The Effects of Crop Insurance Participation on Upland Cotton Acreage Abandonment: A Real Options Approach

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April 7, 2020

Abstract

We search for empirical evidence of moral hazard in the U.S. Federal Crop Insurance Program by examining the effects of crop insurance participation on the post-planting crop abandonment decisions of upland cotton producers. We begin by developing a formal profit-maximization model that explains a farmer's decision to abandon his crop without harvesting it. By introducing flexible aggregation conditions, we derive a structural model that explains aggregate rates of abandonment. The model is estimated using nested-fixed-point maximum likelihood methods using annual county-level upland cotton production and crop insurance participation data. Our estimates indicate that insured cotton farmers abandon their crops at greater rates than uninsured farmers and that approximately 9% of upland cotton acres abandoned between 1980-2006 were abandoned due to crop insurance participation.

Key words: Crop insurance; upland cotton; crop abandonment; moral hazard; real options.

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Introduction

Over the past three decades, a variety of crop yield and revenue insurance contracts have been introduced under the U.S. Federal Crop Insurance Program to assist agricultural producers manage their financial risks. Although crop insurance is designed to protect agricultural producers from unexpected financial loses, many academic researchers and government policy analysts have argued that crop insurance may provide producers with incentives to alter their production practices in a manner that increases the likelihood of indemnifiable loses (e.g., Grossman and Hart 1983; Holmstrom 1979; Shavell 1979). This economic behavioral phenomenon is known as *moral hazard*.

Numerous studies have examined how crop insurance affects producer decisions (e.g., Chambers 1989; Chambers and Quiggin 2002; Coble, Knight, Pope, and Williams 1997; Vercammen and van Kooten 1994). The majority of studies have focused on the effects of crop insurance on acreage allocation and production practices, and have provided contradictory or inconclusive evidence of moral hazard. For example, Smith and Goodwin 1996 concluded that crop insurance participation increased nitrogen application and pesticide use among U.S. Midwest corn producers. In contrast, Babcock and Hennessy 1996 and Smith and Goodwin 1996 found, respectively, that insured Iowa corn producers and insured Kansas dryland wheat producers use less chemical inputs than uninsured producers. In another study, Wu 1999 found that insurance participation encourages Central Nebraska corn producers to switch to crops with higher expected economic returns, leading to increased chemical use. And, more recently, Goodwin, Vandeveer, and Deal 2004 concluded that crop insurance participation leads to relatively modest increases in acreage, but has ambiguous impacts on input use among Corn Belt corn and soybean producers and Upper Great Plains wheat and barley producers.

The failure of empirical studies to uncover unambiguous and conclusive evidence of moral hazard in the U.S. crop insurance program may be attributable to various reasons, two of which are especially relevant to the findings that we report here. First virtually all empirical studies to date have searched for evidence of moral hazard by examining the effects of crop insurance on planting-time acreage allocation and fertilizer input decisions. We contend, however, that the effects of crop insurance on input decisions can easily be masked by other factors affecting planting-time production decisions, making it difficult to detect moral hazard empirically. For example, decisions regarding chemical use may be driven more by weather conditions at planting than by crop insurance participation (Horowitz and Lichtenberg 1993).

Second, most empirical studies to date have focused on the effects of crop insurance on major field crops in the Midwest and Upper Great Plains. The actuarial performance of the U.S. crop insurance program in these regions, however, has historically been substantially better than in other regions of the country, suggesting that the conditions necessary for significant moral hazard are likely to be stronger elsewhere. Figure 1 illustrates regional variation in the ratio of indemnities paid to producers to premiums collected from producers during 1989–2006. As seen in figure 1, the U.S. crop insurance program has operated on a nearly actuarially sound basis in the Corn Belt and Upper Great Plans, but not in the Southern or Northeastern United States.

