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# **Implications of Subjective Probabilities for Crop Insurance Adoption: Evidence from China**

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# Crop Insurance Demand Puzzle

- A large focus of crop insurance demand research in the 1980's and 1990's was focused on explaining why farmers would not participate in a program that appeared to be more than actuarially fair.
  - While on average, the program was paying out more than a dollar for every dollar producers paid in premiums, the participation rate was relatively low.
- Proposed Explanations
  - Adverse Selection (Coble et al. (1996) and many others)
  - Preference for other forms of risk management (Babcock, others)
  - Prospect Theory (Babcock, 2015)
  - Expectation of Ad-hoc Relief from Congress

# Optimism Bias as an Explanation for the Crop Insurance Demand Puzzle

- We present a new behavioral explanation for the crop insurance demand puzzle in the form of subjective probabilities.
- Using a novel data set consisting of elicited risk perceptions regarding historic and future corn yields from 571 Chinese corn farmers, we observe strong evidence of a systematic optimism bias.
  - There is a systematic distortions in subjective probability between future and historic yields
  - On average, farmers anticipate yields in the coming year as coming from a distribution with a higher mean, lower variance, and more positive skewness than their self-reported historical experience would justify.

# Simulating Optimism-Biased Insurance Demand

- Using these data, we model the effects of optimism bias on simulated crop insurance choices using the Beta-PERT distribution,
  - Beta-PERT used extensively in modeling expert elicitations.
- We then simulate choices under expected utility over a range of subsidies, levels of risk aversion, and available coverage levels and find that optimism bias/subjective probabilities dominate all other considerations.
  - most farmers undervalue insurance coverage, choosing not to purchase coverage even at prices subsidized below actuarially fair.
- Our results suggest these such beliefs are common enough to explain the conventional observation of inelastic crop insurance demand and the lack of full crop insurance participation in the presence of subsidies.

# Optimism Bias and Overconfidence

- The focus of this talk is how the phenomenon known as optimism bias affects individual and aggregate demand for insurance
- Large body of evidence suggests that when asked to estimate the probabilities of future events, decision makers are repeatedly optimistically biased. (Irwin, 1953; Weinstein, 1980; Slovic et al., 1982; Slovic, 2000; Braca and Brown, 2010)
  - Optimism bias: the tendency to overestimate the likelihood of favorable future outcomes and underestimate the likelihood of unfavorable future outcomes
- Optimism bias is not merely a hypothetical bias; instead it translates into both microeconomic and macroeconomic activity.
- Agricultural economists have paid little attention to this topic perhaps because the problem is perceived to be solved, even if not adequately explained.

# Subjective Probabilities in Ag. Lit

- Two studies that model the distribution of farmer's subjective yield expectations.
  - Shaik, et al. (2008) use elicitation questions designed to capture the mode, the tenth fractile, and the ninetieth fractile of each distribution. These values are then use to compute the first and second moments of each producer's yield and price.
  - In Sherrick, et al. (2004), expected yields are elicited based on the conviction weight method in which farmers assign probabilities to six categories of yield levels. The elicited probabilities for each category are then used to fit to a Weibull distribution for each farm.
  - Neither study attempts to examine the relationship between these subjective probabilities and the objective/historical distribution, nor how such a bias will affect the demand for crop insurance.

# Yield Elicitation Survey

- We use a survey method to directly elicit risk perceptions from farmers.
- In November 2011, 780 Chinese farmers were surveyed about their expectations for next year's yield, as well as their historical yields.
  - Survey took place in 3 counties (25 villages) in Shaanxi Province, China in October 2011.
  - The survey had 9 sections with 117 questions in total. Only a portion of these were dedicated to crop insurance and the identification of crop yield risks.
  - It was administered by 20 Chinese graduate students of the Northwest Agriculture and Forestry University supervised by faculty researchers.
  - About 55% of respondents were male, with an average age of 48.72 years, and at least high school completion. On average respondents had farmed for about 27 years but this ranged from first year farmers to about 60 years.
  - After eliminating incomplete questionnaires and farmers who do not grow corn or wheat, we have 571 data records for corn.



