Rationality of Choices in Subsidized Crop Insurance Markets

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Plan of talk

Introduction

- Insurance and anomalies in insurance

Overview of US federal crop insurance

- Brief history, current state

A formal model of coverage level decisions with insurance subsidy

Data

Empirical analysis—evidence regarding the hypotheses

Results and discussions

Overarching theme of research

A behavioral approach to farmers' insurance coverage level choices—whether they conform to classical theory and what are the likely rationale.

Behavioral theory in other contexts (a few examples):

- The source of income can affect how carefully one spends the income
- The form of payment can affect one's willingness to spend
- Real-time knowledge of energy use may promote conservation
- Purchase of more coverage after an accident

Your insurance choices

A policy may stipulate that losses are to be reimbursed only in excess of a stated threshold amount—deductible.

For an insurance policy with different deductibles, how do you choose between different deductibles?

- For example, auto insurance, homeowner insurance, health insurance, or crop insurance

Insurance economics—some basics

In theory, when insurance premium is set actuarially fair, risk averse individuals will buy full insurance. (Based on expected utility theory)

Why deductibles are used?

(1) Small losses do not create a claim payment, thus saving the expenses of processing the claim.

(2) Claim payments are reduced, which is translated into premium savings.

(3) A deductible puts the policyholder at risk and so provides an incentive for the policyholder to prevent losses that would lead to claim payments.

Some people are uninsured or under-insured for some risks

Example: the U.S. health insurance market:

- 17 million non-senior people are uninsured (before the implementation of Obama Care)

Health insurance market is very complex and there could be many reasons:

- Actuarial unfairness in the insurance market
- Reaction to premium price—there is evidence that as premium price increases, fewer people have health insurance.

Some examples of over-insurance

Deductibles on home insurance and auto insurance:

- the deductibles are lower than optimal for many people--$500 vs $1000 deductible, the former is by far the most popular, even though the latter would make more sense in terms of net payout.

The purchase of extended warranties:

- on the checkout of electronic products, many customers are offered such warranties, some of them do buy. But these warranties are over-priced.

The subject of our study

The U.S. federal crop insurance

- We examine farmers' choices of insurance products. We test whether such choices conform to economic theory.

The U.S. crop insurance has two distinct features that set itself apart from insurance in other areas:

- Explicit subsidy: an average premium subsidy rate of about 60% in recent years;
- Actuarially fair premium: required by law and followed by USDA (federal government pays administrative and operational costs.)

Overview of US crop insurance

Currently managed by Risk Management Agency of USDA

Two types of insurance products

- yield insurance that triggers payoffs based on yield shortfalls from a predetermined yield level,
- revenue insurance that protects against revenue shortfalls from a predetermined revenue level.

Different coverage levels are offered which range from 50%85% at five percent interval

Private and public partnership

The size of US crop insurance

The federal crop insurance program had over one million insurance policies that covered more than 280 million acres of land with a total liability worth more than $117 billion in recent years (2013 RMA). The taxpayers' costs of the program are predicted to average $8.9 billion per year over 2013-2022

Over 85% of US farmland are covered by crop insurance.

Theoretical framework—based on expected utility theory

Our focus is farmers' coverage level choices: what coverage level does a farmer choose? What are the factors that affect such choices?

We establish important testable hypotheses about coverage level choices

Definition of a few basic concepts

z: Value of underwritten item (crop yield or revenue) with distribution $f(z)$

$\bar{z}$: Average value of z (used to benchmark insurance coverage)