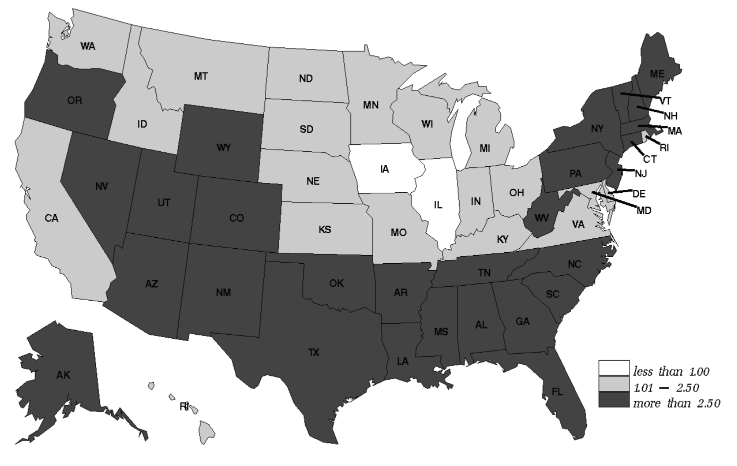

Figure 1: Ratio of indemnities paid to producers to premiums collected from producers under the U.S. Federal Crop Insurance Program, 1989–2006, by state. *Source: U.S. Department of Agriculture, Risk Management Agency.*

In this paper, we seek empirical evidence of moral hazard in the U.S. crop insurance program, departing from the established empirical literature in two significant respects. First, we examine the effects of crop insurance participation on post-planting production decisions that theoretically can be expected to be more sensitive to the incidence of crop insurance than input decisions. Second, we focus our empirical analysis on a crop and regions that have historically experienced high loss ratios under the Federal Crop Insurance Program. In particular, we search for evidence that crop insurance participation increases post-planting crop abandonment among upland cotton producers in the Southern United States.

In the next section, we develop a formal profit-maximization model that explains a producer's crop abandonment decision. The model implies that changes in prices and weather conditions during the growing season and participation in the crop insurance program all affect a cotton producer's decision to abandon his crop. In the subsequent sections, we develop two empirical models of aggregate acreage abandonment motivated by theoretical considerations, a "flexible" model that allows us to directly test the effects of crop insurance participation on county-level crop abandonment rates and a "structural" model that is better suited to quantifying the impacts of crop insurance on aggregate crop abandonment. The models are estimated using annual 1980-2006 county-level upland cotton production and crop insurance participation data. In the remaining sections, we discuss our findings.

A Theoretical Model of Acreage Abandonment

In this section, we develop a formal profit-maximization model that explains a typical cotton farmer's decision to abandon his crop between planting and harvest. In this model, the typical farmer decides whether to abandon his crop or bring it to harvest at a point in time between planting and harvest that we will refer to simply as "mid-season". The farmer's decision will depend on the information available to him at mid-season, including the mid-season cotton futures price and growing conditions. The farmer's decision will also depend on the provisions of the crop insurance contract he has purchased, if any.

Begin by assuming that a typical cotton farmer i's yield per harvested acre in year t is given by

$$y_{it} = \bar{y}_{it} w_{it} \epsilon_{it}.$$

Here, $\bar{y}_{it}$ is the yield farmer i expects in year t, conditional on information known at planting[1]; $w_{it} \geq 0$ is a random weather shock that is fully revealed by mid-season; and $\epsilon_{it} \geq 0$ is a random shock that is independent of all information known through mid-season. We assume, without loss of generality, that $Ew_{it} = E\epsilon_{it} = 1$.

At harvest, the cotton farmer receives a price

$$p_t = f_t\eta_t$$

per unit of output, where f_t is the mid-season cotton futures price for delivery at harvest and η_t is a random shock that is independent of all information known through mid-season. We assume that $E\eta_t = 1$.[2]

At mid-season, farmer i must decide, given currently available information, whether to abandon his crop or bring it to harvest. If the farmer opts to bring his crop to harvest, he incurs a net additional per-acre production cost c_{it} given by

$$c_{it} = \bar{y}_{it}\gamma_{it}.$$

Here, γ_{it} is a random, farmer- and year-specific cost of harvest, expressed per unit of expected yield.

The farmer maximizes expected profit. Thus, his mid-season abandonment decision reduces to comparing expected net profits with and without abandonment, given currently available information. In particular, if the farmer is not insured, he will abandon his crop if the marginal cost of bringing it to harvest exceeds expected marginal revenue, that is, if

$$c_{it} > E_t p_t y_{it} = f_t\bar{y}_{it}w_{it},$$

where E_t is the expectation conditional on information available at mid-season in year t. Substituting and simplifying, the farmer will abandon his crop if

$$\gamma_{it} > f_t w_{it}.$$

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[1] The farmer's expected yield can vary over time due to exogenous secular trends in yields.

