The SURE Program: An Investigation of Moral Hazard Opportunities and Adverse Selection Effects

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The Supplemental Revenue Assistance Payments (SURE) program, introduced in the 2008 Farm Bill, provides disaster aid payments to producers in counties eligible for disaster payments and individual producers with crop production losses that exceed 50% of their expected yields. We show that the program's "rules of the game" create moral hazard and adverse selection incentives. Then, we empirically analyze possible moral hazard and adverse selection behavior in response to the SURE program by corn, soybean, and wheat producers. Results suggest that recent increases in crop insurance participation may be due to increased moral hazard and adverse selection incentives.

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1 Introduction

In the United States, federally subsidized multiple peril crop yield and revenue insurance products have consistently been shown to cause adverse selection and moral hazard behavior by agricultural producers (see for example Goodwin 1993, Smith and Goodwin 1996, Smith and Baquet 1996, Just, Calvin, and Quiggin 1999, Babcock and Hennessy 1996, Goodwin and Smith 2003).[1] A partial saving grace has been the use of deductibles, which are incorporated in property, casualty, and other insurance contracts as a means of mitigating moral hazard by requiring the insured to share a portion of loss burdens (Borch 1989). In agricultural insurance contracts, deductibles serve the same role (Chambers 1989).

Deductibles, however, may also contribute to lower participation in federal crop insurance programs. For example, no more than 50% of eligible acres were enrolled in subsidized federal crop insurance programs during the 1990s. The 2000 Agricultural Risk Protection Act (ARPA) was intended to raise participation by increasing federal crop insurance subsidies to 50-60% of actuarially-fair premiums. Moreover, maximum coverage levels for crop losses in some areas were raised from 75% to 85%, substantially reducing deductibles. Despite an increase in program participation to nearly 80% of eligible acres, the U.S. Congress remained concerned about participation as well as persistent demands for ad-hoc disaster aid from the agricultural sector. As a result, the 2008 Farm Bill established a suite of five permanent or standing disaster programs and in three of these programs, producers were required to purchase a crop insurance

[1] Moral hazard behaviors consist of actions taken by the insured that cannot readily be observed by the insurers and that increase the likelihood and size of indemnity payments. Adverse selection is the creation of a pool of insured individuals who largely have high risks of incurring losses and the pool does not include individuals with relatively low risks of incurring losses.

product to be eligible for disaster program benefits.[2]

The Supplemental Agricultural Disaster Assistance (SURE) program is the permanent crop disaster program established by the 2008 Farm Bill. In an effort to increase federally subsidized crop insurance participation, the U.S. Congress required that producers obtain federal crop insurance coverage to become eligible for the SURE program, and SURE payments were linked to the crop insurance coverage purchased by producers. Smith and Watts (2010) show that SURE's insurance participation requirements and associated payment schedule structures can exacerbate moral hazard incentives, because SURE further diminishes the effectiveness of deductibles embedded in crop insurance products. Consequently, the SURE program can increase adverse selection incentives for producers who are more likely to benefit from SURE disaster payments.

The SURE program may already have led to several unexpected consequences. At the time of the 2008 Farm Bill, the Congressional Budget Office (CBO) estimated that the SURE program would have an annual cost of $425 million. In March 2010, the CBO revised its estimate to $714 million. Most recently, the CBO has re-scored the program at an annual average cost of $1.6 billion for the period 2012-2021. However, actual 2008 SURE program outlays were $2.107 billion, of which $814 million were paid under the Recovery Act of 2008.[3] In addition to exceeding CBO estimates, total expenditures associated with the 2008 permanent disaster programs were more than $1 billion higher than average annual outlays on ad hoc disaster payments between 1998 and 2007 ($1.14 billion).

This study examines the extent to which the SURE program affects moral hazard oppor-

[2] The 2008 Farm Bill created five standing disaster programs: the Supplemental Revenue Assistance Payments Program, Livestock Indemnity Payments program (LIP), Livestock Forage Disaster program (LFP), Emergency Assistance for Livestock, Honey Bees and Farm Raised Fish program (ELAP), and Orchard and Nursery Tree Assistance Program (TAP). To be eligible for SURE, LFP and ELAP payments, producers are required to have purchased federally subsidized agricultural insurance and/or NAP coverage for their crops and/or forages.

[3] In addition to the 2008 expenditures in the SURE program, over $188 million in outlays were associated with payments made from other major permanent disaster programs introduced in the 2008 Farm Bill (LIP and LFP).

tunities and incentives for adverse selection into crop insurance. We begin by describing the structure of the SURE program and show that in most years, many producers can expect to be in counties that are declared to be "disaster eligible" for SURE payments. A stylized theoretical model of the SURE program's effects on farm-level crop insurance and production decisions is then presented. The model indicates that the SURE program has the potential to increase moral hazard behaviors by many producers and affect adverse selection incentives for crop insurance participation. Next, econometric estimates of the SURE program's effects on crop insurance participation are presented. The empirical analysis uses county-level data that includes USDA Risk Management Agency (RMA) information on crop insurance participation and premium rates, Census of Agricultural statistics on farm and farmer characteristics, and USDA National Agricultural Statistical Service time series county yield data. The results indicate that the SURE program has had substantial impacts on crop insurance participation in counties where moral hazard and adverse selection related incentives for participation are most likely to exist.

2 The SURE Program

The Supplemental Revenue Assistance Payment (SURE) program was established in section 12033 of the Food Conservation and Energy Act (2008 Farm Bill) with a stated intent of protecting producers from unsystematic weather-related events that could result in large production losses for some farms. The SURE program, however, applies to all farms within counties declared to be natural disaster areas by the Secretary of Agriculture and all adjacent counties. Farms in those counties are eligible to receive SURE indemnity payments if they experience "at least a 10 percent production loss affecting one crop of economic significance" (FSA Fact Sheet, 2011), although the "economically significant" crop may contribute as little "5 percent of the expected revenue for a producer's farm" (*Ibid.*). SURE disaster aid payments are also available to producers who experience production losses that result in at least a 50%

reduction in total normal farm production, which includes "all crop acreage in all counties that a producer planted or intended to plant for harvest for normal commercial sale or farm livestock feeding" (*Ibid.*).[4]

The SURE program directly links producers' crop insurance decisions to their eligibility for SURE payments and the potential size of those payments. First, each "economically significant" crop on a farm must be insured using a federally subsidized crop insurance policy or the Noninsured Crop Disaster Assistance Program (NAP).[5] Second, a farm's SURE "revenue guarantee" and "revenue to count" determine whether a SURE payment will be made and the payment amount.

A farm participating in a subsidized federal crop insurance program through a yield insurance policy chooses a yield trigger between 50% and 75% or 85% of the actual production history (APH) average yield for the crop, which is established by the USDA Risk Management Agency (RMA).[6] If the farm's per acre average yield for an insured crop falls below a trigger level, then it receives indemnities for the losses. For a farm producing one crop, the amount of the indemnity (CI) is represented by the equation:

$$CI = \begin{cases} pa(c\hat{\mu} - q), & \text{if } q < c\hat{\mu} \\ 0, & \text{otherwise} \end{cases}, \tag{1}$$

where a denotes the planted area (number of acres); q is realized per acre yield; c denotes the

[4]The 2008 Farm Bill provides SURE disaster payments to farms experiencing qualifying production losses. The Farm Service Agency has interpreted "production losses" to mean reductions in expected revenues (Barnaby 2010).

[5]NAP coverage is offered and managed by the USDA Farm Service Agency. The program provides limited coverage for substantial yield losses (those exceeding 50% of expected yields) for any crop or forage that is not covered by the Federal Crop Insurance Corporation.