# The Survey Question

If you grow corn or wheat, identify the lowest yield you believe possible, the yield that you believe is most likely to be received, and the highest possible yield you believe possible (jin/mu) in *the next crop year (2010/11)* If you do not recall exacts, please answer to nearest within 10 jin/mu

Crop	Lowest possible yield (jin/mu)	Most likely yield (jin/mu)	Highest possible yield (jin/mu)
1 Corn			
2 Wheat			

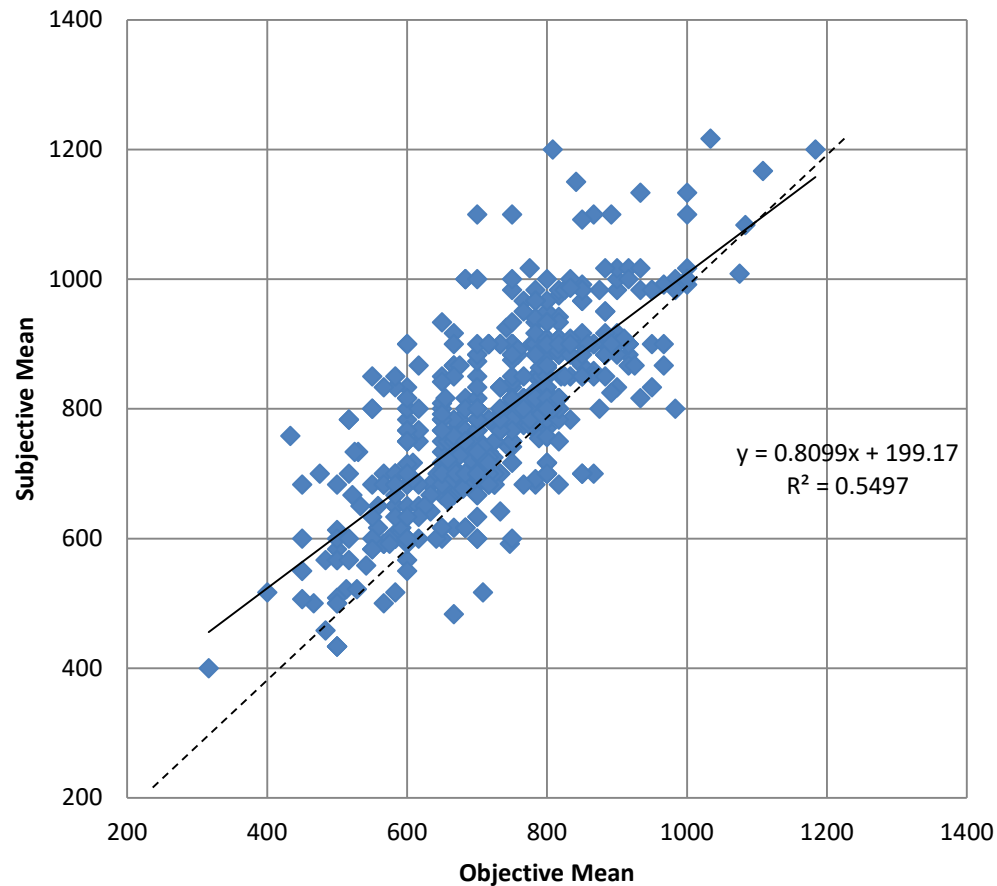
If you grow corn and wheat, what is the lowest and highest yield (jin/mu) that you recall from your years in farming? If you do not recall exacts, please answer to nearest within 10 jin/mu.

Crop	Lowest historical yield (jin/mu)	Year it occurred	Highest historical yield (jin/mu)	Year it occurred	Average yield across year
1 Corn					
2 Wheat					

Note: To avoid possible bias from representativeness, farmers were asked about their future expectations prior to being asked about their historic yields.

