# Subjective Belief, Risk Information and Earthquake Insurance Purchase

Michio Naoi (Keio U.)
Takuya Ishino (Kanazawa Seiryo U.)
Miki Seko (Musashino U.)

# Introduction

- Limited insurance coverage against earthquake
  - ✓ % HHs covered by earthquake insurance = 27% (General Insurance Association of Japan, 2012)
  - ✓ Also common in other countries:
    - California = 11% (2000), Turkey = 19.4% (2006)
  - ✓ Why do so many households not insure against earthquakes?

# Introduction

- Misperception of potential risk
  - ✓ Majority of homeowners underestimate house destruction risks due to earthquake
    - Median subjective prob. = 5%
    - Objective prob. = 5–25%

| Seismic Scale | Under estimation | Good estimation | Over estimation |
|---|---|---|---|
| House destruction risk | | | |
| 6+ | 0.54 | 0.22 | 0.25 |
| 7 | 0.59 | 0.21 | 0.21 |

Source: Fujimi and Kakimoto (2012, Table 6)

# Introduction

- Disseminating risk information
  - ✓ Policy aiming at providing better information for consumers, and enhancing insurance coverage
  - ✓ Effectiveness of the policy depends on…
  1. How consumers perceive the probability/magnitude of a loss *ex-ante*
  2. To what extent additional risk information alters consumer's perception *ex-post*

# Introduction

- Purpose of the paper
  - ✓ Theory:
    - To develop a simple model of insurance purchase where consumers have imperfect knowledge about the potential risk but have an opportunity to seek for better information
  - ✓ Empirical analysis:
    - To test the theoretical predictions using observed insurance behavior
    - To examine whether providing risk information (e.g., earthquake hazard map) has any causal effect on insurance decision

# Theoretical Considerations

- Setting (Kunreuther and Pauly, 2004)
  - ✓ Insurance decision:
    - Risk averse consumers, having wealth $(W)$ and facing a risk of a loss $(L)$, want to determine how much insurance $(I)$ to purchase
  - ✓ Imperfect knowledge:
    - Consumers believe that the probability has $n$ possible values $(p_j; j = 1, \cdots, n)$ with subjective "weights" $(w_j)$
  - ✓ Information search:
    - Consumers can search for and obtain information about the loss probability at a fixed search cost $(C)$

# Theoretical Considerations

- Insurance Decision without Search
  - ✓ Expected utility:

$$\mathrm{EU}(No\ Search) = \sum_{j=1}^{n} w_j \left[ p_j U(W - L + (1-r)I) + \left(1 - p_j\right) U(W - rI) \right]$$
$$= \hat{p} U(W - L + (1-r)I) + (1 - \hat{p}) U(W - rI)$$

  - ✓ Linear in average subjective probability:

$$\hat{p} = \sum_{j} w_j p_j$$

# Theoretical Considerations

- Insurance Decision without Search (cont'd)
  - ✓ Optimal insurance amount:

$$\max_{I} \mathrm{EU}(No\ Search) \ \text{ s.t. } 0 \leq I^* \leq L$$

  - ✓ Insurance decision:

$$a^* = \begin{Bmatrix} 0 \\ 1 \end{Bmatrix} \quad \text{if} \quad \hat{p} \begin{Bmatrix} \leq \\ > \end{Bmatrix} \frac{rU'(W)}{(1-r)U'(W-L) + rU'(W)} \tag{3}$$

# Theoretical Considerations

- Insurance Decision with Searching
  - ✓ Amount of insurance for each subjective probability estimate:

$$I_j^* \equiv \arg\max_I p_j U(W - L + (1-r)I) + \left(1 - p_j\right)U(W - rI)$$