[6]Coverage levels were defined in 5% increments for APH contracts until 2011. In areas that are more risky (typically areas more prone to drought), producers are restricted to coverage levels of 75% or less; in less risky areas (and often for irrigated crops) where smaller deductibles are viewed as reasonable, producers have the option to choose up to 85% coverage levels.

farm's coverage level election for the crop; p is the price at which indemnifiable losses for the crop are valued; and, $\hat{\mu}$ represents the crop's per acre APH yield.[7] In the insurance policy, $\hat{\mu}$ is used as the RMA estimate of the crop's true expected yield, μ.[8]

A farm's SURE program revenue guarantee is defined as 115% of the sum of its crop insurance and NAP liabilities (maximum indemnities) for each crop. The revenue guarantee (*RG*) is determined by a crop's per acre actual production history (APH) yields and the producer's decisions about the insurance coverage level and price election. For a single crop farm the *RG* is defined as:

$$RG = (1+\delta)cpa\hat{\mu} \ , \tag{2}$$

where δ represents a legislatively determined 15% adjustment factor ($\delta = 0.15$). The non-zero adjustment factor implies that the SURE program increases opportunities for producers to receive indemnities beyond those received from subsidized insurance policies, because the farm's revenue guarantee is 115% of total liabilities from each insured (or NAP insured) crop. The 15% adjustment effectively reduces the crop insurance deductible (Smith and Watts 2010).[9]

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[7] Price elections range between 30% and 100%, although most producers choose the maximum price election available because subsidy rates are tied to yield coverage levels but not price elections.

[8] The RMA determines the APH using a farm's crop's yield records over the most recent 4 to 10 years and calculates a farm's actual production history (APH) yield as the average of these yields. The period length depends on the number of years in which recent yield information was provided by the farm. A 1998 data set published by the RMA (the most recent data set available) reports the number of years used to determine APH for buy up contracts across various crops. On average, contracts for corn used the most recent 7.48 years of yield data to calculate APH; barley used 6.85 years; cotton used 7.76 years; soybeans used 7.26 years; and wheat used 7.43 years. It should be noted that if a farm has less than four years of records, the farm's APH is based in part (or whole) on transitional yields established by the RMA for the county (or in some cases, a sub-county area) in which the farm is located.

[9] If a farm's per acre revenue guarantee estimated using equation (2) exceeds 90% of its per acre expected market revenues (the APH yield multiplied by the insurance price), then the guarantee is capped at 90% of the expected revenue. A more general form of equation (2) is $RG = ap\hat{\mu}[Min\{(1+\delta)c, 0.9\}]$. However, when $c \leq 75\%$ – the case for most producers – then *RG* reduces to the form in equation (2). Because of the 90% cap, the SURE program may provide incentives to lower crop insurance coverage levels for producers who are more likely to receive SURE payments and who currently elect an 85% coverage level. By selecting a lower coverage level, producers can reduce their crop insurance participation costs while maximizing the total value of potential SURE indemnities.

A producer who meets SURE's eligibility requirements (because of location and yield losses) will receive SURE indemnity payments, if the farm's revenue guarantee exceeds its total revenue to count. The revenue to count (RTC) is defined as:

$$RTC = raq + CI + \omega + 0.15d \ , \tag{3}$$

and is the sum of the farm's estimated market revenue (the USDA National Agricultural Statistics Service reported harvest price (r) multiplied by the farm's actual production and the crop insurance coverage level selected by the farm, raq), all countercyclical and ACRE payments (ω), federal crop insurance (CI), and 15% of the total direct payments received by the farm ($0.15d$). If the farm's total revenue to count is less than its revenue guarantee and if a farm is in a county eligible for a SURE disaster payment, then the producer's SURE payment is 60% of the difference between the revenue guarantee and total revenue to count;[10] that is:

$$S = \begin{cases} 0.6(RG - RTC), & \text{if } RTC < RG \\ 0, & \text{otherwise} \end{cases} . \tag{4}$$

If disaster declarations by the Secretary of Agriculture were infrequent, then this provision would be much less likely to create moral hazard opportunities and related adverse selection effects. This is not the case. Figure 1 shows the counties declared to be eligible for SURE disaster payments by the USDA in 2008 and 2009 (that is, counties receiving Secretarial disaster declarations and adjacent counties).[11] The figure indicates that the majority of the 3,077 U.S.

[10] SURE program indemnities can also be triggered by producers whose yields fall below 50% of the crop's per acre APH. For expositional purposes and because SURE program payments triggered by a disaster declaration are more frequent, we do not discuss the 50% yield loss trigger in detail. However, it is straightforward to generalize the results in this study to include the 50% yield loss condition.

[11] Associated data were collected from the 2008 and 2009 Farm Service Agency SURE County Disaster Designations Listings.

counties, and especially those located in the Corn Belt and other major crop producing states, were eligible in either or both years. Consequently, farmers that did not experience substantial production losses were likely be eligible for SURE payments, even during periods of high prices.[12] For example, in 2008, the SURE program cost taxpayers $1.293 billion even though corn, soybean, and wheat farmers collected the highest revenues since 1996 (see Table 1). Similarly, $674 million in SURE payments have already been made for losses occurring in 2009, when revenues were the second highest on record for corn and soybeans and third highest for wheat.[13]

3 Moral Hazard Incentives and Adverse Selection Effects

Incentives for moral hazard created by the SURE program and associated effects related to adverse selection on crop insurance program participation are illustrated in the following model. A farm producing a single crop maximizes an expected per acre profit function, $E(\pi)$, consisting of expected profits from market sales and government payments (M), crop insurance (CI)

[12]For example, the Des Moines Register (Brasher 2010) reported that even though many Iowa producers enjoyed record farm revenues because of high corn and soybean prices, SURE payments in Iowa for that year were likely to exceed $169 million. In many cases, producers with relatively small losses received payments because their farms were located in counties adjacent to disaster declared counties. The link between losses and high prices derives from the fact that the SURE program uses RMA forecasted harvest prices to establish each farm's SURE guarantee.

[13]Although data on disaster declarations made by the Secretary of Agriculture are limited to 2008 and 2009, disaster declarations by the Federal Emergency Management Agency (FEMA) appear to be closely correlated and are likely to reflect the long-run frequency of natural disaster declarations. Between 1999 and 2009, annually FEMA declared between 54.2% (in 2000) and 97.6% (in 2005) of all U.S. counties natural disaster areas (the data not presented here but are available on request from the authors). In major corn, soybean, and wheat production states, the proportion of counties with disaster declarations ranged from 64.1% (in 2002) to 100% (in 2008). While FEMA disaster declarations can be made for numerous reasons, most are weather-related and correspond relatively closely to disaster declarations by the Secretary of Agriculture. For example, in 2008 and 2009, years during which USDA secretarial declarations were made, 68.7% of counties and adjacent counties assigned disaster declarations by FEMA were also designated as disaster areas by the Secretary of Agriculture.

indemnities, and SURE (S) payments;[14] that is:

$$E(\pi) = E(M) + E(CI) + E(S). \tag{5}$$

Producer moral hazard behaviors can be characterized through changes in production inputs, X. Rational producers will choose a level of inputs that maximizes their profits on an insured farm. In equation (5), the optimal value of X can be determined by setting $\frac{dE(\pi)}{dX} = 0$ and solving for X.

To specify the term $\frac{dE(\pi)}{dX}$, we first define the three components of the expected profit function. Expected profits from market sales and government payments are characterized by the function:

$$E(M) = \int_0^\infty \int_0^\infty [rf(X)\nu + G - X - Z(c)]g(\nu)h(r)d\nu dr \ , \tag{6}$$

where $f(X)\nu$ represents the realized per acre yield, composed of a deterministic component, $f(X)$, and a multiplicative random component, ν; G denotes per acre government payments, excluding SURE payments; $Z(c)$ is the per acre premium paid for crop insurance coverage, c; and, $g(\nu)$ and $h(r)$ are probability density functions of random variables representing an output shock ν and market price r.[15] Per acre expected crop insurance indemnities are:[16]

$$E(CI) = \int_0^{\nu_{ci}} p[c\hat{\mu} - f(X)\nu]g(\nu)d\nu \ . \tag{7}$$

Without loss of generality, we normalize p and $\hat{\mu}$ to one and the expected value of the market price is assumed to be equal to the insured price ($E[r] = p$). Crop insurance payments occur

[14]It is straightforward to model the behavior of producers whose yields fall below the 50% trigger. Although we do not show this case to conserve space, a fully specified model is available from the authors upon request.

