An Analysis of Farmers' Insurance Choices and Federal Crop Insurance Subsidies

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Abstract

The U.S. crop insurance has two distinct features that set itself apart from insurance in other areas: (i) it is explicitly subsidized with an average premium subsidy rate of about 60 percent in recent years; and (ii) the law requires the premium rate be set at actuarially fair level with the federal government paying the administrative and operational costs related to the sale and service of insurance policies. Bearing in mind these features, we examine to what extent farmers' crop insurance choices conform to economic theory and estimate the implications of changes in premium subsidy structure. A standard expected utility maximization framework is set up to analyze the trade-offs between higher risk protection and larger subsidy payment. We show that, given actuarially fair premium, a rational farmer will choose the coverage level with the highest premium subsidy or a higher coverage level. With a large insurance unit level data, we fail to find empirical support for this theoretical results, which suggest a possible "anomaly" in insurance decisions. Estimation through mixed logit models reveals that out-of-pocket premium has a negative impact on the probability of an insurance product being chosen.

Keywords: actuarial fairness, agricultural policy, coverage level, federal crop insurance, premium subsidy.

JEL Code: Q15, Q18, Q24.

Introduction

A large literature exists on insurance and decision-making regarding financial risks. There are some principle results from basic models; for example, a risk-averse individual will purchase full coverage when faced with an actuarially fair insurance policy. Data from controlled experiments as well as real world insurance choices have been examined in the literature to see how economic theories are consistent with real world decisions. Some inconsistencies, so-called anomalies, have been noted between data and the standard model where rational agents maximize expected utility. Relative to the predictions of the standard model, empirical studies show that people sometimes allow irrelevant considerations to influence their insurance preferences, and that in some markets over-insurance occurs, i.e., people tend to buy lower deductible policies than what should be optimal for them (e.g., Rabin and Thaler 2001; Sydnor 2010). The literation related to anomalies contains analyses of data from a variety of sectors and financial situations such as auto and home insurance, health insurance, and the purchase of extended warranty for electronic products. In this paper, we will theoretically and empirically examine insurance product decisions in a large distinct insurance market, the U.S. crop insurance, which has so far not been studied to see to what extent decisions on insurance coverage level choices are consistent with the predictions of economic theory and what the related policy implications are.

The U.S. crop insurance is different from other insurance markets in that (i) it is explicitly, and heavily, subsidized with an average premium subsidy rate of about 60 percent in recent years; and (ii) the law requires the premium rate be set at actuarially fair level. The federal government sets premium and subsidy rates whereas private companies sell and maintain policies and get reimbursement from the government for administrative and operational costs. The federal crop insurance program had over one million insurance policies that covered more than 250 million acres of land with a total liability worth more than $75 billion in recent years (2010 RMA). The taxpayers' costs of the program are predicted to average $8.9 billion per year over 2013-2022 (USGAO 2012). There is a considerable body of research on U.S. crop insurance, most of which focuses on issues related to product design, rate-setting, and farmers' participation decisions. The impacts of crop insurance subsidies on land use changes have also been studied. But there is a dearth of research that uses insurance-unit-level data to examine to what extent farmers' coverage level choices are consistent with economic theory and to quantify the role of premium and subsidy on coverage level choices.

Coble and Barnett (2013) identified four research areas that will help illuminate policy debate on the future of crop insurance program. One of these areas concerns the price elasticity of demand for crop insurance. There are several studies that have examined the demand elasticity of crop insurance (e.g., Goodwin 1993; Goodwin and Smith 1996). The federal crop insurance program has had considerable changes since these studies and estimates with recent program data will help shed light on how premiums and subsidies might affect crop insurance contract choices. Du, Hennessy, and Feng (2013) examined such choices at the county level with a focus on the roles of natural resource factors. To our knowledge, no studies have examined the extent of subsidies across different insurance plans and coverage levels for individual farmers, and most importantly, how the current subsidy rate structure affects farmers' choice over alternative insurance products. An encompassing framework to study grower preferences for insurance products given different contract benefits and prices does not exist. This is what we intend to provide in the present study. In addition, distinct and perhaps puzzling patterns are observed in farmers' choices of crop insurance products. Our major objectives of the study are to identify the patterns of choices regarding alternative insurance plans and coverage levels and to quantify the role of key driving forces underlying these choices.

While crop insurance is intended for farmers to manage risks in their operations, it is widely recognized crop insurance is an income subsidy apparently because of the billions of dollars of support provided by the federal government (Goodwin 2001; Babcock 2011a and 2013; Sumner and Zulauf 2012). It seems reasonable to assume that individual farmers participate in crop insurance program in order to maximize subsidy transfers, or equivalently total net return when the premium is set at the actuarially fair level. The validity of the "transfer maximization" assumption will be investigated by reconstructing premiums and subsidies of available insurance products and coverage levels for individual farmers using Risk Management Agency (RMA) historical insurance unit level records. The analysis sheds light on the role of government subsidy and insurance premium in insurance product choices. Our estimated empirical relationships between insurance product choices and its determining factors can be a useful tool in assessing the potential effects of the proposed insurance reform scenarios on farmers' insurance choices and the resulting premium subsidy payments.

Background: the Federal Crop Insurance Program and Changes in Government Subsidies[1]

In this section, we will explain briefly the history of the federal crop insurance program with a focus on changes in the structure and level of subsidies. Broadly speaking, the federal crop insurance program offers two types of insurance products: yield insurance that triggers payoffs based on yield shortfalls from a predetermined yield level, and revenue insurance that protects against revenue shortfalls from a predetermined revenue level. The predetermined yield is usually based on historical yield whereas the predetermined revenue is the multiple of this historical yield and a price established for an insurance plan in a given year. Over the years, the crop insurance program has evolved with changes in specific yield and revenue insurance products as the Risk Management Agency (RMA) at U.S. Department of Agricultural, the government agency that administers the federal crop insurance program since 1996, continues to improve rating methods and develop products to meet farmers' insurance needs.

The federal crop insurance was first authorized by Congress in 1930s but remained essentially as an experimental program for the next few decades with its limited availability in terms of crops and regions. The 1980 Federal Crop Insurance Act, which marked the beginning of present crop insurance program, expanded insurance to many more crops and regions reflecting Congress's vision of a program that provides protection for all farmers in all regions.

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[1] References for this section includes the RMA's website (http://www.rma.usda.gov/), Coble et al. (2010) and Glauber (2013).

The act allowed a public-private partnership through which private sector companies sell and service insurance policies and the administrative and operating expenses thus incurred are compensated the federal government. This partnership remains an important feature of the current crop insurance program. Unlike the way that premiums are set for insurance products in other areas, crop insurance premiums are set to generate only enough premium dollars to cover indemnities. That is, the premium can be set actuarially fair which is a goal the RMA is statutorily mandated to achieve.[2]

The 1980 Act also authorized a subsidy equal to 30 percent of the crop insurance premium limited to the dollar amount at 65-percent coverage, which was essentially a lump-sum transfer per acre. Crop insurance participation rate grew in the1980s and hovered around 30 percent in the early 1990s which was lower than what Congress had hoped for. The insufficient growth in participation rate and the recurrent *ad hoc* disaster assistance payments made in the late 1980s and early 1990 led to the Federal Crop Insurance Reform Act of 1994. This act restructured the program with increased premium subsidies and the addition of a “catastrophic” (CAT) insurance policy that compensates farmers for losses beyond 50 percent of average yield paid at 60 percent of the price established for that year. The premium for the CAT policy is fully subsidized with farmers’ paying only a small administrative fee. Also, in the second half of the 1990s, new insurance products were created including some revenue insurance products.

Crop insurance participation rate grew further in the second half of 1990s with 180 million acres covered by insurance in 1998, which was about two thirds of the nation’s total planted acreage for field crops and more than twice the acres insured in 1993. But Congress desired even higher participation rate hoping to eliminate the need for *ad hoc* disaster payments to farmers like those in the late 1990s. Through the passage of the Agricultural Risk Protection Act (ARPA) of 2000, Congress increased subsidies further and extended the percentage subsidies to revenue insurance: prior to 2000, subsidies were equal to the dollar amount of 65 percent coverage for

[2] Prior to the 2008 farm bill, the target loss ratio of indemnity over premium was 1.075; but the bill lowered the target loss ratio to the actuarially-fair value, 1.0.

yield insurance; ARPA allows same percentage subsidy rates to be applied to revenue insurance premium. That is, the percentage subsidy rate is the same for yield and revenue insurance at a given coverage level. Given that revenue insurance is generally more expensive than yield insurance, per acre subsidy is thus generally higher for revenue insurance than for yield insurance.

