Coordination vs. Voluntarism and Enforcement in Sustaining International Environmental Cooperation

Scott Barrett (2016). *Proceedings of the National Academy of Sciences* 113/51, 14515-14522.

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- Scott Barrett, School of International and Public Affairs, Earth Institute, Columbia University.
- https://sipa.columbia.edu/faculty-research/faculty-directory/scott-barrett

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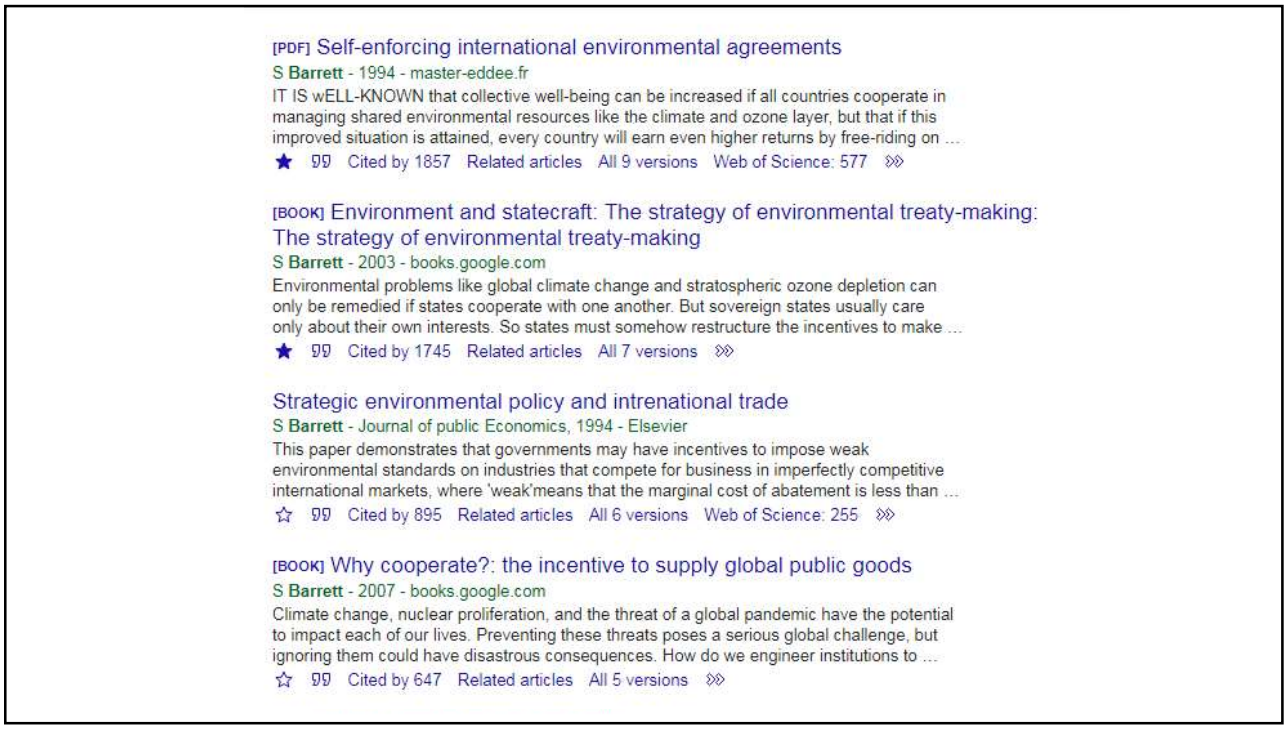

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- Simple game-theoretic models showing whether and how
  can change incentives,

  aligning states' self-interests with
- Generally, states struggle to cooperate voluntarily and enforce agreements to cooperate

  but that they find it relatively easy to coordinate actions.

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- Up to now: negotiators (and economists) have perceived climate change as

  requiring that states either negotiate national reductions in emissions

  or pledge to reduce their emissions voluntarily.
- Neither approach has worked.
- Two successes

  (for both, however,):

  - Eradication of smallpox

  - Montreal (1987)

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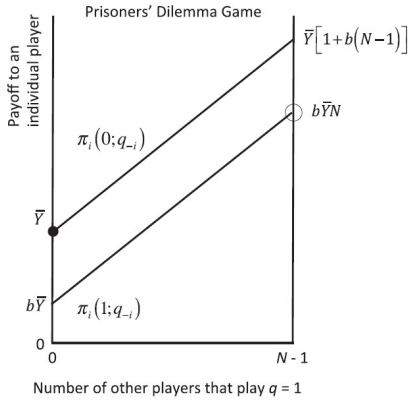
- Model: N-player version of Prisoner's Dilemma.
- Country i chooses $q_i \in \{0,1\}$ to maximize
- Assume $bN > 1 > b > 0$.



