Risk and Demand for Incomplete Insurance: Lab Experiments with Guatemalan Cooperatives

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OBJECTIVE

- *Understanding* demand for incomplete insurance
  "Incomplete" when:

  - Payout < Loss in states of nature covered by insurance
    * Typical of "input" insurance, or "partial" insurance to reduce the premium cost.
    * Index insurance, where payout related to weather index not own loss

  - States of nature with loss that are not insured
    * Insurance for specific risk ("excess rainfall", but not drought or pest)
    * Insurance for specific source of income (specific crop, ag. only, ...)
    * Index insurance: negative shock on own property, despite none on the index

    Referred to as background / basis risk (semantic)

  - Worse state of nature is not among the insured states

- Evaluating demand for "hybrid" insurance product that reduce uninsured risk
  Index-based for a group + some loss adjustment within group

APPROACH : Experimental games in the field to test some of the ideas.

THEORY

- Background risk – statistically independent of the insurable risk
  Gollier & Pratt (1996) and Eeckhoudt, Gollier, Schlesinger (1996)
  Demand for insurance **increases** with unfair background risk if preferences are "**risk vulnerable**" (unfair = with a nonpositive expectation)
  Risk vulnerable more restrictive that DARA –
  Mean-variance preferences (CARA) are not risk-vulnerable. Demand for insurance is independent of background risk

- Partial insurance –
  "Fair" premium: full insurance is optimal
  "Unfair" premium (including insurance costs): Trade-off E(y) – var(y)
  partial insurance is optimal, with deductible, insuring share of loss, etc.
  Higher cost ==> lower optimal share

- Uninsured worse state

  Doherty & Schlesinger (1990) on contract non-performance
  Non-zero probability that a "valid claim" will not be fully paid
  "Valid" (in the mind of the insurer or except for uncontrollable act of nature)

  ==> * Less than full insurance at fair price (premium increases the worst outcome)
  * Demand for insurance can decrease with risk aversion, when risk aversion is very high

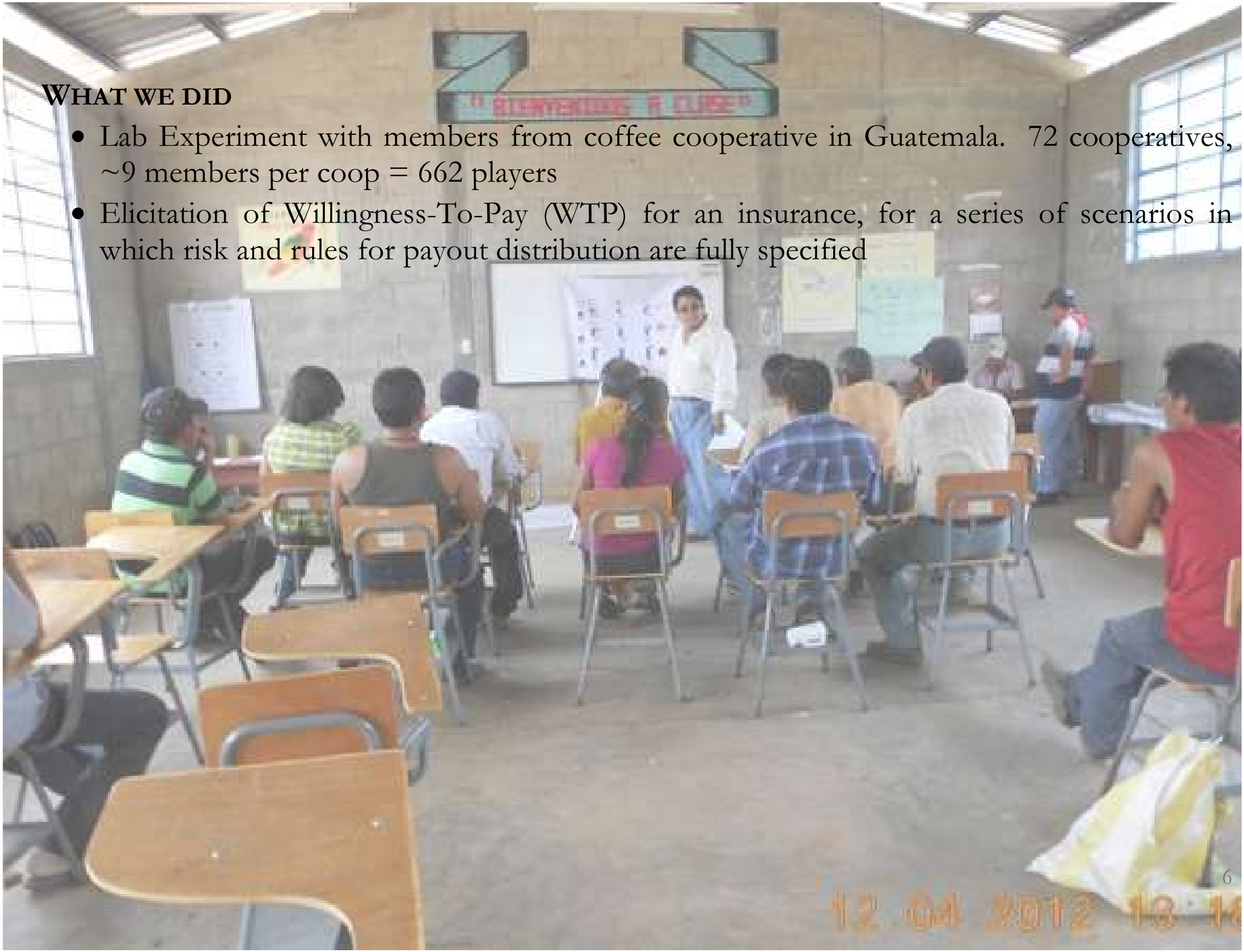
  Applied to basis risk in index insurance by Clarke (2012)

- Delegation of loss adjustment to a group

  Failure to commitments (Ligon)
  Fundamental heterogeneity, which implies net transfer if the contract cannot be written taking into account the differential risk exposure. "Value" of this transfer to friends relative to premium to insurer?
  Implementation problem (elite capture, power structure, lack of trust in the group, etc.)