[15]The price of X is normalized to one, without loss of generality.

[16]Although we present a model using a yield insurance product, it is straightforward to generalize the specification for revenue insurance products.

when a farm's output falls below the farm's selected coverage level. The integration end point ν_{ci} is the value below which crop insurance is triggered; that is, ν_{ci} is the value ν at which $c = f(X)\nu$ and, therefore, $\nu_{ci} = \frac{c}{f(X)}$.

Farms eligible for SURE payments may receive SURE disaster payments whether or not they also receive crop insurance indemnities. When a farm does not receive a crop insurance indemnity, it can still receive a SURE payment when its revenue to count against its SURE revenue guarantee lies between its insurance liability and 115% of that insurance liability.[17] Alternatively, if the farm's actual yield is less than its insurance trigger yield, ($y < c\hat{\mu}$), and its revenue to count is less than its SURE guarantee, then the farm receives both crop insurance and SURE disaster payments. Therefore, a farm's expected SURE indemnities are the sum of its expected SURE payments when it is eligible to receive both SURE payments and crop insurance indemnities, and its expected payments when it only receives SURE payments; that is:

$$\begin{aligned} E(S) &= \int_0^{r_D}\int_0^{\nu_{ci}} 0.6[1.15c - rf(X)\nu - (c - f(X)\nu) - G]g(\nu)h(r)d\nu dr + \\ &\quad \int_0^{R_D}\int_{\nu_{ci}}^{\infty} 0.6[1.15c - rf(X)\nu - G]g(\nu)h(r)d\nu dr \,. \end{aligned} \tag{8}$$

The integration endpoints r_D and R_D are market prices below which SURE payments are triggered. The term r_D is determined by setting $[1.15c - rf(X)\nu - (c - f(X)\nu) - G] = 0$ and solving for r; that is, $r_D = (0.15c - G)/(f(X)\nu) + 1$. Similarly, R_D is determined by setting $[1.15c - rf(X)\nu - G] = 0$ and solving for r; that is, $R_D = (1.15c - G)/(f(X)\nu)$.

The marginal effect of input changes on total expected profit is:

$$\frac{dE(\pi)}{dX} = \frac{dE(M)}{dX} + \frac{dE(CI)}{dX} + \frac{dE(S)}{dX} = 0 \,, \tag{9}$$

[17] Or 90% of the farm's expected revenue if, $1.15c > 0.9$.

where $\frac{dE(M)}{dX} = \frac{\partial f}{\partial X} - 1$, $\frac{dE(CI)}{dX} = \frac{\partial f}{\partial X} \cdot \widetilde{CI}$ and $\frac{dE(S)}{dX} = \frac{\partial f}{\partial X} \cdot \widetilde{S}$. The expressions for $\widetilde{CI}$ and $\widetilde{S}$ are derived in detail in the Appendix. Producers select the optimal level of production inputs X such that $\frac{dE(\pi)}{dX} = 0$. Solving for $\partial f / \partial X$ yields:

$$\frac{\partial f}{\partial X} = \left[\frac{1}{1 + \widetilde{CI} + \widetilde{S}} \right] . \qquad (10)$$

If the SURE program did not exist, then producers would choose an optimal value of X such that $\frac{\partial f}{\partial X} = \left[1/1 + \widetilde{CI} \right]$. However, because the term $\frac{\partial f}{\partial X}$ is now a function of $\widetilde{S}$, determining the marginal effect of introducing the SURE program requires understanding the value of $\widetilde{S}$. Under reasonable assumptions about parameters ν and r, $\widetilde{S}$ can generally be shown to be negative ($\widetilde{S} < 0$). For example, suppose that $\nu \sim N(1, 0.25^2)$, $r \sim N(1, 0.25^2)$, $f(X) = 1$, $c = 0.7$, and $G = 0.01$, then assuming that $\hat{\mu} = \mu$, $\int_0^{\nu_{ci}} \int_0^{r_D} (1 - r)\nu h(r) g(\nu) dr d\nu = 0.0128$ and $\int_{\nu_{ci}}^{\infty} \int_0^{R_D} r\nu h(r) g(\nu) dr = 0.0829$, and, therefore, $\widetilde{S} = -0.043$. Alternatively, if ν and r are assumed to be distributed uniformly – $\nu \sim U[0, 2]$ and $r \sim U[0, 2]$ – then $\int_0^{\nu_{ci}} \int_0^{r_D} (1 - r)\nu h(r) g(\nu) dr d\nu = 0.0053$ and $\int_{\nu_{ci}}^{\infty} \int_0^{R_D} r\nu h(r) g(\nu) dr = 0.0545$, and $\widetilde{S} = -0.030$. This implies that the introduction of the SURE program (characterized by the term $\widetilde{S} < 0$) increases the optimal value of $\frac{\partial f}{\partial X}$. Consequently, assuming $\frac{\partial^2 f}{\partial X^2} < 0$, a producer decreases input use (as well as making changes to other decisions including optimal choice of insurance contracts) until $\frac{dE(\pi)}{dX} = 0$. The reduction in input use is a classic example of moral hazard behavior.[18] Moreover, when a crop's APH insurance yield exceeds its expected yield, $\hat{\mu} > \mu$, the term $\widetilde{S}$ becomes more negative, increasing incentives for (and potentially the magnitude of) moral hazard behavior. The converse holds when $\hat{\mu} < \mu$.

[18] Moral hazard behaviors manifest themselves in multiple ways. Producers that are close to or meet SURE's yield loss requirements may be able to trigger or increase the sum of SURE disaster aid payments and crop insurance indemnities by further reducing yields (with a low probability of detection and penalties). Examples of yield-reducing behavior include using too little fertilizer or reducing irrigation.

3.1 Implications for Adverse Selection Effects on Crop Insurance Participation

Eligibility for the SURE program requires that farmers purchase subsidized crop insurance. Farms that did not insure their crops prior to the SURE program must make the following assessment: does the introduction of the SURE program provide sufficient increases in the sum of expected net crop insurance indemnities and SURE disaster payments to create sufficient incentives for insuring their crops? In making this assessment, a farm has to compare the optimal values of its expected profits in the absence of insurance (and therefore no SURE payments) with the expected profits from market receipts, insurance indemnities, and SURE payments when insurance is purchased, $E(M)+E(CI)+E(S)$. As shown above, the optimal value of $\frac{\partial f}{\partial X}$ increases with the introduction of the SURE program and expected profits increase for farms that purchase crop insurance. Therefore, the SURE program increases the probability that any individual farm will purchase crop insurance and, in the aggregate, is likely to increase crop insurance participation and increased crop land acreage. Moreover, because the effects on expected profits are likely to be larger for farms with greater moral hazard incentives, those farms are likely to have even greater incentives for increasing crop insurance participation.

The above model can also be used to illustrate the SURE program's impacts on crop insurance participation through adverse selection effects. Adverse selection occurs when firms or individuals belonging to a particular insurance pool are able identify their loss risks more accurately than the insurer. As a result, the insurer establishes a premium rate for the pool that is too high for low-risk entities and too low for high-risk entities, leading only higher-risk entities to acquire insurance.

