Does information matter in the commons? Experimental evidence

Jose Apesteguia

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Introduction

- Examples of common-pool resources (CPRs) include fisheries, groundwater basins, oil fields, irrigation systems, grazing commons, and computer facilities
- Studies show that the so-called "tragedy of the commons" may be mitigated to a significant extent by institutional arrange
- Perfect information on the payoff function
- The provision of more accurate information may be highly costly
- Does a better knowledge of the CPR payoff structure make subjects more conscious of the externalities and then help to avoid the "tragedy of the commons"?
- Do subjects use this information to better exploit the resource?

Main Points

- CPR game repeated over a long time horizon
- Two treatments,(1) one with complete information and (2) one with no information on the payoff function.
- Aggregate behavior is not significantly different between the two treatments (NE)
- The results suggest that costly enterprises with the aim of improving the quality of information on the payoff structure of a CPR may not be profitable

The common-pool resource game

- 50 periods, a group of 6 individuals plays a constituent game aimed at representing the appropriation problem in a CPR.
- Players are aware of the number of periods to be played
- The game is symmetric and no communication between players is allowed.
- In the constituent game $\Gamma = (N, X, u)$, players face the decision problem of distributing a fixed endowment (labeled k) between two markets

- the CPR market (market 1) and a 'private market' (market 2)
- x_i is player i's investment in the CPR market, x_i set membership, variant $X_i = \{5.00, 5.01, 5.02, \ldots, 30\}, x = (x_1, x_2, \ldots, x_6)$ and $k = 35$
- $(35 - x_i)$ is player i's investment in the private marke
- Player i's payoff function

$$u_i(x) = \left(120 \sum_{j=1}^{6} x_j - 1.165 \left(\sum_{j=1}^{6} x_j\right)^2\right) \frac{x_i}{\sum_{j=1}^{6} x_j} + (135 - 6(35 - x_i))(35 - x_i). \tag{1}$$

Nash equilibrium and optimal solution

- CPR game has a unique Nash Equilibrium, which happens to be symmetric
- The SNE of the constituent game is calculated by assuming that the individual strategy space is the continuum between 5 and 30.
- player i's best-reply function in the constituent game:

$$b_i(x_{-i}) = \left\{x_i \in X_i : u_i(x_i, x_{-i}) \geq u_i(x_i', x_{-i}) \text{ for all } x_i' \in X_i\right\}, \quad \text{for all } i \in N, \qquad (2)$$

where $x_{-i} = (x_1, \ldots, x_{i-1}, x_{i+1}, \ldots, x_6)$. The individual best-reply function can be obtained by

$$\frac{\partial u_i(x_i, x_{-i})}{\partial x_i} = 405 - 1.165 \sum_{\substack{j=1 \\ j \neq i}}^{5} x_j - 14.33 x_i = 0, \quad \text{for all } i \in N, \qquad (3)$$

and hence

$$b_i(x_{-i}) = 28.26 - 0.08 \sum_{\substack{j=1 \\ j \neq i}}^{5} x_j, \quad \text{for all } i \in N. \qquad (4)$$

- Then,

$$p_i(x_{-i}) = \left\{ x_i \in X_i : \sum_{j=1}^{6} u_j(x_i, x_{-i}) \geq \sum_{j=1}^{6} u_j(x_i', x_{-i}) \text{ for all } x_i' \in X_i \right\}. \quad (5)$$

Then

$$\frac{\partial \sum_{j=1}^{6} u_j(x_i, x_{-i})}{\partial x_i} = 405 - 2.33 \sum_{\substack{j=1 \\ j \neq i}}^{5} x_j - 14.33 x_i = 0, \quad (6)$$

- Laboratory for Experimental Economics at the University of Bonn.
- Volunteer subjects
- Two treatments: (1) Complete-information Treatment and (2) Minimal-information Treatment [all information regarding the structure of payoffs was omitted]
- The period-by-period information about outcomes was the same in both treatments.
- Subjects were told that individual decisions remained anonymous to the group and that the game was symmetric

- **Result 1**. There is no significant difference between the investment decisions at the aggregate level in the two treatments.

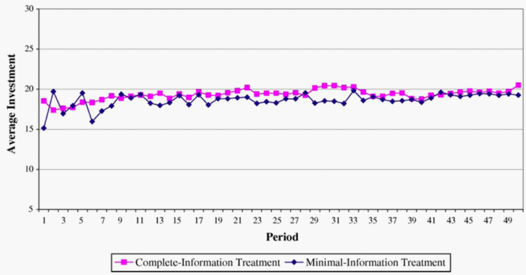


Fig. 1. Time series of average investment by treatment.

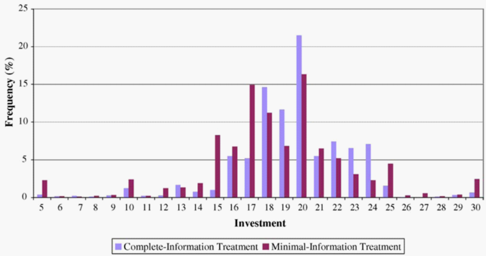
- 

  Fig. 2. Distribution of investment decisions by treatment.

