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The Effects of the Premium Subsidies in the U.S. Federal Crop Insurance Program on Crop Acreage

WORKING DRAFT

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Abstract

The U.S. federal crop insurance program experienced periodic policy changes over the past three decades that increased premium subsidies. These premium subsidies encourage changes in crop acreage for two reasons. First, holding insurance coverage constant, premium subsidies directly increase the expected return, which may encourage more acreage of the insured crop (profit effect). Second, premium subsidies encourage farms to increase crop insurance coverage. With more insurance coverage, farm revenue, which includes crop revenues and expected crop insurance indemnity payments, becomes less variable and therefore, acreage of the insured crop may increase (coverage effect). By exploiting exogenous policy changes, this study estimates the sum of these two distinct effects of premium subsidies on crop acreage. Using about 180,000 county-crop-year observations for seven major crops over 26 years, we estimate that a 10% increase in the premium subsidy causes a 0.39% increase in crop acreage. Taking account of the small share of crop insurance premium subsidies in expected crop revenue, this estimate is analogous to an analogue to the own-price elasticity is about 1.10. This estimate exceeds supply elasticity estimates in the literature because crop insurance premium subsidies has a coverage effect in addition to a profit effect.

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1 Introduction

The U.S. federal crop insurance program expanded rapidly in the last three decades, with substantial increases in insured acres, liability and insurance subsidies (Glauber 2012). The total crop insurance premium subsidy increased from $205 million in 1989 to $6.2 billion in 2014 (Risk Management Agency 2015). Recently, the Agricultural Act of 2014 eliminated major commodity programs, added risk management programs, and enhanced the existing federal crop insurance program.

This study focuses on isolating the effect of the premium subsidies in the U.S. federal crop insurance program on crop acreage from other important factors affecting crop production. The extensive literature on estimating supply response suggests that researchers must carefully deal with issues such as price expectation, crop dynamics, multiple crop alternatives, crop rotation, and government programs (Bessler and Nerlove 2002; Roberts and Schlenker 2013; Hendricks, Smith and Sumner 2014; Hendricks and Sumner 2014). By approaching with a careful identification strategy, the acreage effect of the increased premium subsidies caused by particular policy changes can be estimated without being affected by the issues in estimating supply response.

This paper estimates the effect of the premium subsidies in the U.S. federal crop insurance program on planted acreage. The program experienced several policy changes over the past three decades that increased the premium subsidy rates.[1] These policy changes affected crops and counties differently. In this paper, we exploit these changes in the U.S. federal crop insurance program to identify the effects of the premium subsidy on crop acreage. Using the policy changes assumed to be exogenous, we estimate the acreage elasticity with respect to the premium subsidy in the U.S. federal crop insurance program for major field crops. The results are interpreted as the acreage effect of the increased premium subsidies caused by the series of policy changes.

Previous studies developed the conceptual and empirical foundations for how the U.S. federal crop insurance program affects input demand or crop supply in the context of mainstream insurance issues such as risk aversion, information asymmetry or credit market imperfection (Chambers 1989; Horowitz and Lichtenberg 1993; Ramaswami 1993; Babcock and Hennessy 1996; Smith and Goodwin 1996; Coble et al. 1997; Wu 1999; Young, Vandeveer, and Schnepf 2001; Goodwin, Vandeveer and Deal 2004; Cornaggia 2013; Goodwin and Smith 2013; Weber,

[1] The financial sustainability of crop insurance products are often in question. Crop insurance products experienced historically poor actuarial performance (Hazell 1992).

Key, and O'Donoghue 2015).[2]

The research on the acreage effect of crop insurance is more limited (Wu 1999; Young, Vandeveer, and Schnepf 2001; Goodwin, Vandeveer and Deal 2004; Goodwin and Smith 2013). Wu (1999) estimates a system of equations of crop share and crop insurance choice and finds that making crop insurance available for corn leads to 5-27 % increase in the share of corn acreage. The simulation results of Young, Vandeveer, and Schnepf (2001) imply about 0.4% decrease in the total acreage of eight major field crops as a response to the removal of all federal crop insurance subsidies.

Goodwin, Vandeveer and Deal (2004) empirically investigate the acreage response to the U.S. federal crop insurance program for corn, soybean and wheat and find that a higher crop insurance participation rate induces an acreage expansion. Premium subsidies have positive, but modest acreage effects through higher crop insurance participation rate. For example, their simulation results suggest that a 30% decrease in the insurance premium for corn and soybeans increases corn acreage by about 0.28 - 0.49%. Goodwin and Smith (2013) recently presented preliminary empirical estimates which also indicates potential positive effects of the premium subsidy.

Crop insurance premium subsidies can affect crop production by: a) increasing the expected return of the insured crops holding the coverage level constant and b) encouraging farms to insure their crop revenue thereby reducing the riskiness of the insured crops and stimulate the acreage of those crops (Yu 2016). This study empirically distinguishes these two effects.

This paper starts with a brief discussion on how premium subsidies affect crop acreage following Yu (2016). With county-crop-year observations of seven major field crops and all field crop growing counties in 1989 - 2014, the effect of the crop insurance premium subsidies on crop acreage is estimated. We exploit the natural experiment aspect of the national policy changes to properly identify the effect of the crop insurance premium subsidies.

2 How Premium Subsidies Affect Crop Acreage

There is limited empirical evidence on the effect of the U.S. federal crop insurance program on crop acreage. The literature suggests that U.S. crop insurance premium subsidies lead to

[2] Recent work by Babcock (2015) provides an alternative framework using cumulative prospective theory to explain the crop insurance coverage choices. Prospect theory and loss aversion are still relatively new in the crop insurance literature.

more crop acreage of insured crops (Young, Vandeveer, and Schnepf 2001; Goodwin, Vandeveer and Deal 2004; Goodwin and Smith 2013). To develop an empirical strategy, it is useful to investigate conceptually how premium subsidies affect crop acreage. Yu (2016) derives two ways through which premium subsidies in crop insurance affect crop choices.

2.1 Profit Effect of Premium Subsidies on Crop Acreage

Premium subsidies increase the expected net return from the crop that is covered by crop insurance. An increase in premium subsidies increases the expected net return from the insured crop, holding the crop insurance coverage constant.[3] Therefore, the participating farms receive the increased subsidies in terms of expected value without changing their crop insurance coverage.

The framework of Yu (2016) assumes a single input and two crops. Under this framework, farms allocate the initial resource endowment, K_0, into the production of the risky crop and the safe crop with inputs K_r and K_s. The returns from both crops are linear to the input and the risky crop has a stochastic return with the expected value greater than the return from the safe crop. For the risky crop, farms can purchase crop insurance, θ, with premium π and subsidy γ.

Figure 1 represents the allocation of the initial endowment with the illustration of an indifference curve and a budget line. The indifference curve represents the risk-return trade off based on the expected utility framework. The indifference curve would be linear under the risk-neutrality. The slope of the budget line represents the relative cost of the production.[4]

As the premium subsidy increases, the slope and the intercept of budget line change since the cost of producing the risky crop changes due to the cheaper price of crop insurance. Holding the coverage at θ_0, the budget line shifts from $K_r = (K_0 - K_s)/(1+\theta_0\pi)$ to $K_r = (K_0 - K_s)/(1+\theta_0\pi(1-\gamma))$ and the allocation point moves from A to B. Under any non-increasing absolute risk aversion (NIARA) preference, the allocation of the resource into the risky crop increases. We define this as a direct profit effect of premium subsidies.

2.2 Coverage Effect of Premium Subsidies on Crop Acreage

Premium subsidies also affect crop acreage by providing farms incentives to participate in crop insurance program or increase the coverage of crop insurance. The coverage of crop insurance

[3]We define the term "coverage" as the share of insured revenue in the expected crop revenue. In the U.S. federal crop insurance program, this would be the product of the share of insured acre in total planted acre and the coverage level elected.

[4]This budget line also indicates the production frontier. The production frontier is linear since the return from each crop is linear to its input.

is defined as the product of the share of insured acres in total crop acreage and the coverage level, which is the share of insured expected revenue per acre in the expected revenue per acre. An increase in premium subsidies can encourage non-participating farms to participate in crop insurance or encourage participating farms to increase their coverage for given crop acreage.

Goodwin (1993), Goodwin, Vandeveer, and Deal (2004) and O'Donoghue (2014) find empirical evidence on the positive effect of premium subsidies on the demand for crop insurance. Increases in crop insurance coverage reduce the riskiness of the crop that is covered by crop insurance. The standard expected utility theory suggests that farmers with any NIARA preference would increase the acreage of the crop as the riskiness decreases (Hennessy 1998).

In Figure 1, this effect is illustrated as the change from B to C. As the premium is subsidized with the premium subsidy, γ, the coverage increases from θ_0 to θ_1 for the given crop acreage. The risky crop becomes less risky with the increased coverage level and the slope of the indifference curve shifts pivotally (I_0 to I_1). Under NIARA, the allocation of the resource into the risky crop increases. We define this as an indirect coverage effect of premium subsidies.

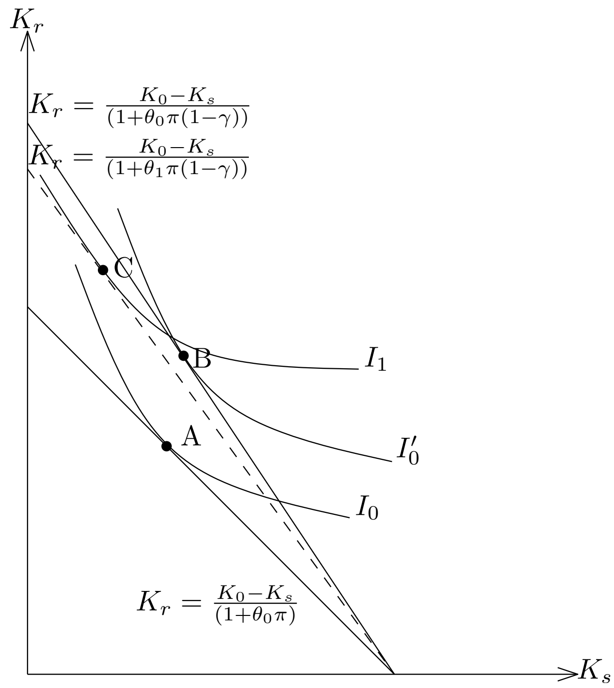

Figure 1: An Illustration of the Effect of Premium Subsidies under NIARA

Therefore, the overall effect of premium subsidies would be the sum of these two effects. In our empirical setting, we first estimate the overall effect of premium subsidies and then compare the estimated effect with the own-price elasticity. The comparison leads to a discussion on the magnitude of the additional indirect coverage effect.

3 Federal Crop Insurance Program

The Risk Management Agency (RMA) and the Federal Crop Insurance Corporation (FCIC) operate the U.S. Federal crop insurance program. Private insurance providers deliver crop insurance products to farms. Government subsidies are delivered as the administrative and operation cost, the reinsurance cost, and the insurance premium (Federal Crop Insurance Corporation 2015; Risk Management Agency 2015).

U.S. crop insurance products are developed by either the FCIC or private insurance providers with an approval of the FCIC. The FCIC and the RMA set premiums and specify the provisions for these crop insurance products. The premium rating practice went through several changes to have the actuarially fair premium rate (Goodwin 1994; Glauber 2012).

The two most common products across crops and counties are Yield Protection and Revenue Protection. In 2014, they account for about 78% of total liability. Yield Protection, formerly called Actual Production History, is the insurance product that insures against yield losses. The indemnity is triggered when the actual yield is smaller than the historical average yield. Revenue Protection insures against revenue losses. The indemnity is triggered when the actual yield times the harvest price is less than the historical average yield times the larger of the projected price and the harvest price. In general, Revenue Protection has a higher premium rate than Yield Protection.

The participating farms are required to pay a part of the crop insurance premium, which is equal to the total premium minus the premium subsidy. The total premium is the premium rate multiplied by the total liability that is insured by a crop insurance product. The total liability is proportional to the total insured acres, the coverage level elected by the farm, the projected or harvest prices of the crop, and the historical individual yield.