I. **TESTABLE HYPOTHESES** WRT BACKGROUND RISK

- Does insurance demand increase with background risk?
- Do people evaluate residual/uninsurable risk in insured states differently from risk in uninsured states
- Is the response to the worse state being uninsured different from what is to be expected from its riskiness?



WHAT WE DID

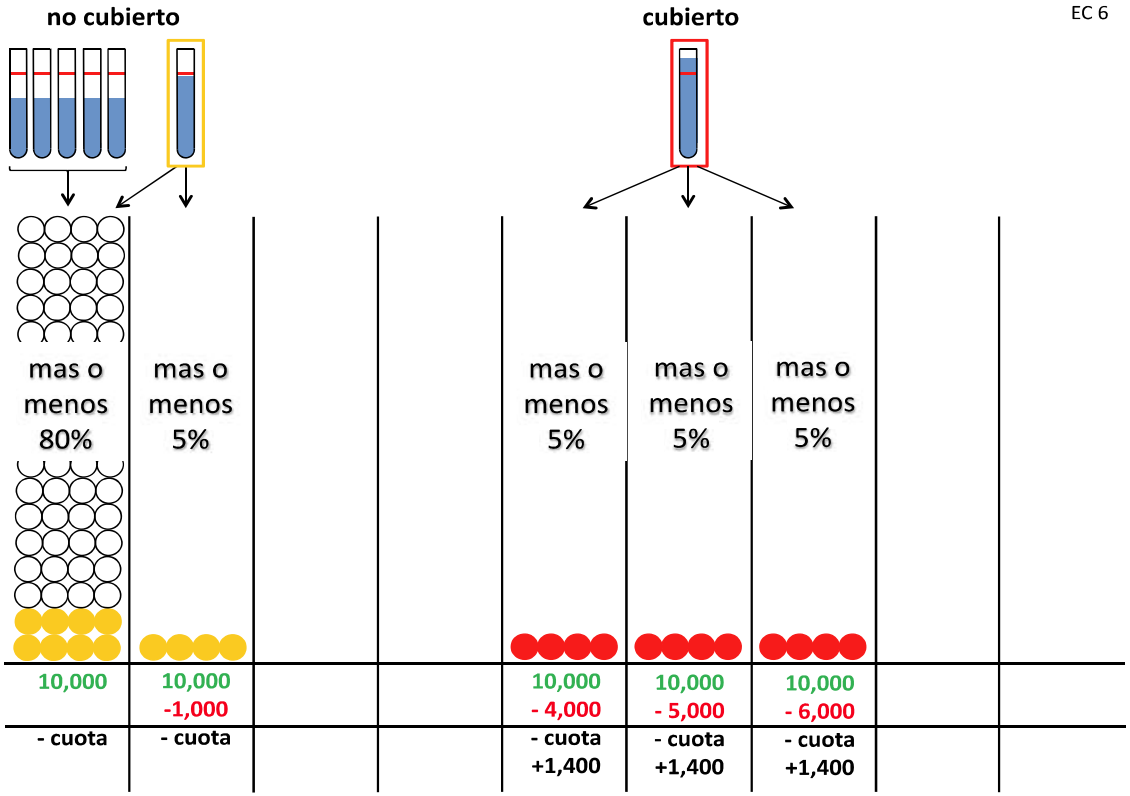
- Lab Experiment with members from coffee cooperative in Guatemala. 72 cooperatives, ~9 members per coop = 662 players
- Elicitation of Willingness-To-Pay (WTP) for an insurance, for a series of scenarios in which risk and rules for payout distribution are fully specified

LAB EXPERIMENT SET-UP – MIMICKING AN EXCESS RAINFALL INSURANCE

- Climate: 5 good years, 1 year with heavy rainfall, 1 year with excess rainfall
- Income in normal years: Q 10,000
- Game losses: Q 0 with normal rainfall, possibly Q 1,000 with heavy rainfall, Q 2,000-8,000 with excess rainfall
- Payout when excess rainfall only: Q 1,400, whatever the loss

Payout<loss
Payout independent of loss
Uninsured states (1,000 in example)

(12 circles per year)



- We do not play insurance games (with random drawing of rainfall and loss), except twice to learn and once at the end to compute payments.
- Respondents record their WTP on a sheet for each scenario presented to them:

Fila:	Precio más alto	Quetzales:														Precio más alto
I4		80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	

- Games are incentivized by payment for the day proportional to the outcome of one of the games being played at the end (Q 10000 in game = Q 70; participants receive Q 10 for attendance)

- 13 individual games + 20 group games + 4 validation games

- Randomization (16 cells: two price brackets x 8 different orders of experiments per bracket)

Individual games for analyzing background risk and worse case scenario

Increasing expected loss in insured states:

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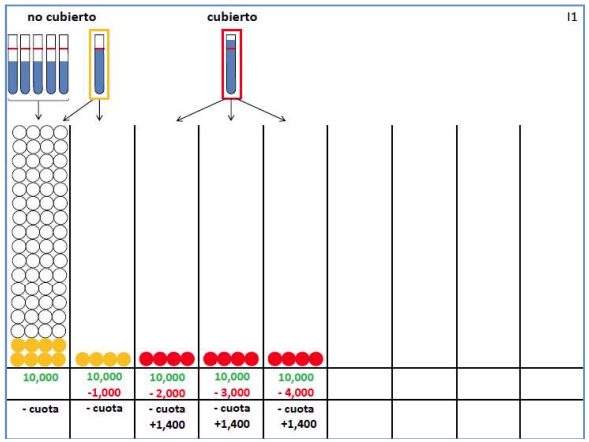

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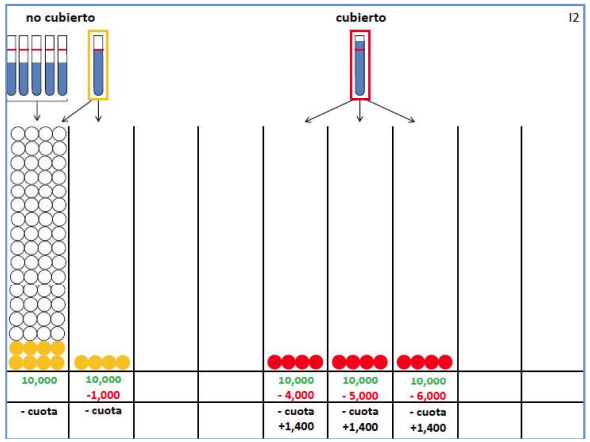