- **Result 2**. In the first third of the experiment, dispersion in the pattern of individual investment decisions in the Minimal-information Treatment is greater than that observed in the Complete-information Treatment.

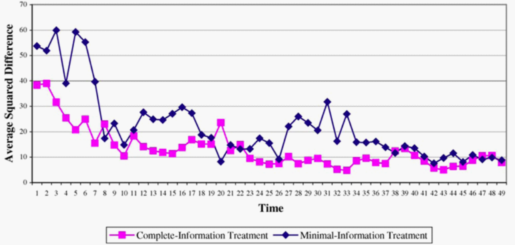
- 

Fig. 4. Time series of the average squared differences between individually observed and predicted investments by the best-reply function.

- Since technical studies that have the aim of improving the knowledge on the relation between decisions and payoffs in CPR settings may be highly costly, it is a crucial question, relevant for policy-making, to evaluate the behavioral usefulness of these studies.
- He finds that there is no significant difference in the investment decisions at the aggregate level between those groups in the Complete-information Treatment, and those in the Minimal-information Treatment.
- The results of this paper suggest that the priorities in the CPR institutional agenda may have to be reconsidered.

Environmental Policy and International Trade when Governments and Producers Act Strategically

Alistar Ulph

JEEM, 1996, 30, pp. 265-281

Introduction

- In the absence of trade policy, governments may relax their environmental policies to give their domestic producers an advantage
- Competitive markets, not transboundary pollution $\Longrightarrow$ No incentive to distort the Environmental Policies
- Reasons for setting too lax environmental policies may be small:
  - Welfare Cost
  - Compete using prices

Model

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- If the Producer does not act strategically: $\min_{\phi} C(x, \phi) + \frac{1}{\phi}$
  - $\phi = \frac{2}{x}$ and unrestricted total cost function $K(x) = x$ [Efficient choice of R&D]

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- When neither act strategically (Two Stage Game):
  - First Best equilibrium (governments and producers act non-cooperatively)

- First Stage: Government chooses standard
- Second Stage: Producers choose output level and use the efficient choice of R&D $\phi = \frac{2}{x}$

- $\max_x (A - x - y)x - x - 0.5(x - e)^2$
- Reaction Function $x = (A - 1 + e - y)/3$

- output level at the 2nd stage:

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  - note that: $\frac{\partial x}{\partial e} = \frac{3}{8} > 0$ and $\frac{\partial x}{\partial \varepsilon} = -\frac{1}{8} < 0$

- Government take as given ε and y
- $\max_{e}(A-x-y)x-x-0.5(x-e)^2-0.5de^2$

- F.O.C $\{(A-1-y+e-3x)\}\frac{\partial x}{\partial e}-x-e-de=0$
- $x-e=de$ or $e=\frac{x}{(1+d)}$

- Symmetric equilibrium: $e=\varepsilon$

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  - $x^* = \frac{(A-1)(1+d)}{(3+4d)}$

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- Governments $\max_{t}(A - x - y)x - x - 0.5t^2 - 0.5d(x - t)^2$

- Producers: $\max_{x,a}(A-x-y)x-x-t(x-a)-0.5a^2$
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  - F.O.C $\{(A-1-y-2x-d(x-t))\}\frac{\partial x}{\partial t}-t+d(x-t)=0$ and $t=\frac{dx}{1+d}$

- The second stage game set out above continue to apply, but in the first stage governments recognize that the output of the rival firm depends on the policy instrument
- F.O.C $\{(A-1-y+e-3x)\}\frac{\partial x}{\partial e} - x\frac{\partial y}{\partial e} + x - e - de = 0$
- $e(1+d) = x - x\frac{\partial y}{\partial e}$ or $e = \frac{9x}{8(1+d)}$

- Comparison: $e = \frac{9x}{8(1+d)} > e = \frac{x}{(1+d)}$
- Higher outcome and higher emissions when government acts strategically.

- F.O.C
  $\{(A-1-y-2x-d(x-t))\}\frac{\partial x}{\partial t}-x\frac{\partial y}{\partial t}-t+d(x-t)=0$
- $t(1+d)-dx=\frac{x\frac{\partial y}{\partial t}}{\frac{\partial x}{\partial t}-1}$ or $t=\frac{(d-0.2)x}{(1+d)}$

- Comparison:$t=\frac{(d-0.2)x}{(1+d)}<t=\frac{dx}{(1+d)}$
- Higher outcome and higher emissions when government acts strategically.

- If governments act strategically this always increases the incentives for producers to overinvest in R& D;
- If producers act strategically, this always reduces, but does not reverse, the incentive for governments to relax their environmental policies.
- When both governments and producers act strategically, distortions to both environmental policy and R& D are larger when governments use emission taxes than when they use emission standards.
- Welfare is lower when both governments and producers act strategically than when only one party acts strategically

Effluent Charges and Licenses Under Uncertainty

Roberts, M.J. and M. Spence
Journal of Public Economics 5, 1976, 193-208.

Introduction

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- Once and for all problem
- **Mixed system is preferable to either effluent fees or the licenses used separately.**

- The point of this exercise is not to prove one or another approach better.

- The problem is to minimize the expected total social cost. The authority must quantify its uncertainty about cleanup costs in the form of subjective probabilities.