[2] The assumption that the futures price is an unbiased predictor of the spot price is reasonable, given the empirical evidence that commodity prices do not embody a significant "risk premiums" See Dusak 1973, Fama and French 1987, and Park, Wei, and Frecka 1990.

If farmer i possesses crop insurance, his mid-season abandonment decision will further take into account the indemnity he expects to receive, with and without abandonment. The indemnity will depend on the type of crop insurance coverage he has purchased, which may be either actual production history coverage (APH) or crop revenue coverage (CRC), and the coverage level he has selected.[3]

Suppose first that farmer possesses APH insurance coverage. If the farmer does not abandon his crop, his expected indemnity, conditional on information available at mid-season, is $E_t p_t^e \max\{0, \theta_i \bar{y}_{it} - y_{it}\}$, where θ_i is the "coverage level" selected by the farmer and p_t^e is the "planting-time expected price" quoted in the APH insurance policy.[4] If the farmer abandons his crop, he will receive an indemnity equal to the maximum liability $\theta_i p_t^e \bar{y}_{it}$.

Taking expected indemnities into account, the APH-insured farmer will abandon his crop at mid-season in year t if the net revenue he expects with abandonment exceeds the net revenue he expects without abandonment, that is, if

$$\theta_i p_t^e \bar{y}_{it} > f_t \bar{y}_{it} w_{it} + E_t p_t^e \max\{0, \theta_i \bar{y}_{it} - y_{it}\} - c_{it}.$$

Thus, substituting and simplifying, the APH-insured farmer will abandon his crop if

$$\gamma_{it} > f_t w_{it} - E_t p_t^e \min\{\theta_i, w_{it}\epsilon_{it}\}.$$

Suppose now that farmer i possesses CRC insurance coverage. The indemnity per acre provided by CRC insurance is given by

$$\max\{0, \theta_i p_t^g \bar{y}_{it} - p_t y_{it}\},$$

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[3] Other crop insurance coverages may be available to the farmer, including Group Risk Plan, Income Protection, Revenue Assurance, and Group Risk Income Protection coverage. However, the indemnities provided by these insurance plans are functions of the final county yield, not the farmer's individual final yield. Because the indemnities provided by these plans are independent of the the farmer's abandonment decision, they are irrelevant to the farmer's abandonment decision and are ignored in our analysis.

[4] The expected price on an APH cotton policy, for most counties, is computed as the average ending daily settlement price of the New York Board of Trade Cotton Exchange December futures contract during preceding January 15 to February 14 period. See New York Board of Trade 2008 and U.S. Department of Agriculture, Risk Management Agency 2008.

where

$$p_t^g = \begin{cases} p_t^m & \text{if } p_t < p_t^m \\ p_t & \text{if } p_t^m \leq p_t \leq p_t^M \\ p_t^M & \text{if } p_t^M < p_t \end{cases}$$

is called the "price guarantee". Here, θ_i is the "coverage level" selected by the farmer, and p_t^m and p_t^M are, respectively, the minimum and maximum "price guarantees" quoted in the CRC insurance policy.[5] Thus, the indemnity that the CRC-insured farmer expects to receive, conditional on information available at mid-season, is

$$E_t \max\{0, \theta_i p_t^g \bar{y}_{it} - p_t y_{it}\},$$

if the farmer does not abandon his crop, and

$$E_t \theta_i p_t^g \bar{y}_{it},$$

if he does abandon his crop.

Taking expected indemnities into account, the CRC-insured farmer will abandon his crop at mid-season in year t if the expected net revenue with abandonment exceeds the expected net revenue without abandonment, that is, if

$$E_t \theta_i p_t^g \bar{y}_{it} > f_t \bar{y}_{it} w_{it} + E_t \max\{0, \theta_i p_t^g \bar{y}_{it} - p_t y_{it}\} - c_{it}.$$

Thus, substituting and simplifying, the CRC-insured farmer will abandon his crop if

$$\gamma_{it} > f_t w_{it} - E_t \min\{\theta_i p_t^g, p_t w_{it} \epsilon_{it}\}.$$

A Flexible Empirical Model of Aggregate Acreage Abandonment

Citations?? U.S. Department of Agriculture Various issues

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[5] The minimum price guarantee on a CRC cotton policy, for most counties, is computed as the average ending daily settlement price of the New York Board of Trade Cotton Exchange December futures contract during preceding January 15 to February 14 period. The maximum price guarantee on a CRC cotton policy is \$0.70 per pound above the minimum price guarantee. See U.S. Department of Agriculture, Risk Management Agency 2008.

