Reinsuring the Poor: Group Microinsurance Design and Costly State Verification

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Motivating question

What sort of insurance product designs might be most appropriate for the poor?

'If economists can be persuaded to be more involved in suggesting other ways of doing things, perhaps the next wave of innovations [in microfinance] is not far away.' Banerjee (2002)

Thesis overview

Chapter I. Theory of rational demand for index insurance and numerical example

Chapter II. Results from microinsurance lab experiment conducted with Ethiopian farmers

Chapter III. A normative theory of insurance contracting for the poor

Insurance for the Poor: Stylised Facts

1. Loss adjustment is very costly
   - Where loss adjustment
     - = Ex post insurance claim processing
     - = Verifying that claims are not fraudulent + paying valid claims
   - See e.g. Handbook of Insurance (2000), Giné, Townsend, and Vickery (2007), Journal of Risk and Insurance September 2002 (special issue on insurance fraud).

Insurance for the Poor: Stylised Facts

1. Loss adjustment is very costly
2. Nonmarket loss adjustment within small groups of individuals may be possible at low cost
   - e.g. within extended families or close-knit communities.
   - Restricted by budget and enforcement constraints?
   - e.g. Townsend (1994), Udry (1994), Ligon et al. (2002)

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1. $\Rightarrow$ Too expensive for insurer to sell individual indemnity insurance to each individual
2. $\Rightarrow$ Economically and socially contiguous groups may be able to sustain (at least partial) risk pooling
3. $\Rightarrow$ Insurer cannot hope to reveal information by playing individuals off against each other

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Asymmetric cost of loss adjustment

$\Rightarrow$ optimal arrangement may be split into:

Formal sector risk transfer: captures aggregate losses; and

Local nonmarket risk pooling: soaks up idiosyncratic risk.

Index choice for formal sector insurance is critical

Suppose

- A group of Ethiopian farmers have total income from agriculture of either Y with probability $4/5$ or $Y-L$ with probability $1/5$
- The group can purchase index insurance which pays if the index is bad

	$Index = Bad$	$Index = Good$	
$Income = Y - L$	$3/20$	$1/20$	$1/5$
$Income = Y$	$1/20$	$15/20$	$4/5$
	$1/5$	$4/5$	

- Index insurance is priced so that coverage of αL costs $\frac{2}{5}\alpha L$ (i.e. loading is 100%)

1. Are there any levels of cover ($\alpha \in [0, 1]$) that are inadvisable?
2. What about if loading is 200% or 275%?

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- Index insurance is priced so that coverage of αL costs $\frac{2}{5}\alpha L$ (i.e. loading is 100%)

1. $\alpha > 33\%$ is irrational if loading is 100% (violates DARA)
2. $\alpha > 12\%$ is irrational if loading is 200% (violates DARA)
3. $\alpha > 0\%$ is irrational if loading is 275% (violates risk aversion)

Overview

Is observed takeup 'too low'?

Observed demand for weather derivatives is lower than expected but is it 'too low'?

- Very difficult to make such statements without an objective joint distribution of index and loss since...
- ...rational demand for indexed insurance is highly sensitive to price and correlation between index and loss (Clarke 2011, PhD thesis, Chapter 1)
- However, very little (rigorous) statistical analysis of basis* risk

*Basis = Loss incurred by farmer − indexed claim payment

Numerical example from a developing country

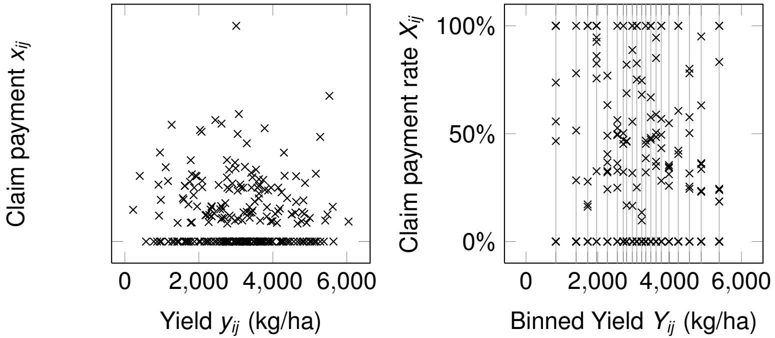
Suppose you are a financial advisor with the following data

- y_{ij}: Average maize yields (kg/ha) within subdistrict j in year i
- x_{ij}: Claim payment for weather index insurance product designed for maize that would have been made in subdistrict j in year i
  - Nine years of data, $i \in \{1999, \ldots, 2007\}$
  - Yield and weather data and product details for 31 subdistricts $j \in \{1, \ldots, 31\}$
- Total of $n = 261$ complete (x_{ij}, y_{ij}) pairs
- Assume that farmer groups perfectly pool risk within each subdistrict.