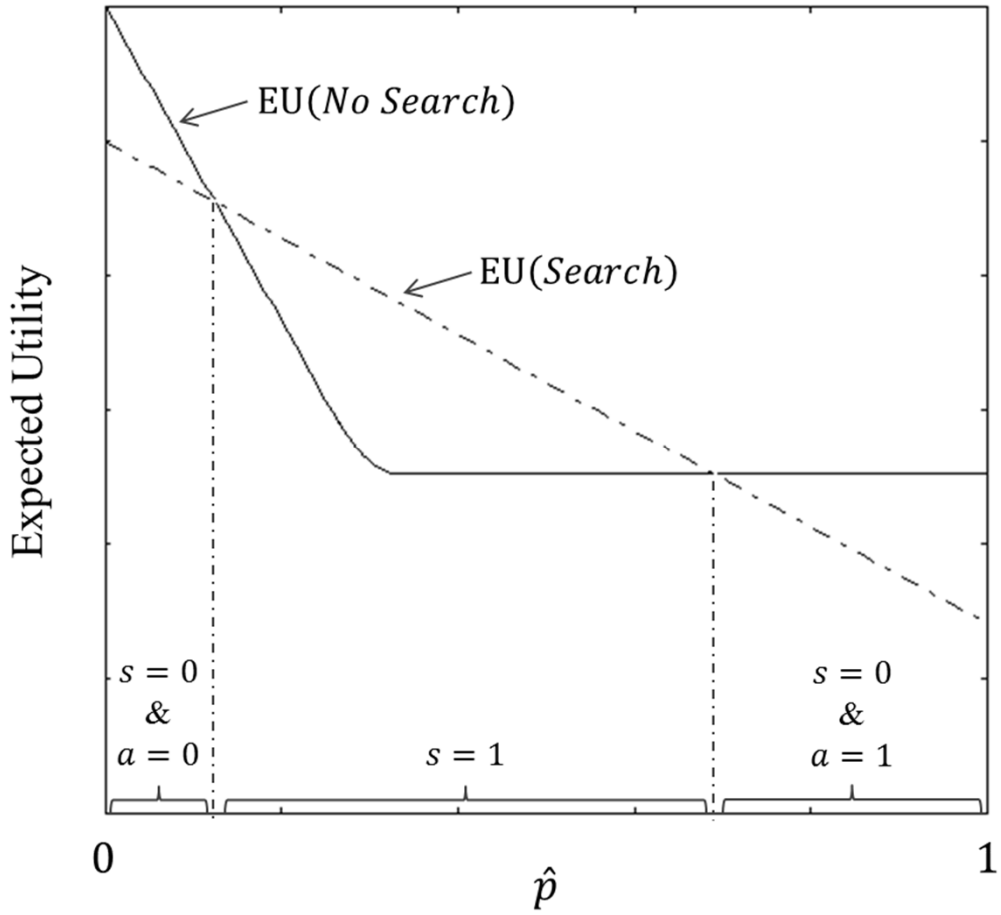
  - ✓ Expected utility:

$$\mathrm{EU}(Search) = \sum_{j=1}^{n} w_j \left[p_j U\left(W - L + (1-r)I_j^*\right) + \left(1 - p_j\right)U\left(W - rI_j^*\right)\right] - C$$

# Theoretical Considerations

- Decision to search for information:
  - ✓ The consumer will search for information on the probability of a loss only if $\mathrm{EU}(Search) \geq EU(No\ Search)$
- Potential trade-off:
  - ✓ Fixed search cost $(C)$
  - ✓ Choosing optimal insurance demand for each "scenario" $(p_j)$