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- Which kind of imperfection is preferable?
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  - EDF is linear, then effluent charge
  - Marginal damage increase sharply, then licenses
- Licenses and effluent charges can be used together further to reduce expected total costs.

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- Total cleanup: $c(x_i, \phi) = \sum_i c^i(x_i, \phi)$
- note that $x = \sum_i x_i$ and for all i and j:$c^i_x(x_i, \phi) = c^j_x(x_j, \phi)$

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- Total cleanup: $c(x_i, \phi) = \sum_i c^i(x_i, \phi)$
- note that $x = \sum_i x_i$ and for all i and j:$c^i_x(x_i, \phi) = c^j_x(x_j, \phi)$
- $D''(x) > 0$ and $C_x < 0$, $C_{xx} > 0$ (mg cleanup costs increase at an increasing rate)

- waste dischargers have the same impact.

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$$c^i(x_i, \phi) + ql_i - s(l_i - x_i) \quad \text{if} \quad x_i \leqq l_i,$$

and

$$c^i(x_i, \phi) + ql_i + p(x_i - l_i) \quad \text{if} \quad x_i \geqq l_i.$$

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The remaining question is what determines the levels of q and x? If $s < q < p$, then $x_i = l_i$ for all i, and hence $x = l$. Condition (3) will be satisfied if

$$s < -c_x(l, \phi) < p. \tag{4}$$

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- The piecewise linear penalty function is:

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- If Min $P(x) + c(x, \phi)$:
  - if $s < -c_x(l, \phi) < p$ they would set $x = l$
  - if $-c_x(l, \phi) < s$ they would set $c_x(x_i, \phi) + s = 0$
  - if $-c_x(l, \phi) > p$ they would set $c_x(x_i, \phi) + p = 0$

- The mixed system implicitly approximates the expected damage function by a piecewise linear penalty

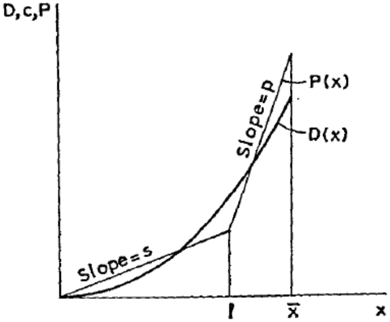

Fig. 1

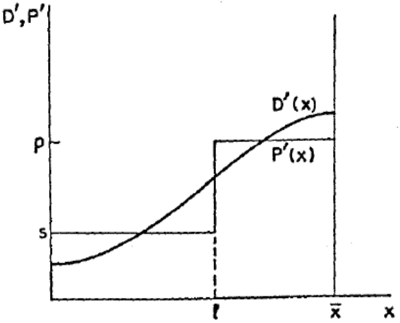

Fig. 2

- Expected total costs are

$$T(s,p,l) = \int_0^{\phi_1} [D(x_1(\phi,s)) + c(x_1(\phi,s),\phi)]f(\phi)\,d\phi$$
$$+\int_{\phi_1}^{\phi_2} [D(l) + c(l,\phi)]f(\phi)\,d\phi$$
$$+\int_{\phi_2}^{b} [D(x_2(\phi,p) + c(x_2(\phi,p),\phi]f(\phi)\,d\phi.$$

- With perfect information about costs, the authority would set

$$D'(x)+c_x(x,\phi) = 0,$$

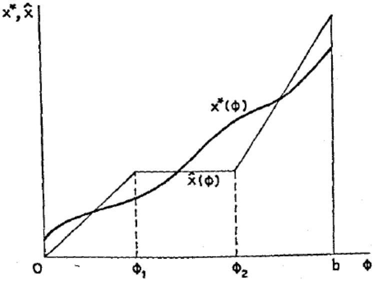

Fig. 4

-

Table 1

Control scheme	Expected total costs	Percentage above the optimum
Optimum (also mixed system)	12.416	0
Pure effluent fee	20.6	66
Pure licenses	18.25	46

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- Once the equilibrium in license prices is established, each firm effectively faces a linear penalty function whose slope is the price of the license.
- As a result marginal; cleanup costs are equalized and total cleanup costs are minimized.

Equilibrium Pollution Taxes in Open Economies with Imperfect Competition

Peter Kennedy

JEEM, 27, pp49-63 (1994)

Introduction

- Opposition to trade liberation
- Possible Strategic Distortion of Environmental Policies
- Lower Environmental Standards
- Competitive Advantage
- Strategic distorsions can operate in the opposite direction
- This paper examines the strategic incentives to distort pollution taxes in free-trading economies.

