The Effects of Crop Insurance on Specialty Crop Acreage: A Focus on Catastrophic Insurance Subsidies using Unique Individual Policy Holder Data

Submission for publication in the American Journal of Agricultural Economics as a contribution to the AAEA Sessions at the ASSA Meeting 2015, "Risk Mitigation Tools in Agriculture: Crop Insurance and Contract Farming"

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Hyunok Lee, Daniel A. Sumner and Jisang Yu
University of California Agricultural Issues Center, the Giannini Foundation and the Department of Agricultural and Resource Economics, University of California, Davis,

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Abstract

Total liabilities for crop insurance policies covering specialty crops are more than $13 billion and Congress has mandated coverage of additional crops in additional regions, so that the subsidies and the influence of such subsidies are growing. We develop conceptual models to consider how a particular type of crop insurance important for specialty crops specialty crop acreage. We formalize implications of crop insurance subsidy on crop acreage response, separate from demand for insurance, to help assess the causal impact of crop insurance on crop choice. We derive acreage response to insurance from model that recognizes differences across farms and locations in alternative crops and risk of crop loss. Catastrophic Risk Protection (CAT) insurance provides at zero farmer premiums relatively small indemnities per dollar of revenue based on yield losses over 50 percent. CAT is the most widely adopted insurance plan for specialty crops, especially in irrigated areas. Since the full premium for CAT is paid by USDA, and is thus a subsidy to producers (and insurers, if the supply of insurance is upward sloping), we use CAT premium subsidies across crops and counties to identify supply response to insurance premium subsidies. In our estimation strategy, we make use of individual policy-holder information from a unique data set.

The Effects of Crop Insurance on Specialty Crop Acreage: A Focus on Catastrophic Insurance Subsidies using Unique Individual Policy Holder Data

Crop insurance programs and risk management more broadly have grown in importance globally. In the United States, government subsidized crop insurance, supplemented by additional risk management programs, now have almost universal coverage for field crops, with exception of hay. The spread to fruits, vegetables and other specialty crops have been continuing. Total liabilities for crop insurance policies covering specialty crops are more than $13 billion and Congress has mandated coverage of additional crops in additional regions, so that the subsidies and the influence of such subsidies are growing.

This study investigates the behavior of specialty crop acreage in response to crop insurance subsidies. Subsidies for catastrophic crop insurance (CAT) available from private companies backed by the USDA Risk Management Agency (RMA). CAT typically covers yield losses of greater than 50% of normal and pays 55% of the assigned market price on the loss. Farmers have no cost other than a small enrollment fee and pay no share of the premium that RMA pays to the insurance companies that offer approved policies.

Focusing exclusively on catastrophic crop insurance (CAT), we empirically examine how premium subsidies affect acreage of specialty crops. We exploit a unique source of data on individual insurance policies. These data which we assembled from the website of the Environmental Working Group, include information on all the insurance policy and policy holder characteristics, but do not include other information about the farm or farmer that might be of interest.

An important feature of our approach is that, since the farm pays none of the CAT premium, under carefully constructed conditions, enrolled acres represent supply response rather than the demand for insurance. Moreover, because we have data on individual farms we can use policy holder fixed effects to control for farm characteristics that affect acreage.

This article is the first to examine CAT for specialty crops in detail using individual farm data based on insurance records. To our knowledge it is the first article to exploit a large sample of individual policy holder records to attempt to estimate acreage response to crop insurance. Moreover this article represents the first examination of the potential effects of CAT subsidies on crop acreage for any crops.

Related literature

As noted above, we focus on acreage response of specialty crops to CAT crop insurance subsidies provided by the Risk Management Agency of USDA. Thus this article relates to the intersection of several strands of literature.

In addition to contributing to the slim crop insurance literature focusing on supply response, our study contributes to the crop insurance literature which concerns specialty crops, a collection of crops including fruits, tree nuts, vegetables and nursery. Lack of disaggregated specialty crop production data, has contributed to the small literature on crop insurance for specialty crops. Previous studies on field crops provide guidance on empirical tools, but are less relevant due to differences in product and market characteristics such as perishability and the prevalence of perennial crops.

Gardner and Kramer (1987), Miranda and Glauber (1997) and Goodwin (2001) discuss general obstacles to market crop insurance without government support. That means the subsidy element and subsidy-driven availability of crop insurance may influence acreage choices. As noted by Lee and Sumner (2013), relatively few crop insurance studies focus on specialty crops (Richards 2000; Lee and Blank 2004; Ligon 2011; Olen and Wu 2013). The study on the demand for crop insurance by Richards (2000) deals with California grapes. Ligon (2011) and Olen and Wu (2013) focus on acreage response to crop insurance in California and include many perennial crops, where supply response raises complex issues especially with time series data (Dorfman and Heien 1989). Even fewer crop insurance studies discuss catastrophic risk protection. Early discussions focus on the interaction between CAT insurance and ad hoc disaster payments and do not consider acreage response to CAT (Lee, Harwood, and Somwaru 1997; Glauber, Collins, and Barry 2001).