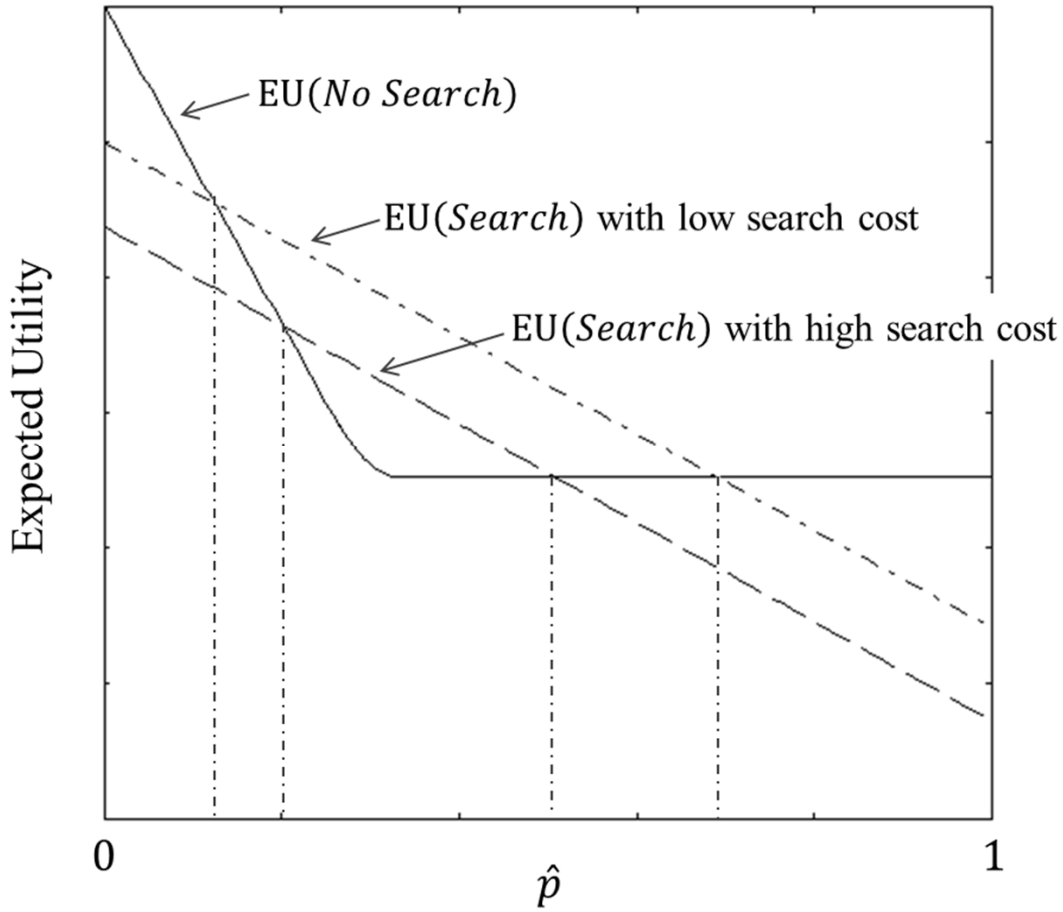
# Theoretical Consideration



# Theoretical Considerations

- Three possible outcomes:
  1. No search $(s = 0)$ & No insurance $(a = 0)$ if $\hat{p}$ is relatively low
  2. Search $(s = 1)$ if $\hat{p}$ is moderate
  3. No search $(s = 0)$ & Buy insurance $(a = 1)$ if $\hat{p}$ is relatively high

# Theoretical Considerations



# Theoretical Considerations

- Effect of additional information:
  - ✓ Additional information will alter the subjective estimate of the loss probability $(\hat{p}')$
  - ✓ After obtaining additional information, insurance decision is made based on the updated subjective probability

$$a^* = \begin{Bmatrix} 0 \\ 1 \end{Bmatrix} \quad \text{if} \quad \hat{p}' \begin{Bmatrix} \leq \\ > \end{Bmatrix} \frac{rU'(W)}{(1-r)U'(W-L) + rU'(W)} \qquad (6)$$

# Data and Variables

- KHPS & JHPS
  - ✓ Household-level longitudinal data
  - ✓ Started in 2004 (KHPS) and 2009 (JHPS), with approx. 4,000 initial households
  - ✓ Conducted every January each year
  - ✓ Household/respondent characteristics

# Data and Variables

- Post-Quake Survey of KHPS/JHPS
  - ✓ Follow-up to the regular survey of KHPS/JHPS:
    - 1st round: June 2011 / 2nd round: Oct. 2011
    - N = 4,215 & 3,591
  - ✓ Questionnaire:
    - Earthquake loss & damage
    - Post-disaster situations of the respondents, including employment, housing, consumption and income
    - Insurance and disaster mitigation activities

# Data and Variables

- Insurance decision
  - ✓ Question about earthquake insurance status in the PQS
    - Already covered by EQ insurance prior to the Great East Japan Earthquake
    - Not covered but plan to purchase EQ insurance in the future
    - Not covered and do not plan to purchase it in the future
  - ✓ Our sample: Homeowners not covered by earthquake insurance in the pre-quake period
  - ✓ Dummy var. = 1 if R plans to buy insurance

