EFFECTS OF WEATHER EXTREMES ON COTTON ACREAGE ABANDONMENT AND INSURANCE INDEMNITIES

George B. Frisvold
Gan Jin
University of Arizona
Tucson, AZ

Abstract

The lost resource costs of cotton acreage abandonment have exceeded $200 million in seven of the last eleven years. Abandonment costs peaked at nearly $900 million in 2011. The effects of different types of weather extremes (such as drought or flooding) on cotton acreage abandonment and crop insurance indemnities are estimated using county-level production and insurance data. Weather extremes are significant predictors of cotton crop abandonment accounting for large losses in economic resources devoted to planting crops that are not harvested. Access to irrigation can significantly mitigate effects of drought, but disruptions in irrigation supply can then lead to significant damages. Analysis of crop insurance indemnities for Arizona and New Mexico suggest that irrigation supply failures are an important source of loss claims.

Introduction

This study seeks to address three research questions. First, what are the “lost resource costs” of cotton acreage abandonment (planting acreage that is not harvested)? Inputs used to plant cotton not subsequently harvested are lost to society. Even if growers have insurance coverage for losses, the inputs devoted to planting are lost to society. This represents a cost of lost resources. Second, how do weather extremes affect abandonment? Third, how do different types of weather extremes contribute to crop insurance indemnities in Arizona and New Mexico?

Materials and Methods

Estimating lost resource costs require estimates of abandoned acres and planting costs. Abandoned cotton acreage is the total upland cotton acres planted minus total acres harvested. The percent of acres abandoned equals total abandoned acres divided by planted acres. State-level cotton acreage data come from annual production statistics of USDA’s National Agricultural Statistical (NASS) for the years 2002 to 2012. Per-acre planting costs serve as a lower bound for lost resource costs because this assumes that growers devote no further resources to cotton production on abandoned acreage after planting.

Average per-acre planting costs were taken from cotton enterprise budgets from the Texas AgriLife Extension Service. For 2002-2012, all land-preparation and planting costs were taken from dryland cotton budgets from Texas District 1 (the Panhandle). Although, many acres are annually abandoned outside of Texas, the Texas dryland planting costs were applied nationally for several reasons. First, Texas accounted for the vast majority of abandoned upland cotton acres in every year. Second, other analysis (discussed below) indicates that non-irrigated acres are more likely to be abandoned than irrigated acres. Third, the Texas AgriLife Extension Service provides annual estimates, which follow a consistent methodology over time. Consistent time series were often unavailable for many states. Fourth, the preparation and planting costs for dryland cotton production in District 1 of Texas tended to be low relative to costs in other states, in cases where comparisons could be made. Thus, applying the District 1 numbers across all acreage is likely to be a conservative estimate of abandonment costs.

Next, multivariate regression analysis was conducted on cross-section – time-series data on upland cotton acreage abandonment for the years 2001-2008. This analysis sought to estimate the influence of weather extremes and other variables on the extent of county-level cotton acreage abandonment. County level data on planted and harvested upland cotton acreage were again obtained from USDA-NASS. Acreage data were use for eight states: Arizona, Arkansas, California, Louisiana, Mississippi, New Mexico, Oklahoma, and Texas. These states were selected because NASS either (a) provides data on the share of county cotton acreage that is irrigated or (b) it can be assumed that all upland cotton acres are irrigated (this latter condition applies to Arizona and California). While this approach does omit many cotton growing states, the states in our sample accounted for 73% total cotton acres planted and 98% of abandoned acres in 2008.

The following explanatory variables were used in regression analysis:

1. *PCIRR:* the percentage of a county's planted cotton acreage that was irrigated;
2. *Heating degree days (HDD)*: the sum of negative differences between the mean daily temperature and 65°F;
3. Cooling degree days (CDD): the sum of positive differences between the mean daily temperature and 65°F;
4. *PMDI Wet*: the absolute value of the Palmer Modified Drought Index (PMDI) x a dummy variable = 1 if PMDI > 0;
5. *PMDI Dry*: the absolute value of the Palmer Modified Drought index x a dummy variable = 1 if PMDI < 0;
6. *PMDI Dry2*: the variable *PMDI Dry* squared
7. *PMDI DryIrr:* an interaction term that is the variable *PMDI Dry* multiplied by the variable *PCIRR*.
8. *PriceDrop:* the absolute value of min[change in December futures price of cotton from January to June, 0].

