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

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Abstract

U.S. farm policy has undergone a series of premium subsidy increases since 1994 to make crop insurance more affordable to farmers. Previous research shows that subsidized crop insurance may cause farmers to shift or expand their production. This study models the acreage response of U.S. cotton at the county level to subsidized crop insurance using simultaneous insurance participation and acreage response equations. Results of panel data analyses from 1995 to 2005 suggest that higher insurance benefits, such as subsidy per unit of production, encourages crop insurance participation which then stimulates additional cotton acreage. In addition, counties with relatively low yields are more responsive to insurance participation and acreage than high yielding counties. Empirical evidence implies that crop insurance policies for cotton are shifting the regional comparative advantage of production from relatively high yielding and quality counties to lower yielding and quality counties.

Key words: subsidy per pound, rate of return, simultaneous, panel, fixed effects

Technological advances, market conditions, and government programs are a few of the many factors that affect cotton plantings and production. Congress formed the Federal Crop Insurance Corporation (FCIC) in 1938 with the objective to protect farm income from crop failure and low prices plus protect consumers from food and fiber shortages and high prices. Crop insurance was further expanded upon the Crop Insurance Act of 1994 which brought about major changes in affordability and return for producer participation through 'catastrophic' (CAT) protection. The entire insurance premium for CAT was paid for by the government and producers pay a modest sign-up fee for each crop. Cotton acreage under insurance increased from 5.8 million acres to 15.8 million acres from 1994 to 1995.[1] The increase in participation is not surprising because the Congress required farmers to purchase crop insurance to be eligible of any disaster payments.

Six years after the introduction of CAT, the Congress implemented the Agricultural Risk Protection Act (ARPA) which significantly increased premium subsidy rates across the board. This made crop insurance program more affordable to all cotton producers regardless of production risks faced by each county. Cotton producers received additional premium subsidies amounting to about $1.2 billion from 2000 to 2001, the year when ARPA took effect. In effect, about 14.68 million cotton acres were insured in 2001, the largest net acreage ever insured for cotton.

The effect of subsidized crop insurance reform on farmers' cropping decisions has been an important debate for many years. Because the probability of yield falling below

[1] However, most of the insured acreage in 1995 was under CAT as around only 30% of the total acreage insured was at Buy Up levels.

50 percent of an established yield for a farm varies greatly by region and crop, the impact of crop insurance reform is not expected to be equal across the cotton belt. To the extent that crop insurance affects farmers' cropping decisions, it is important to quantify how changes in crop insurance policies cause farmers to alter their participation and planting decisions.

Cotton, a highly subsidized crop, has received about 11.6% of the total USDA subsidies from 1995 to 2005. As shown in table 1, subsidies for cotton increased by more than $600 million from 1995 to 1996 while total USDA subsidies did not change much. Aside from the subsidized crop insurance program, many other factors such as the rapid spread of Bt cotton, the “freedom to plant act”, the counter-cyclical payments to bolster income when U.S. cotton prices are below the target price and other cotton policies in the global market contributed to the expansion of cotton production.

Previous studies

Acreage response due to farm programs, particularly farm subsidized crop insurance has been an important topic among researchers (Duffy et al. 1987; Keeton and Skees 1999.; Wu 1999; Vandeveer and Young 2001; Wu and Adams 2001; Barnett et al. 2002.; Goodwin et al. 2004; Deal 2004.). Most of these studies focus on corn, soybeans, wheat or crop mix. Only a few address the impacts of subsidized crop insurance for cotton and the ability for cotton producers to respond to crop insurance subsidies was rather limited until the 1996 FAIR Act.

Crop insurance has received a fair bit of attention not only by politicians but also by agricultural economists. Knight and Coble (1997) outlined econometric studies examining issues related to the Multiple Peril Crop Insurance program since the 1980s. They considered studies on acreage effects of MPCI and other insurance programs as important areas for future research.

Some studies provide contradicting results about the size of the effect. Keeton and Skees (1999) studied acreage shifts for six major U.S. crops from 1978 to 1982 and 1988 to 1992. Their findings show that crop insurance has created incentives for farmers to plant more acres, especially in more risky areas. Estimates show that crop insurance subsidies in the 1980s led to about 50 million additional cropland acres.

Using the national policy simulation model of POLYSYS-ERS, Young et al. (2001) show market impacts across seven regions for the eight largest commodities in the U.S. Their simulation results suggest that an additional 960,000 acres has been added from crop insurance subsidies with wheat and cotton accounting for about 75 percent of the total increase.

Similarly, a recent study by Goodwin et al. (2004) found that the expansion of crop insurance programs has not induced large acreage increases. Acreage response, insurance participation, input usage and CRP participation were jointly evaluated in the Heartland region for corn and soybeans and in the Northern Great Plains for wheat and barley from 1985 to 1993, using a pooled cross-sectional time series model. The elasticity of acreage response to changes in insurance participation for corn, soybeans and barley were 0.014, 0.0025, and 0.19 respectively. Results of policy simulations suggest that large premium decreases (30%) caused planted acreage to increase by about 1.1% for barley and only about 0.28% to 0.49% for corn.

Most of these acreage response studies have focused on crops other than cotton until recently, an unpublished report by Barnett et al. (2002), examined the impacts of crop insurance on cotton planted in Mississippi from 1996 to 2000. Using a single equation, they modeled cotton acreage as a function of expected net returns per acre for cotton and soybeans, a major competing crop in Mississippi. Based on their estimates, results showed that on the average, a 1% increase in expected net returns from crop insurance would increase cotton acreage by 0.036% while the effect of a 1% increase in expected net market returns for cotton would increase cotton acreage by 0.222%. This indicates that the relatively larger return in dollars per acre from market factors has more influence on cotton plantings than the expected return to insurance.