Equilibrium Pollution Taxes in Open Economies with Imperfect Competition

Assumptions

- Imperfect Competition among producers
- Tax choice game is modeled explicitly
- Transboundary pollution

- Two Identical Countries
- x polluting homogeneous good
- Symmetric oligopolistic industry with n firms
- Sunk Cost
- The $2n$ firms compete freely in the two markets
- MPC is θ
- y_i output by a representative firm in country i
- y_i^H and y_i^F
- Y_i total production by country i
- Pollution $Z_i = (Y_i/\theta_i)$
- $\alpha \in [0,1]$ a fraction of this pollution affects other countries
- Environmental damage: $e_i = e(Z_i + \alpha Z_{-i})$
- The inverse demand for x in each country is $p(X_i)$

Efficient Pollution Taxes

- The planning problem is to set the taxes to maximize global welfare
- Efficient taxes are not first-best

- Industry Equilibrium when all firms face the same tax rate

The problem for the representative firm based in country i is

$$\max_{y_i^{\mathrm{H}}, y_i^{\mathrm{F}}, \theta_i} \quad p(X_i) y_i^{\mathrm{H}} + p(X_{-i}) y_i^{\mathrm{F}} - \theta_i y_i - \tau(y_i/\theta_i),$$

- F.O.C:

$$p + yp'/2 = (\theta + \tau/\theta)$$

$$\tau/\theta^2 = 1,$$

- $$W = \left[\int_0^X p(\tilde{X})\, d\tilde{X} - pX\right] + [pX - 2tX] + \tau X/t - e((1+\alpha)X/t)$$
$$= \int_0^X p(\tilde{X})\, d\tilde{X} - tX - e((1+\alpha)X/t), \quad (8)$$

$$[p - t](\partial X/\partial t) - X = (1+\alpha)e'[t(\partial X/\partial t) - X]/t^2$$

- RHS is the marginal global damage
- LHS is the marginal abatement cost [(1) welfare cost of the reduce output and (2) increased mg cost of production]
- PCM: $t^2 = e'(1+\alpha)$

- Taxes rates affect production (foreing and domestic)
- Industry equilibrium

$$p = (t_i + t_{-i}) - Xp'/2n.$$

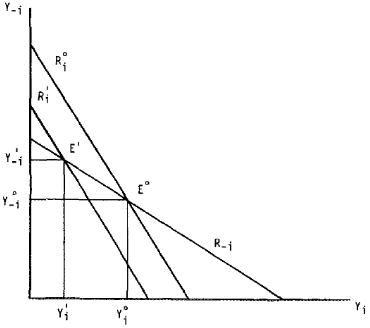
- 

FIG. 1. The effect of a unilateral tax increase by country i.

- Game between National governments:

$$W_i = \left[\int_0^X p(\tilde{X})\, d\tilde{X} - pX\right] + [pY_i - t_i Y_i] - e(\alpha Y_{-i}/t_{-i} + Y_i/t_i). \quad (17)$$

It is instructive to rewrite this expression for welfare as

$$W_i = \left[\int_0^X p(\tilde{X})\, d\tilde{X} - t_i X\right] + [p - t_i][Y_i - X] - e(\alpha Y_{-i}/t_{-i} + Y_i/t_i). \quad (18)$$

-

$$\begin{aligned}\partial W_i/\partial t_i|_{t^*} = {} & (p - t^*)\left[(\partial Y_i/\partial t_i) - (\partial X/\partial t)|_{t^*}\right] \\ & - e'\left[(\partial Y_i/\partial t_i) + \alpha(\partial Y_{-i}/\partial t_i) - (\partial X/\partial t)|_{t^*}\right]/t^* \\ & + \alpha e'\left[t^*(\partial Y/\partial t)|_{t^*} - Y^*\right]/(t^*)^2,\end{aligned}$$

- Transboundary externality effect and rent capture effect

- The rent can be viewed as compromising two parts

$$[p - t_i][Y_i - X] = [p - 2t_i][Y_i - X] + t_i[Y_i - X].$$

- (1)Profits from net exports and (2)tax revenue earned on net exports
- Two effects:

$$RCE = -(p - t^*)(\partial Y_{-i}/\partial t_i)|_{t^*}.$$

$$\text{PSE} = e'(1 - \alpha)\left[(\partial Y_{-i}/\partial t_i)|_{t^*}\right]/t^*.$$

- TABLE I
  The Direction of Distortions from Efficiency

	Imperfect competition			Perfect competition		
Effect	$\alpha = 0$	$0 < \alpha < 1$	$\alpha = 1$	$\alpha = 0$	$0 < \alpha < 1$	$\alpha = 1$
Rent capture	—	—	—	—	—	—
Pollution shifting	+	+	0	+	+	0
Net strategic	—	—	—	0	—	—
Transboundary pollution	0	—	—	0	—	—
Overall	—	—	—	0	—	—

- There are strategic incentives to distort pollution taxes under free trade and benefits of free trade are unlikely to be fully realized in the absence of an accompanying agreement.

International Cooperation and the International Commons

Scott Barrett

Duke Environmental Law & Policy Forum , Vol. 10, 1999

Introduction

- Usually cooperation will be partial and
- There will be some loss in efficiency
- International cooperation in these situations is analogous to domestic politics..
- Agreements that seek to sustain cooperation must be self-enforcing

Motivation

- Free-riding
- Compliance
- The purpose of this article is to try to make sense of the negotiators' problem by discussing what makes international agreements work and how they can be made to work better

- The most important feature of the PD is that the efficient outcome may not be sustainable by a decentralized or anarchic international system.
- There is no third party that can effectively enforce agreements between countries
- Many problems are more akin to coordination games
- One of the differences between the PD and coordination games is that, for the latter, players do not have dominant strategies
- Participation in a treaty may resemble a coordination game, and yet the problem addressed by the treaty may be a PD.