In this section, we develop a "flexible" empirical model of county-level upland cotton acreage abandonment that will allow us to test directly whether crop insurance participation affects county-level acreage abandonment rates. In particular, we posit a conventional Logit model that stipulates that h_{jt}, the proportion of cotton acres planted in county j in year t that are ultimately harvested, satisfies

$$\log\left(\frac{h_{jt}}{1-h_{jt}}\right)=\beta' x_{jt}+\tilde{\epsilon}_{jt}$$

where β is an nx1 vector of unknown parameters to be estimated, x_{jt} is an nx1 vector of explanatory variables observed for county j in year t, and the $\tilde{\epsilon}_{jt}$ are unobserved serially independent, identically normally distributed shocks with mean 0 and unknown constant variance σ^2 (Greene 2003).

The choices of explanatory variables of the model are motivated by theoretical model presented in the preceding section. According to the theoretical model, three observable variables have the most profound impact on farmer crop abandonment decisions: mid-season cotton futures prices, mid-season growing conditions, and crop insurance participation. In particular, the harvest rate is expected to be directly related to the mid-season cotton futures prices, indirectly related to emergence of mid-season drought conditions, and indirectly related to participation in the crop insurance program. A constant term and observations on these three explanatory variables constitute the vector x_{jt}. Precise operational definitions of the explanatory variables now follow.

The mid-season cotton futures price is the July average New York Board of Trade Cotton Exchange near-December cotton futures price, measured in cents per pound. Futures prices were converted to real, 2006-equivalent prices using the Bureau of Labor Statistics national Consumer Price Index. The mid-season month was chosen based on typical cotton planting and harvest times, as documented by the (U.S. Department of Agriculture, National Agricultural Statistics Service, 1997).

The July Palmer "Z" Index (PZI) is used to measure the severity mid-season drought conditions. The PZI is calculated from precipitation, temperature, and soil moisture measures for each climate division in the U.S.. Its values generally range between -6.0 and 6.0, classifying the moisture condition from very dry to very wet. We construct a drought variable by taking the absolute value of the negative part of the July PZI. Thus, our drought variable has a value of 0 if soil moisture is adequate or more than adequate, and has a positive value that increases with the severity of drought conditions.

The construction of a crop insurance participation variable posses some challenges. Goodwin 1993 proposed measuring crop insurance participation as the ratio of insured acres to total planted acres. One drawback of using this ratio as a measure of insurance participation is that producers typically control their degree of participation in the crop insurance program by adjusting their coverage levels, rather than by changing the number of acres they insure. As an alternative, Goodwin, Vandeveer, and Deal 2004 proposed measuring crop insurance participation as the ratio of total liability divided by total possible liability, which they computed as the product of the planting-time futures price, planted acres, and 75% of the county average yield for the preceding 10 years. However, coverage levels other than 75% have become increasingly common over the past decade as a result of the introduction of CAT coverage and changes in the subsidy schedule. In this study, we have chosen to measure insurance participation as the sum of acres insured across all insurance plans and coverage levels, *weighted by coverage level*, divided by total planted acres.

A Structural Empirical Model of Aggregate Acreage Abandonment

The "flexible" empirical model developed in the preceding section will allow us to test directly whether crop insurance participation affects acreage abandonment decisions. However, since the model is designed to provide only a reasonable first-order approximation to the true, underlying structure within the range of the data, it may render highly inaccurate estimates if evaluated outside the range of the available data. In particular, the model may not produce accurate estimates of the number of acres abandoned due to crop insurance, since this would require that the model be simulated under the counterfactual scenario that farmers did not purchase crop insurance during the historical period in question.[6]

In this section, we develop an alternate empirical model that imposes the

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[6] For example, for a non-negligible number of counties and years, the "flexible" model predicts that the number of acres abandoned due to crop insurance exceed the number of acres insured. This is not possible with the "structural" model developed in this section.

key structural features of the theoretical model, allowing us to compute more reliable estimates of the impacts crop insurance on acreage abandonment. Begin by assuming that the marginal cost γ_{it} incurred by farmer i in year t from harvesting his crop can be decomposed into the sum of a random time-varying component γ_t and a farmer-specific, time-invariant component ψ_i:

$$\gamma_{it} = \gamma_t + \psi_i.$$

Further assume that the distribution of the farmer-specific component ψ_i is invariant across space and given by a distribution function H. That is, $H(\psi)$ indicates the proportion of acres planted by farmers whose farmer-specific marginal harvest costs are less than or equal to ψ.