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

Overall, the literature on cotton's acreage response to crop insurance programs is fairly limited and mostly centers on the Mississippi region. In addition, timing is such that these studies had not considered the effect of Bt cotton, which is known to be a major technology shifter for some regions and influence farmer's decision making in terms of how much land to plant and how much land to insure.

The primary objective of this study is to quantify changes in insurance participation and subsequent acreage responses impacts of the crop insurance program for cotton in the United States. Specifically, this study aims to quantify cotton's acreage response to subsidized crop insurance using county level data across the cotton belt over a time period when producers had planting flexibility. In addition, factors like Bt cotton will be considered so that more defensible conclusions can be drawn for policy.

Empirical Model

An unbalanced panel data set of 4,637 pooled annual county-level observations was constructed using 577 cotton-producing counties from 1995 to 2005.[2] Data are unbalanced in the sense that the number of counties varies over time.[3] Creating a

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[2] All cotton-producing states are included except for Kansas

[3] Data were obtained from various sources - insurance contract data were collected from the Risk Management Agency (RMA) summary of business report while acreage planted, state prices and yield data were collected from the National Agricultural Statistics Service (NASS). To avoid disclosure of individual operations, NASS does not publish acreage values for all counties. Total acres in some counties reported by NASS are less than the insured acres reported by RMA. This discrepancy may be due to sampling errors

complete panel from an unbalanced panel data for the purpose of computational simplification is not recommended since it may cause a large loss in efficiency (Baltagi and Chang, 2000).

Several benefits and limitations of using panel data were enumerated by Hsiao (2003) and Baltagi (2005). Increased variability in panel data can yield more insights among variables. In addition, panel data increases the degrees of freedom and exhibits less collinearity among explanatory variables, thereby improving the efficiency of estimates. Most importantly, panel data controls for individual heterogeneity and allows better analysis of dynamic adjustments, unlike time-series data and cross sectional data.

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

$$\Gamma y_{it} + \Lambda x_{it} = \upsilon_{it} \qquad \textbf{(1)}$$

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since NASS uses sample surveys to collect information from farm cooperators to establish county-level acreage data. RMA can report acreage values even if a county has only one producer due to the Freedom of Information Act. Also, the prevented planting provision in insurance policies contributes to this gap. Prevented planting can occur when there is a shortage in irrigation water due to drought, excess moisture to plant or other natural causes that may prevent planting during the planting window for a region. The producer may opt not to plant the insured crop and file for a prevented planting payment. Land under prevented planting is counted under insured acreage but not as planted acreage.

where Γ is an *MxM* matrix of coefficient of endogenous variables, Λ is an *MxK* matrix of coefficient of predetermined variables. *M* is the number of structural equations in the model and *K* is the number of predetermined variables. y_{it}, x_{it} and υ_{it} are column vectors with dimensions *M, K* and *M*, respectively. υ_{it} denotes the error component structure. Equation (1) can also be written in a stacked structural form as,

$$y = Z\delta + \upsilon \tag{2}$$

where $y' = \left[y_1' \,, y_2'\right]$, $Z = diag\left[Z_j\right]$, $\delta' = \left[\delta_1' \,, \delta_2'\right]$ and $\upsilon' = \left[\upsilon_1' \,, \upsilon_2'\right]$.

The estimation procedure used follows the steps suggested by Cornwell et al. (1992) for the fixed effects standard linear simultaneous equation model. Cornwell et al. (1992) shows that the traditional maximum likelihood estimates (MLE) of the structural parameters are equivalent to the MLE of the system after a within transformation. The random effects model was also estimated using the error component specification for simultaneous equations with incomplete panels by Baltagi and Chang (2000) using error component three stage least squares (EC3SLS).

Following Baltagi's EC3SLS, which accounts for the random error component structure of an unbalanced panel, δ is computed as

$$\delta_{EC3SLS} = \left(Z^{*\prime} P_{x*} Z^{*}\right)^{-1} Z^{*\prime} P_{x*} y^{*} \tag{3}$$

where $Z^* = \sum^{-1/2} Z$, $y^* = Z^*\delta + \upsilon^*$, $\upsilon^* = \sum^{-1/2}$, $P_x^* = X^*\left(X^{*\prime} X^*\right)^{-1} X^{*\prime}$,

$X^* = \sum^{-1/2} X$ and X is the instrument matrix.

δ_{EC3SLS} can also be expressed as,

$$\delta_{EC3SLS} = \left[Z'\Sigma^{-1}X\left(X'\Sigma^{-1}X\right)^{-1}X'\Sigma^{-1}Z \right]^{-1} Z'\Sigma^{-1}X\left(X'\Sigma^{-1}X\right)^{-1}X'\Sigma^{-1}y \qquad \textbf{(4)}$$

where $\sum$ is the variance-covariance matrix between the error terms and calculated using the residuals of a 2SLS procedure. The EC3SLS estimator was derived by Baltagi (1981) and is known to perform better than 2SLS and 3SLS in estimating structural parameters of a simultaneous equation model with error components. To further verify that the fixed effects model is most appropriate, the Hausman test was applied.

The marginal effects of the chosen interaction terms were calculated from the reduced form of the two-equation system. SAS and TSP are used to estimate both structural and reduced form models.