$0 \leq \phi \leq 1$: Coverage level

$M \equiv \max\{\phi z - z, 0\}$: Indemnity

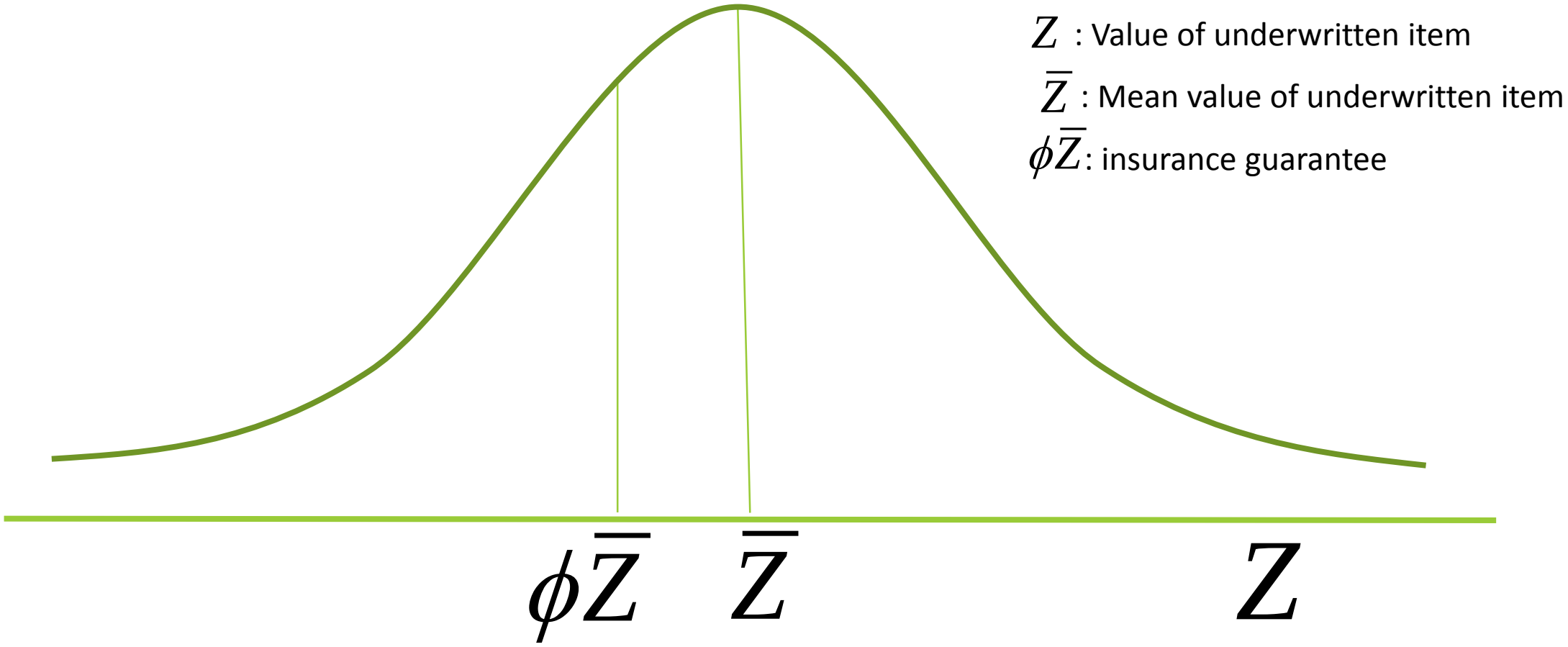
$\mathrm{p}(\phi)$: Premium

$s(\phi)$: Subsidy rate (Proportion of premium paid by government)

$S(\phi) \equiv s(\phi)p(\phi)$: $ subsidy (Proportion of premium paid by government)

$\mathrm{p}(\phi) - s(\phi)\mathrm{p}(\phi)$: Out of pocket premium paid by farmers

An illustration of coverage level



The utility function

Let $U(w)$ denote the utility as a function of income with

$$U_w(\cdot) > 0 > U_{ww}(\cdot)$$

Household income is given as

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

$$r(\phi, \bar{c}, \eta) \equiv [1 - s(\phi)]p(\phi) + \bar{c} - \eta.$$

The expected utility function

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

$$+\int_{\underline{\eta}}^{\bar{\eta}}\int_{\phi\bar{z}}^{\infty} U(z - r(\phi,\bar{c},\eta))dF(z)dG(\eta).$$

Here, expectation is taken over crop income and other income.

We are interested in knowing how expected utility changes with coverage level? That is, $\dfrac{\partial E[U(\bullet)]}{\partial\phi}$.

How does utility change with coverage level?

Determining the sign of $\frac{\partial E[U(\bullet)]}{\partial \phi}$.