How much weather index insurance would you advise each group to purchase?

Data

Figure: Unadjusted and adjusted joint empirical distribution of yields and claim payments



Decision rule

The financial adviser is to choose a level of coverage $\alpha \geq 0$, providing a maximum claim payment of αL, to maximise expected (objective) utility:

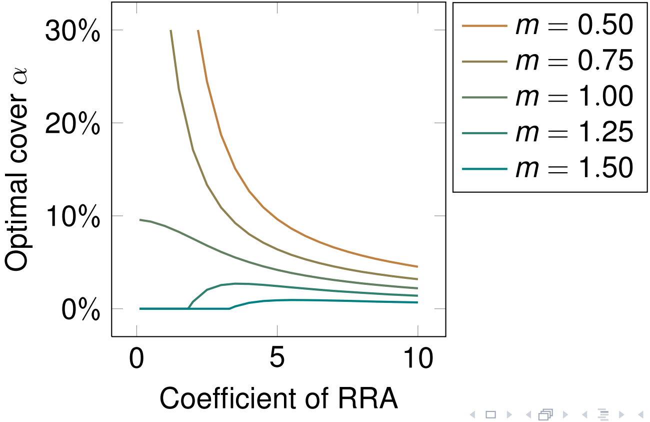
$$\mathbb{E}U = \frac{1}{n} \sum_{ij \in D} u(\tilde{w} + Y_{ij} + \alpha L(X_{ij} - m\bar{X})) \qquad (1)$$

where

- $\bar{X}$ denotes $\frac{1}{n} \sum_{ij \in D} X_{ij}$
- $\tilde{w}$ is random initial background wealth (statistically independent of the joint distribution of (X, Y))
- m is the pricing multiple (premium / expected claim income)
- u is the utility function, assumed to satisfy $u' > 0$ and $u'' < 0$
- L is difference between maximum and minimum binned yield: $5,381 - 831 = 4,550$ kg/ha

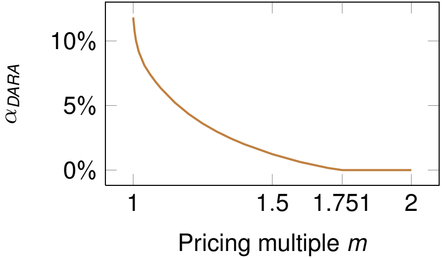
Are poor products being sold to the poor?

Figure: Optimal purchase of index insurance for maize from decision makers with (indirect) CRRA utility function



Upper bounds for financial advice

Risk averse DARA upper bound for purchase of index insurance for maize



Also: No risk averse expected utility maximiser will optimally purchase any index insurance if $m > 1.751$. Cf.:

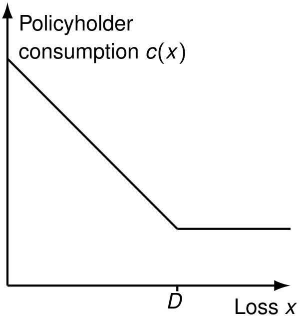
- Giné et al. (2007): Average premium multiple of 3.4
- Cole et al. (2009): Premium multiples of seven products, ranging from 1.7 to 5.3

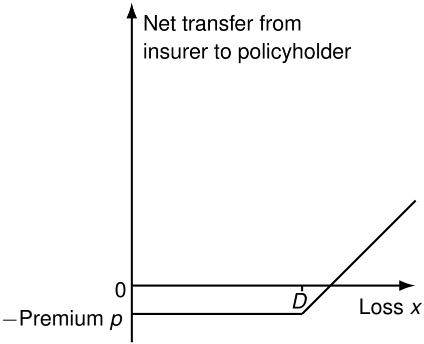
Overview

Optimal consumption and transfer in the bilateral case

$$c(x) = w - p - \min(x, D)$$

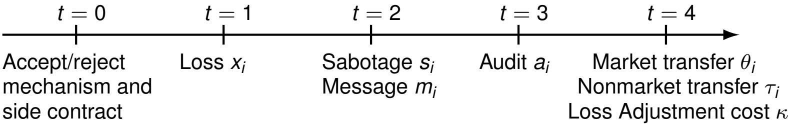
(Arrow 1963, Hölmstrom 1979, Townsend 1979, Picard 2000)





