



## Commons as a risk-management tool: theoretical predictions and an experimental test

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# Commons as insurance: theoretical predictions and an experimental test

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## Context

*“Common-pool resources (CPR) are systems that generate finite quantities of resource units so that one person’s subtracts from the quantity of resource units available to others” (Ostrom 1992)*

→ CPR are irrigation systems, fisheries, reefs, waterways, pastures, agricultural lands, mineral resources, forests...

In developing countries :

- CPR are largely used by individuals to generate additional revenue
- credit and insurance markets are incomplete : households use CPR as risk-management tool
- agricultural crops face many risks : households used Non-Timber Forest Product (NTFP) to cope with such risks (Byron and Arnold 1997)
  - ↪ NTFP can be used directly in consumption or be sold in the market

# Literature

- NTFP extraction is a risk-management tool used by households in complement of agricultural activity :
  - Baland and François (2005) : land privatization has a negative impact on the social welfare of a community
  - Pattanayak and Sills (2001) : NTFP collection is positively correlated with agricultural shortfall and expected agricultural risk
  - Angelsen and Wunder (2002) : two risk management strategies exist, risk diversification / risk coping
- Only few papers deal with the impact of safety-net use of CPR on the individual investment into the commons and extraction from the commons :
  - Delacote (2007, 2008, 2010) : smaller agricultural risk may decrease investment in CPR and extraction from CPR
- Recent empirical tests through case studies (Takasaki et al. 2010 ; Yoshito and Takasaki 2011 ; Andersson et al. 2011)  
↪ these papers do not distinguish between investment and extraction

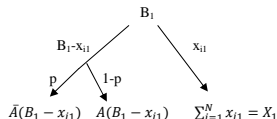
# Objective

We investigate further these impacts of risk on agriculture and NTFP extraction (more generally on private project and CPR use), both theoretically and empirically.

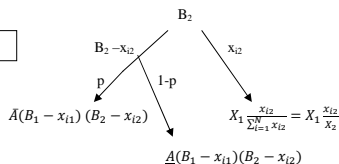
- Theoretical model :
  - Two steps : investment step and extraction step
  - Two types of risk-management tools : diversification / risk-coping
  - Two types of risk : on the private project and/or on the size of the CPR (CPR investment by all the community members)
- Empirical test :
  - Experimental economics
  - Combination of two existing games : Investment game of Ostrom et al. (1994) and Request game of Budescu et al. (1992).
  - “Two-steps CPR game” with the first step as an investment period and the second one as an extraction period

# A two-steps model of CPR extraction

Step 1



Step 2



- Community on  $N$  agents, utility maximizer  $U(I)$
- Allocation of assets between private project (A) which has uncertain return and commons (C) characterized by a tragedy of the commons

## Step 1 : Investment step

- agent  $i$  allocates budget  $B_1$  between CPR constitution ( $x_{i1}$ ) and its private project ( $B_1 - x_{i1}$ )
- productivity of A project is uncertain :  $E(A)(B_1 - x_{i1})$   
 $\rightarrow$  2 states of the world :  $E(A) = p\bar{A} + (1-p)\underline{A}$
- productivity of CPR is not risky :  $CX_1$

with  $X_1 = \sum_{i=1}^N x_{i1}$  the size of the CPR

## Step 2 : Extraction step

- agent  $i$  allocates budget  $B_2$  between CPR constitution ( $x_{i2}$ ) and its private project ( $B_2 - x_{i2}$ )
- income from the private project :  $I_A = A(B_1 - x_{i1})(B_2 - x_{i2})$
- income from CPR extraction :  $I_C = CX_1 \frac{x_{i2}}{X_2}$

with  $X_2 = \sum_{i=1}^N x_{i2}$  the size of the CPR

## Step 2 : Extraction

Agent  $i$  makes her extraction decision to maximize expected utility, taking the first-period investment  $\overline{x}_{i1}$  as given :

$$\max_{x_{i2}} U_i(\overline{x}_{i1}, x_{i2}) = U(I_A(\overline{x}_{i1}, x_{i2}) + I_C(\overline{x}_{i1}, x_{i2}))$$