As coverage level ϕ, increases, there are several different effects

- Probability of receiving indemnity increases
- Indemnity is also higher for any yield
- Subsidy payment also changes: how subsidy changes depends on the subsidy rate structure
- Premium rate increases

Two effects when coverage level changes

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

$$+\underbrace{S_\phi(\phi)\int_{\underline{\eta}}^{\overline{\eta}}\int_0^{\infty}U_w(w(z,\eta))dF(z)dG(\eta)}_{\text{Subsidy transfer effect}}.$$

Insurance effect is positive; subsidy transfer effect depends on how subsidy rate and premium change.

Two critical conditions for analysis

(A1) Farmers are rational (i.e., they behave as predicted by the expected utility maximization theory).

(A2) Premiums are actuarially fair.

We do not assume whether these conditions are true or not.

Instead, we examine empirical data and try to find out how observed behaviors are consistent with these conditions.

Steps in checking the rationality of choices

First, check whether a higher coverage level was associated with a higher $ subsidy payment.

Second, if there were higher coverage levels that were associated with higher $ subsidies, then check whether higher coverage levels were chosen?

How does $ subsidy, $S(\phi)$, changes with coverage level?

The answer depends on how subsidy rate and premium change with the coverage level.

Actuarially fair premium: premium equals expected indemnity, i.e., $\mathrm{p}(\phi) = E[\max\{\phi z - z, 0\}]$

Actuarially fair premium increases as coverage level increases (i.e., $p_\phi(\phi) = \bar{z}F(\phi\bar{z}) > 0$)

Next, we look at how subsidy rate changes.

How $ subsidy changes with coverage level?

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

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

Thus, as coverage level increases, premium increases and subsidy rate decreases, so we cannot say how $ subsidy changes.

Trade-off of risk coverage and subsidy payment

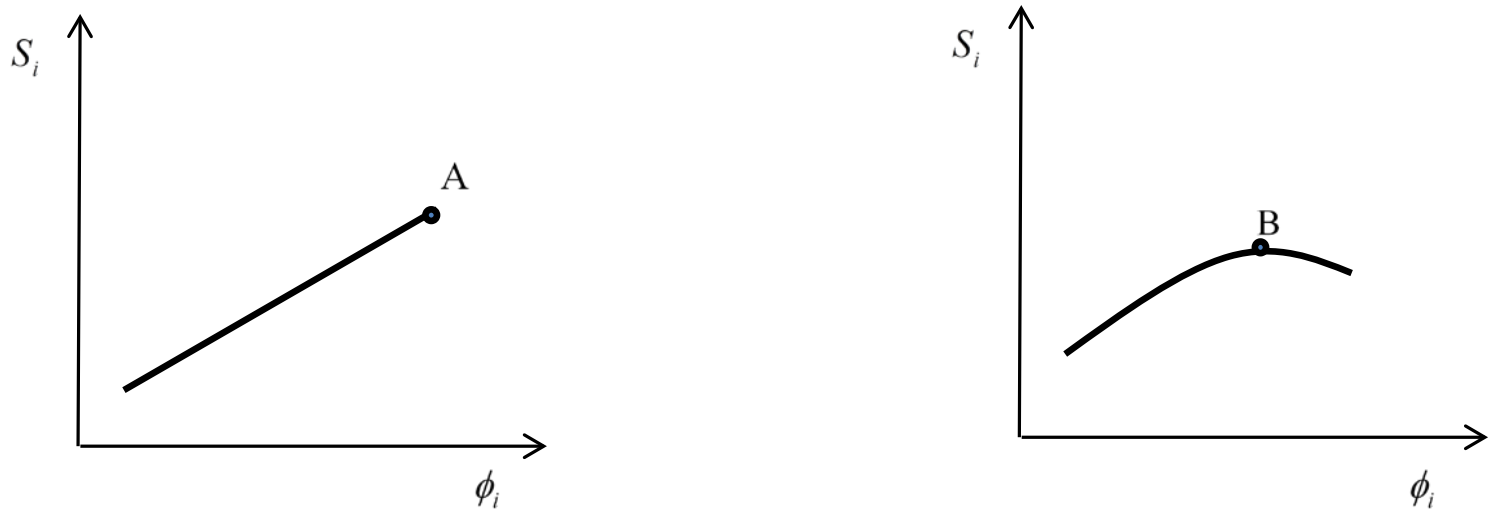


Figure 1. Two illustrations of the relationship between coverage level and premium subsidies

One hypothesis

Testable Hypothesis I:

If the $ premium subsidy increases with coverage levels then growers will choose the highest coverage level available to them.

