Rationality of Choices in Subsidized Crop Insurance Markets*

Xiaodong Du
Hongli Feng
David A. Hennessy

ABSTRACT

The U.S. crop insurance market has several features that set it apart from other insurance markets. These include: i) explicit government subsidies with an average premium subsidy rate of about 60 percent in recent years; and ii) 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 constructed to analyze trade-offs between higher risk protection and larger subsidy payments. We decompose the effect of coverage level on expected utility into insurance, premium loading and subsidy transfer effects where the loading effect vanishes if rates are actuarially fair. Given an actuarially fair premium we infer that 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. In a novel application of the mixed logit framework we show that the probability an insurance product is chosen declines as out-of-pocket premium expenditures increase even though higher values of these expenditures should reflect improved grower welfare. Premium expenditures appear to be more salient than the uncertain future benefits they support. We apply our regression to the recent trend yield adjustment innovation in crop insurance.

Keywords: actuarial fairness; behavioral anomalies; premium subsidy; regret; underinsurance.

JEL Classification: D03, H2, Q18.

Running Head: **Rationality of Choices in Crop Insurance Markets**

---

*Xiaodong Du is Assistant Professor at the Department of Agricultural & Applied Economics, University of Wisconsin-Madison. He may be contacted at xdu23@wisc.edu. Hongli Feng is Associate Professor at the Department of Agricultural, Food & Resource Economics, Michigan State University. She may be contacted at hennes65@msu.edu. David Hennessy is Elton R. Smith Professor of Food & Agricultural Policy at the Department of Agricultural, Food & Resource Economics, Michigan State University. He may be contacted at hennes64@msu.edu. Both Feng and Hennessy also held appointments at the Department of Economics, Iowa State University while Hennessy held affiliation with the Center for Agricultural and Rural Development when this research was completed. We thank, without implications, two journal reviewers and editor Brian Roe for suggestions that substantially improved the paper's content. We also acknowledge the very helpful RMA officials who clarified for us various premium adjustment rules.

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 precipitate exit by less risky contract holders and so further rate increases. Apart from income transfer motives, subsidies can promote insurance market performance. They can incentivize comparatively low-risk prospects to enter and remain in the market, thus preventing collapse. Publicly funded insurance subsidies occur in a variety of settings. As of 2016 the U.S. National Flood Insurance Program continues to provide federally subsidized flood insurance to many property owners while the U.S. Patient Protection and Affordable Care Act (ObamaCare) distributes income dependent health insurance subsidies.

A large literature exists on insurance and decision-making regarding financial risks. Foundational in this literature are results from basic theoretical models under rational behavior, where expected utility (EU) maximization is the standard model. 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 to compare economic theories with actual choices. 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 (Kunreuther, Pauly, & McMorrow 2013). 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 & Thaler 2001; Sydnor 2010), i.e., they over insure. By contrast, many eligible for free health insurance have not enrolled (Baicker, Congdon, & Mullainathan 2012).

In this paper we will consider a large and distinctive insurance market, 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, as far as is practicable, 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, & Lusk 2004). But 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 transfer (Goodwin & Smith 2013). It is reasonable to assume that individual farmers are at least partly motivated to insure in order to acquire larger subsidy transfers. 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 could be used for policy purposes, e.g., to assess the potential effects of any 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 our findings will be compared with the extant literature. A discrete choice model will be estimated to show how yield guarantee and out-of-pocket expenses actually affect choices. This model will be used to study the recent innovation to allow trend adjustment when calculating mean yields. We conclude with some remarks on what our findings mean for crop insurance policy.

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. See Glauber (2013) for a succinct program history. 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 an historical yield average whereas predetermined revenue is the product of this average 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 Bill, of 2014, this partnership has become firmly embedded in legislation.

Crop insurance participation rates grew during the 1980s but stalled at around 30 percent in the early 1990s, lower than many in Congress had hoped for. Congress remained vulnerable to making recurrent *ad hoc* disaster assistance payments (Innes 2003). The Federal Crop Insurance Reform Act of 1994 restructured the program by increasing premium subsidies and adding a 'catastrophic' (CAT) insurance policy that compensates farmers for losses beyond 50 percent of historical average yield paid at 60 percent of the price established for that year. CAT is fully subsidized (i.e., 100 percent) 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 late 1990s with 180 million acres covered in 1998, about two thirds of the nation's total planted acreage for field crops. Congress increased subsidies once more through the passage of the Agricultural Risk Protection Act (ARPA) of 2000. Since ARPA, the percentage subsidy rate has been the same for 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 (Du, Hennessy, & Feng 2014).

By contrast with other insurance markets, crop insurance premiums are set by RMA actuaries with intent to generate only sufficient premium dollars to cover indemnities.[1] 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, where Coble et al. (2010) provide an overview.[2] Higher program participation rates in recent years, likely due in large part to more generous subsidies, have also mitigated adverse selection problems. Nonetheless, concerns remain that premium rates for many crops in marginal growing areas of the United States are too low (USGAO 2015).

For a given crop, a farmer can purchase insurance at three different ‘unit’ levels, namely optional unit (OpU), basic unit (BaU), and enterprise unit (EnU). Broadly stated, EnU coverage would include all land under a given crop that a grower farms in a county; BaU is based on the land ownership split for one crop in a county where acres owned or cash rented are united into one unit and acres sharecropped with each distinct landlord forms a separate unit; and OpUs are subdivisions of a BaU by township sections.

The subsidy rate schedules are given in table 1. We make two general remarks on these rates, the first regarding temporal evolution and the other regarding comparative subsidies across unit structures. In the temporal dimension, the share of premium paid by taxpayers increased from about 25 percent prior to 1994 to around 62 percent in recent years. Meanwhile, total insured acres for major crops increased from less than 30 percent prior to 1990 to over 80 percent 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 most geographic areas. In 2015 the Federal Crop Insurance Corporation issued about 1.2 million insurance policies across the fifty states and covered 285 million acres with a total liability of $96 billion (USDA RMA 2016).

As for comparisons across unit structures, table 1 shows the current subsidy rate to be much higher for EnU than for BaU or OpU. Larger incentives are needed to entice growers into more aggregated units because dollar subsidies scale in proportion to premium levels so that the lower premiums generate lower subsidy transfers. *Ceteris paribus*, actuarially fair premiums for EnU should be lower than for BaU while BaU premiums should be lower than OpU premiums. The ordering ultimately arises from convexity in the insurance payoff function where convexity arises for several distinct reasons. When land units of identical production characteristics are pooled into a portfolio then the expected indemnity payout will decline to the extent that yields are imperfectly correlated. In addition, when land units are heterogeneous in production characteristics then pooling will result in an averaging of yield guarantees and that will also reduce the expected indemnity payout. Finally a single coverage level will be chosen under an enterprise unit while the owner of a basket of finer units from which this enterprise unit is constructed can adapt the coverage level choice to each unit so as to increase subsidy transfers.

How 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 insurance companies have choices over the portions of their book of contract business 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.

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 $0 \leq z \leq \infty$. The mean value will be used to benchmark insurance coverage. If the coverage level is ϕ with $0 \leq \phi \leq 1$ 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. In order to allow for deviations from the actuarially fair rate we introduce a loading factor, $l(\phi)$, that might vary with coverage level. With $E[\cdot]$ as the expectation operator, the actuarially fair premium is $p(\phi) =$ $E[M(z;\phi)] = \int_0^{\phi\bar{z}} (\phi\bar{z} - z)dF(z)$, loaded premium is $[1+l(\phi)]p(\phi)$ and response to coverage level is $[1+l(\phi)]p_\phi(\phi) + l_\phi(\phi)p(\phi) = [1+l(\phi)]\bar{z}F(\phi\bar{z}) + l_\phi(\phi)E[M(z;\phi)]$ where $p_\phi(\phi)$ and $l_\phi(\phi)$ are the appropriate function derivatives. Let $s(\phi)$ be the subsidy rate per dollar of premium at coverage level ϕ, so $S(\phi) = s(\phi)[1+l(\phi)]p(\phi)$ is the subsidy's dollar value and the producer pays $h(\phi) \equiv$ $[1-s(\phi)][1+l(\phi)]p(\phi)$. The response of subsidy amount to coverage level is $S_\phi(\phi) =$ $s_\phi(\phi)[1+l(\phi)]p(\phi) + s(\phi)l_\phi(\phi)p(\phi) + s(\phi)[1+l(\phi)]p_\phi(\phi)$ where $s_\phi(\phi)$ is the derivative of the subsidy rate function. If premiums are actuarially fair then $l(\phi) \equiv 0$ and $S_\phi(\phi) = s_\phi(\phi)p(\phi) +$ $s(\phi)\bar{z}F(\phi\bar{z})$.

We analyze a growers' insurance choices within the standard EU 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 degree 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

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

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

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

In analyzing farmers' insurance choice decisions, the following claim is critical:

(C1) growers are rational, more-is-better, risk-averse EU maximizers.

Rationality claim (C1) requires the value of expression (2) to be maximized over coverage choices available. In this paper we do not assume (C1); rather our intent is to inquire into its soundness as a characterization of behavior.