For a given crop, a farmer can purchase crop insurance at different "unit" levels, optional unit (OU), basic unit (BU), and enterprise unit (EU). Without getting into the technical definition of these units, essentially EU includes all land under one crop production in a county; BU is based on land ownership split for one crop in a county; and OUs are subdivisions of a BU by township sections. These alternative unit structures allow a farmer to better tailor insurance to risk management needs. Because of risk pooling within a unit, insurance with EU is cheaper than BU and BU is cheaper than OU. Before the 2008 farm bill, insurance premium with EU was subsidized at the same percentage rate as BU and OU. To increase the parity of the per acre dollar subsidy across units, subsidy rates for EU were dramatically increased in the bill. The current subsidy rate schedule is given in table 1.

Over the years, the share of premium paid by taxpayers increased from about 25% prior to the 1994 act, to around 50% in the second half of 1990s, and to around 62 percent in recent years. Meanwhile, total insured acres for major crops increased from less than 30% prior to 1990 to over 80 percent of eligible acres in recent years. Crop insurance is set to become the pillar of farm safety net programs in the next farm bill to be passed in later 2013. But there are several reasons why crop insurance has been a tempting target for further reform again, including, e.g. (i) the political pressure to reduce federal budget deficit and high crop prices that have placed farmers in strong financial standing in recent years, (ii) concerns about incentivizing effects of insurance payment for farmers to expand production into marginal land that is environmentally sensitive and prone to yield disasters (Rashford, Walker, and Bastian 2011), and (iii) within-agriculture fairness and efficacy issues regarding unintended recipients and unequal distribution of insurance subsidies (Smith 2011). On the other hand, growers have come to value crop insurance subsidies and are willing to expend political capital on protecting and expanding these programs (Glauber 2013).

Different policy alternatives have been discussed for implementation in forthcoming federal farm bill legislation. The structure and extent of premium subsidies as specified in the farm bills have attracted particular attention. For example, through a report the General Accounting Office (GAO) recommended: "To reduce crop insurance program costs, Congress should consider limiting premium subsidies for individual farmers, reducing subsidies for all farmers, or both" (USGAO 2012). Others have argued that the high subsidies rates are not necessary and cause loss of social efficiency (Babcock 2013; Goodwin and Smith 2013). Subsidy rates were substantially raised in the 2000 farm bill to boost participation. While data seem to suggest that higher participation rates are associated with higher subsidy rates, the relationship is not all that clear due to concurrent changes in different factors (Coble and Barnett 2013). In this paper, we will examine the role of subsidies in farmers' crop insurance decisions based on insurance-unit-level data.

Analytical Framework

For the stochastic underwritten item Z on a given insurance unit, be it yield or revenue, let the institutional estimate of mean value be $\overline{Z}$, and distribution function be $f\left(z\right)$ for $0 \le z \le \infty$. The mean value will be used as the benchmark of insurance coverage. That it, if the coverage level is set at ϕ with $0 \le \phi \le 1$ on the unit, then the indemnity is $M \equiv \max[\phi\overline{Z} - Z, 0]$. Let P be total premium at coverage level ϕ on the unit. With $E[\cdot]$ as the expectation operator then an actuarially fair premium would mean $P = E[M]$. Let s be the subsidy rate per dollar of premium payment at coverage level ϕ, so $S = sP$ is the subsidy's dollar value. That is, the producer pays $(1-s)P$ for the crop insurance. As coverage level changes, both premium and subsidy may change, i.e., P and s are actually a function of ϕ and are written as $P(\phi)$ and

$s(\phi)$ explicitly when needed for clarification.

We use a standard expected utility model to analyze a farmers' insurance choices. Let $U(R)$ denote the utility as a function of wealth R with $\frac{\partial U}{\partial R} > 0,$ and $\frac{\partial^2 U}{\partial R^2} <= 0$. For a given coverage level with corresponding premium and subsidy rate, let R_L and R_H denote the return from the underwritten item when it is less than or equal to $\bar{Z}$ and when it is greater than $\bar{Z}$, respectively, that is,

(1) $$R_L \equiv \phi\bar{Z} - P(\phi) + s(\phi)P(\phi) \quad \text{and} \quad R_H \equiv Z - P(\phi) + s(\phi)P(\phi).$$

Without loss of generality for our purpose of analysis, assuming that a farmer derives all wealth from the insured product, we can write a farmer's expected utility as

(2) $$E\left[U(\bullet)\right] \equiv E[U(R(\phi, P, s))] = \int_0^{\phi\bar{Z}} U\left(R_L\right) f(z)dz + \int_{\phi\bar{Z}}^{\infty} U\left(R_H\right) f\left(z\right)dz$$

To derive the optimal level of insurance, we differentiate $E\left[U(\bullet)\right]$ with respect to ϕ,

(3) $$\frac{\partial E\left[U(\bullet)\right]}{\partial\phi} = \int_0^{\phi\bar{Z}} \left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_L} \left(\bar{Z} - \frac{\partial P(\phi)}{\partial\phi}\right) f\left(z\right)dz + \int_{\phi\bar{Z}}^{\infty} \left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_H} \left(-\frac{\partial P(\phi)}{\partial\phi}\right) f\left(z\right)dz + K;$$

$$where \;\; K \equiv \int_0^{\phi\bar{Z}} \left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_L} \left(\frac{\partial\left(s(\phi)P(\phi)\right)}{\partial\phi}\right) f\left(z\right)dz + \int_{\phi\bar{Z}}^{\infty} \left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_H} \left(\frac{\partial\left(s(\phi)P(\phi)\right)}{\partial\phi}\right) f\left(z\right)dz.$$

The symbols, $\left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_L}$ and $\left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_H}$, represent the derivative of function $U(\bullet)$ with respect to R and evaluated at $R = R_L$ and $R = R_H$, respectively. Being the value of marginal utility, both derivative terms are positive. Equation (3) captures the two effects of a change in ϕ. The first is the effect through changes in premium and the trigger point of indemnity payment. The second, represented by K, is the effect through changes in dollar subsidy per unit resulting from changes in percent subsidy rate and total premium payment. Given that these two effects are likely to work in opposite directions, without further information, we do not know the sign of $\frac{\partial E\left[U(\bullet)\right]}{\partial \phi}$, which is key in farmers' decisions on the optimal coverage level.

In analyzing farmers' insurance choice decisions, assumptions on the following two conditions are critical:

(A1) Farmers are rational.

(A2) Premiums are actuarially fair.

In crop insurance, RMA is required by law to set the premiums actuarially fair, although this can be difficult to implement in practice. If (A2) is true, it means premium equals the expected indemnity, i.e.,

$$P(\phi) = \max[\phi\bar{Z} - Z, 0] = \int_0^{\phi\bar{Z}} \left(\phi\bar{Z} - z\right) f(z)dz \tag{4}$$

Differentiate (4) with respect to ϕ , we have

$$\frac{\partial P(\phi)}{\partial \phi} = \int_0^{\phi\bar{Z}} \bar{Z} f(z)dz > 0 \tag{5}$$

Plugging (5) into the two integral terms in (3), we get

$$\begin{aligned} \frac{\partial E\left[U(\bullet)\right]}{\partial \phi} = & \left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_L} \int_0^{\phi\bar{Z}} \bar{Z} f(z)dz \\ & -\left(\int_0^{\phi\bar{Z}} \left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_L} f\left(z\right)dz + \int_0^{\phi\bar{Z}} \left.\frac{\partial U(\bullet)}{\partial R}\right|_{R=R_H} f\left(z\right)dz\right)\int_0^{\phi\bar{Z}} \bar{Z} f(z)dz \\ & +K \end{aligned} \tag{6}$$

The concavity of the utility function implies that the sum of the first two lines in (6) is greater than zero. The sign of K, which represents how dollar subsidy will change as coverage level changes, is unknown. If there is no subsidy, i.e., $s(\phi) = 0$ for all ϕ, then the last line is zero. Similarly if there is positive subsidy rate, i.e., $s(\phi) > 0$ but $s(\phi)$ is the same for all ϕ, the third line will be positive. Thus, we have the following remark,

Remark: Under the conditions (A1) and (A2), if there is no premium subsidy or premium subsidy stays the same for all coverage levels, farmers will choose the highest coverage level.

If the highest offered coverage level is 100 percent, then we get the standard result that a farmer will choose full coverage when faced with actuarially fair premium. In the actual crop insurance program, premium subsidy varies with coverage level. Then farmers' insurance decision will involve a tradeoff between higher risk protection and larger dollar subsidy. If the highest coverage level also provides the highest subsidy, then a farmer will choose that level of coverage. However, if choosing highest coverage level means less subsidy than choosing other coverage levels, farmers' insurance decisions will depend on how they value risk protection relative to the subsidy payment. Thus, it is important that we know how insurance subsidy per acre varies with coverage levels. It is generally believed that subsidy per acre increases with coverage level in the setting of the current crop insurance programs. For example, Shields (2010) states that "The subsidy rate declines as the coverage level rises, but the total premium subsidy in dollars increases because the policies are more expensive." Given our individual level data, it is straightforward to verify to what extent this is true for each individual farmer:

<u>*Testable Hypothesis I*</u>: Higher coverage levels have higher subsidy payments.