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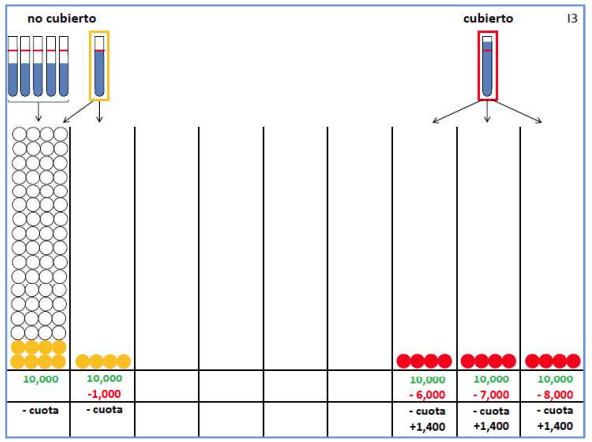

Increasing variance in loss in insured states:

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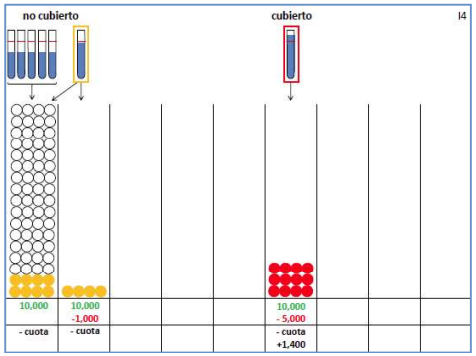

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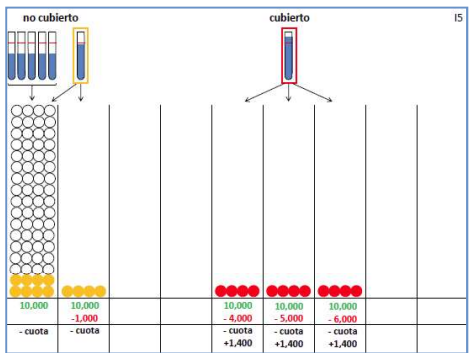

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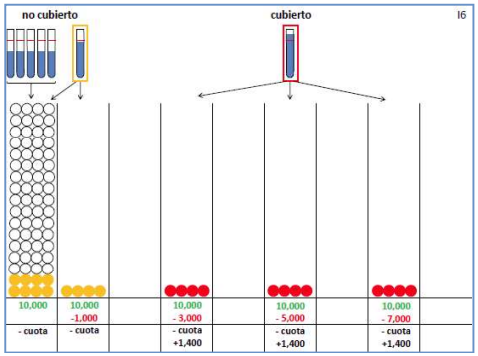

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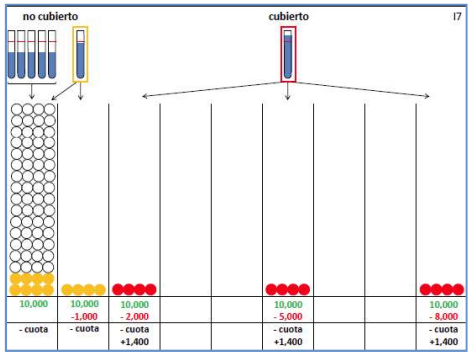

Uninsured states (drought) with variable loss and probability:

Worst case not insurable

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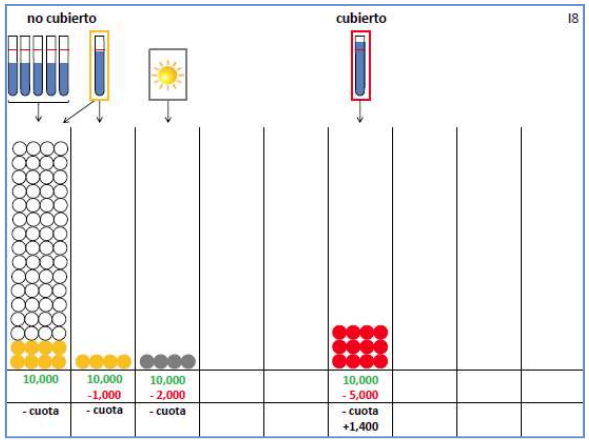

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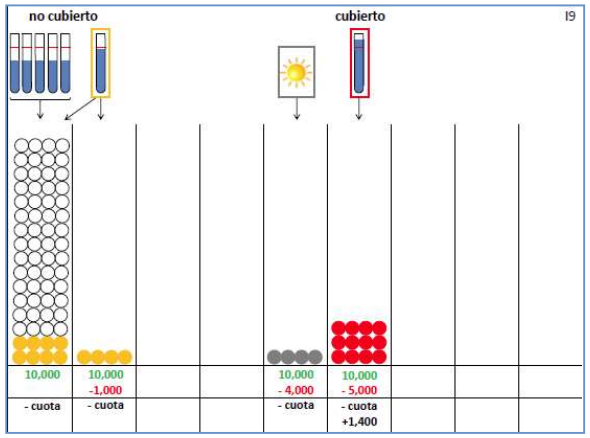

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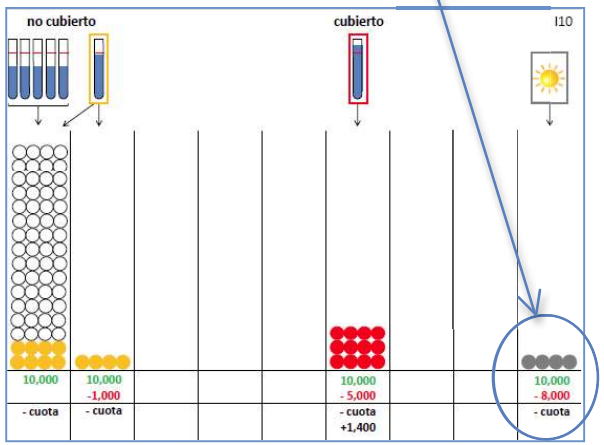

