Rationality of Choices in Subsidized Crop Insurance Markets

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ABSTRACT

The U.S. crop insurance market has several features that set it apart from other insurance markets. These include:(*a*) explicit government subsidies with an average premium subsidy rate of about 60% in recent years; and (*b*) the legislative requirement that premium rates be set at actuarially fair levels, where the federal government sets rates and pays all costs related to insurance policy sales and services. Bearing these features in mind, we examine to what extent farmers' crop insurance choices conform to economic theory. A standard expected utility maximization framework is set up to analyze tradeoffs between higher risk protection and larger subsidy payments. Given an actuarially fair premium, a rational farmer should choose either the coverage level with the highest premium subsidy or a higher coverage level. Evidence from a large insurance unit level dataset contradicts this theoretical inference, and so suggests anomalous insurance decisions. Mixed logit estimation reveals that larger out-of-pocket premium reduces the probability that an insurance product is chosen.

Keywords: actuarial fairness; behavioral anomalies; premium subsidy; under-insurance.
JEL Classification: D03, H25, Q18.
Highlights:

- Under standard economic theory, farmers should choose subsidized crop insurance contracts at high coverage levels.
- Scrutiny of contract choice data shows that farmers underinsure their crops.
- A mixed logit model suggests that behavior is motivated by aversion to incurring out-of-pocket premiums.

1. Introduction

In the public policy arena how consumers respond to insurance subsidies is of considerable importance. Adverse selection and community-based rating requirements can lead insurance markets to collapse as rate increases lead to exit by less-risky contract holders and thus further rate increases. Apart from income transfer motives, subsidies can promote insurance market performance—incentivizing comparatively low-risk prospects to enter and remain in the market, thus preventing collapse. Publicly funded insurance subsidies are provided in a variety of contexts. The United States Federal Emergency Management Agency provided explicit flood insurance for many years, until phase-out commenced in 2012. The U.S. Patient Protection and Affordable Care Act (Obamacare) provides income-dependent health insurance subsidies.

A large literature exists on insurance and decision making regarding financial risks. Results from basic theoretical models under rational behavior, where expected utility maximization is the standard model are foundational in this literature. For example, a risk-averse individual will purchase full coverage when faced with an actuarially fair insurance policy (Mossin 1968). Data from controlled experiments as well as real world insurance choices have been examined in the literature to compare economic theories with real choices. Some inconsistencies, so-called anomalies, have been noted between data and the standard model. In some markets, over-insurance occurs while in others we observe under-insurance.

These inconsistencies arise in a variety of sectors and financial situations such as auto and home insurance, health insurance, and the purchase of an extended warranty for electronic products. It is clear that how agents' decisions deviate from inferences grounded in standard choice theory under uncertainty depends on the choice-taking context. For example, in auto and home insurance, people tend to buy lower deductible policies than should be optimal for them (e.g., Rabin and Thaler 2001; Sydnor 2010), that is, they over-insure. By contrast, many eligible for free health insurance have not enrolled (Baicker, Congdon, and Mullainathan 2012).

In this paper, we will consider a large and distinctive insurance market for crop insurance in the United States, which has so far received little attention regarding the extent to which insurance coverage decisions are consistent with predictions from economic theory. The market is distinctive because large and explicit government subsidies are provided—an arm of the government sets premiums and these premiums are required by law to be actuarially fair. Our analysis seeks to shed further light on how people make insurance decisions in addition to providing an understanding of the effectiveness of a large federal program. Most of the considerable body of research on U.S. crop insurance has focused on issues related to product design, rate-setting, and farmers' participation decisions (e.g., Goodwin 2001; Sherrick et al. 2004; Norwood, Roberts, and Lusk 2004). However, there is a dearth of research on whether farmers' coverage level choices are consistent with economic theory, and how premiums and subsidies affect coverage level choices.

While crop insurance is ostensibly intended for farmers to manage production and marketing risks, the program is widely viewed as primarily an income subsidy (Goodwin and Smith 2013). It is reasonable to assume that individual farmers are at least partly motivated to insure in order to maximize subsidy transfers, or equivalently to maximize total net return when the premium is set at the actuarially fair level. Our research has two motivations. Firstly we will investigate the validity of this 'transfer maximization' claim by reconstructing premiums and subsidies given on available insurance products and coverage levels for individual farmers using United States Risk Management Agency (RMA) historical insurance unit level records. Secondly, we intend to shed light on the role of government subsidies and insurance premiums in insurance product choices. To this end, the empirical relationships we estimate between insurance product choices and its determining factors can be used for policy purposes (e.g., to assess the potential effects of any post 2014 U.S. Farm Bill insurance reforms on farmers' insurance choices and consequent premium subsidy payments).

We will commence by outlining the relevant features of the U.S. crop insurance market, and will then provide the formal framework in which we develop behavioral hypotheses. Data will be explained, the hypotheses will be confronted with descriptive statistics, and econometric analysis will be conducted to test these hypotheses. A comparison of our findings with the literature will be followed by concluding remarks.

2. Crop Insurance Markets

In this section, we briefly explain the history of the federal crop insurance program with a focus on changes in the structure and level of subsidies.[1] Broadly speaking, the program presently offers two types of insurance products. Yield insurance triggers payoffs when yield falls short of a predetermined level, while revenue insurance pays out when revenue falls short of a predetermined level. Predetermined yield is usually based on historical yield whereas predetermined revenue is the product of this historical yield and a price established for an insurance plan in a given year. The RMA at the U.S. Department of Agriculture (USDA) has administered the federal crop insurance program since 1996. Over the years, the program has evolved with changes in contract offerings as the USDA continues to improve rating methods and develop products to meet program goals.

Federal crop insurance was first authorized by Congress in the 1930s but remained essentially an experimental program for many decades with limited availability in terms of crops and regions. The 1980 Federal Crop Insurance Act expanded insurance to many more crops and regions, reflecting Congress's vision of a program that provides protection for all farmers in all regions. The act set the framework for a public-private partnership through which private sector companies sell and service insurance policies while administrative and operating expenses incurred are reimbursed by the federal government. As reflected in the Agricultural Act, or Farm

[1] Glauber (2013) provides a succinct program history.

Bill of 2014, this partnership has become firmly entrenched in legislation.

In contrast to other insurance markets, crop insurance premiums are set by RMA actuaries to generate only sufficient premium dollars to cover indemnities. The RMA is required by statute to set actuarially fair rates.[2] For insured land units, large volumes of historical and cross-sectional yield records are available to use when setting premiums. In contrast with many other insurance markets, risks are very well defined. Over the years, a large body of empirical work by government, university, and consulting economists, and actuaries have sought to identify and correct for rating structure biases. Coble et al. (2010) provide an overview.[3]

Crop insurance participation rates grew during the1980s but stalled at around 30% in the early 1990s, lower than the rate many in Congress had hoped to attain. Congress remained vulnerable to providing recurrent *ad hoc* disaster assistance payments (Innes 2003). That is precisely what happened in the late 1980s and early 1990s, leading 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% of average yield paid at 60% of the price established for that year. The premium for CAT is fully subsidized (i.e., 100%) 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 rates grew further in the second half of the 1990s with 180 million acres covered in 1998, about two-thirds of the nation’s total planted acreage for field crops. Congress increased subsidies further through the passage of the Agricultural Risk Protection Act (ARPA) of 2000. Since ARPA, the percentage subsidy rate has been the same 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.

[3] One qualification on the above is that when considering a unit’s yield history during rate setting, the RMA is constrained to using only the unit’s mean yield and how it compares with county mean yields. Thus, if units in a given county and with a given mean historical yield are heterogeneous in other ways then rates may not be actuarially fair for all units.

yield and revenue insurance at a given coverage level. As average revenue insurance premiums are larger than yield insurance premiums, per acre subsidy is generally higher for revenue insurance than for yield insurance (Du, Hennessy, and Feng 2014).

For a given crop, a farmer can purchase insurance at three different ‘unit’ levels—optional unit (OU), basic unit (BU), and enterprise unit (EU). Broadly stated, EU coverage would include all land under a given crop that a grower farms in a county; BU is based on the land ownership split for one crop in a county where land owned or cash rented are united into one unit and land sharecropped with each distinct landlord forms a separate unit; 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 while in turn BU is cheaper than OU.

Table 1 shows the subsidy rate schedules as of February 2014. Over the years, the share of premium paid by taxpayers increased from about 25% prior to 1994 to around 50% in the second half of the 1990s, and to around 62% in recent years. Meanwhile, total insured acres for major crops increased from less than 30% prior to 1990 to over 80% of eligible acres in recent years. Given the long claims histories that rate setters have on specific farm units and on proximate units, and given high enrollment levels, adverse selection is no longer considered to be a major concern in these markets. The federal crop insurance program has over one million insurance policies in fifty states and covers more than 250 million acres with a total liability worth more than $75 billion in recent years (USDA RMA 2012). Program costs to taxpayers are predicted to average about $8.9 billion per year over 2013–2022 (USGAO 2012).