The variable *PCIRR* comes from USDA NASS annual data files. Data for weather variables were obtained from the National Climatic Data Center (NCDC), National Environmental Satellite, Data, and Information Service (NESDIS), National Oceanic and Atmospheric Administration (NOAA). The data is monthly, climate division data from 2001 to 2010. Counties in all states are categorized into climate divisions, based on the climate division map provided by Climate Prediction Center (CPC), NOAA. Climate divisions span multiple counties, so county-level abandonment data was matched to weather data from the climate division that the county fell in. The modified Palmer Drought Index (PMDI) attempts to measure the departure of local soil moisture from long-term normal moisture (Heddinghaus and Sabol, 1991). The index is cumulative accounting for the state of soil moisture over a length of time. The PMDI takes on values (roughly) from –6 to +6, with negative values indicating drought conditions, while positive values indicate wet conditions. Normal conditions would have a value of 0, while –4 or lower indicates extreme drought and +4 or greater reflects extreme wet conditions. Because the index measures deviations from normal moisture conditions, we hypothesize that either too dry (drought) or too wet (flooding) of a year could increase acreage abandonment. The variables *PMDI Wet* account for the fact that wetter than normal conditions may have different effects than dryer than normal years. *PMDI Dry2* is included to test the hypothesis that extreme droughts have non-linear threshold effects on acreage abandonment. The variable *PMDI DryIrr* is meant to test the hypothesis that the presence of irrigation mitigates the effects of drought on acreage abandonment.

An economic variable *PriceDrop* takes on a value of 0 if the New York Commodity Exchange December nearby futures price for cotton was stable or rise between January and June of the planting year or the absolute value of the reduction in price over this period if the price fell. Data come from the National Cotton Council's website. It is hypothesized that price fluctuations over the growing season have an asymmetric effect on harvest and abandonment decisions. Price reductions are hypothesized to encourage abandonment, while stable or rising prices are hypothesized to have no effect.

Finally, we examine "cause of loss" data from USDA's Risk Management Agency (RMA) for cotton producers in Arizona and New Mexico. We follow the approach of Lobell et al. (2011) who examined crop insurance indemnity payments by reported cause of loss for all crops in California. Crop insurance indemnity records were obtained from the RMA website (www.rma.usda.gov/FTP/Miscellaneous_Files/cause_of_loss/) sorted by year, county, state, crop, insurance policy, and cause of loss. Records were analyzed for 1989 to 2008 (the most recent year with data), with 2,639 and 4,410 observations obtained from Arizona and New Mexico. In Arizona, 1,100 insurance records had indemnity claims for all crops, with total indemnity payments totaling roughly $137 million. In New Mexico, 2,597 insurance records had indemnity claims for all crops with indemnities totaling $131 million. For the insurance analysis, data on upland and Pima cotton were combined. The average indemnity payment was $124,812 per claim in Arizona and $50,427 per claim in New Mexico.

Results and Discussion

Abandoned cotton acreage has fluctuated considerably over the last 11 years (Figure 1). The effects of extreme drought in Texas in 2011 are evident as abandonment exceeded 5 million acres.