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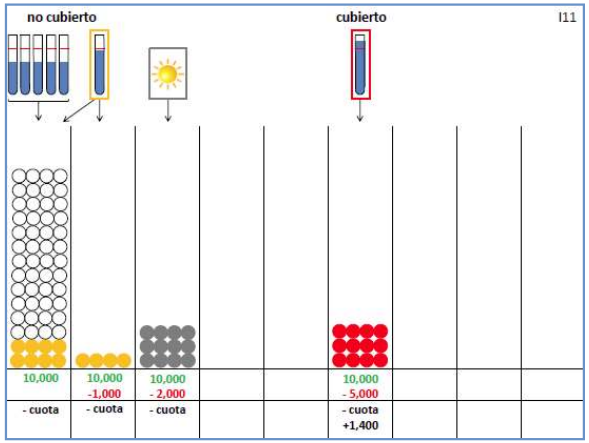

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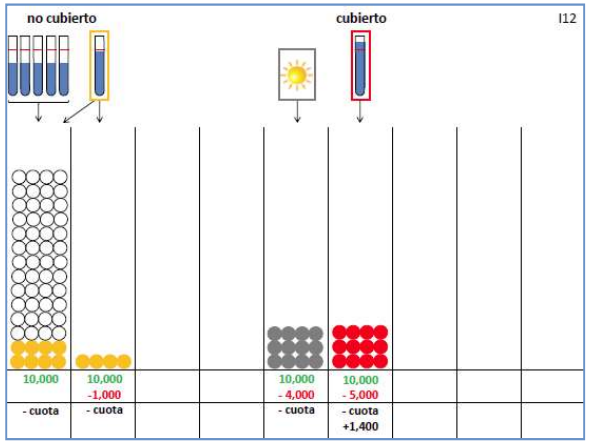

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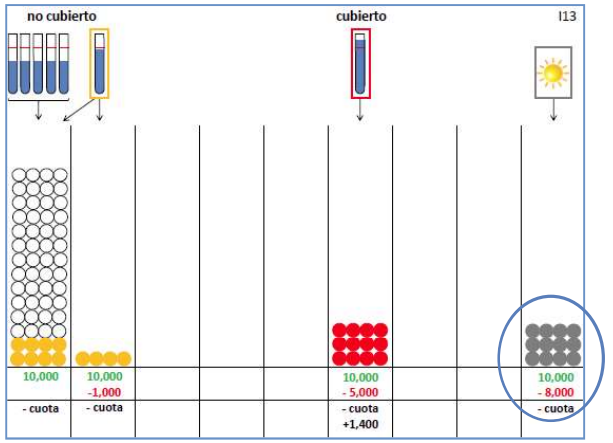


EMPIRICAL ANALYSIS

Each game is characterized by 2 distributions of income with and without insurance:

Without insurance: $y^0 = ymax - loss^i - loss^u$ Overall risk

With insurance: $y^I = ymax - loss^i + C - loss^u$ Uninsurable risk

WTP defined by: $EU\left(y^0\right) = EU\left(y^I - WTP\right)$

or approximately: $WTP = \dfrac{EU\left(y^I\right) - EU\left(y^0\right)}{EU'\left(y^I\right)} = \dfrac{\text{Benefit of insurance}}{\text{Marginal utility cost of WTP}}$

In the empirical analysis, consider the first two moments of the income distribution:

$EU\left(y^I\right) - EU\left(y^0\right)$ is characterized by $\Delta \text{sd}(y)$

"Uninsurable risk" is characterized by $E(loss) = ymax - E\left(y^I\right)$ and $\text{sd}\left(y^I\right)$

$EU'\left(y^I\right)$ increases with $E(loss)$, and decreases with $\text{sd}\left(y^I\right)$ if preferences are vulnerable.

Estimation equation:

$$WTP_{ig} = \mu_i + \beta_1 \Delta sd_g + \beta_2 Eloss_g^I + \beta_3 sdy_g^I + \varepsilon_{ig}$$

for individual *i* and game *g*, with ε_{ig} clustered at the individual level.

Weighted with randomization propensity weights (inverse of the proportion of cell sample size in each randomization cell).

Strong collinearity between these three variables in each block of experiments (increasing mean loss, increasing variance of loss, and background risk), but not when using games from all three blocks.

WTP increases with benefit of insurance, decreases with E(loss), and increases with background risk. Smaller but still significant effect if in uninsured states.

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Mean (SD)	Does Variance have Different Effect if within Payout States vs. if in Non-payout States?	
	(1)	(2)	(3)
WTP	25.49		
	(13.50)		
Improvement in SD from Purchasing Insurance	70.02	0.31**	0.17***
	(6.94)	(0.14)	(0.02)
Uninsurable Standard Deviation of Income	219.63	0.25***	0.22***
	(48.15)	(0.03)	(0.01)
Uninsurable Expected Loss in Game	106.06	-0.50***	-0.41***
	(33.63)	(0.08)	(0.02)
Background Risk Game	0.37	-8.69	
	(0.48)	(8.05)	
Uninsurable SD(Income) * Background Risk Game	85.25	-0.18***	-0.17***
	(111.65)	(0.01)	(0.01)
Uninsurable Expected Loss * Background Risk Game	50.16	0.43***	0.33***
	(67.30)	(0.10)	(0.02)
Observations	7067	7067	7067
R-squared		0.768	0.768
Number of Individuals		659	659
Games Used		3-9,10,11,13,14	

WTP ↗ with bckgr. risk

WTP ↘ with E(loss)

Smaller when due to uninsured states:
.25 - .18 = .077 (.030)
-.50 + .43 =-.068 (.015)

Summary of results and back to theory:

- WTP increases with background risk.

  ⇒ consistent with preference being vulnerable (Gollier & Pratt (1996) and Eeckhoudt, Gollier, Schlesinger (1996)

- Smaller effect if in uninsured states, even controlling for uninsurable risk (mean. variance)

  ⇒ People sensitive to the correlation between insurance and shocks

- Risk aversion: The response of WTP to the benefit of insurance increases with risk aversion, when lowest income states insured.