The premium rate is set by the RMA. In general, the premium rate depends on the riskiness of the insured crop in the county, the coverage level, the insurance product and the practice of the farm. The RMA targets actuarially fair premium rates, which means the premium rates should be equal to the expected indemnities per dollar of liability. For example, the premium rates for the riskier crops or the crops in riskier counties are higher (Coble and Barnett 2013).

The premium subsidy is equal to the total premium multiplied by the subsidy rate. The subsidy rate varies across coverage levels, crop insurance products, and units. Every crop and every county face same subsidy rate for a given coverage level, holding product and unit type equal. The subsidy rate is determined by the legislation and the changes in the subsidy rate are described in the next section. The subsidy rate decreases as the coverage level increases. Group or area-based products, which have indemnity payout schedules tied with county-level yields or revenue, have higher subsidy rates. Enterprise or whole farm units have higher subsidy rates than others since 2008.

By definition, the actuarially fair premium is equal to the expected indemnity for the participating farms. Therefore, if the premium is set at the actuarially fair level, the premium subsidy is equal to the expected net gain. The premium rates and the subsidy rates, which are set by the FCIC and the RMA, determine how much subsidy per dollar of insured liability the participating farms receive ($Subsidy\ per\ liability = Premium\ Rate * Subsidy\ Rate$). We focus on how the subsidy per dollar of insured liability affects planted acreage. We exploit policy changes on the subsidy rates. The premium rates and the subsidy rates that participating farms face are endogenous to their production decisions. We address the endogeneity issues and relevant exogenous policy changes in detail.

4 Institutional Changes

The U.S. federal crop insurance program experienced several large policy changes (Glauber 2012). We focus on the policy changes during 1989-2014, and tie the changes to the identification strategy. The subsidy per dollar of insured liability is the main variable of this study. As illustrated above, the premium rates and the subsidy rates are set by the FCIC and the RMA. Legislation changes and introductions of new crop insurance products led significant changes in the average premium rate and the average subsidy rate across crops and counties.

4.1 Major Legislative Changes

The Federal Crop Insurance Act of 1980 made private insurance providers to deliver crop insurance products. The 1980 act added more coverage levels and expanded crop insurance to more crops and regions. It mandated the FCIC to pay the 30% of total premium for any coverage level up to 65%. These changes were attempts to increase the participation rate of the federal crop insurance program.

The participation rate increased slowly and the congress created the mandatory risk protection program and increased the premium subsidy (Glauber 2012). The Crop Insurance Reform

Act of 1994 created "Catastrophic" risk protection program (CAT) with 100% subsidy rate that protects 50% of the historical yield at 60% of projected price. The 1994 act made CAT mandatory for any commodity program participants but this mandate was repealed in 1996. The 1994 act also increased the subsidy rates for "Buy-up" coverage levels, which have positive farm paid premiums. For example, the subsidy rate increased from 30% to 42% for the 65% coverage level for all products except area-based products.

The Federal Crop Insurance Act of 2000 reduced the premium rate and increased the subsidy rate. The 2000 act codified the ad hoc premium reductions in 1998 and 1999 into the law and led about 25% reduction of premium (O'Donoghue 2014). Supplementary legislations in 1998 and 1999 provided ad hoc premium reductions for crop years 1999 and 2000 (Glauber and Collins 2002). As a result, the 2000 act increased the subsidy rate for all coverage levels.

The 2008 Farm Bill includes a new title for crop insurance and disaster payments. The new title supported the RMA to undertake research and development on designing crop insurance products. The 2008 Farm Bill increased the subsidy rates for enterprise and whole farm units. [5] Also, the 2008 Farm Bill reduced the subsidy rates for area-based products, which had higher subsidy rates than Yield Protection or Revenue Protection.

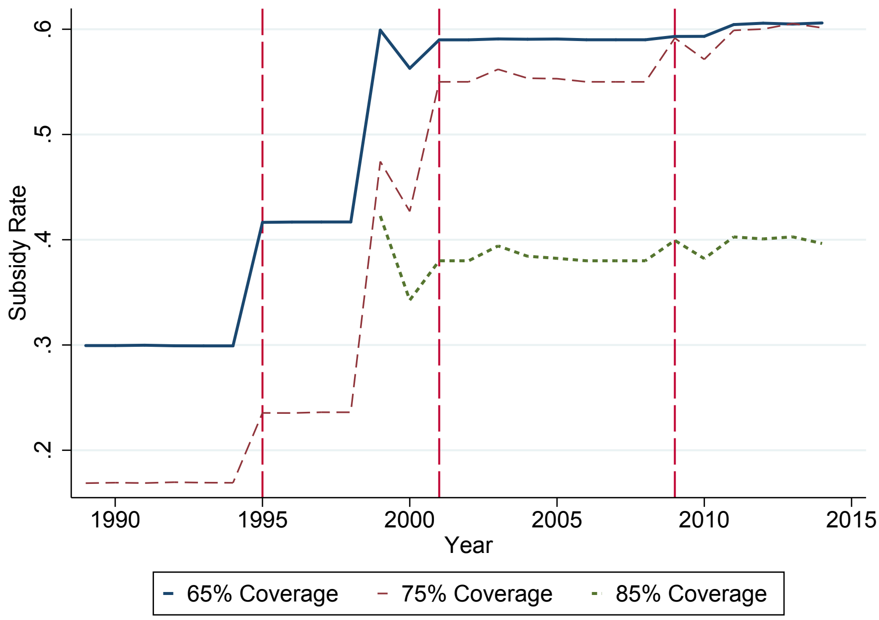

Figure 2: Subsidy Rate by Coverage Level (1989-2014)

[5] Enterprise and whole farm units have low premium per acre and the 2008 Farm Bill made them to receive premium subsidy per acre as much as other two units.

Figure 2 illustrates the changes in the subsidy rates for three coverage levels, 65%, 75%, and 85%, of Yield Protection or Revenue Protection since 1989. All coverage levels experience similar changes in the subsidy rates. Two significant changes in 1994 and 2000 are observed that are due to the 1994 and 2000 acts. After 2008, due to the 2008 Farm Bill the national average subsidy rates depend on the proportion of unit structures.

4.2 Introductions of New Crop Insurance Products

Introductions of new crop insurance products also affect the premium subsidy that farms face since the new products have different premium rates and subsidy rates from the existing products. In 1996, Crop Revenue Coverage for corn and soybean was introduced. Since then, revenue products expanded across crops and counties. The subsidy rates are same as the yield products. The premium rates for the revenue products is generally higher than those of the yield products (Coble and Barnett 2013).

Area-based products are products that are based on the area-level yield or revenue. The FCIC and the RMA introduced the first area-yield products called Group Risk Plan in 1993 and the first area-revenue products (Group Risk Income Plan) in 1999 (Glauber 2012). For the same coverage level, the area-based products have higher subsidy rates than other products.

Cornaggia (2013) treats the introduction of new products as a quasi-experiment. The study classifies crops that faced an introduction of the new crop insurance product as a "treatment" group and finds a positive relationship between risk management and crop yield. We do not use the introductions of new products as experimental events directly but use the variations in the premium rates and the subsidy rates due to the introductions.

The increases in the subsidy rates and the development of new products affect how much premium subsidy that participating farms receive. The increases in the subsidy rates and the shift to revenue or area-based products increase the subsidy per acre or per dollar of insured liability, *ceteris paribus*. With county-crop-level panel data, we estimate the acreage effects of the U.S. crop insurance premium subsidy by exploiting the changes in the subsidy rates as results of the legislative changes. In other words, we use a quasi-experimental nature of the changes in the subsidy rates for the U.S. federal crop insurance program.

5 Data and Variables Construction

We use annual county level information on crop acreage and crop insurance characteristics for major field crops from the survey of National Agricultural Statistics Service (NASS) of U.S. Department of Agriculture and RMA Summary of Business (SOB). We focus on major field crops, barley, corn, cotton, sorghum, soybean, rice and wheat. NASS also reports the price received by farms at the state level. Futures price data for corn, cotton, soybean, rice and wheat are obtained from Commodity Research Bureau. The price is deflated by the Producer Price Index from the Bureau of Labor Statistics.

The expected price variable is constructed using both futures price and price received by farms. By regressing the state-level prices received by farms from NASS on state dummies and futures prices, we obtain the state-level basis of the expected price for each crop. We use the predicted values of the basis regression as the expected prices. The underlying assumption of the price expectation is that a) throughout the period of analysis the relationships between the realized prices and the futures prices, and the realized prices and the states do not change and b) the farms know these relationships.[6] We use similar futures prices as those of the RMA price projection. We use the average price from January to sign-up deadline of crop insurance contracts. For barley and sorghum, we use corn futures.

The SOB from RMA includes detailed county-crop level crop insurance characteristics by insurance product, and coverage level. The SOB reports insured acres, total liability, total premium, premium subsidy, and indemnity paid. From the SOB information, the average premium rate and the average subsidy rate for each crop in each county can be computed. We focus on the premium subsidy per dollar of insured liability, which is computed by dividing total premium subsidy by total insured liability for each county-crop observation.

[6] We also consider the possibility of the state-level basis for the expected price changes after 2006. Carter, Rausser, and Smith (2016) estimate about 30% increase in the corn price from 2006 to 2014 due to biofuel policies. We consider the possibility of a structural change in the basis regression. The results are in Appendix B.1.

Table 1: Means and Standard Deviations of County-crop Panel for Seven Field Crops and All Counties Reported by NASS

Variables	Mean (SD)	Mean (SD)	Mean (SD)
Full Sample			
	1989-1993	**2010-2014**	**Overall**
Planted Acreage	28,123	44,196	34,661
	(49,192)	(57,367)	(52,855)
Avg. Subsidy per Liability	0.021	0.088	0.062
	(0.018)	(0.052)	(0.052)
Avg. Buy-up Subsidy per Liability	0.021	0.089	0.056
	(0.018)	(0.052)	(0.050)
Avg. Share of Revenue Insured	0.100	0.484	0.275
	(0.150)	(0.411)	(0.304)
Number of County-crop Combinations	9,456	6,573	10,030
Number of Observations	43,060	25,820	179,180
Balanced Panel			
	1989-1993	**2010-2014**	**Overall**
Planted Acreage	60,137	65,977	63,663
	(64,824)	(64,764)	(64,446)
Avg. Subsidy per Liability	0.021	0.076	0.056
	(0.014)	(0.043)	(0.040)
Avg. Buy-up Subsidy per Liability	0.021	0.077	0.054
	(0.014)	(0.043)	(0.039)
Avg. Share of Revenue Insured	0.136	0.546	0.362
	(0.155)	(0.352)	(0.288)
Number of County-crop Combinations	2,778	2,778	2,778
Number of Observations	13,890	13,890	72,228

We constructed the county-crop panel from NASS and RMA data. The county-crop panel is unbalanced since NASS combines counties with small planted acreage into one county-crop observation for each state in each year. We do not include the combined observations since the counties in that combined observations change over time. The issue of unbalanced panel is discussed in Section 8.

Table 1 shows the descriptive statistics of all 179,180 county-crop-year combinations and the 72,228 county-crop-year combinations from county-crop combinations that stay in dataset for all 26 years (balanced panel). The average planted acreage is about 35 thousand acres. Farms used to receive about 2% of the insured liability as the premium subsidy during the early period whereas they receive about 9% of the insured liability as the premium subsidy in the later period. The overall average of subsidy per dollar of insured liability is about 6 cents and excluding the subsidy from Catastrophic Risk Protection would not change significantly. The share of the expected revenue covered by crop insurance increased over time and it has an average of 28%. The descriptive statistics by crop are in Appendix A.

The planted acreage of county-crop combinations that exist for all 26 years in NASS dataset tend to be larger. The average is about 64,000 acres. The average subsidy per dollar of insured liability is slightly smaller than the all sample average for the later periods and the share of revenue insured is slightly higher than the all sample average. We present the empirical results for this subsample as a sensitivity analysis in Section 8.