Most studies of crop supply response, as far back as Nerlove (1956) focus on acreage. Recent studies such as Hendricks, Smith, and Sumner (2014) characterize supply response in terms of acreage. The insensitive yield response to price is supported by estimates of Choi and Helmberger (1993), Berry and Schlenker (2011) and Roberts and Schlenker (2013).

Farm subsidies, including insurance subsidies have been a perennial in trade negotiations, with much of the controversy centering on supply response to subsidy depending on the form of the subsidy and what counterfactual policy question underlies the issue. Goodwin and Mishra (2006) and Hendricks and Sumner (2014) are among the recent studies that supply empirical estimates.

Crop insurance availability and subsidies affect input demand and crop acreage through effects on expected revenue and risk mitigation. Several empirical studies consider uncertainty, information asymmetry, or credit market imperfections (e.g. Horowitz and Lichtenberg 1993; Ramaswami 1993; Quiggin, Karagiannis, and Stanton 1993; Babcock and Hennessy 1996; Smith and Goodwin 1996; Coble et al. 1997; Wu 1999; Goodwin, Vandemeer and Deal 2004).

Goodwin, Vandemeer and Deal (2004) empirically investigate the supply response to subsidized crop insurance for field crops and find that higher crop insurance participation is associated with acreage expansion and premium subsidy has positive acreage effects. Goodwin and Smith (2013) indicate positive but small acreage effects of premium subsidies.

We frame our discussion in the context of response to a specific type of farm subsidy rather than simply as response to insurance. This article adds to the literature by using unique data to explore how CAT insurance subsidies affect acreage of specialty crops. The fully subsidized nature of the premium for CAT insurance has not been exploited by researchers as a way to separate acreage response from demand for insurance. We discuss more below how we exploit this feature of CAT.

The Context of Catastrophic Crop Insurance for Specialty Crops

The federal government through the Risk Management Agency (RMA) provides "catastrophic" and "buy-up" insurance plans. Catastrophic crop insurance (CAT) typically insures eligible farms for a loss of 50% of normal yield at 55% of a RMA-set price. Thus, the liability under a CAT policy is about 27.5% of the expected market revenue. The CAT policies are insured by private companies but the premium is paid entirely by the Federal government though RMA. To receive benefits, a farm must enroll in the program and pay a small processing fee for each crop in each county covered. Buy-up policies, which are far more common than CAT for major field crops, cover up to 85% of expected yield with value up to 100% of a USDA price and are often based on revenue. Buy-up policies require farmer premiums, but include government premium subsidies.

Federally subsidized crop insurance has expanded in scope and importance over the past two decades, with the availability of CAT starting in 1995 as an important part of that expansion (Glauber et al., 2002). The CAT program was authorized by the Federal Crop Insurance Reform

Act of 1994. Table 1 presents a sketch of selected crop insurance variables focusing on CAT, specialty crops and the intersection of the two.

In 1995, more than half of all the 221 million crop insurance acres enrolled in CAT which accounted for about half of the $889 million premium subsidy, about 35% of the $23.73 billion liability and 11% of the $1.57 billion in indemnity paid that year. Since crop insurance participation was required to be eligible for the commodity subsidy programs, many program crop growers enrolled in CAT simply to assure they would receive their farm payments (Lee et al., 1997; Glauber et al., 2002). For all crops the CAT share of acreage declined rapidly to 11% by 2005 and 5% of about 300 million acres enrolled in 2013. As crop insurance premium subsidy rose to $7.3 billion in 2013, the share accounted for by CAT fell to 4%. As liability rose to about $124 billion, the share accounted for by CAT fell to 6%, in part reflecting the run-up in field crop prices in 2013. Indemnity was $12 billion in 2013 (a high loss year for field crops) but CAT accounted for less than one-half of 1% in 2013. In the early years the CAT share of premium subsidy was higher than the share of liability, but that relationship reversed in 2005 and subsequent years. The CAT share of premium subsidy has been much higher than the share the share of indemnity in all years. This relationship reflects the high ratio of premium to liability for CAT compared to the ratio of indemnity to liability for CAT.