In crop insurance, adverse selection may in part be affected by the Risk Management Agency's (RMA) approach to establishing farms' production histories. The RMA uses the most recent 4 to 10 years of yields to establish a farm's APH yield, $\hat{\mu}$. When a farm's estimated actual production history yields are not representative of their expected yields, $\hat{\mu} \neq \mu$, farmers may have stronger or weaker incentives to adversely select into or out of crop insurance coverage. For example, suppose the RMA established APH yield exceeds the farm's actual expected yield, $\hat{\mu} > \mu$. In this case, a farm's trigger level for insurance payments and the SURE revenue guarantee is higher than if the APH yields equaled the farm's actual expected yields effectively increasing the farm's expected indemnity.[19] Consequently, farms with APH yields that exceed their expected yields are more likely to purchase crop insurance coverage (and also engage in moral hazard behaviors) in response to the introduction of the SURE program, regardless of the reasons for the gap between $\hat{\mu}$ and μ.[20] While the difference between the farm's APH yield and expected yield provides the farmer with an incentive to purchase crop insurance even in the absence of the SURE program, equation (10) shows that these incentives become larger once the SURE program is introduced, because the terms $\widetilde{CI}$ and $\widetilde{S}$ become more negative as $\hat{\mu}$ increases relative toμ. Hence, the introduction of the SURE program is likely to have a larger impact on crop insurance participation for farms with APH yields that exceed their expected yields, and vice versa.

The SURE program, however, can have another effect on adverse selection. As discussed above, the expected value of SURE payments is positive; that is, $E(S) > 0$. Therefore, a farm that does not initially purchase crop insurance may be induced to participate in the crop insurance program, because the SURE program increases expected returns from participation. Although these effects are also likely to be larger for farms with more extensive opportunities for moral hazard behavior, they also exist for farms that have relatively low risks of indemnifiable

[19]The opposite holds for farms with APH yields that are lower than their expected yields.

[20]Over the long-run, farmers may also respond to the SURE program by taking dynamic moral hazard actions. One example of dynamic moral hazard behavior is strategic management of APH yields (Vercammen and van Kooten 1994). By strategically manipulating APH yields, producers can optimally affect the probability of receiving insurance and SURE payments as well as increasing the average payment size. This aspect is out of the scope of this study, but is an avenue for future research.

insurance losses and may not have participated in crop insurance prior to the introduction of the SURE program. Entry of these low risk farms into the crop insurance program is likely to improve the overall loss ratio of the insured pool and increase underwriting gains from that pool. However, because entry of these farms into the insurance pool is likely to increase the sum of total crop insurance indemnities and SURE program payments (net of the increase in producers' insurance premium payments), the sum of total tax payer subsidies for the SURE program and the federal crop insurance program will increase.

4 An Empirical Model of Crop Insurance Participation

Actual production histories and historical yield data are readily available to farmers before they make their annual crop insurance participation decisions, enabling them to determine whether their APH yields are higher than their actual expected yields (that is, whether or not $\hat{\mu} > \mu$). As discussed above, for farms where $\hat{\mu} > \mu$, the SURE program exacerbates moral hazard opportunities and related adverse selection incentives, resulting in increased incentives for crop insurance participation. Using county-level yields collected from the National Agricultural Statistical Service (NASS-USDA), we examine yield deviations over a 60-year time period (years 1949 to 2008). Data are examined for counties in the top ten corn, soybean, and wheat producing states.[21]

Over time, technological advances have increased crop yields and these effects have to account for in obtaining unbiased estimates of actual expected yields.[22] In each county, k,

[21] The following states are included:
Corn – Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Ohio, Kansas, Wisconsin, Missouri.
Soybeans – Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Ohio, Missouri, Arkansas, North Dakota.
Wheat – Nebraska, Minnesota, South Dakota, North Dakota, Kansas, Montana, Washington, Oklahoma, Idaho, Texas.

[22] Goodwin and Ker (2001) provide an overview of various techniques used for "detrending" yield data. Following Skees and Reed (1986), we assume that as yields change, yield variances are homoskedastic.

yields are specified as a function of time t: $y_{kt} = f(t)$. Non-parametric penalized B-splines with a single knot at the data's fiftieth percentile are then used to estimate this function and predict "detrended" yields, ty_{kt}.[23] A cross-validation criterion is used to determine the optimal smoothing parameter.[24] The corrected Akaike information criterion (AICC) is used to select the preferred model among the set of candidate models.

Once the time series yield data are "detrended" for a crop in each county, we calculate the ratio of recent yields to their expected levels. A ratio greater than (less than) one indicates that recent county yields have been above (below) their expected levels. In counties where the ratio is greater than one, the introduction of the SURE program is more likely to increase moral hazard incentives, because larger estimates of the true expected yield increase a farm's APH and SURE guarantee relative to its long-run historical average. Farms in those counties are also more likely to adversely select into federal crop insurance programs and to receive crop insurance indemnities.

To calculate a county's recent and historical average yields, we use predicted ("detrended") yields from the non-parametric penalized B-spline estimation. Recent yields are calculated as the average of "detrended" yields in the seven most recent years; that is, for each county, k, the county equivalent to a farm's APH, $\hat{\mu}$, is computed as $\frac{1}{7}\sum_{t=T-6}^{T} \hat{y}^{*}_{kt}$, where T is the most recent year.[25] The seven-year average corresponds to the typical number of years for which yields are reported by farmers to establish their actual production history. Historical yield averages are also calculated using "detrended" yields from the most recent 30 years; that is,

[23]Smith (1979) offers a description of splines and Eilers and Marx (1996) discuss penalized B-splines.

[24]Cross-validation reduces the likelihood of a non-parametric estimation overfitting the data by using continuous out-of-sample forecast accuracy measures: one observation from the data is iteratively omitted, and a fitted model is used to predict the omitted data point.

[25]The term $y_k t^*$ represents the detrended value of y, normalized to the most recent year; that is, $y_k t^* = (\hat{y}_{kt}/\hat{y}_{kT}) \cdot y_{kt}$.

the true county expected yield, the county equivalent of μ, is estimated as $\frac{1}{30}\sum_{t=T-29}^{T}\hat{y}^*_{kt}$.[26] The ratio describing the relationship of recent detrended yields to their long run expected levels is therefore calculated as follows:

$$\frac{\frac{1}{7}\sum_{t=T-6}^{T}\hat{y}^*_{kt}}{\frac{1}{30}\sum_{t=T-29}^{T}\hat{y}^*_{kt}} \tag{11}$$

This yield ratio indicates the extent of the moral hazard incentives and adverse selection opportunities. Crop insurance is expected to be positively correlated with the yield ratio variable as defined in equation (11).

SURE program payments are more likely to be triggered in counties where yields have historically exhibited a relatively high degree of variability. Moral hazard incentives and adverse selection effects on insurance participation are also expected to be greater in these counties. Yield variability in each county is measured by the standard error of the estimated yield trend line.

Other federal crop insurance, farm, and farmer characteristics also affect crop insurance participation, including premium rates and loss ratios, a farmer's age and the farm's degree of enterprise diversification (see for example Gardner and Kramer 1986, Goodwin 1993, Smith and Baquet 1996, Coble, Knight, Pope, and Williams 1997, Goodwin and Smith 2003). County-level premium rates and loss ratio data for years 2007 and 2009 were obtained from the Summary of Business Reports published by the USDA Risk Management Agency. Observations on these variables for 2009 are divided by observations for 2007 to construct a cross-sectional data set.[27]

[26] The most recent 30 years occur after the point at which a knot is specified in the penalized B-spline procedure. This implies that after the knot, the slope of the estimated trend line does not change.

[27] Although the SURE program was introduced in the 2008 Farm Bill, farmers' ability to participate in 2008 became available after the deadline for purchasing most federal crop insurance policies. This may have limited SURE's impact on MPCI participation rates. Observations from 2009 are more likely to represent the program's true effects because farmers could learn about the program prior to making planting decisions.