6 Estimation Strategy

6.1 Model Specifications

The dependent variable of the main specification is *Planted Acreage*. Suppose a farm allocates the farm's acreage across crops and has the option to buy crop insurance for each crop. The farm chooses planted acreage for crop j, A_j, and the crop insurance coverage, θ_j. The coverage, which is the share of the expected crop revenue of each crop that is protected by crop insurance, is defined as $\theta_j = \frac{Insured\ Acres_j}{A_j} Coverage\ Level_j$ where $Coverage\ Level_j$ is the share of per acre insured expected revenue in per acre expected crop revenue for crop j. The crop insurance coverage is defined as a combination of two choices, which are the coverage level and the insured acres.

Recall that the premium rate, which is the premium per dollar of insured liability, and the subsidy rate, which is the share of premium subsidy in total premium, are set by RMA and legislation. The premium rate and the subsidy rate of the U.S. federal crop insurance program can be represented as

$$Premium\ Rate_j = f^p(Coverage\ Level_j;\ M_j,\ Z)$$

and

$$Subsidy\ Rate_j = f^s(Coverage\ Level_j;\ Z)$$

where M_j is a vector of parameters defining the distribution of the crop revenue per acre for crop j, R_j, and Z is a vector of crop insurance policy parameters that are same for all crops.

The expected profit function for given year for the farm assuming the actuarially fair premium rate is defined as following:

$$E\pi = \sum_j (E(R_j)A_j(1 + Subsidy\ Rate_j Premium\ Rate_j \theta_j) - c(A_j)) \tag{1}$$

which is a function of the crop revenue per acre, R_j, $Subsidy\ Rate_j$, $Premium\ Rate_j$ and the cost function, $c(.)$. Also, note that $Subsidy\ Rate_j$ times $Premium\ Rate_j$ is equal to $Subsidy\ per\ Liability_j$.

The farm chooses planted acreage, A_j, and the crop insurance coverage, θ_j. By treating $Subsidy\ per\ Liability_j$ as an exogenous variable, they can be characterized as following implicit functions:

$$A_j = f^A(\theta_j,\ Subsidy\ per\ Liability_j;\ X_j)$$

and

$$\theta_j = f^\theta(A_j,\ Subsidy\ per\ Liability_j;\ X_j)$$

where X_j is a vector of other parameters affecting production and crop insurance decisions. Note that X_j includes the expected price and the subsidy of the competing crop. The endogeneity of $Subsidy\ per\ Liability_j$ will be discussed in Section 6.2.

An exogenous increase in *Subsidy per Liability* increases the expected profit for the given level of acreage and insurance coverage, holding revenue per acre and the cost of production constant. The increase in *Subsidy per Liability* implies how much additional expected profit from crop insurance that farms get proportional to their expected crop revenue. Similar to the framework of Yu (2016), this characterization clarifies that the premium subsidy affects the planted acreage not only indirectly through crop insurance demand but also directly. In other words,

(2)
$$\frac{\partial A_j}{\partial Subsidy\ per\ Liability_j} = \frac{\partial A_j}{\partial \theta_j} * \left.\frac{\partial \theta_j}{\partial Subsidy\ per\ Liability_j}\right|_{A_j} + \left.\frac{\partial A_j}{\partial Subsidy\ per\ Liability_j}\right|_{\theta_j}.$$

The reduced-form representations of A_j is

$$A_j = g^A(Subsidy\ per\ Liability_j;\ X_j)$$

and we focus on the estimation of the effect of $Subsidy\ per\ Liability_j$ on A_j, which is the sum of the two different effects as illustrated in Equation (2).

For the estimation equation, $Subsidy\ per\ Liability_{ijt}$ is defined as average $Subsidy\ per\ Liability$ across farms in county i, that plant crop j in year t. The regression equation is

$$\begin{aligned} ln(Planted\ Acreage_{ijt}) = &\beta_0 + \beta_1 ln(Subsidy\ per\ Liability_{ijt}) \\ &+ \beta_2 ln(Subsidy\ per\ Liability\ of\ Competing\ Crop_{ijt}) \\ &+ \beta_3 ln(Expected\ Price_{ijt}) \\ &+ \beta_4 ln(Expected\ Price\ of\ Competing\ Crop_{ijt}) \\ &+ \beta_5 ln(Planted\ Acreage_{ijt-1}) + Time_t + v_{ij} + u_{ijt}. \end{aligned} \tag{3}$$

The competing crop for crop j is defined with following rules. If crop j is the most planted crop among the seven field crops in county i, the competing crop for crop j is the second most planted crop in county i. If crop j is not the most planted crop among the seven crops in the county, the competing crop for crop j is the most planted crop. The ranking is based on the 5-year moving average planted acreage in each county. If a county has only one crop planted, we use the state-level ranking. Both results with and without controlling for the subsidy and price of the competing crop are presented.

The logarithmic transformation is used since the scales of acreage and price are different across crops and counties. For the zero values of subsidy per dollar of liability, the values are replaced with 0.0001 before the transformation. The results are robust with respect to the transformation.[7] The estimations in levels or in the logarithmic transformation without the replacements of zeros provide similar outcomes. The coefficients are interpreted in terms of the elasticities.

6.2 Endogeneity Issues and Identification Strategy

The main variable of the interest, $Subsidy\ per\ Liability_{ijt}$, is endogenous to the dependent variable of Equation (3), $Planted\ Acreage_{ijt}$. The premium subsidy per dollar of insured liability for county i, crop j, and year t, $Subsidy\ per\ Liability_{ijt}$, is defined as the products of the premium rate and the subsidy rate. The premium rate, which is assigned by RMA, reflects the assessed riskiness of each crop in each county and the choice of crop insurance such as product types or coverage levels. The subsidy rate, which also follows the government-determined schedule, is determined by the crop insurance choice.

[7] The results with log-linear specifications are in Appendix B.2.

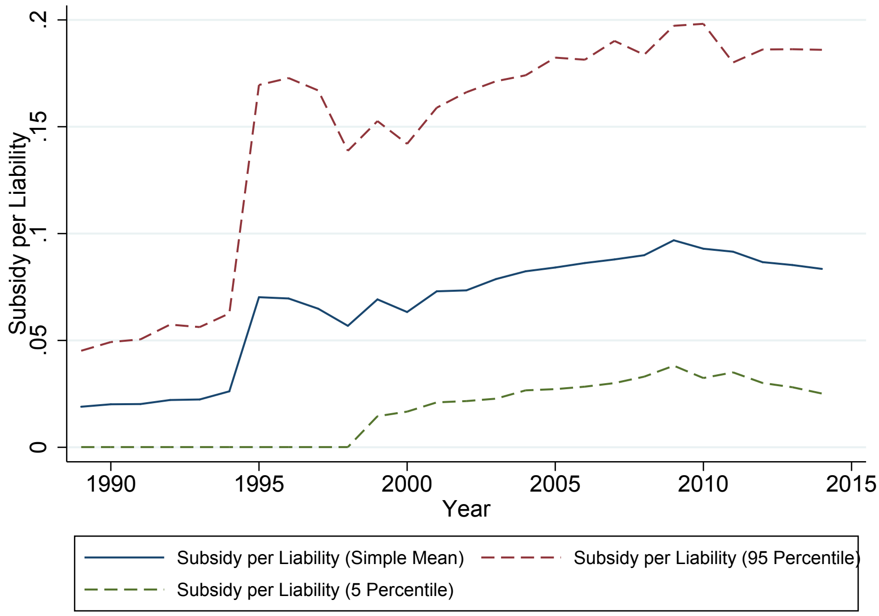

Figure 3: Subsidy Rate and Subsidy per Liability

Note: The mean, 95 percentile, and 5 percentile are computed from unweighted distribution of the subsidy per dollar of insured liability. The figure represents the distribution of county-crop combination for each year and its change over time.

Figure 3 illustrates large cross-section variations in $Subsidy\ per\ Liability_{ijt}$ and how the variations change over time. The time-series and cross-sectional variations depend on the choices of crop insurance in each county for each crop. The policy changes related to the premium rates and the subsidy rates drive the time-series variations of $Subsidy\ per\ Liability_{ijt}$.

Both riskiness and crop insurance choice raise endogeneity concerns. Both riskiness and crop insurance choice cause a downward bias in the estimated coefficient for $Subsidy\ per\ Liability_{ijt}$. A more risky crop or a more risky county has a higher premium rate for a given crop insurance choice. Farmers tend to plant less of riskier crops and plant less in riskier counties, *ceteris paribus*. Thus, omitting the "riskiness" variable causes a downward bias in the coefficient of $Subsidy\ per\ Liability_{ijt}$ since it is positively correlated with $Subsidy\ per\ Liability_{ijt}$ and negatively correlated with $Planted\ Acreage_{ijt}$.

The choice of crop insurance also may cause a downward bias in the coefficient of $Subsidy\ per\ Liability_{ijt}$ as a measure of the effect of crop insurance premium subsidy on planted acreage. An increase in crop insurance coverage decreases $Subsidy\ per\ Liability_{ijt}$ since the subsidy rate is lower for the higher coverage levels. If higher crop insurance coverage affects crop acreage positively through risk reduction, omitting the variable for the choice of crop insurance induces a downward bias. However, including the variable for the choice of crop insurance is still problematic since that causes a simultaneity bias.

A concrete illustration makes the concerns more clear. Suppose a farm had chosen coverage level of 65% before 1998 and changed to 85% after 2000 due to the increase in the subsidy rates for each coverage level. The subsidy rate for the farm would have fallen by about 10%, which means the subsidy per dollar of insured liability would have fallen by 10% holding the premium rate constant. And if the farm increased its planted acreage, then that increase would be due to the risk reduction from higher crop insurance coverage level; not due to the change in the subsidy per dollar of insured liability, which had fallen not risen.[8]

Several studies attempt to deal with the endogeneity issues of crop insurance participation to crop acreage decision (Goodwin, Vandeveer, and Deal 2004; Cornaggia 2013; Weber, Key, and O'Donoghue 2015). In the context of estimating the effects of premium subsidies on the demand for crop insurance, O'Donoghue (2014) uses the lag of the change in the premium subsidy per acre between 2007 and 2012 as the instrument for the change in the premium subsidy per acre between 2007 and 2012 to estimate the effect on the changes in crop insurance participation.

As described above, several legislative changes affected the premium subsidy that farms face. We exploit the exogenous variation in the subsidy rate to deal with the endogeneity issues of the premium subsidy. In order to motivate the identification strategy, we consider three major legislation changes, the 1994 act, the 2000 act, and the 2008 Farm Bill, that affected the premium subsidy rates as exogenous separate events.

For the 1994 act, we compare 1994 and 1996 instead of 1994 and 1995 since the mandatory provision of CAT in 1995 does not allow us to identify the effect of premium subsidy increase. For the 2000 act, we compare 1998 and 2001 since the 2000 act codified the ad hoc premium reductions that already happened in 1999 and 2000. For the 2008 Farm Bill, we compare 2008 and 2009. Note that the 1994 act, the 2000 act, and the 2008 Farm Bill become affective for the crop years, 1995, 2001 and 2009.

The variables are transformed into the differences between *pre* and *post* legislations. For example, the estimation model for the 1994 act is

[8] We treat the variable $Subsidy\ per\ Liability\ of\ Competing\ Crop_{ijt}$ as exogenous. Riskiness of the competing crop, which is correlated with the subsidy per liability of the competing crop, may affect the planted acreage. We believe that the county-crop fixed effect solves this issue. We also assume that the county- or state-level average crop insurance choices for the competing crop would not affect the planted acreage directly. Again, the results both with and without the subsidy per liability of the competing crop are presented and we do not find any significant difference.

$$
\begin{aligned}
&ln(Planted\ Acreage_{ij1996}) - ln(Planted\ Acreage_{ij1994}) \\
&\quad = \alpha_0 + \alpha_1(ln(Subsidy\ per\ Liability_{ij1996}) - ln(Subsidy\ per\ Liability_{ij1994})) \\
&\qquad + \alpha_2(ln(Subsidy\ per\ Liability\ of\ Competing\ Crop_{ij1996}) \\
&\qquad\qquad - ln(Subsidy\ per\ Liability\ of\ Competing\ Crop_{ij1994})) \\
&\qquad + \gamma(X_{ij1996} - X_{ij1994}) + (u_{ij1996} - u_{ij1994}).
\end{aligned}
$$

The vector X includes the logs of expected price of own and its competing crop.[9]

Table 2: The Estimated Acreage Effects of the Major Legislation Changes

	(1)	(2)	(3)
	1994 vs 1996	1998 vs 2001	2008 vs 2009
VARIABLES	Dependent Variable: D.ln(Planted Acres)		
D.ln(Subsidy per Liability)	0.00708	0.0333***	0.0220**
	(0.00436)	(0.00764)	(0.00919)
D.ln(Subsidy per Liability of Competing Crop)	-0.00541*	-0.00230	0.00243
	(0.00283)	(0.00518)	(0.00506)
Number of county-crop combinations	7,382	6,592	4,376

Note: Cluster robust standard errors are in parentheses. The log of expected price and that of the competing crop are included as control variables.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table 2 suggests the positive effect of the premium subsidies on planted acreage. The results imply that the increase in the premium subsidies due to the legislative changes induced more crop acreage.