If the $ premium subsidy increases with coverage level at low levels and decreases with coverage levels at high levels then growers will not choose coverage levels lower than the level that maximizes the $ premium subsidy.

How $ subsidy changes with coverage level? –more specifics

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Based on how subsidy rate changes from the above table, we can make more specific conjectures on the coverage level choice.

How $ subsidy changes based on the table?

Testable Hypothesis II:

No grower enrolling in i) OU or BU will choose a coverage level lower than $\phi = 0.7$;

No grower enrolling in EU will choose a coverage level lower than $\phi = 0.75$.

Full coverage

Under conditions (A1) and (A2), if there is no premium subsidy or premium subsidy does not decrease as coverage level increases, farmers will choose the highest coverage level.

- If the highest coverage level is 100% coverage, then a farmer will choose this full coverage

How does demand for coverage level change with premium rate?

If we consider premium rate as price of insurance, then we would expect a negative relationship.

However, if premium rates are set actuarially fair, then higher premium rates are a mere reflection of higher expected losses. In this line of thinking, we will not necessarily see a negative relationship in data.

Data used in empirical analysis

Unit level insurance record data of corn and soybean maintained by USDA.

The individual insurance records contains information on

- its location and size (e.g., state, county, acres, number of sections), production and practice (e.g., yield, planted crop, practice), and insurance choices (e.g., contract, coverage level, elected price, total premium and subsidy payment).

We don’t observe premiums and subsidies of insurance products that are not chosen by the farmer. Therefore, we use RMA procedure to re-construct the prices that we do not observe.

More description of data

We focus on corn and soybean in 2009 and 997 counties of 12 states in the Midwest and Great Plains.

2009 is chosen because the 2008 farm bill had made some substantial changes and grower had reason to spend time to reconsider their insurance decisions.

The final constructed dataset includes per acre premium and subsidy for 21 insurance products that farmers faced when making their choices.

Different insurance plans

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

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

Distribution of the choices--corn, plan 90

Panel A	Full Sample	50%	55%	60%	65%	70%	75%	80%	85%
APH Yield	135.43	134.68	131.35	127.43	130.15	131.97	142.81	153.05	160.96
Share of unit type									
BU	0.44	0.14	0.02	0.05	0.32	0.21	0.17	0.05	0.03
EU	0.02	0.03	0.01	0.04	0.14	0.30	0.34	0.12	0.01
OU	0.54	0.11	0.01	0.05	0.29	0.28	0.18	0.06	0.03
Sample size	99838	11736	1498	5189	30238	24858	17933	5637	2749
% of sample	100%	11.76%	1.50%	5.20%	30.29%	24.90%	17.96%	5.65%	2.75%