Farm and farmer characteristics used in the analysis include a producer's age, farm size, planted crops, and proportion of irrigated land. Age may indicate experience and knowledge that affect a producer's ability to access and interpret information, as well as their willingness to adjust participation in federal crop insurance programs in response to the SURE program. Farm size, number of different planted crops, and proportion of irrigated land are indicators of a farm family's degree of income diversification, which may affect a producer's demand for crop insurance. For variables describing farm and farmer characteristics, data were obtained from the U.S. Census of Agriculture for 2002 and 2007 (United States Department of Agriculture). Because these county-level characteristics are not available for 2008, natural splines are used to extrapolate these data.[28]

The crop insurance participation model is used to examine the determinants of changes in the ratio of net insured acres to total acres planted for counties between 2007 and 2009. An increase in the ratio of net insured acres to total planted acres between 2007 and 2009 indicates that a larger proportion of total planted acreage eligible for insurance is being insured with federal crop insurance products. These changes are modeled using a double-log linear model as follows:

$$\begin{aligned} \ln \frac{Net\ Acres_{i,k,2009}}{Net\ Acres_{i,k,2007}} &= \beta_{0,i} + \beta_{1,i} \ln yld\_dev_{ik} + \beta_{2,i} \ln Std_{ik} + \beta_{3,i} \ln E(yld)_{ik} + \\ &\quad \boldsymbol{\beta}_i^{Ins} \boldsymbol{W}_{ik}^{Ins} + \boldsymbol{\beta}_i^{Farm} \boldsymbol{W}_{ik}^{Farm} + \varepsilon_{ik}\ . \end{aligned} \tag{12}$$

The variable $\ln \frac{Net\ Acres_{i,k,2009}}{Net\ Acres_{i,k,2007}}$ is defined as the logged ratio of net insured acres to total planted acres between years 2009 and 2007 for crop i in location k, $\ln yld\_dev_{ik}$ is the logged ratio of recent to expected actual yields, $\ln Std_{ik}$ is the standard deviation of the yield trend, and $\ln E(yld)_{ik}$ is the logged expected actual yield. In addition, log ratios of MPCI premium rates

[28] A continuous data series is preferred. However, interpolation/extrapolation is commonly used to obtain measures on population for years in which the census is not conducted.

and loss ratios between 2009 and 2007 are represented by the $\boldsymbol{W}_{ik}^{Ins}$ vector. Log ratios of producer age, farm acreage, number of planted crops, and proportions of full farm owners and irrigated acres are represented by vector $\boldsymbol{W}_{ik}^{Farm}$. The β's represent parameters and ε_{ik} is the error term. All dollar-denominated variables are deflated to 1990 equivalent dollars using the prices-paid-by-farmers index (NASS-USDA). Summary statistics and descriptions are presented in table 2.

Figure 2 shows the ratio of net acres insured in 2009 to net acres insured in 2007 for each county included in the empirical analysis. Visual inspection of Figure 2 indicates that between 2007 and 2009, the acreage insured using federal crop insurance products substantially increased in many counties, including Iowa, Illinois, Minnesota and North Dakotas - major production areas for corn, soybean, and wheat. Specifically, in 2009, the amount of net insured acres in these counties was between 1.5 and 2.5 times larger than in 2007. The data in Figure 2 suggest that in many U.S. counties, differences between APH yields and expected actual yields may have provided increased incentives for participation in crop insurance in response to the introduction of the SURE program.

5 Empirical Results

The empirical crop insurance participation models are estimated using ordinary least squares. Robust standard errors are computed to account for potential heteroscedasticity. Changes in the ratio of net insured acres to total planted acres across all multiple peril yield and revenue products are first estimated for all corn, soybeans, and wheat farms in the sample.

Table 3 presents parameter estimates for four alternative models. The first is a parsimonious model of crop insurance participation that regresses the logged ratio of net insured acres on the primary variables of interest - the ratio of APH yields to expected yields, the standard deviation of the estimated yield trend, and the expected yield. The second model includes additional variables that control for differences in farm characteristics. The third and fourth models differ from the first two models in that they account for potential state-level fixed effects.

The results from all four models indicate that after the introduction of the SURE program, crop insurance participation was positively and statistically significantly related to both the ratio of APH yields to expected actual yields and the standard deviation of expected yields. Furthermore, crop insurance participation was negatively and statistically significantly related to expected yields. These findings have important implications for the short- and long-term actuarial performance of insurance products for all three crops. In the short-term, loss ratios are likely to increase in counties where the SURE program has encouraged participation by producers who are more likely to have losses. In addition, increases in participation are by farms whose yields have been lower in recent years relative to their long trends. Consequently, total SURE payments are likely to be higher than Congressional estimates suggested. In the longer term, as RMA increases premium rates in response to higher losses, some producers who are already insured may suffer adverse consequences. Furthermore, because current subsidies are proportional to actuarially-fair premiums, taxpayers are likely to incur higher costs from subsidizing federal crop insurance programs. Alternatively, if the SURE program creates incentives for lower-risk farmers to enter the insurance pool, then although loss ratios could decrease, the sum of the additional subsidized crop insurance indemnities and SURE disaster payments would be positive, increasing taxpayer costs for the two safety net programs.

The double logarithmic form for the empirical models means that estimated coefficients presented in table 4 can be interpreted as elasticities. The estimated coefficients for the fully specified model, which includes farm characteristic control variables and state-level fixed-effects model, have the following interpretations. A 1% increase in yld_dev – the variable indicating the extent of potential incentives for moral hazard and adverse selection behavior resulting from the introduction of the SURE program – would increase net insured acres by

3.25%. A 1% increase in the standard deviation of a farm's yields increases net insured acres by 2.17%, and a 1% decrease in productivity increases crop insurance participation by 0.35%. Parameter estimates for most farm characteristic control variables are not statistically significant in each of the four models reported in Table 3. This finding suggests that adverse selection and moral hazard effects engendered by the SURE program were a force in increasing crop insurance participation between 2007 and 2009.

In addition, the estimated models reported in table 4 separate crop insurance participation models for each crop: corn, soybeans, and wheat.[29] For all three crops, parameter estimates for yld_dev are positive and statistically significant, indicating that moral hazard and adverse selection incentives associated with the introduction of the SURE program contributed to increased crop insurance participation in the three major grain production sectors. However, only results for the wheat crop insurance model provide evidence of statistically significant and expected effects on participation for the expected yield standard deviation and expected yield variables. This result suggests that wheat producers with large moral hazard and adverse selection incentives were most likely to increase their crop insurance participation between 2007 and 2009.

6 Conclusion

The SURE program was introduced in the 2008 Farm Bill as a permanent crop disaster program for agricultural producers who experience catastrophic yield and revenue losses. Smith and Watts (2010) showed that the SURE program's structure creates the potential for substantial moral hazard incentives for producers, because the program diminishes the effectiveness of deductibles. These incentives are exacerbated by the high frequency with which many counties

[29]We present results for the state-level fixed effects model with crop insurance and farm characteristics control variables. Estimates of the more parsimonious models are qualitatively similar, but provide a lesser fit to the data. These results are available from the authors upon request.

are declared disaster areas, which increases the likelihood of receiving SURE payments with only small production losses. This study has extended the work of Smith and Watts by developing a more detailed theoretical model of the SURE program's effects on moral hazard, adverse selection and aggregated incentives for crop insurance participation by agricultural producers and testing empirically the predictions of that model.

The model is used to show that the SURE program encouraged producers to expand their moral hazard behaviors to increase the likelihood they will receive SURE payments and also to increase the expected size the amount of the payment. Being eligible to receive a SURE payment requires that producers also purchase federally subsidized crop insurance products for all economically significant farmed crops. This suggests that, after the SURE program was introduced, increases in crop insurance participation were in part driven by producers who can benefit most from SURE payments. In areas where moral hazard and adverse selection are more likely, larger proportional increases in crop insurance participation rates are an indication that producers in were responding to the more extensive opportunities for moral hazard that existed in those areas.