Now assume that the mid-season weather shock in a given county, w_t, is invariant across farmers and that the farmer-specific post-mid-season yield shock ϵ_{it} are identically distributed across farmers within a given a county. Given the distribution of farmer-specific costs H within the county, it follows that the proportion of uninsured acres harvested in year t in the county will be

$$H\left(f_t w_t - \gamma_t\right)$$

and the proportion of insured acres harvested in year t in the county will be

$$H\left(f_t w_t - z_{jt} - \gamma_t\right)$$

where

$$z_{jt} = E_t \min\{\theta_j p_t^e, p_t^e w_t \epsilon_t\}$$

is the expected net indemnity from abandonment provided by an APH contract purchased at coverage level θ_j and

$$z_{jt} = E_t \min\{\theta_j p_t^g, p_t w_t \epsilon_t\}$$

is the expected net indemnity from abandonment provided by a CRC contract purchased at coverage level θ_j.

Denoting by q_{jt} the proportion of acres in the county that are insured in year t using crop insurance product j, the proportion h_t of planted acres that are ultimately harvested in the county in year t will be the weighted average

$$h_t = \sum_{j=0}^{n} q_{jt} \cdot H\left(f_t w_t - z_{jt} - \gamma_t\right).$$

Here, n is the total number of APH and CRC products available; furthermore, we adopt the convention that $j = 0$ indicates no insurance, and set $q_{0t} = 1 - \sum_{j=1}^{n} q_{jt}$ and $z_{0t} = 0$.[7]

We estimate the structural model using the method of maximum likelihood (Dhrymes 1974). The variables h_t, q_{jt}, θ_j, f_t, w_t, and z_{jt} are directly or indirectly observable in any given year t at the county-level. To proceed with estimation, only the forms of the farmer-specific cost distribution function H and the probability density function of the time-specific cost variable γ_t remain to be specified. To this end, assume that

$$H(\psi; \alpha) = L(\alpha_0 + \alpha_1 \psi)$$

where

$$L(x) = \frac{\exp(x)}{1 + \exp(x)}$$

is the common "logistic" function. Also assume that γ_t is i.i.d. normal with mean μ and variance σ^2.

Under these assumptions, the likelihood function for the unknown parameters, α_0, α_1, μ, and σ^2, given a set of observations on the dependent variable h_t, is given by

$$\mathcal{L}(\alpha, \mu, \sigma^2) = -\frac{T}{2}\log(2\pi) - \frac{T}{2}\log(\sigma^2) - \frac{1}{2\sigma^2}\sum_{t=1}^{T}(\gamma_t - \mu)^2 - \sum_{t=1}^{T}\log(J_t)$$

where γ_t is implicitly defined by the relation

$$h_t = \sum_{j=0}^{n} q_{jt} L(\alpha_0 + \alpha_1(f_t w_t - z_{jt} - \gamma_t))$$

and

$$J_t = \alpha_1 \sum_{j=0}^{n} q_{jt} L'(\alpha_0 + \alpha_1(f_t w_t - z_{jt} - \gamma_t))$$

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[7] The indemnity provisions of a CAT contract are indistinguishable from those of a standard APH policy with a 50% coverage level, and is treated as such.

denotes the Jacobian of the transformation.

Careful inspection of the likelihood function reveals that although the parameters α_1 and σ^2 and the nonlinear combination $\alpha_0 + \alpha_1\mu$ are identified, the parameters α_0 and μ are not independently identified. We are therefore free to fix the value of one of the two unidentified parameters arbitrarily and, for analytic simplicity, we set $\mu = 0$. Also, by performing a straightforward exercise in differentiation, one can show that the likelihood function is maximized only if

$$\sigma^2 = \frac{1}{T}\sum_{t=1}^{T} \gamma_t^2.$$

Substituting the expressions for μ and σ^2 into the likelihood functions allows us to derive the "concentrated" likelihood function

$$\hat{\mathcal{L}}(\alpha) = -\frac{T}{2}(1 + \log(2\pi)) - \frac{T}{2}\log(\frac{1}{T}\sum_{t=1}^{T}\gamma_t^2) - \sum_{t=1}^{T}\log(J_t),$$

which is a function of the two remaining free parameters, α_0 and α_1.