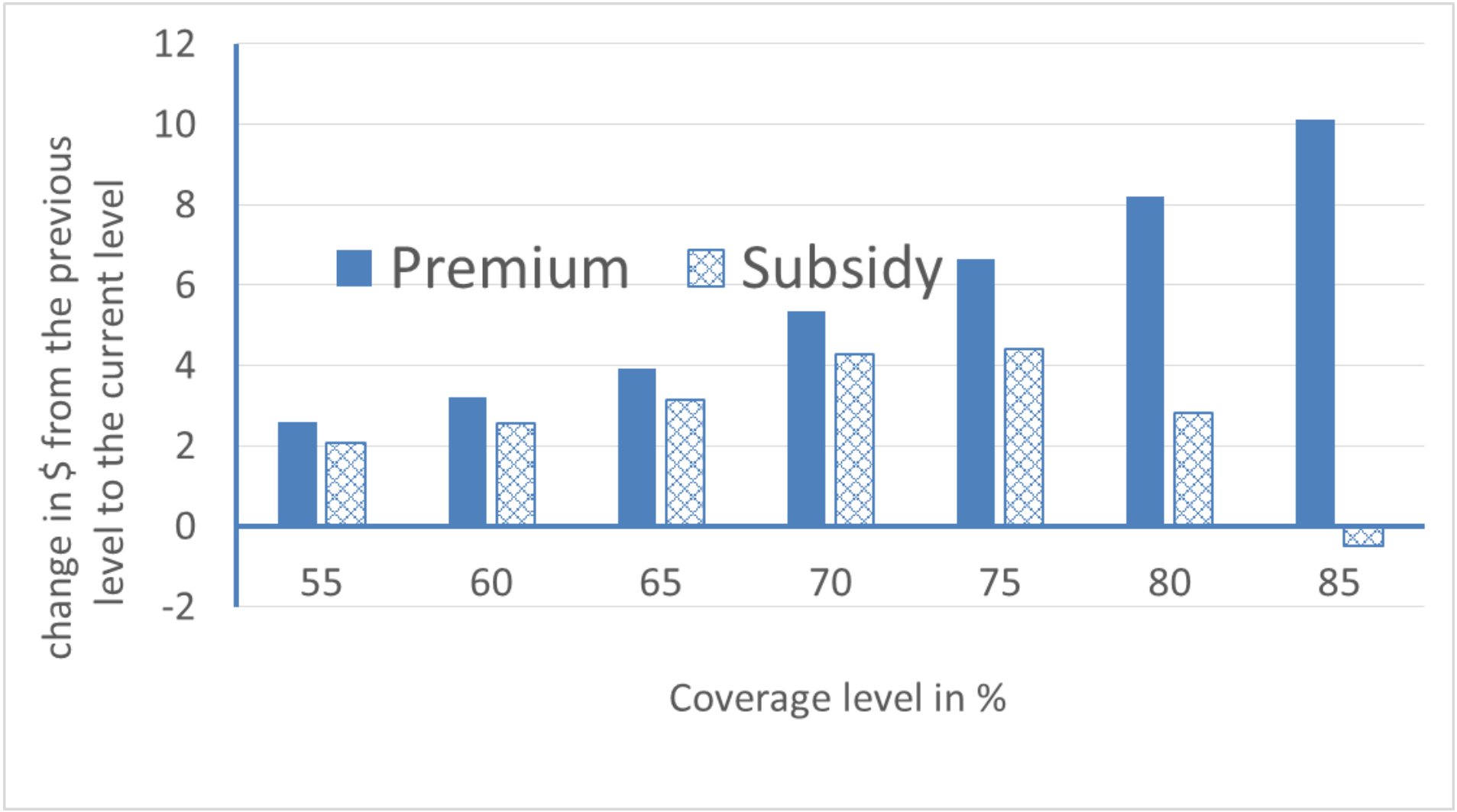
Distribution of choices --corn, plan 44

Panel A	Full sample	50%	55%	60%	65%	70%	75%	80%	85%
APH Yield	147.99	132.58	130.69	124.05	138.52	138.94	146.00	154.40	164.32
Share of Unit type									
BU	0.19	0.016	0.005	0.019	0.106	0.292	0.333	0.174	0.055
EU	0.46	0.007	0.001	0.005	0.023	0.083	0.279	0.394	0.207
OU	0.35	0.009	0.003	0.019	0.105	0.343	0.337	0.145	0.038
Sample size	610425	5856	1523	7493	41108	129958	188735	162605	73147
Percent of sample	100.00%	0.96%	0.25%	1.23%	6.73%	21.29%	30.92%	26.64%	11.98%