An empirical model is used to examine changes in county-level crop insurance participation after the introduction of SURE. For counties in the top ten largest corn, soybean, and wheat producing states, there is statistically significant evidence that the SURE program encourages participation by producers who are more likely to receive SURE indemnities and also more likely to individually exploit moral hazard opportunities with resulting adverse selection effects.

The empirical results of the insurance demand model suggest that the SURE program may have had important unexpected consequences, because of its impact on moral hazard opportunities and adverse selection effects. One consequence is that the frequency and size of SURE indemnity claims may be greater than the Congressional Budget Office anticipated in 2008. A second potential consequence is that crop insurance premium rates may change in response to higher loss ratios driven by increases in moral hazard behavior, but those effects may be moderated by increased participation in the insurance pools by some producer with relatively low risks of crop insurance losses, reducing adverse selection in the insurance pools. However, aggregate tax payer subsidies for both the crop insurance and SURE program are likely to increase because the SURE program's moral hazard incentives increase the likelihood and size of both types of outlays.

References

Babcock, B., and D. Hennessy. 1996. “Input demand under yield and revenue insurance.” *American Journal of Agricultural Economics* 78:416–427.

Barnaby, G. 2010. “SURE Is Not Your Fathers Disaster Program.” Kansas State University: AgManager; http://www.agmanager.info/crops/insurance/risk_mgt/rm_pdf10/AB_SURE_Cropins.pdf.

Borch, K. 1989. *Economics of Insurance*. Amserdam: North Holland Publishers.

Brasher, P. 2010. “Little loss, but big disaster aid for farms.” Des Moines Register: May 23, 2010, http://www.desmoinesregister.com/article/20100523/BUSINESS01/5230354/-1/GETPUBLISHED03WP-CONTENT/Little-loss-but-big-disaster-aid-for-farms, *accessed May 23, 2010*.

Chambers, R. 1989. “Insurability and moral hazard in agricultural insurance markets.” *American Journal of Agricultural Economics* 71:604–616.

Coble, K., T. Knight, R. Pope, and J. Williams. 1997. “An Expected Indemnity Approach to the Measurement of Moral Hazard in Crop Insurance.” *American Journal of Agricultural Economics* 79:216–226.

Eilers, P., and B. Marx. 1996. “Flexible Smoothing with B-Splines and Penalties.” *Statistical Science* 11:89–121.

Gardner, B., and R. Kramer. 1986. Experience with crop insurance programs in the United States, P. Hazall, C. Pomareda, and A. Valdez, eds. *Crop Insurance for Agricultural Development*, Baltimore, MD: Johns Hopkins University Press.

Goodwin, B. 1993. "An Empirical Analysis of the Demand for Multiple Peril Crop Insurance." *American Journal of Agricultural Economics* 75:425–434.

Goodwin, B., and A. Ker. 2001. *A Comprehensive Assessment of the Role of Risk in U.S. Agriculture*, J. Richard and R. Pope, eds. Norwell, MA: Kluwer.

Goodwin, B., and V. Smith. 2003. *The effects of crop insurance and disaster relieve programs on soil erosion: the case of soybeans and corn*, J. Lekakis, R. Fraser, and B. Babcock, eds. Dordrecht, Netherlands: Kluwer Academic Publishers.

Just, R., L. Calvin, and J. Quiggin. 1999. "Adverse selection in crop insurance: actuarial and asymmetric information incentives." *American Journal of Agricultural Economics* 81:834–849.

NASS-USDA. Various Years. "State and County Data." www.nass.usda.gov.

Skees, J., and M. Reed. 1986. "Rate-making for farm-level crop insurance: implications for adverse selection." *American Journal of Agricultural Economics* 68:653–659.

Smith, P. 1979. "Splines as a Useful and Convenient Statistical Tool." *The American Statistician* 33:57–62.

Smith, V., and A. Baquet. 1996. "The demand for multiple peril crop insurance: evidence from Montana." *American Journal of Agricultural Economics* 78:189–201.

Smith, V., and B. Goodwin. 1996. "Crop Insurance, Moral Hazard, and Agricultural Chemical Use." *American Journal of Agricultural Economics* 78:428–438.

Smith, V., and M. Watts. 2010. "The New Standing Disaster Program: A SURE Invitation to Moral Hazard Behavior." *Applied Economic Perspectives and Policy* 32:154–169.

United States Department of Agriculture. Various Years. "Census of Agriculture." www.nass.usda.gov.

USDA Farm Service Agency. 2011. "Fact Sheet: Supplemental Revenue Assistance Payments (SURE) Program." http://www.fsa.usda.gov/Internet/FSA_File/sure_2011.pdf.

Vercammen, J., and G. van Kooten. 1994. "Moral Hazard Cycles in Individual Coverage Crop Insurance." *American Journal of Agricultural Economics* 76:250–261.

Table 1: U.S. Yield and Price Rankings for Corn, Soybeans, and Wheat, 1996 2009[a]

	Corn	Soybeans	Wheat
Yield			
Rank in 2008	3	7	2
Rank in 2009	1	1	3
Price			
Rank in 2008	1	1	1
Rank in 2009	3	2	3
Revenue			
Rank in 2008	1	1	1
Rank in 2009	2	2	3
Total SURE outlays			
2008[b]		$1.293 billion	
2009[c]		$674 million	

Notes:
[a] Data are from the National Agricultural Statistics Service, USDA.
[b] Outlays do not include the $841 million appropriated under the Recovery Act of 2008.
[c] The deadline for filing 2009 SURE payment claims ended July 31, 2011. The shown outlays for 2009 are likely to increase as funds for the claims are distributed.

Table 2: Summary statistics

Variable		*Overall*			*Corn*			*Soybeans*			*Wheat*	
	Mean	**Median**	**MAD**	**Mean**	**Median**	**MAD**	**Mean**	**Median**	**MAD**	**Mean**	**Median**	**MAD**
Net Acres	657.93	2.87	3.61	44.2	6.86	6.41	7.56	0.89	0.97	3.12	3.01	3.87
APH Yield / Expected Yield	1.14	1.13	0.07	1.17	1.17	0.06	1.14	1.12	0.04	1.08	1.07	0.07
Stdev. of Expected Yield	9.24	6.82	3.87	14.86	14.62	2.45	4.57	4.45	0.65	6.51	6.52	1.25
Expected Yield	68.88	42.01	20.62	117.5	120	20.38	35.89	36.95	6.46	35.54	34.17	6.94
Premium rate	1.14	1.12	0.12	1.09	1.09	0.08	1.15	1.15	0.15	1.18	1.16	0.15
Loss ratio	2.45	0.31	0.46	1.42	0.12	0.18	0.81	0.17	0.25	6.18	1.69	2.2
Farmers' average age	1.01	1.01	0.01	1.01	1.01	0.01	1.01	1.01	0.01	1.01	1.01	0.01
Average farm size	0.98	0.99	0.03	0.98	0.99	0.03	0.98	0.99	0.03	0.99	0.99	0.04
Number of planted crops	1.05	1	0.12	1.05	1	0.12	1.05	1	0.17	1.04	1	0.13
Proportion of fully owned farms	0.94	0.95	0.09	0.92	0.94	0.08	0.92	0.94	0.08	0.96	0.98	0.09
Proportion of irrigated farms	1.04	1.03	0.08	1.04	1.03	0.09	1.05	1.03	0.07	1.03	1.02	0.09

Note: The variable "Net Acres" is the 2009 to 2007 ratio of net insured acres. All other variables except APH Yield / Expected Yield, Stdev. of Expected Yield, and Expected Yield are ratios 2008 to 2007 ratios.