Data

Data on Bt adoption rates were obtained from the Mississippi State University archive of Beltwide Cotton Insect Loss (CIL) data. The data utilized are all at the state level due to difficulties in matching regional data with individual counties. Other data such as futures prices, average world price for cotton and deficiency payments were obtained from Agricultural Marketing Service (AMS), USDA. Prices and other economic variables were deflated using the CPI for all goods and are in 2007 dollars.

As mentioned earlier, a systems equation approach is proposed. The two equation system proposed is:

$$INSURANCE_{it} = \alpha + \beta_1 ACRES_{it} + \beta_2 SUBSIDYPERLB_{it-1} + \beta_3 ROR_{it-1} + \beta_4 EXPRICE_{it} + \beta_5 LAGYLD_{it} + \beta_6 EXPRICE_{it} * LAGYLD_{it} + \beta_7 YLDVAR_{it} + \beta_8 BT_{it} + \beta_9 D1 + \beta_{10} D2 \qquad \textbf{(5)}$$

$$ACRES_{it} = \gamma + \delta_1 INSURANCE_{it} + \delta_2 EXPPRICE_{it} + \delta_3 LAGYLD_{it} + \delta_4 EXPRICE_{it} * LAGYLD_{it} + \delta_5 YLDVAR_{it} + \delta_6 BT_{it} + \delta_7 PICC_{it} + \delta_8 D1 + \delta_9 D2 \quad \textbf{(6)}$$

where $ACRES_{it}$ is the percent of crop acreage in county *i* planted to cotton in year *t*, $INSURANCE_{it}$ is the participation rate for cotton insurance, $EXPPRICE_{it}$ is the expected price for the state that county *i* resides in prior to when planting decisions occur for year *t*, $LAGYLD_{it}$ is yield (lbs./acre) for county *i* lagged, $EXPPRICE_{it}*LAGYLD_{it}$ is an interaction term between price and yield that is also a form of expected revenue, $YLDVAR_{it}$ represents yield variability for county *i*, BT_{it} is the adoption rate for Bt cotton of the state county *i* resides in, $SUBSIDYPERLB_{it}$ ($/lb.) is the expected premium subsidy, ROR_{it-1} is the rate of return for the producer to buying insurance in *t-1* as measured by the ratio between total indemnity and producer premium costs (net premium plus sign up fee), $PICC_{it}$ is a price index of competing crops for county *i*, and lastly, *D1* and *D2* are period dummies for 2000 to 2001 and 2002 to 2005, respectively, to reflect different premium subsidy regimes.

In order for the systems of equation to be identified, valid instruments are used for the insurance participation and cotton acreage equation. *SUBSIDYPERLB* and *ROR* are used as instruments for the insurance participation equation while *PICC* is used as an instrument in the acreage equation. These instruments are valid in the sense that *SUBSIDYPERLB* and *ROR* should not directly influence acreage planted to cotton and *PICC* should not directly influence insurance participation. Variables used in the model are described in tables 2 and 3 and descriptive statistics are summarized in table 4.

The literature measures crop insurance participation in different ways. The conventional way of measuring crop insurance participation is simply the ratio of insured to total acres planted or in a binary model participation has a value of 1 when insurance is purchased and 0 otherwise. Goodwin (1993) proposes an alternative approach to measuring participation by considering changes in buy-up coverage levels. Goodwin et al. (2004) argues that one can increase insurance participation without increasing acres insured by merely increasing the coverage level, which is reflected in total liability. Similarly, $INSURANCE_{it}$ equals the total possible liability or maximum liability by multiplying the 5-year historical yield for a county by the price election for a given year times the maximum price election coverage of 75% for years before 2000 and 85% for years 2002 to 2005.

Variables included to capture influences of market and government incentives and technology on farmer's decision making include *EXPPRICE*, *LAGYLD* and the interaction term between *EXPPRICE* and *LAGYLD*. *EXPPRICE* is calculated using the December futures price in February plus the 'November state basis' to incorporate state level supply and demand conditions. The expected LDP is incorporated into the basis value to capture the effect of government price support programs on *EXPPRICE* for the producer. The December futures price in February is chosen because the sales closing date for cotton insurance is in February and this is about the latest date that producers can significantly alter their planting decisions for the upcoming cropping year. Basis is the difference between the lagged state price a county resides in and the average of the lagged December futures prices for the Fridays during the last quarter the contract is traded. This is the most recent basis information available and it corresponds to the nearest futures price at the time when a large percentage of cotton is marketed. If the AWP is below 52 cents per lb. when producers sell their cotton they are eligible to receive this difference on their quantity sold. The expected LDP or "market gain" is constructed as:

$$ExpectedLDP = Max\begin{cases} 52 - E[AWP] & if \;\; E[AWP] < 52 \\ 0 & Otherwise \end{cases}$$

$$E[AWP] = DECfutures + E(BasisLDP) \quad \textbf{(9)}$$

$$E(BasisLDP_t) = AWPlq_{t-1} - DECfutureslq_{t-1} \quad \textbf{(10)}$$

where *E[AWP]* is the expected Adjusted World Price while *AWPlq* and *DECfutureslq* are the AWP and December futures in the last quarter of the year, respectively.

The interaction of *EXPPRICE* and *LAGYLD* is given by *EXPPRICE*LAGYLD*. *EXPPRICE* has a mean of $0.747 per lb. It is expected that counties with high yield insure less when expected price increases and increase insurance participation when expected price goes down. Similarly, counties with high yields are expected to have less acreage response when price goes up while counties with very low yield are expected to be more responsive to price changes.