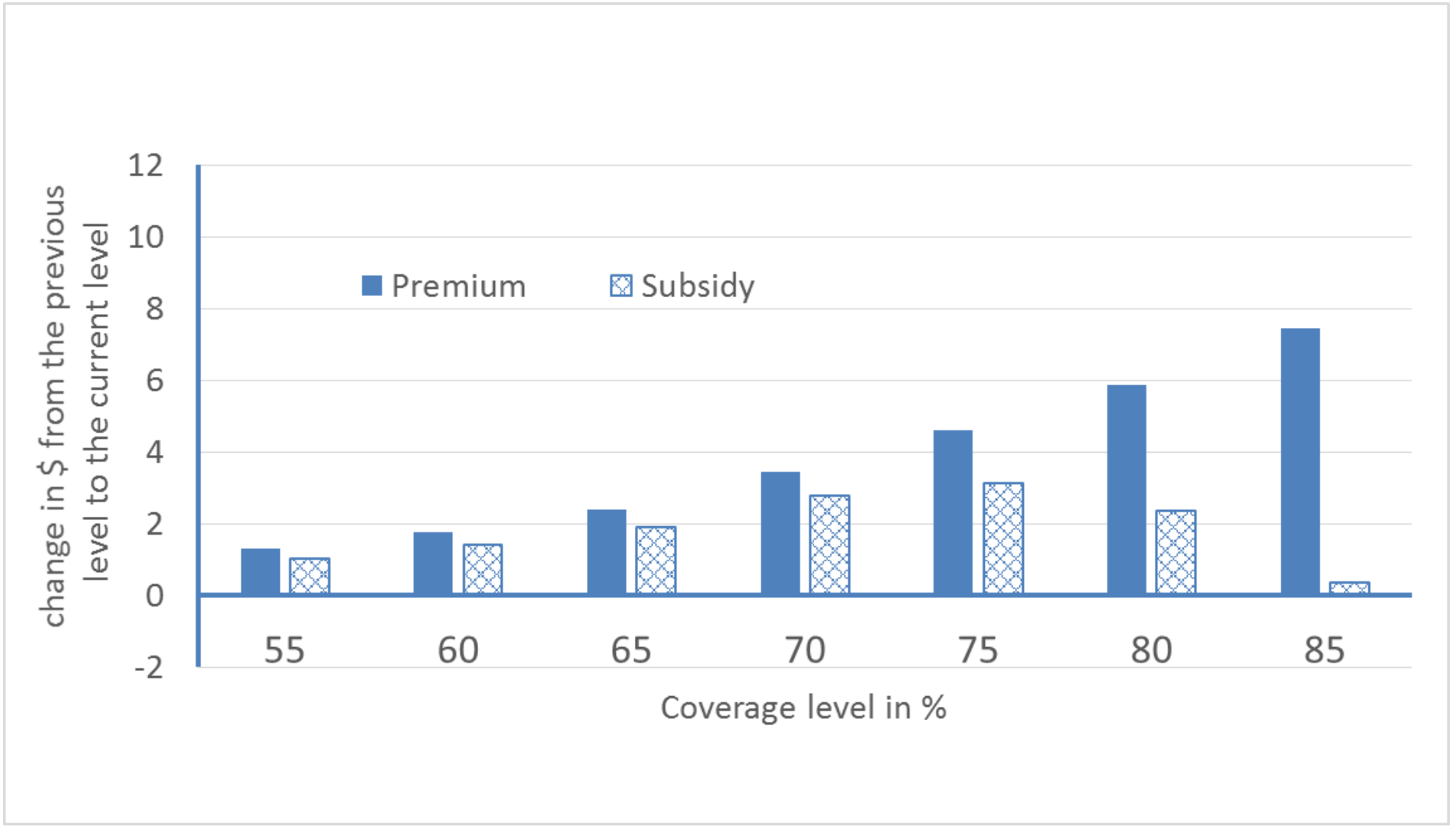
Higher coverage level means higher $ subsidy?

Some believe the answer is yes.

Shields (2010) states “The subsidy rate declines as the coverage level rises, but the total premium subsidy in dollars increases because the policies are more expensive.”



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



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

Crop/Plan/Unit	% of samples choosing the level (or higher) with highest subsidy payment
Corn	
Plan 90 – OU	4.0
– BU	3.5
– EU	13.7
Plan 44 – OU	4.3
– BU	6.2
– EU	40.2
Plan 25 – OU	3.4
– BU	3.0
– EU	25.8

Crop/Plan/Unit	% of samples choosing the level (or higher) with highest subsidy payment
Soybean	
Plan 90 – OU	2.8
– BU	2.4
– EU	4.5
Plan 44 – OU	4.7
– BU	6.4
– EU	22.9
Plan 25 – OU	4.9
– BU	3.9
– EU	30.9

Remarks regarding the hypothesis: underinsurance very likely?