- With sanctions imposed on non-signatories, every party prefers to participate if a significant number of others do as well.
- If the treaty also requires that the parties supply the public good, then this resembles the PD game
- Number of countries affected by the commons problem
- It is neither essential nor reasonable to assume that all choices are binary

General Remedies

- 200 multilateral agreements
- Treaties are specific remedies
- Why not simply allocate rights, pursuant to the Coase Theorem, to all the earth's resources and let bargaining take care of the rest?

General Remedies

- Customary international law states that shared resources should be subject to "equitable utilization," but the law is silent on what makes for an equitable allocation
- Enforcement by a third party

Specific Remedies

- The harder problem is figuring out how to ensure full participation in the agreement effecting an allocation and
- How to enforce an allocation.
- In general, negotiating allocations is a simpler problem as compared with enforcement.

Compliance

- Though the punishment for breaking with this customary law is not specified, it is real
- Few treaties specify explicit punishments, or "sticks," for noncompliance

- Noncompliance will only be deterred if the act of noncompliance is punished.
- The compliance problem needs to be interpreted differently.

- It is a rule of international law that participation in a treaty is voluntary
- free riding is manifest in every party providing too little of the public good
- The problem of international cooperation is the deterrence of free riding.
- There is a much deeper reason for thinking that free riding is not a problem
- How can credibility be augmented in order to deter nonparticipation?

- If a trade sanction works well, then it will never need to be implemented.
- It can only be acceptable to impose sanctions against freeriders, as opposed to nonparticipants.
- To reduce leakage, some kind of border tax adjustment would probably be needed

Free-riding in international environmental agreements:
A signaling approach to non-enforceable treaties

Ana Espinola-Arredondo and Felix Munoz

School of Economic Sciences
Washington State University

Introduction

- Why should we care about IEA?

Introduction

- Why should we care about IEA?
    - GLOBAL PUBLIC GOODS

Motivation

- IEA's are usually played sequentially.
- IEA's are first signed by the executive but enter into force only after legislative ratification.
- Countries sometimes disregard the IEA they ratified.

Assumptions

- Every country benefits from the global environmental quality.

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- Every country benefits from the global environmental quality.
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- Noncompliance Cost
- Countries do not have information about other countries' noncompliance costs.

Outline of the Presentation

- Related literature
- Model : Equilibrium Proposal
- Equilibria under general utility functions
- Discussion and Applications
- Conclusion

Main Contributions

-

Barrett's Model	Free-riding and cooperation
• Complete Information	• Incomplete Information
• Countries fulfill their agreements.	• Relative fulfillment of the agreement.
• Collective welfare and individually.	• Countries behave individually.
• Number of Signatories	• Commitment levels
• Commitment level is exogenous	• Commitment level is endogenous

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1. *First stage (negotiation): signaling game.*

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- Two countries.

- Country i's quasilinear utility function:
$U_i\left(x_i, c_i\right) = w - x_i + \ln\left[m(x_i + x_j) + \alpha_i\left(x_i - c_i\right)\right]$

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$$\underbrace{m(x_i + x_j)}_{\text{Public Good Dimension}} + \underbrace{\alpha_j(x_j - c_j)}_{\text{Fulfillment Dimension}}$$

Time structure of the game

- Nature selects country i's political costs, $\alpha_i \geq 0$, assume that the political costs are either high ($\alpha_i = 1$) or low ($\alpha_i = 0$), with associated probabilities p and $1 - p$, respectively.

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- Country i announces a particular commitment level, c_i, to country j.
- Country j decides c_j, given its posterior beliefs about country i's political cost ($\mu(H|S)$ and $\mu(H|NS)$).

Time structure of the game

- Nature selects country i's political costs, $\alpha_i \geq 0$, assume that the political costs are either high $(\alpha_i = 1)$ or low $(\alpha_i = 0)$, with associated probabilities p and $1 - p$, respectively.
- Country i announces a particular commitment level, c_i, to country j.
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- Countries play a simultaneous-move game in which they determine the investment levels in emission-reducing technologies, x_i and x_j, that are finally implemented.
- We assume that Country j's political cost is high ($\alpha_j = 1$) and if $c_j = 0$ then IEA is not valid.

- **Lemma 1:** *In the investment game, every country i's Nash equilibrium investment in emission-reducing technologies is*

$$x_i^* = \begin{cases} 1 + \frac{\alpha_i c_i}{m+\alpha_i} \text{ if } \alpha_i > \bar{\alpha}_i \\ \frac{\alpha_i(1+c_i)(\alpha_j+m)-\alpha_j m c_j}{\alpha_j m+\alpha_i(\alpha_j+m)} \text{ if } \alpha_i \in (\hat{\alpha}_i, \bar{\alpha}_i] \\ 0 \text{ if } \alpha_i \in (0, \hat{\alpha}_i] \end{cases}$$

where $\bar{\alpha}_i = \frac{\alpha_j c_j m}{(1+c_i)(\alpha_j+m)}$ *and* $\hat{\alpha}_i = \frac{m c_j+\alpha_j(1+c_j)(m+c_j)}{(1+c_i)m}$