YLDVAR is included to capture yield variability among counties. *YLDVAR* is calculated as the ratio of the moving standard deviation to the moving mean. Having an unbalanced panel made construction of this variable difficult. To avoid losing a large number of observations, counties with at least one year of historical yield from 1985 to the county's initial year of cotton production are considered. Counties facing high yield risks are expected to increase participation.

ROR measures the rate of return of insurance for producers. This is calculated as the proportion of indemnity received to producer costs. Producer costs are calculated as the sum of their premiums and administrative fees paid. *ROR* is expected to be positively associated with insurance participation. This variable is also used as an instrument for the insurance equation. *ROR* varies greatly by region and has a mean of 2.387 which means that producer benefits derived from insurance are over twice as much as their cost across all counties and participating producers. *SUBSIDYPERLB* is constructed as total premium subsidies received in a county divided by the counties 5-year moving average yield. A positive association between *SUBSIDYPERLB* and *INSURANCE* is expected.

The introduction of Bt cotton has shifted the competitive advantage of production for many regions, particularly those susceptible to bollworms. Higher Bt adoption rates would appear to be associated with increased plantings for these regions. On the other hand, the effect of Bt adoption on insurance participation may be negative since Bt cotton reduces production risk. Table 4 shows that average Bt cotton adoption varies by region.

The effect of competing crops on cotton acreage is also considered. Wheat, corn and soybeans are selected as the major competing crops for all counties. The expected price for each crop is constructed using a futures price or loan rate and state basis which is the difference between the US average and state price in the previous year. To compare these prices, a Laspeyres price index with 1996 as the base year was constructed. For example, the price index for wheat is computed as

$$Priceindex_w = \left(\frac{P_{w,t}}{P_{w,1996}} \right) * \left(\frac{acres_w}{acres_w + acres_s + acres_c} \right). \quad \textbf{(11)}$$

Price indices of all competing crops are added to get the Price Index of Competing Crops (*PICC*). Note that prices used in the computation are state-level while acres are measured at the county-level. Using this measure, more weight is given to the relatively larger competing crops in a county. *PICC* has a mean of 0.956. A high *PICC* is expected to decrease the acreage planted to cotton. This variable is also used as an instrument for the acreage equation.

The counties can be grouped into 4 distinct production regions[4] namely Southeast, Delta, Southwest and West regions. Crops yields, prices and hydrological conditions differ across production regions. Among the four regions, insurance participation is highest in the Southwest region (78.4%) over the sample period. The Southwest region is also characterized by counties having low cotton yields, low cotton prices, and high production risk. Conversely, insurance participation is lowest in the West region (48.2%) where cotton yields and prices are highest and production risk is lowest. Examining the subsidy per unit of production across different production regions, it appears that subsidy is highest for the Southwest (4 cents/lb) and lowest for the West (1 cent/lb). Do counties in riskier areas benefit more from the subsidized crop insurance?

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[4] Southeast region includes Alabama, Florida, Georgia, North Carolina, South Carolina and Virginia; Delta region includes Arkansas, Louisiana, Mississippi, Missouri and Tennessee; Southwest region includes Oklahoma and Texas; and West region includes Arizona, California and New Mexico.

Results

Based on figure 1, total cotton acreage decreased from 1995 to 1998, slowly increased from 1998 to 2001, and then declined in 2002. In 1995, the year with the highest percent of acreage insured, about 57% of the insured acreage was under CAT while only 43% under BUP. High CAT participation is associated with 1994 crop insurance legislation which mandated participation in at least CAT to be eligible for farm commodity programs. But this requirement was rescinded in the 1996 Farm Bill. A series of subsidy increases followed to encourage insurance participation and in effect, insured acreage increased, especially at the BUP level. In 2001, about 76% of the insured acreage was under BUP while CAT only comprised 24% of the total acreage insured. From 2000 to 2002, about 56% of the insured acreage was at the 65% coverage level or greater.

Fixed Effects Model

Following Goodwin et al. (2004) a simultaneous framework is employed to estimate the effect of subsidized crop insurance program on US cotton acreage. The equations are simultaneous because acreage decisions and crop insurance program participation decisions are made at the same time. Unlike Goodwin et al. (2004), a panel data structure and fixed effects specification[5] was applied. It can be argued that μ_i is correlated with the explanatory variables. For example, the location of the county, size of county, and land quality can be correlated with the regressors. Therefore, correlation

[5] A random effects model was also estimated and the Hausman test was applied to test for model specification. However, the Hausman test is not well-defined because of a non-positive definite covariance matrix. This may imply that there are no obvious efficiency gains from the random effects model.

between μ_i and the explanatory variables are assumed. Another reason for choosing the fixed effects model is that the counties observed are not randomly sampled but more or less exhaust the population. Parameter estimates for equations 5 and 6 are given in table 5.

Insurance Participation

Instruments used for the insurance equation are *SUBSIDYPERLB* and *ROR*. The estimate of *ROR* in the insurance equation shows a strong and positive association between *ROR* and crop insurance participation (*INSURANCE)*. Similarly, *SUBSIDYPERLB* is highly significant and positive. If subsidy per lb. of production increases then *INSURANCE* also increases. Generally, counties that receive higher subsidy per lb. of production are counties where production risks are high and yields are relatively low. Because subsidy rates are structured as a percentage of total premiums, it favors high risk and or low yielding counties. Keeton and Skees (1999) suggest targeting a per unit of production subsidy so that subsidies will no longer favor high risk regions at a cost to low-risk regions.