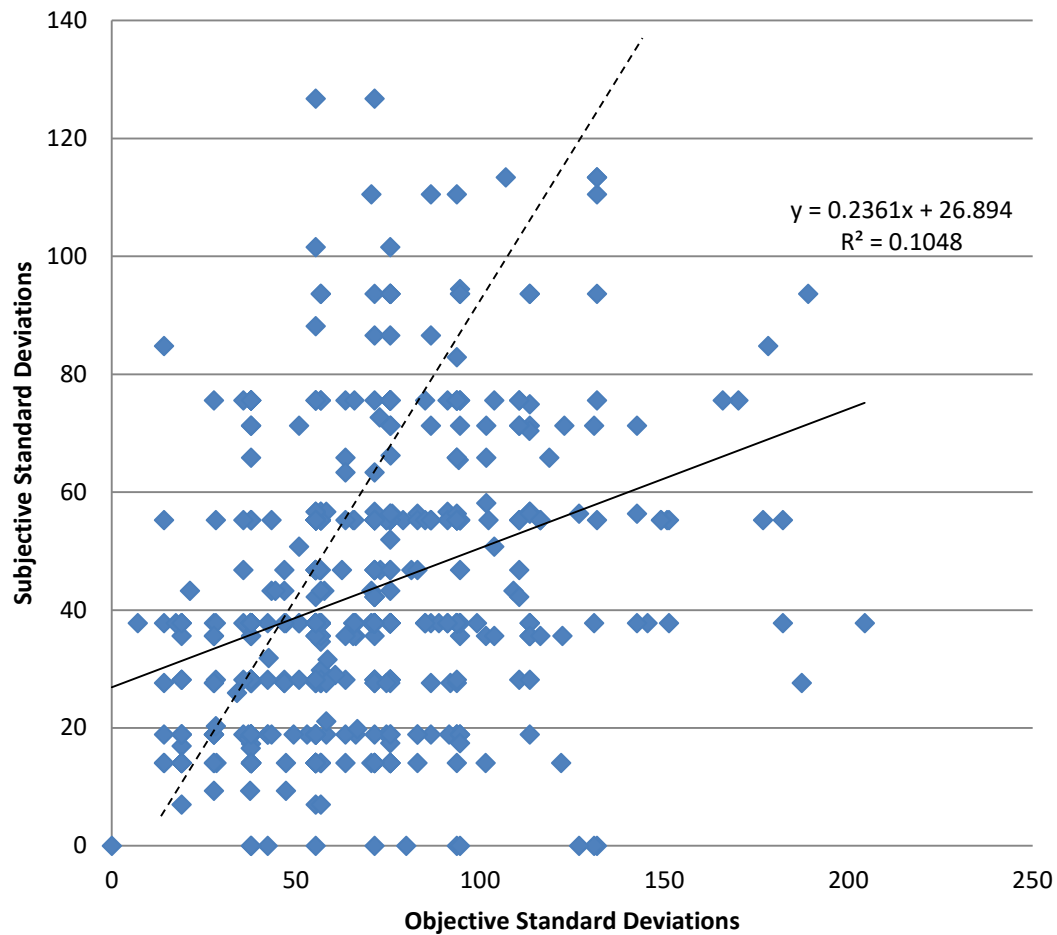
# Subjective Mean Yields are Higher than Objective Mean Yields