How then do growers pay for crop insurance and how do insurance companies cover administration costs when actuarially fair rates are required? If the subsidy rate is s on premium amount p, as set by the RMA, then the grower pays $(1-s)p$ directly to the insurance company. Residual sp is transferred from the government to the insurance company at a later date. The grower may not be aware of the subsidy level. In separate payments, the government also pays for insurer administration and allied costs. In addition, a reinsurance arrangement is in place, such that the insurance companies have choices over the portions of their book of contract business to retain and to transfer to the government. Finally, the premium is due at the earlier of harvest time or when an indemnity payment is made. So insured growers can almost always rely on either the harvest proceeds or the indemnity to pay for the premium's residual component.

3. Formal Model

For the stochastic underwritten item z on a given insurance unit, be it yield or revenue, let the institutional estimate of mean value be $\bar{z}$. The item's distribution function is given as $F(z)$ with density function $f(z)$ on $0 \le z \le \infty$. The mean value will be used to benchmark insurance coverage. If the coverage level is ϕ with $0 \le \phi \le 1$ on the unit, then the indemnity is $M(z;\phi) \equiv \max[\phi\bar{z} - z, 0]$. Let $p(\phi)$ be total premium at coverage level ϕ on the unit. With $E[\cdot]$ as the expectation operator the actuarially fair premium is $p(\phi) = E[M(z;\phi)] = \int_0^{\phi\bar{z}} (\phi\bar{z} - z) dF(z)$ so that premium response to coverage level is $p_\phi(\phi) = \bar{z}F(\phi\bar{z})$. Let $s(\phi)$ be the subsidy rate per dollar of premium payment at coverage level ϕ, so $S(\phi) = s(\phi)p(\phi)$ is the subsidy's dollar value and the producer pays $h(\phi) \equiv [1 - s(\phi)]p(\phi)$. The response of subsidy amount to coverage level is given as $S_\phi(\phi) = s_\phi(\phi)p(\phi) + s(\phi)p_\phi(\phi)$. If premiums are actuarially fair then $S_\phi(\phi) = s_\phi(\phi)p(\phi) + s(\phi)\bar{z}F(\phi\bar{z})$.

We analyze a growers' insurance choices within the standard expected utility framework. The insurance choices predicted by this model will be compared with the choices actually made. Let $U(w)$ denote the utility as a function of income w with $U_w(\cdot) > 0 > U_{ww}(\cdot)$, where the number of subscripts on the appropriate symbol identifies the order of differentiation. Production costs are assumed to be nonrandom and are represented by $\bar{c}$. Finally, random variable η represents other sources of grower household income so that household income is given as

$$w(z,\eta) \equiv \max[\phi\bar{z}, z] - r(\phi,\bar{c},\eta); \qquad r(\phi,\bar{c},\eta) \equiv h(\phi) + \bar{c} - \eta. \tag{1}$$

Here η is assumed to be independent of z with support $[\underline{\eta},\bar{\eta}]$ and distribution function $G(\eta)$. We can write a farmer's expected utility as

$$E[U(w)] = F(\phi\bar{z})\int_{\underline{\eta}}^{\bar{\eta}} U(\phi\bar{z} - r(\phi,\bar{c},\eta))dG(\eta) + \int_{\underline{\eta}}^{\bar{\eta}}\int_{\phi\bar{z}}^{\infty} U(z - r(\phi,\bar{c},\eta))dF(z)dG(\eta). \tag{2}$$

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

(A1) growers are rational, more-is-better, risk-averse expected utility maximizers; and

(A2) premiums are actuarially fair.

Rationality assumption (A1) requires the value of expression (2) to be maximized over coverage choices available. In this paper, we do not assume (A1); rather our intent is to inquire into its soundness. Assumption (A2) holds that the RMA does a good job when setting rates to satisfy legislative intent.

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

$$\begin{aligned} \frac{dE[U(\cdot)]}{d\phi} &= [\bar{z} - h_\phi(\phi)]F(\phi\bar{z})\int_{\underline{\eta}}^{\bar{\eta}} U_w(\phi\bar{z} - r(\phi,\bar{c},\eta))dG(\eta) \\ &\quad - h_\phi(\phi)\int_{\underline{\eta}}^{\bar{\eta}}\int_{\phi\bar{z}}^{\infty} U_w(z - r(\phi,\bar{c},\eta))dF(z)dG(\eta). \end{aligned} \tag{3}$$

Equation (3) captures the two effects of a change in ϕ . For high crop yield values the only impact is on increasing the cost of net premium and this should be multiplied by the effect on expected marginal utility to capture the utility metric cost. For low crop yield values an indemnity is paid so that the marginal effect changes to $\bar{z} - h_\phi(\phi)$ times marginal utility.

Insert the actuarial fairness inference $p_\phi(\phi) = \bar{z}F(\phi\bar{z})$ into (3), use the previously established computation for $S_\phi(\phi)$ and then rearrange to obtain

$$\frac{dE[U(\cdot)]}{d\phi} = \underbrace{\bar{z}F(\phi\bar{z})\int_{\underline{\eta}}^{\bar{\eta}}\left\{U_w(\phi\bar{z} - r(\phi,\bar{c},\eta)) - \int_0^{\infty}U_w(w(z,\eta))dF(z)\right\}dG(\eta)}_{\text{Insurance effect}}$$
$$+ \underbrace{S_\phi(\phi)\int_{\underline{\eta}}^{\bar{\eta}}\int_0^{\infty}U_w(w(z,\eta))dF(z)dG(\eta)}_{\text{Subsidy transfer effect}}. \qquad (4)$$

Concavity of the utility function, together with independence between the two sources of randomness, implies that the term in brackets is positive. This is the insurance effect. The sign of the second term has the sign of $S_\phi(\phi)$, or how dollar subsidy will change as coverage level changes. The quantity's sign is unknown without further information on how subsidy rate and premium vary with coverage level. However, we do know that if no subsidy is provided (i.e., $s(\phi) = 0$ for all ϕ), then the subsidy transfer effect is zero. Similarly if the subsidy's $ value increases (at least weakly) with an increase in coverage level (i.e., $S_\phi(\phi) \geq 0$), then the subsidy transfer effect will be positive and consistent in sign with the insurance effect. Thus, we have the following remark,

Remark 1: Under assumptions (A1)-(A2), suppose that either (a) there is no premium subsidy, or (b) the subsidy's $ value is at least weakly increasing as coverage level increases. Then farmers will choose the highest coverage level, ϕ, available. More generally, if (c) the subsidy's $ value is weakly larger for a higher coverage level (i.e., $S(\phi'') \geq S(\phi')$ where $\phi'' > \phi'$) then the farmer will never choose ϕ' over ϕ''.

If the highest offered coverage level is 100%, then we obtain the standard result that a grower chooses full coverage when faced with an actuarially fair premium. In the actual crop insurance program, the $ premium subsidy varies with coverage level and may not increase with coverage level. If the highest coverage level also provides the highest $ subsidy, then a farmer should choose that coverage level. However, if choosing the highest coverage level means a lower $ subsidy when compared with other coverage levels then farmers' insurance decisions will depend on how they value risk protection relative to the decrease in subsidy payment. In that case the growers' insurance decision will involve a tradeoff between higher risk protection and larger dollar subsidy. For example, it is generally believed that $ subsidy per acre increases with coverage level in the current crop insurance program context. Shields (2010) states "The subsidy rate declines as the coverage level rises, but the total premium subsidy in dollars increases because the policies are more expensive." We use individual level data to establish how $ subsidies change with coverage level, and this allows us to ground-truth remark 1.

Testable Hypothesis I: (labeled H-I) If the $ premium subsidy increases with coverage levels then growers will choose the highest coverage level available to them. If the $ premium subsidy increases with coverage level at low levels and decreases with coverage levels at high levels then growers will not choose coverage levels lower than the level that maximizes the $ premium subsidy.

If $S_\phi(\phi) > 0$ for all relevant values of ϕ (i.e., subsidy transfer increases with coverage level), then the highest total subsidy will be achieved at the highest coverage level, as illustrated by point A in the left panel of Figure 1. If this is not true, then we may see a relationship of the form given in the right panel of Figure 1. Table 1 shows that subsidy rate is monotone non-increasing in coverage level. Given $p_\phi(\phi) > 0$, the sign of $S_\phi(\phi) = s(\phi)p_\phi(\phi) + s_\phi(\phi)p(\phi)$ cannot be inferred without further study. Remark 1, together with a review of Table 1, does allow us to make a further observation. If the subsidy rate is flat across two coverage levels then the higher coverage level will always be chosen.

Testable Hypothesis II: (labeled H-II) No grower enrolling in (*a*) OU or BU will choose coverage level $\phi = 0.55$ over $\phi = 0.6$ or $\phi = 0.65$ over $\phi = 0.7$; (*b*) EU will choose coverage levels $\phi \le 0.65$ over $\phi = 0.7$.