Table 3: Estimation results for the crop insurance participation model: all crops

(Top ten production states for corn, soybeans, and wheat[a])

Variable	*Model 1*		*Model 2*		*Model 3*		*Model 4*	
	Estimate	**t-stat.**	**Estimate**	**t-stat.**	**Estimate**	**t-stat.**	**Estimate**	**t-stat.**
Intercept	-2.86***	-7.63	-2.29***	-4.95	-3.69***	-6.72	-3.04***	-4.43
APH Yield / Expected Yield	3.42***	4.16	3.92***	4.39	2.53***	3.31	3.25***	3.65
Std. of Expected Yield	2.35***	13.16	2.43***	11.62	2.05***	10.69	2.17***	9.31
Expected Yield	-0.41***	-2.44	-0.52***	-2.67	-0.16	-0.85	-0.35*	-1.78
Premium rate	–		0.19	0.3	–		0.04	0.09
Loss ratio	–		0.11***	3.62	–		0.09***	2.59
Farmers' average age	–		-10.01	-1.38	–		0.29	0.04
Average farm size	–		-1.29	-0.92	–		-1.84	-1.29
Number of planted crops	–		-0.11	-0.35	–		0.46	1.02
Proportion of fully owned farms	–		-0.67*	-1.87	–		-0.73***	-2.3
Proportion of irrigated farms	–		-0.18	-0.88	–		-0.14	-0.63
State fixed effects?	No		No		Yes		Yes	
Adjusted R^2	0.238		0.236		0.308		0.309	
Observations	1,906		1,906		1,906		1,906	

Notes:

Single, double, and triple asterisks indicate statistical significance at the 0.10, 0.05, and 0.01 levels, respectively. Heteroscedasticity-consistent standard errors (White, 1980).

[a] For each estimated crop insurance participation model, data are included for counties in the top ten corn, soybean, and wheat producing states. The following states are included:

Corn – Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Ohio, Kansas, Wisconsin, Missouri.

Soybeans – Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Ohio, Missouri, Arkansas, North Dakota.

Wheat – Nebraska, Minnesota, South Dakota, North Dakota, Kansas, Montana, Washington, Oklahoma, Idaho, Texas.

Table 4: Estimation results for the crop insurance participation model: corn, soybeans, and wheat

(Top ten production states for corn, soybeans, and wheat[a])

	Corn		***Soybeans***		***Wheat***	
Variable	**Estimate**	**t-stat.**	**Estimate**	**t-stat.**	**Estimate**	**t-stat.**
Intercept	1.93	0.49	0.6	0.16	6.55***	2.95
APH Yield / Expected Yield	4.45***	3.33	12.63***	3.57	2.81**	2.2
Std. of Expected Yield	-0.39	-0.69	-1.69**	-2.51	1.67**	2.23
Expected Yield	0.07	0.11	0.13	0.16	-2.17***	-3.44
Premium rate	-0.57	-0.69	0.11	0.09	-1.37*	-1.62
Loss ratio	0.01	0.25	0.07	1.04	-0.11	-1.56
Farmers' average age	-6.98	-0.81	19.32	1.42	-3.29	-0.32
Average farm size	0.94	0.6	-2.57	-1.27	-4.18*	-1.83
Number of planted crops	0.26	0.54	0.66	1.47	0.44	0.45
Proportion of fully owned farms	-0.15	-0.45	-0.13	-0.36	-1.90***	-4.18
Proportion of irrigated farms	0.07	0.28	0.2	0.79	-0.21	-0.67
State fixed effects?	Yes		Yes		Yes	
Adjusted R^2	0.234		0.26		0.36	
Observations	762		688		456	

Notes:

Single, double, and triple asterisks indicate statistical significance at the 0.10, 0.05, and 0.01 levels, respectively. Heteroscedasticity-consistent standard errors (White, 1980).

[a] For each estimated crop insurance participation model, data are included for counties in the top ten corn, soybean, and wheat producing states. The following states are included:

Corn – Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Ohio, Kansas, Wisconsin, Missouri.

Soybeans – Iowa, Illinois, Nebraska, Minnesota, Indiana, South Dakota, Ohio, Missouri, Arkansas, North Dakota.

Wheat – Nebraska, Minnesota, South Dakota, North Dakota, Kansas, Montana, Washington, Oklahoma, Idaho, Texas.

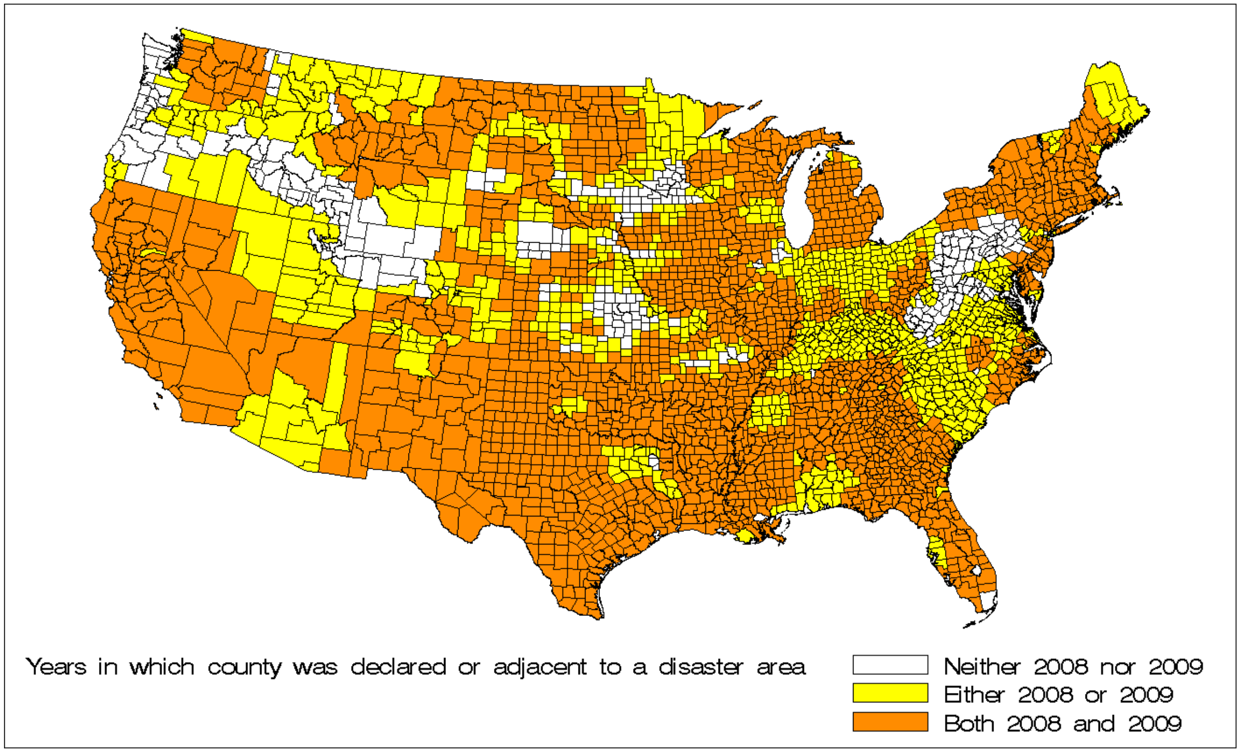

Fig. 1: County-level USDA Secretarial disaster declarations in 2008 and 2009

Note: Figure constructed by authors. Associated data were collected from the 2008 and 2009 Farm Service Agency SURE County Disaster Designations Listings.