Subjective vs Objective Corn Standard Deviations

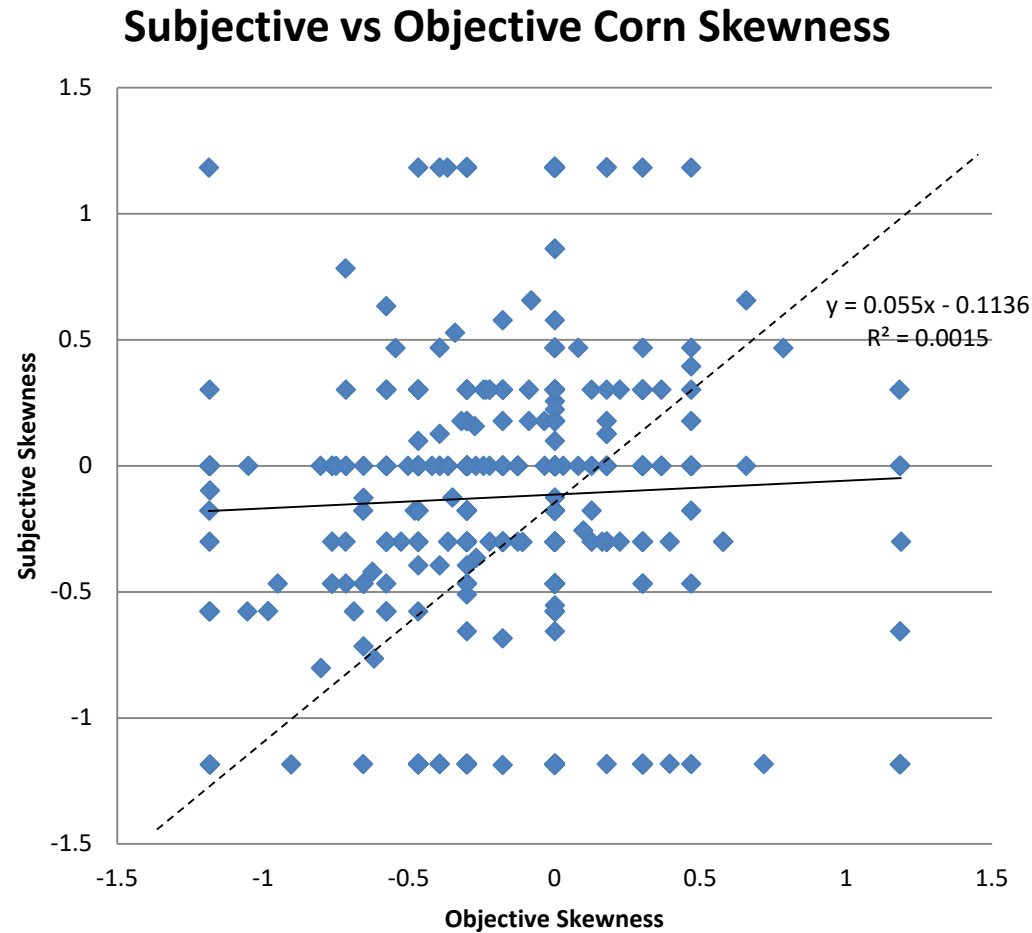


# Subjective Standard Deviations are Lower than Objective Distributions

## Subjective vs Objective Corn Standard Deviations



# Subjective Crop Yields are Predominantly More Positively Skewed than Objective Skewness



# Modeling Subjective Yield Distributions

- Our subjective yield elicitation method (i.e. min, mode, max) has both pros and cons.
  - Pro: Can compare self-reported historic and future yields. No information asymmetry.
  - Con: No explicit information about probabilities.
- Beta-PERT Distribution designed to handle just these types of elicitations.

# Beta-PERT Distribution

- The Beta-PERT distribution ('Program Evaluation Research Task') was developed originally by Malcolm et al (1959) to study the critical paths in the development and manufacture of the Polaris Fleet Ballistic Missile program.