  ⇒ As expected

- Worst state of nature uninsured reduces demand for insurance, but not differentially for more risk averse producers

GROUP INSURANCE

Hybrid product: - Group gets payout based on the index
- Allocation of payout within group according to actual losses

This is not sharing of idiosyncratic losses, only of payout

WTP for the hybrid product

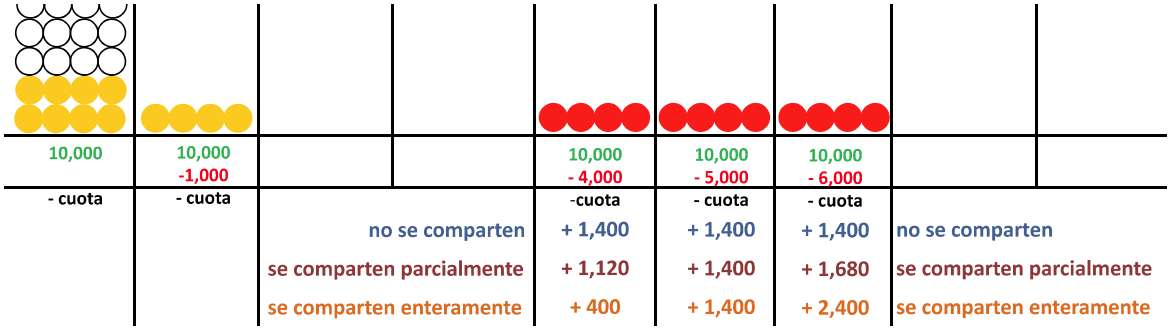
- Does the within group loss adjustment increase the demand for the index insurance?
- Do people value groups in and for themselves (beyond the insurance value)
- What do people expect in terms of sharing?
- Does heterogeneity affect demand for group insurance?
- How do people value "implicit transfers" to other members relative to payments to insurance company

Limits to potential within-group insurance

- How much do people expect the group to be sharing (if not imposed by contract)
- Failures of commitment

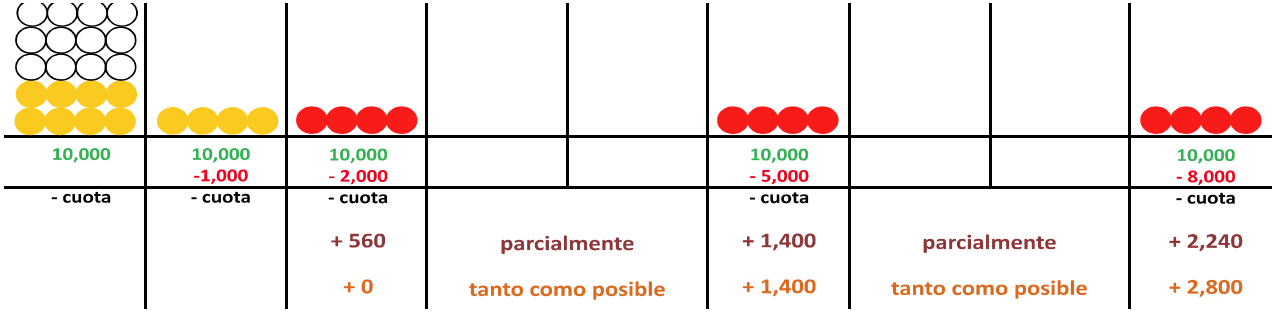
GROUP GAMES

Seven scenarios analogous to individual games. Hence group "effect" is straightforwardly estimated by difference.
Within-group loss adjustment is fully specified: "no adjustment", "partial adjustment", or "maximum adjustment"



Note: Only sharing of payout, i.e. idiosyncratic basis risk is not fully internalized

➔ Within-group variance in loss possible even with maximum sharing



WTP increases with sharing within group, but WTP for individual insurance > WTP for group insurance with partial sharing

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Demand for Group Insurance	
	(1)	(2)
Group with No Loss Adjustment	-5.24***	-5.50***
Pure preference for group	(0.52)	(0.47)
Group with Moderate Loss Adjustment	-2.31***	-2.23***
	(0.53)	(0.48)
Group with Maximal Loss Adjustment	0.77	-0.04
	(0.56)	(0.49)
Medium Risk Game		2.84***
		(0.17)
High Risk Game		5.90***
		(0.23)
Trust in Group * Group Game		
Trust in Group * Moderate Loss Adjustment		
Trust in Group * Maximal Loss Adjustment		
Constant (WTP in individual game)	29.14***	29.38***
	(0.38)	(0.35)
Games used	Ind. + Group Low risk	Ind. + Group All risk

Summary of results on group insurance:

- Demand for fully specified group insurance
  - ✓ There is a demand for sharing payout according to losses within the group.
  - ✓ However there is a "dislike" for group (at given risk coverage) ≈ 20% WTP

  ⇒ These two almost completely offset each other,
  i.e., WTP (individual)≈ WTP (group with maximum sharing)

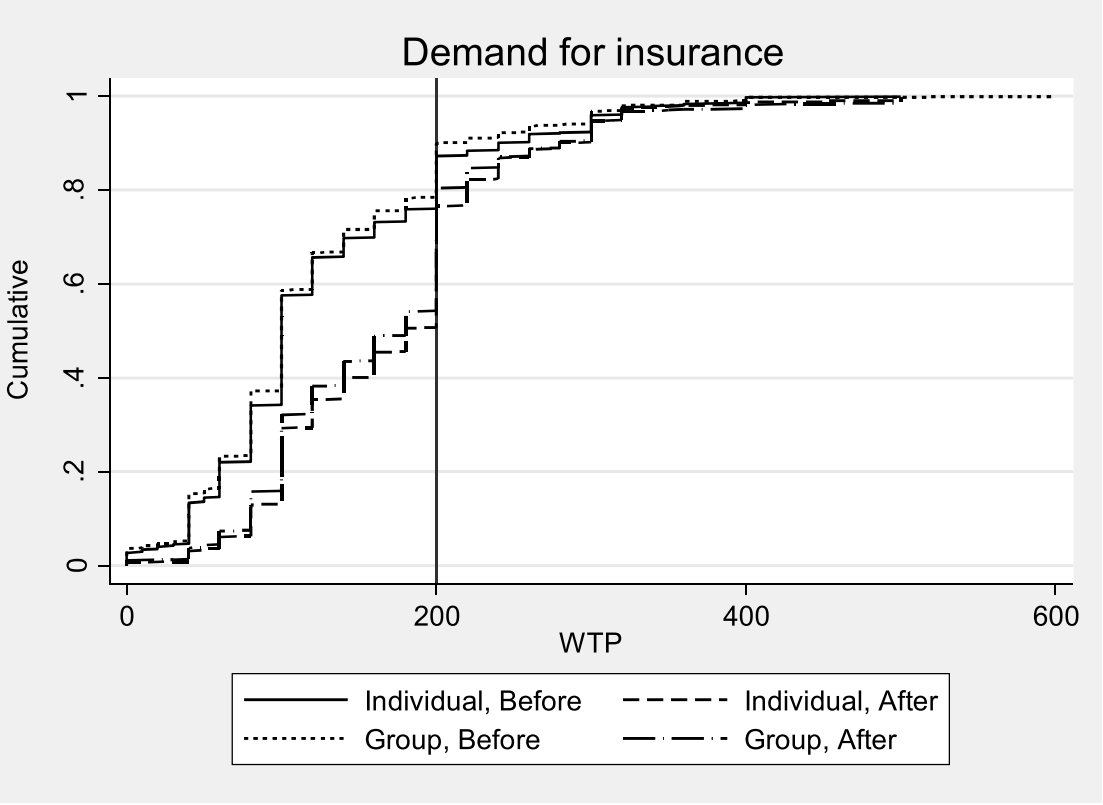
  - ✓ There is a "dislike" for group heterogeneity (≈ 20% WTP), and this regardless of whether people are among the riskiest or least risky members.