⇒ Several modalities function of information revelation (yield of the private project and/or CPR size) between first and second step

**Risk coping** → agents are informed at the end of the first step of the yield of the private project and of the CPR size

- Agents make their decision upon :  $I_A(\overline{x}_{i1}, x_{i2}) = A(B_1 - \overline{x}_{i1})(B_2 - x_{i2})$  and  $I_C(\overline{x}_{i1}, x_{i2}) = CX_1 \frac{x_{i2}}{X_2}$ .
- FOC defines the extraction decision  $x_{i2}^* \rightarrow$  decreasing with the private project return, increasing with the size of the CPR and the return from the CPR and decreasing with the extraction decisions of the other agents

## Step 2 : Extraction

**Risk diversification** → agents are informed at the end of the first step of the CPR size but not of the yield of the private project

- Agents make their decision upon :  $I_A(\overline{x}_{i1}, x_{i2}) = E(A)(B_1 - \overline{x}_{i1})(B_2 - x_{i2})$  and  $I_C(\overline{x}_{i1}, x_{i2}) = CX_1 \frac{x_{i2}}{X_2}$ .
- FOC defines the extraction decision  $x_{i2}^* \rightarrow$  decreasing with the probability to be in the best state of the world

Comparison of FOC in risk coping case and in risk diversification case leads to :

**Proposition 1** : *When CPR extraction is certain while the private project provides uncertain returns, extraction decisions from the CPR are less (more) intensive in the risk-coping case than in the risk-diversification case when the private yield is high (low)*

⇒ extraction with R-C when  $(1 - p) >$  extraction with R-D  $>$  extraction with R-C when  $p$

**Uncertainty about the size of the CPR** → agents are informed at the end of the first step of the yield of the private project but not on the CPR size

- Agents make their decision upon :  $I_A(\overline{x}_{i1}, x_{i2}) = A(B_1 - \overline{x}_{i1})(B_2 - x_{i2})$  and  $I_C(\overline{x}_{i1}, x_{i2}) = CE(X_1) \frac{x_{i2}}{X_2}$ .

**Proposition 2** : *When the size of the CPR is not revealed, CPR extraction is less intensive when expectations about CPR investment are low. Hence, if agents are pessimistic (optimistic) about the other agent's investment, their extraction decision will be smaller (larger) when the size of the CPR is not revealed*



## Step 1 : Investment

Agent  $i$  makes her investment decision given that both the return of the private project and the CPR size are uncertain :

$$\max_{x_{i1}} U_i(x_{i1}, x_{i2}) = U(I_A(x_{i1}, x_{i2}) + I_C(x_{i1}, x_{i2}))$$

with  $I_A(x_{i1}, x_{i2}) = E(A)(B_1 - x_{i1})(B_2 - x_{i2})$  and  $I_C(x_{i1}, x_{i2}) = CE(X_1) \frac{x_{i2}}{X_2}$ .

$\Rightarrow$  investment in the CPR decreases with expected return on the private project and increases with the expectations about the other agent's CPR investment.

## Existing CPR games

### Investment game (Ostrom et al. 1994)      Request game (Budescu et al. 1992)

- how much to invest in a certain private activity and in a risky activity (CPR) ?
  - yield of the risky activity depends on the investment realized by all the group members
  - for small levels of group investment, the return of the risky activity is  $>$  to the individual private return and inversely.
- how many token to request from a 'pot' with a value uniformly distributed between  $a$  and  $b$  ? subjects know the distribution but not the value of the size of the 'pot'
  - if the sum of the requests is  $\leq$  to the realized value then all will receive their request
  - if the aggregate request is  $>$  to the realized value of the 'pot' then everyone receive zero token  
 $\Rightarrow$  tragedy of the commons

**Problem** : each game is interested in either investment or extraction while our problematic deals with both investment in the resource and extraction

$\Rightarrow$  We propose a new game which is a partial combination of the two existing games