  - They needed a simple probability distribution that could capture the essence of risk while maintaining the flexibility for differences when the true distribution is, or cannot be, known.
- Beta-PERT provided a simple means by which engineers could simply state shortest time, longest time and most likely time for any task to be completed at any node.

# Beta-PERT Distribution

• The PERT method uses three points to estimate a corresponding Beta distribution:

- $a$ , the lowest possible value
- $b$ , the highest possible value, and
- $m$ , the most likely value

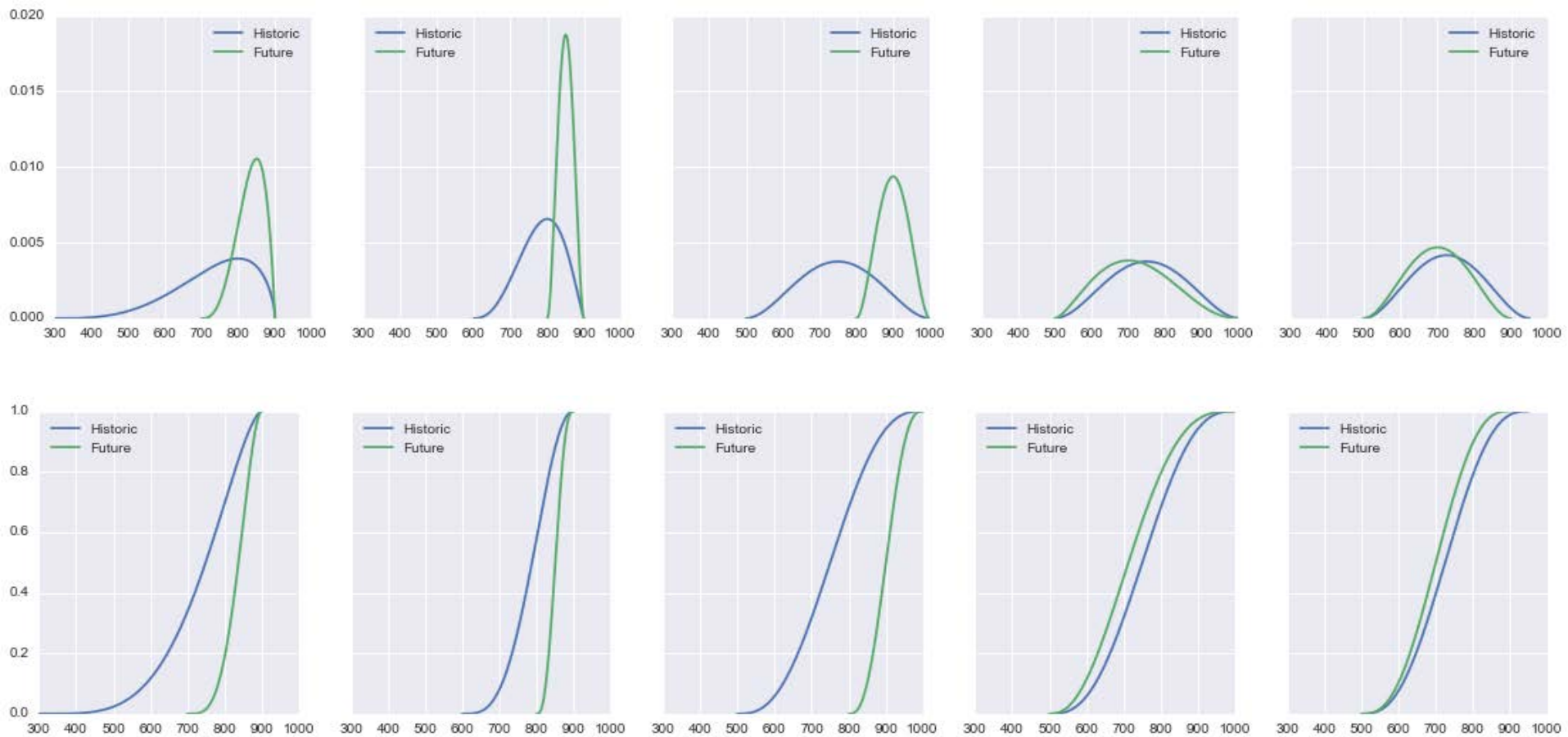
• Standard deviation is assumed to be  $\sigma = \frac{1}{6}(b-a)$  with  $\bar{y} = \frac{a+4m+b}{6}$