The correlation of yield variability and insurance participation is also highly significant and positive. High insurance participation among counties having relatively higher yield variability or unstable yield is not surprising due to high risks in production that these counties face. This is supported by table 4 which shows that the Southwest (West) has the highest (lowest) yield variability and level of insurance participation.

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

Lastly, a positive correlation between Bt cotton adoption rates and insurance participation suggests that areas with a high rate of adoption insure more. However, Bt cotton is relatively more expensive than non-transgenic varieties and the producer may be insuring to protect the repayment of their investment.

Acreage Response

For the *ACRES* equation, the instrument is the Price Index of Competing Crops (*PICC*). The estimate for *PICC* is significant and negative. An increase in the expected price of these competing crops causes a decrease in cotton plantings, albeit an inelastic response. The effect of *YLDVAR* on cotton acreage is negative and highly significant. Other things equal, counties with high yield variation tend to plant less cotton compared to counties with relatively stable yields. High yield variation is also common in dry land counties. Similarly, for counties with very low yields, the marginal effect of the price expectation on cotton acreage is positive, whereas it is negative for high yielding counties. Policy implications of this result are given in the next section.

The effect of Bt cotton adoption on cotton plantings is negative. While higher adoption is generally associated with a technology shift and competitive advantage for these regions, increased yields from Bt cotton decrease the need for more acreage in the aggregate. However, the results on Bt adoption are not conclusive since Bt adoption data are at the state rather than county level.

The key result of this research is that the positive and significant correlation between insurance participation and cotton acreage. Similar to other studies, the effect of insurance is positive and inelastic. The elasticity of acreage with respect to insurance participation at data means is about 0.198 while the elasticity of insurance participation with respect to subsidy per unit production is 0.0286. Acreage elasticity estimates found by other studies are 0.014, 0.0025 and 0.19 for corn, soybean, barley (Goodwin et al. 2004) and 0.099 for cotton in Mississippi portal and Southern Seaboard (Deal 2004). Thus, while our estimated elasticity of acreage with respect to insurance participation is still inelastic, our magnitude is almost double that of other studies.

The fixed effects estimates of the reduced form are given in table 6. Based on these results, the subsidy per unit of production positively affects cotton acreage. Increasing *SUBSIDYPERLB* by $0.10 would lead to an increase in *ACRES* by 0.48%. However, the effect is not statistically significant at the data means. The effect of subsidy per unit of production on acres is also computed segregating the data by regions and results show that the effect of *SUBSIDYPERLB* on *ACRES* is positive for the Delta (0.293), West (1.398) and Southwest (0.155) regions. The effect is only significant for the Southeast and Southwest. However, the estimate for the Southeast region is -0.217, which seems counterintuitive. The explanation of the negative effect of *SUBSIDYPERLB* on acres for the Southeast region may be attributed to the larger yield impacts of Bt in the

Southeast than other regions and the state level data for Bt adoption. A contribution of future studies would be to quantify Bt adoption at the county level to more accurately control for the effects of Bt technology on cotton acreage.

Insurance participation and cotton acreage were also considered by segmenting the data into the four regions. Parameter estimates of insurance participation on cotton acreage for these regions were positive and significant except for the Delta and West regions. Elasticities for the Southeast and Southwest at their data means are 0.26 and 0.38, respectively.

Marginal Effects of Expected Price and Yield

Generally, counties that exhibit the highest cotton yields are those that are irrigated or have the lowest production risk. Prices are also relatively higher for irrigated counties due to better overall quality. On the other hand, dryland production or counties with limited rainfall can be characterized with relatively low yields and high production risks. Prices are also generally lower, due in large part to lower quality, as evidenced by lower average state prices.

Based on the parameter estimates and standard errors of the reduced form, the marginal effects of *EXPPRICE* on insurance participation (figure 2) suggest that an increase in the price expectation causes a decline in insurance participation among counties with relatively higher yields. In counties where yields are relatively high, crop insurance participation will decline with a high expected price because the probability of receiving indemnity payments in these counties is low. However, a lower price expectation may cause counties with very high yields to insure more. On the other hand, counties with very low yields behave differently. The association between expected price and insurance participation is positive which is likely due to higher production risks in counties with very low yields.

The marginal effect of *EXPPRICE* on cotton acreage is given in figure 3. The direction of the effect is similar to figure 2 where in the marginal impact of price is decreasing in yield. That is, an increase in the expected price has a smaller impact on acreage when yield is very high and there is more acreage response from counties with extremely low yields. This may indicate that counties with extremely high yields are those that are irrigated. Because of limited irrigation water, these counties are not able to respond as much as counties with dry land agriculture. Another intuition is that since yield is very high in these counties, it can be argued that the current land quality being used is also high. An increase in acreage response due to changes in price expectation may suggest bringing less productive land into cotton production. Therefore, when yields are very high, an increase in price results in a smaller impact on acreage because the options for putting more land into production are limited.

Conclusions and Implications

Insurance participation for cotton and its effect on cotton acreage is examined for the entire U.S. cotton belt, and not just one or two regions. Planting restrictions were removed in 1996 for the first time in decades, allowing producers to respond to market and crop insurance incentives more than previously. Using simultaneous crop and acreage response equations, results show that counties with extremely low yields, usually those in dry land/rainfed regions, have more response to insurance participation compared to those with very high yields as the price expectation goes up. Moreover, counties with extremely low yields respond more to changes in expected price than counties with relatively high yields. An important policy implication of this result is that price supports are likely to benefit counties more that have relatively greater production risks. Furthermore, higher insurance subsidies lead to greater insurance participation and cotton production in relatively riskier counties.

