Compound risk and index insurance: a WTP experiment in Mali

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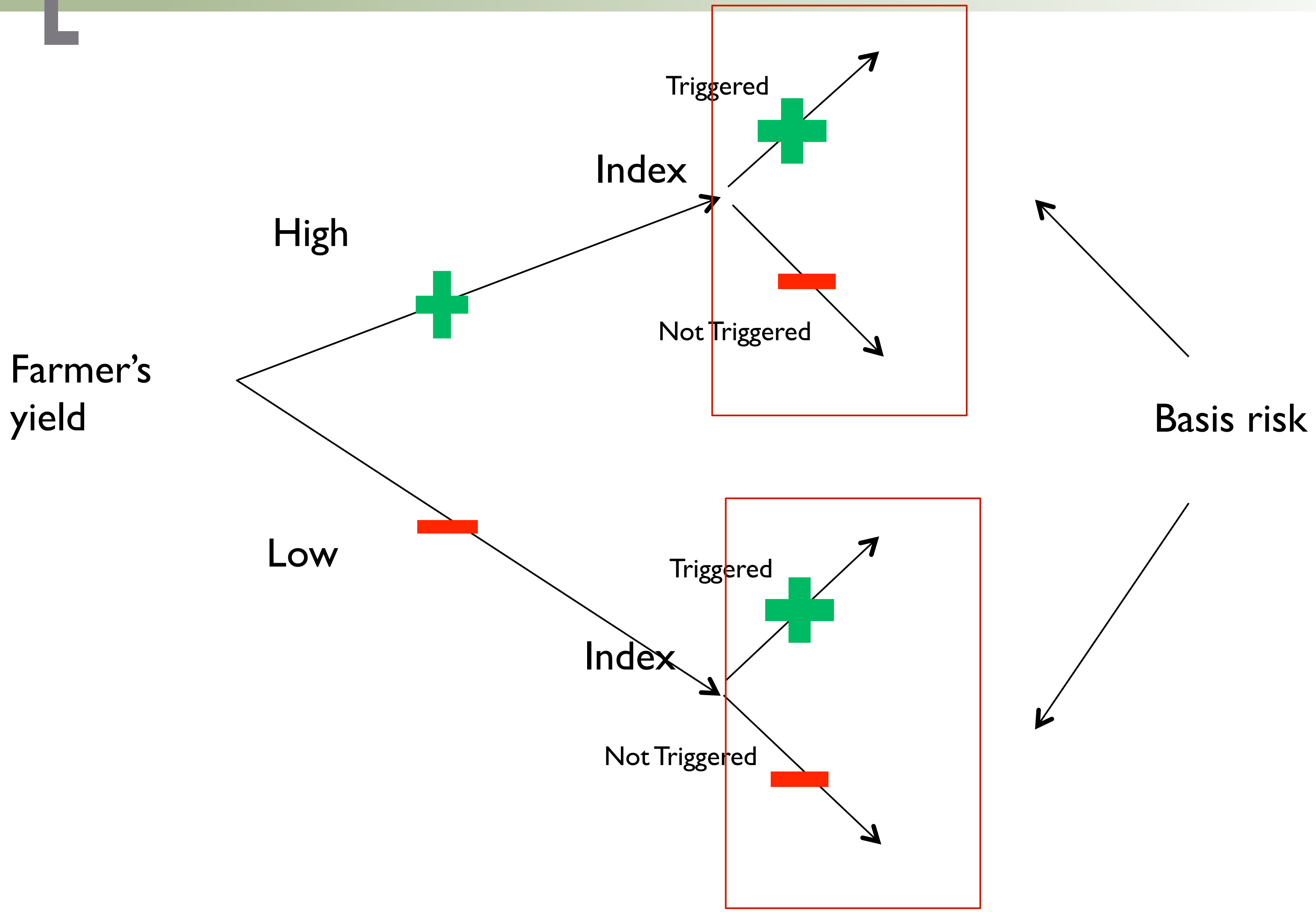
Introduction

- Index insurance is promising in theory (transaction costs, moral hazard, ..)
- In practice, low uptake despite efforts
  - Lack of trust
  - Lack of understanding
  - Design of the index itself
- Basis risk and how it is perceived by farmers

Index insurance from the farmer's point of view : a compound lottery:



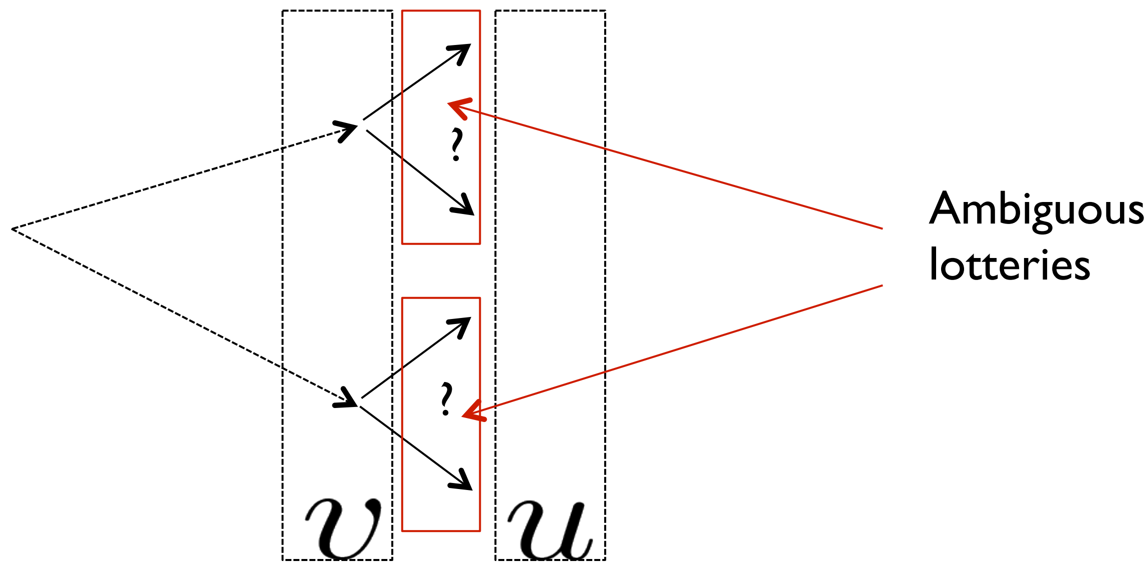
Background: People dislike probabilistic insurance

- Empirical evidence: Whakker et al.(1997): They demand more than 20% reduction in the premium to compensate for 1% default risk
- One explanation: the weighting function of prospect theory
- Our explanation: violation of reduction of compound lottery axiom (ROCL)

Compound lotteries and ambiguity aversion

- The compound lottery structure is a potential source of ambiguity
- Segal (1987), Haveley (2007), Abdellaoui et al (2011): attitudes towards compound risk and towards ambiguity are tightly associated

Ambiguity as aversion to compound lotteries : Smooth model of ambiguity aversion

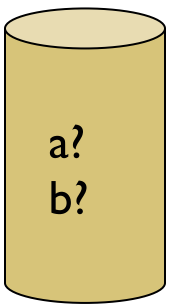


$E_{f_y}[v(E_{f_{X/y}}u(X))]$ Objective function

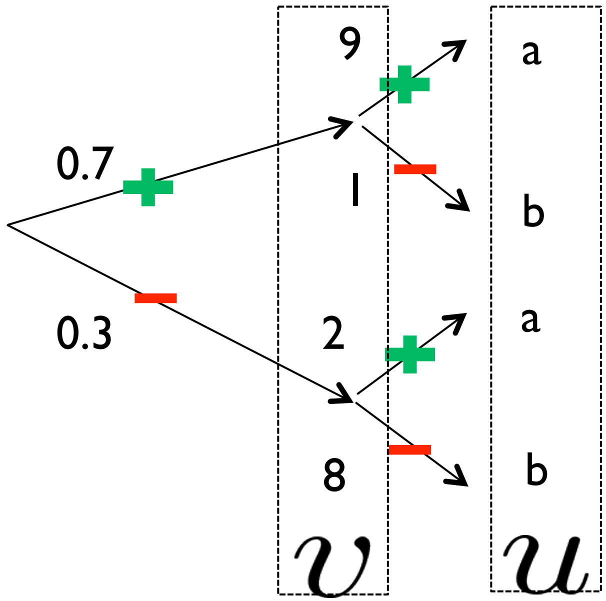
v External function: attitude towards "ambiguity" $v' > 0 \quad v" \leq 0$