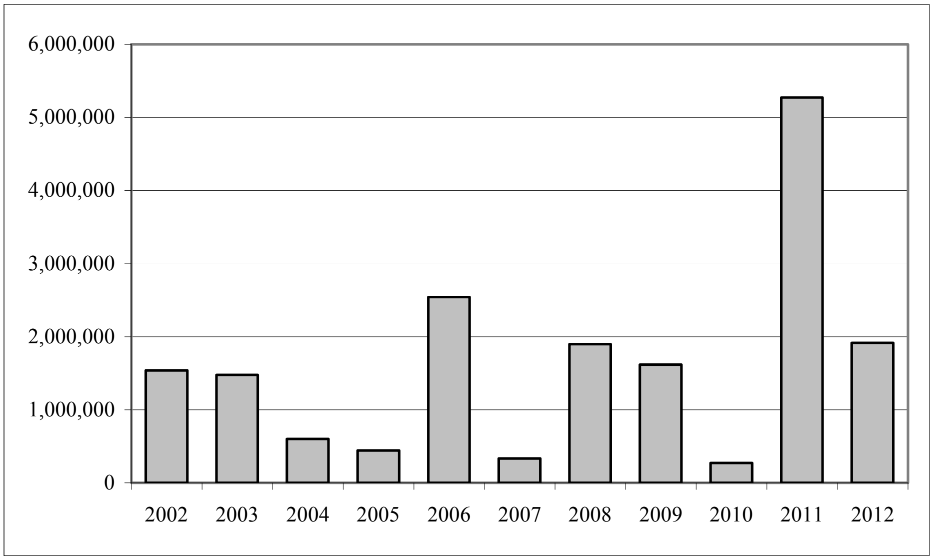

Figure 1. Total U.S. upland cotton acres abandoned

The estimated resource costs of abandonment were converted to constant 2012 dollars using the GDP price deflator. Lost resource costs track acres abandoned closely (Figure 2).

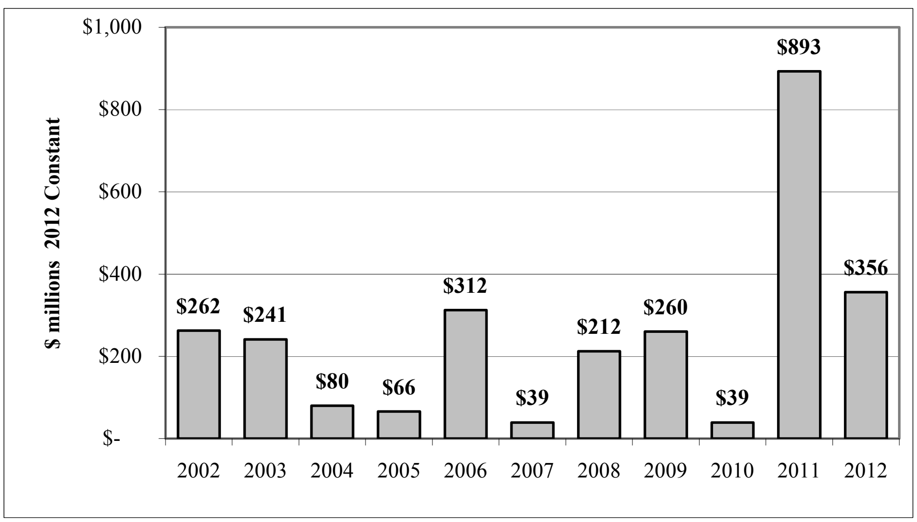

Figure 2. Total lost resource costs of U.S. upland cotton acreage abandonment

The cost of acreage abandonment reached a peak of $893 million in 2011. This loss pattern is similar to those of many natural hazards such as hurricanes or wildfires, where the losses of the most damaging event can be much larger than the second most damaging event. Damages totaled more than $200 million in seven of eleven years.

Regression results suggest that weather extremes are significant predictors of acreage abandonment (Table 1). The model had 1,334 observations with an $R^2 = 0.29$. The percent of acres abandoned in a county is positively associated with cooling degree days (CDD) and heating degree days (HDD). This indicates that the frequency of days with deviations of average temperature either above or below 65°F encourages abandonment. Wetter than normal years (measured by *PMDI Wet*) appear to have no statistically significant effect on abandonment. Dryer than normal years do, however. The effect is positive and significant for the drought variable (*PMDI Dry*) and its squared term (*PMDI Dry2*). The drought indicator increases abandonment at an increasing rate. The percentage of irrigated acreage (*PCIRR*) is negative and significant, suggesting that counties with a higher percentage of irrigated acreage have a lower percentage of abandoned acreage. The negative sign of the interaction term (*PMDI DryIrr*) indicates that irrigation substantially mitigates the effects of drought on abandonment. In other words, drought encourages abandonment much more on dryland acreage. The variable measuring the absolute value of a reduction in the futures price of cotton is positive and significant. This means that the more price falls during the season, the more acres are abandoned. This model explains nearly 30% of the variation in abandonment data using a relatively small number of variables, with a few non-linear transformation and interaction terms. Although a promising, preliminary step there remains a significant amount of variation that is unexplained.