To take a further look, write the change in subsidy with a move from coverage level ϕ_0 to ϕ_1 as

(4) $$\Delta S = s_1 P_1 - s_0 P_0$$

Rearranging to obtain

(7) $$\Delta S = s_1 (P_1 - P_0) + (s_1 - s_0) P_0.$$

If ΔS is greater than zero for all $\phi_1 > \phi_0$ then higher coverage level means higher total net subsidy payment and the highest total subsidy will be achieved at the highest coverage level, as illustrated in Point A of figure 1. If this is not true, then we may see a relationship like that right panel in figure 1. For $\phi_1 > \phi_0$, table 1 indicates $s_0 > s_1$. We know from (5), $P_0 < P_1$ because higher coverage level means larger payout and higher probability of receiving payout. Then equation (7) means two changes in opposite directions with a movement from ϕ_0 and ϕ_1: additional subsidy from the increase in premium, i.e., $s_1(P_1 - P_0)$, and the lost subsidy due to the lowered subsidy rate for the original premium, i.e., $(s_1 - s_0)P_0$. In theory, we do not know whether ΔS will be positive when moving to a higher coverage level, although $\Delta S > 0$ is more likely with larger premium increase and smaller decline in subsidy rate.

If Hypothesis I is true and (A2) is true, then farmers will choose the highest coverage level. In the illustration of Figure 1, point A will be chosen on the left panel whereas B will not necessarily be chosen because the trade-off between risk coverage and subsidy payment will determine the optimal coverage level. Suppose ϕ^* is the coverage level with the highest subsidy. Compare ϕ^* with another coverage level denoted as ϕ' with $\phi' < \phi^*$. If ϕ' generates higher $E[U(\bullet)]$ than ϕ^*, then it implies that $E[U(\bullet)]$ declines with ϕ. For this to be true, we have to have the sum in the third line of equation (6) to be negative given that the sum of the first two lines are positive. However, the fact that $\phi' \le \phi^*$ and ϕ^* has the highest dollar subsidy means that dollar subsidy is increasing with coverage level, i.e., the third line is positive. This leads to the conclusion that a rational farmer will not choose a lower coverage level than ϕ^*.

Testable Hypothesis II: Given (A1) and (A2), let ϕ^* be the coverage level that generates the highest subsidy payments, then a farmer will choose ϕ^* or a higher coverage level.

With a premium schedule for each available insurance choice, it is straightforward to compute the subsidy for each of the choices, then we can evaluate to what extent Hypothesis II holds regarding farmers' coverage level choices.

Testable hypothesis II(a): For the coverage levels with the same subsidy rates in Table 1, the highest coverage level will be chosen.

This is a straightforward extension of Hypothesis II. Specifically, given that higher coverage level requires higher premium, then the schedule in Table 1 indicates that $\phi = 55\%$ is dominated by $\phi = 60\%$, and $\phi = 65\%$ is dominated by $\phi = 70\%$. That is, the coverage level $\phi = 55\%$ and $\phi = 65\%$ should not be chosen. This is because they are dominated by the next coverage level both in terms of risk coverage and the size of subsidy payment. To what extent this holds in the empirical data will indicate to what extent (A1) or (A2) or both are true.

To examine the relative subsidy payment across different insurance alternatives, we note that the 2008 farm bill requires that the rationale of increasing the premium for Enterprise Units (EU) was to equalize the insurance subsidies farmers get per acre under EU and those under Optional Units (OU) and Basic Units (BU). We can show whether this has been the case from the observed data:

Testable hypothesis III: Insurance subsidies farmers get per acre under EU and those under Optional Units (OU) and Basic Units (BU) are equal.

In our empirical analysis, we use the established rules for premium and subsidy calculation to reconstruct premiums and subsidies for yield and revenue insurance products at individual coverage levels that farmers face when making their choices.[3] This step is necessary because the insurance-unit level data do not provide premiums facing growers for contracts not chosen on a unit. Our focus is on revenue and yield insurance for corn and soybean crops. We then present a general picture of the relationships between insurance subsidies and farmers' crop insurance choices. In particular, we explore whether higher coverage level means higher subsidies within the same insurance plan and how farmers' insurance choice depended on government subsidies. Next, we employ discrete choice (e.g., mixed logit) models to estimate empirical relationships between farmers' insurance choices and determining factors, which include not only the constructed premium and subsidy, but also other farmer- and county-level

[3] We very much appreciate assistance from RMA officials when working through the implementation of these rules.

explanatory variables such as farmer's risk exposure, local geographic and climatic variables. Finally, we apply the model to develop insights on the nature of demand across coverage levels and product categories, to inquire into behavioral anomalies regarding demand. How our model can be applied to simulate over alternative policy reform scenarios will be discussed.

Summary Statistics of Insurance Choice, Premium and Subsidy

Unit level insurance record data of corn and soybean maintained by the Risk Management Agency (RMA) of the U.S. Department of Agriculture (USDA) are employed for the empirical analyses in the present study.[4] The individual insurance records contains information of an insurance unit on its location and size (e.g., state, county, acres, number of sections), production and practice (e.g., yield, planted crop, practice), and insurance choices (e.g., contract, coverage level, elected price, total premium and subsidy payment). As discussed above, we don't observe premiums and subsidies of insurance products that are not chosen by the farmer.[5] But these data are essential for our analysis. Therefore, we reconstruct per acre insurance premium and subsidy for each insurance unit in the sample by following the rules established by the RMA. In particular we focus on corn and soybean in 2009 and 997 counties of 12 states in the Midwest and Great Plains regions (IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, SD, and WI). We consider three insurance contracts, plans 25, 44 and 90.[6] For plans 44 and 90, farmers' choices are among eight coverage levels (50%, 55%, 60%, 65%, 70%, 75%, 80% and 85%), while plan 25 only provides coverage levels above 65% (i.e., 65%, 70%, 75%, 80% and 85%). As shown in table 2, the three plans cover 95% of farmers' enrolled acres for each crop. Note that with much smaller enrolled acres CAT insurance coverage, whose premium is fully covered by the federal government, is very different from other buy-up plans and thus is excluded from the sample. The

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[4] We thank RMA officials for making the data available.

[5] In this study an insurance product refers to a combination of insurance plan and coverage level.

[6] See the insurance plan names and codes in the lower panel of table 2. Readers are referred to the RMA website for more detailed definitions http://www.rma.usda.gov/policies/2013policy.html.

final constructed dataset includes per acre premium and subsidy of total 21 insurance products that farmers face when making their choices. These are 8 products of plan 90, 8 of plan 44, and 5 of plan 25 for each observed insurance unit.

A comprehensive summary of insurance products of corn for plans 90, 44 and 25 are presented in Tables 3, 4, and 5, respectively.[7] Panel A in the tables illustrates that within individual insurance plans, higher coverage levels (60%-85%) correspond to increasing APH yield, acres, and lower production risk, the latter of which is represented by increasing yield ratio, i.e., higher yield relative to county average yield.[8] In other words, larger size insurance units with higher yield and thus relatively lower production risk tend to choose higher insurance coverage levels. Panel A also reveals that around 90% of farmers in the sample choose coverage levels higher than 65%. The coverage level of 65% is the most popular choice in yield insurance plan (90), while 75% (70%) is the coverage level picked by the highest percentage of farmers buying revenue insurance plan 44 (25). The first two rows in Panel B of the tables 3, 4, and 5 report average premium and subsidy observed in the sample for the lowest coverage level available (50% for plans 90 and 44; 65% for plan 25). We see an inverse-U relationship between per acre premium (and subsidy) and coverage levels, which peaks at the level of 70% for both crops and all unit types except BU/OU of corn and OU of soybean. The other rows in panel B present average incremental increase in premium (or subsidy) a farmer would need to pay (or receive) if he holds the next higher coverage level. For example, \$8.96 (Table 3, the second to the last row) means that on average a farmer would need to pay an extra \$8.96 in order to hold the 85% coverage level instead of the 80% coverage level. We find that the extra premium increases significantly for coverage levels higher than 70%, while extra subsidy increases in relatively smaller amount.

In the following, we report the empirical tests for Hypotheses I-III discussed above.

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[7] Results for soybean are similar and are not presented here because of space limitation. They are available upon request.
[8] The discussion in this subsection is motivated by a similar discussion in Syndor (2010).

Hypothesis I states that higher coverage levels have higher subsidy payments. Figure 2 graphs the Gaussian kernel regression results for the three plans (90, 44 and 25) of corn and soybean, respectively.

Kernel regression is a non-parametric statistical method to estimate the potential non-linear relation between two random variables, y and x. The conditional expectation of y relates to the variable x by a non-parametric function f, $E(y \mid x) = f(x)$. The Gaussian kernel regression estimates the function f as a locally weighted average with a Gaussian kernel as the weighting function, which is based on the so-called Nadaraya-Watson estimator (Nadaraya 1964), and can be written as:

(6) $$\hat{f}_h(x) = \sum_{i=1}^{n} K_h(x - x_i) y_i / \sum_{i=1}^{n} K_h(x - x_i)$$

where K_h is the Gaussian kernel with bandwidth of h. The kernel regression results confirm that higher subsidy payments are associated with higher coverage levels.