u Internal function: attitude towards "simple" risk

Modeling aversion to compound risk: a numerical example

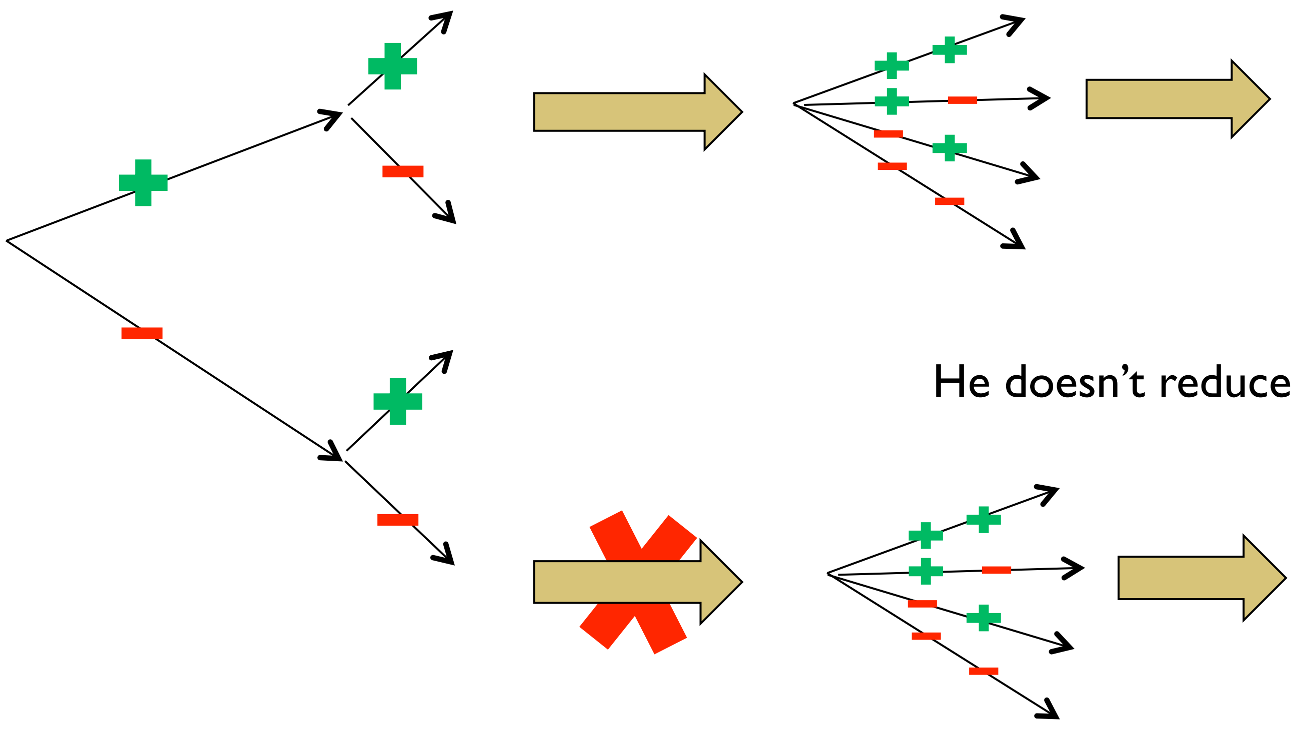


a+b=10



$$E_{f_y}[v(E_{f_{X/y}}u(IX))] = 0.7 * v[0.9u(a) + 0.1u(b)] + 0.3 * v[0.2u(a) + 0.8u(b)]$$

Framework: How does a farmer think about Index insurance?



He reduces compound lottery

WTP = basis risk premium

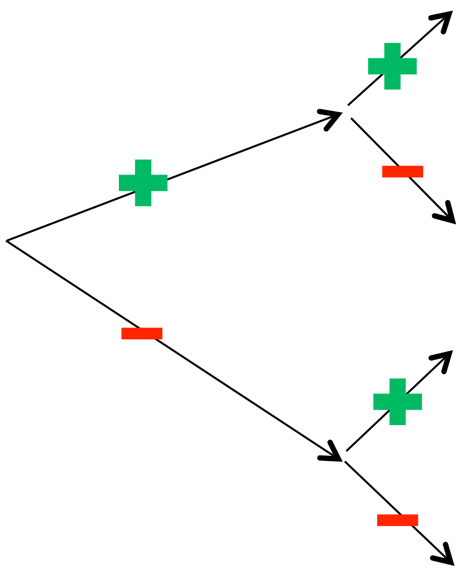
He doesn't reduce compound lottery

WTP = function of basis risk premium

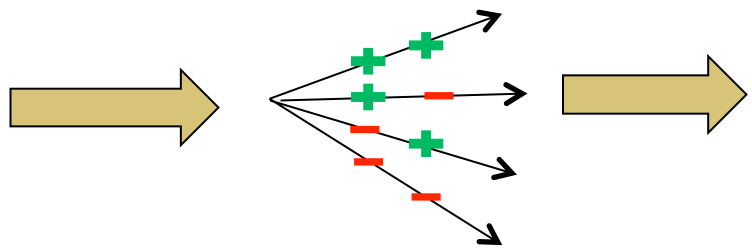
and

<u>compound risk premium</u>

Framework: How does a farmer think about Index insurance?