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

$$(3) \qquad \begin{aligned} \frac{dE[U(\cdot)]}{d\phi} &= \bar{z}F(\phi\bar{z})\int_{\underline{\eta}}^{\bar{\eta}} U_w(\phi\bar{z} - r(\phi,\bar{c},\eta))dG(\eta) - h_\phi(\phi)E[U_w(w(z,\eta))]; \\ E[U_w(w(z,\eta))] &\equiv \int_{\underline{\eta}}^{\bar{\eta}}\int_0^{\infty} U_w(w(z,\eta))dF(z)dG(\eta). \end{aligned}$$

Equation (3) captures the two effects of an increase in ϕ. For low crop yield or revenue values a larger floor is placed on outcomes. These outcomes receive weight $\bar{z}F(\phi\bar{z})$, reflecting the ex-ante probability that the floor is in place. For all crop yield or revenue values the cost of net premium increases by $h_\phi(\phi)$ at the margin so that there is an adverse effect on marginal utility of income that must be weighted by $h_\phi(\phi)$ to capture the utility metric cost.

Use the previously established computation for $S_\phi(\phi)$ under actuarial fairness inference and then rearrange (3) to obtain

$$\text{4)}\quad \begin{aligned}\frac{dE[U(\cdot)]}{d\phi} &= \underbrace{\bar{z}F(\phi\bar{z})\int_{\underline{\eta}}^{\bar{\eta}}\left\{U_w(\phi\bar{z}-r(\phi,\bar{c},\eta))-\int_0^\infty U_w(w(z,\eta))dF(z)\right\}dG(\eta)}_{\text{Insurance effect}} \\ &+\underbrace{\left[-l(\phi)\bar{z}F(\phi\bar{z})-l_\phi(\phi)p(\phi)\right]E[U_w(w(z,\eta))]}_{\text{Premium loading effect}}+\underbrace{S_\phi(\phi)E[U_w(w(z,\eta))]}_{\text{Subsidy transfer effect}}.\end{aligned}$$

Concavity of the utility function implies that $U_w(\phi\bar{z}-r(\phi,\bar{c},\eta))\geq\int_0^\infty U_w(w(z,\eta))dF(z)$ and so the first term after the final equality, the insurance effect, is positive. We label it the insurance effect because it reflects how an actuarially fair contract would affect production.

As $\phi\bar{z}F(\phi\bar{z})\geq p(\phi)$ and, presumably, $l(\phi)\geq 0$ a sufficient condition for the loading effect to be non-positive is that $l(\phi)\geq -l_\phi(\phi)$ and a necessary condition for the effect to be nonnegative is that $0\geq l_\phi(\phi)$. The loading effect is strictly positive (negative) whenever $-l_\phi(\phi)/l(\phi)>(<)$ $\bar{z}F(\phi\bar{z})/p(\phi)$. In addition $0\leq p(\phi)\leq\phi\bar{z}F(\phi\bar{z})$ so that $\bar{z}F(\phi\bar{z})/p(\phi)\geq 1/\phi$, confirming that the loading effect is strictly positive whenever $-\phi l_\phi(\phi)/l(\phi)>1$.

Remark 1: Suppose that $l(\phi)>0$. *Then the premium loading effect is strictly positive whenever* $-\phi l_\phi(\phi)/l(\phi)>1$ *and is strictly negative whenever* $l_\phi(\phi)>0$.

The third term after the final equality has the sign of $S_\phi(\phi)$, or how dollar subsidy changes as coverage level changes. The quantity's sign is unknown without further information on how subsidy rate and premium vary with coverage level. But 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 dollar 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. One final comment is that the loading and subsidy transfer effects may be combined so that the sum of effects will be nonnegative whenever $S_\phi(\phi) \geq l(\phi)\bar{z}F(\phi\bar{z}) + l_\phi(\phi)p(\phi)$, i.e., whenever $s_\phi(\phi)[1+l(\phi)]p(\phi) + s(\phi)\bar{z}F(\phi\bar{z}) \geq [1-s(\phi)]l(\phi)\bar{z}F(\phi\bar{z}) + [1-s(\phi)]l_\phi(\phi)p(\phi)$. When both subsidy rate and load are constant then this condition resolves to $s/(1-s) \geq l$, i.e., $s \geq l/(1+l)$. Thus the minimum subsidy required to offset the load is always smaller than the load.

Henceforth we will presume that the RMA has satisfied legislative intent and posit our second claim:

(C2) premiums are actuarially fair.

If (C2) holds then $l(\phi) \equiv 0$, $l_\phi(\phi) \equiv 0$ and the loading effect vanishes. In regard to our setting, with unloaded rates, we have the following observation,

Remark 2: Under claims (C1)-(C2), suppose that either i) there is no premium subsidy, or ii) the subsidy's dollar value is at least weakly increasing as coverage level increases. Then farmers will choose the highest coverage level, ϕ, available. More generally, if iii) the subsidy's dollar 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 percent, 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 dollar premium subsidy varies with coverage level and may not increase with coverage level. If the highest available coverage level also provides the highest dollar subsidy, then a farmer should choose that coverage level. However, if choosing the highest available coverage level means a lower dollar 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 a larger dollar subsidy. Growers may reduce coverage level somewhat, and so accept increased risk exposure, in order to increase subsidy transfers. However, it is generally believed that dollar subsidy per acre increases with coverage level in the current crop insurance program context so that the need to make this trade-off may not arise. We use individual level data to establish how dollar subsidies change with coverage level, and this allows us to ground-truth Remark 2.

Hypothesis I: (labeled H-I) If the dollar premium subsidy increases with coverage levels then growers will choose the highest coverage level available to them. If the dollar 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 dollar 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 per acre 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 figure's right panel. Table 1 shows that subsidy rate is monotone non-increasing in coverage level. Were (C2) valid and 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 2, 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.

Hypothesis II: (labeled H-II) No grower enrolling in *i*) OpU or BaU will choose coverage level $\phi = 0.55$ over $\phi = 0.6$ or $\phi = 0.65$ over $\phi = 0.7$; *ii*) EnU 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. As $0 \le p(\phi) \le \phi\bar{z}F(\phi\bar{z})$, we may write

(5) $$S_\phi(\phi) \overset{\text{sign}}{=} \frac{s_\phi(\phi)}{s(\phi)} + \frac{\bar{z}F(\phi\bar{z})}{p(\phi)} \ge \frac{s_\phi(\phi)}{s(\phi)} + \frac{1}{\phi}.$$

An implication is

Remark 3: A sufficient condition for subsidy payments to increase with an increase in coverage level, or $S_\phi(\phi) > 0$, is

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

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,

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

In table 2 we see that the values of these elasticity estimates are always non-positive and that the absolute values are smaller than 1 for low coverage levels but always larger than 1 for coverage levels at or above 0.8. These calculations lead us to the conclusions that no grower enrolling in OpU or BaU will choose coverage level $\phi = 0.5$ over $\phi = 0.55$, and that no grower enrolling in EnU will choose coverage level $\phi = 0.7$ over $\phi = 0.75$. For OpU and BaU 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 EnU the elasticity condition allows us to discard $\phi = 0.7$ as a rational choice. Thus we can strengthen H-II to read as

Testable Hypothesis II': (labeled H-II') No grower enrolling in *i*) OpU or BaU will choose a coverage level lower than $\phi = 0.7$; *ii*) EnU will choose a coverage level lower than $\phi = 0.75$.

For OpU and BaU, 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 $p(\phi) \le \phi\bar{z}F(\phi\bar{z})$ 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 $p(\phi) = \phi\bar{z}F(\phi\bar{z})$ only if we assume that $F(0) = F(\phi\bar{z})$, i.e., that the probability weight below yield realization $\phi\bar{z}$ is massed on complete crop failure. Any less pessimistic yield distribution will allow bound -1 to be replaced by a more negative number.

In preparation for our econometric analysis, we make two comments about the likely effects on preferences of changes in out-of-pocket expenses and in yield guarantee, i.e., the product of coverage level and some measure of mean yield. These are two characteristics that we can observe to vary across units in the data available to us. Notice that a change in out-of-pocket expense will be due either to a change in premium charged or an increase in coverage level. In either case an increase in out-of-pocket expense should be associated with more benefits to the grower. Furthermore the increase in benefits should be to the grower's net benefit, i.e., net of costs incident on the grower.