We instrument $Subsidy\ per\ Liability_{ijt}$ with $Subsidy\ Rate\ 65\%_t$ and $Subsidy\ Rate\ 75\%_t$, which are the subsidy rates for Yield Protection or Revenue Protection with 65% and 75% coverage levels. Subsidy rates for other coverages also experienced similar exogenous changes but 65% and 75% coverage levels are chosen since it is the most common coverage levels and span whole 26 years. We rely on the fact that $Subsidy\ Rate\ 65\%_t$ and $Subsidy\ Rate\ 75\%_t$ changed only due to the exogenous policy changes. We argue that this variation is only affecting $Planted\ Acreage_{ijt}$ through $Subsidy\ per\ Liability_{ijt}$ that each crop in each county receives.

We do not include the ad hoc premium reductions in 1999 and 2000 into the computations of the variables $Subsidy\ Rate\ 65\%_t$ and $Subsidy\ Rate\ 75\%_t$.[10] These two premium reductions occur due to bad weather and market conditions which are endogenous to production decisions (Glauber and Collins 2002). Also, the exact reduction rates announced in the middle of

[9] For the comparison between 1994 and 1996, the vector X includes a variable representing Acreage Reduction Program. Details on the Acreage Reduction Program is in Section 8.

[10] We do include the ad hoc premium reductions when we compute our main explanatory variable, $Subsidy\ per\ Liability_{ijt}$ since they are parts of the premium subsidy that insurance-participating farms receive.

insurance sales periods (RMA 1999).

The policy changes can be endogenously determined. However, the policy changes are at the national level and the subsidy rates are same across crops and counties. Therefore, at least at the county-crop level, it is unlikely that the legislative changes for the subsidy rates are endogenous to the planted acreage.

The Panel Fixed Effect (FE) regression can mitigate the bias from time-invariant omitted variables such as any variables related to the "riskiness" that are time-invariant. Therefore, in addition to instrumenting the variable *Subsidy per Liability*, we employ the county-crop FE regression (Panel FE-IV). The Panel FE without instrumenting the explanatory variable, *Subsidy per Liability*, is also considered (Panel FE).[11]

If there is no acreage effect from increasing crop insurance coverage levels or no time-varying riskiness of the crop in the county, the estimates from the Panel FE without the instrumenting *Subsidy per Liability* would be consistent. In such case, the estimated coefficients from the Panel FE and the Panel FE with instrumenting *Subsidy per Liability* should be close to each other.

Table 3 shows the result of the first stage regression for Equation (3) without and with controlling for the competing crop price and premium subsidy. As expected, the instruments *Subsidy Rate* $65\%_t$, and *Subsidy Rate* $75\%_t$ are strongly correlated with the variable of interest, $ln(Subsidy\ per\ Liability_{ijt})$.

For the estimation, we employ two-step Generalized Method of Moment (GMM) estimator. The standard errors are clustered at the state level. The sample has more than one clusters and there are multiple ways to cluster the standard errors. As Cameron, Gelbach and Miller (2011) discuss, for the nested clusters one should simply cluster at the highest level of cluster. For example, the standard errors should be clustered at the state level not at the county level.

[11] We are not concerned about the endogeneity of lagged dependent variable, i.e. Nickell Bias, since we have long enough panel. Note that the bias is proportional to the inverse of T (Nickell 1981). Also, our interest is to identify the causal relationship between the planted acreage and the crop insurance premium subsidy not the dynamic relationship between the current planted acreage and its lag. The bias in the coefficient of the premium subsidy is less problematic when the covariance of the demeaned premium subsidy variable and the demeaned lagged dependent variable is small. The results with Arellano-Bond estimator are in Appendix B.3 (Arellano and Bond 1991). The results remain robust.

Table 3: The First Stage Regression with County-Crop Fixed Effects

VARIABLES	(1)	(2)
	Dependent Variable: ln(Subsidy per Liability)	
Subsidy Rate 65%	13.7***	11.9***
	(1.11)	(0.98)
Subsidy Rate 75%	-7.13***	-6.20***
	(0.681)	(0.599)
ln(Subsidy per Liability of Competing Crop)		0.116***
		(0.0121)
ln(Expected Price)	0.0631	0.070
	(0.0469)	(0.0468)
ln(Expected Price of Competing Crop)		-0.00692
		(0.0171)
L.ln(Planted Acres)	0.171***	0.170***
	(0.0274)	(0.0261)
Corn x Time	0.0228***	0.0161***
	(0.00465)	(0.00449)
Soybeans x Time	0.0262***	0.0201***
	(0.00433)	(0.00398)
Wheat x Time	0.0515***	0.0482***
	(0.00497)	(0.00505)
Barley x Time	0.0435**	0.398**
	(0.0184)	(0.0164)
Cotton x Time	0.0181***	0.0131***
	(0.00479)	(0.00432)
Rice x Time	0.0231***	0.0195***
	(0.00791)	(0.00740)
Sorghum x Time	0.0513***	0.0484***
	(0.00965)	(0.00957)
Observations	160,014	159,942
Number of county-crop combinations	8,994	8,994

Cluster robust standard errors are in parentheses.

7 Results and Interpretations of the Acreage Effect of the Premium Subsidy

7.1 The Estimation Results of the Acreage Effect of the Premium Subsidy

Table 4 shows the estimated results for Equation (3). Column (1) and (2) are the estimation results without controlling for the premium subsidy and the expected price of the competing crop and Column (3) and (4) are the results with the competing crops variables included. The results from the Panel FE estimation without instrumenting are presented in Column (1) and (3). As expected, the estimated coefficients for $ln(Subsidy\ per\ Liability)_{ijt}$ are smaller than those of the Panel FE-IV, which are reported in Column (2) and (4). The differences suggest that the time-varying "riskiness" and the choice of crop insurance cause the downward bias of the coefficient.

Table 4: Biased and Consistent Estimates for the Effect of the Premium Subsidy on Crop Acreage

	(1)	(2)	(3)	(4)
	(FE)	(FE-IV)	(FE)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)			
ln(Subsidy per Liability)	0.0131***	0.0333***	0.0133***	0.0391***
	(0.00216)	(0.00572)	(0.00215)	(0.00705)
ln(Subsidy per Liability of Competing Crop)			-8.72e-05	-0.00509**
			(0.00124)	(0.00199)
ln(Expected Price)	0.200***	0.188***	0.221***	0.209***
	(0.0305)	(0.0250)	(0.0300)	(0.0240)
ln(Expected Price of Competing Crop)			-0.0282***	-0.0259***
			(0.00510)	(0.00499)
L.ln(Planted Acres)	0.707***	0.713***	0.707***	0.711***
	(0.0283)	(0.0272)	(0.0282)	(0.0270)
Corn x Time	0.000501	-0.000722	0.000762	-0.000384
	(0.000995)	(0.000847)	(0.00103)	(0.000864)
Soybeans x Time	0.00573***	0.00468***	0.00589***	0.00489***
	(0.00134)	(0.00122)	(0.00136)	(0.00123)
Wheat x Time	-0.00647***	-0.00871***	-0.00662***	-0.00896***
	(0.00121)	(0.00131)	(0.00120)	(0.00129)
Barley x Time	-0.0141***	-0.0152***	-0.0140***	-0.0152***
	(0.00209)	(0.00208)	(0.00214)	(0.00211)
Cotton x Time	-0.00376	-0.00688**	-0.00321	-0.00617**
	(0.00286)	(0.00270)	(0.00290)	(0.00272)
Rice x Time	-0.00463**	-0.00566***	-0.00430*	-0.00540**
	(0.00208)	(0.00210)	(0.00221)	(0.00219)
Sorghum x Time	-0.0121***	-0.0126***	-0.0120***	-0.0128***
	(0.00287)	(0.00268)	(0.00289)	(0.00267)
First Stage F-statistics		121.98		121.78
Observations	160,014	160,014	159,942	159,942
Number of county-crop combinations	8,994	8,994	8,994	8,994

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Note that the number of observations in Table 4 is less than that of Table 1. Having the first order lagged dependent variable as an explanatory variable accounts for the most of losses in the number of observations. We also lose some observations from singleton panels, i.e. panels with only one observation, when we implement the county-crop fixed effect estimation.

There are additional losses in the number of observations after introducing the competing crop variables. Recall that the competing crop is determined by the ranking that is based on the 5-year moving average planted acreage in each county or state. In some states, there are some years with no planted acres for the competing crop for some county-crop combinations. Note that the number of county-crop combinations does not change as we introduce the competing crop variables.

The average change in crop acreage as responses to changes in the premium subsidy per dollar of liability insured by federal crop insurance program ranges from 0.033 to 0.039. That is a 10% increase in the premium subsidy induces about 0.39% more planted acres. Failure to account for the endogeneity of the premium subsidy from the county-crop-specific riskiness and the choice of crop insurance results in underestimation of the acreage effect of the premium subsidy by 60 - 66%.

The estimates on the own-price elasticity of crop acreage are around 0.19 - 0.22 and are stable across the different specifications. This implies the distribution of the expected prices for each crop in each county is independent from a) unobserved heterogeneity such as the riskiness and the choice of crop insurance coverage of the crop in the county, and b) the competing crop price and premium subsidy. The estimated own-price elasticity of crop acreage is not directly comparable with the literature since the estimates of Table 4 represents the average of responsiveness across county-crop combinations which includes the seven field crops. Note there is an extensive literature on the supply response of corn and soybeans which will be discussed in the later of this section.

Controlling for the competing crop price and premium subsidy does not change the estimated coefficient of $ln(Subsidy\ per\ Liability)$ by much. The estimations find the significant effects of the competing crop price and premium subsidy but the magnitudes are relatively small.

Goodwin, Vandeveer and Deal (2004) present the policy simulation results that suggest the acreage effect for corn ranging from 0.28% to 0.49% as a response to a 30% decrease in the premium rate. This is significantly smaller than what Table 4 reports, which is equal to the acreage effect of a 2.17% increase as a response to the same change.[12] The difference suggests that there is an additional effect, which is the profit effect proposed by Yu (2016). In the next section, we convert the own-subsidy acreage elasticities into a comparable estimate with the own-price acreage elasticities, which provides better understanding on the implications of the estimation results.