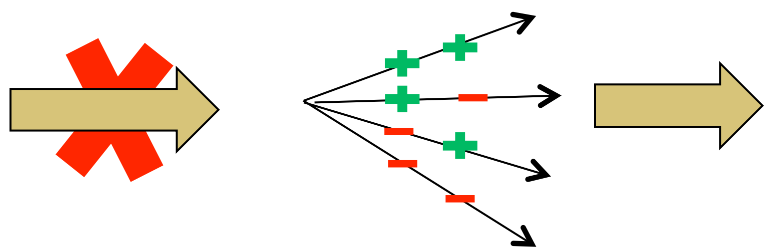


He reduces compound lottery



WTP = basis risk premium

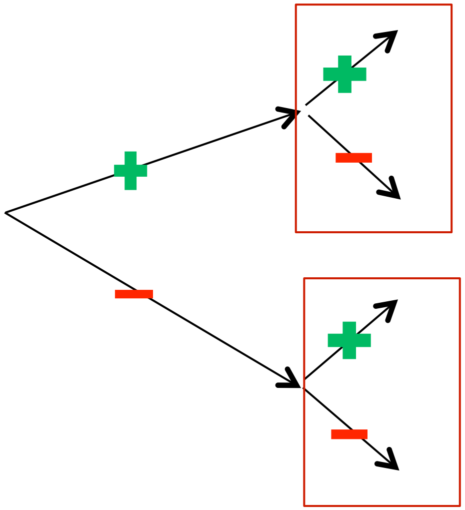
He doesn't reduce compound lottery



WTP = function of basis risk premium
and
<u>compound risk premium</u>

Notations

Index Insurance contract

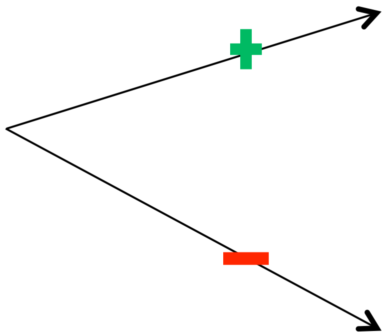


y_{IX} Farmer's revenue

f_y pdf of the yield

f_X pdf of the index

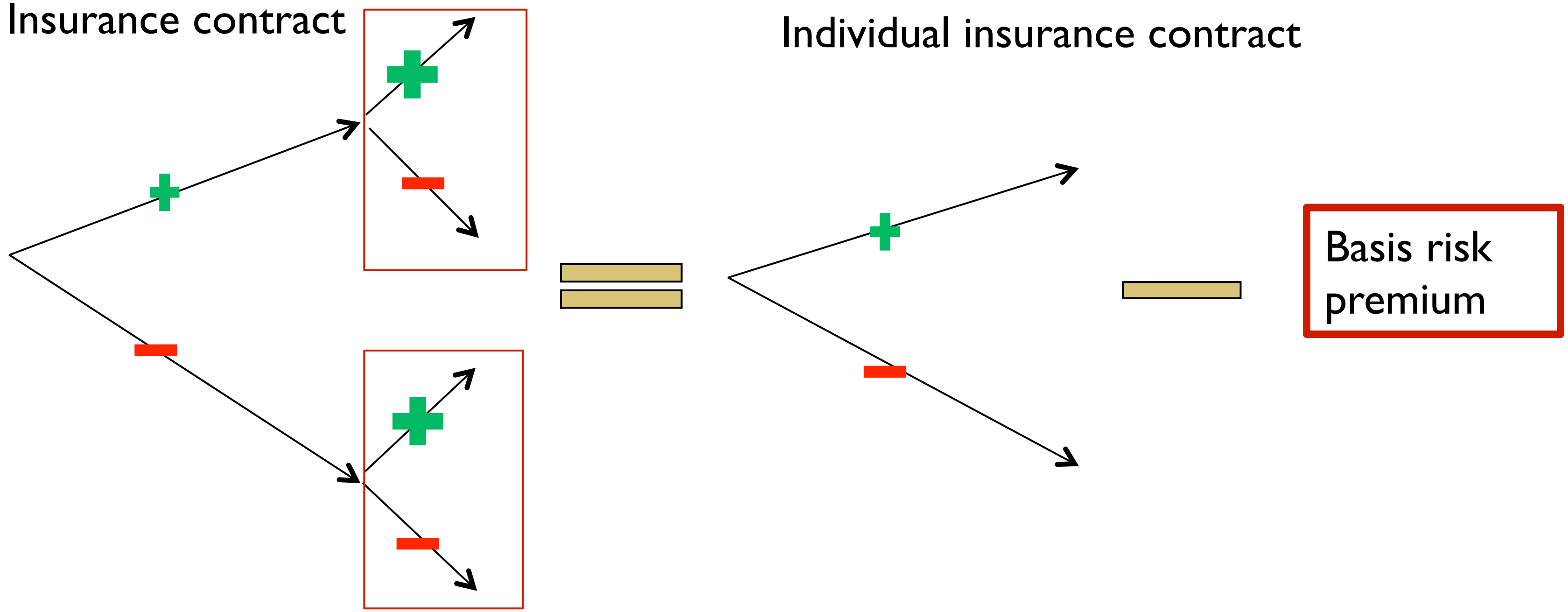
Individual insurance contract



y_I Farmer's revenue

f_y pdf of the yield

EUT: WTP = Basis risk premium

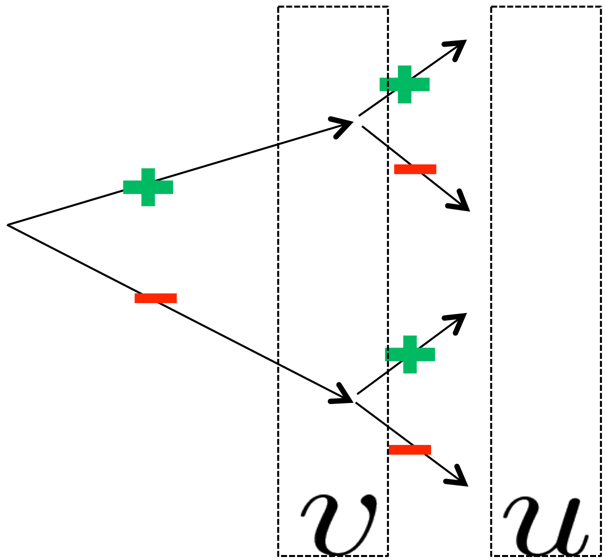


objective function $E_{f_{yx}} u(y_{IX})$ $E_{f_y} u(y_I)$

Basis risk premium, ρ, is solution to :