To make the point more explicit, we introduce a factor θ into expected utility specification (2) that scales up both indemnity payouts and out-of-pocket expenses to the grower. Thus, if we allow for no loading then $w(z,\eta) \equiv z + \max[\phi\overline{z} - z, 0] - [1 - s(\phi)]p(\phi) - \overline{c} + \eta$ changes to $w(z,\eta;\theta) \equiv z + \theta\max[\phi\overline{z} - z, 0] - \theta[1 - s(\phi)]p(\phi) - \overline{c} + \eta$ and

(8)
$$\begin{aligned}\frac{dE[U(w(z,\eta;\theta))]}{d\theta} &= E[U_w(w(z,\eta))]\int_0^\infty \{\max[\phi\overline{z} - z, 0] - [1 - s(\phi)]p(\phi)\}\, dF(z) \\ &+ \operatorname{Cov}\left(\int_{\underline{\eta}}^{\overline{\eta}} U_w(w(z,\eta;\theta))dG(\eta), \max[\phi\overline{z} - z, 0] - [1 - s(\phi)]p(\phi)\right).\end{aligned}$$

Now $\int_0^\infty \{\max[\phi\overline{z} - z, 0] - [1 - s(\phi)]p(\phi)\}\, dF(z) = s(\phi)p(\phi) > 0$ as the insurance product is priced at the unloaded, actuarially fair rate. Furthermore marginal utility is positive so that the product of terms after the equality sign has positive value. As wealth is non-decreasing in z, concavity of the utility function ensures that $\int_{\underline{\eta}}^{\overline{\eta}} U_w(w(z,\eta;\theta))dG(\eta)$ is non-increasing in z. Thus both arguments in the covariance relation are non-increasing in the value of z. Cebyçev's inequality for covariance then ensures that the covariance expression is non-negative so that $dE[U(w(z,\eta;\theta))]/d\theta \geq 0$. We summarize with

Remark 4: Under Claim (C2), an increase in out-of-pocket expenses together with a commensurate increase in insurance benefits will increase grower expected utility.

We note in passing that Remark 4 tells us much about how the general level of a commodity's price should affect the extent of subsidy transfers, program attractiveness and incentive to increase coverage levels. An increase in the overall price level will mean an increase in reference prices used to calculate premiums. As such, an increase in price level can be viewed as an increase in θ and so should make the insurance subsidies more attractive. Furthermore, as reference price levels multiply coverage levels in determining the expected indemnity, an increase in reference price level should generally make higher coverage more attractive. We cannot investigate these matters in our empirical inquiry because to date we have only been able to reconstruct one year of premium data.

Turning to our second comment, we specify yield guarantee as coverage level $\times$ mean yield, or $\phi\bar{z}$. Yield guarantee is of interest to us because it varies with coverage choice made in an econometrically identifiable way. We show (see discussions on figures 2 and 3 below) that an increase in coverage level should generally lead to an increase in subsidy transfers and so should strengthen a grower's preference for a product. Regarding the impact of the size of $\bar{z}$ on preference for a coverage level, let us develop further our model of stochastic yield or revenue. Suppose now that $z = \bar{z}\varepsilon$ with $E[\varepsilon]=1$, i.e., yield's coefficient of variation is invariant to mean yield level. Then we have expected indemnity payoff $E\{\max[\phi\bar{z} - \bar{z}\varepsilon, 0]\} = \bar{z}E\{\max[\phi - \varepsilon, 0]\}$ and differential $d(\bar{z}E\{\max[\phi - \varepsilon, 0]\})/d\bar{z} = E\{\max[\phi - \varepsilon, 0]\} \geq 0$. So if risk scales proportionately with mean yield then the magnitude of subsidies should increase with mean yield. In reality it is likely that the coefficient of yield variation will decrease with mean yield where better soils and climate are likely to ensure that yield variance does not increase in proportion to mean yield (Du et al., 2015). However if the subsidy transfer is to decrease with an increase in yield guarantee then the decline in coefficient of variation would have to be very large. We conclude that an increase in yield guarantee should lead to an increase in subsidy transfer level and so an increase in grower expected utility.

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. We then 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.[3] Finally we ask what our mixed logit model can say about demand for an insurance contract upon a contract innovation, namely the introduction of the trend yield adjustment alternative.

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 for 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.[4] But 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.[5]

The rate setting formulas arose out of a sequence of incremental modifications made by the RMA as it sought to set premiums at actuarially fair rates. 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, 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 EnU, 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. We study 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, namely plans 25, 44 and 90.[6] 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. 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 CAT insurance coverage is quite different from other buy-up plans and has much smaller acres enrolled, we exclude it from the sample. For each of the three unit types (OpU, BaU and EnU) 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 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 EnU, figures 2 (for corn) and 3 (for soybean) provide summary data on premiums and subsidies per acre as coverage level increases. Data for other plan and unit structures are very similar, and are not reported but are available upon request. Notice that corn subsidy per acre declines between the 80% and 85% coverage levels, similar to the non-monotone curve in figure 1, while soybean subsidy per acre barely increases over that interval.

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, & 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. Were the left panel of figure 1 applicable then, according to H-I, the highest coverage level should be chosen. Were the right panel to apply then 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. Since the subsidy rate is fixed for a given coverage level, the variation depicted at each coverage level in figure 4 is due entirely to variation in premium levels across enrolled units. 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% levels. 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 dollar 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 BaU or OpU choose the coverage level with the highest subsidy payment or higher coverage levels, while the percentage increases to 13.7% for growers under EnU. Similar results are found for other corn and soybean plans. It is clear that H-I is not supported by the data.

Part *i*) of H-II states that for BaU and OpU coverage levels 55% and 65% are dominated by levels 60% and 70%, respectively, and should not be considered by insurance buyers while farmers in EnU should choose coverage levels at or above 70%. 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 BaU and OpU 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 BaU and OpU in plan 90 and about 5%-10% for plan 44). Although many farmers buying plans 44 and 25 choose 70% coverage, 65% coverage is not dominated by 70% coverage.

The second last column in table 6 reports evidence on part *ii*) of H-II, which states that no grower in EnU will choose $\phi \leq 0.65$. In fact coverage levels lower than 65% are 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 65% or lower. The last column in table 6 reports evidence on H-II', which states that no grower in BaU or OpU will choose coverage levels lower than 70% and no growers in EnU 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.

Some qualifications are in order in regard to data in tables 5 and 6. Summary of Business information available from the USDA RMA show, when compared with 2009, in 2015 a larger share of corn acres that were insured were insured at higher coverage levels.[7] Some of this shift may have been due to a realization among growers that crop insurance subsidies are such that increasing coverage pays for itself while also reducing risk exposure. Other changes have also occurred. EnU policies have become more popular in light of the comparatively high subsidy rates and low out-of-pocket expenses involved. In addition, commencing 2012 insurance products that adjust for trend growth in yields have become available. This innovation allowed the rate-making process to formally recognize the fact that technology innovations have shifted yield distributions to the right over time, lowering premiums and perhaps increasing demand as a result. In due course we will comment further on trend adjustment.

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 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 EU framework (see, e.g., Rabin & Thaler 2001). This is not our concern. Although we use the EU model to motivate our reasoning, our basic arguments apply for any more-is-better decision model in which there is a preference for income stability. Nor are we concerned with low uptake of subsidized insurance that might be due to the priorities that low income individuals have for their very limited budget, see, e.g., Cowley (2015), as farmers in the area typically handle market revenues in the order of a quarter million dollars or more while crop insurance is a second-tier expenditure in line with fuel and machinery maintenance but smaller than seed, fertilizer and pesticide costs. 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 (Pashigian, Schkade, & Menefee 1966; Sydnor 2010). Apparently, the insured do not understand how premium should decrease as the deductible increases (Shapira & Venezia 2008).[8] Our case is quite different. We document a preference for high deductible insurance contracts even when lower deductible (i.e., higher coverage level) contracts provide higher 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 rare and minor losses, highly specific items and emotion-inducing objects, such as heirlooms. These too are irrelevant in our setting.

Risk managers often act 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 underinsured in 2009 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, although coverage levels had risen over time, low average coverage levels had been a persistent feature of crop insurance for many years prior to 2009. 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). So 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 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 & Pauly 2005) is unlikely to apply.

Optimism bias is a further rationale for underinsurance, i.e., the presumption that this undesirable outcome will 'never happen to me.' The notion does not comport well with standard decision models, including EU. 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. Bulut & Collins (2015) have modeled roles of overconfidence in low demand for crop insurance. Rationalizations for such behavior based on neuroeconomic foundations are now emerging (Bracha & Brown 2012). However the primary source of crop yield risk is weather, where belief in individual control does not bear external validation.

Another perspective on underinsurance is that the cost of arriving at a sense of the risk posed can exceed the expected benefit from taking out insurance. If so then disasters viewed as being rare are optimally left uninsured (Kunreuther & 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 the insurance decision is prone to cherry pick past outcomes where insurance was ex post an unfortunate choice and place low weight on past outcomes where insurance was ex post fortunate. In practice it may be difficult to distinguish such preferences from grower concerns about actuarial fairness and from peculiarities residing in grower decision making processes. 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 & 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.

A separate motivation that we cannot readily dismiss is that some growers are reluctant insurers, only doing so to access credit where lenders often require that a crop be insured. In one sense lender requirements would strengthen our findings because we find underinsurance even when some growers are forced to insure. On the other hand our data do not include those demonstrating the most extreme form of underinsurance, i.e., who do not insure at all. A lender requirement to take out insurance would force credit-taking growers with such preferences into the data we scrutinize, pushing up instances of underinsurance and pushing down even more anomalous instances of being uninsured. A $300 administration fee aside, CAT is available for free and so those who feel compelled to insure could take it to comply. Nationwide about 10% of those insuring corn in 2009 took out CAT while about 7% did so for soybeans in that year. But it is possible that growers who are required to insure may completely reassess their insurance preferences and choose other than bare minimum coverage.