Table 5: The Estimated Acreage Effects of the Premium Subsidy with the Subsample of Crops

	(1)	(2)	(3)	(4)
	Corn, Soybeans and Wheat		Corn and Soybeans	
	(FE)	(FE-IV)	(FE)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)			
ln(Subsidy per Liability)	0.0111***	0.0409***	0.00952**	0.0407***
	(0.00280)	(0.00877)	(0.00354)	(0.0109)
ln(Subsidy per Liability of Competing Crop)	-0.000602	-0.00550***	-0.000832	-0.00629**
	(0.00130)	(0.00205)	(0.00155)	(0.00272)
ln(Expected Price)	0.204***	0.198***	0.178***	0.203***
	(0.0314)	(0.0237)	(0.0290)	(0.0223)
ln(Expected Price of Competing Crop)	-0.0223***	-0.0199***	-0.0330***	-0.0330***
	(0.00488)	(0.00448)	(0.00772)	(0.00768)
L.ln(Planted Acres)	0.724***	0.727***	0.778***	0.773***
	(0.0273)	(0.0261)	(0.0304)	(0.0292)
Corn x Time	0.000838	-0.000587	0.000792	-0.00101
	(0.000937)	(0.000776)	(0.000704)	(0.000618)
Soybeans x Time	0.00573***	0.00436***	0.00487***	0.00307***
	(0.00120)	(0.00118)	(0.000997)	(0.00101)
Wheat x Time	-0.00590***	-0.00873***		
	(0.00119)	(0.00140)		
First Stage F-statistics		163.36		159.32
Observations	124,980	124,980	84,262	84,262
Number of county-crop combinations	6,517	6,517	4,233	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Note that the estimated acreage effect in Table 4 is an average of acreage responses to the premium subsidy across 8,994 county-crop combinations including all seven crops. The acreage responses across different crops may be heterogeneous.[13] Table 5 reports the results with the subsamples. The subsamples with corn, soybeans and wheat only and with corn and

[12]The effect is computed by $(0.039/\textit{Subsidy Rate}) * 30\%$ where *Subsidy Rate* is measured at its overall average, which is 54%.

[13]We also check for the regional heterogeneity. The results are in Appendix B.4.

soybeans only are considered. Column (1) and (2) report the results from the 6,517 county-crop combinations, i.e. combinations of corn, soybeans and wheat and the counties grow at least one of these three. Similarly, Column (3) and (4) report the results from the 4,233 county-crop combinations from the counties that produce at least one of corn and soybeans.

The direction of bias is consistent with the prediction in Section 6 and the results in Table 4. The estimation results from the subsample suggest that corn, soybeans and wheat are more responsive than the other field crops. The estimates for the coefficient of $ln(Subsidy\ per\ Liability)$ from Panel FE-IV estimation are greater than those of Table 4 (Column (2) and (4)).

The short-run own-price elasticities range from 0.18 to 0.20. The own-price elasticities in the recent literature range from 0.17 to 0.45 for corn, from 0.30 to 0.63 for soybeans, and from 0.25 to 0.34 for wheat (Lin and Dismukes 2007; Hendricks, Smith, and Sumner 2014; Miao, Khanna, and Huang 2015). Although there some differences in data and interpretation, our estimates of own-price elasticities in Table 5 are consistent with the recent literature.

7.2 The Interpretation of the Acreage Effect of the Premium Subsidy

The estimated coefficient for $ln(Subsidy\ per\ Liability)_{ijt}$ in Equation (3) indicates how the change in the premium subsidy for a crop in a county affects the planted acreage of the crop in the county since the unit of observation is at the county-crop-year level. The estimated parameter indicates the overall response including an intensive margin response across crops within a given field and an extensive margin response as total crop acreage of counties increases. Also, recall that the estimated effect of the premium subsidy on the crop acreage is the mixture of the coverage effect and the profit effect as Equation (2) describes.

The estimated coefficient of $ln(Subsidy\ per\ Liability)$ in Column (4) of Table 4 indicates that if a policy increases *Subsidy per Liability* by 10% for a crop in a county, then the planted acreage of that crop in that county would be 0.39% greater than otherwise. This also implies if an increase in *Subsidy per Liability* for a crop, for example, corn in a certain county is 10% greater than those for other crops in that county, then an increase in the corn acres in that county would be 0.39% greater than the changes in the planted acres of other crops. Similarly, if a policy increases *Subsidy per Liability* by 10% more for corn in a certain county than some other counties, the planted acreage of corn in the county with the 10% greater increase would have 0.39% greater increase than the other counties. The estimation results from the subsample of crops in Table 5 indicate similar acreage responses to the same changes.

Note that the increase in *Subsidy per Liability* of the competing crop has little statistically significant effect on the planted acreage. A 10% increase in the competing crop premium subsidy results 0.05 - 0.06% reduction in the own-planted acreage. This implies that if a policy changes both the own-subsidy and the subsidy for the competing crop by 10%, the planted acreage would increase by about 0.34 - 0.35%.

For the better understanding on the estimated coefficient of $ln(Subsidy\ per\ Liability)$, we convert the estimate into an estimate that can be directly compared with own-price acreage elasticity. The elasticity representation of the coefficient is

$$\varepsilon_S = \frac{\partial Acreage}{\partial Subsidy\ per\ Liability} \frac{Subsidy\ per\ Liability}{Acreage}$$

which is own-subsidy elasticity and we want to compare with own-price elasticity, ε_P.

From Equation (1),

$$Revenue\ per\ Acre = E(R)(1 + Subsidy\ per\ Liability * \theta)$$

and own-revenue acreage elasticity, ε_R is

$$\varepsilon_R = \frac{\partial Acreage}{\partial Revenue\ per\ Acre} \frac{Revenue\ per\ Acre}{Acreage}.$$

And this own-revenue elasticity is equal to the own-price elasticity, ε_P, if only the price changes and others, including yield, *Subsidy per Liability*, and θ, remain constant.

Now, suppose $E(R)$ and θ are constant and *Subsidy per Liability* varies. The own-revenue elasticity, ε_R, becomes

$$\varepsilon_R = \frac{\partial Acreage}{E(R) * \theta * \partial Subsidy\ per\ Liability} \frac{E(R)(1 + Subsidy\ per\ Liability * \theta)}{Acreage}$$

$$= \frac{\partial Acreage}{\partial Subsidy\ per\ Liability} \frac{(1 + Subsidy\ per\ Liability * \theta)}{\theta * Acreage}$$

$$= \varepsilon_S * \frac{(1 + Subsidy\ per\ Liability * \theta)}{Subsidy\ per\ Liability * \theta}.$$

Thus, the estimated coefficient for $ln(Subsidy\ per\ Liability)_{ijt}$ in Equation (3) times $(1 + Subsidy\ per\ Liability * \theta)/(Subsidy\ per\ Liability * \theta)$ is equal to the own-revenue elasticity ε_R holding other variables constant. We denote the converted own-subsidy elasticity as η_S, which is

$$\eta_S = \varepsilon_S * \frac{(1 + Subsidy\ per\ Liability * \theta)}{Subsidy\ per\ Liability * \theta}.$$

And this is directly comparable with the own-price elasticity, ε_P.

Table 6 compares the own-subsidy elasticity to the own-price elasticity by converting the own-subsidy elasticity into a comparable estimate, η_S. For the conversion, we consider the average crop insurance coverage, θ, and the average *Subsidy per Liability* during the period 2010 - 2014. Column (2) reports the estimates of the converted own-subsidy elasticity. The converted own-subsidy elasticity ranges 1.10 to 1.18. This analogue to the own-price elasticity is substantially greater than the own-price elasticity.

Using the bootstrapped standard errors, we tested whether the converted own-subsidy elasticity is significantly greater than the own-price elasticity. The estimates from Panel FE-IV estimation, both with all crops and with corn and soybeans only, show that the converted own-subsidy elasticity is significantly greater than the own-price elasticity.

Table 6: Comparing the Own-subsidy Elasticity to the Own-price Elasticity

	(1)	(2)	(3)	(4)
	ε_S	η_S	ε_P	η_S-ε_P
All Crops				
Panel FE	0.0131***	0.392***	0.225***	0.167***
	(0.00202)	(0.0657)	(0.0247)	(0.0705)
Panel FE-IV	0.0369***	1.102***	0.215***	0.888***
	(0.00845)	(0.241)	(0.0219)	(0.248)
Corn and Soybeans Only				
Panel FE	0.00906***	0.272***	0.183***	0.0884
	(0.00319)	(0.0990)	(0.0275)	(0.0979)
Panel FE-IV	0.0397***	1.186***	0.203***	0.983***
	(0.0108)	(0.301)	(0.0229)	(0.294)

Note: Cluster robust standard errors are in parentheses. The estimation is done by bootstrapping with 100 repetitions. For the computation of ε_R, *Subsidy per Liability* and θ are bootstrapped from the subsample of 2010-2014 period.
*** 1% significance level, ** 5% significance level, * 10% significance level

The significant difference indicates that crop acreage is more responsive to the premium subsidy than the price for the same amount of revenue change. This relates to the discussions on the coverage effect in Section 2. If an increase in the coverage of crop insurance and the corresponding risk reduction have no effect on crop acreage, the difference between the converted own-subsidy elasticity and the own-price elasticity should be close to zero.

The estimated own-price elasticities in Table 4 and 5 are smaller than the own-price elasticities in the previous studies. For example, the recent study by Hendricks, Smith and Sumner (2014) finds the short-run own-price elasticities of 0.4 and 0.36 for corn and soybean using field-level data whereas the own-price elasticities in Table 4 and 5 are about 0.2. Their price variable includes the loan deficiency payments. Note that given the negative correlation between the crop prices and the government payments, the estimated coefficients for the own-price elasticities in Table 4 and 5 are likely to be smaller.

This suggests further researches including the government payments variables. However, the implication from comparing the converted own-price elasticities to the own-price elasticity remains robust. The converted own-subsidy elasticities from the results of Panel FE with instrumenting $ln(Subsidy\ per\ Liability)$ is still greater than the own-price elasticities of Hendricks, Smith and Sumner (2014).

8 Sensitivity Analysis and Robustness of the Results

The Acreage Reduction Program, which lasted until 1996, may affect the results. For wheat, feed grains, cotton and rice, the Acreage Reduction Program requires farms who participate in federal commodity programs to remain a nationally set portion of the crop acreage base to be idled. Thus, it is necessary to check whether the estimated coefficient of $ln(Subsidy\ per\ Liability)$ is affected by including the policy variable related to the Acreage Reduction Program.

The nationally set portion is crop-specific and changes over time until 1996. We include the annual crop-specific portions for the Acreage Reduction Program, ARP, as an additional control variable to Equation (3). The unit of ARP is percentage. The information for the Acreage Reduction Program is from USDA (ERS 1995a-d). Table 7 shows the results. As expected, the estimated coefficient of ARP is negative and significant. The estimated coefficient of ARP ranges from -0.005 to -0.007 and this indicates a 1% point increase in ARP results a 0.5 - 0.7% decrease in the planted acreage.

Table 7: The Estimated Acreage Effects of the Premium Subsidy with Acreage Reduction Program Variable

VARIABLES	(1) All Crops (FE-IV)	(2) Corn, Soybeans and Wheat (FE-IV)	(3) Corn and Soybeans (FE-IV)
	Dependent Variable: ln(Planted Acres)		
ln(Subsidy per Liability)	0.0229***	0.0257***	0.0258**
	(0.00646)	(0.00741)	(0.0107)
ln(Subsidy per Liability of Competing Crop)	-0.00342*	-0.00403**	-0.00451*
	(0.00182)	(0.00183)	(0.00250)
ln(Expected Price)	0.199***	0.185***	0.191***
	(0.0253)	(0.0251)	(0.0226)
ln(Expected Price of Competing Crop)	-0.0223***	-0.0168***	-0.0315***
	(0.00466)	(0.00440)	(0.00736)
ARP	-0.00497***	-0.00534***	-0.00712***
	(0.000956)	(0.000880)	(0.00204)
L.ln(Planted Acres)	0.714***	0.732***	0.778***
	(0.0274)	(0.0261)	(0.0291)
Corn x Time	-0.00106	-0.00137*	-0.00240***
	(0.000877)	(0.000772)	(0.000575)
Soybeans x Time	0.00602***	0.00549***	0.00397***
	(0.00124)	(0.00115)	(0.000975)
Wheat x Time	-0.00866***	-0.00854***	
	(0.00127)	(0.00138)	
Barley x Time	-0.0147***		
	(0.00213)		
Cotton x Time	-0.00786***		
	(0.00284)		
Rice x Time	-0.00631***		
	(0.00205)		
Sorghum x Time	-0.0120***		
	(0.00268)		
First Stage F-statistics	119.13	163.00	161.93
Observations	159,942	124,980	84,262
Number of county-crop combinations	8,994	6,517	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

The estimated coefficients of $ln(Subsidy\ per\ Liability)$ are smaller than those of Table 4 and 5. Also, note that the standard errors increase with the inclusion of the Acreage Reduction Program variable. We suspect this is due to the high correlation between ARP and the instruments and the possibility of endogenous *ARP*. However, despite of some losses in the statistical significance and the reduction in the point estimate, the results still remain positive and significant and the converted own-subsidy elasticities are still greater than the own-price elasticities.