Now we turn to what statistical analysis can reveal about the implications of the subsidy schedule. We seek conditions under which the expression $S_\phi(\phi) = s_\phi(\phi)p(\phi) + s(\phi)\bar{z}F(\phi\bar{z})$ can be signed. Noting, from an integration-by-parts, that $p(\phi) \equiv \int_0^{\phi\bar{z}} F(z)dz,$ we may write

$$S_\phi(\phi) \overset{\text{sign}}{=} \frac{s_\phi(\phi)}{s(\phi)} + \frac{\bar{z}F(\phi\bar{z})}{\int_0^{\phi\bar{z}} F(z)dz}. \tag{5}$$

Next we seek to establish a bound on the value of $\bar{z}F(\phi\bar{z}) / \int_0^{\phi\bar{z}} F(z)dz$. Monotonicity of $F(z)$ ensures that $0 \le \int_0^{\phi\bar{z}} F(z)dz \le \phi\bar{z}F(\phi\bar{z})$ so that a lower bound is given by $\bar{z}F(\phi\bar{z}) / \int_0^{\phi\bar{z}} F(z)dz$ $\ge \bar{z}F(\phi\bar{z}) / [\phi\bar{z}F(\phi\bar{z})] = 1/\phi$. An implication is

Remark 2: A sufficient condition for subsidy payments to increase with an increase in coverage level, or $S_\phi(\phi) > 0$, *is*

$$\mathbb{S}(\phi) \equiv \frac{\phi s_\phi(\phi)}{s(\phi)} > -1. \tag{6}$$

Here $\mathbb{S}(\phi)$ is the elasticity of $s(\phi)$ with respect to ϕ. Table 2 assesses Table 1 data to establish whether this elasticity condition applies. Consider two adjoining coverage levels from Table 1, labeled as ϕ_- and ϕ_+ where $\phi_+ > \phi_-$. Two elasticity estimates are used,

$$\begin{aligned} &\text{Conservative:} \quad \hat{\mathbb{S}}(\phi) = \frac{s(\phi_+) - s(\phi_-)}{\phi_+ - \phi_-} \times \frac{\phi_+}{s(\phi_+)}; \\ &\text{Arc Elasticity:} \quad \hat{\mathbb{S}}(\phi) = \frac{s(\phi_+) - s(\phi_-)}{\phi_+ - \phi_-} \times \frac{\phi_- + \phi_+}{s(\phi_-) + s(\phi_+)}. \end{aligned} \tag{7}$$

These calculations lead us to the conclusions that no grower enrolling in OU or BU will choose coverage level $\phi = 0.5$ over $\phi = 0.55$, and that no grower enrolling in EU will choose coverage level $\phi = 0.7$ over $\phi = 0.75$. For OU and BU we have concluded that $\phi = 0.6$ should dominate $\phi = 0.55$ and $\phi = 0.7$ should dominate $\phi = 0.65$. Although the elasticity condition does not allow a ranking of $\phi = 0.65$ against $\phi = 0.6$, this inability to rank is not an impediment for inference because $\phi = 0.65$ is dominated in any case. For EU the elasticity condition allows us to discard $\phi = 0.7$ as a rational choice. Thus we can strengthen H-II to read as

<u>*Testable Hypothesis II'*</u>: (labeled H-II') No grower enrolling in (*a*) OU or BU will choose a coverage level lower than $\phi = 0.7$; (*b*) EU will choose a coverage level lower than $\phi = 0.75$.

For OU and BU, the absolute schedule elasticity at $\phi = 0.75$ barely exceeds unity. Given risk management benefits and the weak nature of the upper bound identified with $\int_0^{\phi\overline{z}} F(z)dz \leq \phi\overline{z}F(\phi\overline{z})$ it is reasonable to assume that $\phi = 0.75$ would be a better choice than $\phi = 0.7$, but of course we have not demonstrated that in a formal sense. To clarify how weak the bound actually is, note that $\int_0^{\phi\overline{z}} F(z)dz = \phi\overline{z}F(\phi\overline{z})$ only if we assume that $F(0) = F(\phi\overline{z})$ (i.e., that the probability weight below yield realization $\phi\overline{z}$ is massed on complete crop failure). Any less pessimistic yield distribution will allow bound -1 to be replaced by a more negative number.

We turn now to testing the hypotheses. In our empirical analysis, we use the rules established by the RMA 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. Next, we present a general picture of the relationships between insurance subsidies and farmers' crop insurance choices. In particular, we explore whether a higher coverage level implies higher subsidies within the same insurance plan and how government subsidies have affected farmers' insurance choices. Empirical evidence on H-I, H-II and H-II' are examined and discussed. Finally we employ discrete choice (specifically, mixed logit) models to estimate empirical relationships between farmers' insurance coverage level choices and determining factors, which include the constructed premium and subsidy and county-level soil quality.[4]

4. Data and Empirical Evidence on Hypotheses

Our focus is on revenue and yield insurance for corn and soybean crops. Unit level insurance record data for corn and soybean maintained by RMA/USDA are employed. The individual insurance records contain limited information on an unit's location and size (e.g., state, county, acres, number of sections), crop, practices chosen and production outcome (e.g., yield, planted crop, irrigated), as well as insurance choices (e.g., contract, coverage level, elected price, total premium and subsidy payment). We don't directly observe premiums and subsidies of insurance products that are not chosen by the farmer because the unit level insurance data do not provide premiums for coverage levels not chosen on a unit.[5] However, the unobserved information is essential for the analysis of grower choices. Therefore, we reconstruct per acre insurance premium and subsidy for each insurance unit in the sample following the rules established by the RMA.[6]

Premium reconstruction is an involved and tedious process. The rate setting formulas arose out of a sequence of incremental modifications made by the RMA as it sought to set premiums at the actuarially fair. Briefly speaking, the RMA rating procedure involves using historical loss cost experience to establish county base rates. To obtain premium rates for each insurance unit,

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[4] Other farmer- and county-level control factors are omitted mainly due to computational burden when using more variables in large data sets. Based on the results obtained on smaller samples, including these variables has little impact on our main empirical results. Results are available from the authors upon request.

[5] In this study an insurance product refers to a specific choice of insurance plan, unit type and coverage level. We focus on coverage level choices under a given insurance plan and unit type.

[6] We thank RMA officials for making the data available and for assisting us in rule implementation during our reconstruction of premium prices. We followed the formula in Exhibit 11-11 of RMA's "Data Acceptance System Handbook—Appendix III," when reconstructing the menu of insurance product premiums. It is available at http://www.rma.usda.gov/FTP/Publications/M13_Handbook/2009/approved/REC11CAL.pdf. For each insurance product we double checked the premium prices with results from RMA's online premium calculator, available at http://www.rma.usda.gov/tools/premcalc.html.

the county rates are then adjusted for different factors including coverage level, unit format, crop type, and crop practice. Premium menu reconstruction involves the calculation of liability, base premium rate, and premium rate differentials among the coverage levels. For revenue insurance, crop price volatility and the correlation between crop yield and prices are also important factors in the premium calculation. For EU, a unit's premium rate is adjusted by the unit's total acreage. We reconstruct premiums and subsidies for all coverage levels under a specific insurance plan and unit type chosen by an individual grower.

We focus on corn and soybean in 2009 in 997 counties across twelve Midwest and Great Plains states—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The first three of these states account for more than 40% of U.S. corn production and more than 35% of U.S. soybean production. Our data were generated just after the substantial subsidy rate revisions in the 2008 Farm Bill, so they reflect decisions that growers had reason to spend considerable time on. All of the constructed premium and subsidy data were compared with RMA records to ensure accuracy. The largest difference is less than 1%.

We consider three insurance plans—plans 25, 44 and 90.[7] As shown in Table 3, these plans cover 95% of farmers' enrolled acres for each crop. Plans 25 and 44 are alternative forms of revenue insurance (i.e., insuring against the product of yield and a futures price falling below a threshold level). Plan 90 insures against yield shortfalls below a reference level where the yield shortfall is multiplied by a predetermined price to arrive at the indemnity. As discussed above, CAT insurance coverage is quite different from other buy-up plans and has much smaller acres enrolled. Therefore, we exclude CAT coverage from the sample. For each of the three unit types (OU, BU, and EU) in 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 at or

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[7] See the lower panel of Table 3 for insurance plan names and codes. Readers are referred to RMA website http://www.rma.usda.gov/policies/2013policy.html for detailed definitions.

above 65%. So for each observed insurance unit the constructed dataset includes eight products for plan 90, eight for plan 44, and five for plan 25. In each case, coverage levels, premiums and subsidies are available for analysis.

For plan 44 and EU, Figures 2 (for corn) and 3 (for soybean) provide summary data on incremental changes in premium and subsidy as coverage level increases. Data for other plan and unit structures are very similar and not reported, but are available upon request. We see an inverse-U relationship between coverage level and per acre subsidy. Incremental subsidy peaks at 70% or 75% coverage and may become negative at 85% coverage.

Comprehensive summary statistics for observed choices on corn insurance products under plans 90, 44, and 25 are presented in Table 4. Data for soybeans are similar. Within individual insurance plans, higher coverage levels (60%–85%) correspond to higher APH (or historical average) yield and reported acres. Higher coverage levels are also associated with lower production risk as represented by increasing yield ratio (i.e., higher unit level yield relative to county average yield). In other words, larger-size insurance units with generally higher mean yield and lower production risk tend to choose higher coverage levels. Development on the yield distribution structures that support this finding can be found in Du, Hennessy, and Feng (2014). The table also reveals that around 90% of farmers in the sample choose coverage levels higher than 65%. The 65% coverage level is the most popular choice under yield insurance (plan 90), while 75% and 70% are, respectively, the modal coverage levels for farmers buying revenue insurance (plans 44 and 25).