Overview of Benchmark Model

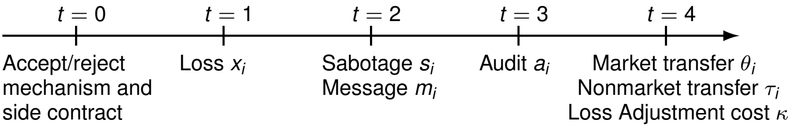
Figure: Timeline For Benchmark Model



- Two risk averse agents
- Affiliated losses $x_i \in [0, \bar{x}]$
- Risk-neutral insurer
- Deterministic audit rule: $a_i : M_1 \times M_2 \rightarrow \{0, 1\}$
- Insurer loss adjustment cost of κ

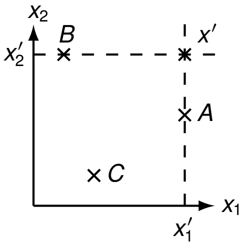
Overview of Benchmark Model

Figure: Timeline For Benchmark Model



- Multilateral mechanism $G = (\{M_i, a_i, \theta_i\}_{i=1,2})$
- Side contract $S = (\{s_i, m_i, \tau_i\}_{i=1,2})$ is Pareto optimal for two agents
- Insurer's ex-post profit $\pi = \theta_1 + \theta_2 - \kappa$
- Agent i's ex-post consumption $c_i = w_i - x_i - \theta_i - \tau_i$

Incentive Compatibility: Revelation Principle



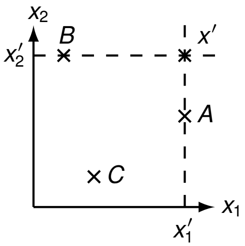
Denote $\theta_0(x) := \theta_1(x) + \theta_2(x)$
Question: What are IC restrictions on $\theta_0(x')$?

Suppose that:

- $a_1(A) = 1$, $a_2(A) = 0$
- $a_1(B) = 0$, $a_2(B) = 1$
- $a_1(C) = 0$, $a_2(C) = 0$

- $\theta_0(x') \leq \theta_0(C) := p_0$
  - with equality if neither agent audited in state x'

Incentive Compatibility: Revelation Principle



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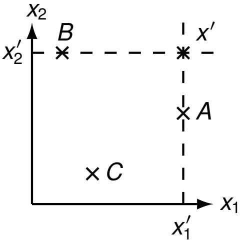
- $\theta_0(x') \leq \theta_0(A) := p_0 - y_1(x'_1)$
  - with equality if only agent 1 audited in state x'
- $\theta_0(x') \leq \theta_0(B) := p_0 - y_2(x'_2)$
  - with equality if only agent 2 audited in state x'
- $\Rightarrow \theta_0(x') \leq p_0 - \max(y_1(x'_1), y_2(x'_2))$
  - with equality if only one agent audited in state x'

Incentive Compatibility: Revelation Principle



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So there exists a constant p_0 and functions y_1, y_2, z such that

$$\theta_0(x) = p_0 - \max(y_1(x_1), y_2(x_2)) - z(x)$$

$$a_i(x) = 1 \text{ if } \begin{cases} z(x) > 0 \text{ or} \\ y_i(x_i) > y_j(x_j) \end{cases}$$

Where $p_0, y_1(x_1), y_2(x_2), z(x) \geq 0$

Incentive Compatibility

Aggregate net transfer from agents to insurer θ_0:

- Can only vary with audited information
- Does not increase with (truthful) audited information

Also, the possibility of sabotage & ability of agents to side contract $\Rightarrow$ no marginal overinsurance:

$$\boxed{x_1 + x_2 - \theta_0(x_1, x_2) \text{ is weakly increasing in each } x_i,\ i = 1, 2}$$

Deadweight cost assumption

Assumption

The deadweight loss adjustment cost to the insurer of a feasible mechanism $\{a, \theta\}$ *is* $\kappa(\mathbb{E}y, \mathbb{E}z)$ *where* $\kappa(0,0) \geq 0$ *and* $D_2\kappa(Y,Z) \geq D_1\kappa(Y,Z) > 0$ *for all* $Y, Z \geq 0$.

Generalised Stop Loss Contract

A direct mechanism (a, θ) is said to be a **Generalised Stop Loss** contract if:

$$\theta_0(x) = p_0 - \max(0, x_1 - D_1, x_2 - D_2, x_0 - D_{12}) \text{ for almost all } x \in X$$

for some $D_1, D_2 \in [0, \bar{x}]$ and $D_{12} \in [0, 2\bar{x}]$.

