03	-0.01	**0.99**
BWE							1	**0.85**	-0.12	-0.13	-0.13	**0.74**
Variety								1	-0.18	-0.16	-0.18	**0.75**
May Weather									1	0.17	-0.02	-0.08
June Weather										1	**0.70**	0.00
July Weather											1	-0.02
Net Expenses $_{t-1}$												1

Note: BWE represents Boll Weevil Eradication.

Table 21. Correlation Matrix for Acreage in Region Three

	Acres	Price Cotton$_{t-1}$	Acres$_{t-1}$	1981 Farm Bill	1985 Farm Bill	1990 Farm Bill	1996 Farm Bill	2002 Farm Bill	Price Corn$_{t-1}$	Price Soybeans$_{t-1}$	Net Expenses$_{t-1}$	Trend	PIK	BWE
Acres	1	-0.01	**0.65**	**-0.60**	-0.27	**0.57**	0.24	0.05	**-0.41**	-0.23	**0.51**	**0.52**	**-0.47**	0.19
Price Cotton$_{t-1}$		1	-0.26	0.10	0.02	0.25	-0.16	**-0.43**	**0.51**	**0.59**	**-0.48**	**-0.50**	0.03	**-0.64**
Acres$_{t-1}$			1	**-0.53**	**-0.39**	**0.52**	0.30	0.16	-0.21	-0.20	**0.69**	**0.66**	-0.25	0.35
1981 Farm Bill				1	-0.19	-0.21	-0.21	-0.19	**0.47**	0.18	**-0.47**	**-0.51**	**0.47**	-0.24
1985 Farm Bill					1	-0.24	-0.24	-0.22	-0.25	-0.12	**-0.40**	-0.32	-0.09	-0.27
1990 Farm Bill						1	-0.27	-0.24	0.05	-0.02	0.03	0.00	-0.10	-0.30
1996 Farm Bill							1	-0.24	-0.34	-0.27	**0.39**	**0.39**	-0.10	0.10
2002 Farm Bill								1	-0.10	0.05	**0.66**	**0.66**	-0.09	**0.81**
Price Corn$_{t-1}$									1	**0.79**	**-0.38**	**-0.43**	0.08	-0.31
Price Soybeans$_{t-1}$										1	-0.22	-0.25	-0.08	-0.23
Net Expenses$_{t-1}$											1	**0.99**	-0.20	**0.74**
Trend												1	-0.25	**0.75**
PIK													1	-0.11
BWE														1

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication.

Table 22. Correlation Matrix for Yield in Region Four

	Yield	Price Cotton $_{t-1}$	Yield$_{t-1}$	El Niño	La Niña	Trend	BWE	Variety	May Weather	June Weather	July Weather	Net Expenses $_{t-1}$
Yield	1	-0.31	**0.67**	-0.31	-0.20	**0.83**	**0.66**	**0.82**	-0.19	-0.24	-0.14	**0.80**
Price Cotton $_{t-1}$		1	-0.36	-0.06	0.32	-0.31	-0.11	-0.32	0.20	-0.26	**0.47**	-0.30
Yield $_{t-1}$			1	-0.28	0.11	**0.77**	**0.62**	**0.77**	-0.05	0.21	-0.12	**0.78**
El Niño				1	-0.18	-0.35	-0.32	-0.32	0.01	-0.11	-0.08	-0.32
La Niña					1	-0.07	0.00	-0.14	**0.43**	-0.08	**0.66**	-0.06
Trend						1	**0.87**	**0.71**	0.02	-0.11	-0.09	**0.99**
BWE							1	**0.50**	0.02	-0.13	0.04	**0.87**
Variety								1	-0.06	0.00	-0.12	**0.70**
May Weather									1	0.18	**0.46**	-0.02
June Weather										1	-0.16	-0.09
July Weather											1	-0.13
Net Expenses $_{t-1}$												1

Note: BWE represents Boll Weevil Eradication.