Prospect theory's aversion to loss feature (Kahneman & 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. Zhang (2008), Bougherara and Piet (2014) and Pétraud, Boucher and Carter (2015) and have all studied willingness to pay for crop insurance when preferences are loss averse, but did not consider coverage level. The last two of these works have posited prospect-type preferences as a factor in low uptake of unsubsidized crop insurance contracts. Both Du, Feng and Hennessy (2014) and Babcock (2015) have noted potential for prospect theory to explain low coverage levels where Babcock has provided supporting simulations.

Our reasoning for why prospect theory may be relevant is rooted in the view that 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. Deviations from reference yield would then be seen largely as losses over a convex loss function, motivating risk loving behavior over most of the yield outcomes domain (Kahneman, Knetsch, & Thaler 1991). This would explain low uptake of unloaded actuarially fair crop insurance contracts absent subsidies. However prospect theory is more involved than that. It does not imply risk loving behavior over losses; it just admits the possibility. Losses likely to occur with high probability are hypothesized as motivating risk loving behavior but this is not so for losses likely to occur with low probability. In addition to characterizing values over loss and gain domains, prospect theory assigns unlikely outcomes additional weight beyond their probability. For unlikely loss outcomes the additional weight could tilt the convex value function such that the decision maker is risk averse in behavior. Kahneman (2011, Ch. 29) and Scholten and Read

(2014) provide excellent discussions on the matter. Losses relative to potential outcome are common in field cropping and so, probability weight adjustments notwithstanding, our reading is that prospect theory should promote risk loving when growers anchor at or near potential yield.

It is also possible that growers anchor their reference point well below potential yield where plausible alternatives are *i*) their estimate of mean yield and *ii*) the actual production history (APH) mean yield. Then prospect theory's implications are not clear as outcomes will spill into both gain and loss domains. Since the theory holds that losses are more negatively valued than comparable gains are positively valued, there should be a bias toward risk management through insurance. On the other hand, a negative skew on the yield distribution is consistent with a long fat tail in the loss domain, comparatively little variation in the gain domain and so a bias toward risk loving. The literature on anchoring points to availability and recency biases (Kahneman 2011, Ch. 11), among others, so that there is reason to view the reference yield as random across years. Much work needs to be done in the area before we fully understand what prospect theory can have to relate about crop insurance choices.

Empirical evidence elsewhere from agricultural settings provide support for loss averse behavior. Based on survey and lottery experiment data obtained from mixed enterprise farmers in France, Bocquého, Jacquet, & Reynaud (2014) find choices consistent with loss aversion rather than EU. Liu & Huang (2013) and Liu (2013) collect pesticide use data from 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, & Nguyen (2010) elicitation and estimation methodology. Liu & Huang infer that their subjects behave in a loss averse manner regarding health implications from using pesticides. Liu concludes 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 with testable inferences different from prospect theory. In particular, salience theory due to Bordalo, Gennaioli, & Shleifer (2012, 2014) can explain risk seeking for losses. However, little work is presently available on how well this view matches with actual choices in the field or how it fares in comparison with other views. In our setting, premium is a salient feature of insurance as it must be paid whereas indemnities only may be received. So one could view an aversion to paying premium, even if a very good deal, as evidence supporting saliency in decision processes.

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 transaction cost barriers such as 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. Handel and Kolstad (2015) show evidence that informational frictions can tilt a consumer toward a lower deductible comprehensive health insurance plan. This may be in part due to confusion over how services differ across plans. In our setting, however, we do not have a particular concern that information issues will change preferences over coverage levels. In terms of context, a single federal crop insurance program exists, has been available for many years, and is easy to apply for. Furthermore, the target audience is generally well-educated, English speaking, asset rich, socially well-integrated in the locality and unlikely to see legal risks. Thus a transaction cost motive is unlikely to be a primary driver of the choice incongruity.

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, & Madrian (2011) have found widespread untaken arbitrage opportunities among U.S. corporate employees, while a survey informing employees 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 further shrouded by a blanket of random outcomes.

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 (Ch. 11 in Train 2009). We are the first to consider choice across contracts in this way. We are able to do so because we have retrieved reliable price data for choices not taken. Such data are difficult to obtain in insurance markets. To ensure tractability, and because data do not allow us to do otherwise, we confine the analysis to choices within a given plan and unit type. In that way only coverage level differs across contracts. The mixed logit model allows us to estimate farmers' heterogeneity in preferences which are unobservable to researchers. These unobservables could include heterogeneity in risk preferences or in capacity to bear risk. However accounting for this heterogeneity is computationally demanding, which is another reason why restricting attention to a given plan and unit type might be the best practical alternative even were data available for estimating a larger model. One implication of confining attention to a given plan and unit type is that actual, i.e., less constrained, responses are likely to be larger than those that we estimate.

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 *i*th insurance unit, $i \in \Omega^N \equiv \{1, 2, \ldots, N\}$, has 'utility' under choice *k* given by U_{ik} with overall specification

(9) $U_{ik} = X_{ik}'\beta_i + Z_i'\gamma + \varepsilon_{ik}$, $i \in \Omega^N$, $k \in \Omega^K$;

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 of 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 decisions. County-level soil quality is represented by the percentages of farmland acres under Land Capability Classes (LCC) I and II in the total acreage of LCC I-IV. Given the requirement that unsubsidized premiums be actuarially fair, this conditioner should control for the magnitude of unsubsidized premium. The mixed logit model specified in (9) is estimated on observed coverage level choices for individual insurance plans (eight for plans 90/44 and five for plan 25) for corn and soybean using the Maximum Simulated Likelihood method (Ch. 11 in Train 2009).[9] The estimation results are presented in table 7 where the results for fixed coefficients are provided in the supplementary appendix online.

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 EnU among the three unit structures, where a rationalization for this pattern is not entirely clear to us. This phenomenon may be because the distribution of a yield aggregate is less dispersed than the distributions of its components. All else equal, it follows that EnU premiums should be more sensitive to the yield guarantee and so any impacts that yield guarantees have on choices should be larger for the more aggregated rate structure. 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.

One further comment on table 7 is that soybean yield guarantee responses are considerably larger than corresponding corn yield guarantee responses whereas out-of-pocket coefficients are comparable across crops. One reason why this is so is that out-of-pocket expense is measured in dollars while yield guarantee is measured in bushels. If the coefficients are to be placed in common units then one needs to multiply yield guarantee coefficients by respective commodity prices, where market soybean prices are typically twice those for corn.

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 $\beta = \beta_i$ and for data realizations (X_{ikt}, Z_i) are given by $r_{kt}(\beta_i; X_{ikt}, Z_i) = e^{X'_{ikt}\beta_i + Z'_i\gamma} / \sum_{j\in\Omega^K} e^{X'_{ijt}\beta_i + Z'_i\gamma}$. With distribution on β written as $\mathrm{B}(\beta)$, the *k*th contract's share among all contracts under a given plan is $\bar{r}_{kt}(X_{ikt}, Z_i) = \int r_{kt}(\beta; X_{ikt}, Z_i) d\mathrm{B}(\beta)$. Writing out-of-pocket premium coefficient as β_p and *j*th contract premium as p_j, the own- and cross-price elasticities are given as

$$(10) \qquad \bar{\xi}_{kj}(X_{ikt}, Z_i) = \begin{cases} \dfrac{p_j}{\bar{r}_{kt}(X_{ikt}, Z_i)} \displaystyle\int \beta_p r_j(\beta; X_{ikt}, Z_i)[1 - r_j(\beta; X_{ikt}, Z_i)] d\mathrm{B}(\beta), & \text{for } j = k; \\ -\dfrac{p_j}{\bar{r}_{kt}(X_{ikt}, Z_i)} \displaystyle\int \beta_p r_j(\beta; X_{ikt}, Z_i) r_k(\beta; X_{ikt}, Z_i) d\mathrm{B}(\beta) & \text{for } j \neq k. \end{cases}$$

Table 8 provides the average of the $\bar{\xi}_{kj}(\gamma; X_{ikt}, Z_i)$ across all realizations of (X_{ikt}, Z_i).

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 EnU format, for corn and soybeans in revenue insurance plan 25 when under BaU format, and for soybean in plan 25 under the OpU format. In all other cases, i.e., when negative, the responses are inelastic. Thus, we conclude that an increase in out-of-pocket portion 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 payments to obtain these transfers, we posit the following structure to the grower's value function;

(11) $V[\phi_i, s(\phi_i), p(\phi_i)] = A(\phi_i) + H[s(\phi_i)\, p(\phi_i)] + C[(1 - s(\phi_i))\, p(\phi_i)].$

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 $H[\cdot]$ 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. One might view this function as a penalty on the saliency of out-of-pocket expenses. 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 $H[\cdot]$. To the extent that out-of-pocket payments increase with coverage level, including this function will decrease the value of $dV[\cdot]/d\phi = \partial V[\cdot]/\partial\phi + \{\partial V[\cdot]/\partial s\} s_\phi(\phi) + \{\partial V[\cdot]/\partial p\} p_\phi(\phi)$ such that a lower coverage level is preferred.