In the following, we report empirical evidence on H-I and H-II as discussed in the previous section. H-I states that the farmer will choose either the coverage level that provides the largest subsidy or a coverage level higher than that. In the left panel of Figure 1, H-I asserts that the highest coverage level should be chosen. In the right panel, the shape is such that any coverage level at or to the right of point B should be chosen. Figure 4 graphs the boxplots with median, 25% and 75% quantiles of per acre subsidy under all coverage levels for the three insurance plans. As with the trends shown in Figures 2 and 3, Figure 4 illustrates that the premium subsidy increases with lower coverage levels until the 80% level, but may decrease between the 80% and 85% level. The pattern is consistent across plans and crops. Therefore the second inference in H-I is applicable (i.e., "… growers will not choose coverage levels lower than the coverage level that maximizes the $ premium subsidy"). To test H-I, we count the observed coverage level choices that are equal to or higher than the level with the highest subsidy for each insurance plan. Data in Table 5 indicate that for corn plan 90 less than 5% of farmers in BU or OU choose the coverage level with the highest subsidy payment or higher coverage levels, while the percentage increases to 13.7% for growers under EU. Similar results are found for other corn and soybean plans. It is clear that H-I is not supported by the data.

H-II states that for BU and OU coverage levels 55% and 65% are dominated by levels 60% and 70%, respectively, and should not be considered by insurance buyers, while farmers in EU should not choose coverage levels lower than or equal to 65%. The results presented in Table 6 provide little support for H-II. The 55% coverage level is not popular, being purchased by less than 2% of BU and OU units in plans 90 and 44 across crops. This level is not available for plan 25. The 60% coverage level is not a popular choice either. Around 5% of farmers in the sample choose the 60% level when purchasing plan 90 and the number is 2% for plan 44. A significant number of farmers chose the 65% level (about 30% for BU and OU in plan 90 and about 5%–10% for plan 44). Although many farmers buying plans 44 and 25 choose the 70% coverage, the 65% coverage is not dominated by the 70% coverage. For farmers in EU, coverage levels lower than 65% are also chosen by a significant number of farmers. About 55% of corn growers in plan 90, 7% in plan 44, and 21% in plan 25 purchased levels at 65% or lower.

The second last column in Table 6 reports evidence on part (*b*) of H-II, which states that no grower in EU will choose $\phi \leq 0.65$. For plan 90, the majority of corn and soybean growers choose a dominated coverage level according to H-II, while for the other two plans the number of violations is considerably lower. The last column in Table 6 reports evidence on H-II', which states that no grower in BU or OU will choose coverage levels lower than 70% and no growers in EU will choose levels lower than 75%. The data show that this hypothesis is also inconsistent with observed farmers' choices. Of the nine plan and unit type combinations, the top half of the right-most column in Table 6 shows that with corn the majority violate the posited behavior in three combinations. Viewing the bottom part of that column, with soybean this is so for four of the nine combinations interactions.

5. Relevant Literature and Possible Explanations for Anomalies

The matter we address can be viewed in many ways. One regards irrational choice of insurance coverage. A literature exists on this phenomenon, borne out of observations made in commercial insurance markets that carry a loading factor. Another regards arbitrage or near-arbitrage in the form of a refusal to take up a free lunch offered by an external party. A corpus of work exists here too, where generally the external party is an employer or a government. We will overview samples of each literature in turn in order to clarify our findings and place our contribution.

Much of the literature pertaining to anomalous behavior in insurance and related risk markets identifies behavior inconsistent with the implications of risk aversion within the expected utility framework (see, e.g., Rabin and Thaler 2001). This is not our concern. Although we use the expected utility model to motivate our reasoning, our basic arguments apply for any decision model in which there is a preference for income stability. Our primary concern is that farmers are declining offers that both increase expected income and stabilize income. A widely observed peculiarity in insurance markets is a preference for low deductible policies (i.e., a tendency to over-insure in that context) (Pashigian, Schkade, and Menefee 1966; Sydnor 2010). Apparently, the insured do understand that the premium should decrease as the deductible increases but do not understand that the rate of decrease should become less rapid as the deductible increases (Shapira and Venezia 2008).[8] Thus, a high deductible premium looks to be excessively priced so that the choice is confined to low deductible contracts or no contract at all. Our case is quite different. We document a preference for high deductible insurance contracts even when low deductible contracts provide greater subsidy transfers.

Another curiosity in insurance markets is the reluctance to file a claim out of concern that premiums will subsequently be adjusted upward (Braun et al. 2006). This is not relevant in our setting because growers are obliged to report yields in any case and the only farm-level determinant of premium is average historical yield, regardless of claim history. Further anomalies surround seemingly excessive demand for insurance against minor losses, highly specific items, and emotion-inducing objects, such as heirlooms. These too are irrelevant in our setting.

Risk managers often lock the door after the horse has bolted by taking action only in the aftermath of a major event (Weinstein 1988). The data that we analyze are for 2009 choices, which had followed several good growing years when viewing the United States as a whole. It is possible that growers underinsure because information on the magnitude of perceived risk faced has been crowded out of working memory. We do not believe this to be the case because low average coverage levels have been a persistent feature of crop insurance for many years. Several other possible motivations for underinsurance have been provided in the literature. One is hyperbolic discounting, in which the discount rate on money in the near future is much larger than in the more distant future (Laibson 1997). Therefore, premium paid early in the season would receive much more weight than possible indemnities received after harvest. However, in order to relieve growers of cash flow constraints, an unusual feature of crop insurance is that

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[8] Differentiate the premium expression twice to obtain the density evaluated at the yield guarantee, or $\partial^2 \text{premium} / \partial(\phi\bar{z})^2 = f(\phi\bar{z}) \geq 0$.

premiums are not payable until either after harvest or when a claim is made. Thus, this motive for underinsurance is not relevant either. For the same reason, the commonly suggested budget constraint motive for underinsurance (Kunreuther and Pauly 2005) is unlikely to apply.

Optimism bias is a further rationale for underinsurance (i.e., the notion that this undesirable outcome will never occur to me). The notion does not comport with standard decision models, including expected utility. Documented evidence suggests that the belief emerges from a view on one's own capacity to control the risk, and we have no reason to doubt that some growers hold such beliefs. Rationalizations for such behavior based on neuroeconomic foundations are now emerging (Bracha and Brown 2012). However, the primary source of crop yield risk is weather, where a belief in individual control would not bear external validation.

Another perspective on underinsurance is that the cost of arriving at a sense of the risk posed can be excessive when compared with the expected benefit from taking out insurance. If so, then disasters viewed as being rare are optimally left uninsured (Kunreuther and Pauly 2004). In our case, the analog might be that a high deductible is chosen because the event of a major disaster is rare and difficult to comprehend. Evidence is not in favor of this threshold risk rationale. United States Corn Belt crops suffered major crop killing droughts in the late 1980s and again in 2012, while the floods of 1993 were just as devastating.

A motivation that is more difficult to dismiss concerns regret (i.e., where the decision maker imposes an ex ante penalty on deviations between utility obtained and highest utility that could have been obtained given the realized state of nature). In other words, the grower deliberating on taking out or renewing insurance is prone to cherry picking past outcomes where insurance was ex post an unfortunate choice and either ignoring or placing low weight on past outcomes where insurance was ex post fortunate. In practice it may be difficult to distinguish such preferences from grower decision making processes and concerns about actuarial fairness. Growers accustomed to thinking about business expenditures as investments may view a sequence of years in which no indemnity payouts are made as evidence that insurance is a bad investment, or perhaps that the actuaries miscalculated. Braun and Muermann (2004) show that, in contrast to Mossin's finding, underinsurance will arise under regret preferences even when the insurance contract is actuarially fair. Some experimental evidence by Ratan (2013), though not with insurance products, lends support to the existence of a regret motive.

Prospect theory's aversion to loss feature (Kahneman and Tversky 1979) could also explain underinsurance, where Vetter et al. (2013) have used it to explain low enrollment in the subsidized U.S. Medicare Part D prescription drug insurance program. Growers may naturally anchor their reference outcome at or near potential yield. In good growing areas, actual yield outcomes tend to be bunched close to potential yield outcomes (i.e., negatively skewed). Loss aversion would then involve risk-loving behavior over most of the yield outcomes domain (Kahneman, Knetsch, and Thaler, 1991). This would explain low uptake of unloaded actuarially fair crop insurance contracts absent subsidies. As premium payments also amount to a loss relative to reference yield, loss averse behavior could also explain a disposition toward high deductibles even in the presence of subsidies that promote low deductibles.

Empirical evidence elsewhere from agricultural settings do provide support for loss averse behavior. Based on survey and lottery experiment data obtained from 107 mixed enterprise farmers in France, Bocquého, Jacquet, and Reynaud (2014) find choices consistent with loss aversion rather than expected utility. Liu and Huang (2013) and Liu (2013) collect pesticide use data from 320 cotton farmers in China as well as lottery experiment data. These farmers can complement conventional cotton seed with high levels of pesticides, or use a more novel pest killing seed together with low levels of pesticide. As with Bocquého et al., these papers apply the Tanaka, Camerer, and Nguyen (2010) elicitation and estimation methodology. Liu and Huang find that their subjects behave in a loss averse manner when it comes to health implications from using pesticides. Liu finds that growers who are more risk averse or more loss averse were later to adopt the novel seed. Other behavioral theories on risk attitudes have been developed having testable inferences that contrast with prospect theory. In particular, salience theory due to Bordalo, Gennaioli, and Shleifer (2012; 2013) can explain risk seeking for losses. However, little work is presently available on how well this view describes actual choices in the field or how it fares in comparison with other views.