Table 23. Correlation Matrix for Acreage in Region Four

	Acres	Price Cotton $_{t-1}$	Acres $_{t-1}$	1981 Farm Bill	1985 Farm Bill	1990 Farm Bill	1996 Farm Bill	2002 Farm Bill	Price Corn $_{t-1}$	Price Soybeans $_{t-1}$	Net Expenses $_{t-1}$	Trend	PIK	BWE
Acres	1	**0.42**	0.29	-0.17	-0.15	0.04	-0.22	0.01	0.15	0.27	-0.28	-0.24	-0.24	-0.13
Price Cotton$_{t-1}$		1	0.20	-0.09	-0.04	0.35	-0.22	-0.26	**0.50**	**0.57**	-0.30	-0.31	-0.05	-0.11
Acres$_{t-1}$			1	0.08	-0.21	0.08	-0.28	-0.05	0.34	0.27	-0.27	-0.34	-0.07	-0.17
1981 Farm Bill				1	-0.19	-0.21	-0.21	-0.19	**0.43**	0.16	**-0.45**	**-0.51**	**0.47**	**-0.41**
1985 Farm Bill					1	-0.24	-0.24	-0.22	-0.31	-0.14	-0.35	-0.32	-0.09	**-0.47**
1990 Farm Bill						1	-0.27	-0.24	0.05	-0.03	0.00	0.00	-0.10	0.00
1996 Farm Bill							1	-0.24	-0.32	-0.29	**0.40**	**0.39**	-0.10	**0.52**
2002 Farm Bill								1	0.01	0.12	**0.66**	**0.66**	-0.09	**0.47**
Price Corn$_{t-1}$									1	**0.78**	-0.25	-0.30	0.15	-0.13
Price Soybeans$_{t-1}$										1	-0.15	-0.19	-0.07	-0.09
Net Expenses$_{t-1}$											1	**0.99**	-0.25	**0.87**
Trend												1	-0.25	**0.87**
PIK													1	-0.19
BWE														1

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication.

Table 24. Correlation Matrix for Yield in Region Five

	Yield	Price Cotton $_{t-1}$	Yield$_{t-1}$	El Niño	La Niña	Trend	BWE	Variety	May Weather	June Weather	July Weather	Net Expenses $_{t-1}$
Yield	1	**-0.63**	**0.66**	-0.25	-0.31	**0.75**	**0.49**	**0.79**	-0.32	**-0.40**	-0.30	**0.73**
Price Cotton$_{t-1}$		1	**-0.60**	0.10	0.25	**-0.50**	-0.25	**-0.46**	0.37	0.30	0.27	**-0.42**
Yield$_{t-1}$			1	-0.20	0.10	**0.75**	**0.55**	**0.75**	-0.06	-0.18	-0.02	**0.73**
El Niño				1	-0.18	-0.35	-0.18	-0.33	-0.21	-0.23	-0.13	-0.34
La Niña					1	-0.07	0.16	-0.14	**0.54**	**0.39**	**0.69**	-0.07
Trend						1	**0.75**	**0.72**	0.12	-0.06	0.03	**0.98**
BWE							1	0.30	0.25	0.07	0.11	**0.71**
Variety								1	-0.15	-0.28	-0.11	**0.71**
May Weather									1	**0.69**	**0.82**	0.12
June Weather										1	**0.60**	-0.09
July Weather											1	0.00
Net Expenses$_{t-1}$												1

Note: BWE represents Boll Weevil Eradication.

Table 25. Correlation Matrix for Acreage in Region Five

	Acres	Price Cotton$_{t-1}$	Acres$_{t-1}$	1981 Farm Bill	1985 Farm Bill	1990 Farm Bill	1996 Farm Bill	2002 Farm Bill	Price Corn$_{t-1}$	Net Expenses $_{t-1}$	Trend	PIK	BWE
Acres	1	**0.62**	**0.86**	0.36	0.17	0.14	-0.34	**-0.66**	0.20	**-0.90**	**-0.91**	-0.01	**-0.61**
Price Cotton$_{t-1}$		1	**0.51**	0.11	0.05	0.31	-0.33	-0.33	**0.50**	**-0.42**	**-0.50**	0.02	-0.25
Acres$_{t-1}$			1	**0.40**	0.15	0.09	-0.30	**-0.65**	0.23	**-0.88**	**-0.91**	0.22	**-0.71**
1981 Farm Bill				1	-0.19	-0.21	-0.21	-0.19	0.32	**-0.47**	**-0.51**	**0.47**	**-0.71**
1985 Farm Bill					1	-0.24	-0.24	-0.22	**-0.39**	-0.31	-0.32	-0.09	0.05
1990 Farm Bill						1	-0.27	-0.24	0.04	-0.03	0.00	-0.10	0.30
1996 Farm Bill							1	-0.24	-0.24	**0.39**	**0.39**	-0.10	0.30
2002 Farm Bill								1	0.10	**0.65**	**0.66**	-0.09	0.27
Price Corn$_{t-1}$									1	-0.09	-0.17	0.10	**-0.43**
Net Expenses$_{t-1}$										1	**0.98**	-0.18	**0.71**
Trend											1	-0.25	**0.75**
PIK												1	-0.33
BWE													1