Table 8: The Estimated Acreage Effects of the Premium Subsidy with Balanced Panel

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
ln(Subsidy per Liability)	0.0552***	0.0522***	0.0498***
	(0.00713)	(0.00952)	(0.0136)
ln(Subsidy per Liability of Competing Crop)	-0.00460***	-0.00439***	-0.00398**
	(0.00144)	(0.00144)	(0.00178)
ln(Expected Price)	0.178***	0.165***	0.155***
	(0.0148)	(0.0169)	(0.0188)
ln(Expected Price of Competing Crop)	-0.0287***	-0.0204***	-0.0387***
	(0.00480)	(0.00486)	(0.00789)
L.ln(Planted Acres)	0.743***	0.746***	0.804***
	(0.0257)	(0.0305)	(0.0261)
Corn x Time	-0.00159***	-0.00149***	-0.00158**
	(0.000475)	(0.000549)	(0.000725)
Soybeans x Time	0.00137	0.00150	0.000742
	(0.000975)	(0.00103)	(0.000982)
Wheat x Time	-0.00895***	-0.00841***	
	(0.00106)	(0.00124)	
Barley x Time	-0.0119***		
	(0.00146)		
Cotton x time	-0.00509**		
	(0.00237)		
Rice x Time	-0.00629***		
	(0.00170)		
Sorghum x Time	-0.00923***		
	(0.00181)		
First Stage F-statistics	292.55	323.42	329.69
Observations	69,423	61,200	46,875
Number of county-crop combinations	2,778	2,448	1,875

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

As discussed in Section 5, the county-crop panel of planted acreage is unbalanced. Some county-crop combinations with small planted acreage are dropped out from the panel. The unbalanced panel can lead to attrition bias if the reason for observations dropping out from the county-crop panel is correlated with the error term (Cameron and Trivedi 2005). For the robustness check, we restricted the sample into the county-crop combinations that have observations for every year.

Table 8 shows the results of the estimations that are equivalent to Table 4 and 5 but only with the restricted sample. The estimated coefficient of $ln(Subsidy\ per\ Liability)$ increases when the sample is restricted to county-crop combinations which span for all 26 years. For all crops or subsample of corn, soybeans, and wheat, the difference indicates that county-crop combinations with greater planted acreage are more responsive to the premium subsidy changes. For the subsample of corn and soybeans, we do not find statistically significant result.

The estimated coefficients for the other variables are close to those of Table 4 and 5. Although restricting sample into balanced panel does not solve the attrition bias completely, Table 8 indicates that the results are not driven by the observations with missing years.

Recall that the Catastrophic risk protection (CAT) is a crop insurance product with a 100% subsidy rate insures 50% of historical yield at 60% of projected price. The last sensitivity analysis is related to the introduction of CAT and the mandatory provision of CAT due to the 1994 act. We estimate the effect of the premium subsidy excluding the CAT premium subsidy. The new premium subsidy variable, $ln(Buy-up\ Subsidy\ per\ Liability)$, only captures the premium subsidy from Buy-up products, which are the products with non-zero farm paid premium.

Table 9 reports the results. The results suggest that acreage is more responsive to the Buy-up premium subsidy. Similar to Table 6, we converted the estimated subsidy elasticity into a comparable estimate with the own-price elasticity by considering the small share of Buy-up premium subsidy in revenue. This analogue to the own-price elasticity is about 4.14 and it is considerably larger than that of Table 6.

Table 9: The Estimated Acreage Effects of the Premium Subsidy Excluding the Catastrophic Risk Protection Premium Subsidy

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
ln(Buy-up Subsidy per Liability)	0.112***	0.107***	0.0929***
	(0.0201)	(0.0234)	(0.0277)
ln(Buy-up Subsidy per Liability of Competing Crop)	-0.00751***	-0.00725***	-0.00790**
	(0.00226)	(0.00253)	(0.00307)
ln(Expected Price)	0.314***	0.304***	0.285***
	(0.0359)	(0.0392)	(0.0415)
ln(Expected Price of Competing Crop)	-0.0145***	-0.0119**	-0.0230***
	(0.00458)	(0.00502)	(0.00831)
L.ln(Planted Acres)	0.670***	0.689***	0.744***
	(0.0276)	(0.0270)	(0.0282)
Corn x Time	-0.00715***	-0.00732***	-0.00628***
	(0.00169)	(0.00181)	(0.00193)
Soybeans x Time	-0.00216	-0.00236	-0.00152
	(0.00183)	(0.00199)	(0.00198)
Wheat x Time	-0.0173***	-0.0158***	
	(0.00215)	(0.00254)	
Barley x Time	-0.0246***		
	(0.00274)		
Cotton x Time	-0.00567**		
	(0.00289)		
Rice x Time	-0.0133***		
	(0.00247)		
Sorghum x Time	-0.0243***		
	(0.00333)		
First Stage F-statistics	142.07	110.43	96.97
Observations	159,942	124,980	84,262
Number of county-crop combinations	8,994	6,517	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

The results of Table 7 and 8 show the robustness of the results. Including the Acreage Reduction Program reduces the estimated coefficient of $ln(Subsidy\ per\ Liability)$ but the implied revenue elasticity still remains significantly greater than the own-price elasticity. The estimated coefficient becomes greater when the sample is restricted to the balanced sample.

Table 9 indicates the greater response to the "Buy-up" subsidy compared to the premium subsidy from Catastrophic protection. Possible explanations are behavioral differences between responses to zero and non-zero farm paid premium, between responses to catastrophic and non-catastrophic losses, or the difference in the premium rate setting between the "Buy-up" and Catastrophic products. Further research is required to analyze the difference in the acreage responses. Appendix B has additional supplementary regression results which support the robustness of our empirical results.[14]

9 Conclusions

The U.S. federal crop insurance program had a significant growth in the last two decades. We estimate the acreage effects of the growth of the crop insurance program and subsidies embedded in the program. The study focuses on the exogenous policy changes that increased the premium subsidy in the U.S. federal crop insurance program.

The study illustrates potential identification issues of estimating the effects of premium subsidies. Exploiting the policy changes that increased the premium subsidy mitigates the endogeneity concerns from the omission of the variables that are related to the riskiness of crops in each county, and the simultaneity across planted acreage, the choice of crop insurance, and the amount of the expected subsidy that farms receive.

The estimates of the overall acreage effect imply that the premium subsidy has a significant effect on crop acreage. We find that the legislative changes with increases in the premium subsidy affected crop acreage significantly. For example, the Federal Crop Insurance Act of 2000 increased *Subsidy per Liability* for corn by about 19% over the time period 1989-2014. The estimated acreage effect indicates that the 19% increase in *Subsidy per Liability* increases the planted acreage by about 0.74%, holding the competing crop subsidy constant. For wheat, the 2000 act only increased *Subsidy per Liability* by about 10% and thus the implied increase in the planted acreage is about 0.39%, also holding the competing crop subsidy constant. The subsidy rate increase clearly has differential effects across crops.

The estimated effect is substantially greater than the estimated effects of Young, Vandeveer, and Schnepf (2001) and Goodwin, Vandeveer, and Deal (2004). The profit effect of the premium subsidy on the crop acreage, which is suggested by the conceptual framework of Yu

[14] All sensitivity analysis specifications in Section 8 and Appendix B have smaller estimated coefficient of *Subsidy per Liability* in Panel FE than Panel FE-IV. This is consistent with the discussion on the endogeneity of *Subsidy per Liability* in Section 6.2.

(2015), explains the larger overall acreage effects compare to the estimates in the literature.

We find the premium subsidy changes have a greater effect on the planted acreage than the price changes considering a small share of the premium subsidy in revenue. This suggests there is an coverage effect which is from the fact that a higher crop insurance coverage induces more planted acreage. This is also supported by the presence of the downward bias in the estimated coefficient of Panel FE without instrumenting *Subsidy per Liability*.

We find the premium subsidy in the U.S. federal crop insurance program induced significant increases in crop acreage. This finding provides parameters for evaluating the incidence of crop insurance premium subsidies in the past and predicting the economic consequences from the newly implemented farm programs of the 2014 Farm Bill.

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Appendix A: Descriptive Statistics by Crop

Table A: Summary Statistics by Crop

	Mean	Mean	Mean
	1989-1993	**2010-2014**	**Overall**
Barley			
Planted Acreage	10,268	11,775	10,918
Avg. Subsidy per Liability	0.016	0.074	0.045
Avg. Share of Revenue Insured	0.080	0.260	0.148
Number of Observations	4,025	940	12,141
Corn			
Planted Acreage	32,826	53,394	40,388
Avg. Subsidy per Liability	0.021	0.077	0.058
Avg. Share of Revenue Insured	0.108	0.468	0.293
Number of Observations	11,369	8,148	51,403
Cotton			
Planted Acreage	24,392	32,352	28,379
Avg. Subsidy per Liability	0.030	0.105	0.075
Avg. Share of Revenue Insured	0.128	0.475	0.338
Number of Observations	2,547	1,601	11,414
Sorghum			
Planted Acreage	12,169	20,267	14,573
Avg. Subsidy per Liability	0.021	0.143	0.076
Avg. Share of Revenue Insured	0.073	0.335	0.176
Number of Observations	4,656	1,169	14,751
Soybeans			
Planted Acreage	34,192	52,161	43,803
Avg. Subsidy per Liability	0.025	0.082	0.064
Avg. Share of Revenue Insured	0.105	0.481	0.315
Number of Observations	8,672	7,167	41,126
Rice			
Planted Acreage	25,880	38,698	31,034
Avg. Subsidy per Liability	0.008	0.038	0.028
Avg. Share of Revenue Insured	0.130	0.516	0.317
Number of Observations	561	331	2,480
Wheat			
Planted Acreage	32,649	36,029	34,549
Avg. Subsidy per Liability	0.018	0.100	0.063
Avg. Share of Revenue Insured	0.090	0.433	0.227
Number of Observations	11,230	6,464	45,865

Appendix B: Supplementary Regression Results for Sensitivity Analysis

B.1: Using an Alternative Specification on the Expected Price Estimation

Table B1.1: Biased and Consistent Estimates for the Effect of the Premium Subsidy on Crop Acreage (Table 4)

	(1)	(2)	(3)	(4)
	(FE)	(FE-IV)	(FE)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)			
ln(Subsidy per Liability)	0.0130***	0.0292***	0.0132***	0.0343***
	(0.00211)	(0.00525)	(0.00212)	(0.00662)
ln(Subsidy per Liability of Competing Crop			-0.000311	-0.00445**
			(0.00123)	(0.00196)
ln(Expected Price)	0.171***	0.183***	0.187***	0.201***
	(0.0301)	(0.0246)	(0.0308)	(0.0242)
ln(Expected Price of Competing Crop)			-0.0202***	-0.0201***
			(0.00532)	(0.00490)
L.ln(Planted Acres)	0.707***	0.705***	0.707***	0.703***
	(0.0282)	(0.0275)	(0.0281)	(0.0273)
Corn x Time	0.000363	-0.000868	0.000591	-0.000577
	(0.00103)	(0.000874)	(0.00107)	(0.000890)
Soybeans x Time	0.00490***	0.00368***	0.00499***	0.00379***
	(0.00141)	(0.00126)	(0.00143)	(0.00127)
Wheat x Time	-0.00675***	-0.00856***	-0.00686***	-0.00883***
	(0.00121)	(0.00129)	(0.00121)	(0.00128)
Barley x Time	-0.0145***	-0.0161***	-0.0143***	-0.0161***
	(0.00212)	(0.00209)	(0.00217)	(0.00213)
Cotton x Time	-0.00471	-0.00569**	-0.00425	-0.00507*
	(0.00282)	(0.00270)	(0.00288)	(0.00275)
Rice x Time	-0.00511**	-0.00638***	-0.00485**	-0.00615***
	(0.00211)	(0.00210)	(0.00221)	(0.00216)
Sorghum x Time	-0.0125***	-0.0142***	-0.0124***	-0.0144***
	(0.00287)	(0.00262)	(0.00289)	(0.00261)
First Stage F-statistics		122.57		120.70
Observations	160,014	160,014	159,942	159,942
Number of county-crop combinations	8,994	8,994	8,994	8,994

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

We consider the case when the state-level basis for the expected price changes after 2006. Carter, Rausser, and Smith (2016) estimate about 30% increase in the corn price from 2006 to 2014 due to the increase in the demand for corn caused by biofuel policies. It is possible that the state-level basis would have changed as well. The results remain robust with this alternative specification of the expected price (Table B1.1 - B1.5).