Table 1 shows that specialty crops covered by crop insurance, which include fruits, tree nuts, vegetables, melons and nursery products, have accounted for a small number of insured acres (about 3% of the total), but about 12% of the liability, subsidy and indemnity in 1995. Specialty crops accounted for about 11% of liability, 7% of subsidy and about 3% of indemnity in 2013. In 1995, the shares of CAT in acres, liability subsidy and indemnity for specialty crops were similar to those shares for all crops. As the role of CAT declined for field crops it remained important for specialty crops. In 2013, CAT accounted for 30% of insured specialty crop acreage, 34% of liability, 25% of subsidy and about 1% of indemnity. Although a small share of all crop insurance, specialty crops account for the majority of CAT liability. In 2013, the $4.6 billion specialty crop liability under CAT accounted for 64% of $7.4 billion total CAT liability.

The availability of crop insurance for specialty crops expanded substantially over the last three decades, covering more crops and regions (Ligon, 2011; Lee and Sumner, 2013). Crop insurance was available for 28 specialty crops by 1995, and further expansion increased the number of insurable crops to 77 by 2005 and 81 by 2013 (RMA, 2014). Major insurance plans used for specialty crops include yield insurance based on the farms Actual Production History (APH), Dollar Plan and Tree Dollar Plan, with about 60 percent of liability accounted for by APH in 2013 (RMA, 2014). Whereas revenue insurance dominates for most field crops the importance of APH for specialty crop insurance indicates difficulty in monitoring price variation for many specialty crops. There are no organized futures markets for specialty crops and wide price differences by variety, grade, location and timing of marketing make determining price variation challenging (Lee and Blank, 2004). The sheer diversity of specialty crop markets raises costs of expanding buy-up coverage for specialty crops (Ligon, 2011; Olen and Wu, 2013).

Descriptive Statistics on a Unique Sample of Individual CAT Crop Insurance Policies

For our empirical analysis we exploit a unique set of data, based on a sample of individual RMA insurance records that we assembled from the Environmental Working Group (EWG) based on the material they present in the farm subsidy section of their website. EWG obtained individual policy holder insurance records for 2011 from RMA through a Freedom of Information Act request. The information for each selected policy holder includes the following information for each insurance policy held by the policy holder: (1) insured acres, (2) liability, (3) premium, (4) premium subsidy, (5) indemnity, (6) crop, (7) county, (8) delivery type, and (9) insurance plan.

The EWG website provides these policy level data for the top 100 premium subsidy recipients (policy holders) in each county for the year 2011. For some counties the top 100 recipients includes all crop insurance participants in the county. For example, in Eldorado County California, there are only 31 policy holders listed and the premium subsidy amounts range from $15,072 to $94 for 2011. However, for Yolo County California, there are 230 policy holders in total and in this case our EWG data capture only a part of population in that county. For each policy held by the listed policy holders listed in any county, the EWG includes the nine data items listed above for each policy in each county in which that policy holder has a policy.

Many of the listed policy holders operate in more than one county and may not be within the top 100 subsidy recipients in all counties where they operate. Since we have each policy holder's data from in all counties in which they have a policy, the data set includes information on relatively small acreages and liabilities, especially in counties where that policy holder is outside the top 100.

Even though the EWG information on individual policies is limited to a single year, it provides a unique look into the insurance relationships on a large sample of individual farms and policies that is much broader than the relatively specific focus of this paper. We know of no other research that has used this information and one purpose of this paper is to introduce these data for econometric use.

To access the EWG data files and focus on farm acreage response to CAT for specialty crops, we selected the four states that are main specialty crop producing regions with high shares of the national specialty crop production. The four states including California, Florida, Texas and Washington, together represent more than 65% in acreage and 74% in liability of the nation's specialty crop CAT policies in 2011. In each of the counties selected, we examined the detailed record for each policy holder and selected information on any CAT policies for specialty crops--a laborious process. We obtained information on 1,877 specialty crop CAT policies, held by 1,174 policy holders.

As a first step to examining acreage we excluded the 180 policies held by policy holders who also have buy-up insurance for the selected crop in that county. This restriction allows us to designate the CAT insured acreage as the total acreage for that crop operated by that policy holder in that county. That is, by excluding buy-up policies we separate the acreage decision for the crop in that county from the decision about which type of crop insurance and how much coverage to demand. We also restricted our sample to yield insurance under APH policies, which cover 94% of CAT policies for the selected specialty crops in these four states. That leaves us with a base data set of 1,604 policies held by 964 policy holders.

Table 2 reports the aggregate statistics of our sample of 1,604 policies and documents the extent to which the CAT APH policies in our sample represent the total CAT APH policies for the covered specialty crops in each state. These policies account for 23% of the total number of specialty crop CAT APH policies in these four states. Because our sample tends to capture relatively large operations, the included policies account for 59% of total CAT APH insured acreage, 64% of the liability and 71% of the premium subsidy.