Another important issue addressed is the notion that crop insurance impacts acreage decisions. There has been increasing concern about the production-inducing effect, especially in riskier production areas, of crop insurance. Based on Goodwin et al. (2004), elasticities of acreage response on changes in insurance participation at data means for corn, soybeans and barley are 0.014, 0.0025 and 0.19, respectively. In the Mississippi portal and Southern Seaboard, Deal (2004) also found inelastic response of about -0.104 in 1990 to 1995 and 0.099 in 1996 to 2000. Findings of this study also support literature that claimed a positive but marginal effect of insurance participation on crop acreage. Specifically, results show that on average, a 1% increase in insurance participation causes an increase in cotton acreage of 0.198%.

References

Baltagi, Badi, “Simultaneous Equations With Error Components," Journal of Econometrics, 1981, 17, 189-200.

Baltagi, Badi H., Econometric Analysis of Panel Data, 3rd ed., Wiley, 2005.

Baltagi, Badi H., and Young-Jae Chang, “Simultaneous Equations With Incomplete Panels," Economic Theory, 2000, 16, 269-279.

Barnett, Barry, Keith Coble, Thomas Knight, Leslie Meyer, Robert Dismukes, and Jerry Skees, “Impact of the Cotton Crop Insurance Program on Cotton Planted Acreage," Technical Report, Report prepared for the Board of Directors, Federal Crop Insurance Corporation, Risk Management Agency, U.S. Department of Agriculture 2002.

Cornwell, Christopher, Peter Schmidt, and Donald Wyhowski, “Simultaneous equations and panel data," Journal of Econometrics, 1992, 51, 151-181.

Deal, John, “The Empirical Relationship Between Federally-Subsidized Crop Insurance and Soil Erosion." PhD dissertation, North Carolina State University 2004.

Duffy, Patricia A., James W. Richardson, and Michael K. Wohlgenant, “Regional Cotton Acreage Response," Southern Journal of Agricultural Economics, July 1987, 19 (1), 9-110.

Goodwin, Barry K., “An Empirical Analysis of the Demand for Multiple Peril Crop Insurance," American Journal of Agricultural Economics, May 1993, 75 (2), 425-434.

Goodwin, Barry K., Monte L. Vandeveer, and John L. Deal, “An Empirical Analysis of Acreage Effects of Participation in the Federal Crop Insurance Program," American Journal of Agricultural Economics, November 2004, 86 (4), 1058-1077.

Hsiao, Cheng, Analysis of Panel Data, 2nd ed., Cambridge University Press, 2003.

Keeton, Kara Kate and Jerry R. Skees, “The Potential Influence of Risk Management Programs on Cropping Decisions at the Extensive Margin," Master's thesis, University of Kentucky 1999.

Knight, Thomas O. and Keith H. Coble, “Survey of U.S. Multiple Peril Crop Insurance Literature since 1980," Review of Agricultural Economics, 1997, 19 (1), 128-156.

Vandeveer, Monte L. and Edwin Young, “The Effects of the Federal Crop Insurance Program on Wheat Acreage," Technical Report, Economic Research Service, US Department of Agriculture March 2001.

Wu, JunJie, “Crop Insurance, Acreage Decisions, and Nonpoint-Source Pollution," American Journal of Agricultural Economics, 1999, 81, 305-320.

Wu, JunJie, and R.M. Adams, “Production Risk, Acreage Decisions and Implications for Revenue Insurance Programs," Canadian Journal of Agricultural Economics, 2001, 49, 19-35.

Young, Edwin, Monte Vandeveer, and Randall Schnepf, “Production and Price Impacts of U.S. Crop Insurance Programs," American Journal of Agricultural Economics, 2001, 83 (5), 1196-1203.

Table 1. Crop Insurance Subsidies and those for Cotton, 1995-2005

Year	Total USDA Subsidies (in million US$)	Cotton Subsidies (in million US$)	Cotton Share (in %)
1995	7,242	30	0.41
1996	7,274	647	8.9
1997	7,455	595	7.98
1998	12,358	1,163	9.41
1999	21,572	1,721	7.98
2000	23,391	1,850	7.91
2001	22,441	3,033	13.52
2002	12,949	2,389	18.45
2003	16,438	2,697	16.41
2004	12,533	1,654	13.2
2005	21,057	3,331	15.82
Total	164,710	19,110	11.6

Table 2. Variable Description and Expected Signs for Insurance Equation

Variables	Variable Description	Source of Data	Expected Signs
Dependent variable			
INSURANCE	Insurance participation measured as total liability over total possible liability	RMA/ NASS	
Independent variables			
ACRES	Total acres planted for cotton over county's total cropland acres	NASS/ Ag. Census	+
SUBSIDYPERLB	Subsidy per lb of production measured by total subsidy over 5-year moving average county yield	RMA/ NASS	+
ROR	Rate of return from insurance measured as total indemnity over producer's premium	RMA	+
EXPPRICE	Expected price for cotton ($/lb): Closing December Futures for the last four Fridays prior to the February sales closing date plus the expected basis (i.e., lagged basis of state price minus December Futures for the Fridays during the last quarter of trading) plus expected LDP if positive (i.e., December Futures in February minus lagged AWP basis using last quarter of year)	AMS/NASS	+
LAGYLD	Lagged yield (lbs./acre)	NASS	+
EXPPRICE LAGYLD*	Interaction between *EXPPRICE* and *LAGYLD*	AMS/NASS	-
YLDVAR	Yield variability measured by moving coefficient of variation	NASS	+
BT	Bt cotton adoption rate	CIL	-
D1	Dummy for years 2000 to 2001		
D2	Dummy for years 2002 to 2005		