$$E_{f_{yx}} u(y_{IX}) = E_{f_y} u(y_I - \rho)$$

Modeling aversion to compound risk

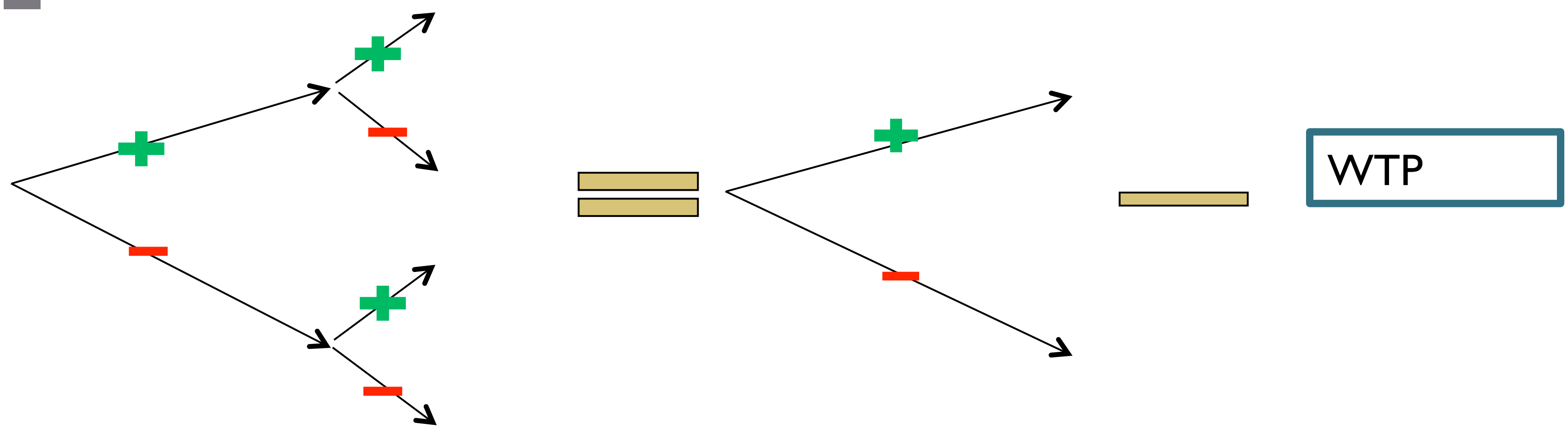


$E_{f_y}[v(E_{f_{X/y}}u(IX))]$ Objective function

v External function: attitude towards "compound" risk $\quad v' > 0 \quad v" \leq 0$

u Internal function: attitude towards "simple" risk

WTP to avoid Index Insurance



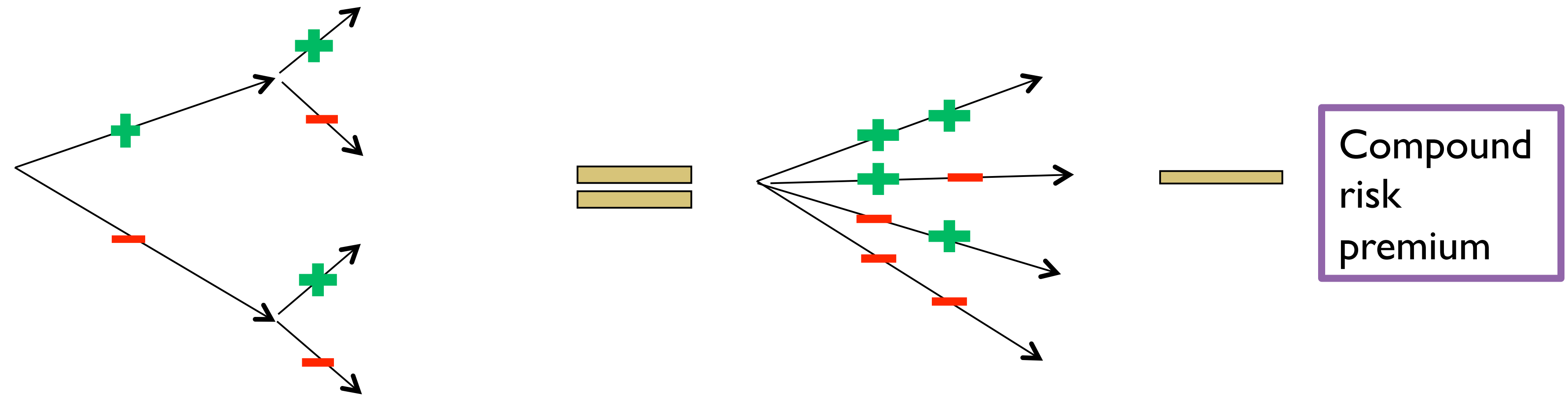
$E_{f_y}[v(E_{f_{X/y}}u(IX))]$

$E_{f_y}u(y_I)$

The WTP to avoid index insurance:

$$E_{f_y}[v(E_{f_{X/y}}u(IX))] = E_{f_y}u(y_I - \rho^t)$$

Compound risk premium

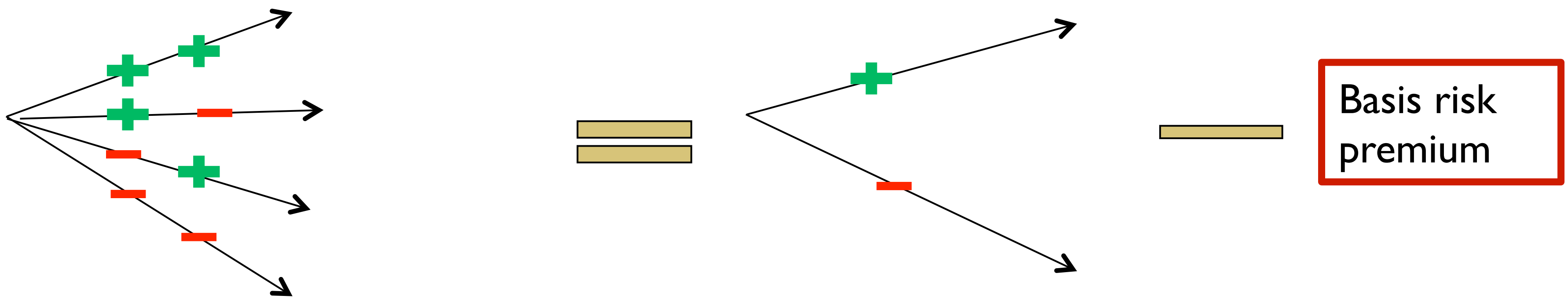


$E_{f_y}[v(E_{f_{x/y}}u(y_{IX}))]$ $E_{f_{yx}}u(y_{IX})$ Objective function

Compound risk premium, ρ^c, as a solution to :

$$E_{f_y}[v(E_{f_{X/y}}u(y_{IX}))] = E_{f_y}u(y_{IX} - \rho^c)$$

Basis risk premium



$E_{f_{yx}} u(y_{IX})$ $\quad$ $E_{f_y} u(y_I)$ $\quad$ Objective function

Basis risk premium, ρ , as a solution to :

$$E_{f_{yx}} u(y_{IX}) = E_{f_y} u(y_I - \rho)$$

Testable hypothesis

- If u is CRRA, then the 2nd order Taylor approximation of total WTP is:

$$\left(\frac{\bar{y_I}}{r} + \rho^t\right)^2 \simeq \left(\frac{\bar{y_I}}{r} + \rho\right)^2 + \left(\frac{y_{\bar{I}X}}{r} + \rho^c\right)^2 - \left(\frac{y_{\bar{I}X}}{r}\right)^2$$

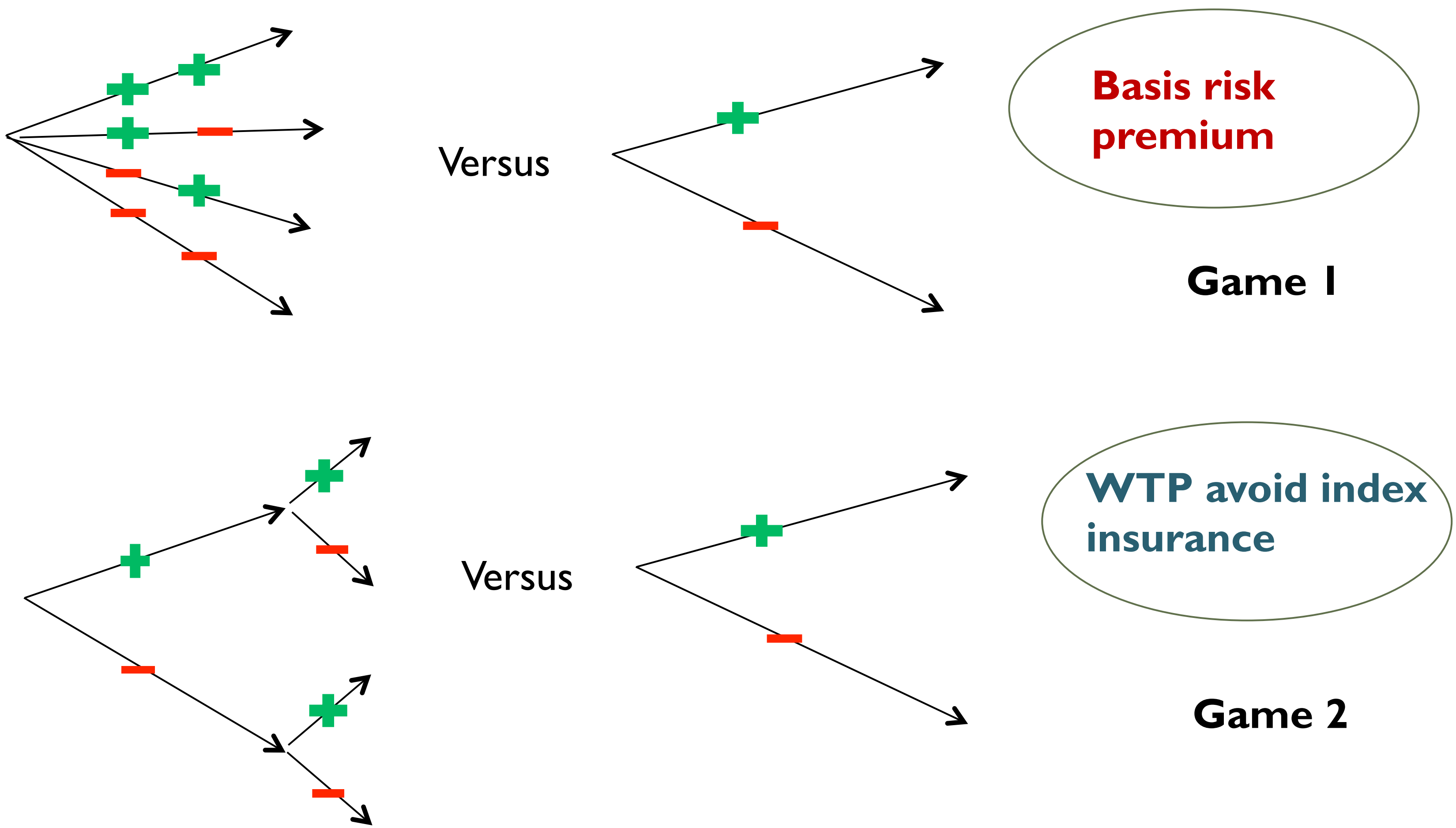
WTP **Basis risk premium** **Compound risk premium:**