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- Similar model: Classic (linear) public goods game.
- Country i chooses $Y_i \in [0, \bar{Y}]$ to maximize

- Assume $bN > 1 > b > 0$.
- Theoretical predictions not observed in experiments.
- Conditional cooperators

Table 1. Equilibrium properties of various games

Equilibrium properties	Dilemma/public goods	Tre
Unique?	Yes	
Dominant strategy?	Yes	
First best efficient?	No	
Intermediately efficient?	No	
Symmetric?	Yes	

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- Institutions (context) matter.
- → Elinor Ostrom: success with some institutions on local levels.
- What about treaties? Participation remain voluntary, and participants can withdraw (see Brexit).
- Treaty Game in three stages:

  Stage 1:

  Stage 2:

  Stage 3:

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- Backward induction.

  Stage 3:

  Stage 2: if and only if $k \geq \hat{k}$, with $\hat{k}$ as smallest integer greater than $1/b$.

  Stage 1: if $\hat{k} - 2$ or fewer countries join, then country cannot lose by joining since treaty will not be in effect anyway.
- If $\hat{k}$ or more countries,
- If $\hat{k} - 1$ join, then a country is

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- In equilibrium: $k^* = \hat{k}$ countries join and play $q_i = 1$ or $Y_i = \bar{Y}$, rest does not join and plays $q_i = 0$ or $Y_i = 0$.

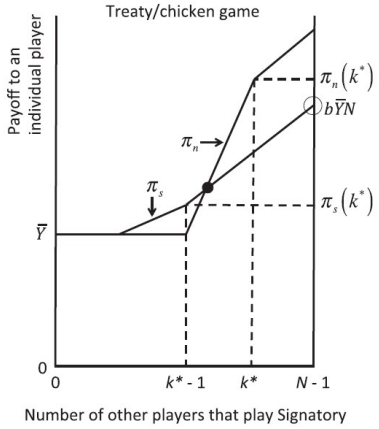

Table 1. Equilibrium properties of various games

Equilibrium properties	Dilemma/public goods	Treaty/chicken
Unique?	Yes	Yes*
Dominant strategy?	Yes	No
First best efficient?	No	No
Intermediately efficient?	No	Yes
Symmetric?	Yes	No

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- Every player better off with agreement than without it.
- No player has incentive to deviate (definition of equilibrium), even though signatories would rather be non-signatories (chicken).
- In dilemma game everybody free-rides, here only some do.
- How much improvement? Depends on parameters. Aggregate gain is $\bar{Y}k^*(bN-1)$.
- Trade-off: with large N, either k^*or b is small.

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- Eradication of smallpox biggest success story of international cooperation.
- Saving lives and sparing countries from costly and risky vaccine.
- . Here simplified version:
- Country i chooses level $v_i \in [0,1]$.
- There is critical value $\bar{v}$:

  $v_i < \bar{v}$: disease remains locally endemic.

  $v_i \geq \bar{v}$: disease is eliminated in i.

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- i maximizes
- $g\left(v_{-i}^{min}\right) = 0$ if $v_{-i}^{min} < \bar{v}$, and
- $g\left(v_{-i}^{min}\right) = D$ if $v_{-i}^{min} \geq \bar{v}$.
- $\pi_i^{Control}\left(\hat{v}; v_{-i}^{min} < \bar{v}\right) = f(\hat{v}) = \beta,$
- $\pi_i^{Elimination}\left(\bar{v}; v_{-i}^{min} < \bar{v}\right) = \alpha\ (< \beta),$
- $\pi_i^{Eradication}\left(\bar{v}; v_{-i}^{min} = \bar{v}\right) = \alpha + D\ (> \beta).$

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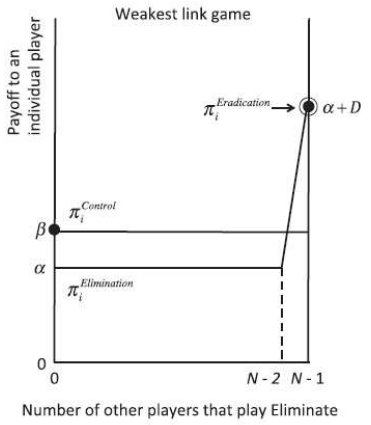

Fig. 3. In this weakest link game, there are two Nash equilibria, and one of which yields a higher payoff for achieving eradication.

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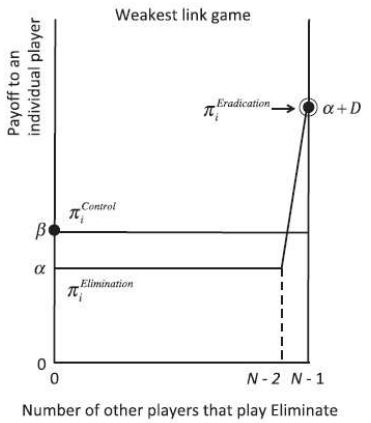

Fig. 3. In this weakest link game, there are two Nash equilibria, an which yields a higher payoff for achieving eradication.