Although it was not possible for us to include all plans and unit types in a single estimation, it behooves us to assess if not doing so might affect estimates. The partial estimates will almost certainly differ materially from more comprehensive estimates, but the magnitude and direction of differences is not clear to us. It has been found elsewhere (table 5 in Du, Hennessy, & Feng 2014) that demand for yield insurance is comparatively stronger in areas of the country with poorer soils and climate for cropping, and also (table 4 there) that these growing conditions affect choice of coverage level where higher coverage levels are preferred in better growing areas. Thus one response to a higher yield guarantee may be to change from yield insurance to revenue insurance. We have sought to provide some control for this class of sample selection concern by use of land quality controls.

Trend Yield Adjustment

Corn and soybean yield growth in the Central Corn Belt have been, respectively, about 2 and 0.5

bushels per acre per year over the past two decades. Traditionally, reference yield was calculated as an average of historical yield data over up to ten years. Thus reference yields upon which indemnities are calculated are likely too small and coverage relative to expected yield is likely lower than the chosen coverage level would indicate. Commencing 2012, the RMA offered a voluntary contract modification that seeks to address the issue.

The trend yield adjustment (TYA) works by seeking to renormalize historical yields to the current year. For example if the adjustment in a county is 2 bushels per year and a unit has 10 consecutive yields on record then recorded yield ten (resp., nine) years ago would be adjusted up by 20 (resp., 18) bushels and so on up to a two bushel adjustment for last year. The average upward adjustment is $0.1\sum_{j=1}^{10} 2(11-j) = 11$. The same actuarial formula is applied as under the traditional approach but the yield guarantee point of evaluation differs. Now write the actuarially fair premium calculation as follows:

$$v[\phi(\bar{z}+\tau)] = \int_0^{\phi(\bar{z}+\tau)} [\phi(\bar{z}+\tau) - z]dF(z), \tag{12}$$

where τ is the annual adjustment. For coverage level ϕ the premium is $v[\phi\bar{z}]$ absent the TYA election and it is $v[\phi(\bar{z}+\tau)]$ under the election. Clearly $v[\phi\bar{z}] \le v[\phi(\bar{z}+\tau)]$. Out-of-pocket expenses are $[1-s(\phi)]v[\phi\bar{z}]$ absent the TYA election and $[1-s(\phi)]v[\phi(\bar{z}+\tau)]$ under the election so that out-of-pocket expenses are larger too.

On the other hand subsidy transfer is larger under TYA, at $s(\phi)v[\phi(\bar{z}+\tau)] \ge s(\phi)v[\phi\bar{z}]$. Indeed subsidy transfer grows with adjustment according to $d\{s(\phi)v[\phi(\bar{z}+\tau)]\}/d\tau =$ $s(\phi)\phi F(\phi(\bar{z}+\tau))$. Upon differentiating once more we have

$$\begin{aligned} \frac{d^2\{s(\phi)v[\phi(\bar{z}+\tau)]\}}{d\tau d\phi} &= [s(\phi)+s_\phi(\phi)\phi]F(\phi(\bar{z}+\tau)) + s(\phi)\phi(\bar{z}+\tau)f(\phi(\bar{z}+\tau)) \\ &\ge [s(\phi)+s_\phi(\phi)\phi]F(\phi(\bar{z}+\tau)). \end{aligned} \tag{13}$$

The second cross-derivative is certainly positive whenever $\mathbb{S}(\phi) \equiv \phi s_{\phi}(\phi) / s(\phi) > -1$.

Remark 5: If $\mathbb{S}(\phi) \geq -1$ *then the magnitude of transfers increases with an increase in coverage level upon switching from the traditional approach to the TYA approach for calculating APH.*

Thus TYA should be attractive to growers for two reasons. If they are using the traditional approach at coverage level ϕ' then they can switch to TYA and reduce coverage to ϕ'' where $\phi'' < \phi'$. If $\phi' > \phi'' \geq \phi'\bar{z} / (\bar{z} + \tau)$ then true coverage level is higher and the premium is at most as large. But the subsidy has probably increased because $s(\phi'') > s(\phi')$. Second, according to Remark 5 if the grower is seeking to reduce risk exposure and obtain larger effective transfers then she should, at least weakly, increase coverage level.

How does this line of reasoning comport with our empirical analysis? The table 7 regressions indicate that an increase in mean yield will increase yield guarantee, i.e., coverage level × mean yield, for any given coverage level. But, as the marginal value of an increase in mean yield increases with coverage level chosen, there should be an incentive not just to switch over but to increase coverage level while doing so. However the distaste for out-of-pocket expenses suggests that growers may be inclined not to increase coverage.

To provide a numerical example on a representative pair of parameters, consider Corn Plan 44 (Crop Revenue Coverage) under BaU in table 7 where the yield guarantee and out-of-pocket coefficients are 0.17 and -0.07, respectively. Let $(\phi, \bar{z}) = (180, 0.75)$ and set corn price at planting to be \$4.00. For yield growth at 2 bu./acre/year, over 10 year the adjustment is 11 so that the value of yield guarantee is boosted by 0.75(11)(4)=\$31. An upper bound for the premium absent TYA is $4\phi\bar{z}F(4\phi\bar{z}) = 540F(540)$ while the subsidy rate is 0.55 so that maximum out-of-pocket expenditure is $(0.45)540F(540) = 243F(540)$. Under TYA the same upper bound formula becomes $4\phi(\overline{z}+\tau)F(4\phi(\overline{z}+\tau)) = 573F(573)$ so that the maximum out-of-pocket expenditure becomes $257.85F(573)$. Now approximate $257.85F(573) - 243F(540)$ by assuming $F(573) = 0.3 > F(540) = 0.2$ so that $257.85F(573) - 243F(540) \approx 28.7$. So weighting the effect of change in yield guarantee by the effect of change in out-of-pocket premium we get 0.17($31) - 0.07($28.7) > 0. The move to TYA is such a good deal in this case that even strong aversion to paying for premium should not be a barrier to uptake at the same coverage level or higher. In general, our view is that if growers' distaste for out-of-pocket expenses leads growers to avoid TYA altogether then this would be an anomaly quite separate from that which we have observed in this paper. We know that TYA has proven to be popular in many parts of the country, where available, though we do not have available to us information on national uptake.

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 prospect theory, 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 done much to address market failures due to information problems. Subsidy interventions may have also helped to overcome the political system's inability to be time consistent when demanding that growers take out insurance to be eligible for any disaster payment program. Insurance product innovations, such as revenue insurance and the inclusion of a harvest price protection provision, have also helped in this regard. The U.S. drought of 2012 did not involve large additional outlays for crop disaster relief.

Might there be other motives for tying transfers to crop insurance? Crop insurance subsidies are notified to the World Trade Organization as general subsidies with a generous threshold below which they need not be counted as general support (Smith & Glauber 2012). Although at least one formal complaint has been lodged with the WTO for resolution, brought by Brazil and regarding upland cotton, as of late 2015 the WTO has not ruled that U.S. federal crop insurance programs violate trade agreements (Glauber 2015). The transfer tie also has appeal because the image of a crop disaster softens opposition to such transfers while the indirect channel through which premiums are made is somewhat obscure.

Suppose then that promoting transfers through crop insurance is a political goal. How might policies help in this regard? The history of crop insurance programs suggests that larger subsidies would increase demand, but what of policies intent on addressing the behavioral anomalies? We think that our understanding of these anomalies is presently insufficient to manage them toward better meeting policy goals. Further inquiry is in order into why growers choose to pass up opportunities to both increase expected income and reduce income variability. Nonetheless we will tentatively posit some recommendations. Making growers more aware of transfers presently available but not taken up is one approach. As we have pointed out in our literature overview, this approach is not certain to succeed if that is all that is done. 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 thought processes that give rise to the behavioral anomalies that we observe. In regard to managing any additional saliency afforded to 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, e.g., as put forth in Sunstein (2011).

In regard to managing loss averse behavior that might explain our empirical findings, it is tempting to suggest that policy makers should seek to manipulate how growers anchor their reference point for outcomes. However little is known about how anchors might emerge in crop insurance choice or how an anchor might affect choice. A safer recommendation, and one more likely to be robust to misspecification of the mental decision model(s) that people use, is to help growers broaden the frame in which crop insurance decisions are taken and to foster more reflective decisionmaking (Kahneman 2011, Ch. 31). Actually public policy efforts to this general end have long been in place in the United States. Many Land Grant University outreach materials emphasize the need to view crop insurance within the context of broader production choices made, and to use accounting and other decision tools when making these decisions. For example, in 2015 the U.S. Department of Agriculture provided $7 million in grants to generate education and training programs aimed at growers' insurance choices. In our view a cheap approach to better understanding these markets and their failings is to provide more open access to data in a way that preserves anonymity. The first step to understanding the origin of anomalies and devise redress is to document them.

References

Aizer, A. 2007. "Public Health Insurance, Program Take-Up, and Child Health." *Review of Economics and Statistics* 89(3):400-415.

Babcock, B.A. 2015. "Using Prospect Theory to Explain Anomalous Crop Insurance Coverage Choice." *American Journal of Agricultural Economics* 97(5):1371-1384.

Baicker, K., W.J. Congdon, and S. Mullainathan. 2012. "Health Insurance Coverage and Take-Up: Lessons from Behavioral Economics." *Milbank Quarterly* 90(1):107-134.