Turning to pertinent work in the free lunch literature, Medicaid is a free health care insurance program operated by the United States Federal government available to certain categories of low income residents. Aizer (2007) has inquired into why millions of eligible children were not enrolled. Based on outcomes from outreach programs in California, she finds that transactions cost barriers that include search costs, form-filling, language barriers, and perceived risks regarding family immigration status can explain much of the shortfall. For crop insurance our observation is a sub-optimal choice and not a failure to enroll, but both reflect underinsurance. In terms of context, a single federal crop insurance program exists and has been available for many years. It is easy to apply for while the target audience is generally well-educated, English speaking, asset rich, socially well-integrated in the locality stretching back generations, and unlikely to see legal risks. Thus, a transactions cost motive has little appeal to us.

Many employers offer matching contributions to defined contribution retirement plans. If employees are eligible to withdraw the funds immediately then one can contribute up to the matching limit and either remove the funds or leave them there as one see fits. Failure to contribute to the limit amounts to forgoing a pure arbitrage. Choi, Laibson, and Madrian (2011) have found widespread untaken arbitrage opportunities among U.S. corporate employees, while a survey informing them of the opportunity had negligible impact. Direct payment into a savings account may provide the contribution source with additional saliency. In our case, crop insurance does not provide pure arbitrage opportunities and so the anomalous behavior is not as stark. To the risk neutral investor, the choice can be viewed as an investment with excellent expected returns investment so that time preferences still matter.

6. Discrete Choice Model of Coverage Level Choices

In order to better understand determinants of farmers' insurance choices, we set up a mixed logit model in the random utility framework (Train 2009, ch.11). To ensure tractability, we confine the analysis to choices within a given plan and unit type. Thus, actual (i.e., less constrained) responses are likely to be larger than those that we estimate. The model seeks to capture farmers' heterogeneity in preferences which are unobservable to researchers. These unobservables could include heterogeneity in risk preferences or in capacity to bear risk.

Let the subsidized contract choice set be $\Omega^K \equiv \{1, 2, \ldots, K\}$ where the associated subsidy and coverage levels are s_k and ϕ_k, $k \in \Omega^K$. The ith insurance unit, $i \in \Omega^N \equiv \{1, 2, \ldots, N\}$, has 'utility' under choice k given by U_{ik} with overall specification

$$U_{ik} = X'_{ik}\beta_i + Z'_i\gamma + \varepsilon_{ik},\ i \in \Omega^N,\ k \in \Omega^K, \qquad (8)$$

where X_{ik} is a vector of M explanatory variables with random coefficients. In our case, these are the out-of-pocket premium (i.e., net premium payment after subsidy), and the yield guarantee ($M = 2$). The corresponding coefficients β_i are assumed to follow normal random distributions $\beta_m \sim N(\mu_{\beta_m}, \sigma^2_{\beta_m}),\ m \in \{1, \ldots, M\}$. Vector Z_i represents county-level control variables with fixed coefficients captured in γ, while ε_{ik} follows an i.i.d. extreme value distribution.

Out-of-pocket premium payment and yield guarantee vary across choices for any given insurance unit and are included in the X matrix with random coefficients. Yield guarantee is defined as coverage level $\times$ unit rate yield. The unit rate yield is the average, recorded historical unit yield when signing the insurance contract. For vector Z, besides coverage-level specific intercepts, we include county-level soil quality, which does not vary for a given unit and are considered to be exogenous factors affecting farmers' insurance decision. County-level soil quality (named “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 mixed logit model specified in (8) is estimated on observed coverage level choices for individual insurance plans (eight for plans 90 and 44 and five for plan 25) for corn and soybean using the Maximum Simulated Likelihood method (Train 2009, ch.11).[9] The estimation results presented in Table 7 have controlled for magnitude of product benefits through conditioning on county land quality. The results for fixed coefficients are provided in Supplementary Materials.

Given the requirement that unsubsidized premiums be actuarially fair, these conditioners should control for the magnitude of unsubsidized premium. The results indicate that farmers generally prefer an insurance product with relatively lower out-of-pocket premium payment. Seven of nine responses are negative for corn while six of nine are negative for soybeans. These data provide indirect evidence against H-I that in choosing an insurance product, not only subsidy but also out of pocket premium are factored into farmers’ decisions. This is also consistent with findings in observed farmers’ insurance choices that a majority of farmers don’t choose the coverage level providing the highest subsidy payment, or a higher coverage level.

Demand response to yield guarantee are positive for eight of nine corn plan-unit combinations and all such soybean combinations. It is noteworthy that they are generally greatest for EU among the three unit structures, where a rationalization for this pattern is not clear to us. We also see significant individual heterogeneity in both out-of-pocket premium and yield guarantee effects, as indicated by relatively large estimates on their standard deviations.

Coverage level choices on the *i*th unit are made to $\max_{k\in\Omega} U_{ik}$. Given the random error structure, choice probabilities for a given parameter draw $\beta = \beta_i$ are given by

[9] The Matlab code we used can be found at Kenneth Train’s website http://elsa.berkeley.edu/Software/abstracts/train1006mxlmsl.html.

$$r_{kt}(\beta_i,\gamma)=\frac{e^{X'_{ikt}\beta_i+Z'_i\gamma}}{\sum_{j\in\Omega^K}e^{X'_{ijt}\beta_i+Z'_i\gamma}}. \tag{9}$$

With distribution on β written as $\mathrm{B}(\beta)$, the *k*th contract's share among all contracts under a given plan is

$$\bar{r}_{kt}(\beta)=\int\left(\frac{e^{X'_{ikt}\beta_i+Z'_i\gamma}}{\sum_{j\in\Omega^K}e^{X'_{ijt}\beta_i+Z'_i\gamma}}\right)d\mathrm{B}(\beta). \tag{10}$$

Writing out-of-pocket premium coefficient as β_p and *j*th contract premium as p_j, the average own- and cross-price elasticities are given as

$$\bar{\xi}_{kj}=\begin{cases}\dfrac{p_j\beta_p}{\bar{r}_{kt}(\beta)}\displaystyle\int r_j(\beta)[1-r_j(\beta)]d\mathrm{B}(\beta), & \text{for } j=k;\\ -\dfrac{p_j\beta_p}{\bar{r}_k(\beta)}\displaystyle\int r_j(\beta)r_k(\beta)d\mathrm{B}(\beta) & \text{for } j\neq k.\end{cases} \tag{11}$$

Table 8 provides own-price elasticity estimates based on the mixed logit estimations.

We draw two broad inferences from Table 8. Firstly, elasticity of demand with response to out-of-pocket premium is positive for two of nine corn plan-unit combinations and three of nine soybean plan-unit combinations. The positive responses are for corn and soybean in the yield insurance plan (plan 90) when under enterprise unit format, for corn and soybeans in revenue insurance plan 25 when under basic unit format, and for soybean in plan 25 under the optional unit format. In all other cases, i.e., when negative, the responses are inelastic. Thus, we conclude that an increase in out-of-pocket expense is likely to reduce demand but increase out-of-pocket expenditure.

Our second comment regards how one might view preferences in light of the regression findings. Given a preference for transfers and a dislike of out-of-pocket requirements to obtain these transfers, we posit the following structure to the grower's value function;

$$V[\phi_i,s(\phi_i),p(\phi_i)]=A(\phi_i)+B[s(\phi_i)p(\phi_i)]+C[(1-s(\phi_i))p(\phi_i)]. \tag{12}$$

Here $A(\cdot)$ represents standard preferences under actuarially fair prices where we have argued that the function should increase with coverage level to account for the value of protection against risk. Function $B[\cdot]$ reflects the value of transfers, amounting to $s(\phi_i)p(\phi_i)$. This should be an increasing function of the amount transferred. Finally, function $C[\cdot]$ reflects dislike for out-of-pocket expenditure as reflected in the mixed logit regressions. We have ignored interaction terms in order to clarify first-order effects. Our hypotheses have been based only on consideration of functions $A(\cdot)$ and $B[\cdot]$. To the extent that out-of-pocket payments increase with coverage level, the inclusion of this function will decrease the value of $dV[\cdot]/d\phi =$ $\partial V[\phi, s(\phi)]/\partial\phi + \{\partial V[\phi, s(\phi), p(\phi)]/\partial s\}s_\phi(\phi) + \{\partial V[\phi, s(\phi), p(\phi)]/\partial p\}p_\phi(\phi)$ such that a lower coverage level is preferred. So the regression findings are consistent with our evidence concerning the hypotheses.