Table 3. Variable Description and Expected Signs for Cotton Acreage Equation

Variables	Variable Description	Source of Data	Expected Signs
Dependent variable			
ACRES	Total acres planted for cotton divided by a county's total cropland acres	NASS/ Ag. Census	
Independent variables			
INSURANCE	Insurance participation measured as total liability over total possible liability	RMA/ NASS	+
EXPPRICE	Expected price for cotton ($/lb.) (please see table 2 above)	AMS/NASS	+
LAGYLD	Lagged yield (lbs./acre)	NASS	+
EXPPRICE LAGYLD*	Interaction between *EXPPRICE* and *LAGYLD*	AMS/NASS	-
YLDVAR	Yield variability measured by moving coefficient of variation	NASS	-
BT	Bt cotton adoption rate	CIL	+
PICC	Expected price index of the major 3 competing crops (corn, soybean, wheat)	NASS	-
D1	Dummy for years 2000 to 2001		
D2	Dummy for years 2002 to 2005		

Table 4: Summary Statistics

Variables	Delta *(21.2%)*	Southeast *(43.7%)*	Southwest *(28.9%)*	West *(6.2%)*	U.S. *(100%)*
Dependent variables					
INSURANCE	0.545	0.725	0.784	0.482	0.689
	(0.291)	(0.281)	(0.318)	(0.239)	(0.309)
ACRES	0.214	0.24	0.173	0.121	0.208
	(0.153)	(0.176)	(0.185)	(0.128)	(0.175)
Independent variables					
SUBSIDYPERLB	0.021	0.029	0.044	0.012	0.031
	(0.009)	(0.014)	(0.023)	(0.009)	(0.019)
ROR	2.35	2.429	2.361	2.333	2.387
	(9.3)	(4.891)	(2.586)	(6.116)	(5.748)
EXPPRICE	0.743	0.77	0.703	0.796	0.747
	(0.117)	(0.124)	(0.112)	(0.13)	(0.123)
LAGYLD	732	618	472	1,072	628
	(168)	(169)	(236)	(304)	(249)
*EXPPRICE*LAGYLD*	537	474	326	845	468
	(121)	(142)	(160)	(253)	(197)
YLDVAR	0.182	0.236	0.28	0.159	0.232
	(0.066)	(0.098)	(0.116)	(0.1)	(0.106)
BT	0.588	0.552	0.148	0.246	0.424
	(0.291)	(0.247)	(0.102)	(0.276)	(0.298)
PICC	0.958	0.954	0.977	0.861	0.956
	(0.213)	(0.215)	(0.207)	(0.302)	(0.22)
D1	0.098	0.102	0.101	0.108	0.101
	(0.298)	(0.312)	(0.301)	(0.31)	(0.302)
D2	0.386	0.376	0.405	0.385	0.387
	(0.487)	(0.484)	(0.491)	(0.488)	(0.487)
Other descriptors					
Planted	37,061	15,544	44,925	34,151	29,761
	(34,483)	(15,108)	(68,515)	(52,576)	(45,984)
Insured acres	31,544	14,329	43,704	27,492	27,292
	(34,483)	(14,348)	(67,319)	(43,573)	(43,861)

No. of observations = 4,637

Table 5. Fixed Effects Results

Independent Variable	Dependent Variable	
	INSURANCE	ACRES
Intercept	0.0181 (0.0102)	-0.0017 (0.0018)
EXPPRICE	0.1957 (0.1328)	0.0479* (0.022)
LAGYLD	-0.0001 (0.0002)	0.0001** (<0.0001)
*EXPPRICE*LAGYLD*	-0.0005** (0.0002)	-0.0001 (<0.0001)
YLDVAR	0.3275** (0.0695)	-0.0479** (0.0101)
BT	0.2926** (0.0254)	-0.0220** (0.0074)
D1	-0.0734* (0.0339)	0.0226** (0.0027)
D2	-0.0086 (0.0214)	-0.0075* (0.0032)
SUBSIDYPERLB	0.6364* (0.2835)	
ROR	0.0042** (0.0008)	
ACRES	3.6750** (1.2135)	
PICC		-0.0154** (0.0045)
INSURANCE		0.0599** (0.0218)

Note: Asterisks indicate statistical significance at the 5%(*) and 1%(**) levels.

Standard errors in parentheses.

Table 6. Fixed Effects Estimates of the Reduced Form

Independent Variable	Dependent Variable	
	INSURANCE	ACRES
Intercept	0.0153* (0.0077)	-0.0007 (0.002)
EXPPRICE	0.4739** (0.0805)	0.0769** (0.0212)
LAGYLD	0.0003** (0.0001)	0.0001** (0.00002)
*EXPPRICE*LAGYLD*	-0.0009** (0.0001)	-0.0001** (0.00002)
YLDVAR	0.1938** (0.034)	-0.0363** (0.0108)
BT	0.2721** (0.0202)	-0.0059 (0.0045)
D1	0.0127 (0.0127)	0.0233** (0.0031)
D2	-0.0462** (0.0139)	-0.0102** (0.0035)
SUBSIDYPERLB	0.8223** (0.2763)	0.0485 (0.0348)
ROR	0.0053** (0.0002)	0.0003 (0.0002)
PICC	-0.0689** (0.0042)	-0.0203** (0.0042)

Note: Asterisks indicate statistical significance at the 5%(*) and 1%(**) levels.