The key Hypotheses regarding coverage level choice is not supported by data

Thus, either condition (A1) or (A2) does not hold.

(A1) Farmers are rational (i.e., their decisions are consistent with classic utility maximization.)

(A2) Premiums are actuarially fair.

We looked at the data by crop, by plans, and by regions, we found the same pattern—it is unlikely the pattern is driven by premium rates given that the rates were set to achieve actuarial fairness.

The role of premium in choice decisions: Mixed logit model

Mixed logit model allows capturing the heterogeneity of farmer's "taste" in choosing insurance products, which is unobservable to researcher such as risk preference, through the inclusion of random coefficients.

Specification of mixed logit model

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

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

where X_{ik} is a vector of M explanatory variables with random coefficients.

Results for corn

Variables	Corn 90			Corn 44			Corn 25		
Mean	OU	BU	EU	OU	BU	EU	OU	BU	EU
Out-of-pocket premium	-0.12[c] (0.005)	-0.22[c] (0.01)	0.01 (0.03)	-0.05[c] (0.001)	-0.07[c] (0.002)	-0.10[c] (0.002)	-0.003[a] (0.001)	0.009[c] (0.003)	-0.05[a] (0.004)
Yield guar.	0.09[c] (0.004)	0.08[c] (0.006)	-0.03[b] (0.01)	0.15[c] (0.003)	0.17[c] (0.005)	0.21[c] (0.004)	0.09[c] (0.003)	0.09[c] (0.005)	0.22[c] (0.01)
Std. Dev.									
Out-of-pocket premium	0.06[c] (0.005)	0.13[c] (0.009)	0.06 (0.04)	0.04[c] (0.002)	0.08[c] (0.003)	0.02[c] (0.003)	0.001 (0.003)	0.003 (0.006)	0.007 (0.009)
Yield guar.	0.12[c] (0.005)	0.16[c] (0.008)	0.002 (0.02)	0.08[c] (0.002)	0.08[c] (0.003)	0.10[c] (0.002)	0.10[c] (0.004)	0.14[c] (0.006)	0.21[c] (0.009)
Sample size (# of units)	53953	43757	1922	211666	114107	281210	104839	55700	44435

Results for corn (looking at plan 90 only)

Variables	Corn 90		
Mean	OU	BU	EU
Out-of-pocket premium	-0.12[c] (0.005)	-0.22[c] (0.01)	0.01 (0.03)
Yield guar.	0.09[c] (0.004)	0.08[c] (0.006)	-0.03[b] (0.01)
Std. Dev.			
Out-of-pocket premium	0.06[c] (0.005)	0.13[c] (0.009)	0.06 (0.04)
Yield guar.	0.12[c] (0.005)	0.16[c] (0.008)	0.002 (0.02)
Sample size (# of units)	53953	43757	1922

A grower's value function: one conjecture

We posit that there three parts on a growers value function for crop insurance coverage:

A: standard preferences under actuarially fair prices where we have argued this part should increase with coverage level to account for the value of protection against risk.

B: the value of transfers. This should be an increasing function of the amount transferred.

C: dislike for out-of-pocket expenditure as reflected in the mixed logit regressions.

Some possible reasons for under-insurance

Liquidity constraint

Discounting future payout (hyperbolic discounting, time-inconsistency): undervalue the benefits from indemnity later

Other safety net insurance options are available for farmers

The impact of regret

Inertia

Over-optimistic of own risk

Others?

Conclusions

The literature has found both under-insurance and over-insurance in empirical data relative to the prediction of the expected utility theory.

- Our results indicate under-insurance is very likely in crop insurance decisions.
- It seems that people over-insure moderate and small risks and under-insure larger risks like health insurance and crop insurance.

Behavior economics can help us understand: why growers chose to pass up opportunities to both increase expected income and reduce income variability?