• These values can be used to calculate the two shape parameters of the desired Beta distribution.

□ Namely, the probability density function:  $f(y) = B(y-a)^{\alpha_1} (b-y)^{\alpha_2}$

$$\text{where } \alpha_1 = \frac{(\bar{y}-a)(2m-a-b)}{(m-\bar{y})(b-a)} \text{ and } \alpha_2 = \frac{\alpha_1(b-\bar{y})}{\bar{y}-a}$$

# Example Beta-PERT Yield Distributions from data





# Insurance Demand Simulations

- Insurance Prices are a function of coverage and subsidy levels where coverage levels are defined in terms of percentage of mean historic yields.

$$Guar = g = coverage \times historic\ mean$$

$$Premium(g)_{fair} = \int_0^g h(y)(g - y)dy$$

$$P(g)_{subsidized} = Premium(g)_{fair} \times (1 - s)$$

# Insurance Demand Simulations, con't

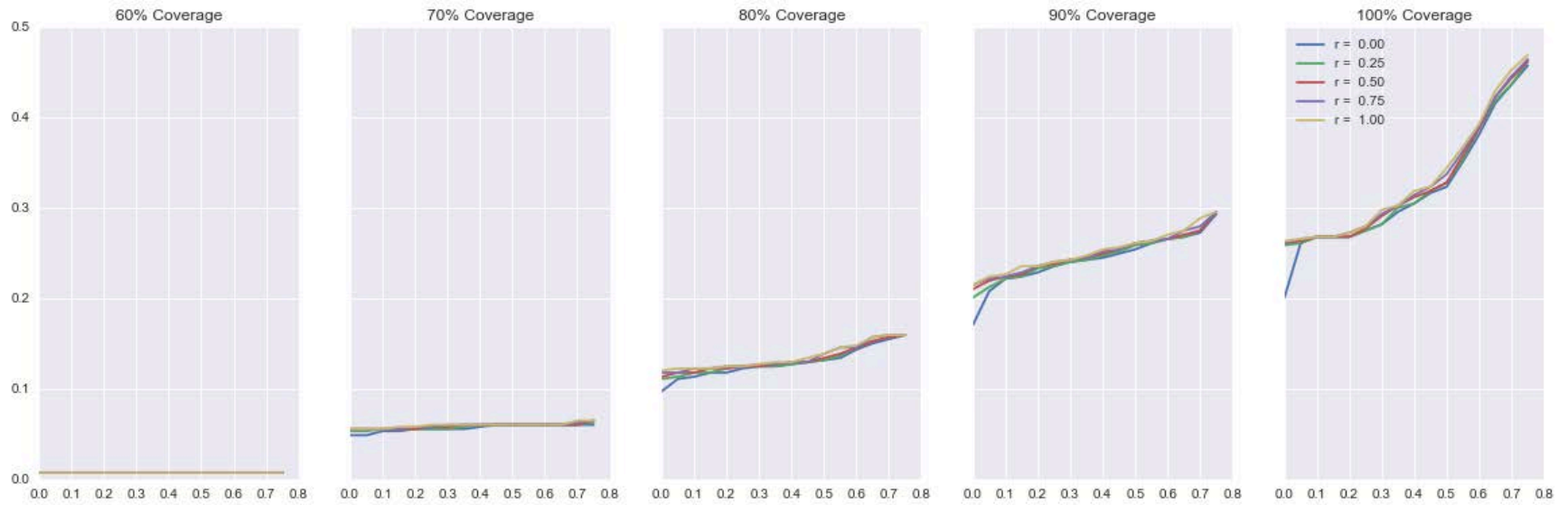
- We model farmer's Utility in the form  $U(y)=y^{1-r}/(1-r)$  where  $r$  is a farmer's coefficient of relative risk aversion.