The concentrated likelihood function is maximized in Matlab using the CompEcon Toolbox routine `qnewton`, which employs a quasi-Newton unconstrained optimization algorithm with Broyden-Fletcher-Goldfarb-Shanno Hessian update (Gill, Murray, and Wright 1981; Miranda and Fackler 2002. The routine was implemented with analytic derivatives for the concentrated likelihood function, as given by the formula

$$\frac{\partial\hat{\mathcal{L}}}{\partial\alpha_k} = -\frac{1}{\sigma^2}\sum_{t=1}^{T}\gamma_t\frac{\partial\gamma_t}{\partial\alpha_k} - \sum_{t=1}^{T}\frac{1}{J_t}\frac{\partial J_t}{\partial\alpha_k}.$$

Here,

$$\frac{\partial\gamma_t}{\partial\alpha_k} = -(\sum_{j=0}^{n} q_{jt}L'(x_{jt})\frac{\partial x_{jt}}{\partial\alpha_k})/(\sum_{j=0}^{n} q_{jt}L'(x_{jt})\frac{\partial x_{jt}}{\partial\gamma_t})$$

$$\frac{\partial J_t}{\partial\alpha_0} = \alpha_1\sum_{j=0}^{n} q_{jt}L''(x_{jt})(\frac{\partial x_{jt}}{\partial\alpha_0} - \alpha_1\frac{\partial\gamma_t}{\partial\alpha_0})$$

$$\frac{\partial J_t}{\partial\alpha_1} = \alpha_1\sum_{j=0}^{n} q_{jt}L''(x_{jt})(\frac{\partial x_{jt}}{\partial\alpha_1} - \alpha_1\frac{\partial\gamma_t}{\partial\alpha_1}) + \sum_{j=0}^{n} q_{jt}L'(x_{jt})$$

where

$$
\begin{aligned}
& x_{jt} = \alpha_0 + \alpha_1(f_t w_t - z_{jt} - \gamma_t) \\
& \frac{\partial x_{jt}}{\partial \alpha_0} = 1 \\
& \frac{\partial x_{jt}}{\partial \alpha_1} = f_t w_t - z_{jt} - \gamma_t \\
& \frac{\partial x_{jt}}{\partial \gamma_t} = -\alpha_1.
\end{aligned}
$$

Data and Data Sources

The empirical models proposed in the preceding two sections were estimated using a time-series cross-section of county-level cotton production and crop insurance participation data, Palmer "Z" Index data, cotton futures price data, and consumer price index data, spanning the years 1980-2006. The database includes all 246 US counties in the states of Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas that produced upland cotton continuously during 1972-2006.

County-level upland cotton production data, which included acres planted, acres harvested, and total production in pounds, were downloaded from the National Oceanic & Atmospheric Administration, National Climatic Data Center 2008 website. Climate division Palmer "Z" Index data were downloaded from the U.S. Department of Labor, Bureau of Labor Statistics 2008 website. Monthly average New York Board of Trade Cotton Exchange near December cotton futures contract prices, in cents per pound, were computed by taking the simple average of daily ending settlement prices. Daily settlement prices were drawn from a proprietary data set purchased directly from the Commodity Research Bureau 2009. Monthly Consumer Price Index data were downloaded from the U.S. Department of Agriculture, Risk Management Agency 2008 website.

Crop insurance participation data, which includes acres insured and total liability by county and year, were downloaded from the U.S. Department of Labor, Bureau of Labor Statistics 2008 website. The data from 1989-2006 were broken down by plan (CAT, APH, and CRC) and coverage level (35%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, and 85%). The data for 1980-1988 was broken down by insurance plan, but not coverage level. For this period, we have assumed that all APH buy-up policies were purchased at the 65% coverage level; CRC was not introduced until the mid-1990s.