- Potential contractual issues
  - ✓ People seem to assume that sharing of payout will be minimal in groups, if it is not specified by the contract.
  - ✓ Ex-post reneging on sharing after shocks are revealed

WTP FOR A "REAL" INSURANCE PRODUCT (IN THE PARTICIPANT'S OWN CONTEXT)

Product:

- Insurance covers excess rainfall that happens once every seven years on average
- Next weather station located … kilometers away from cooperative center
- Payout equal to Q 1,400 (roughly fertilizer/pesticide costs)
- "Fair" price Q 200; loading of Q 70
- Either individual or group insurance



Appendix I: Individual Games Analysis

WTP increases with benefit of insurance, decreases with E(loss), and increases with background risk. Smaller but still significant effect if in uninsured states.

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Mean (SD)	Does Variance have Different Effect if within Payout States vs. if in Non-payout States?	
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Uninsurable Expected Loss in Game	106.06	-0.50***	-0.41***
	(33.63)	(0.08)	(0.02)
Background Risk Game	0.37	-8.69	
	(0.48)	(8.05)	
Uninsurable SD(Income) * Background Risk Game	85.25	-0.18***	-0.17***
	(111.65)	(0.01)	(0.01)
Uninsurable Expected Loss * Background Risk Game	50.16	0.43***	0.33***
	(67.30)	(0.10)	(0.02)
Observations	7067	7067	7067
R-squared		0.768	0.768
Number of Individuals		659	659
Games Used		3-9,10,11,13,14	

WTP ↗ with bckgr. risk

WTP ↘ with E(loss)

Smaller when due to uninsured states:
.25 - .18 = .077 (.030)
-.50 + .43 =-.068 (.015)

Risk aversion: The response of WTP to the benefit of insurance increases with risk aversion.

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Does Variance have Different Effect if within Payout States	Differential Effects by Risk Aversion	
	(2)	(4)	(5)
Improvement in SD from Purchasing Insurance	0.31**	0.20	0.31**
	(0.14)	(0.14)	(0.14)
Uninsurable Standard Deviation of Income	0.25***	0.25***	0.25***
	(0.03)	(0.03)	(0.03)
Uninsurable Expected Loss in Game	-0.50***	-0.50***	-0.50***
	(0.08)	(0.08)	(0.08)
Background Risk Game	-8.69	-8.81	-6.64
	(8.05)	(8.05)	(8.09)
Uninsurable SD(Income) * Background Risk Game	-0.18***	-0.18***	-0.18***
	(0.01)	(0.01)	(0.01)
Uninsurable Expected Loss * Background Risk Game	0.43***	0.43***	0.44***
	(0.10)	(0.10)	(0.10)
Improvement from Insurance * Risk Aversion		0.05***	
		(0.01)	
Background Risk Game * Risk Aversion			-1.04***
			(0.29)
Observations	7067	7067	7067
R-squared	0.768	0.77	0.771
Number of Individuals	659	659	659

Risk aversion	
1	46.15
2	14.79
3	18.05
≥ 4	21.01

Worst state of nature uninsured:
Reduces demand for insurance, but not differentially for more risk averse producers

Dependent Variable: Willingness to Pay, US$
Actuarially fair price: $31.73

	(1)	(2)
Worst State without Payout is Possible in Game	-3.05***	-3.50***
	(0.55)	(0.55)
Worst State Possible * Risk Aversion		0.05
		(0.13)
Background Risk Game * Risk Aversion		-0.90***
		(0.27)
Improvement in SD from Purchasing Insurance	0.34***	0.33***
Uninsurable Standard Deviation of Income	-0.52***	-0.52***
Uninsurable Expected Loss in Game	0.26***	0.26***
Background Risk Game	-10.58***	-8.53***
Uninsurable SD(Income) * Background Risk Game	0.45***	0.45***
Uninsurable Expected Loss * Background Risk Game	-0.17***	-0.17***

Using all individual games 3-15

Appendix II: Group Games Analysis

WTP increases with sharing within group, but WTP for individual insurance > WTP for group insurance with partial sharing

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Demand for Group Insurance		Trust in Group	
	(1)	(2)	(3)	(4)
Group with No Loss Adjustment	-5.24***	-5.50***	-5.52***	-5.52***
Pure preference for group	(0.52)	(0.47)	(0.47)	(0.47)
Group with Moderate Loss Adjustment	-2.31***	-2.23***	-2.25***	-2.25***
	(0.53)	(0.48)	(0.49)	(0.49)
Group with Maximal Loss Adjustment	0.77	-0.04	-0.05	-0.06
	(0.56)	(0.49)	(0.49)	(0.49)
Medium Risk Game		2.84***	2.81***	2.81***
		(0.17)	(0.16)	(0.16)
High Risk Game		5.90***	5.91***	5.91***
		(0.23)	(0.23)	(0.23)
Trust in Group * Group Game			0.93*	0.89*
			(0.51)	(0.54)
Trust in Group * Moderate Loss Adjustment	Trust increase the WTP for group insurance, but not differentially for higher loss adjustment			0.14
				(0.27)
Trust in Group * Maximal Loss Adjustment				-0.04
				(0.34)
Constant (WTP in individual game)	29.14***	29.38***	29.43***	29.43***
	(0.38)	(0.35)	(0.35)	(0.35)
Games used	Ind. + Group Low risk	Ind. + Group All risk	Ind. + Group All risk	Ind. + Group All risk

Expectation on sharing (if unspecified)

Prior to introduction of specified payout allocation rules, game without specified rule.