Beshears, J., J.J. Choi, D. Laibson, and B.C. Madrian. 2013. "Simplification and Savings." *Journal of Economic Behavior & Organization* 95:130-145.

Bocquého, G., F. Jacquet, and A. Reynaud. 2014. "Expected Utility or Prospect Theory Maximizers? Assessing Farmers' Risk Behavior from Field-experiment Data." *European Review of Agricultural Economics* 41(1):135-172.

Bordalo, P., N. Gennaioli, and A. Shleifer. 2012. "Salience Theory of Choice Under Risk." *Quarterly Journal of Economics* 127(3):1243-1285.

Bordalo, P., N. Gennaioli, and A. Shleifer. 2014. "Salience and Asset Prices." *Journal of Political Economy* 121(5):803-843.

Bougherara, D., and L. Piet. 2014. "The Impact of Farmer's Risk Preferences on the Design of an Individual Yield Crop Insurance.” Paper presented at EAAE Congress, Ljubljana, Slovenia, 26-29 August.

Bracha, A., and D.J. Brown. 2012. “Affective Decision Making: A Theory of Optimism Bias.” *Games and Economic Behavior* 75(1):67-80.

Braun, M., and A. Muermann. 2004. “The Impact of Regret on the Demand for Insurance.” *Journal of Risk and Insurance* 71(4):737-767.

Braun, M., P.S. Fader, E.T. Bradlow, and H. Kunreuther. 2006. “Modeling the “Pseudodeductible” in Insurance Claims Decisions.” *Management Science* 52(8):1258-1272.

Bulut, H., and K.J. Collins. 2015. “Managing Catastrophic Risk in Agriculture through Ex-Ante Subsidized Insurance or Ex-Post Disaster Aid.” Unpublished Working Paper, March, National Crop Insurance Services, Overland Park, KS.

Choi, J.J., D. Laibson, and B.C. Madrian. 2011. “$100 Bills on the Sidewalk: Suboptimal Investment in 401(K) Plans.” *Review of Economics and Statistics* 93(3):748-763.

Coble, K.H., T.O. Knight, B.K. Goodwin, M.F. Miller, and R.M. Rejesus. 2010. A Comprehensive Review of the RMA APH and COMBO Rating Methodology Final Report. A report completed by Sumaria Systems for the United States Department of Agriculture, Risk Management Agency. Available at http://www.rma.usda.gov/pubs/2009/comprehensivereview.pdf.

Cowley, S. 2015. “Insurance Out of Reach for Many, Despite Law.” *New York Times*, October 21, p. B1.

Du, X., D.A. Hennessy, and H. Feng. 2014. “A Natural Resource Theory of U.S. Crop Insurance Contract Choice.” *American Journal of Agricultural Economics* 96(1):232-252.

Du, X., H. Feng, and D.A. Hennessy. 2014. “Rationality of Choices in Subsidized Crop

Insurance Markets." Center for Agricultural and Rural Development working paper 14-WP 545, February, Department of Economics, Iowa State University.

Du, X., C.L. Yu, D.A. Hennessy, and R. Miao. 2015. "Geography of Crop Yield Skewness." *Agricultural Economics* 46(4):463-473.

Glauber, J.W. 2013. "The Growth of the Federal Crop Insurance Program, 1990-2011." *American Journal of Agricultural Economics* 95(2):482-488.

Glauber, J.W. 2015. "Agricultural Insurance and the World Trade Organization." International Food Policy Research Paper 01473, Markets, Trade and Institutions Division, Washington DC, October.

Goodwin, B.K. 2001. "Problems with Market Insurance in Agriculture." *American Journal of Agricultural Economics* 83(3):643-649.

Goodwin, B.K., and V.K. Smith. 2013. "What Harm is Done by Subsidized Crop Insurance?" *American Journal of Agricultural Economics* 95(2):489-497.

Handel, B.J., and J.T. Kolstad. 2015. "Health Insurance for "Humans": Information Frictions, Plan Choices, and Consumer Welfare." *American Economic Review* 105(8):2449-2500.

Innes, R. 2003. "Crop Insurance in a Political Economy: An Alternative Perspective on Agricultural Policy." *American Journal of Agricultural Economics* 85(2):318-335.

Kahneman, D. 2011. *Thinking Fast and Slow*. New York: Farrar, Straus and Giroux.

Kahneman, D., and A. Tversky. 1979. "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47(2):263-292.

Kahneman, D., J.L. Knetsch, and R.H. Thaler. 1991. "Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias." *Journal of Economic Perspectives* 6(1):193-206.

Kunreuther, H., and M. Pauly. 2004. "Neglecting Disaster: Why don't People Insure against

Large Losses?" *Journal of Risk and Uncertainty* 28(1):5-21.

Kunreuther, H., and M. Pauly. 2005. "Insurance Decision-Making and Market Behavior." *Foundations and Trends® in Microeconomics* 1(2), 63-127.

Kunreuther, H.C., M.V. Pauly, and S. McMorrow. 2013. *Insurance & Behavioral Economics*. Cambridge UK: Cambridge University Press.

Laibson, D. 1997. "Golden Eggs and Hyperbolic Discounting." *Quarterly Journal of Economics* 112(2):443-477.

Liu, E.M. 2013. "Time to Change What to Sow: Risk Preferences and Technology Adoption Decisions of Cotton Farmers in China." *Review of Economics and Statistics* 95(4):1386-1403.

Liu, E.M., and J. Huang. 2013. "Risk Preferences and Pesticide Use by Cotton Farmers in China." *Journal of Development Economics* 103(July):202-215.

Mossin, J. 1968. "Aspects of Rational Insurance Purchasing." *Journal of Political Economy* 76(2):533-568.

Norwood, B., M.C. Roberts, and J.L. Lusk. 2004. "Ranking Crop Yield Models Using Out-of-Sample Likelihood Functions." *American Journal of Agricultural Economics* 86(4):1032-1043.

Pashigian, B.P., L.L. Schkade, L.L., and G.H. Menefee. 1966. "The Selection of an Optimal Deductible for a given Insurance Policy." *Journal of Business* 39(1):35-44.

Pétraud, J.P., S.R. Boucher, and M.R. Carter. 2015. "Competing Theories of Risk Preferences and the Demand for Crop Insurance: Experimental Evidence from Peru." Paper presented at 29th International Conference of Agricultural Economists, Milan, Italy, 8-14 August.

Rabin, M., and R.H. Thaler. 2001. "Anomalies: Risk Aversion." *Journal of Economic*

Perspectives 15(1):219-232.

Ratan, A. 2013. "Anticipated Regret or Endowment Effect? A Reconsideration of Exchange Asymmetry in Laboratory Experiments." *The B.E. Journal of Economic Analysis & Policy* 14(1):277-298.

Scholten, M., and D. Read. 2014. "Prospect Theory and the "Forgotten" Fourfold Pattern of Risk Preferences." *Journal of Risk and Uncertainty* 48(1):67-83.

Shapira, Z., and I. Venezia. 2008. "On the Preference for Full-Coverage Policies: Why do People Buy too much Insurance?" *Journal of Economic Psychology* 29(5):747-761.

Sherrick, B.J., P.J. Barry, P.N. Ellinger, P.N., and G.D. Schnitkey. 2004. "Factors Influencing Farmers' Crop Insurance Decisions." *American Journal of Agricultural Economics* 86(1):103-114.

Smith, V.H., and J.W. Glauber. 2012. "Agricultural Insurance in Developed Countries: Where Have we Been and Where are we Going?" *Applied Economic Perspectives and Policy* 34(3):363-390.

Sunstein, C.R. 2011. "Empirically Informed Regulation." *The University of Chicago Law Review* 78(4):1349-1429.

Sydnor, J. 2010. "(Over)insuring Modest Risks." *American Economic Journal: Applied Economics* 2(October):177-199.

Tanaka, T., C.F. Camerer, and Q. Nguyen. 2010. "Risk and Time Preferences: Linking Experimental and Household Survey Data from Vietnam." *American Economic Review* 100(1):557-571.

Train, K. 2009. *Discrete Choice Methods with Simulation* 2nd ed. New York: Cambridge University Press.

U.S. Department of Agriculture, Risk Management Agency (USDA RMA), 2012. *Summary of Business*.

U.S. Department of Agriculture, Risk Management Agency (USDA RMA), 2016. *Summary of Business*.

United States Government Accountability Office (USGAO), 2015. In Areas with Higher Crop Production Risks, Costs Are Greater, and Premiums May Not Cover Expected Losses. Report GAO-15-215, published February 9. Washington, DC.

Vetter, S., F. Heiss, D. McFadden, and J. Winter. 2013. "Risk Attitudes and Medicare Part D Enrollment Decisions." *Economic Letters* 119(2):128-132.

Weinstein, N.D. 1988. "The Precaution Adoption Process." *Health Psychology* 7(4):355-386.

Zhang, L. 2008. "Three Essays on Agricultural Risk and Insurance." PhD dissertation, Department of Economics, Iowa State University.