$$EU_{no\ insurance} = \frac{1}{1-r} \int_0^{\infty} f(y) y^{1-r} dy$$

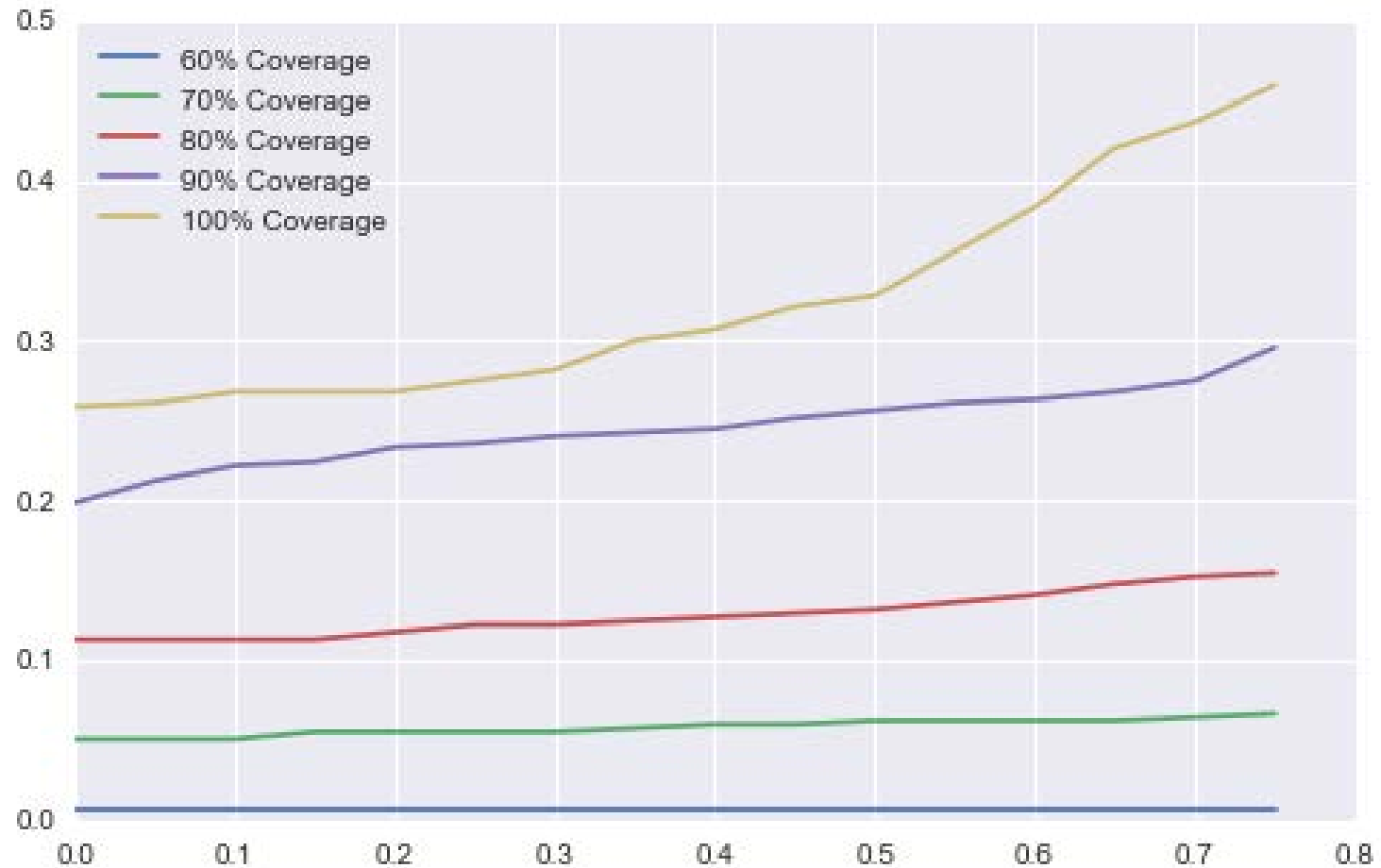
$$EU_{with\ insurance} = \frac{1}{1-r} F(y) (g - p(g)_s)^{1-r} + \frac{1}{1-r} \int_g^{\infty} f(y) (y - p(g)_s)^{1-r} dy$$