(all games with exactly the same risk scenario)

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Low Risk Games Only
	(1)
Group Game, Loss Adjustment not Stipulated	-3.60**
	(1.43)
Group with No Loss Adjustment	-5.23***
	(0.50)
Group with Moderate Loss Adjustment	-2.30***
	(0.51)
Group with Maximal Loss Adjustment	0.78
	(0.54)
Constant (WTP in individual game)	29.13***
	(0.45)
Observations	3284
R-squared	0.41
Number of Individuals	662
Games Used:	7,19,22-24

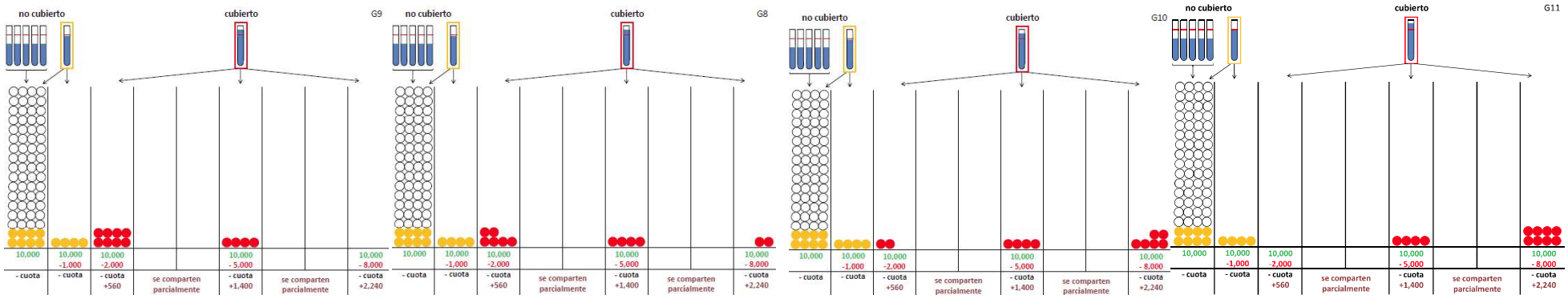
→ **Players expect the group to share between low and moderate loss adjustment levels**

Generalizing the result: All risks, not differential by trust level

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Low Risk Games Only	All Risk Games	Trust in Group
	(1)	(2)	(3)
Group Game, Loss Adjustment not Stipulated	-3.60**	-2.89*	-2.92*
	(1.43)	(1.54)	(1.55)
Group with No Loss Adjustment	-5.23***	-5.23***	-5.27***
	(0.50)	(0.46)	(0.46)
Group with Moderate Loss Adjustment	-2.30***	-2.21***	-2.24***
	(0.51)	(0.47)	(0.48)
Group with Maximal Loss Adjustment	0.78	-0.03	-0.04
	(0.54)	(0.48)	(0.48)
Medium Risk Game		3.10***	3.07***
		(0.16)	(0.16)
High Risk Game		6.38***	6.38***
		(0.25)	(0.25)
Trust in Group * Group Game			0.93*
			(0.50)
Trust in Group * Loss Adjustment not Stipulated			-0.72
			(1.16)
Constant	29.13***	29.13***	29.18***
	(0.45)	(0.51)	(0.52)
Observations	3284	8530	8413
R-squared	0.41	0.386	0.386
Number of Individuals	662	662	653
Games Used:	7,19,22-24	7-9,19-28	7-9,19-28

Tolerance for group heterogeneity

Scenarios in which members can have different risk levels



Least risky Less risky More risky Most risky

Partial sharing of payout implies that there are expected subsidies across members (less risky ones subsidize more risky ones).

Does heterogeneity undermine group demand?

Less WTP in heterogeneous group, but (surprisingly) not differentially by own risk exposure relative to group

Dependent Variable: Willingness to Pay, US$ Actuarially fair price: $31.73	Heterogeneous vs. Homogenous	Group	Expected Transfer Resulting from Outcome Heterogeneity	
	(1)	(2)	(3)	(4)
Group is Heterogeneous	-6.56***	-5.28***		-5.28***
	(0.66)	(0.33)		(0.33)
Expected Transfer to Others			-0.20***	-0.005
			(0.04)	(0.04)
Improvement in SD from Purchasing Insurance		0.17***	0.07***	0.17***
		(0.01)	(0.02)	(0.02)
Uninsurable Standard Deviation of Income		0.18***	0.13***	0.18***
		(0.01)	(0.01)	(0.01)
Uninsurable Expected Loss in Game		-0.33***	-0.20***	-0.33***
		(0.01)	(0.01)	(0.01)
Constant	33.02***	7.30***	13.50***	7.42***
	(0.31)	(0.65)	(1.40)	(1.41)
Observations	1,254	12,017	12,017	12,017
R-squared	0.789	0.619	0.591	0.619
Number of Individuals	661	662	662	662
Games Used:	27 &29	3–9 & 22–33	3–9 & 22–33	3–9 & 22–33

Deliberation, and potential of ex-post defection

- Presentation of pros (better risk protection) and cons (tensions within the group) of group sharing.
- Record individual preferences
- Deliberation and decision (recorded in details)
- Drawings of rain shock and individual outcome
- Restate their preference for sharing

⇒ Compare pre-deliberation and post shock individual preference, in relation to rainfall drawing – 11% of individual change opinions

Dependent Variable: Desire for Sharing of Risk via Loss Adjustment (1=none, 2=moderate, 3=maximum possible)	Sharing Change after Shock (Coop FE)
	(3)
Loss Shock Drawn after Deliberation ('000 US dollars)	0.0657**
	(0.03)
Constant	-0.0535**
	(0.02)
Observations	626