Standard errors in parentheses.

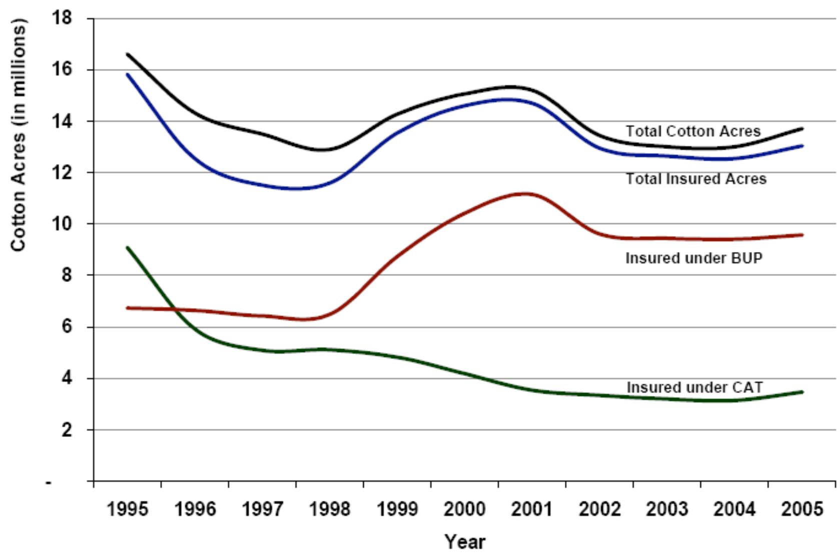

Figure 1. Insured acreage by coverage levels, 1995-2005

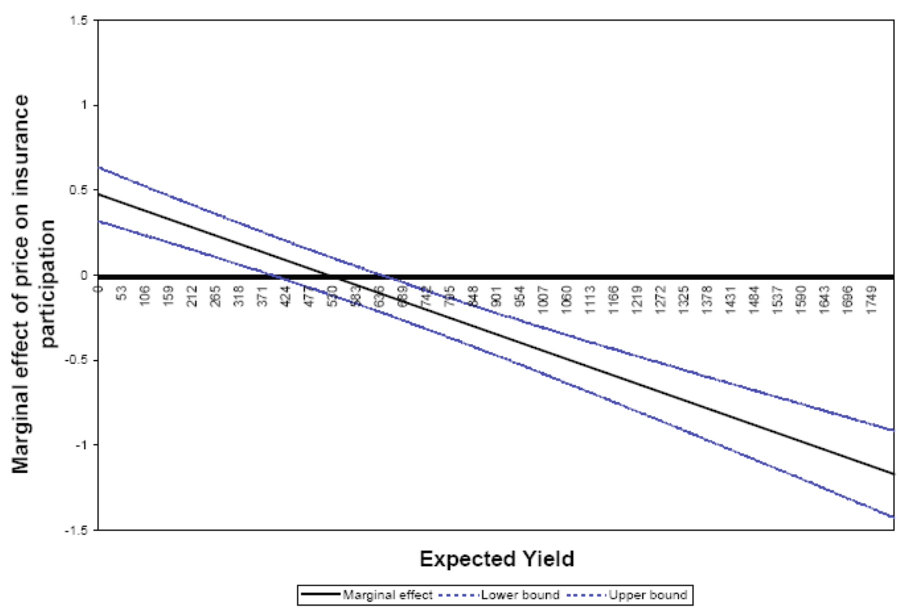

Figure 2. Marginal effects of expected price on insurance participation given yield expectation

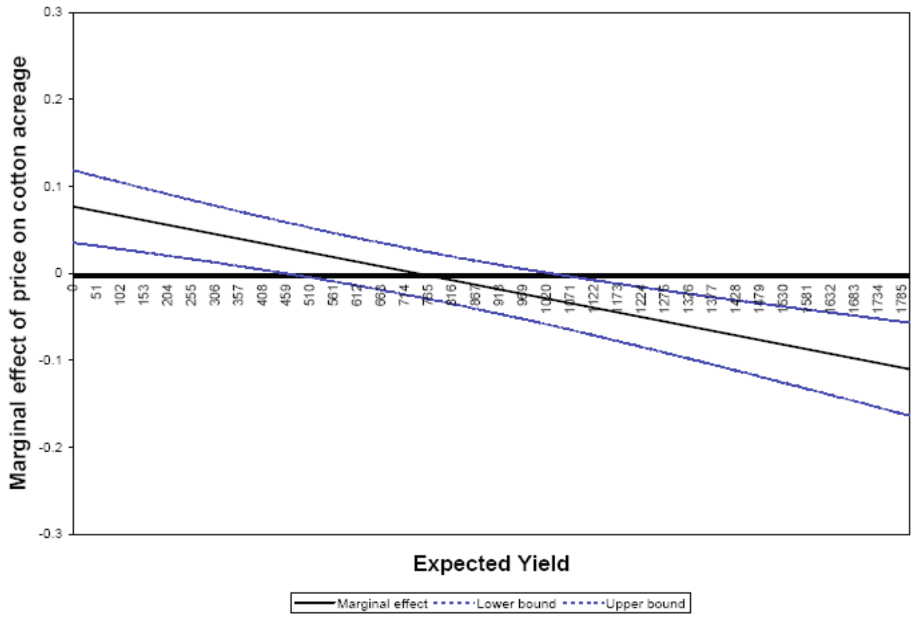

Figure 3. Marginal effects of expected price on cotton acreage given yield expectation