Estimation Results

Estimation results for the flexible empirical Logit model are presented in table 1. The results are provided for the full sample of county-level observations, and regionally for each of the following self-defined production regions: The "Southeast" region includes Alabama, Georgia, North Carolina, South Carolina, and Tennessee NCDC climate division 2. The "Mississippi River" region includes Arkansas, Louisiana, Mississippi, and Tennessee NCDC climate division 4. The "North Texas and Oklahoma" region includes Oklahoma and Texas NCDC climate divisions 3, 4, 7, and 8. The "South Texas" region includes Texas NCDC climate divisions 9 and 10. And the "West Texas" region includes Texas NCDC climate divisions 1, 2, 5, and 6.

As can be seen in Table 1, the participation parameter estimates are significant at the 5% level for the full sample and for each region. The negative signs of the participation parameter indicate that crop insurance participation significantly reduced the proportion of upland cotton acres planted that were harvested during the period 1980–2006.

The estimates of the other two parameters, which indicate the sensitivity of harvest rates with respect to mid-season futures prices and drought conditions, yielded mixed, though mostly expected results. According to the theoretical model, the emergence of drought conditions during the growing season should lead to lower harvest rates. Drought parameter estimates were negative, as expected, for the full sample and for all regions, with the exception of South Texas, where the estimate was positive but not significant at the 5% level. All negative parameter estimates were significant at the 5% level, with the exception of the Mississippi River region.

According to the theoretical model, higher prices should lead to higher harvest rates. Price parameter estimates for the full sample and the Mississippi River region were significantly negative, and thus inconsistent with this prediction. Price parameter estimates for all remaining regions were positive, as expected, but not statistically significant at the 5% level.

Estimation results for the structural empirical model are presented in table 2. Only the sign, significance, and magnitude of the estimate of the parameter α_1, which measures the sensitivity of the harvest rate to changes in the expected net revenue from harvesting, is of interest. According to the theoretical model, an increase in the expected net revenue from harvesting should lead to higher harvest rates, implying a positive sign for α_1. Our estimates of α_1 are indeed positive and significant at the 5% level for the full sample and for all regions, with the singular exception of the Mississippi River region.

The structural model estimated using the full sample was used to compute annual estimates of the number of acres that were abandoned by farmers due to crop insurance participation. Table 3 presents, in thousands, the number of upland cotton acres that were actually planted and the number of acres that were subsequently abandoned in our ten state region during the period 1980–2006. The table also presents our estimates, in thousands, of the number of acres that were abandoned due to crop insurance participation. The final column expresses the number of acres abandoned due to crop insurance as a percent of all acres abandoned.

As can be seen in table 3, we estimate that the percentage of acres abandoned that were abandoned due to crop insurance remained in single digits prior to 1995, but climbed to double digits starting in 1996, shortly after a significant expansion in participation in the crop insurance program. Our results further indicate that, between 1980 and 2006, over 2.5 million acres of upland cotton, approximately 9% of all acres abandoned after planting, were abandoned as a result of crop insurance participation.

Summary and Conclusions

In this paper, we have searched for empirical evidence of moral hazard in the U.S. Federal Crop Insurance Program. Our investigation departed from the established empirical literature on this subject in two significant respects. First, we examined the effects of crop insurance participation on post-planting production decisions, rather than planting-time acreage allocation and input use decisions. Second, we focused our empirical analysis on a crop and regions that have historically experienced high loss ratios under the Federal Crop Insurance Program. In particular, we sought evidence that crop insurance participation increased post-planting acreage abandonment by upland cotton producers during the period 1980–2006.

We constructed a theoretical model of a profit-maximizing farmer who decides whether to abandon his crop or bring it to harvest based on mid-season futures prices and drought conditions, and the indemnities he can expect to receive from his crop insurance contract, if any. The theoretical model provided guidance in the specification of two empirical models of aggregate acreage abandonment, a “flexible” Logit model that allowed us to directly test the effects of crop insurance participation on county-level crop abandonment rates and a “structural” model that allowed us to compute more reliable estimates of the number of acres abandoned by cotton producers due to crop insurance participation. Both models were estimated empirically using a annual 1980-2006 county-level upland cotton production and crop insurance participation data.