7. Concluding Remarks

Economic theory suggests that individuals exposed to risk should take up actuarially fair insurance if risk averse. When contracts are heavily subsidized and subsidy transfers increase with extent of coverage then uptake should tilt toward the contracts providing the greatest dollar subsidy. The U.S. crop insurance market allows for direct observation on whether choices comply with these very basic inferences. We find that farmers turn down contracts that transfer comparatively more subsidy and retain comparatively less risk in favor of contracts transferring less subsidy and retaining more risk. Given the market context and program attributes, the rationalizations most plausible to us are loss aversion, optimization in the presence of a regret penalty, and placement of particular emphasis on the premium cost when compared with the state-contingent benefit.

Our concern has been with understanding behavior and not with policy implications. Stepping beyond this remit, if we are to understand policy implications then we must take a stance on what the policy goals are. By increasing participation, the program has likely addressed market failures due to information problems. It may have also overcome the political system's inability to be time consistent when demanding that growers must take out insurance to be eligible for any disaster payment program. The U.S. drought of 2012 did not involve large additional outlays for crop disaster relief. Why then tie transfers to crop insurance? Perhaps because such transfers have escaped scrutiny under World Trade Organization rules addressing the trade implications of domestic transfers, whereas other forms of support have not. Perhaps because the image of a crop disaster has softened opposition to such transfers while the indirect channel through which premiums are made is somewhat obscure. Perhaps because tying transfers to crop insurance allows the government to promote higher coverage levels and so further reduce any political need for post-disaster payments. Looking forward, and in light of the present generous subsidy levels, continuing demands for further subsidy interventions are more likely motivated by political demands for income transfers.

Suppose then that promoting transfers through the crop insurance channel is a political goal. Making growers more aware of transfers presently available, but as we point out not taken up, is one approach. As we have pointed out in our literature overview, this approach is not certain to succeed. Simplifying the process may help (see Beshears et al. 2013), but the process is presently quite simple and concerns about fraud limit movement in that direction.

Another approach is to seek to manage in some way the saliency of out-of-pocket payments. The ability to do so is limited if one requires growers to make some payments. In addition, our view is that economic underpinnings for salience are insufficiently solid to have much confidence that such a plan would be effective. A version of the Lucas critique may apply. If salience is an equilibrium outcome of interactions between the market environment and more primitive preference 'parameters' then what is salient and extent of salience may shift as one seeks to manage it. We do not think that our understanding of saliency in insurance markets is sufficient to support policy recommendations as put forth in Sunstein (2011). Further inquiry is in order into why growers choose to pass up opportunities to both increase expected income and reduce income variability.

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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

Notes: Under the 2014 Farm Bill, early career growers will be eligible for higher premium subsidies.

Table 2. Evaluation of subsidy elasticity condition for different programs.

Coverage level ϕ	CAT	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85
Subsidy rate, OU and BU	1.0	0.67	0.64	0.64	0.59	0.59	0.55	0.48	0.38
$\hat{\mathbb{S}}(\phi)$			-0.52	0	-1.32	0	-1.09	-2.33	-4.47
$\widehat{\mathbb{S}}(\phi)$			-0.48	0	-1.02	0	-1.02	-2.11	-3.84
Subsidy rate, EU	NA	0.80	0.80	0.80	0.80	0.80	0.77	0.68	0.53
$\hat{\mathbb{S}}(\phi)$		0	0	0	0	0	-0.58	-2.12	-4.81
$\widehat{\mathbb{S}}(\phi)$		0	0	0	0	0	-0.55	-1.92	-4.09

Table 3. Insurance choices summary statistics, 2009.

Buy-up	Corn		Soybean	
Insurance plans	Enrolled acres	% of total	Enrolled acres	% of total
12 (GRP)	648,833	1	953,020	1.6
25 (RA)	12,773,217	19	16,251,787	27.6
42 (IP)	71,110	0.1	80,236	0.1
44 (CRC)	43,417,618	64.6	31,503,341	53.5
45 (IIP)	59,764	0.1	26,610	0.05
73 (GRIP)	3,103,689	4.6	2,346,016	4
90 (APH)	7,114,696	10.6	7,677,462	13
Total enrolled acres	67,188,927		58,838,472	
CAT				
12	86,454	1.8	60,480	1
45	7,410	0.2		
90	4,600,456	98	5,579,823	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

Notes: Percentages do not sum to 100 due to rounding errors.

Table 4. Summary statistics for farmers' observed choices, corn in twelve Midwest and Great Plains states.

Plan 90	Full Sample	50%	55%	60%	65%	70%	75%	80%	85%
APH Yield	135.4	134.7	131.4	127.4	130.2	132.0	142.8	153.1	161.0
Current Yield ratio	1.11	1.11	1.08	1.09	1.09	1.11	1.12	1.15	1.17
Reported Acres	66.3	67.6	60.9	64.4	64.9	64.3	66.1	78.4	77.9
Share of unit type-OU	0.54	0.11	0.01	0.05	0.29	0.28	0.18	0.06	0.03
-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
Sample size ('000)	99.8	11.7	1.5	5.2	30.2	24.9	17.9	5.6	2.7
Percent of sample (%)	100	11.8	1.5	5.2	30.3	24.9	18.0	5.7	2.8
Plan 44	Full Sample	50%	55%	60%	65%	70%	75%	80%	85%
APH yield	148.1	132.6	130.8	124.3	138.6	139.0	146.2	154.4	164.3
Current yield ratio	1.16	1.13	1.11	1.11	1.13	1.14	1.15	1.18	1.20
Reported acres	82.9	71.9	69.7	67.3	78.5	77.4	79.9	86.3	98.5
Share of unit type - OU	0.35	0.009	0.003	0.019	0.105	0.343	0.337	0.145	0.038
- 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	0.276	0.396	0.208
Sample size ('000)	609.0	5.8	1.5	7.5	41.0	129.7	187.7	162.6	73.1
Percent of sample (%)	100	1.0	0.3	1.2	6.7	21.3	30.8	26.7	12.0
Plan 25	Full sample				65%	70%	75%	80%	85%
APH yield	127.6				125.4	123.2	130.1	136.7	144.4
Current yield ratio	1.13				1.12	1.12	1.13	1.17	1.16
Reported acres	72.6				72.5	72.9	72.3	72.1	74.7
Share of unit type - OU	0.51				0.175	0.457	0.288	0.068	0.013
- BU	0.27				0.215	0.453	0.263	0.056	0.013
- EU	0.22				0.064	0.200	0.399	0.293	0.044
Sample size ('000)	205.6				33.2	82.3	62.8	23.3	4.1
Percent of sample (%)	100				16.1	40.0	30.5	11.3	2.0

Notes: APH yield is an historical average of actual crop yield history based on a minimum of four years and maximum of ten years historical yield for that crop and land unit. Current yield ratio is the ratio of a farm's APH yield to reference yield for the county in which the farm is located, where the latter is an estimate of county average yield for the crop. Reported acres is the average number of acres in the units at issue.

Table 5. Evidence on Hypothesis I.

Crop/Plan/Unit	% of samples choosing the level (or higher) with highest subsidy payment	Crop/Plan/Unit	% of samples choosing the level (or higher) with highest subsidy payment
Corn		*Soybean*	
Plan 90 – OU	4.0	Plan 90 – OU	2.8
– BU	3.5	– BU	2.4
– EU	13.7	– EU	4.5
Plan 44 – OU	4.3	Plan 44 – OU	4.7
– BU	6.2	– BU	6.4
– EU	40.2	– EU	22.9
Plan 25 – OU	3.4	Plan 25 – OU	4.9
– BU	3.0	– BU	3.9
– EU	25.8	– EU	30.9

Table 6. Evidence on Hypotheses II and II'.

		% obs. at 50%	% obs. at 55%	% obs. at 60%	% obs. at 65%	% obs. at 70%	% EU at ≤ 65%	% BU/OU (EU) at ≤ 65% (70%)
Corn								
Plan 90	– OU	12.5	1.6	4.6	29.6	20.9	---	48.4
	– BU	13.6	1.7	5.1	32.5	21.3	---	52.9
	– EU	10.8	3.1	4.8	36.3	29.6	55	56.2
Plan 44	– OU	1.1	0.3	1.1	6.2	17.4	---	8.8
	– BU	1.6	0.5	1.9	10.6	29.2	---	14.6
	– EU	1.0	0.2	0.9	5.3	14.8	7.4	22.3
Plan 25	– OU	---	---	---	14.9	34.2	---	14.9
	– BU	---	---	---	21.5	45.3	---	21.5
	– EU	---	---	---	21.4	45.5	21.4	66.8
Soybean								
Plan 90	– OU	14.2	1.8	4.5	31.3	20.7	---	51.8
	– BU	14.1	1.8	4.6	33.3	21.3	---	53.7
	– EU	21.6	3.3	6.4	29.1	10.7	60.4	71.1
Plan 44	– OU	2.2	0.4	1.6	7.9	19.1	---	12.1
	– BU	2.2	0.5	2.1	10.6	26.0	---	15.4
	– EU	1.7	0.3	1.1	5.8	14.3	8.9	23.2
Plan 25	– OU	---	---	---	13.8	33.5	---	13.8
	– BU	---	---	---	19.0	44.2	---	19.0
	– EU	---	---	---	20.9	44.3	20.9	65.1

Table 7. Mixed logit model estimation results, random coefficients (standard errors in parentheses).