- If averse to compound risk, then

WTP is larger than basis risk premium

- If neutral to compound risk, then WTP is the same as the basis risk premium

The experiments

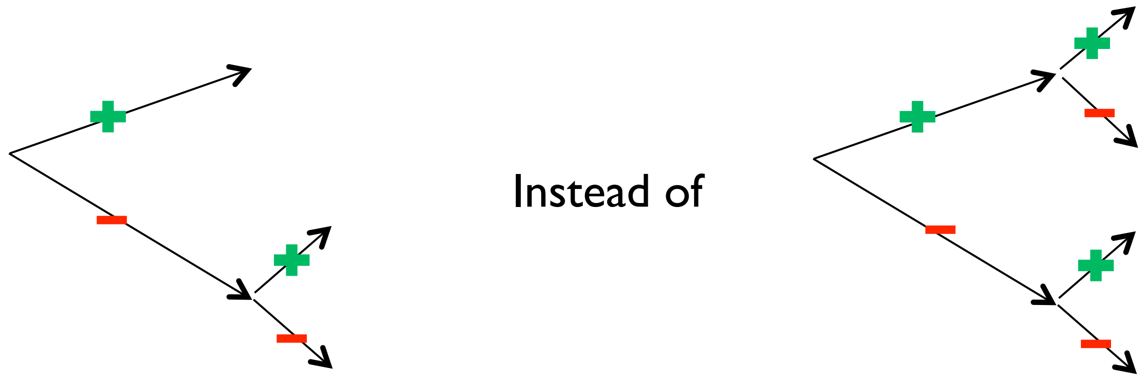


Game 1

- Farmers decide whether they want an individual insurance contract, if so they choose among 6 coverage levels
- Assuming CRRA and EUT, we can derive the WTP to avoid index insurance, which is also the basis risk premium

Game 2

- Presenting the index insurance contract:



  - Keep the price of the index insurance contract constant, vary the price of the individual insurance contract
  - Elicit he price at which he will switch from the individual insurance contract to the index insurance contract

Preliminary results

- 60% of the farmers are averse to compound risk
- They are willing to pay up to 27% extra-premium for an individual insurance contract to compensate for 20% probability of absence of payment.

Policy implications

- cost effectiveness of index insurance
- Implications for impact evaluation of index insurance :
  - heterogeneity of farmers implies heterogeneous impacts
  - Offer alternative contracts for compound risk averse farmers?

Next step:

- More empirical work
- Predict the uptake of index insurance using the findings of the experiments

Thank you!

APPENDIX

The Basis risk premium

$$E_{f_{yx}} u(y_{IX}) = E_{f_y} u(y_I - \rho)$$

2nd order Taylor approximation:

$$Eu(y_{IX}) \approx u(\bar{y}_{IX}) + \frac{1}{2}\sigma^2_{y_{Ix}} u"(\bar{y}_{IX})$$

$$Eu(y_I - \rho) \approx u(\bar{y}_I) - \rho * u'(\bar{y}_I) + \frac{1}{2}(\rho^2 + \sigma^2_{\bar{y}_I})u"(\bar{y}_I)$$

Solving for basis risk premium:

$$\rho \approx \frac{u'(\bar{y}_I) - \sqrt{\Delta}}{u"(\bar{y}_I)}$$

$$\Delta = (u'(\bar{y}_I))^2 - 2 * u"(\bar{y}_I)[u(\bar{y}_I) - u(\bar{y}_{IX}) + \frac{1}{2}\sigma^2_{y_I} u"(\bar{y}_I) - \frac{1}{2}\sigma^2_{y_{IX}} u"(\bar{y}_{IX})]$$

The Compound risk premium

$$E_{f_y}[v(E_{f_{X/y}}u(y_{IX}))] = E_{f_y}u(y_{IX} - \rho^c)$$

2nd order Taylor approximation:

$$E_{f_y}[v(E_{f_{X/y}}u(y_{IX}))] \approx v(u(\bar{y_{I}X}) + \frac{1}{2}\sigma^2_{\bar{y_{I}X}} v''(u(\bar{y_{I}X})(u'(\bar{y_{I}X}))^2 + \frac{1}{2}\sigma^2_{y_{IX}} v'(u(\bar{y_{I}X}))u''(\bar{y}_{IX})$$

$$Eu(y_{IX} - \rho^c) \approx u(\bar{y}_{IX}) - \rho^c * u'(\bar{y_{I}X}) + \frac{1}{2}(\rho^{c2} + \sigma^2_{\bar{y}_{IX}})u''(\bar{y_{I}X})$$