Estimates obtained with the flexible model provided strong and unambiguous evidence that crop insurance participation significantly increased the number of upland cotton acres that were abandoned after planting during the period 1980–2006. Estimates obtained with the structural model indicated that between 1980 and 1996, over 2.5 million acres of upland cotton, approximately 9% of all acres abandoned after planting, were abandoned as a result of crop insurance participation.

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Table 1: Flexible Model Parameter Estimates

	Parameter Estimate	Standard Error	T-Statistic
All Regions			
Constant	3.909	0.100	38.96∗
Price	−0.004	0.001	−6.38∗
Drought	−0.309	0.017	−18.05∗
Participation	−2.407	0.112	−21.53∗
Southeast			
Constant	4.700	0.203	23.19∗
Price	0.000	0.001	0.28
Drought	−0.426	0.030	−14.02∗
Participation	−1.568	0.213	−7.35∗
Mississippi River			
Constant	4.733	0.109	43.44∗
Price	−0.008	0.001	−9.81∗
Drought	−0.033	0.028	−1.21
Participation	−0.383	0.136	−2.82∗
North Texas & Oklahoma			
Constant	3.065	0.202	15.17∗
Price	0.001	0.001	0.58
Drought	−0.249	0.035	−7.08∗
Participation	−1.541	0.229	−6.73∗
South Texas			
Constant	2.434	0.847	2.87∗
Price	0.007	0.006	1.17
Drought	0.060	0.155	0.39
Participation	−2.640	0.859	−3.07∗
West Texas			
Constant	1.543	0.191	8.09∗
Price	0.005	0.001	4.50
Drought	−0.332	0.027	−12.20∗
Participation	−0.573	0.214	−2.68∗

Source: *Statistically significant at 5% level, one-tailed test.

Table 2: Structural Model Parameter Estimates

	Parameter Estimate	Standard Error	T-Statistic
All Regions			
α_0	3.5466	0.0399	89.0$*$
α_1	0.0045	0.0005	8.6$*$
σ^2	3.5728	0.0620	57.6$*$
Southeast			
α_0	4.6705	0.0637	73.3$*$
α_1	0.0016	0.0009	1.8$*$
σ^2	2.5376	0.0844	30.1$*$
Mississippi River			
α_0	5.0477	0.0536	94.1$*$
α_1	-0.0079	0.0006	-12.9
σ^2	1.6295	0.0502	32.5$*$
North Texas & Oklahoma			
α_0	3.0052	0.0987	30.5$*$
α_1	0.0072	0.0012	5.8$*$
σ^2	3.2690	0.1463	22.4$*$
South Texas			
α_0	2.2889	0.2961	7.7$*$
α_1	0.0113	0.0038	3.0$*$
σ^2	3.4585	0.4706	7.4$*$
West Texas			
α_0	1.5480	0.0664	23.3$*$
α_1	0.0133	0.0010	12.8$*$
σ^2	2.8696	0.1008	28.5$*$

Source: *Statistically significant at 5% level, one-tailed test.

Table 3: Thousands of Cotton Acres Planted, Abandoned, and Estimated Abandoned Due to Crop Insurance, 1980-2006, Ten Selected States

Year	Planted Actual	Abandoned Actual	Abandoned Due to Insurance	Percent
1980	11,129	1,157	47	4.1%
1981	10,964	352	18	5.0%
1982	8,638	1,565	98	6.3%
1983	6,032	518	21	4.0%
1984	8,400	714	55	7.7%
1985	8,010	404	21	5.2%
1986	7,850	1,498	38	2.6%
1987	7,853	331	15	4.4%
1988	9,394	481	30	6.2%
1989	7,976	984	58	5.9%
1990	9,432	540	34	6.3%
1991	10,777	1,029	51	4.9%
1992	10,108	1,997	61	3.1%
1993	10,255	570	32	5.6%
1994	10,286	333	18	5.3%
1995	12,288	840	141	16.7%
1996	10,661	1,596	226	14.1%
1997	10,165	435	68	15.6%
1998	9,972	2,441	344	14.1%
1999	11,137	1,262	157	12.4%
2000	11,581	2,239	257	11.5%
2001	11,766	1,810	213	11.8%
2002	10,355	1,312	119	9.0%
2003	10,081	1,364	155	11.3%
2004	10,150	531	66	12.4%
2005	10,679	377	35	9.3%
2006	11,406	2,183	210	9.6%
Total	267,346	28,861	2,585	9.0%