Table 2 also shows that data from California and Washington together account for more than 90% of the sample policies, acreage and liability, and about 90% of the sample subsidy. The sample size in Florida is relatively small because no EWG data are available on citrus which is the top crop insurance crop in the state. Compared to the other states, our sample for

California represents relatively a small share (53%) of the state's acreage under CAT APH. The 100 policy holder limit for each county was binding for several large California counties.. That means in California some commercial specialty crop farms in the major specialty crop counties were excluded. However, as indicated by liability share, overall, our sample seems to cover a substantial proportion of the farms that are enrolled in CAT APH and produce much of the specialty crop value in the selected states.

Table 3 presents the means (averages per policy) of the important insurance variables by state and for all states. Policies average 429 acres and $523,000 in liability. These averages are moderate relative to some of the very large farms that grow specialty crops, but do represent revenue of somewhat more than $2 million per policy. California has the highest mean in liability ($550,000) per policy, and Texas has the highest mean in acreage (484 acres) per policy. The average premium (subsidy) per policy is $20,000. The average individual premium rates (premium divided by liability) of our sample is similar but slightly smaller than the average county-level premium rates. This indicates our sample well-represents the distribution of the premium rate. These average individual rates are 0.037, 0.038, and 0.062 in California, Washington, and Florida but much higher in Texas (0.16. Premiums are also high for onions and potatoes in Texas.

We also consider in our econometric analysis a sample of 975 polices held by policy holder who have more than one policy in our base sample. This subsample captures policy holders who either have more than one CAT APH crop in a county or have CAT APH crops in more than one county. The 975 CAT policies in this subsample are held by 335 policy holders, and account for 41% of acreage and 45% of liability insured under CAT in these four state. These policies average 497 acres and $602 thousand in liability, which are higher than those of the base sample. This sample allows application of individual policy holder fixed effects as an econometric estimation strategy.

Overall, the policies in our EWG selected sample are held by relatively large farms that are associated with relatively large crop insurance subsidies. However, this sample may be representative of full-time commercial specialty crop farms, which are expected to play a major role in aggregate acreage response.

The Economic Relationship between Insurance Subsidy and Acreage of Specialty Crops

We turn to developing the effects of insurance on crop acreage. As is common in the econometric supply literature, we explore crop acreage rather than production, treating yield as mainly the result of long term productivity differences and random weather or other shocks (Dorfman and Heien, 1989; Berry and Schlenker, 2011; Hendricks et al., 2014). We exploit information on CAT observations. Because the CAT policy holder does not pay the CAT premium, variation in acreage enrolled across crops and counties represents an acreage supply decision, rather than an insurance demand decision. Using data from individual insurance records allows us to focus on the role of the subsidy. We do not have any data variations across the sample farms on expected crop prices, costs of production or other characteristics. Our estimation strategy and interpretation of the empirical model are explained in the following section, and first we outline the economic relationships of our model.

In equation (1), we specify the acreage, A_{ijk}, for farm i growing crop j in county k, that is enrolled in CAT insurance, as a function of expected market revenue per acre, expected CAT indemnity and other factors:

$$(1) \qquad A_{ijk} = f_{ijk}\left(P_{jk}\bar{y}_{ijk},\ \ \rho_{ijk}\left(0.55P_{jk}\left(0.5\bar{y}_{ijk} - E\left(y_{ijk}\middle|y_{ijk} \leq 0.5\bar{y}_{ijk}\right)\right)\right);\ X_{ijk}\right).$$

The first argument in (1) reflects the expected gross revenue per acre. The expected market price, P_{jk}, is assumed to be same for all farmers who grow crop j in county k. The expected yield is denoted as $\bar{y}_{ijk}$, which differs by farm. The second argument in (1) represents the expected indemnity per acre from CAT insurance, which is a product of the probability of receiving CAT insurance indemnity times the average magnitude of the indemnity. The variable ρ_{ijk}, represents the probability of CAT insurance triggers, that is $\rho_{ijk} = Prob(y_{ijk} \leq 0.5\bar{y}_{ijk})$.

For simplicity, we assume that each farmer's expected yield, which determines the expected market revenue, is the same as the expected yield that RMA uses to construct the trigger for CAT indemnity payments. Farmers report their yield history to RMA when they sign up for the program (Coble et al., 2010). The historical average of individual yields is used to establish $\bar{y}_{ijk}$, which is used to construct the trigger and the indemnity payment calculation.

These historical data from farm records, as well as other information about that crop from the local region, inform both the farmer expectations and RMA calculations. Equation (1) shows that the magnitude of indemnity payments conditional on CAT insurance being triggered is equal to 55% of the RMA established expected price times the amount of shortfall from the trigger yield, which is 50% of $\bar{y}_{ijk}$. We assume here that the farmers' expected price is equal to the RMA-established expected price for each crop and each county. RMA establishes the expected market price before the deadline of insurance sign-up, which is typically in the winter or the spring before final acreage decisions for the coming season. The expected shortfall of yield in equation (1) is the difference between the CAT insurance trigger yield, $0.5\bar{y}_{ijk}$, and the expected value of the yield distribution truncated from above by $0.5\bar{y}_{ijk}$, which is $E(y_{ijk} | y_{ijk} \leq 0.5\bar{y}_{ijk})$.