Regarding Hypothesis II that farmers choose the coverage level (or a higher coverage level) that generates the highest subsidy payment, we run the matching test over units' observed choices and count the choices of the coverage level (or higher coverage levels) with the highest subsidy. The results in table 6 indicate that for plan 90 of corn 3.95% of farmers in the sample chose the coverage level with the highest subsidy payment, while the percentage increases to 9% for plan 25 and 21.43% for plan 44. Similar results are found for the insurance choices of soybean.

We also hypothesize that coverage levels 55% and 65% are dominated by the levels of 60% and 70%, respectively, and should not be considered in farmer's choices. But the test results presented in Table 7 provide limited support for this hypothesis. The 55% coverage level is not a popular choice purchased by less than 2% of all the units in plans 90 and 44. This level is not available for plan 25. 60% level is not a popular choice either. A significant number of farmers chose the level of 65% (over 30% for plan 90, about 14%-16% for plan 25, and around 6% for plan 90). 65% coverage is not dominated by the 70% coverage and two products are equally important in farmers choice.

Hypothesis III states that farmers under EU get equal amount of subsidy per acre to those under OU and BU. We use the typical t-test to test the null hypothesis of equal means of BU/OU and EU and report the average of percent differences per acre in Table 8. We find that the equal subsidy hypotheses are rejected for all coverage levels of all three plans.

In this section, using unit level insurance record data we test the three hypotheses based on the assumptions that farmers are rational in insurance choices and crop insurance premiums are actuarially fair. Consistent with Hypothesis I, per acre subsidy is found to increase with the coverage level except the level of 85%, which is not typically available for all the counties in the sample. In general, farmers' insurance product choice is not consistent with the hypothetical prediction. They typically don't choose the coverage level (or a higher level) that generates the highest subsidy payment. To further investigate the underlying determining factors in farmers' insurance choices, we turn to the Mixed Logit regression model in the next section.

Empirical estimation and results

For disclosing the driving forces of farmers' insurance choices, we set up the following mixed logit model in the random utility framework (Train 2009; Ch. 11). Mixed logit model allows capturing the heterogeneity of farmer's "taste" in choosing insurance products, which is unobservable to researcher such as risk preference, through the inclusion of random coefficients. Estimation of the distribution of the random coefficient including mean and variance provides useful information about the population. We assume normal distributions for all included random coefficients.

Let the subsidized contract choice set be $\Omega \equiv \{1, 2, \ldots, J\}$, the associated subsidy levels are s_k, $k \in \Omega$, and the associated coverage levels are $\phi = \phi_k$. We have *i*th insurance unit 'utility' under choice *k* in situation *t* as U_{ikt} with overall specification as

(7) $$U_{ikt} = x'_{ikt}\beta_i + z_{ikt}\alpha + \varepsilon_{ikt}, \qquad i \in \{1, 2, \ldots, N\}, \qquad k \in \Omega, \qquad t \in \{1, 2, \ldots, T\}.$$

where ε_{ikt} follows i.i.d. extreme value distribution. The coefficients in the vector of β_i are random. Each element of the coefficient vector is assumed to follow a Normal distribution with mean b_l and variance W_l. x_{ikt} admits unit-specific characteristics for the *l*th explanatory parameter of β_i. α is a vector of fixed coefficients on unit- and county-level variables included in vector z_{ikt}.

In our case, out-of-pocket premium payment (premium net of subsidy), yield guarantee and its squared term (yield guarantee^2) vary across choices for any given insurance unit and are included in the x matrix having random coefficients. Yield guarantee is defined as coverage level factor × Unit rate yield. The unit rate yield is the average of historical unit yield self-reported when signing the insurance contract. We hypothesize that demand for a given contract increases in yield guarantee, but it should also be convex because that the indemnity is convex in yield guarantee. The squared term is intended to capture the nonlinear effect.

For the variables in the z vector, we include individual risk indicator, which is defined as the inverse of yield ratio, i.e., the county reference yield divided by the unit rate yield. The reference yield is the average of county yield history. Therefore the variable of individual risk indicator reflects deviation of an individual farmer's yield from the county average and thus reflects individual farmers' risk exposure under various insurance products (Coble et al. 2010). The RMA assumes that higher rate yield (relative to the county reference yield) is associated with lower yield risk. Furthermore to control county fixed effects on farmers' insurance choices, we include a number of county-level explanatory variables such as county-level soil quality, growing season temperature and precipitation attributes. These variables do not vary for a given unit and are considered to be exogenous factors determining farmers decision and are briefly discussed next.[9]

County level soil quality (Soil) is represented by the percentages of farmland acres under Land Capability Classes (LCC) I and II in the total acreage of LCC I-IV. The effect of growing season temperature is captured by the variables of Growing-degree-days (GDD) and Overheating damage (GDD34). GDD is defined as the sum of degrees between lower and upper thresholds (8°C and 32°C, respectively, for both corn and soybean) during the growing season. GDD is the 31-year average over 1975-2005.[10] To capture the damaging effect of overheating on crop yields, GDD34 is constructed as the county average GDDs above 34°C over 1975-2005. The variable of Prec is constructed as average growing season precipitation for individual counties over the same period.[11]

The mixed logit model specified in (7) is estimated on 21 choices across three insurance plans (plans 90, 44 and 25) for corn and soybean separately using the Bayesian Monte carlo Markov Chain method (Train 2009, Ch. 12). As stated in Train (2009), one important advantage of Bayesian method over classical procedures is that the Bayesian method overcomes the convergence problem as classical methods need to maximize the simulated likelihood function and may fail to converge to the global maximum in many cases. We encounter the same convergence difficulty due to the large sample size, which is about 700,000-800,000 observations for each crop. Bayesian method is a viable solution in our case.

The estimation results presented in Table 9 provide evidence supporting that farmers prefer an insurance product with relatively lower out-of-pocket premium payment. It means that in choosing a insurance product, not only subsidy but also premium are factored into farmer’s decision. This is consistent with what we find in the test of the three hypotheses where we find that a majority of farmers didn’t choose the insurance product with the highest subsidy payment.

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[9] See Du, Hennessy and Feng 2013 for a more detailed discussion on the construction of these variables.

[10] The dataset developed in Schlenker and Roberts (2009) is used for the construction.

[11] Schlenker and Roberts’ (2009) dataset is also used for this calculation.

As expected, farmers' insurance choices tend to be associated with higher yield guarantee and the relationship between insurance choices and yield guarantee is convex.

As estimated in the mixed logit model the empirical relationships between insurance product choices and its determining factors will allow for an expectation on the probability of making insurance choices of farmers in the sample. We will be able to simulate what happens upon changing the subsidy rate schedule by keeping premium rate and other control variables unchanged. The budget consequences for a given county can also be characterized in the simulation.

Concluding remarks

In the present study, we first establish three testable hypotheses on farmers crop insurance choices. They are (i) higher coverage levels have higher subsidy payments, (ii) a farmer will choose the coverage level (or a higher level) that generates the highest subsidy payment, and (iii) premium subsidies per acre under different units are equal. The hypotheses are based on two critical assumptions that farmers are rational and premiums are actuarially fair. The hypotheses are found to be inconsistent with the observed farmers' choices, especially a majority of farmers did not choose the insurance product that pays the highest subsidy. Similar results are confirmed in a mixed logit regression that farmers factor in not only subsidy but also premium in making insurance product choices.

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Table 1. Crop Insurance Premium Subsidies on Yield- and Revenue-Based Products (government-paid portion of premium as a fraction of total premium)

Coverage level ϕ	CAT	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85
Subsidy rate for BU and OU	1.0	0.67	0.64	0.64	0.59	0.59	0.55	0.48	0.38
Subsidy rate for EU	NA	0.80	0.80	0.80	0.80	0.80	0.77	0.68	0.53

Table 2. Insurance choices summary statistics, 2009.

Buy-up	Corn		Soybean	
Insurance plans	Enrolled acres	% of total	Enrolled acres	% of total
12 (GRP)	648,833	0.01	953,020	0.02
25 (RA)	12,773,217	0.19	16,251,787	0.28
42 (IP)	71,110	0.001	80,236	0.001
44 (CRC)	43,417,618	0.65	31,503,341	0.54
45 (IIP)	59,764	0.001	26,610	0.001
73 (GRIP)	3,103,689	0.05	2,346,016	0.04
90 (APH)	7,114,696	0.11	7,677,462	0.13
Total enrolled acres	67,188,927		58,838,472	
CAT				
12	86,454	0.02	60480	0.01
45	7,410	<0.001		
90	4,600,456	0.98	5,579,823	0.99

Insurance Plan Code, Abbreviation, and Name		
12	GRP (Group Risk Plan)	Yield insurance
25	RA (Revenue Assurance)	Revenue insurance
42	IP (Income Protection)	Revenue insurance
44	CRC (Crop Revenue Coverage)	Revenue insurance
45	IIP (Indexed Income Protection)	Revenue insurance
73	GRIP (Group Risk Income Protection)	Revenue insurance
90	APH (Actual Production History)	Yield insurance

Table 3. Summary statistics for farmers' observed choices of plan 90, Corn.