Solving for compound risk premium:

$$\rho^c \approx \frac{u'(\bar{y_{I}X}) - \sqrt{\Delta^c}}{u''(\bar{y_{I}X})}$$

$$\Delta^c = (u'(y_{Ix}))^2 - 2 * u''(\bar{y_{I}x})[u(\bar{y_{I}x}) - v(u(\bar{y}_{IX})) + \frac{1}{2}\sigma^2_{y_{Ix}} u''(\bar{y_{I}x}) - \frac{1}{2}\sigma^2_{\bar{y_{I}X}} v''(u(\bar{y_{I}x})(u'(\bar{y_{I}X}))^2 - \frac{1}{2}\sigma^2_{y_{IX}} v'(u(\bar{y_{I}X}))u''(\bar{y}_{Ix})]$$

WTP

$$E_{f_y}[v(E_{f_{X/y}}u(IX))] = E_{f_y}u(y_I - \rho^t)$$

2nd order Taylor approximations:

$$E_{f_y}[v(E_{f_{X/y}}u(IX))] \approx v(u(y_{\bar{I}X}) + \frac{1}{2}\sigma^2_{y_{\bar{I}X}} v^{''}(u(y_{\bar{I}X})(u^{'}(y_{\bar{I}X}))^2 + \frac{1}{2}\sigma^2_{y_{IX}} v^{'}(u(y_{\bar{I}X}))u^{''}(\bar{y}_{IX})$$

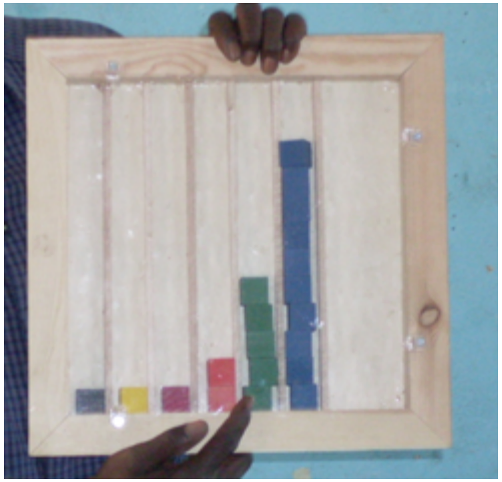
$$Eu(y_I - \rho^t) \approx u(\bar{y}_I) - \rho^t * u'(\bar{y}_I) + \frac{1}{2}(\rho^{t2} + \sigma^2_{\bar{y}_I})u''(\bar{y}_I)$$

Solving for WTP:

$$\rho^t \approx \frac{u'(\bar{y}_I) - \sqrt{\Delta^t}}{u''(\bar{y}_I)}$$

$$\Delta^t = (u'(y_I))^2 - 2*u''(\bar{y}_I)[u(\bar{y}_I) - v(u(\bar{y}_{IX})) + \frac{1}{2}\sigma^2_{y_I} u''(\bar{y}_I) - \frac{1}{2}\sigma^2_{y_{\bar{I}X}} v^{''}(u(y_{\bar{I}x})(u^{'}(y_{\bar{I}x}))^2 - \frac{1}{2}\sigma^2_{y_{IX}} v^{'}(u(y_{\bar{I}X}))u^{''}(\bar{y}_{Ix})]$$

The yield distribution



Game I

Rendement	250	450	645	740	880	1530
Sans assurance	d2400	d10400	d18200	d22000	d27600	d53600
Contrat à 1 cube (d120)	d4280	d10280	d18080	d21880	d27480	d53480
Contrat à 2 cubes (d1200)	d15200	d15200	d17000	d20800	d26400	d52400
Contrat à 3 cube (d1740)	d18260	d18260	d18260	d20260	d25860	d51860
Contrat à 4 cubes (d2700)	d21300	d21300	d21300	d21300	d24900	d50900
Contrat à 5 cubes (d6180)	d25420	d25420	d25420	d25420	d25420	d47420

Game II: Eliciting the WTP

d1740	d18260	d18260	d18260	d20260	d25860	d51860
d1940	d18060	d18060	d18060	d20060	d25660	d51660
d2140	d17860	d17860	d17860	d19860	d25460	d51460
d2340	d17660	d17660	d17660	d19660	d25260	d51260
d2540	d17460	d17460	d17460	d19460	d25060	d51060
d2740	d17260	d17260	d17260	d19260	d24860	d50860
d2940	d17060	d17060	d17060	d19060	d24660	d50660
d3140	d16860	d16860	d16860	d18860	d24460	d50460
d3340	d16660	d16660	d16660	d18660	d24260	d50260
d3540	d16460	d16460	d16460	d18460	d24060	d50060

The index insurance contract

Rendement	250	450	645	740	880	1530

Sans assurance	d2400	d10400	d18200	d22000	d27600	d53600

Contrat à trois cube (d1740)	d18260	d18260	d18260	d20260	d25860	d51860

Contrat à deux sacs (d1400)	d18600	d18600	d18600	d20600	d26200	d52200
	d1000	d9000	d16800	d20600	d26200	d52200

Preliminary results