The other characteristics, including costs of production, that differ across farms due to soils, climate and management, are represented in equation (1) by vector X_{ijk}. Conceptually, the vector X_{ijk} includes all factors that influence acreage aside from the expected revenue from the market and the expected return from CAT indemnities. When we form the empirical specification, the vector X_{ijk} is represented mostly by crop, state, and plan dummy variables and especially by individual policy holder fixed effects.

We do not explicitly include in equation (1) terms for the higher moments of the distribution of per acre returns, which would reflect the costs riskiness of crop production, such as higher costs of credit or farmer aversion to risk. However, by specifying the expected market revenue and the expected indemnity from CAT insurance as two separate arguments of the acreage response function, we allow flexibility for different responses to the changes in expected returns in normal years and to the changes in expected returns in the years with catastrophic losses. These two distinct acreage responses allow for the influence of risk-averse agents or associated costs from riskiness on acreage choice. Specifying a single response to total expected gross revenue, which is simply the sum of the expected market revenue and the expected indemnity, as single argument of the acreage response function, would not allow this flexibility. Therefore, our estimates, which are discussed later, should be interpreted differently from typical supply elasticity parameters. Also, note we do not allow the acreage response to vary within each argument. We implicitly assume the acreage response to marginal increase of the expected indemnity is same for small and large $\bar{y}_{ijk}$.

Holding the expected revenue per acre from crop production, $P_{jk}\bar{y}_{ijk}$, and other characteristics, X_{ijk}, constant, any change in acreage can be viewed as a response to a change in expected CAT indemnity. That is, holding the other arguments constant, an increase in the second argument increases the expected profit. Of course, if an actuarially fair insurance premium was paid by farm rather than by RMA, expected net revenue would not rise as the expected indemnity increases, since a higher expected indemnity would increase the actuarially fair premium by an identical amount. In the case of the fully subsidized CAT, response to the expected indemnity is a mixture of the response to increased expected revenue and to reduced riskiness of crop production.

Let us now develop in more detail the relationships between the CAT premium per acre and the actuarially fair CAT premium per acre and the expected indemnity per acre. As noted above, by definition of actuarially fair insurance, the fair CAT premium per acre equals the expected indemnity per acre, that is:

(2) $$Fair\ CAT\ Premium_{ijk} = \rho_{ijk}\left(.55P_i\left(.5\bar{y}_{ijk} - E\left(y_{ijk}\middle|y_{ijk} \leq .5\bar{y}_{ijk}\right)\right)\right)$$

Expression (2) is useful given we do not observe expected indemnity directly. Combining (1) and (2), we can express acreage response as a function of the actuarially fair premium, given we can control for other relevant variables, especially, $\bar{y}_{ijk}$. That is, equation (1) may be rewritten as:

(3) $$A_{ijk} = g_{ijk}\left(P_{jk}\bar{y}_{ijk}, Fair\ CAT\ Premium_{ijk}, X_{ijk}\right).$$

We recognize that the actual CAT premium may not be actuarially fair. However, the actual premium is expected to be a positive function of the fair premium as expressed in equation (4):

(4) $$CAT\ Premium_{ijk} = h_{ijk}\left(Fair\ CAT\ Premium_{ijk}\right).$$

Recognizing that the premium is increasing in the actuarially fair premium implies a positive relationship between the premium and the expected indemnity, which further suggests the positive acreage response to changes in the premium (again remembering that for CAT the farmer does not pay for the insurance the premium reflected expected indemnity). We can express these relationships as:

$$\frac{\partial A_{ijk}}{\partial Expected\ Indemnity_{ijk}} = \left(\frac{\partial A_{ijk}}{\partial Fair\ Premium_{ijk}}\right)\left(\frac{\partial Fair\ Premium_{ijk}}{\partial Expected\ Indemnity_{ijk}}\right)$$

$$= \frac{\partial A_{ijk}}{\partial Fair\ Premium_{ijk}} = \left(\frac{\partial A_{ijk}}{\partial Premium_{ijk}}\right)\left(\frac{\partial Premium_{ijk}}{\partial Fair\ Premium_{ijk}}\right).$$

Expressed as elasticity form, where ε denotes elasticities, we rewrite as

(5) $$\varepsilon_{A_{ijk},Expected\ Indemnity_{ijk}} = \varepsilon_{A_{ijk},Premium_{ijk}} \cdot \left(\frac{\partial Premium_{ijk}}{\partial Fair\ Premium_{ijk}}\right)\left(\frac{Fair\ Premium_{ijk}}{Premium_{ijk}}\right).$$

Equation (5) relates acreage response to expected CAT indemnities as specified in equation (1) to the potentially measureable response to the data on actual CAT premium in elasticity terms. The acreage elasticity with respect to the expected CAT indemnity equals the supply elasticity with respect to the CAT premium (which is fully subsidized) times the product of the ratio of the actuarially fair premium over the actual CAT premium times the derivative of the actual premium with respect to the fair premium.