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 BaU and OpU	1.0	0.67	0.64	0.64	0.59	0.59	0.55	0.48	0.38
Subsidy rate for EnU	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, OpU and BaU	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, EnU	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-OpU	0.54	0.11	0.01	0.05	0.29	0.28	0.18	0.06	0.03
-BaU	0.44	0.14	0.02	0.05	0.32	0.21	0.17	0.05	0.03
-EnU	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-OpU	0.35	0.01	0.00	0.02	0.11	0.34	0.34	0.15	0.04
-BaU	0.19	0.02	0.01	0.02	0.11	0.29	0.33	0.17	0.06
-EnU	0.46	0.01	0.00	0.01	0.02	0.08	0.28	0.40	0.21
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-OpU	0.51				0.18	0.46	0.29	0.07	0.01
-BaU	0.27				0.22	0.45	0.26	0.06	0.01
-EnU	0.22				0.06	0.20	0.40	0.29	0.04
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. Also, the three unit type shares (OpU, BaU, EnU) sum to 1. The shares across coverage levels in a row sum to 1, and not to that unit type's share.

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 –OpU	4.0	Plan 90 –OpU	2.8
–BaU	3.5	–BaU	2.4
–EnU	13.7	–EnU	4.5
Plan 44 –OpU	4.3	Plan 44 –OpU	4.7
–BaU	6.2	–BaU	6.4
–EnU	40.2	–EnU	22.9
Plan 25 –OpU	3.4	Plan 25 –OpU	4.9
–BaU	3.0	–BaU	3.9
–EnU	25.8	–EnU	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%	% EnU at ≤65%	% BaU/OpU (EnU) at ≤65% (70%)
Corn							
Plan 90 –OpU	12.5	1.6	4.6	29.6	20.9	---	48.4
–BaU	13.6	1.7	5.1	32.5	21.3	---	52.9
–EnU	10.8	3.1	4.8	36.3	29.6	55	56.2
Plan 44 –OpU	1.1	0.3	1.1	6.2	17.4	---	8.8
–BaU	1.6	0.5	1.9	10.6	29.2	---	14.6
–EnU	1.0	0.2	0.9	5.3	14.8	7.4	22.3
Plan 25 –OpU	---	---	---	14.9	34.2	---	14.9
–BaU	---	---	---	21.5	45.3	---	21.5
–EnU	---	---	---	21.4	45.5	21.4	66.8
Soybean							
Plan 90 –OpU	14.2	1.8	4.5	31.3	20.7	---	51.8
–BaU	14.1	1.8	4.6	33.3	21.3	---	53.7
–EnU	21.6	3.3	6.4	29.1	10.7	60.4	71.1
Plan 44 –OpU	2.2	0.4	1.6	7.9	19.1	---	12.1
–BaU	2.2	0.5	2.1	10.6	26.0	---	15.4
–EnU	1.7	0.3	1.1	5.8	14.3	8.9	23.2
Plan 25 –OpU	---	---	---	13.8	33.5	---	13.8
–BaU	---	---	---	19.0	44.2	---	19.0
–EnU	---	---	---	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	OpU	BaU	EnU	OpU	BaU	EnU	OpU	BaU	EnU
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)	53,953	43,757	1,922	211,666	114,107	281,210	104,839	55,700	44,435
	Soybean 90			Soybean 44			Soybean 25		
Mean	OpU	BaU	EnU	OpU	BaU	EnU	OpU	BaU	EnU
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)	59,574	53,064	2,478	145,528	97,736	222,400	146,545	75,821	51,315

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 supplementary appendix online. The fixed effects are county control variables on Land Capability Classes I or II as a share of acres that are Classes I through IV.

Table 8. Own Elasticity Estimates Based on Mixed Logit Model Estimation

Elasticity	Corn 90			Corn 44			Corn 25		
Coverage Levels	OpU	BaU	EnU	OpU	BaU	EnU	OpU	BaU	EnU
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	OpU	BaU	EnU	OpU	BaU	EnU	OpU	BaU	EnU
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

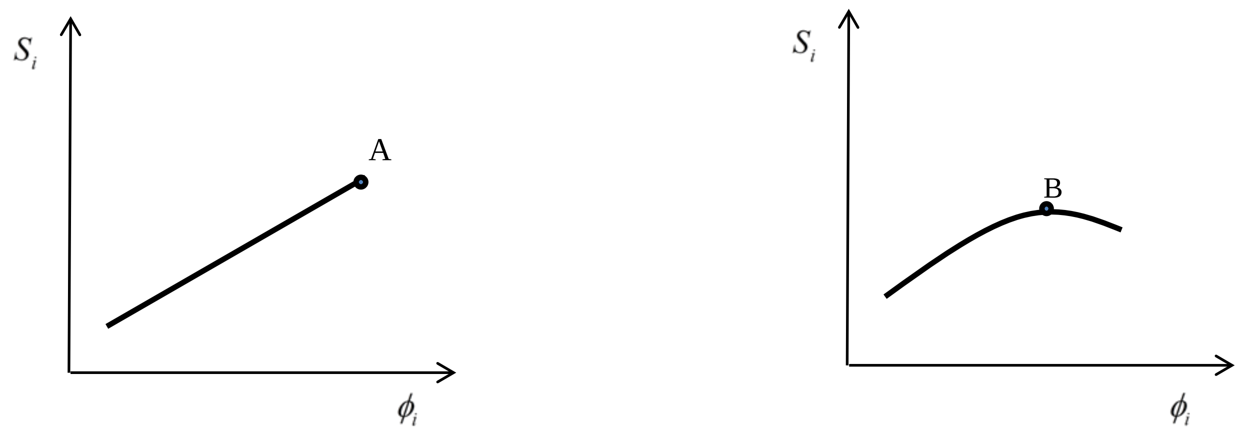

Figure 1. Two illustrations of possible relationship between coverage level and dollar amount of premium subsidies per acre

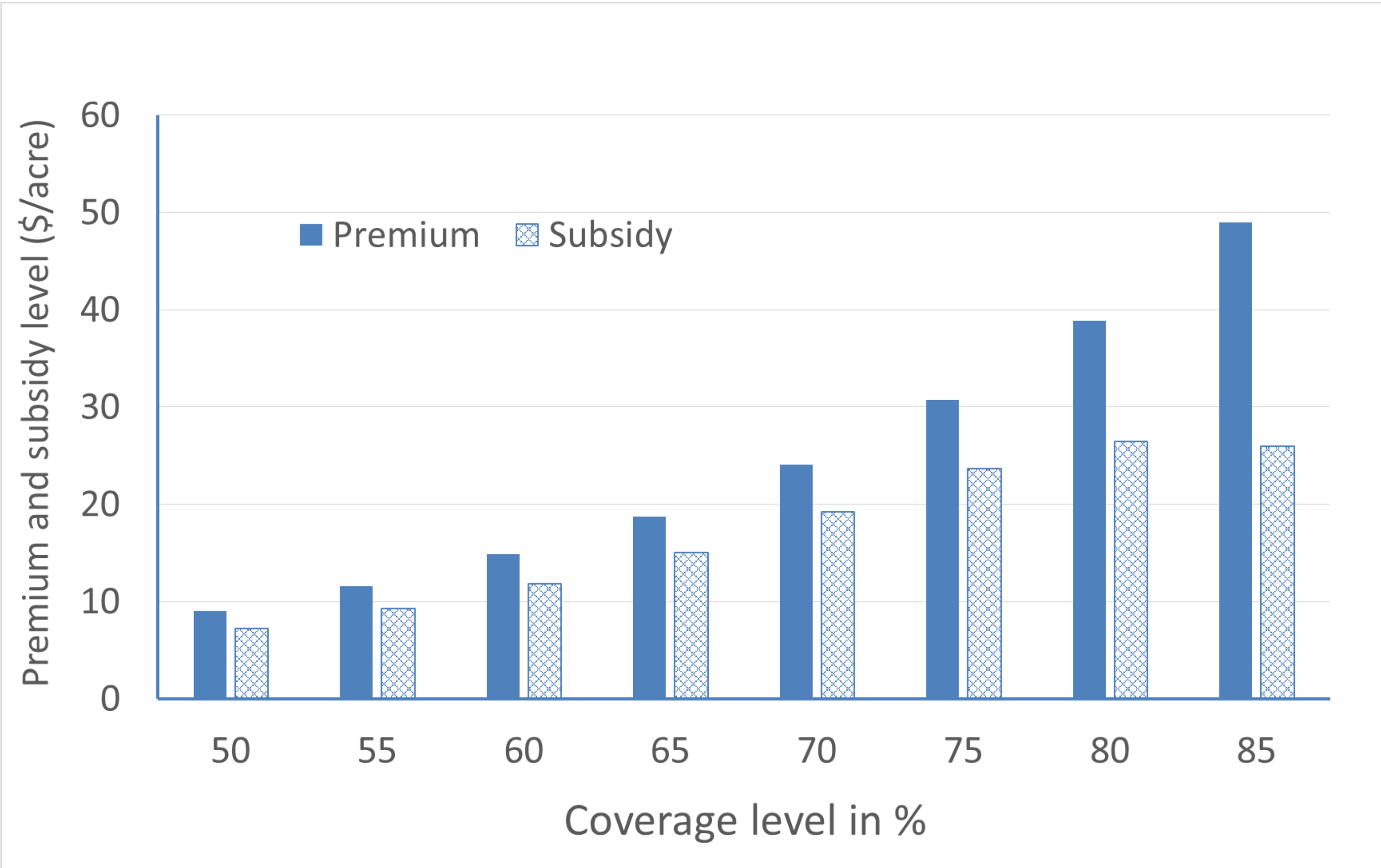

Figure 2. Premium per acre and subsidy per acre as coverage level increases; corn, plan 44 and EnU