Variables	Corn 90			Corn 44			Corn 25		
Mean	OU	BU	EU	OU	BU	EU	OU	BU	EU
Out-of-pocket premium	-0.12[c]	-0.22[c]	0.01	-0.05[c]	-0.07[c]	-0.10[c]	-0.003[a]	0.009[c]	-0.05[a]
	(0.005)	(0.01)	(0.03)	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)	(0.004)
Yield guar.	0.09[c]	0.08[c]	-0.03[b]	0.15[c]	0.17[c]	0.21[c]	0.09[c]	0.09[c]	0.22[c]
	(0.004)	(0.006)	(0.01)	(0.003)	(0.005)	(0.004)	(0.003)	(0.005)	(0.01)
Std. Dev.									
Out-of-pocket premium	0.06[c]	0.13[c]	0.06	0.04[c]	0.08[c]	0.02[c]	0.001	0.003	0.007
	(0.005)	(0.009)	(0.04)	(0.002)	(0.003)	(0.003)	(0.003)	(0.006)	(0.009)
Yield guar.	0.12[c]	0.16[c]	0.002	0.08[c]	0.08[c]	0.10[c]	0.10[c]	0.14[c]	0.21[c]
	(0.005)	(0.008)	(0.02)	(0.002)	(0.003)	(0.002)	(0.004)	(0.006)	(0.009)
Sample size (# of units)	53953	43757	1922	211666	114107	281210	104839	55700	44435
	Soybean 90			Soybean 44			Soybean 25		
Mean	OU	BU	EU	OU	BU	EU	OU	BU	EU
Out-of-pocket premium	-0.15[c]	-0.18[c]	0.23[c]	-0.08[c]	-0.08[c]	-0.08[c]	0.02[c]	0.04[c]	-0.02[c]
	(0.008)	(0.01)	(0.08)	(0.002)	(0.003)	(0.003)	(0.002)	(0.004)	(0.006)
Yield guar.	0.48[c]	0.37	1.89[c]	0.71[c]	0.81[c]	1.00[c]	0.55[c]	0.50[c]	0.88[c]
	(0.03)	(0.02)	(0.54)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.04)
Std. Dev.									
Out-of-pocket Premium	0.07[c]	0.10[c]	0.09	0.07[c]	0.11[c]	0.03[c]	0.009[a]	0.002	0.01
	(0.008)	(0.01)	(0.09)	(0.003)	(0.004)	(0.008)	(0.005)	(0.009)	(0.02)
Yield guar.	0.73[c]	0.62[c]	1.36[c]	0.28[c]	0.31[c]	0.44[c]	0.54[c]	0.61[c]	0.83[c]
	(0.04)	(0.03)	(0.46)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.04)
Sample size (# of units)	59574	53064	2478	145528	97736	222400	146545	75821	51315

Notes: a, b, and c denote significance at 0.10, 0.05, and 0.01 levels, respectively. The estimation results of the fixed coefficients are included in the Appendix. The fixed effects are for the following county control variables: percent of a county's acres that are Land Capability Classes I or II as a share of acres that are Classes I through IV, the county's 31 year average growing degree days from April through September over 1975-2005, and also average precipitation over those time intervals.

Table 8. Own elasticity estimates based on mixed logit model estimation.

Elasticity	Corn 90			Corn 44			Corn 25		
Coverage Levels	OU	BU	EU	OU	BU	EU	OU	BU	EU
50%	-0.74	-0.60	0.18	-0.50	-0.34	-0.48			
55%	-0.84	-0.71	0.18	-0.55	-0.36	-0.53			
60%	-0.83	-0.71	0.18	-0.54	-0.35	-0.52			
65%	-0.84	-0.73	0.19	-0.55	-0.37	-0.51	-0.05	0.14	-0.44
70%	-0.85	-0.76	0.19	-0.56	-0.39	-0.51	-0.06	0.16	-0.51
75%	-0.86	-0.78	0.19	-0.56	-0.39	-0.51	-0.06	0.16	-0.50
80%	-0.86	-0.78	0.19	-0.56	-0.38	-0.51	-0.06	0.16	-0.49
85%	-0.83	-0.71	0.19	-0.54	-0.35	-0.49	-0.06	0.16	-0.48
Elasticity	Soybean 90			Soybean 44			Soybean 25		
Coverage Levels	OU	BU	EU	OU	BU	EU	OU	BU	EU
50%	-0.61	-0.45	0.69	-0.34	-0.15	-0.23			
55%	-0.75	-0.55	0.83	-0.36	-0.16	-0.25			
60%	-0.73	-0.54	0.79	-0.35	-0.16	-0.24			
65%	-0.74	-0.55	0.76	-0.37	-0.19	-0.24	0.24	0.30	-0.11
70%	-0.75	-0.57	0.73	-0.39	-0.21	-0.24	0.29	0.38	-0.13
75%	-0.77	-0.59	0.72	-0.40	-0.22	-0.24	0.29	0.37	-0.12
80%	-0.78	-0.60	0.72	-0.41	-0.22	-0.24	0.28	0.37	-0.12
85%	-0.75	-0.57	0.71	-0.39	-0.20	-0.23	0.27	0.35	-0.12

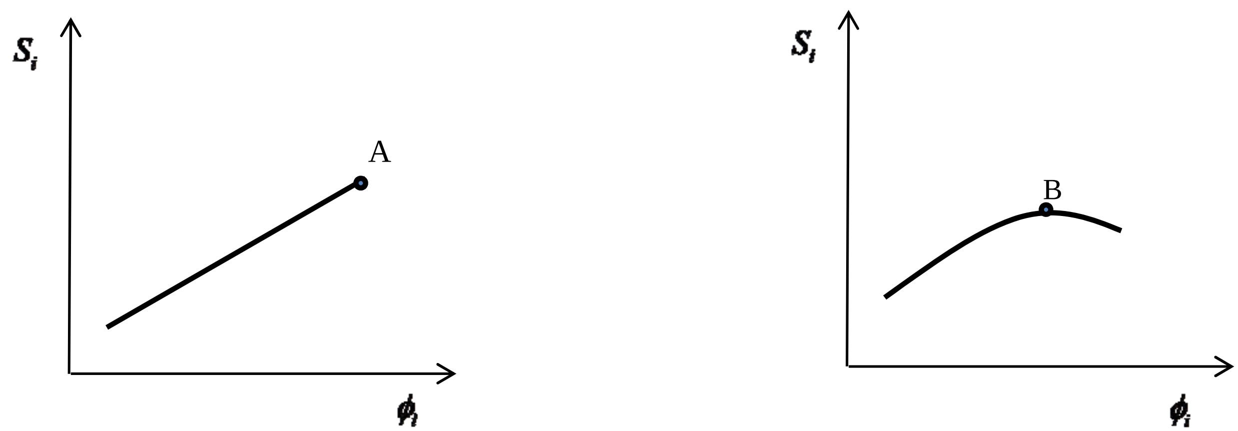

Figure 1. Two illustrations of possible relationship between coverage Level and premium subsidies in $.