Panel A	Full Sample	50%	55%	60%	65%	70%	75%	80%	85%
APH Yield	135.43	134.68	131.35	127.43	130.15	131.97	142.81	153.05	160.96
Current Yield ratio	1.11	1.11	1.08	1.09	1.09	1.11	1.12	1.15	1.17
Reported Acres	66.32	67.61	60.88	64.42	64.85	64.34	66.11	78.37	77.92
Share of unit type									
BU	0.44	0.14	0.02	0.05	0.32	0.21	0.17	0.05	0.03
EU	0.02	0.03	0.01	0.04	0.14	0.30	0.34	0.12	0.01
OU	0.54	0.11	0.01	0.05	0.29	0.28	0.18	0.06	0.03
Sample size	99838	11736	1498	5189	30238	24858	17933	5637	2749
Percent of sample	100.00 %	11.76%	1.50%	5.20%	30.29%	24.90%	17.96%	5.65%	2.75%

Panel B

BU	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
Premium 50	7.18	10.45	10.69	10.83	7.57	7.18	4.50	3.22	2.48
Subsidy 50	4.81	7.00	7.16	7.26	5.08	4.81	3.02	2.16	1.66
Premium 55	1.71	2.23	2.27	2.32	1.74	1.72	1.34	1.11	0.94
Subsidy 55	0.88	1.11	1.13	1.16	0.89	0.89	0.72	0.61	0.52
Premium 60	2.04	2.59	2.62	2.70	2.06	2.05	1.64	1.39	1.22
Subsidy 60	1.31	1.66	1.68	1.73	1.32	1.31	1.05	0.89	0.78
Premium 65	2.40	3.02	3.04	3.13	2.41	2.41	1.96	1.68	1.48
Subsidy 65	0.87	1.02	1.01	1.06	0.85	0.88	0.78	0.71	0.64
Premium 70	3.67	4.68	4.69	4.85	3.70	3.70	2.95	2.50	2.19
Subsidy 70	2.16	2.76	2.77	2.86	2.18	2.18	1.74	1.48	1.29
Premium 75	4.46	5.63	5.65	5.84	4.49	4.52	3.63	3.09	2.72
Subsidy 75	1.77	2.18	2.17	2.26	1.77	1.80	1.50	1.31	1.16
Premium 80	5.34	6.71	6.67	6.93	5.37	5.41	4.40	3.76	3.31
Subsidy 80	1.06	1.22	1.18	1.25	1.04	1.08	0.99	0.89	0.82
Premium 85	6.39	7.99	7.93	8.25	6.42	6.46	5.30	4.54	4.03
Subsidy 85	-0.25	-0.50	-0.55	-0.53	-0.30	-0.25	-0.03	0.05	0.10

EU	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
Premium 50	12.30	10.88	16.78	11.84	10.69	12.03	13.00	12.64	16.03
Subsidy 50	9.84	8.71	13.43	9.47	8.55	9.62	10.40	10.11	12.82
Premium 55	2.25	1.96	2.96	2.21	2.14	2.22	2.33	2.19	2.77
Subsidy 55	1.80	1.57	2.36	1.77	1.71	1.78	1.87	1.76	2.21
Premium 60	2.61	2.21	3.59	2.64	2.45	2.57	2.75	2.47	3.17
Subsidy 60	2.09	1.77	2.87	2.11	1.96	2.06	2.20	1.97	2.53
Premium 65	2.95	2.50	3.93	2.97	2.80	2.91	3.11	2.76	3.61
Subsidy 65	2.36	2.00	3.14	2.38	2.24	2.33	2.49	2.21	2.89
Premium 70	4.64	4.02	5.80	4.72	4.38	4.55	4.92	4.38	5.43

Subsidy 70	3.71	3.22	4.64	3.78	3.50	3.64	3.93	3.50	4.35
Premium 75	5.40	4.73	6.76	5.69	5.19	5.33	5.65	5.01	5.93
Subsidy 75	3.41	3.00	4.21	3.65	3.33	3.38	3.57	3.13	3.64
Premium 80	6.26	5.57	7.82	6.79	6.13	6.24	6.45	5.77	6.84
Subsidy 80	1.54	1.42	1.74	1.91	1.68	1.58	1.52	1.27	1.33
Premium 85	7.47	6.69	9.07	8.01	7.33	7.41	7.76	6.73	8.70
Subsidy 85	-1.50	-1.24	-2.34	-1.28	-1.18	-1.45	-1.62	-1.72	-1.95
OU	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
Premium 50	11.25	15.30	17.28	18.53	11.45	11.32	8.66	5.60	3.84
Subsidy 50	7.54	10.25	11.58	12.41	7.67	7.58	5.80	3.75	2.58
Premium 55	2.50	3.10	3.39	3.54	2.50	2.52	2.17	1.68	1.41
Subsidy 55	1.26	1.52	1.65	1.71	1.26	1.27	1.13	0.91	0.78
Premium 60	2.93	3.55	3.84	4.00	2.91	2.95	2.60	2.08	1.80
Subsidy 60	1.88	2.27	2.46	2.56	1.87	1.89	1.66	1.33	1.15
Premium 65	3.41	4.07	4.35	4.53	3.38	3.44	3.07	2.49	2.18
Subsidy 65	1.17	1.30	1.34	1.37	1.15	1.19	1.14	1.00	0.94
Premium 70	5.25	6.30	6.73	7.08	5.22	5.32	4.67	3.74	3.24
Subsidy 70	3.10	3.72	3.97	4.18	3.08	3.14	2.76	2.21	1.91
Premium 75	6.34	7.53	7.92	8.35	6.29	6.46	5.69	4.60	4.01
Subsidy 75	2.47	2.85	2.93	3.08	2.44	2.53	2.28	1.91	1.71
Premium 80	7.52	8.88	9.23	9.72	7.45	7.67	6.84	5.56	4.89
Subsidy 80	1.39	1.47	1.38	1.44	1.35	1.44	1.40	1.26	1.19
Premium 85	8.96	10.50	10.90	11.40	8.87	9.14	8.21	6.73	5.93
Subsidy 85	-0.51	-0.88	-1.13	-1.24	-0.55	-0.49	-0.25	-0.02	0.11

Table 4. Summary statistics for farmers' observed choices of plan 44, Corn.

Panel A	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
APH Yield	147.99	132.58	130.69	124.05	138.52	138.94	146.00	154.40	164.32
Current Yield ratio	1.16	1.13	1.12	1.11	1.13	1.14	1.16	1.18	1.20
Reported Acres	82.93	71.91	69.81	67.38	78.48	77.39	79.87	86.29	98.45
Share of Unit type									
BU	0.19	0.016	0.005	0.019	0.106	0.292	0.333	0.174	0.055
EU	0.46	0.007	0.001	0.005	0.023	0.083	0.279	0.394	0.207
OU	0.35	0.009	0.003	0.019	0.105	0.343	0.337	0.145	0.038
Sample size	610425	5856	1523	7493	41108	129958	188735	162605	73147
Percent of sample	100.00%	0.96%	0.25%	1.23%	6.73%	21.29%	30.92%	26.64%	11.98%
Panel B									
BU	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
Premium 50	8.61	17.69	16.75	16.87	10.51	9.70	7.78	6.26	5.51
Subsidy 50	5.77	11.86	11.23	11.30	7.04	6.50	5.21	4.19	3.69
Premium 55	2.57	3.97	3.84	3.75	2.85	2.75	2.49	2.17	1.98
Subsidy 55	1.39	2.01	1.95	1.90	1.51	1.47	1.36	1.20	1.10
Premium 60	3.19	4.69	4.57	4.42	3.47	3.37	3.11	2.77	2.55
subsidy 60	2.04	3.00	2.93	2.83	2.22	2.15	1.99	1.77	1.63
Premium 65	3.89	5.54	5.43	5.21	4.19	4.08	3.82	3.42	3.17
Subsidy 65	1.58	1.95	1.95	1.82	1.63	1.62	1.58	1.46	1.37
Premium 70	5.96	8.62	8.45	8.12	6.45	6.27	5.82	5.21	4.81
Subsidy 70	3.52	5.09	4.98	4.79	3.81	3.70	3.44	3.07	2.84
Premium 75	7.56	10.57	10.35	9.93	8.10	7.92	7.42	6.70	6.21
Subsidy 75	3.19	4.19	4.13	3.93	3.36	3.31	3.16	2.89	2.69
Premium 80	9.49	12.80	12.58	12.03	10.05	9.87	9.38	8.56	7.98
Subsidy 80	2.33	2.57	2.58	2.39	2.33	2.35	2.37	2.25	2.13
Premium 85	11.95	15.51	15.27	14.55	12.46	12.31	11.88	11.02	10.34
Subsidy 85	0.42	-0.49	-0.39	-0.50	0.17	0.28	0.53	0.68	0.71
EU	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
Premium 50	9.09	15.55	14.19	18.30	13.01	13.48	11.02	8.16	5.62
Subsidy 50	7.28	12.44	11.35	14.64	10.41	10.78	8.82	6.53	4.50
Premium 55	2.62	3.60	3.51	4.01	3.26	3.30	2.94	2.50	1.99
Subsidy 55	2.09	2.88	2.81	3.21	2.61	2.64	2.35	2.00	1.59
Premium 60	3.23	4.26	4.20	4.72	3.93	3.95	3.57	3.11	2.54
Subsidy 60	2.58	3.41	3.36	3.77	3.15	3.16	2.86	2.48	2.03
Premium 65	3.92	5.07	5.00	5.54	4.69	4.71	4.30	3.80	3.15
Subsidy 65	3.14	4.06	4.00	4.43	3.75	3.77	3.44	3.04	2.52
Premium 70	5.35	6.91	6.78	7.44	6.36	6.37	5.85	5.20	4.33
Subsidy 70	4.28	5.53	5.43	5.95	5.09	5.10	4.68	4.16	3.46
Premium 75	6.65	8.41	8.27	8.99	7.81	7.79	7.22	6.50	5.48