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication.

Another way of determining multicolinearity is by using the Variance Inflation Factor (VIF). The VIF suggests multicolinearity if the value it produces is greater than 10 (Richardson 2008). Normally the variables that have high VIF values come in pairs. In the yield regressions, trend in Region One has a VIF of 13.224, a 13.076 in Region Two, and a 50.610 in Region Four. In Region Three, trend has a VIF of 69.190 and net expenses has a VIF of 66.3. In Region Five, the June weather variable has a VIF of 34.314.

Table 26. Variance Inflation Factors for the Yield Regressions

	Region 1	Region2	Region 3	Region 4	Region 5
Cotton Price$_{t-1}$	1.852	1.594	2.042	1.623	2.534
Yield$_{t-1}$	2.815	1.364	2.473	4.604	6.029
El Niño	1.310	1.382	1.263	1.265	2.506
La Niña	1.589	1.509	1.894	2.971	1.884
Peanut Prices$_{t-1}$	5.524	6.601	0.000	0.000	0.00
Trend	13.224	13.076	69.190	50.610	1.721
BWE	3.756	4.243	4.907	5.162	1.275
Variety	2.401	2.410	4.954	3.072	7.036
May	1.651	1.253	1.352	1.530	2.386
June	1.312	1.492	2.425	1.506	34.314
July	1.360	1.383	2.183	1.366	9.149
Net Expenses$_{t-1}$	4.161	4.348	66.300	9.132	1.134

Note: BWE represents Boll Weevil Eradication.

In the acreage regressions for Region One, trend had a VIF of 33.650. In Region Two, lagged acres, the 2002 farm bill, and trend had VIFs of 16.336, 27.207, and 31.761 respectively. In Region Three, the 2002 farm bill had a VIF of 14.910, 154.689 for net expenses, and 136.848 for lagged peanut prices. In Region Four, trend had a VIF of 91.539. In Region Five, net expenses had a VIF of 34.291.

Table 27. Variance Inflation Factors for the Acreage Regressions

	Region 1	Region2	Region 3	Region 4	Region 5
Cotton Price$_{t-1}$	2.123	3.093	2.874	1.700	2.543
Acreage$_{t-1}$	6.451	16.366	5.355	1.218	6.004
1981 Farm Bill	2.391	3.882	2.782	0.000	2.498
1985 Farm Bill	2.600	3.521	2.528	1.999	1.892
1990 Farm Bill	2.810	5.529	6.413	2.769	1.727
1996 Farm Bill	1.564	2.903	4.810	1.822	1.278
2002 Farm Bill	5.365	27.207	14.910	8.859	7.040
Price Corn$_{t-1}$	5.499	5.958	4.828	3.196	2.386
Price Soybeans$_{t-1}$	4.610	5.948	4.638	2.840	0.000
Peanut Price$_{t-1}$	2.963	4.630	0.000	0.000	0.000
Net Expenses$_{t-1}$	2.671	5.415	154.689	5.993	34.291
Trend	33.650	31.761	136.848	91.539	9.063
PIK	1.259	1.322	1.627	1.375	1.134
BWE	3.863	9.164	5.539	5.850	4.292

Note: PIK represents Payment-in-Kind and BWE represents Boll Weevil Eradication.