Table B1.2: The Estimated Acreage Effects of the Premium Subsidy with the Subsample of Crops (Table 5)

	(1)	(2)	(3)	(4)
	Corn, Soybeans and Wheat		Corn and Soybeans	
	(FE)	(FE-IV)	(FE)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)			
ln(Subsidy per Liability)	0.0110***	0.0353***	0.00842**	0.0231**
	(0.00278)	(0.00851)	(0.00346)	(0.00968)
ln(Subsidy per Liability of Competing Crop)	-0.000772	-0.00517**	-0.00156	-0.00463*
	(0.00128)	(0.00202)	(0.00155)	(0.00257)
ln(Expected Price)	0.178***	0.200***	0.120***	0.169***
	(0.0337)	(0.0255)	(0.0351)	(0.0265)
ln(Expected Price of Competing Crop)	-0.0161***	-0.0166***	-0.00928	-0.0131**
	(0.00483)	(0.00437)	(0.00640)	(0.00579)
L.ln(Planted Acres)	0.724***	0.721***	0.778***	0.771***
	(0.0271)	(0.0262)	(0.0303)	(0.0292)
Corn x Time	0.000650	-0.000797	0.000760	-0.000540
	(0.000989)	(0.000811)	(0.000760)	(0.000618)
Soybeans x Time	0.00487***	0.00333***	0.00436***	0.00328***
	(0.00127)	(0.00120)	(0.000972)	(0.000944)
Wheat x Time	-0.00616***	-0.00844***		
	(0.00121)	(0.00142)		
First Stage F-statistics		165.74		162.24
Observations	124,980	124,980	84,262	84,262
Number of county-crop combinations	6,517	6,517	4,233	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table B1.3: The Estimated Acreage Effects of the Premium Subsidy with Acreage Reduction Program Variable (Table 7)

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
ln(Subsidy per Liability)	0.0169***	0.0197***	0.00865
	(0.00588)	(0.00712)	(0.00968)
ln(Subsidy per Liability of Competing Crop)	-0.00269	-0.00358**	-0.00291
	(0.00178)	(0.00180)	(0.00237)
ln(Expected Price)	0.185***	0.182***	0.165***
	(0.0251)	(0.0268)	(0.0268)
ln(Expected Price of Competing Crop)	-0.0156***	-0.0133***	-0.0130**
	(0.00461)	(0.00431)	(0.00569)
ARP	-0.00584***	-0.00645***	-0.00874***
	(0.000915)	(0.000870)	(0.00206)
L.ln(Planted Acres)	0.707***	0.728***	0.776***
	(0.0274)	(0.0261)	(0.0291)
Corn x Time	-0.00133	-0.00180**	-0.00242***
	(0.000918)	(0.000829)	(0.000578)
Soybeans x Time	0.00525***	0.00466***	0.00412***
	(0.00129)	(0.00118)	(0.000918)
Wheat x Time	-0.00866***	-0.00858***	
	(0.00126)	(0.00141)	
Barley x Time	-0.0155***		
	(0.00214)		
Cotton x Time	-0.00747***		
	(0.00284)		
Rice x Time	-0.00730***		
	(0.00201)		
Sorghum x Time	-0.0132***		
	(0.00260)		
First Stage F-statistics	118.75	165.82	163.36
Observations	159,942	124,980	84,262
Number of county-crop combinations	8,994	6,517	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table B1.4: The Estimated Acreage Effects of the Premium Subsidy with Balanced Panel (Table 8)

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
ln(Subsidy per Liability)	0.0485***	0.0427***	0.0256**
	(0.00724)	(0.00949)	(0.0117)
ln(Subsidy per Liability of Competing Crop)	-0.00484***	-0.00451***	-0.00213
	(0.00133)	(0.00137)	(0.00154)
ln(Expected Price)	0.175***	0.157***	0.0956***
	(0.0183)	(0.0217)	(0.0229)
ln(Expected Price of Competing Crop)	-0.0202***	-0.0111**	-0.00651
	(0.00505)	(0.00510)	(0.0111)
L.ln(Planted Acres)	0.734***	0.743***	0.796***
	(0.0261)	(0.0303)	(0.0257)
Corn x Time	-0.00140***	-0.00119**	-0.000607
	(0.000506)	(0.000581)	(0.000647)
Soybeans x Time	0.00147	0.00168*	0.00178**
	(0.000974)	(0.000993)	(0.000896)
Wheat x Time	-0.00816***	-0.00732***	
	(0.00116)	(0.00138)	
Barley x Time	-0.0117***		
	(0.00145)		
Cotton x Time	-0.00560**		
	(0.00237)		
Rice x Time	-0.00607***		
	(0.00164)		
Sorghum x Time	-0.00962***		
	(0.00186)		
First Stage F-statistics	279.97	306.58	310.76
Observations	69,423	61,200	46,875
Number of county-crop combinations	2,778	2,448	1,875

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table B1.5: The Estimated Acreage Effects
of the Premium Subsidy Excluding the Catastrophic Risk Protection Premium Subsidy (Table 9)

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
ln(Buy-up Subsidy per Liability)	0.0748***	0.0662***	0.0237
	(0.0191)	(0.0209)	(0.0226)
ln(Buy-up Subsidy per Liability of Competing Crop)	-0.00514***	-0.00446**	-0.00240
	(0.00196)	(0.00215)	(0.00240)
ln(Expected Price)	0.260***	0.255***	0.183***
	(0.0352)	(0.0390)	(0.0397)
ln(Expected Price of Competing Crop)	-0.0128***	-0.0111**	-0.0132**
	(0.00427)	(0.00459)	(0.00610)
L.ln(Planted Acres)	0.685***	0.695***	0.754***
	(0.0276)	(0.0267)	(0.0274)
Corn x Time	-0.00514***	-0.00495***	-0.00148
	(0.00168)	(0.00174)	(0.00171)
Soybeans x Time	-0.00109	-0.000671	0.00253
	(0.00200)	(0.00208)	(0.00193)
Wheat x Time	-0.0136***	-0.0117***	
	(0.00223)	(0.00244)	
Barley x Time	-0.0213***		
	(0.00282)		
Cotton x Time	-0.00513*		
	(0.00284)		
Rice x Time	-0.0105***		
	(0.00246)		
Sorghum x Time	-0.0220***		
	(0.00350)		
First Stage F-statistics	150.02	123.33	126.49
Observations	159,942	124,980	84,262
Number of county-crop combinations	8,994	6,517	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

B.2: Functional Form Change: Log-Linear Model

We reproduced Table 4, 5, 7, 8, and 9 with log-linear models instead of log-log models. Instead of *ln*(*Subsidy per Liability*) and *ln*(*Subsidy per Liability of Competing Crop*), *Subsidy per Liability* and *Subsidy per Liability of Competing Crop* are included as explanatory variables. This allows us to check whether the results are sensitive to functional forms and whether adding 0.0001 to the zero values for logarithmic transformation is problematic.

Table B2.1 - B2.5 are parallel to Table 4, 5, 7, 8, and 9. The results remain robust. The estimated coefficient of *Subsidy per Liability* in Column (4) of Table B2.1 is equivalent to the subsidy elasticity of 0.0973 at the overall mean of *Subsidy per Liability*, which is about 0.062. Recall that the estimated subsidy elasticity in Table 4, which is the estimated coefficient of *ln*(*Subsidy per Liability*), is 0.0391.

Table B2.1: The Estimated Acreage Effects of the Premium Subsidy (Table 4 with *Subsidy per Liability*)

	(1)	(2)	(3)	(4)
	FE	FE-IV	FE	FE-IV
VARIABLES	Dependent Variable: ln(Planted Acres)			
Subsidy per Liability	0.151	1.251***	0.111	1.570***
	(0.112)	(0.195)	(0.120)	(0.266)
Subsidy per Liability of Competing Crop			0.130*	-0.341***
			(0.0645)	(0.118)
ln(Expected Price)	0.193***	0.190***	0.215***	0.214***
	(0.0296)	(0.0247)	(0.0290)	(0.0231)
ln(Expected Price of Competing Crop)			-0.0279***	-0.0274***
			(0.00516)	(0.00585)
L.ln(Planted Acres)	0.710***	0.714***	0.709***	0.713***
	(0.0282)	(0.0272)	(0.0281)	(0.0274)
Corn x Time	0.00108	-0.00174**	0.00102	-0.00132
	(0.000962)	(0.000857)	(0.000946)	(0.000871)
Soybeans x Time	0.00628***	0.00356***	0.00617***	0.00374***
	(0.00133)	(0.00114)	(0.00132)	(0.00113)
Wheat x Time	-0.00568***	-0.0102***	-0.00607***	-0.0106***
	(0.00127)	(0.00160)	(0.00125)	(0.00164)
Barley x Time	-0.0132***	-0.0156***	-0.0134***	-0.0152***
	(0.00213)	(0.00226)	(0.00223)	(0.00231)
Cotton x Time	-0.00352	-0.00815***	-0.00341	-0.00695***
	(0.00299)	(0.00266)	(0.00301)	(0.00262)
Rice x Time	-0.00385*	-0.00535***	-0.00404*	-0.00399*
	(0.00201)	(0.00201)	(0.00229)	(0.00228)
Sorghum x Time	-0.0115***	-0.0173***	-0.0119***	-0.0176***
	(0.00300)	(0.00274)	(0.00303)	(0.00272)
First Stage F-statistics		118.90		72.18
Observations	160,014	160,014	159,942	159,942
Number of county-crop combinations	8,994	8,994	8,994	8,994

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table B2.2: The Estimated Acreage Effects of the Premium Subsidy with the Subsample of Crops (Table 5 with *Subsidy per Liability*)

	(1)	(2)	(3)	(4)
	Corn, Soybeans and Wheat		Corn and Soybeans	
	(FE)	(FE-IV)	(FE)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)			
Subsidy per Liability	0.0315	1.583***	-0.00771	1.387***
	(0.126)	(0.317)	(0.138)	(0.322)
Subsidy per Liability of Competing Crop	0.156**	-0.335***	0.0763	-0.468***
	(0.0638)	(0.104)	(0.0857)	(0.116)
ln(Expected Price)	0.198***	0.202***	0.171***	0.209***
	(0.0306)	(0.0228)	(0.0282)	(0.0224)
ln(Expected Price of Competing Crop)	-0.0222***	-0.0220***	-0.0327***	-0.0388***
	(0.00492)	(0.00499)	(0.00793)	(0.00763)
L.ln(Planted Acres)	0.726***	0.733***	0.779***	0.781***
	(0.0272)	(0.0258)	(0.0303)	(0.0285)
Corn x Time	0.00102	-0.00150*	0.00120*	-0.000992
	(0.000860)	(0.000822)	(0.000637)	(0.000717)
Soybeans x Time	0.00596***	0.00321***	0.00530***	0.00287***
	(0.00120)	(0.00114)	(0.00105)	(0.00102)
Wheat x Time	-0.00539***	-0.0102***		
	(0.00129)	(0.00167)		
First Stage F-statistics		125.42		78.53
Observations	124,980	124,980	84,262	84,262
Number of county-crop combinations	6,517	6,517	4,233	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table B2.3: The Estimated Acreage Effects of the Premium Subsidy with Acreage Reduction Program Variable (Table 7 with *Subsidy per Liability*)