Comparative Statics

	a_i	a_j	c_i	c_j
X_i	+	-	+	-

$c_i =$ country i's commitment level

$c_j =$ country j's commitment level

$\alpha_i =$ country j's concern level

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Lemma 2

- *If country i does not sign the IEA, country j will not sign the agreement, for any commitment levels included in the IEA, and for any probability distribution about country i's political cost of reneging from the IEA.*

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- $$\underbrace{m(x_i + x_j)}_{\textit{Public Good Dimension}} + \underbrace{\alpha_j(x_j - c_j)}_{\textit{Fulfillment Dimension}}$$

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2. $\mu(H|S) > \frac{c_j}{\overline{c_j}(c_i, m)}$, *when that all types of country i do not sign the IEA, or*
3. $c_j \leq (\overline{c_j}(c_i, m))$, *when country i signs the IEA if and only if country i is highly concerned about the political costs of reneging from the IEA.*

Lemma 3

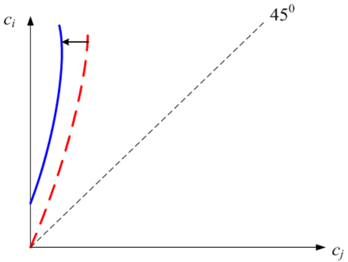
- 

Figure 1. Level set $c_j = p \cdot \overline{c_j}(c_i, m)$ for $p = 1$ (dashed), and $p = 0.7$ (solid).

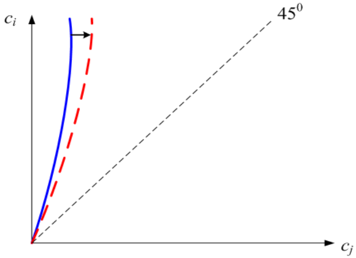


Figure 2. Level set $c_j = \overline{c_j}(c_i, m)$ for $m = 0.3$ (solid), and $m = 0.8$ (dashed).

Lemma 4 (country i's benefits)

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2. Increasing in the return from the investment in clean technologies (return from the global public good, m); and
3. Decreasing in the commitment level that the IEA specifies for country i

Lemma 5

- *The pooling strategy profile: Country i signs* $\forall \alpha_i$, *cannot be supported as a pure-strategy PBE of the environmental signaling game if* $c_j < p \times (\overline{c_j}(c_i, m))$.

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Proposition 1

- *In the IEA signaling game, the following strategy profile can be supported as a separating PBE:*

1. *Country i signs the IEA when $\alpha_i = 0$ for any parameter values, and when its $\alpha_i = 1$ country i does not sign .*
2. *Country j responds by not signing the IEA when it observes that country i did not sign the agreement, for any parameter values. Similarly, when it observes that country i signed the IEA, country j responds by not signing the agreement, for any parameter values. In this separating PBE country j's posterior beliefs are $\mu(H|S) = 0$ and $\mu(H|NS) = 1$.*

- *Full revelation* of information to country j.
- Thus, the first mover's offer "I sign high commitment levels and you then sign high commitment levels as well", can be understood as a void proposal in equilibrium

- Countries with high political costs announce that they would only sign a high commitment level in the IEA if other countries sign high commitment levels as well.

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- Countries with high political costs only accept to participate in the IEA if they can strongly benefit from other country's investment in clean technology during the second stage of the game (free-riding incentives).

- Countries with low political costs will be willing to participate in IEAs, since the environmental benefits offset their (low) noncompliance costs.

- *Introducing more countries in the IEA?*

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- *Participation in IEAs*

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- *Participation in IEAs*
- *Optimistic Result?*

We show that country's decision on joining the agreement is more likely:

1. the higher the return from the improved environmental quality resulting from the agreement;
2. the lower the commitment level that the agreement specifies to the follower;
3. the higher the commitment level that the leading country signs in the IEA; and
4. the higher the probability that the leading country implements most of the commitments it signed in the treaty.

Green Auctions: A Biodiversity Study of Mechanism Design With Externalities

Ana Espínola-Arredondo

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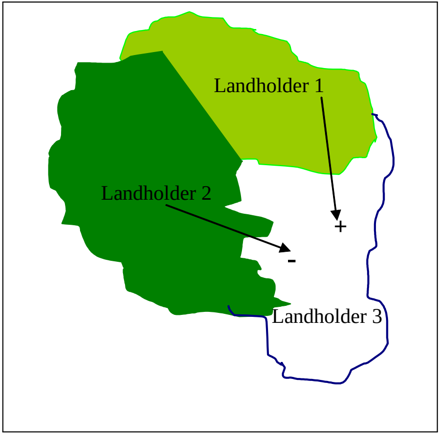
Introduction

- Problems that the government faces when implementing a biodiversity project:
  - It does not develop the environmental project by itself.
  - Landholders have more information (Information Asymmetry)
  - Double objective (Trade-off): Cost of the project – Biodiversity Improvement
  - Existence of externalities.