Although the fair CAT premium is unobserved, given the lack of farmer payment of any portion of CAT premiums, the incentives of insurance companies, and the evidence of low loss ratios for these policies, we may expect the actual CAT premiums are likely larger than the actuarially fair premium. If this ratio is less than one, there is a tendency for a rise in the actuarially fair premium to generate a more than dollar for dollar increase in the actual premium. Thus, ratio of fair premium to actual premium and the derivative tend to offset one another. The elasticity of actual premium to fair premium is near 1.0 and thus we argue that there is no *a prioi* reason to expect the acreage response (in elasticity terms) to actual CAT premium differs systematically from the acreage response (in elasticity terms) to the expected CAT indemnity.

Finally, from (3) and (4), the acreage equation becomes

(6) $$A_{ijk} = g_{ijk}\left(P_{jk}\bar{y}_{ijk},\ \ CAT\ Premium_{ijk};\ \ X_{ijk}\right)$$

where g_{ijk} is increasing in $P_{jk}\bar{y}_{ijk}$ and also increasing in $CAT\ Premium_{ijk}$.

Empirical Implementation, Interpretation and Estimation Strategy

The empirical implementation of (6) requires variables that represent CAT premium as well as that effectively control the individual yield effect, namely $\bar{y}_{ijk}$. We use the individual policy premium rate, which is available from the EWG files, as the proxy for the expected yield, and the county average premium rate, which is available from RMA, as the proxy for the actual premium. The full premium per acre is calculated as the insured liability per acre times the premium rate, where RMA sets premium rates. For our estimation specification, we exploit important principles of the RMA rate-making mechanism. Actuarial documents, such as detailed reports of Josephson, Lord, and Mitchell (2000) and Coble et al. (1997), describe how the premium rates are determined in relation to historical yields and other information.

We focus especially on how the premium rate that each farm faces for each crop in each county differs from the county level premium rates for that crop. According to Coble et al. (2010), RMA sets the county level premium rate using the county unloaded rate and other adjustment factors. County unloaded rate is a weighted combination of the ratio of indemnity, not including CAT indemnity, over liability in that county and surrounding counties. The individual premium rate is based on this county-level premium rate with adjustments using individual policy holder characteristics.

The key factor that converts the county-level premium rate to the individual premium rate is the ratio of historical average of yield for each individual over the reference yield for that crop in that county, which is called the yield ratio. The yield ratio is used to weight the county unloaded rate. More specifically, the weight is computed as the yield ratio raised to negative of some positive exponent, θ, which is $\left(\frac{Historical\ average\ of\ individual\ yield}{County\ reference\ yield}\right)^{-\theta}$. For the details of this conversion, see equation (4.1) and (4.2) of Coble et al. (2010). Based on these rate making procedures, the individual premium rate captures the difference in the expected yield for each individual.

Recall that, in equation (6), we hypothesize that the acreage is increasing in the expected market revenue, $P_{jk}\bar{y}_{ijk}$, and in the CAT premium, $Premium_{ijk}$. If a farm faces same expected market revenues, but a higher CAT premium for growing one crop rather than another in a given county the farm would tend to allocate more land to the crop with higher CAT premium, since the farm does not pay the premium and the expected indemnity is greater. The identical point applies to the choice for a simple crop across counties. Farms expect to receive more subsidies in the counties or for the crops with higher CAT premium, holding expectations about market revenue constant.

By including information on the individual premium rate, and county-level premium rate, we can test the hypothesis of positive acreage response to premium subsidy. To control for the negative relationship between premium and expected revenue we use the variation in the individual premium rate that does not stem from the variation in the county-level premium rate.

We estimate following equation:

$$A_{ijk} = \beta_0 + \beta_1 County\ premium\ rate_{jk} + \beta_2 \frac{Premium\ rate_{ijk}}{County\ premium\ rate_{jk}} + \gamma D_{ijk} + u_{ijk} \quad (7).$$

The subscripts i, j, k denote individual policy i, crop j, and county k. The dependent variable, A_{ijk}, is the CAT insured acreage, which because of our sample restrictions and the nature of CAT represents all acreage of this farm for this crop in this county. The explanatory variables,

$County\ premium\ rate_{jk}$ and $\frac{Premium\ rate_{ijk}}{County\ premium\ rate_{jk}}$, represent the county premium rate the ratio of individual premium rate over the county premium rate.