In summary, the multicolinearity diagnostics indicate likely problems of colinearity among the following pairs of independent variables in the yield regressions: La Niña and the precipitation variables, trend and boll weevil eradication and variety, lagged yield with trend, boll weevil eradication, and variety. The problems of colinearity among variables in the acreage regressions are: trend and boll weevil eradication, lagged acreage and the farm bills, lagged net expenses, and trend, and the 1981 farm bill and trend, PIK, and BWE. These relationships likely exist because these variables are measuring some of the same things, for example the removal of La Niña from all yield regressions because it conflicts with July weather, and removing trend because of its correlation with varieties in Region Four yield The existence of multicolinearity is a rationale for excluding some of these variables in the original regression specifications.

Heteroskedasticity

Heteroskedasticity involves a situation where the error variances are not the same for all of the observations which leads to biased variance estimates in each of the parameters. This does not happen in time-series analysis, so heterskedasticity was not examined here (Pindyck and Rubinfeld 1991).

CHAPTER VI

CONCLUSIONS AND FURTHER APPLICATIONS

This chapter will make final conclusions on the work presented in this paper and will provide the framework for further analysis.

Conclusions

This project used a two equation model to estimate structural changes in U.S. cotton supply. Supply functions were estimated for five regions homogeneous regions across the cotton belt. Yield was estimated as a function of lagged cotton price, lagged yield, El Niño, La Niña, trend, boll weevil eradication, varieties, May, June and July precipitation, and lagged net expenses. Acreage was estimated as a function of lagged cotton price, lagged acreage, 1981, 1985, 1990, 1996, and 2002 farm bills, lagged price of corm, soybeans, and peanuts, lagged net expenses, trend, payment-in-kind, and boll weevil eradication. In Chapter III, the methodology explained how the regions were formulated, the development of the data and explained the *a priori* assumptions about the supply functions. Chapter IV gave a thorough analysis of the results. In Chapter V, the work presented in this thesis was validated by using various validation techniques consisting of comparing the restricted versus the unrestricted model, correlation matrices, and also by identifying whether the model has exhibited signs of serial correlation and multicolinearity.

The results show that there is a lot of unpredictability and some inconsistency associated with estimating supply functions. This is part may be due to variable misspecification by not using the correct variables, or not having the right data. It is also difficult to statistically track biological processes and weather effects. The supply functions presented here contain parameters that may be explaining one aspect of the regression that also interfere with other variables. An attempt was made here to reflect weather patterns by using El Niño and La Niña climate variables in addition to regional precipitation. The task proved to be quite daunting. Government policies cause distortion and using dummy variables for several farm bills made the distortion more distinct.

The parameter results suggest that when estimating yield, the major determinate was surprisingly, El Niño. It was significant in three out of the five regions. Yield is also very affected by trend, which measures technology increases over time, cottonseed varieties, and July weather. These variables were significant in two out of the five regions. This implies that yield is strongly influenced by weather and technology.

The major determinate in estimating acreage across the United States was lagged acreage. Lagged acreage was significant in three out of the five regions. Also important in estimating the regional regressions are lagged cotton price, the 1996 farm bill, trend, and PIK. These variables are significant in two out of the five regions. This implies that production in the previous year and policy variables are important indicators of cotton acreage.

The overall purpose of this paper was to estimate cotton supply elasticities. Our results show that as you move from the Southeast to the West, the elasticities become more inelastic. Regions One and Two were expected to have more elastic results because changes in price would impact their planting decisions due to their competitive crops, and Regions Three and Four and Five were expected to have inelastic elasticities because of the lack of competitive crops in these regions. Changes in price are unlikely to affect planting decisions, especially in Region Four (Texas). Comparing our results to FAPRI (2009) shows very different results. However, our elasticity results for acreage are close to the results presented by Pan et al. (2006) and Shumway, Saez, and Gottret (1988).

Study Implications and Further Applications

About one-third of U. S. cotton production is marketed to domestic mills for processing, while the remaining two-thirds are shipped to international markets that are located throughout the world, but primarily in Asia. Therefore, a significant majority of both U.S. and Texas cotton production is dependent on foreign trade (Robinson, Park and Fuller 2006). This results of this project will be used in a spatial equilibruim model involving cotton transportation and logistics. The elasticities estimated here can be used to develop excess supply functions for cotton in these five U.S. regions.

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