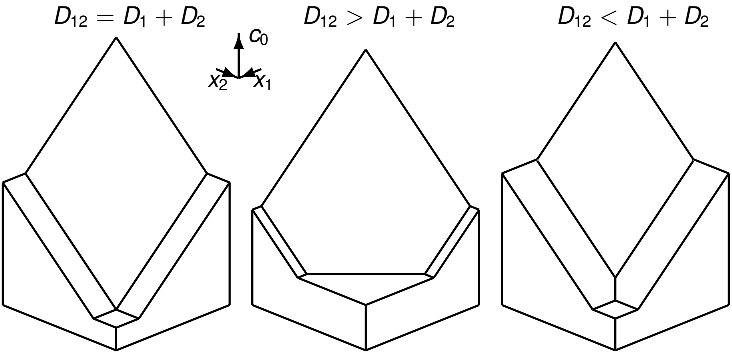
$$\therefore c_0(x) = w_0 - p_0 - \min(x_1 + x_2, D_1 + x_2, x_1 + D_2, D_{12})$$

Theorem

In the benchmark model, any optimal feasible mechanism is a Generalised Stop Loss contract.

2D projection of Generalised Stop Loss Contract

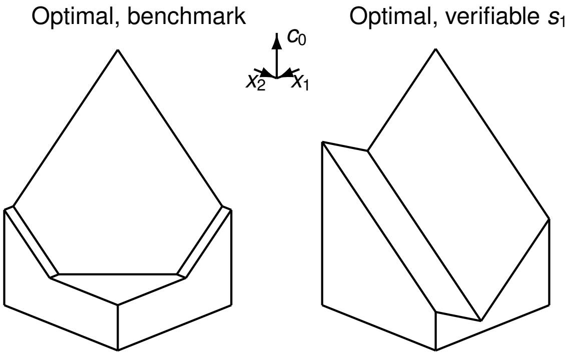
$$c_0(x) = w_0 - p_0 - \min(x_1 + x_2, D_1 + x_2, x_1 + D_2, D_{12})$$



Verifiable Sabotage and Area Index Insurance

Now suppose that the insurer can observe agent 1 sabotage of s_1 when auditing.

- Marginal overinsurance of agent 1's loss is now optimal
- If loss correlation is high, optimal contract similar to area index insurance contract



Indices and Stop Loss Gap Insurance

Suppose finally that there is a index v which is jointly affiliated with the losses and costless for the insurer and agents to observe.
A mechanism (a, θ) is said to offer **Index Plus Generalised Stop Loss Gap** insurance if:

$$\theta_0(x, v) = p_0 - \max(I(v), x_1 - D_1, x_2 - D_2, x_0 - D_{12}) \text{ for almost all } x \in X, v \in V$$

for some $I(v) : V \rightarrow [0, \infty)$, $D_1, D_2 \in [0, \bar{x}]$ and $D_{12} \in [0, 2\bar{x}]$.

$$\therefore c_0(\omega) = w_0 - p_0 - \min(x_1 + x_2 - I(v), D_1 + x_2, x_1 + D_2, D_{12})$$

Theorem

Any optimal feasible mechanism under ex ante side contracting with a costlessly observable index offers Index Plus Generalised Stop Loss Gap insurance.

Examples of such contracts

1. Crop insurance:
   - Self-Insurance Funds in Mexico (Ibarra 2004): Stop Loss
   - India's pilot modified NAIS (Mahul et al. 2011)
     - Sample-based area yield index insurance
     - with early weather indexed payout,
     - and CCEs targeted based on remote sensing index.
     - Rice insurance in China (Cai et al.): Sample-based area yield index insurance
2. Life insurance
   - Longevity insurance: If fifteen of twenty over-50s are still alive in five years time
   - Assurances: If more than four of forty 20-40 year olds die in the coming year (cf. reinsuring funeral societies)

Overview

A template for formal insurers

1. Think of role as that of reinsurer.
2. Contract with economically and socially contiguous groups
   - Cheap loss adjustment technology?
   - Can sustain (at least partial) risk pooling?
3. Use contracting power to support nonmarket insurance
4. Condition transfers (and audits/monitoring) on any cheaply observable indices...
5. ...but consider an indemnity-based floor based on
   i. a sample of sabotage free losses, or
   ii. or group/subgroup aggregate losses

Theorem 2: CRRA and CARA

Figure: Rational hedging and risk aversion for CRRA and CARA