Most of variation in the individual premium rate is accounted for by variation in the county premium rate. As we discuss above, the individual premium rate differs from the county premium rate to the extent that the individual yield differs from the county reference yield. The ratio of the individual premium rate over the county-level premium rate as a control variable represents a proxy for the individual yield deviations from the county base.

To confirm this interpretation, we also estimated the acreage response equation using as our control the residuals from regression of the individual premium rate on the county-level premium rate instead of the ratio of the individual premium rate over the county-level premium rate. The results of those regressions are indistinguishable from those of equation (7).

After accounting for the individual yield effect, the coefficient of the county premium rate represents the effect of insurance subsidy on acreage, which we expect to be positive. The individual premium rate increases as the individual yield decreases thus we expect a negative coefficient for this ratio.

We estimate the acreage response equation (7) using the two samples of individual farms. The full sample of 1,604 observations consists of CAT APH policies held by the policy holders who do not also have any buy-up policy for the same crop in the same county. More importantly the subsample of 975 observations includes only CAT APH policies held by policy holders who have more than one CAT APH policy, either for another crop in the same county or for the same crop in another county. This subsample allows us to use fixed effects to better control for omitted variables that may vary by policy holder, in addition to variation by crop and state.

Econometric Results for the Acreage Response Equation

Table 4 reports the estimation results. The reported results are from two samples and two estimation approaches, OLS and fixed effects. All specifications include control dummy variables for crop and state. Column (1) shows the result of OLS estimation on our base sample, which consists of the CAT APH policies that are held by the policy holders who do not have a buy-up policy for same crop in same county as their CAT APH policy. Column (2) and (3) are the results of estimation on our subsample, which consists of the CAT APH policies that are held by policy holders who have more than one policy in our base sample. For this subsample, we estimate with both OLS and fixed effects.

The signs of the coefficients in all regressions are consistent with our hypotheses. We find a positive and (moderately) significant effect of CAT premium subsidy on the acreage response. The results are robust across sample specifications and models. The proxy for the individual yield variation also negative as expected. The sample of the policy holders with more than one CAT APH policies are likely to be more flexible in their acreage choices and this is what we find. We also find larger acreage response when controlling for individual policy holder fixed effects. The coefficients are large, but not highly significant in statistical terms. Although our fixed effects sample is almost 1000 policy holders, they are spread across many crops that range from annual vegetable crops to trees and vines. A larger sample might allow interactions between crop effects and the slope coefficients or other more complex specifications.

In order to interpret the magnitudes of coefficients, we compute the elasticities of acreage with respect to the CAT premium subsidy at the mean of our samples. The calculate elasticity rises from 0.26 using the coefficient estimated Columns (1) to 0.46 using the estimate in column 3. The acreage response to subsidy combines the typical response to higher expected revenue from the subsidy with the strong risk mitigating elements associated with the conditional nature of the insurance indemnity payments. The estimated response is a mixture of an increase in expected subsidy and reduction in the risk of facing catastrophic losses. The combination of these effects implies a large acreage response in percentage terms.

Conclusion and Implications

Most empirical research on crop insurance in the United States has focused on issues of moral hazard, adverse selection, rating and crop insurance demand for the major field crops (Smith and Goodwin 1996; Coble et al. 1997; Wu 1999; Goodwin, Vandemeer and Deal 2004, Goodwin and Smith 2013). Here we contribute to the relatively small body of literature attempting to develop information on how crop insurance influences acreage across crops, and to the even smaller literatures on insurance for specialty crops and particularly response to catastrophic insurance (CAT). CAT has the useful feature that the insured pay none of the premium so insurance demand issues are not prominent. We further exploit the nature of CAT such that for farms who do not also have buy-up insurance for that crop in the given county, CAT acreage will represent the total acreage of the crop for the farm in that county. That means insurance records may be used to capture acreage supply demand for insurance.

An important contribution of this paper is exploration of a unique set of crop insurance data on individual farms based on RMA records for 2011. We used online data files from the Environmental Working Group on a sample of policy holders for each county in the United States. We drew on these data to assemble a large sample of individual policy holders and then focused on CAT policies for specialty crops in four important specialty crop states-California, Florida, Texas and Washington. These data have much potential to help researchers without other access to individual insurance records to investigate how and why premiums vary from far to farm and how that variation affects farmer behavior.