- A non-biased farmer, i.e.  $f(y)=h(y)$ , will be willing to purchase insurance for any scenario such that  $s \geq 0$  and  $r \geq 0$ .

# Crop Insurance Demand by Coverage Level and Risk Preferences



# Crop Insurance Demand by Coverage Level

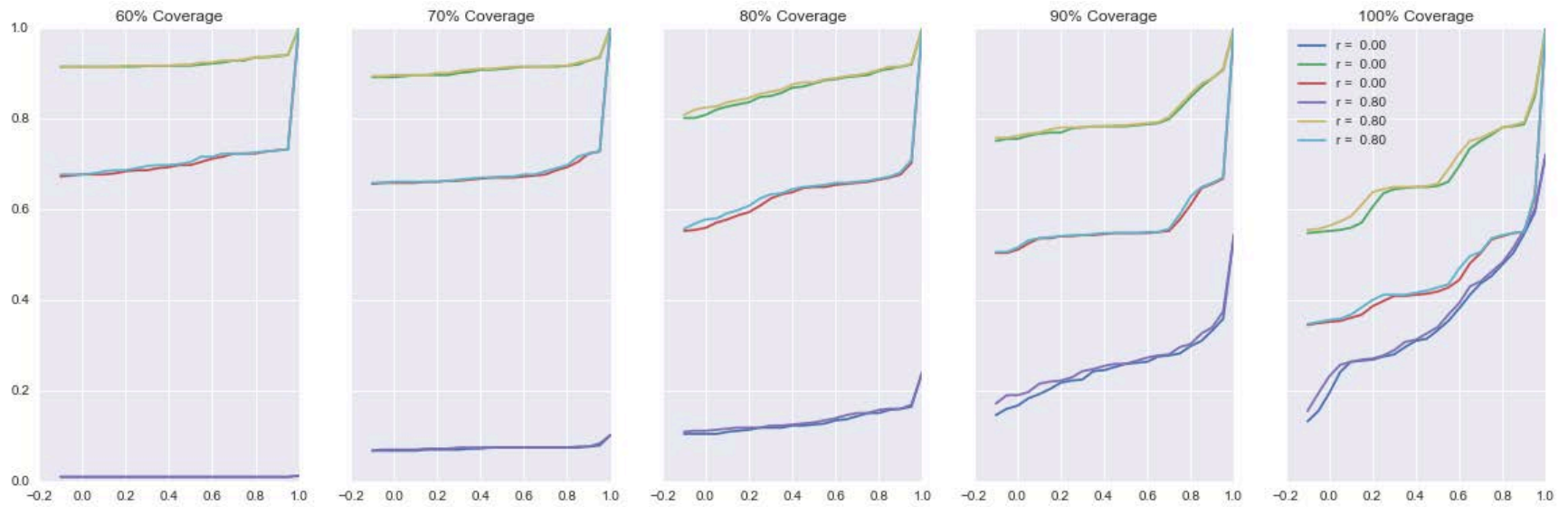


-Elasticity positively correlated with coverage levels

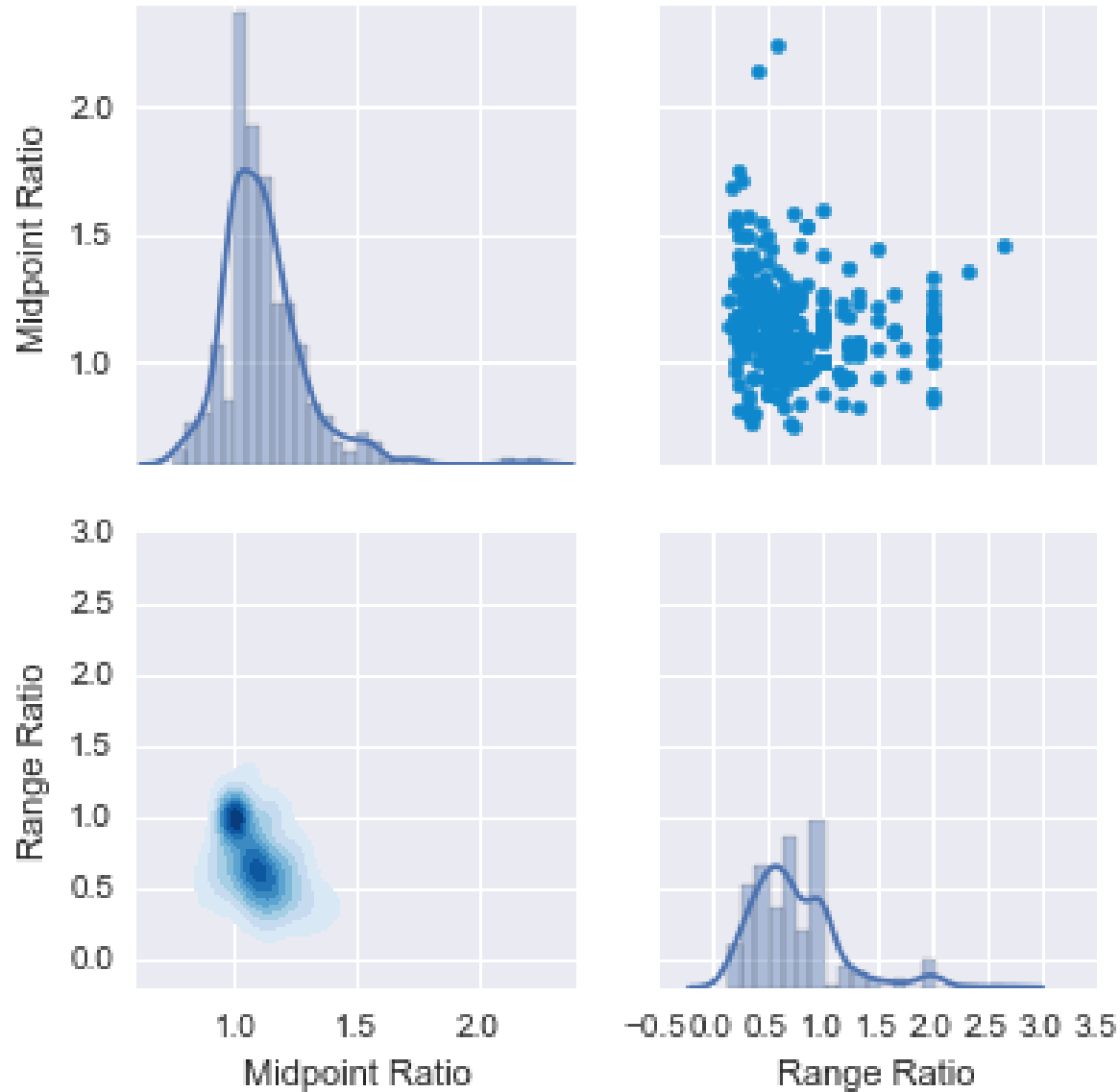
# Adverse Selection and Optimism Bias

- The term "adverse selection" originates from the insurance literature. It describes a situation where an individual's demand for insurance is positively correlated with the individual's risk of loss and is a symptom of asymmetric information.
- If insurers charge a uniform rate based on average risk profiles, higher risk individuals will purchase insurance in large amounts than lower risk individuals
- In theory, this problem disappears as insurers can more accurately measure individual risk.
- If individuals are overly optimistic about their own future risk, even those being offered overly fair prices may still choose not to participate in insurance.
- Despite advances in statistical discrimination and risk assessment among insurers, optimism bias can create an additional "artificial adverse selection" problem that may not be easily differentiate from true adverse selection.

# Crop Insurance Demand Under Uniform/Group Rates



# Joint Distribution Plots



# Preliminary Findings

- Optimism Bias induces positive correlation between coverage level and elasticity of demand.
- Group pricing attenuates effect of optimism on crop insurance demand.
  - Does not necessarily reduce total subsidy costs
- Interaction effect between adverse selection and optimism bias is diminished as coverage levels increase
- Evidence of distinct groups/types of farmers in terms of optimism bias

## Still to do

- Compare results under other distributions
- Control for upward drift over time
- Look further into interaction effects with adverse selection
- Type classifications/Mixture model
- Identify further evidence