Subsidy 75	4.40	5.42	5.35	5.72	5.07	5.05	4.73	4.32	3.69
Premium 80	7.86	9.43	8.81	7.21	8.12	8.42	8.06	8.05	6.90
Subsidy 80	2.56	2.47	2.22	0.50	2.00	2.16	2.34	2.84	2.61
Premium 85	10.06	12.04	11.71	12.18	11.22	11.18	10.60	9.99	8.74
Subsidy 85	-0.48	-1.61	-1.41	-1.98	-1.13	-1.28	-0.82	-0.30	0.13
OU	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
Premium 50	12.75	22.44	26.30	23.31	15.14	14.09	11.72	9.09	8.35
Subsidy 50	8.54	15.04	17.62	15.62	10.15	9.44	7.85	6.09	5.59
Premium 55	3.70	5.06	5.62	5.10	3.97	3.87	3.62	3.17	3.00
Subsidy 55	1.99	2.56	2.81	2.57	2.09	2.05	1.97	1.76	1.67
Premium 60	4.56	5.95	6.55	5.98	4.80	4.72	4.50	4.02	3.84
Subsidy 60	2.92	3.81	4.19	3.83	3.07	3.02	2.88	2.57	2.46
Premium 65	5.54	7.00	7.62	7.01	5.77	5.71	5.51	4.96	4.75
Subsidy 65	2.22	2.46	2.57	2.42	2.21	2.23	2.26	2.11	2.04
Premium 70	8.51	10.91	11.79	10.97	8.90	8.78	8.42	7.54	7.21
Subsidy 70	5.02	6.44	6.95	6.47	5.25	5.18	4.97	4.45	4.26
Premium 75	10.76	13.32	14.17	13.33	11.14	11.07	10.71	9.69	9.29
Subsidy 75	4.52	5.27	5.48	5.24	4.58	4.60	4.54	4.18	4.02
Premium 80	13.47	16.12	16.92	16.05	13.77	13.77	13.48	12.35	11.89
Subsidy 80	3.26	3.21	3.08	3.11	3.13	3.23	3.36	3.24	3.16
Premium 85	16.88	19.49	20.27	19.31	17.02	17.12	16.99	15.82	15.32
Subsidy 85	0.49	-0.68	-1.19	-0.84	0.12	0.30	0.66	0.93	0.99

Table 5. Summary statistics for farmers' observed choices of plan 25, Corn.

Panel A	Full sample	65%	70%	75%	80%	85%
APH Yield	126.94	124.73	122.50	129.39	136.19	144.13
Current Yield ratio	1.14	1.12	1.13	1.14	1.17	1.17
Reported Acres	72.75	72.62	73.11	72.45	72.19	74.59
Share of Unit type						
- BU	0.27	0.215	0.454	0.263	0.055	0.013
- EU	0.22	0.063	0.205	0.401	0.287	0.042
- OU	0.51	0.175	0.459	0.286	0.067	0.013
Sample size	210661	33838	84430	64427	23865	4101
Percent of sample	100.00%	16.06%	40.08%	30.58%	11.33%	1.95%
Panel B						
BU	Full sample	65%	70%	75%	80%	85%
Premium 65	25.00	25.43	25.81	23.96	23.01	18.94
Subsidy 65	14.75	15.01	15.23	14.13	13.57	11.18
Premium 70	7.67	7.51	7.57	7.85	8.16	7.90
Subsidy 70	4.52	4.43	4.47	4.63	4.82	4.66
Premium 75	9.31	9.08	9.15	9.59	10.05	9.85
Subsidy 75	3.81	3.68	3.70	4.00	4.28	4.34
Premium 80	10.22	9.72	9.87	10.74	12.19	12.07
Subsidy 80	1.97	1.72	1.76	2.26	2.96	3.23
Premium 85	13.09	12.67	12.74	13.64	14.60	14.59
Subsidy 85	-0.25	-0.36	-0.40	-0.03	0.21	0.67
EU	Full sample	65%	70%	75%	80%	85%
Premium 65	30.45	31.94	34.98	31.25	26.97	22.21
Subsidy 65	24.36	25.55	27.99	25.00	21.58	17.77
Premium 70	8.64	8.48	8.76	8.66	8.55	8.67
Subsidy 70	6.91	6.78	7.01	6.93	6.84	6.93
Premium 75	10.31	10.09	10.36	10.32	10.28	10.56
Subsidy 75	6.77	6.56	6.66	6.75	6.85	7.20
Premium 80	9.58	9.18	7.95	9.41	10.70	12.04
Subsidy 80	2.07	1.70	0.54	1.88	3.15	4.46
Premium 85	13.60	13.25	13.20	13.52	13.89	14.77
Subsidy 85	-1.64	-1.93	-2.31	-1.78	-1.11	-0.19
OU	Full sample	65%	70%	75%	80%	85%
Premium 65	35.49	36.23	37.07	33.95	30.59	28.94
Subsidy 65	20.94	21.38	21.87	20.03	18.05	17.08
Premium 70	10.83	10.53	10.81	11.00	11.01	11.10
Subsidy 70	6.39	6.21	6.38	6.49	6.50	6.55
Premium 75	13.14	12.71	13.05	13.43	13.57	13.74
	(5.18)	(5.39)	(5.30)	(4.91)	(4.95)	(4.54)

Subsidy 75	5.38	5.12	5.26	5.59	5.80	5.96
Premium 80	14.27	13.39	13.53	15.37	16.48	16.75
Subsidy 80	2.69	2.27	2.23	3.29	4.05	4.28
Premium 85	18.42	17.63	18.04	19.13	19.77	20.16
Subsidy 85	-0.37	-0.59	-0.59	-0.11	0.35	0.61

Table 6. Empirical test results for Hypothesis II.

	# of observations choosing highest subsidy payment	% of total samples
Corn; plan 90	3,394	3.95
Corn; plan 44	130,812	21.43
Corn; plan 25	18,968	9.00
Soybean; plan 90	3,792	3.16
Soybean; plan 44	64,790	13.81
Soybean; plan 25	29,687	10.48

Table 7. Empirical test results for Hypothesis II (a).

	# of obs. choosing 55% coverage level	% of total samples	# of obs. choosing 60% coverage level	% of total samples	# of obs. choosing 65% coverage level	% of total samples	# of obs. choosing 70% coverage level	% of total samples
Corn plan 90	1,498	1.50	5,189	5.20	30,238	30.29	24,858	24.90
Corn plan 44	1,523	0.25	7,493	1.23	41,108	6.73	129,958	21.29
Corn plan 25	--	--	--	--	33,838	16.06	84,430	40.08
Soybean plan 90	1,754	1.46	5,618	4.68	35,830	29.88	30,906	25.77
Soybean plan 44	1,148	0.24	5,725	1.22	29,696	6.33	85,356	18.20
Soybean plan 25	--	--	--	--	38,539	13.61	109,393	38.63

Table 8. Average of percent differences of per acre subsidy between units.