## The two-steps CPR game

- Step 1 : how much of their endowment they want to invest in private activity and in commons  
→ both the yield of the private project and the yield of the CPR are risky  $\neq$  Investment game where the yield of the private project is certain
- Step 2 : how much they want to extract from their private activity and commons  
→ subjects do not really decide to extract but to invest an another initial endowment in private activity and commons  $\neq$  Request game where the decision bears on extraction  
→ in the Request game, the size of the 'pot' is a constraint  $\neq$  in our game, the higher the requirements, the lower the yield, indicating a non-efficiency of CPR extraction (compare to private activity) rather than a disappearance of the resource

## Experiment design

Uncertainty either on the yield of the private project or on the size of the CPR → to compare these situations, we have the following three treatments :

TABLE: Description of the treatments

Treatment	Step 1 : Investment	Step 2 : Extraction
T1. Risk coping	Yield of the private project is uncertain and size of the CPR is uncertain	No uncertainty : yield of the private project and size of the CPR are revealed (benchmark)
T2. Risk diversification		Uncertainty on the yield of the private project but not on the CPR size
T3. Uncertainty on the CPR size		Uncertainty on the CPR size but not on the yield of the private project

Treatment :

- is a between-subject variable,
- gathers 6 groups of 8 subjects (identical during all the experience, no communication)
- is played for 20 periods (of 2 steps), 10 with a probability  $p = 0.6$  to be in the best state in terms of the yield of the private project and 10 with  $p = 0.8$

# Decision tasks

## Investment decision

- endowment of 10 ecus to allocate between private project and commons
- yield of the private project depends on her own decision only and on the state of the nature which randomly occurs ( $p$  or  $(1 - p)$ )
- yield of the CPR depends on the individual decision and on the other group members choices  
⇒ at the end of the step 1, yield of the private project and CPR size are known but not necessarily revealed

## Risk aversion

- procedure of Eckel and Grossman (2008) revisited by Couture and Reynaud (2011)
- subjects face a table with nine lotteries and among them, they have to choose the game they accept to play for
- each game is associated to an interval for relative risk aversion coefficient

## Extraction decision

- endowment of 10 ecus to allocate between private project and commons
- either knowing the yield of the private project and the CPR size (T1), or just the size of the CPR (T2) or just the yield of the private project (T3)  
⇒ at the end of the step 2, individual incomes are obtained

## Social trust

- “Faith in people scale” of Rosenberg (1956)
- such a scale is designed to assess one’s degree of confidence in the trustworthiness, honesty, goodness, generosity and otherness of people in general
- scale of two forced-choice and three agree-disagree statements

# Preliminary analysis

## Participants and incentives

- Laboratory of Experimental Economics of Montpellier (LEEM)
- 144 subjects, 44.4% men and 55.6% women, average age = 24.49 years
- 17 nationalities represented : French (68.1%) and Algerian (15.3%), others < 5%
- 88.2% were students : 16.5% in economics, 11% in biology, 10.2% in law, 7.9% in social and economics administration....
- different university levels : 24.4% in Licence 1, 11% in Licence 2, 20.5% in Licence 3, 27.5% in Master 1, 13.4% in Master 2 and 3.1% were Ph-D students
- each session lasted approximately 2 hours
- at the end, two choices were randomly selected by the computer (one with a low probability to be in the best state and another with a high one)
- gains between 4.8 euros and 22.8 euros (average 15.49 euros) + transportation costs, 2 or 6 euros

## Descriptive statistics

- 81.94% of our sample is risk averse, 6.3% is risk-neutral and 11.8% is risk-loving
- average relative risk-aversion coefficient of 0.782
- extreme behaviors are well-represented, 35.4% expressed the higher degree of risk aversion and 6.9% the higher degree of risk-loving
- for the faith, the average score is 3.49 (minimum possible 1 and maximum possible is 6)
- the more represented scores are 4 and 3 with 29.9% and 27.1% respectively while the less represented one are the extremes, 6 and 1 with 4.2% and 6.9% respectively

Thank you for your attention !