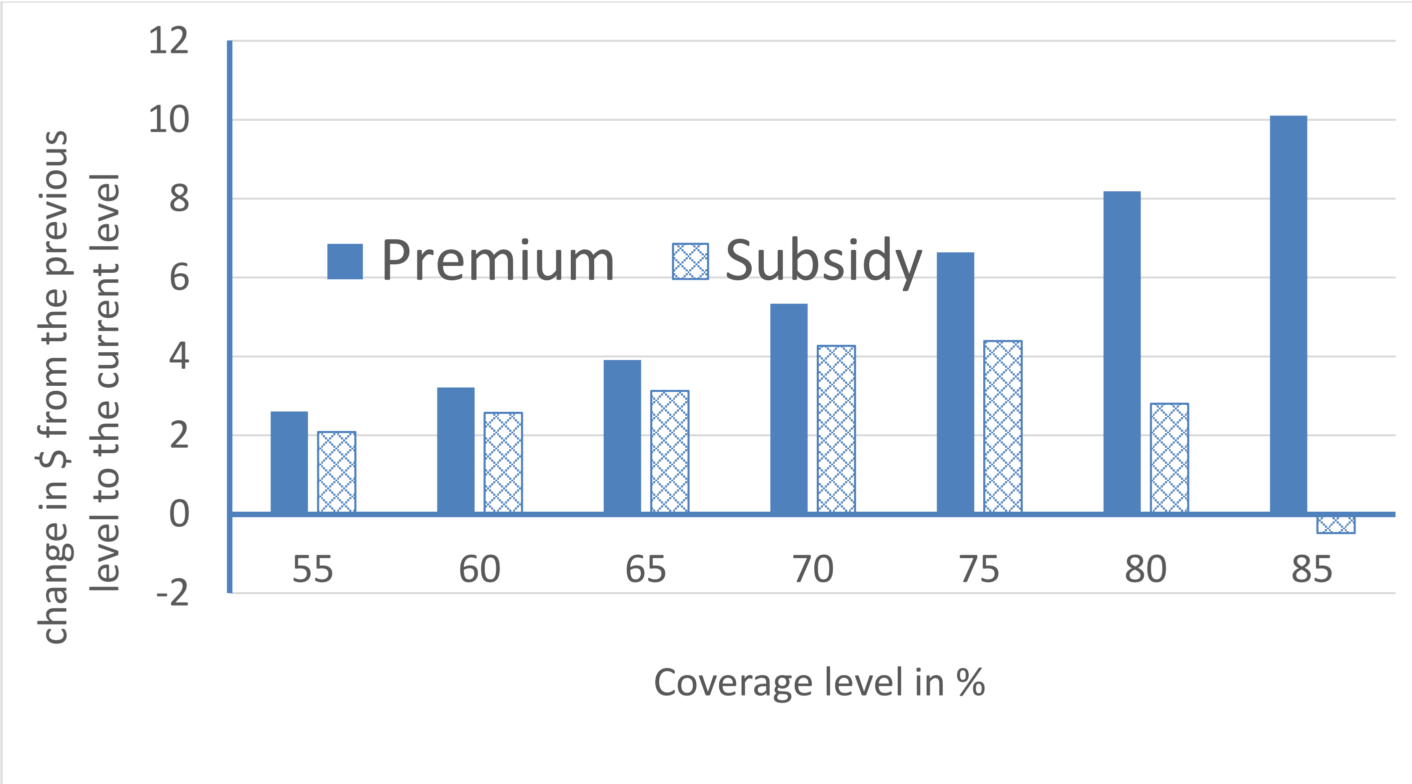

Figure 2. Incremental changes in premium and subsidy as coverage level increases from previous, lower level to current level; corn, plan 44 and EU.

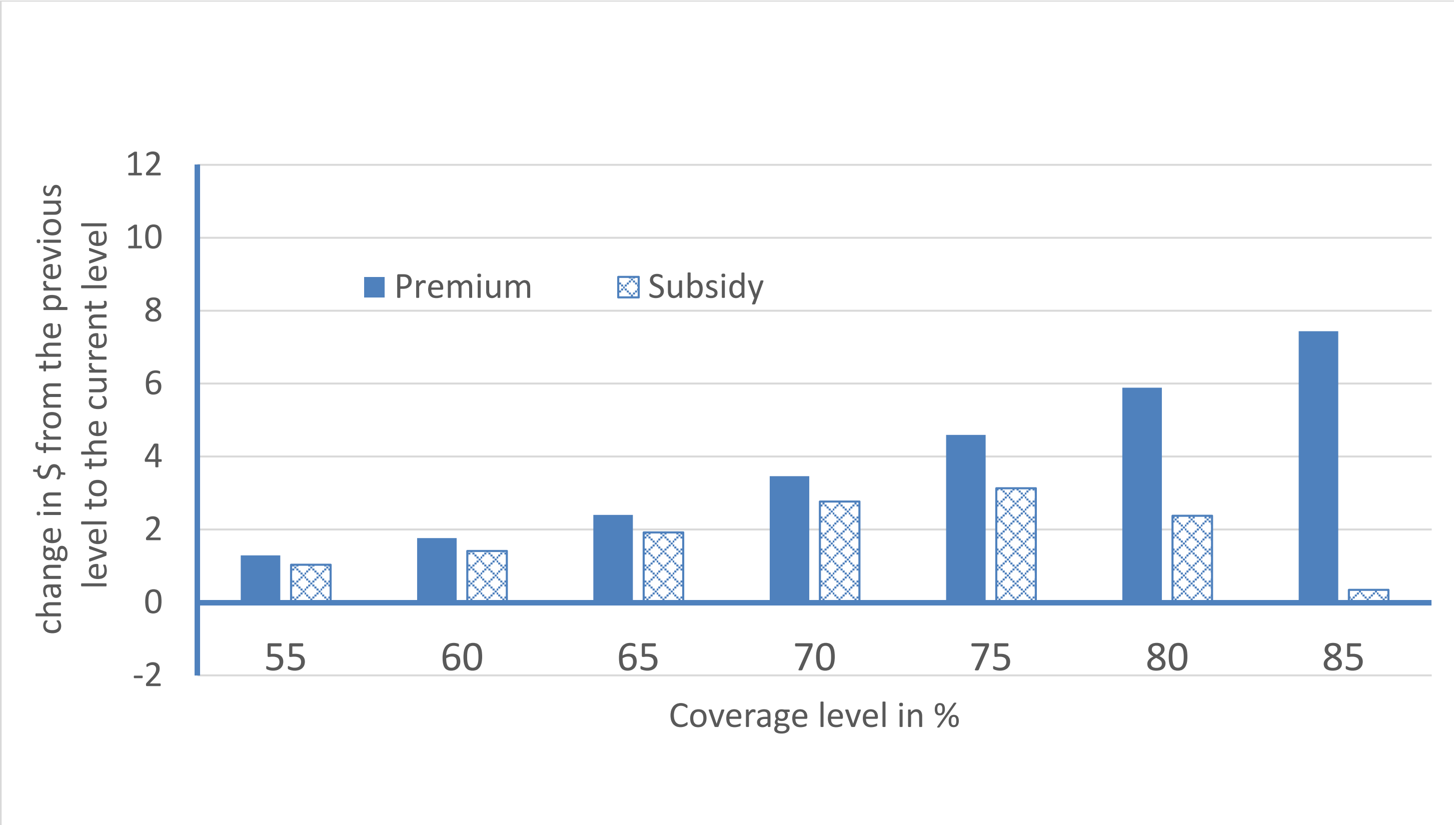

Figure 3. Incremental change in premium and subsidy as coverage level increases from previous lower level to current level; soybean, plan 44 and EU.

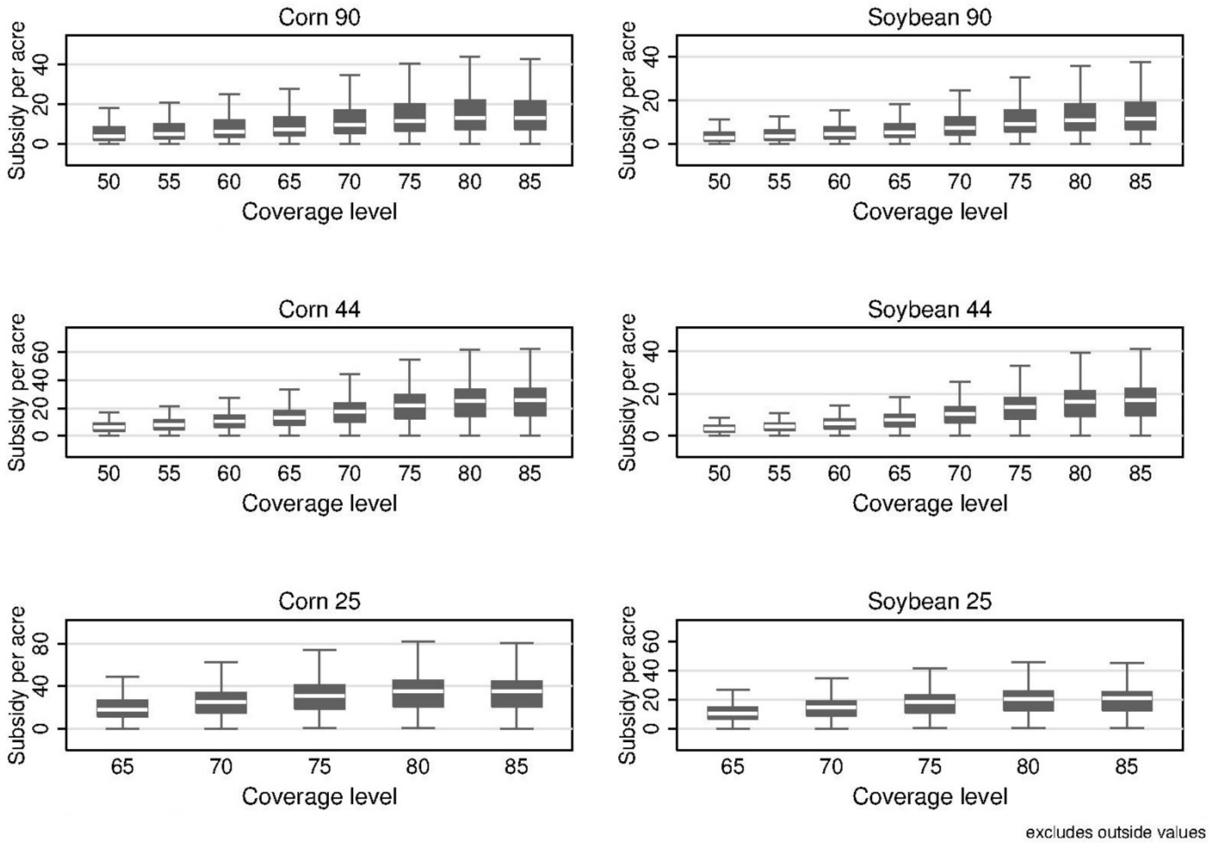

Figure 4. Empirical test results for Hypothesis I.

Notes: On each box, the central mark is the median, the edges are the 25th and 75th percentiles (Q1 and Q3), and the length (Q3-Q1) is defined as the interquantile range (IQR). The upper (lower) whisker extends to include data points within $+(-)1.5\times IQR$.