With these unique but limited data, our empirical approach isolates the insurance subsidy effect from the confounding recognition that higher insurance premiums (and hence subsidies) also reflect when market revenues are expected to be low for that producer in that county for that crop. With our sample of specialty crop growers, we find significant and moderate acre response to CAT subsidies. Our results represent the first estimates in the literature of the acreage response of specialty crops to CAT subsidies. Because CAT indemnities are paid during years of severely low yield, the response to expected indemnities is both a response to higher expected income from the payment and to risk mitigation.

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Table 1. CAT Shares in All Insurance for All Crops and Specialty Crops for Selected Years

	Units: Million acres and $ Millions			
	Acres	Liability	Subsidy*	Indemnity
1995 All Crops				
All insurance	221	23,728	889	1,568
CAT share	0.52	0.35	0.51	0.11
Specialty Crops				
All insurance	6	2,939	105	181
CAT share	0.55	0.47	0.53	0.11
2000 All Crops				
All insurance	206	34,444	951	2,595
CAT share	0.23	0.21	0.28	0.03
Specialty Crops				
All insurance	8	7,988	220	435
CAT share	0.43	0.53	0.52	0.03
2005 All Crops				
All insurance	246	44,529	2,344	2,367
CAT share	0.11	0.16	0.10	0.04
Specialty Crops				
All insurance	8	10,395	350	598
CAT share	0.33	0.49	0.36	0.14
2010 All Crops				
All insurance	256	78,085	4712	4,254
CAT share	0.08	0.09	0.06	0.01
Specialty Crops				
All insurance	9	12,427	471	484
CAT share	0.26	0.38	0.26	0.02
2013 All Crops				
All insurance	296	123,786	7,295	12,059
CAT share	0.05	0.06	0.04	0.00
Specialty Crops				
All insurance	8	13,638	519	410
CAT share	0.30	0.34	0.25	0.01

*Premium subsidy only.

Source: Risk Management Agency (RMA) and author's calculations.

Table 2. Summary of Sampled Individual Crop Insurance Policies and Shares for CAT Covered Crops in 2011

	California	Florida	Texas	Washington	Four States Total
No. of crops*	21	4	4	17	28
No. of counties	38	10	7	19	74
No. of policies	948	33	16	607	1,604
Share**	21%	73%	5%	29%	23%
Acreage (‘000)	446.7	8.4	7.8	225.1	688
Share**	53%	99%	97%	74%	59%
Liability ($ Mil)	521.3	11.3	12.5	293.9	839
Share**	56%	99%	99%	77%	64%
Subsidy ($Mil)	19.1	0.6	2.6	10.0	32
Share**	65%	98%	99%	78%	71%

* Crops include covered fruits, vegetable and tree nuts for which CAT APH is available in these states, except citrus which is not included in the EWG files.

** Share represents the share that our EWG sample represents of all CAT APH policies for the covered commodities.

Source: Environmental Working Group (EWG), USDA Risk Management Agency (RMA), and authors’ calculations.

Table 3. Means and Standard Deviations for Individual CAT APH polices for Specialty Crops, by State*

	California	Florida	Texas	Washington	All States
	Mean (Standard Deviation)				
Insured acres	471 (1,163)	255 (306)	488 (841)	371 (726)	429 (1005)
Liability ($1,000)	550 (1,311)	342 (332)	765 (1457)	484 (896)	523 (1159)
Subsidy ($1,000)	20 (56)	18 (21)	16 (372)	16 (31)	20 (61)
Individual premium rate	0.037 (0.027)	0.062 (0.042)	0.163 (0.037)	0.038 (0.019)	0.039 (0.028)
County premium rate	0.043 (0.033)	0.072 (0.063)	0.180 (0.063)	0.040 (0.020)	0.047 (0.040)

* Based on 1,697 policies for policy holders who do not also have buy-up for the same crop in the same county.

Source: Environmental Working Group (EWG), Risk Management Agency (RMA) and authors' calculations.

Table 4. Estimated Coefficients of Acreage Response Equation

	CAT APH policy	More than one CAT APH policy	
	OLS (1)	OLS (2)	Fixed effect (3)
	Dependent variable: Insured acres		
Explanatory variables:			
$County\ premium\ rate_{jk}$	2913.18†	4961.85†	6056.94*
	(1904.68)	(3046.82)	(3525.10)
$\frac{Premium\ rate_{ijk}}{County\ premium\ rate_{jk}}$	-203.59†	-350.2500	-266.7900
	(132.5049)	(275.1996)	(315.2099)
Constant	1375.88***	1648.33***	1179.85***
	(295.33)	(488.76)	(417.89)
R-square	0.1182	0.1127	0.2186
No of Obs.	1604	975	975

Note: Crop, state, and plan dummy variables are included in the estimation. Standard errors are clustered at the policy holder level and reported in parenthesis. Statistical significance at 0.01, 0.05, 0.1, and 0.15 level are denoted by ***,**,*, and †.