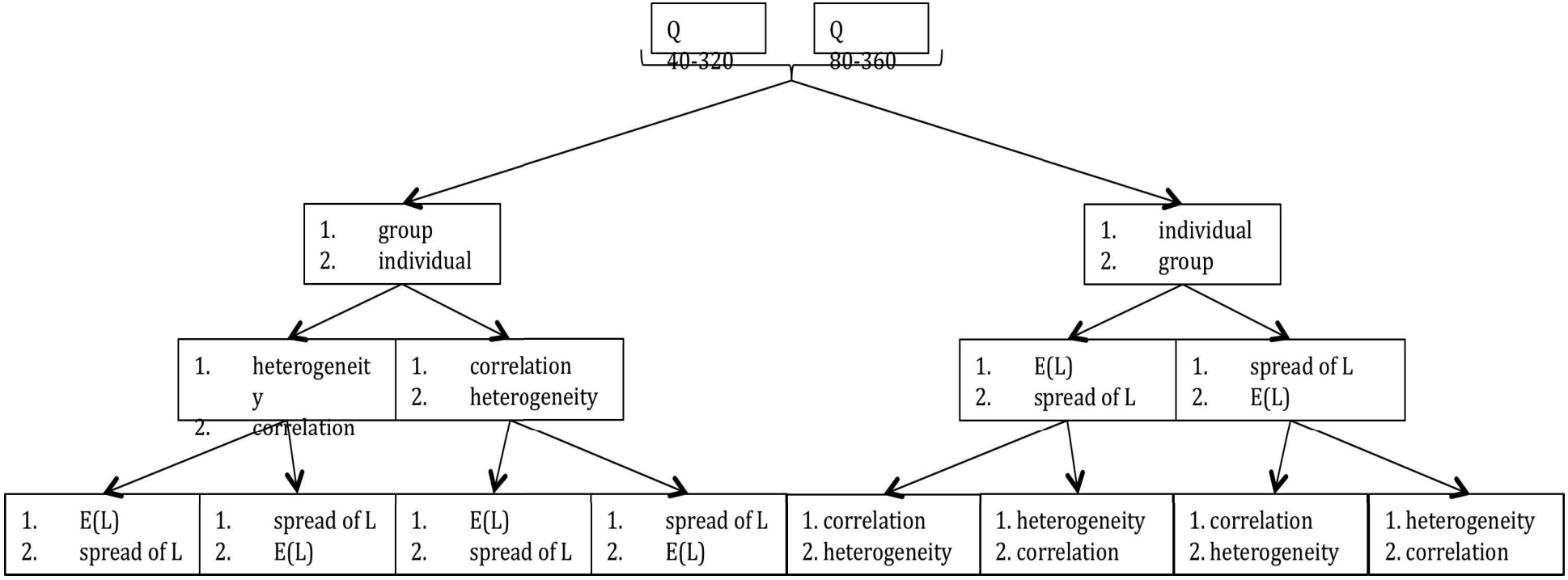
APPENDIX: DETAILS ON THE GAMES PROTOCOL

Field exercise – structure:

1. Intake survey: six pages including information related to weather index based insurance; risk aversion, ambiguity aversion, time preference, trust in outsiders, etc.
2. Marketing exercise: explanation of product; first elicitation of WTP for "real" individual and group insurance
3. Training: framing; interactive rainfall simulations and related insurance payouts
4. Financial literacy test
5. Explanation of game incentive scheme
6. Games
7. Second elicitation of WTP for "real" individual and group insurance
8. Payment for participation

Randomization:

- 16 cells
- 4 to 5 coops per cell
- seating order of participants randomized and recorded



Experiments – Group insurance I:

- Correlation game without distribution rule

  always before distribution rule is framed

  3 scenarios with increasing spread of loss

- Correlation game with distribution rule

  3 scenarios with increasing spread of loss

Experiments – Group insurance II:

- Heterogeneity game

  4 scenarios with increasing heterogeneity within group (twice participant tends to be less affected, twice more affected by excess rainfall)

- Deliberation game

  stated preferences regarding distribution within group

  group discussion regarding distribution within group

Experiments – individual insurance I:

- Change in expected loss game

  3 scenarios with increasing expected loss

- Change in spread of loss game

  4 scenarios with increasing spread of loss

Experiments – individual insurance II:

- Drought game

  3 scenarios with increasing loss due to uninsured drought (low frequency)

  3 scenarios with increasing loss due to uninsured drought (high frequency)

Bryan, G. (2010), Ambiguity and Insurance; Yale University, Department of Economics.

Clarke, D. (2011), Insurance Design for Developing Countries; Balliol College, University of Oxford.

Cole, S., X. Giné, J. Tobacman, P. Topalova, R. Townsend and J. Vickery (2009), Barriers to Household Risk Management: Evidence from India; Harvard Business School.

de Janvry, A., E. Sadoulet and V. Dequiedt (2011), Group insurance against common shocks; University of California, Berkeley, and CERDI, France.

Dercon, S., J. Gunning and A. Zeitlin (2011), The demand for insurance under limited credibility: Evidence from Kenya; University of Oxford und VU University Amsterdam.

Dercon, S., J. De Weerdt, T. Bold and A. Pankhurst (2006), Group-based funeral insurance in Ethiopia and Tanzania; World Development, 34(4).

Gine, X., R. Townsend und J. Vickery (2008), Patterns of rainfall insurance participation in rural India; The World Bank Economic Review, 22(3).

Gollier, C., und J. Pratt (1996), Risk vulnerability and the tempering effect of background risk; Econometrica, 64

Ligon, Ethan (2009), "Risk Management in the Cooperative Contract", Amer. J. Agr. Econ. 91 (Number 5, 2009): 1211–1217

FORMALIZATION

Simplify the rainfall scenarios to a three-state environment: one with no loss, and two insured states with low and high losses.

Expected utility under no insurance and insurance, respectively.
q are probability of states, *Y* income, *L* losses, *p* premium, *C* compensation (1400) if insured:

$$EU^N = q_0 u(Y) + q_l u(Y - L_l) + q_h u(Y - L_h)$$
$$EU^I = q_0 u(Y - p) + q_l u(Y - L_l - p + C) + q_h u(Y - L_h - p + C)$$

To formalize the uninsured states:

$$EU^N = q_n u(Y) + q_d u(Y - L_d) + q_r u(Y - L_r)$$
$$EU^I = q_n u(Y - p) + q_d u(Y - L_d - p) + q_r u(Y - L_r - p + C)$$

WTP is the premium that solves for: $EU^i = EU^n$.