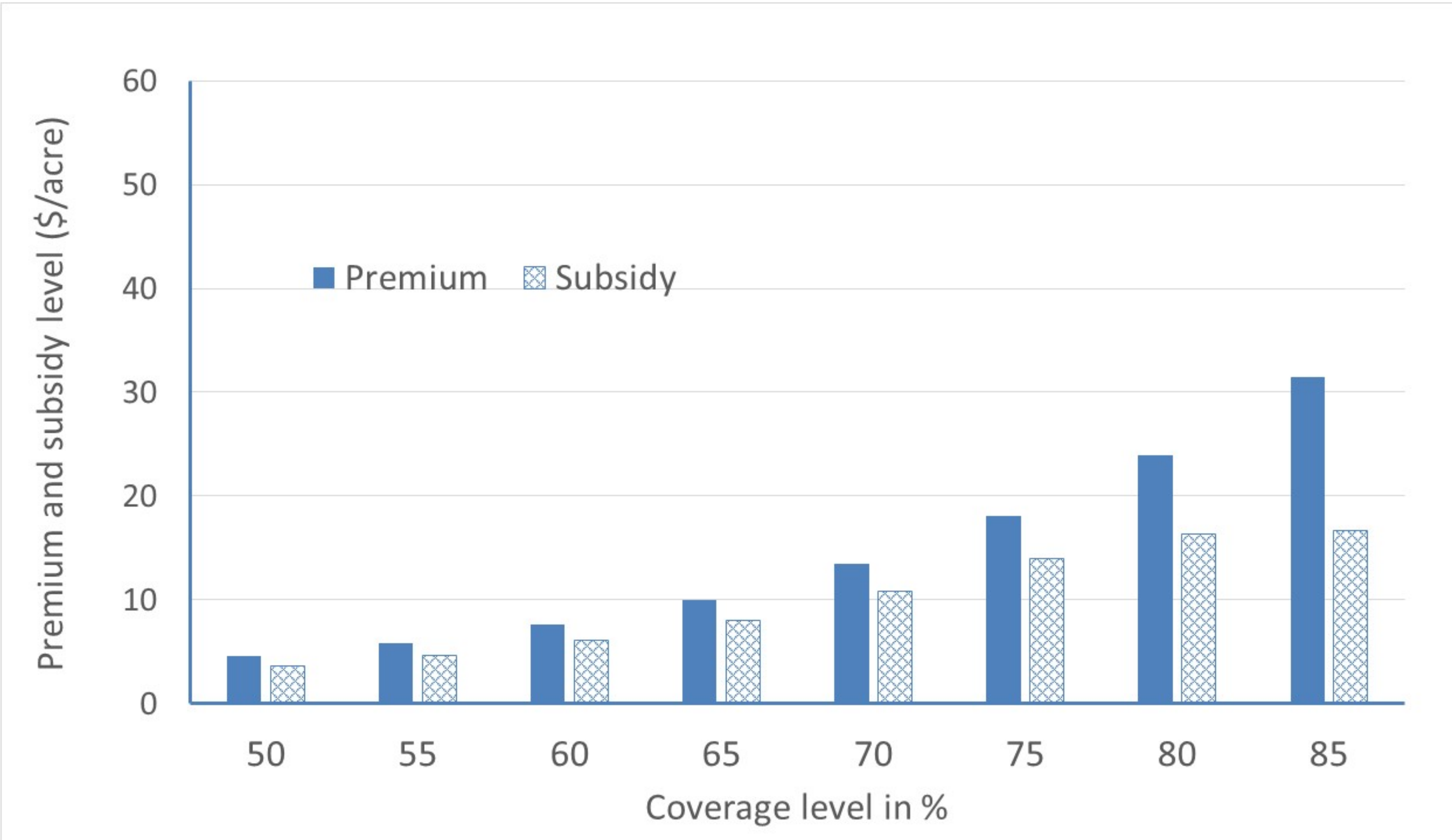

Figure 3. Premium per acre and subsidy per acre as coverage level increases; soybean, plan 44 and EnU

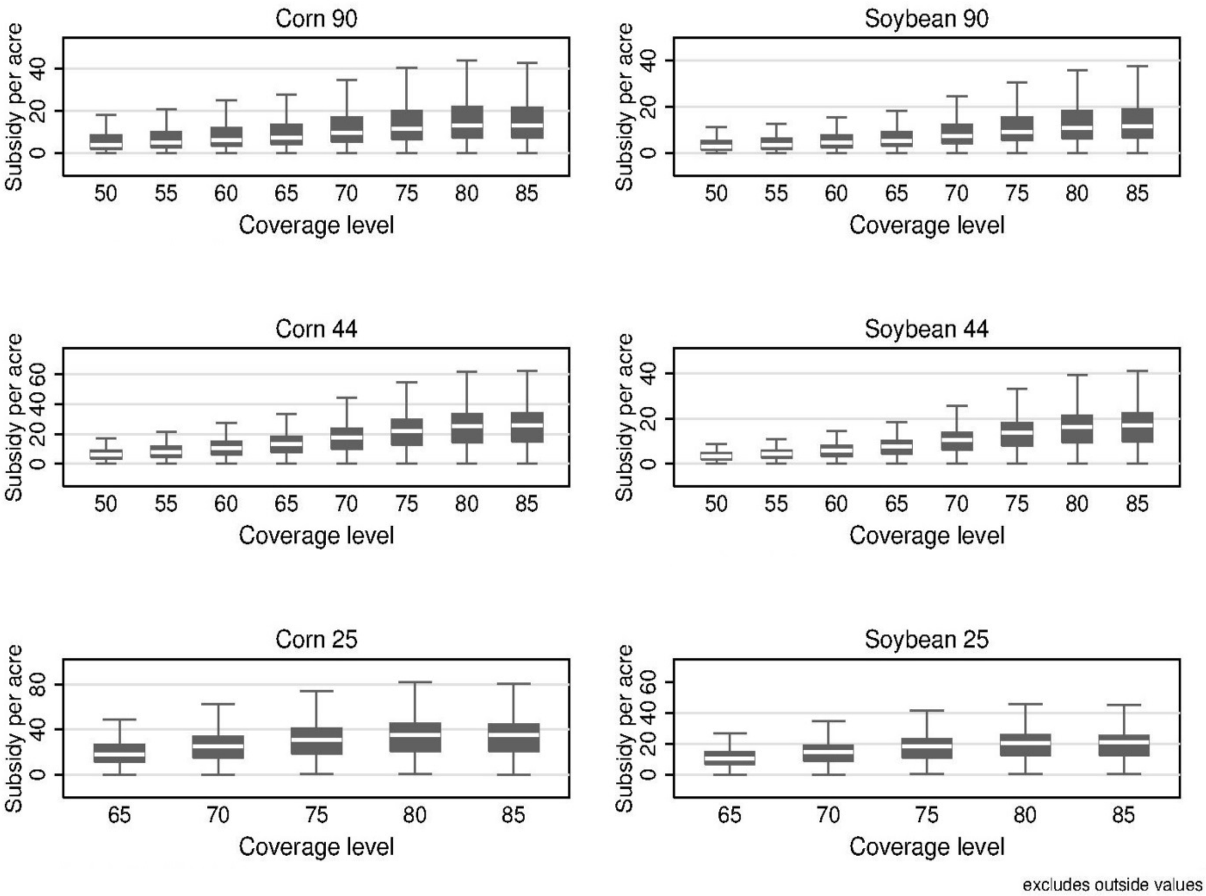

Figure 4. Empirical assessment of Hypothesis I

Notes: Per acre subsidies on the vertical axis are pooled over all unit types, EnU, BaU and OpU. 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 $+(-)1.5\times IQR$. Data points beyond the upper and lower whiskers are excluded using the *nooutsides* from the *graph box* command in Stata.

Footnotes

[1] Prior to the 2008 Farm Bill, the target loss ratio of indemnity over premium was 1.075. The bill lowered the target loss ratio to the actuarially-fair value, 1.0.

[2] 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.

[3] 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.

[4] 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. Although we would have liked to extend our study of coverage choices to include choice of aggregate structure, be it OpU, BaU or EnU, data available to us do not provide information on the OpU that a BaU aggregates or the OpU and BaU that an EnU aggregates.

[5] We are indebted to RMA officials for making the data available and for patiently 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.

[6] 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/2015policy.html for detailed definitions.

[7] See http://www.rma.usda.gov/data/sob.html, visited 2/8/2016. We thank, without implication, an anonymous reviewer for working with us on considerations regarding changes in demand for coverage since 2009.

[8] Premium should be nonlinear in the deductible. For crop insurance, premium should be convex in yield guarantee because $\partial^2 \text{premium} / \partial(\phi\bar{z})^2 = f(\phi\bar{z}) \geq 0$.

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