		50%	55%	60%	65%	70%	75%	80%	85%
Corn-90	(BU-EU)/EU	-51%	-51%	-49%	-51%	-49%	-49%	-48%	-46%
	(OU-EU)/EU	-23%	-24%	-22%	-26%	-25%	-25%	-24%	-21%
Corn-44	(BU-EU)/EU	-21%	-24%	-23%	-29%	-26%	-26%	-25%	-22%
	(OU-EU)/EU	17%	12%	13%	4%	7%	6%	8%	12%
Corn-25	(BU-EU)/EU	--	--	--	-39%	-38%	-39%	-38%	-36%
	(OU-EU)/EU	--	--	--	-14%	-13%	-14%	-12%	-9%
Soybean-90	(BU-EU)/EU	-40%	-40%	-38%	-39%	-37%	-37%	-8%	-7%
	(OU-EU)/EU	-8%	-10%	-7%	-10%	-7%	-8%	29%	31%
Soybean-44	(BU-EU)/EU	-12%	-15%	-14%	-20%	-17%	-18%	-17%	-13%
	(OU-EU)/EU	22%	18%	19%	10%	14%	14%	15%	20%
Soybean-25	(BU-EU)/EU	--	--	--	-23%	-24%	-27%	-28%	-27%
	(OU-EU)/EU	--	--	--	8%	7%	2%	-1%	1%

Table 9. Mixed logit model estimation results for corn and soybean (standard errors are in the parentheses)

Corn

Random coefficient (normal distribution parameters)	Mean	Std. Dev.
Out-of-pocket Premium	-0.26***	0.03***
	(0.01)	(0.002)
Yield guarantee	1.22***	0.18***
	(0.37)	(0.05)
Yield guarantee^2	0.006***	0.0006***
	(0.0009)	(0.0001)

Fixed coefficients

Variables	Estimates	Variables	Estimates	Variables	Estimates	Variables	Estimates	Variables	Estimates	Variables	Estimates
Intercept	3.12***	Risk	0.66	LCC	-1.96***	GDD	-1.86***	GDD34	1.03***	Prec	0.71***
90-55%	(0.49)	90-55%	(0.57)	90-55%	(0.21)	90-55%	(0.33)	90-55%	(0.29)	90-55%	(0.19)
90-60%	7.23***	90-60%	5.74***	90-60%	-3.11***	90-60%	-0.48**	90-60%	-1.36***	90-60%	-0.62
	(0.76)		(1.12)		(0.43)		(0.22)		(0.25)		(0.50)
90-65%	10.19***	90-65%	11.19***	90-65%	-5.46***	90-65%	-2.03***	90-65%	0.57**	90-65%	0.63***
	(1.35)		(1.19)		(0.62)		(0.45)		(0.28)		(0.24)
90-70%	11.40***	90-70%	11.63***	90-70%	-6.39***	90-70%	-2.96***	90-70%	-0.69*	90-70%	0.83***
	(1.57)		(1.16)		(0.60)		(0.55)		(0.42)		(0.26)
90-75%	4.97***	90-75%	9.50***	90-75%	-6.50***	90-75%	-3.17***	90-75%	-3.62***	90-75%	1.16***
	(0.59)		(1.32)		(0.63)		(0.30)		(0.77)		(0.23)
90-80%	-3.19***	90-80%	-3.58***	90-80%	-2.68***	90-80%	-0.17	90-80%	-2.28**	90-80%	-1.07***
	(0.22)		(0.29)		(0.21)		(0.35)		(0.92)		(0.22)
90-85%	-21.24***	90-85%	-16.22***	90-85%	11.98***	90-85%	6.68***	90-85%	5.09***	90-85%	-3.47***
	(2.42)		(1.28)		(0.90)		(0.60)		(0.70)		(0.42)
44-50%	-1.40***	44-50%	1.42***	44-50%	0.40*	44-50%	1.20***	44-50%	-0.55	44-50%	-0.30
	(0.24)		(0.47)		(0.24)		(0.28)		(0.39)		(0.30)
44-55%	2.70***	44-55%	1.33**	44-55%	-0.67	44-55%	-1.33***	44-55%	-0.32	44-55%	2.00***
	(0.51)		(0.52)		(0.60)		(0.25)		(0.20)		(0.23)
44-60%	6.55***	44-60%	8.10***	44-60%	-2.96***	44-60%	-0.58**	44-60%	0.84**	44-60%	0.08
	(0.83)		(0.92)		(0.42)		(0.27)		(0.40)		(0.34)
44-65%	12.29***	44-65%	11.11***	44-65%	-5.26***	44-65%	-1.39***	44-65%	-0.32	44-65%	-0.68***
	(1.52)		(0.98)		(0.62)		(0.35)		(0.24)		(0.20)
44-70%	15.38***	44-70%	11.23***	44-70%	-6.32***	44-70%	-2.76***	44-70%	-1.76***	44-70%	0.24
	(1.96)		(0.66)		(0.63)		(0.46)		(0.58)		(0.18)

44-75%	11.51***	44-75%	8.25***	44-75%	-5.99***	44-75%	-4.15***	44-75%	-3.55***	44-75%	0.87***
	(0.96)		(0.87)		(0.63)		(0.56)		(0.55)		(0.25)
44-80%	2.52***	44-80%	-1.94***	44-80%	-1.95***	44-80%	-2.33***	44-80%	-3.32***	44-80%	-0.54**
	(0.40)		(0.48)		(0.19)		(0.31)		(0.46)		(0.23)
44-85%	-16.10***	44-85%	-14.76***	44-85%	10.95***	44-85%	6.10***	44-85%	5.85***	44-85%	-4.14***
	(2.03)		(1.67)		(0.86)		(0.51)		(0.59)		(0.87)
25-65%	11.71***	25-65%	11.64***	25-65%	-5.14***	25-65%	-1.87***	25-65%	1.01***	25-65%	0.04
	(1.17)		(1.31)		(0.64)		(0.46)		(0.26)		(0.24)
25-70%	14.79***	25-70%	12.07***	25-70%	-5.92***	25-70%	-2.84***	25-70%	-0.69	25-70%	0.65***
	(1.91)		(1.31)		(0.63)		(0.47)		(0.58)		(0.17)
25-75%	10.66***	25-75%	8.83***	25-75%	-5.66***	25-75%	-3.90***	25-75%	-2.92***	25-75%	0.61***
	(0.85)		(0.84)		(0.62)		(0.53)		(0.56)		(0.17)
25-80%	0.31	25-80%	-0.55	25-80%	-1.63***	25-80%	-2.13***	25-80%	-3.05***	25-80%	-1.93***
	(0.38)		(0.33)		(0.17)		(0.28)		(0.31)		(0.39)
25-85%	-18.14***	25-85%	-14.08***	25-85%	11.72***	25-85%	5.20***	25-85%	5.94***	25-85%	-4.04***
	(2.27)		(1.43)		(0.98)		(0.79)		(0.65)		(0.57)

Soybean

Random coefficient (normal distribution parameters)	Mean	Std. Dev.
Out-of-pocket Premium	-0.06***	0.015***
	(0.006)	(0.001)
Yield guarantee	2.27**	19.77
	(0.91)	(14.38)
Yield guarantee^2	0.008	0.007***
	(0.01)	(0.003)

Fixed coefficients

Variables	Estimates	Variables	Estimates	Variables	Estimates	Variables	Estimates	Variables	Estimates	Variables	Estimates
Intercept	2.56***	Risk	-1.96***	LCC	-0.96	GDD	-0.18	GDD34	2.03***	Prec	0.89***
90-55%	(0.24)	90-55%	(0.36)	90-55%	(0.49)	90-55%	(0.30)	90-55%	(0.31)	90-55%	(0.15)
90-60%	3.31***	90-60%	3.12***	90-60%	-0.88***	90-60%	0.31	90-60%	0.06	90-60%	-1.07***
	(0.34)		(0.79)		(0.15)		(0.28)		(0.15)		(0.31)
90-65%	5.10***	90-65%	5.73***	90-65%	-1.50***	90-65%	-0.67***	90-65%	1.76***	90-65%	0.55*
	(0.49)		(0.72)		(0.14)		(0.16)		(0.21)		(0.30)
90-70%	4.66***	90-70%	5.39***	90-70%	-1.88***	90-70%	-0.72***	90-70%	0.20	90-70%	0.43**
	(0.58)		(0.36)		(0.13)		(0.19)		(0.21)		(0.18)