Existence of Externalities

- 

- Externalities generate an increase or decrease of landholder's cost

Related Literature

- Externalities in mechanism design:
  - Jehiel, Moldovanu and Stacchetti (1996) and (1998)
  - Skreta and Figueroa (2004)
- Multidimensional bids:
  - Hansen (1988)
  - Dasgupta and Spulber (1990)
  - Che (1993) and Branco (1997)

Outline of the Presentation

- Presentation of the Model (Negative Externalities)
- Optimal Revelation Mechanism
- Possibility of Positive Externalities
- Conclusion

Main Assumptions

- Government is the seller (Conservation Program)
- N risk neutral bidders (landholders), $i = 1, ..., n$
- Landholders submit simultaneous bids of the form (B_i, t_i) for a single project that will be developed in his own land.
- Landholders have private information θ about the cost of the project.
- Landholders' cost parameters are i.i.d with $F(\cdot)$ defined on $[\underline{\theta}, \overline{\theta}]$ which is common knowledge.

Main Assumptions

- Landholder *i*'s cost function (Biodiverity): $C_i(B_i, \theta_i)$.
- $C_B > 0$ and $C_{BB} > 0$.
- $C_i(0, \theta_i) = 0,\ C_{B\theta} < 0$.
- Landholder *i*'s cost function (Market Good):$C_i^M(q, B_{-i}, \theta)$
- B_{-i} is the negative externality.
- Government's utility:

$$\begin{aligned} U_g(B_i, t_i) &= V(B_i) - t_i \\ W &= \sum_{i=1}^{n} (V(B_i) - (1+\lambda)t_i) \end{aligned}$$

Main Assumptions

- Landholders' utility is:

$$U_I(B_i, t_i) = \phi(i \text{ wins the auction})[t_i - C_i(B_i, \theta)] + \phi(i \text{ does not win}) \left[\pi - C_i^M(q, B_{-i}, \theta)\right]$$

- Negative Externality: $C^M_{qB_{-i}} > 0$ and $C^M_{\theta B_{-i}} > 0$

Time structure of the game

1. Nature chooses the type of every bidder, θ, the landholder privately observes his own type. The government does not observe θ.
2. Landholders develop a market activity,
3. Government calls for the procurement of some specific area,
4. All the landholders who live in the area to be procured submit their two-dimensional bid,
5. The government chooses the optimal project,
6. Those bidders who do not win the auction dedicate their land to some market activity,
7. Those bidders who win the auction generate some negative externality to all the nonparticipating bidders in their surroundings.

The Optimal Revelation Mechanism

- The mechanism $(B(\theta), t(\theta))$ is said to be Incentive Compatible for landholder i if:

$$U_i(B_i(\theta_i), t_i(\theta_i), \theta_i) \geq U_i(B_i(\widehat{\theta}_i), t_i(\widehat{\theta}_i), \theta_i)$$
$$\forall \theta_i \in [\underline{\theta}, \overline{\theta}] \text{ and } \forall \widehat{\theta}_i \neq \theta_i$$

- The mechanism $(B(\theta), t(\theta))$ satisfies the participation constraint if:

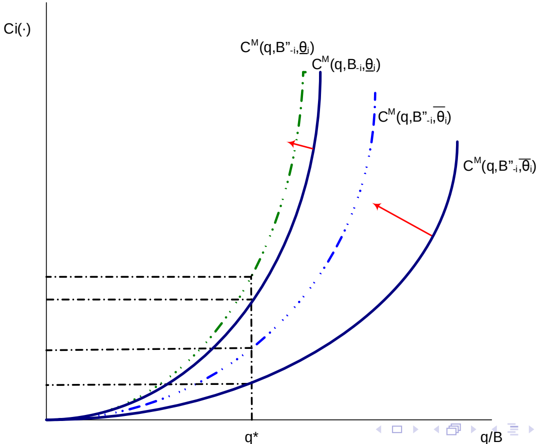
$$U_i(B_i(\theta_i), t_i(\theta_i), \theta_i) \geq \pi - E_\theta[C_i^M(q, B_{-i}, \theta_i)] \quad \forall \theta_i \in [\underline{\theta}, \overline{\theta}]$$

  - Reservation Utility is *Type Dependent*

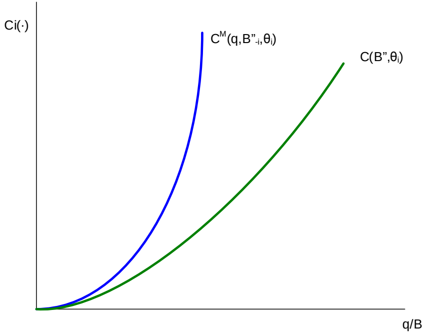
The Reservation Utility is Type dependent

- *Decreasing* in B_{-i} and *increasing* in θ

$$\pi - E_\theta[C_i^M(q, B_{-i}, \theta_i)]$$

- 

The Reservation Utility is Type dependent

- Given the assumption:
  - $C^M_{qB_{-i}} > 0$ and $C^M_{\theta B_{-i}} > 0$
- $C_{BB}(B_i, \theta) < C^M_{qB}(q, B_{-i}, \theta) \;\; \forall \theta_i \in [\underline{\theta}, \overline{\theta}]$
- 