Table 1. Ordinary least squares regression of factors contributing upland cotton acreage abandonment

Dependent Variable:	Percentage of upland cotton acres abandoned			
Adjusted R Square:	0.29863			
Observations:	1334			
Variable	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	-19.180	3.590	-5.34	0.00000
Percent Irrigated	-0.052	0.015	-3.51	0.00047
Cooling Degree Days	0.065	0.011	6.00	0.00000
Heating Degree Days	0.131	0.013	9.78	0.00000
|PMDI | x Wet	-0.501	0.330	-1.52	0.12851
| PMDI] x Dry	9.777	1.133	8.63	0.00000
PMDI dry squared	0.800	0.280	2.86	0.00433
PMDI dry x % Irrigated	-12.918	0.906	-14.27	0.00000
Cotton Futures Price Drop	1.452	0.403	3.61	0.00032

In Arizona, cotton ranked first among crops in number of crop insurance claims and indemnity payments. Cotton accounted for 604 of 1,100 crop insurance indemnity claims (<54%) and more than 80% of total indemnity payments. In New Mexico, cotton ranked third (behind wheat and sorghum) in claims and payments. In both states, weather-related problems accounted for a large share of loss claims.

Table 2. Causes of insured losses among Arizona and New Mexico cotton producers, 1989-2008

Cause of Loss	Arizona	Arizona's Share	New Mexico	New Mexico's Share
Cold	15,607,819	14%	1,540,712	7%
Decline in Price	6,012,209	5%	677,101	3%
Drought	1,065,366	1%	1,656,300	7%
Excess Moisture	18,435,239	17%	10,941,370	48%
Heat	24,582,780	22%	1,915,454	8%
Irrigation Supply Failure	25,647,145	23%	4,364,691	19%
Other	11,680,379	11%	171,438	1%
Wind	7,358,435	7%	1,518,039	7%
Total	110,389,372	100%	22,785,105	100%

Source: USDA, Risk Management Agency

Among cotton producers in both states, weather related problems accounted for the bulk of indemnity payments. Price declines accounted for 3% of payments in New Mexico and 5% in Arizona. The larger share of claims listed under "other" in Arizona is attributable to pest infestations in the early 1990s.

Despite much of the attention given to heat and drought in recent years, excess moisture and cold combined to account for 31% of indemnities in Arizona and 55% in New Mexico (Table 2). Drought was rarely a designated cause of loss in Arizona and accounted for only 7% of payments in New Mexico. Heat accounted for a greater share of payments in Arizona than in New Mexico. In both states, irrigation failure accounts for roughly one fifth of indemnities. All cotton acreage in both states is irrigated. It could be that irrigation mitigates the effects of drought, when it is working.

Summary

This study presented results of a simple procedure to derive a conservative estimate of the lost resource costs of upland acreage abandonment. These costs exceeded $200 million in seven of the last eleven years. In 2011, abandonment costs reached nearly $900 million. Based on regression analysis it was found that a small number of weather extremes variables are highly significant predictors of a county's abandoned acres as a share of total planted acres. Dryer than normal conditions had a strong positive effect on abandonment, while wetter than normal years had no statistically significant effect. Access to irrigation greatly mitigates the effects of drought on abandonment. Risk Manaagement Agency data for Arizona and New Mexico suggests that cold and excessive moisture were major contributors to crop insurance indemnities over the last 20 years. These factors combined appeared more important than heat and drought combined in both states, perhaps because cotton in both states is irrigated. These results are similar to the study of Lobell et al. (2011) for California, where excessive moisture were also main contributors to crop insurance indemnities. Again, California agriculture has a high proportion of acres irrigated. While irrigation can mitigate effects of drought, this depends on reliable irrigation supplies. Irrigation failures accounted for about one fifth of indemnities pay to cotton growers for losses in Arizona and California. While cotton growers cannot control the weather, it may be possible to reduce losses from irrigation failures in the future.

References

Heddinghaus, T. R. and P. Sabol, 1991. A review of the Palmer Drought Severity Index and where do we go from here? In: Proc. 7th Conf. on Applied Climatology, September 10-13,1991. American Meteorological Society, Boston, pp. 242-246.

Lobell, D. B., A. Torney, A., and C.B. Field. 2011. Climate extremes in California agriculture. Climatic Change, 109: 355-363.