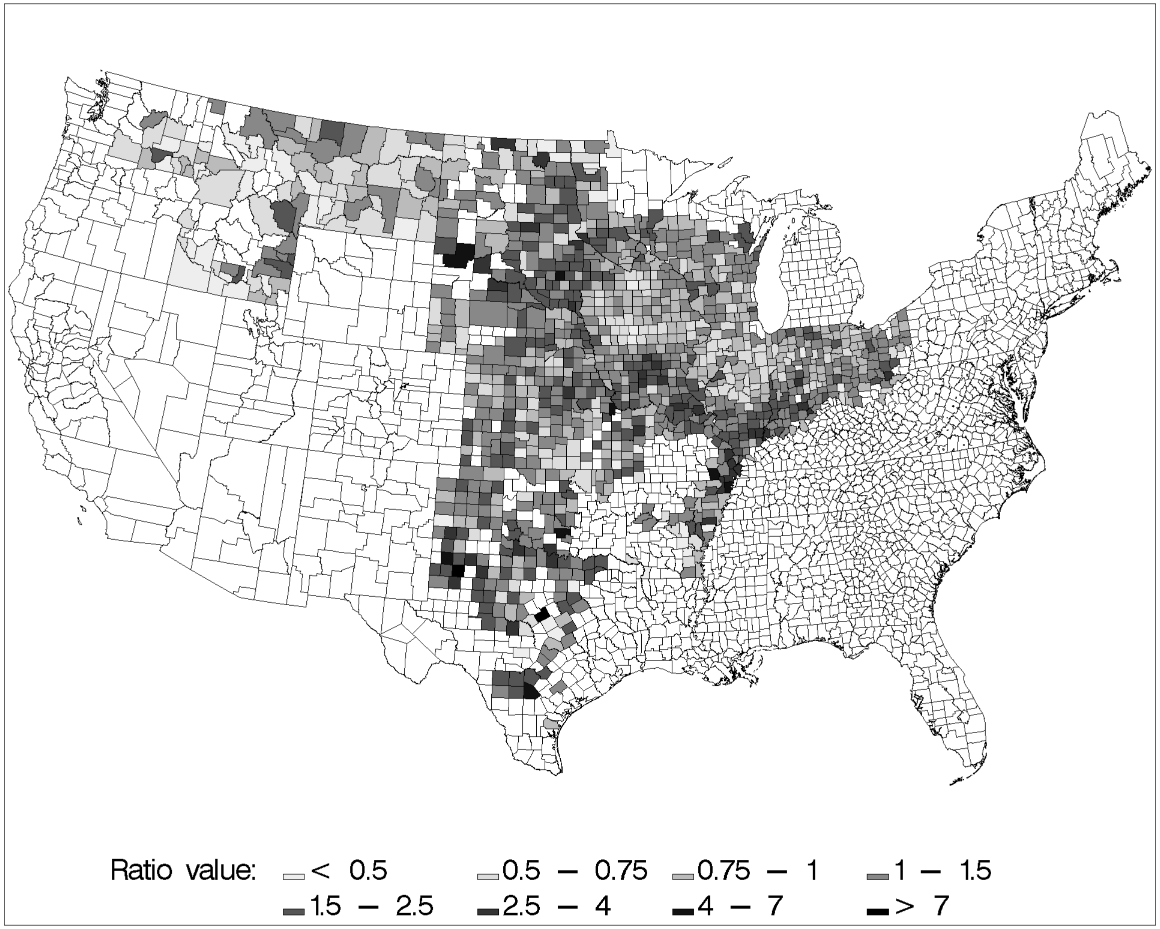

Fig. 2: Changes in net crop insurance participation from 2007 to 2009

Ratio of Relative Net Insured Acres in 2009 to Relative Net Insured Acres in 2007
(Relative net insured acres are the ratio of net insured acres to total planted acres)

Note: Figure constructed by authors. Associated data were collected from the 2007 and 2009 Risk Management Agency (USDA) Summary of Business reports.

A Appendix

Marginal effects of input changes on the components of expected farm profits are as follows:

1. Expected market profits for a farm located in or adjacent to counties under a secretarial disaster declaration.

$$E(M) = \int_0^{\infty} \int_0^{\infty} [rf(X)\nu + G - X - Z(c)] g(\nu) h(r) d\nu dr$$

$$E(M) = f(X)\nu + G - X - Z(c)$$

$$\frac{\partial E(M)}{\partial X} = \frac{\partial f}{\partial X} - 1 \tag{A.1}$$

2. Expected crop insurance indemnities for a farm located in or adjacent to counties under disaster declarations.

$$E(CI) = \int_0^{\nu_{ci}} (c - f(X)\nu)\, g(\nu) d\nu$$

$$\frac{\partial E(CI)}{\partial X} = \frac{\partial f}{\partial X} \int_0^{\nu_{ci}} -\nu g(\nu) d\nu$$

$$\frac{\partial E(CI)}{\partial X} = \frac{\partial f}{\partial X} \cdot \widetilde{CI} \tag{A.2}$$

3. Expected SURE payments for a farm located in or adjacent to counties under a disaster declaration.

$$
\begin{aligned}
E(S) \;=\; & \int_0^{r_D}\int_0^{\nu_{ci}} 0.6[1.15c - rf(X)\nu - (c - f(X)\nu) - G]g(\nu)h(r)d\nu dr + \\
& \int_0^{R_D}\int_{\nu_{ci}}^{\infty} 0.6[1.15c - rf(X)\nu - G]g(\nu)h(r)d\nu dr\;. \qquad \text{(A.3)}
\end{aligned}
$$

To simplify differentiation of $E(S)$, the order of integration can be switched. Then, differentiating and rearranging yields the following:[30]

$$
\begin{aligned}
\frac{\partial E(S)}{\partial X} \;=\; & 0.6\Bigg(\frac{\partial \nu_{ci}}{\partial X}\int_0^{r_D}[0.15c + (1-r)f(X)\nu_{ci} - G]h(r)dr \qquad \text{(A.4)}\\
& + \frac{\partial r}{\partial X}\int_0^{\nu_{ci}}[0.15c + (1-r_D)f(X)\nu - G]g(\nu)d\nu \qquad \text{(A.5)}\\
& + \int_0^{\nu_{ci}}\int_0^{r_D}(1-r)\frac{\partial f}{\partial X}\nu h(r)g(\nu)drd\nu \qquad \text{(A.6)}\\
& - \frac{\partial \nu_{ci}}{\partial X}\int_0^{R_D}[1.15c - rf(X)\nu_{ci} - G]h(r)dr \qquad \text{(A.7)}\\
& + \frac{\partial R_D}{\partial X}\int_{\nu_{ci}}^{\infty}[0.15c - Rf(X)\nu - G]g(\nu)d\nu \qquad \text{(A.8)}\\
& + \int_{\nu_{ci}}^{\infty}\int_0^{R_D} -r\frac{\partial f}{\partial X}\nu h(r)g(\nu)drd\nu\Bigg) \qquad \text{(A.9)}
\end{aligned}
$$

[30] To differentiate a double-integral in which the endpoints are functions of a random variable, the following differentiation rule is used:

$$Y = \int_0^{h(a)}\int_0^{g(a)} f(a,x,z)dxdz$$

$$\frac{dY}{da} = \int_0^{h(a)}\int_0^{g(a)}\frac{df}{da}dxdz + \frac{dg}{da}\int_0^{h(a)} f(a,g(a),z)dz + \frac{dh}{da}\int_0^{h(a)} f(a,x,h(a))dx$$

Combining equations (A.4) and (A.7) yields $\frac{\partial v_{ci}}{\partial X}\int_0^{r_D}[-c+f(X)v_{ci}]h(r)dr=0$, after evaluating the term inside of the integral at $v_{ci}=c/f(X)$.[31] Furthermore, the terms inside of integrals in equations (A.5) and (A.8) are zero when evaluated using the definitions $r=(0.15c-G)/(f(X)v)+1$ and $R=(1.15c-G)/f(X)v$. Therefore, $\frac{\partial E(S)}{\partial X}$ is as follows:

$$\begin{aligned}\frac{\partial E(S)}{\partial X} &= 0.6\frac{\partial f}{\partial X}\left[\int_0^{v_{ci}}\int_0^{r}(1-r)vh(r)g(v)drdv\right.\\ &\quad - \left.\int_{v_{ci}}^{\infty}\int_0^{R_D} rvh(r)g(v)dr\right]\\ &= \frac{\partial f}{\partial X}\cdot\widetilde{S} \qquad \text{(A.10)}\end{aligned}$$

[31]The term $r=R_D$ when $v=v_{ci}$.