Government's maximization problem

$$\max_{\{B_i(\cdot),U(\cdot)\}} E\left[\sum_{i=1}^{N}(V(B_i(\theta_i)) - (1+\lambda)[C_i(B_i(\theta_i),\theta) + U_i(\theta_i)])\right]$$

subject to: $B(\cdot)$ is non-decreasing in $\theta \in [\underline{\theta}, \overline{\theta}]$

$$U_i(\theta_i) = U_i(\underline{\theta}_i) - \int_{\underline{\theta}}^{\theta_i} \frac{\partial C_i(B_i(x),x)dx}{\partial \theta_i} \; \forall \theta_i \in [\underline{\theta}, \overline{\theta}] \qquad (I.C)$$

$$U_i(\theta_i) \geq (\pi - E_\theta[C_i^M(q, B_{-i}, \theta_i)]) \qquad (P.C)$$

Proposition 1

- *Let (t^*, B^*) be the optimal mechanism. Then, the optimal menu of contracts specifying a biodiversity level to be implemented, $B_i^*(\theta)$ and a transfer $t_i^*(\theta)$ to be received for the implementation of such biodiversity level must satisfy,*

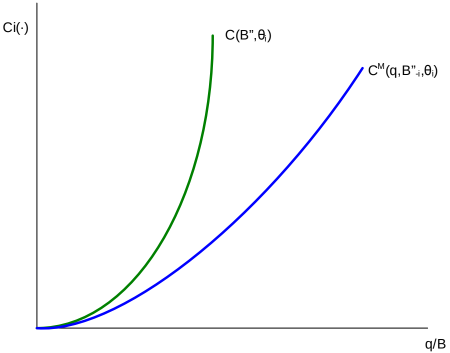
  $$\frac{V(B_i(\theta))}{dB_i} = (1+\lambda)\left(\frac{C_i(B_i(\theta),\theta)}{\partial B_i} - \frac{1-F(\theta_i)}{f(\theta_i)}\frac{\partial^2 C_i(B_i(\theta),\theta)}{\partial B_i \partial \theta_i}\right)$$

  and $t_i^*(\theta) = (1+\lambda)\left(C_i(B_i(\theta),\theta) - \frac{1-F(\theta_i)}{f(\theta_i)}\frac{\partial C_i(B_i(\theta),\theta)}{\partial \theta}\right)$, $\forall$ $\theta \in \left[\underline{\theta}, \overline{\theta}\right]$ and $\forall$ $i \in N$

- Low types will obtain a *higher* transfer if they decide to participate in the procurement.

Positive Externality Case

- *Non-decreasing* in B_{-i} and θ
- $C^M_{qB} < 0$
  - $C_{BB}(B, \theta_i) > C^M_{qB}(q, B_{-i}, \theta_i)$



Proposition 2

- So, we need to find a cutoff that induces the participation of those inefficient types who belong to some range $\left[\underline{\theta}, \widehat{\theta}\right]$, where $\widehat{\theta} < \overline{\theta}$

Proposition 2

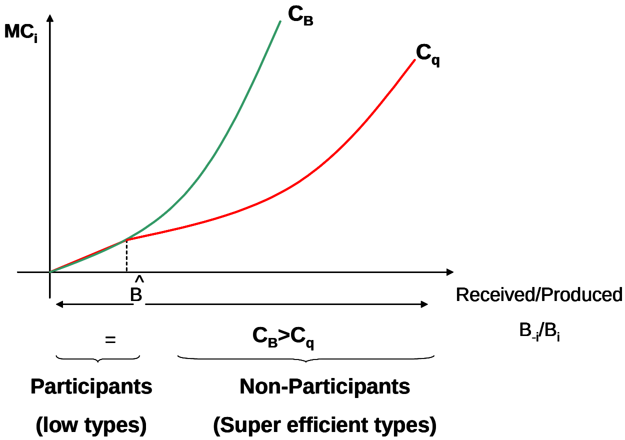
- $t_i^*(\theta) = (1+\lambda)\left(C_i(B_i(\theta),\theta) - \frac{1-F(\theta_i)}{f(\theta_i)}\frac{\partial C_i(B_i(\theta),\theta)}{\partial\theta}\right)$, If we assume $\theta\tilde{}\ U[0,1]$.
- *High Type*: The optimal transfer will be equal to the cost of the project. But, given that $C_{BB} > C_{qB}^M$
    - $\overline{\theta}$ will not Participate

Proposition 2

- $t_i^*(\theta) = (1+\lambda)\left(C_i(B_i(\theta),\theta) - \frac{1-F(\theta)}{f(\theta)}\frac{\partial C_i(B_i(\theta),\theta)}{\partial\theta}\right)$, If we assume $\theta \in \left[\underline{\theta}, \widehat{\theta}\right]$, where $\widehat{\theta} < \overline{\theta}$

- $MC_i\left(q|\ B_{-i} \in \left[0, \widehat{B}\right]\right) = MC_i\left(B_i \in \left[0, \widehat{B}\right]\right)$

Proposition 2



Conclusions

- The existence of externalities has clear consequences in the solution of an optimal mechanism that solves the government's maximization problem.
- Negative externality: the optimal transfer depends on the efficiency of the landholder. Therefore, those landholders with high types (very efficient) will receive lower transfers.
- Positive externalities: those less efficient landholders (low types) will be the ones selected to develop the biodiversity project.

Further Research

- Risk averse landholders
- Correlation of the landholders' types
- Externality as a random variable