Table 1. Equilibrium properties of various games

Equilibrium properties	Dilemma/public goods	Treaty/chicken	Weakest link
Unique?	Yes	Yes*	No
Dominant strategy?	Yes	No	No
First best efficient?	No	No	Yes
Intermediately efficient?	No	Yes	No
Symmetric?	Yes	No	Yes

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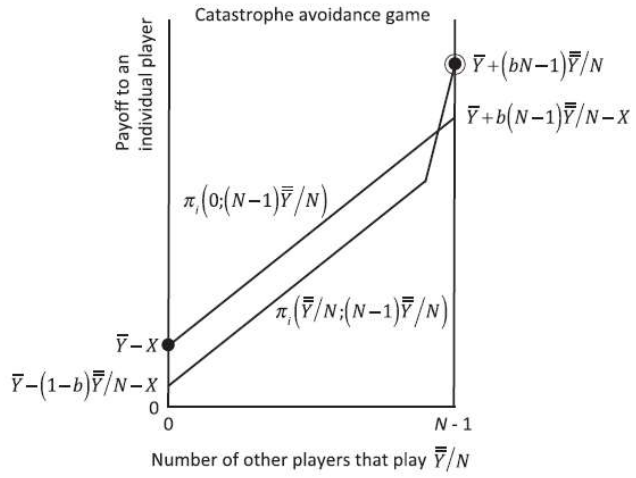

Fig. 4. In this catastrophe avoidance game, there are two Nash equilibria, with selection of the better one, on the right, requiring coordination.

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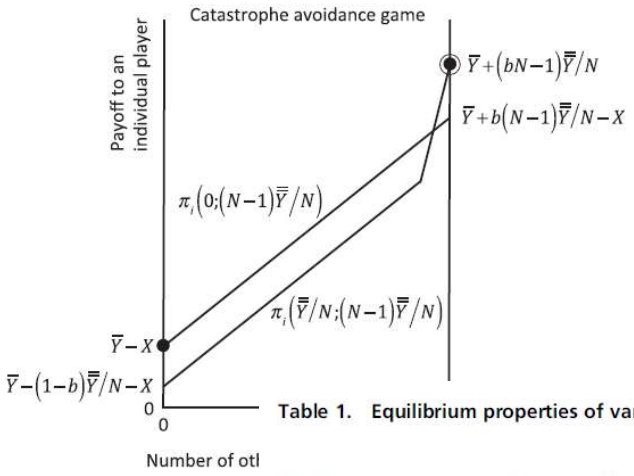

Fig. 4. In this catastrophe avo
with selection of the better on

Table 1. Equilibrium properties of various games

			Coordination	
Equilibrium properties	Dilemma/public goods	Treaty/chicken	Weakest link	Catastrophe avoidance
Unique?	Yes	Yes	No	No
Dominant strategy?	Yes	No	No	No
First best efficient?	No	No	Yes	Possibly
Intermediately efficient?	No	Yes	No	Possibly
Symmetric?	Yes	No	Yes	Probably

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- Differences between last two cases. In last game:
- Preferred NE could still be inefficient.
  There could be asymmetric NE.
- Threshold for catastrophe might be uncertain.
  (which turns game back into cooperation game)

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- Montreal and CFCs: negotiators did not establish global goal.
- Merely tried to limit production and consumption by banning trade between parties and nonparties.
- Free trade can bring "leakage"—emissions increase in non-treaty countries.

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- $\pi_i(\bar{Y}; z\bar{Y}) = b\bar{Y}(z+1)[1 - l(\bar{Y}; z\bar{Y})]$, vs.
- $\pi_i(0; z\bar{Y}) = b\bar{Y}z[1 - l(0; z\bar{Y})] + \bar{Y}$.
- $l(.)$ leakage rate.
- With ban on trade, no leakage but also no gains from trade ($g(.)$).
- $\tilde{\pi}(\bar{Y}; z\bar{Y}) = b\bar{Y}(z+1) - g[N - (z+1)]$, vs.
- $\tilde{\pi}(0; z\bar{Y}) = b\bar{Y}z + \bar{Y} - gz$.
- → (interior) tipping point.

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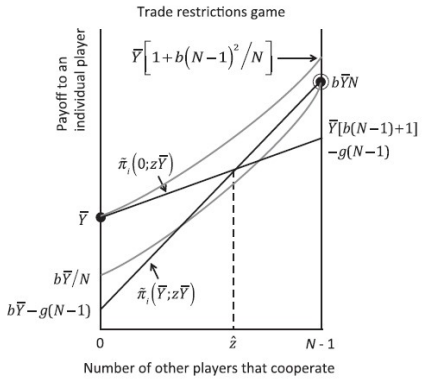

Table 1. Equilibrium properties of various games

			Coordination		
Equilibrium properties	Dilemma/public goods	Treaty/chicken	Weakest link	Catastrophe avoidance	Trade restrictions
Unique?	Yes	Yes	No	No	No
Dominant strategy?	Yes	No	No	No	No
First best efficient?	No	No	Yes	Possibly	Yes
Intermediately efficient?	No	Yes	No	Possibly	No
Symmetric?	Yes	No	Yes	Probably	Yes

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