90-75%	0.73** (0.32)	90-75%	4.69*** (0.21)	90-75%	-2.22*** (0.15)	90-75%	-1.23*** (0.19)	90-75%	-2.14*** (0.33)	90-75%	0.61*** (0.20)
90-80%	-1.86*** (0.27)	90-80%	-1.05*** (0.42)	90-80%	-1.78*** (0.23)	90-80%	-0.85*** (0.28)	90-80%	-0.84*** (0.25)	90-80%	-0.61*** (0.23)
90-85%	-9.79*** (1.02)	90-85%	-7.42*** (0.56)	90-85%	0.16 (0.39)	90-85%	0.02 (0.30)	90-85%	1.88*** (0.54)	90-85%	-0.57 (0.30)
44-50%	-0.96*** (0.23)	44-50%	-0.05 (0.25)	44-50%	-0.07 (0.16)	44-50%	0.06 (0.19)	44-50%	0.55 (0.50)	44-50%	1.31*** (0.19)
44-55%	1.69*** (0.49)	44-55%	-0.99*** (0.19)	44-55%	0.14 (0.33)	44-55%	-0.37 (0.30)	44-55%	-0.93** (0.43)	44-55%	2.42*** (0.24)
44-60%	3.17*** (0.64)	44-60%	4.05*** (0.37)	44-60%	-0.73*** (0.12)	44-60%	1.64*** (0.24)	44-60%	0.51 (0.37)	44-60%	-0.55* (0.32)
44-65%	6.43*** (0.93)	44-65%	4.74*** (0.25)	44-65%	-1.43*** (0.13)	44-65%	-0.35* (0.18)	44-65%	1.04*** (0.24)	44-65%	0.32 (0.26)
44-70%	7.05*** (0.68)	44-70%	4.66*** (0.26)	44-70%	-1.86* (0.08)	44-70%	-0.70*** (0.16)	44-70%	-1.37*** (0.21)	44-70%	0.11 (0.20)
44-75%	6.10*** (0.40)	44-75%	2.05*** (0.19)	44-75%	-1.95*** (0.12)	44-75%	-2.07*** (0.18)	44-75%	-2.14*** (0.32)	44-75%	0.92*** (0.12)
44-80%	1.16*** (0.37)	44-80%	-1.28*** (0.32)	44-80%	-1.41*** (0.2)	44-80%	-2.01*** (0.38)	44-80%	-2.41*** (0.20)	44-80%	1.53*** (0.15)
44-85%	-9.77*** (1.19)	44-85%	-4.96*** (0.43)	44-85%	-0.29 (0.40)	44-85%	0.18 (0.34)	44-85%	1.57*** (0.22)	44-85%	-1.08*** (0.21)
25-65%	6.21*** (0.56)	25-65%	5.53*** (0.55)	25-65%	-1.10*** (0.11)	25-65%	-0.52*** (0.19)	25-65%	1.55*** (0.15)	25-65%	0.77*** (0.29)
25-70%	8.40*** (0.70)	25-70%	4.31*** (0.28)	25-70%	-1.08*** (0.06)	25-70%	-0.68*** (0.17)	25-70%	0.02 (0.12)	25-70%	0.78*** (0.21)
25-75%	4.88*** (0.42)	25-75%	3.97*** (0.22)	25-75%	-1.17*** (0.11)	25-75%	-1.51*** (0.22)	25-75%	-1.54*** (0.22)	25-75%	0.94*** (0.14)
25-80%	0.54 (0.28)	25-80%	-1.46** (0.68)	25-80%	-0.82*** (0.19)	25-80%	-1.84*** (0.42)	25-80%	0.05 (0.21)	25-80%	0.24* (0.14)
25-85%	-11.77*** (1.13)	25-85%	-8.04*** (0.22)	25-85%	2.04*** (0.40)	25-85%	2.08*** (0.43)	25-85%	2.72*** (0.28)	25-85%	-3.16*** (0.45)

Note: Due to computational complexity the mixed logit models are run on a randomly selected dataset of 10,000 observations.

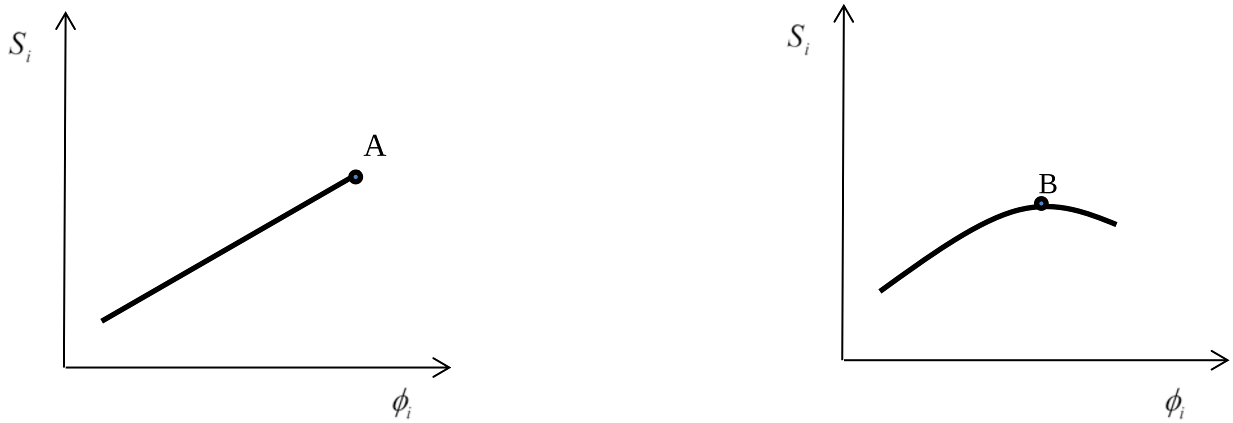
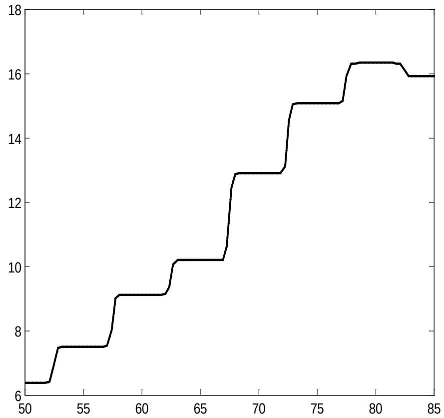
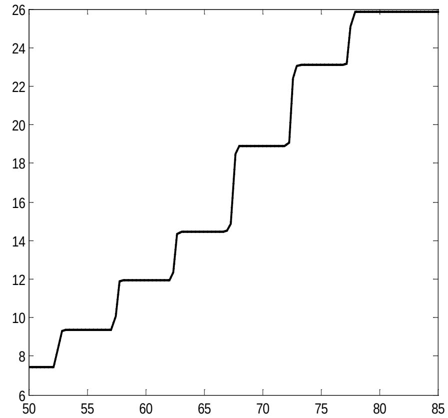


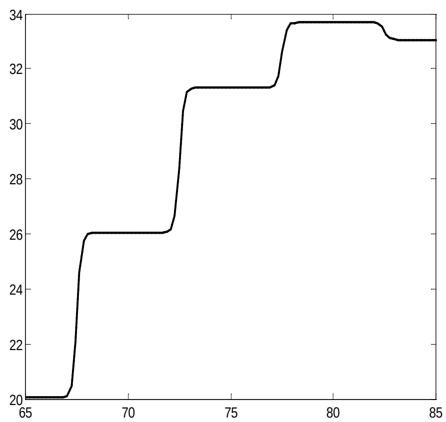
Figure 1. Two illustrations of the relationship between coverage level and premium subsidies



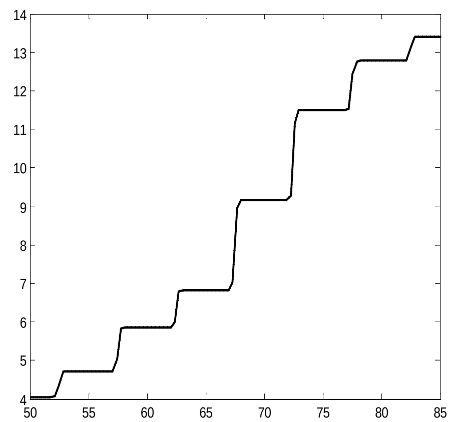
(i) Corn, Plan 90



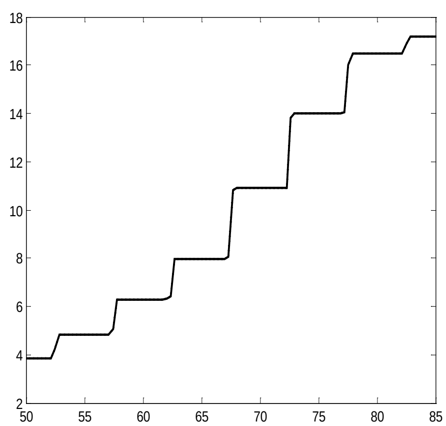
(ii) Corn, Plan 44



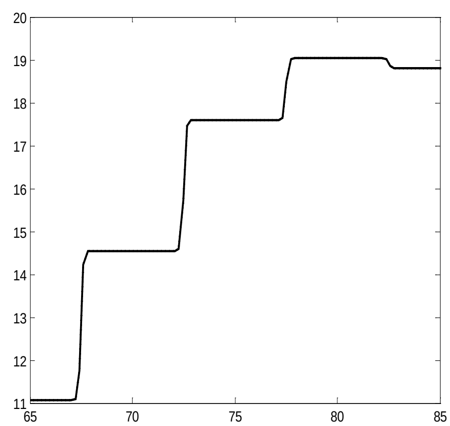
(iii) Corn, Plan 25



(iv) Soybean, Plan 90



(v) Soybean, Plan 44



(vi) Soybean, Plan 25

Figure 2. Empirical test results of Hypothesis I.