# Data and Variables

- Risk information
  - ✓ Whether or not the respondent obtained the regional hazard information such as earthquake hazard map provided by the local governments
    - external risk information for potential insurance customers which may alter their *ex-ante* subjective probability
  - ✓ Dummy var. = 1 if respondents obtained hazard information and 0 otherwise

# Data and Variables

- Objective earthquake probability
  - ✓ Probabilistic Seismic Hazard Map (PSHM)
  - ✓ Probability that earthquakes with JMA seismic intensity of $6^-$ will take place in the next 30 years
- Other geospatial data
  - ✓ Insurance premium
  - ✓ Distance from the coastline
  - ✓ Site liquefaction index

# Data and Variables

- Other control variables
  - ✓ Respondent's age, sex, marital status, household size, income, wealth, self-reported house value (KHPS/JHPS2011)
  - ✓ Self-reported score of fear/anxiety toward possible aftershocks (1st round PQS)

# Empirical Model

- Subjective probability of a loss

$$\hat{p}(s) = f(p^o, x) + \beta s + \varepsilon \qquad (8)$$

- ✓ $\hat{p}(s)$: (unobservable) subjective probability
- ✓ $p^o$: 30-year probability (PSHM)
- ✓ $x$: control variables
- ✓ $s$: dummy var. whether R obtained risk info.

# Empirical Model

- Insurance purchase (eqns. (3) & (6))

$$a = \begin{Bmatrix} 0 \\ 1 \end{Bmatrix} \quad \text{if} \quad \hat{p}(s) \begin{Bmatrix} < \\ \geq \end{Bmatrix} g(r, W, L) \tag{7}$$

  - ✓ $a$: insurance purchase
  - ✓ $r$: insurance premium
  - ✓ $W$: household wealth
  - ✓ $L$: potential loss from a quake (= proxied by a self-reported house value)

# Empirical Model

- Causal effect of obtaining risk information:
  - ✓ $\beta$ in equation (8)
- Probit model with endogenous variable:
  - ✓ $s$ can be endogenous
  - ✓ IVs: variables regarding the cost of obtaining information $(C)$
    - Whether paper- or web-based earthquake hazard information is available in the respondent's municipality (with latter variable interacted with resp's internet access at home)

# Empirical Results

- Standard probit model
  - ✓ Assuming exogeneity of $s$

| Plan to purchase insurance (yes = 1) | Coef. | AME |
|---|---|---|
| Obtained the regional hazard info. (yes = 1) | 0.1998* | 0.0744 |
| Wealth (in 10 mil. JPY) | -0.1048* | -0.0299 |
| Wealth$^2$ | 0.0086+ | |
| Self-reported house value (in 10 mil. JPY) | 0.1777+ | 0.0407 |
| Self-reported house value$^2$ | -0.0386+ | |
| Insurance premium (Single-family, detached) | -0.0348+ | -0.0129 |
| Insurance premium (condominium) | -0.4052* | -0.1211 |

# Empirical Results

- Probit model with binary endog. var.

| Plan to purchase insurance (yes = 1) | Coef. | AME |
|---|---|---|
| Obtained the regional hazard info. (yes = 1) | 0.0780* | 0.0291 |
| First-stage results | | |
| Paper-based hazard info. available (yes = 1) | 0.3666* | 0.1286 |
| Web-based hazard info. × Internet access | | |
| Web info. = 0 × Internet access at home = 0 | (Omitted) | |
| Web info. = 0 × Internet access at home = 1 | 0.1400 | 0.0513 |
| Web info. = 1 × Internet access at home = 0 | 0.2178 | 0.0791 |
| Web info. = 1 × Internet access at home = 1 | 0.2928+ | 0.1052 |

# Conclusion

- Theory
  - ✓ To present a simple model of insurance purchase where consumers have imperfect knowledge about the potential risk but have an opportunity to obtain better risk information
- Empirical analysis
  - ✓ obtaining the regional disaster hazard information makes the consumer's subjective probability of a loss significantly higher, thereby facilitating insurance demand