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
Subsidy per Liability	0.897***	0.912***	0.867***
	(0.209)	(0.243)	(0.314)
Subsidy per Liability of Competing Crop	-0.158*	-0.142*	-0.293**
	(0.0882)	(0.0778)	(0.115)
ln(Expected Price)	0.200***	0.185***	0.195***
	(0.0248)	(0.0245)	(0.0228)
ln(Expected Price of Competing Crop)	-0.0230***	-0.0179***	-0.0354***
	(0.00494)	(0.00444)	(0.00724)
ARP	-0.00509***	-0.00580***	-0.00740***
	(0.000925)	(0.000906)	(0.00207)
L.ln(Planted Acres)	0.716***	0.737***	0.783***
	(0.0276)	(0.0262)	(0.0292)
Corn x Time	-0.00173**	-0.00212***	-0.00252***
	(0.000848)	(0.000795)	(0.000648)
Soybeans x Time	0.00531***	0.00478***	0.00383***
	(0.00118)	(0.00114)	(0.000986)
Wheat x Time	-0.00971***	-0.00956***	
	(0.00146)	(0.00154)	
Barley x Time	-0.0149***		
	(0.00224)		
Cotton x Time	-0.00864***		
	(0.00279)		
Rice x Time	-0.00582***		
	(0.00209)		
Sorghum x Time	-0.0148***		
	(0.00272)		
First Stage F-statistics	70.89	126.31	79.49
Observations	159,942	124,980	84,262
Number of county-crop combinations	8,994	6,517	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table B2.4: The Estimated Acreage Effects of the Premium Subsidy with Balanced Panel (Table 8 with *Subsidy per Liability*)

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
Subsidy per Liability	2.056***	1.941***	1.590***
	(0.323)	(0.365)	(0.466)
Subsidy per Liability of Competing Crop	-0.389***	-0.414***	-0.417***
	(0.136)	(0.121)	(0.149)
ln(Expected Price)	0.187***	0.171***	0.159***
	(0.0157)	(0.0180)	(0.0195)
ln(Expected Price of Competing Crop)	-0.0275***	-0.0192***	-0.0442***
	(0.00723)	(0.00666)	(0.00867)
L.ln(Planted Acres)	0.737***	0.744***	0.803***
	(0.0242)	(0.0283)	(0.0240)
Corn x Time	-0.00246***	-0.00222***	-0.00154*
	(0.000569)	(0.000672)	(0.000793)
Soybeans x Time	0.000759	0.000935	0.000860
	(0.000857)	(0.000933)	(0.000927)
Wheat x Time	-0.0106***	-0.00985***	
	(0.00145)	(0.00162)	
Barley x Time	-0.0117***		
	(0.00193)		
Cotton x Time	-0.00688***		
	(0.00217)		
Rice x Time	-0.00400**		
	(0.00191)		
Sorghum x Time	-0.0147***		
	(0.00254)		
First Stage F-statistics	90.95	87.91	68.84
Observations	69,423	61,200	46,875
Number of county-crop combinations	2,778	2,448	1,875

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

Table B2.5: The Estimated Acreage Effects of the Premium Subsidy Excluding the Catastrophic Risk Protection Premium Subsidy (Table 9 with *Subsidy per Liability*)

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
Buy-up Subsidy per Liability	2.681***	2.668***	1.987***
	(0.411)	(0.510)	(0.575)
Buy-up Subsidy per Liability of Competing Crop	-0.00268*	-0.00442	-0.0118***
	(0.00142)	(0.00296)	(0.00258)
ln(Expected Price)	0.306***	0.300***	0.269***
	(0.0280)	(0.0306)	(0.0337)
ln(Expected Price of Competing Crop	-0.0249***	-0.0205***	-0.0372***
	(0.00599)	(0.00508)	(0.00785)
L.ln(Planted Acres)	0.696***	0.708***	0.762***
	(0.0269)	(0.0247)	(0.0269)
Corn x Time	-0.00726***	-0.00763***	-0.00533***
	(0.00132)	(0.00155)	(0.00169)
Soybeans x Time	-0.00264*	-0.00298	-0.00110
	(0.00157)	(0.00186)	(0.00188)
Wheat x Time	-0.0166***	-0.0160***	
	(0.00222)	(0.00249)	
Barley x Time	-0.0217***		
	(0.00273)		
Cotton x Time	-0.00816***		
	(0.00271)		
Rice x Time	-0.00721***		
	(0.00198)		
Sorghum x Time	-0.0311***		
	(0.00332)		
First Stage F-statistics	103.91	230.33	173.61
Observations	159,942	124,980	84,262
Number of county-crop combinations	8,994	6,517	4,233

Note: Cluster robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

B.3: Arellano-Bond Estimator

Table B3: The Estimated Acreage Effects of the Premium Subsidy with Arellano-Bond Estimator (Column (4) of Table 4 and Column (2) and (4) of Table 5)

	(1)	(2)	(3)
	All Crops	Corn, Soybeans and Wheat	Corn and Soybeans
	(FE-IV)	(FE-IV)	(FE-IV)
VARIABLES	Dependent Variable: ln(Planted Acres)		
ln(Subsidy per Liability)	0.0201***	0.0161***	0.0124***
	(0.00266)	(0.00268)	(0.00359)
ln(Subsidy per Liability of	-0.000389	-0.00226***	-0.000519
Competing Crop)	(0.000810)	(0.000824)	(0.000983)
ln(Expected Price)	0.274***	0.280***	0.209***
	(0.00779)	(0.00858)	(0.00946)
ln(Expected Price of -0.0371***	-0.0266***	-0.0497***	
Competing Crop)	(0.00374)	(0.00376)	(0.00551)
L.ln(Planted Acres)	0.237***	0.212***	0.256***
	(0.0121)	(0.0124)	(0.0183)
Corn x Time	-0.000674	0.00193***	0.00148**
	(0.000721)	(0.000717)	(0.000707)
Soybeans x Time	0.00764***	0.0101***	0.00852***
	(0.000939)	(0.000918)	(0.000846)
Wheat x Time	-0.0262***	-0.0249***	
	(0.00102)	(0.00102)	
Barley x Time	-0.0398***		
	(0.00235)		
Cotton x Time	-0.00124		
	(0.00240)		
Rice x Time	-0.00783**		
	(0.00307)		
Sorghum x Time	-0.0434***		
	(0.00269)		
Observations	146,668	115,354	78,195
Number of county-crop combinations	8,923	6,473	4,208

Note: Robust standard errors are in parentheses.
*** 1% significance level, ** 5% significance level, * 10% significance level

We use the Arellano-Bond Estimator to show that the endogeneity of the lagged dependent variable in the fixed effect model is not problematic (Arellano and Bond 1991). The moment conditions are

$$E(ln(PlantedAcres)_{ijs} * u_{ijs}) = 0 \;\vee\; s < t - 1,$$

$$E(ln(Subsidy\ per\ Liability)_{ijs} * u_{ijs}) = 0 \ \vee \ s < t-1,$$

$$E(Z_{ijt} * u_{ijs}) = 0$$

where Z is the vector of instruments. Table B3 shows the robust results.

B.4: Regional Heterogeneity

We also check for geographic abnormal heterogeneity. We divide our sample into 5 geographic regions. The classification of the states is listed in Table B4. The estimated coefficients of $ln(Subsidy\ per\ Liability)$ remain robust. The results tentatively suggest the regional heterogeneous responses to the policy changes (Table B4).

Table B4: The Estimated Acreage Effects of the Premium Subsidy (by Region)

	(1)	(2)	(3)	(4)	(5)
	Eastern	North Central	Central and Northern Plains	Delta and Southern Plains	Far Western
VARIABLES		Dependent Variable: ln(Planted Acres)			
ln(Subsidy per Liability)	0.00697**	0.0542***	0.0863***	0.0248***	0.0224***
	(0.00275)	(0.00414)	(0.0118)	(0.00696)	(0.00792)
ln(Subsidy per Liability of Competing Crop)	0.000466	-0.00336**	-0.00357	0.00165	-0.00103
	(0.00111)	(0.00132)	(0.00305)	(0.00232)	(0.00328)
ln(Expected Price)	0.316***	0.152***	0.149***	0.381***	0.313***
	(0.0107)	(0.00681)	(0.0120)	(0.0146)	(0.0361)
ln(Expected Price of Competing Crop)	-0.0228***	-0.0381***	-0.0441***	-0.0118**	-0.0594*
	(0.00454)	(0.00721)	(0.00736)	(0.00473)	(0.0327)
L.ln(Planted Acres)	0.675***	0.700***	0.776***	0.578***	0.602***
	(0.00708)	(0.0107)	(0.00997)	(0.0118)	(0.0212)
Corn x Time	-0.00476***	-0.00149***	0.00182**	0.00631***	0.00691***
	(0.000430)	(0.000261)	(0.000837)	(0.00151)	(0.00244)
Soybeans x Time	0.00617***	0.000819**	0.00766***	-0.00347***	
	(0.000494)	(0.000334)	(0.00108)	(0.00102)	
Wheat x Time	-0.00215***	-0.0123***	-0.0118***	-0.00985***	-0.0123***
	(0.000610)	(0.000750)	(0.000992)	(0.000926)	(0.00147)
Barley x Time	-0.00504***	-0.0299***	-0.0153***	-0.0958***	-0.0207***
	(0.00125)	(0.00227)	(0.00108)	(0.0179)	(0.00178)
Cotton x Time	0.00550***	-0.000127	-0.0348	-0.00513***	-0.0271***
	(0.00106)	(0.00435)	(0.0281)	(0.00123)	(0.00604)
Rice x Time		0.0190**		-0.00949***	-0.00396*
		(0.00836)		(0.00151)	(0.00214)
Sorghum x Time	-0.00195	-0.0353***	-0.0164***	-0.0122***	0.0750*
	(0.00404)	(0.00254)	(0.00149)	(0.00141)	(0.0385)
First Stage F-statistics	671.13	712.42	236.41	302.04	102.13
Observations	46,904	46,132	30,805	28,273	7,828
Number of county-crop combinations	2,833	2,275	1,648	1,743	495

Note: Cluster robust standard errors are in parentheses (Clustered at the county level). Eastern states are AL, DE, FL, GA, KY, MD, NJ, NY, NC, PA, SC, TN, VA, and WV. North Central states are IL, IN, IA, MI, MN, MO, OH, and WI. Central and Northern Plains states are CO, KS, MT, NE, ND, SD, and WY. Delta and Southern Plains states are AR, LA, MS, NM, OK, and TX. Far Western states are AZ, CA, ID, NV, OR, UT, and WA.
*** 1% significance level, ** 5% significance level, * 10% significance level

B.5: Crop Specific Instruments

In addition to the crop specific time trend variables, we also consider interaction terms between crop specific dummies, and *Subsidy Rate* 65% and *Subsidy Rate* 75% as our instruments. Thus, we have 14 instruments instead of two instruments (Table B5). The results remain robust.

Table B5: The Estimated Acreage Effects of the Premium Subsidy with Crop Specific Instruments (Column (4) of Table 4)

VARIABLES	(1) (FE-IV) Dependent Variable: ln(Planted Acres)
ln(Subsidy per Liability)	0.0294***
	(0.00430)
ln(Subsidy per Liability of Competing Crop)	-0.00433***
	(0.00161)
ln(Expected Price)	0.233***
	(0.00950)
ln(Expected Price of Competing Crop)	-0.0269***
	(0.00315)
L.ln(Planted Acres)	0.711***
	(0.0177)
Corn x Time	-0.000396
	(0.000722)
Soybeans x Time	0.00453***
	(0.00101)
Wheat x Time	-0.00819***
	(0.000960)
Barley x Time	-0.0131***
	(0.00162)
Cotton x Time	-0.00488***
	(0.00101)
Rice x Time	-0.00399***
	(0.00141)
Sorghum x Time	-0.0133***
	(0.00193)
First Stage F-statistics	105.70
Observations	159,942
Number of county-crop combinations	8,994

Note: Cluster robust standard errors in parentheses
*** 1% significance level, ** 5% significance level, * 10% significance level