

Climate Contracts

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- 2 How valuable are agreements?

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- 5 How long should the agreement last?
- 6 How should we update agreements?

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- *But*: Typically 2x2 games

- ① Climate Contracts: A Game of Emissions, Investments, Negotiations, and Renegotiations
Review of Economic Studies (forthcoming) [theoretical framework]
- ② The Dynamics of Climate Agreements [welfare, length, and trade]
- ③ Coalitions and Climate Contracts (w Marco Battaglini) [endogenous coalitions] ...

- ① The model
- ② Analysis
 - ① Business as usual
 - ② Short-term agreements
 - ③ Long-term agreements
 - ④ Long-term agreements with renegotiation
- ③ Trade policies
- ④ Robustness
- ⑤ Conclusions

(1) Model: Equations

- A model with $n + 1$ stocks:

$$G = (1 - d_G) G_- + \sum g_i + \theta, \quad i \in \{1, 2, \dots, n\}$$

$$\theta \sim F(0, \sigma^2)$$

$$R_i = (1 - d_R) R_{i,-} + dr_i + e \sum r_j, \quad j \in \{1 \dots n\} \setminus i$$

$$g_i = y_i - R_i$$

$$u_i = B(y_i) - C(G) - Kr_i$$

$$U_i = \sum u_i \delta^t$$

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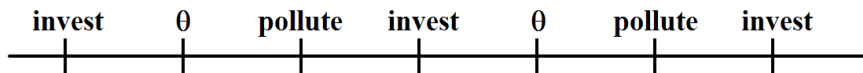
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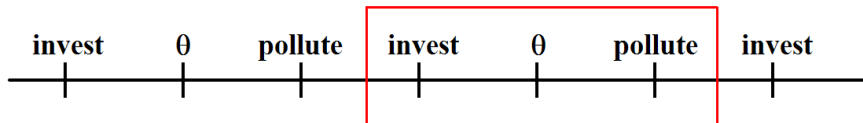
- For example,

$$B(.) = -\frac{b}{2} (\bar{y} - y_i)^2, \quad C(.) = \frac{c}{2} G^2 \quad (\text{Q})$$

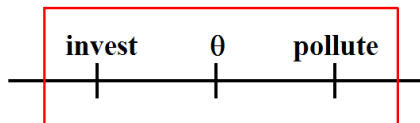
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(1) Model: Solution Concepts

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 - "simplest form of behavior that is consistent with rationality" (Maskin and Tirole, 2001)
- The countries may negotiate short-term or long-term emission levels
- The bargaining solution: Pareto-efficient and symmetric
 - ⇐ Nash Bargaining Solution
 - ⇐ Take-it-or-leave-it with transfers

(2) Analysis

(2.1) Business as Usual

(2.1) Business as Usual: Solution Method

- ① Rather than choosing g_i , i can choose y_i

$$B'(y_i) = C' (q_G G_- + \sum y_j - \sum R_j + \theta) + \delta \partial U_{i,+} / \partial G$$

- ② Same mc/mb. Thus, $y_i = y_j$ even if $R_i \neq R_j$
- If j does not condition r_j or g_j on $R_j - R_i$, neither will i
- ③ Continuation values are $U(G, R)$ and $V(G, R)$, where $R = \sum R_i$
- ④ Since kr_i linear, $V_R(G, R) = k$. Thus, $\partial U / \partial R_- = q_R k / n$
- ⑤ Thus, $R = q_G G_- + \text{constant}$. $\partial U_i / \partial G_- = -k q_G / n + \delta U_R q_G$
- ⑥ Hence, U_i linear in G_- as well

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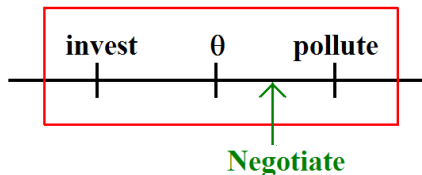
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⇒ A dynamic common pool problem that is **worse** than its static counterpart

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Proposition 1 continues to hold:

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Intuition:

- Hold-up problem: After i has invested, it is cheap to reduce g_i
- Technically: Negotiating the g_i s is equivalent to negotiating the y_i s
- The marginal effects of y_i and y_j are the same even if $R_i \neq R_j \Rightarrow y_i = y_j$

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- Similar outcomes, but not identical. Under (Q):

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- Important when e.g. n and δ large, making $U^{st} < U^{bau}$

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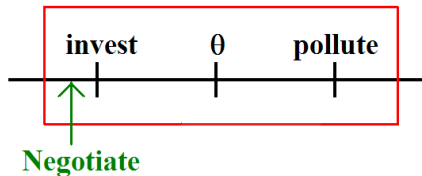
$$u^{bau} > u^{st} \text{ if}$$
$$(n-1)^2 - (1 - \delta [1 - d_R])^2 > \sigma^2 \left[\frac{(b+c)(bcnD/K)^2}{(b+cn^2)(b+cn)^2} \right]$$

ie, *always* if

$$n \rightarrow \infty \text{ or } \sigma \rightarrow 0$$

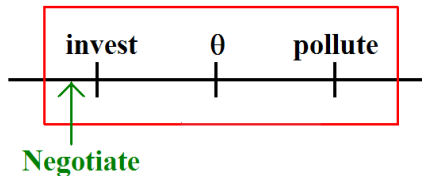
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- Fix g_i before r_i ? No adverse effect of r_i on g_i

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- Fix g_i before r_i ? No adverse effect of r_i on g_i
- But still underinvestments if $e > 0$ or $\delta(1 - d_R) > 0$

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Proposition

- *The optimal agreement is $g^{lt} < Eg^*(r^{lt})$, and more ambitious if e and δ are large*

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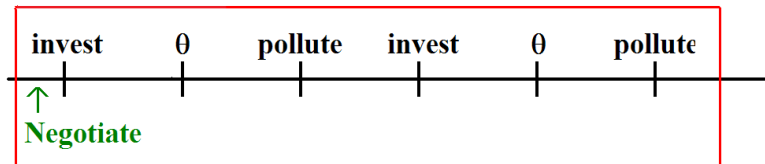
- *Intuition:*

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- g_i^{lt} should satisfy (if Q):

$$g_i^{lt} = Eg_i^*(R^{lt}) - \frac{K(n-1)}{D(b+cn^2)} \left(\frac{e[1-\delta(1-d_R)] + \delta(1-d_R)/n}{D-e(n-1)} \right)$$

(2.3) Long-Term Agreements: Multiple Periods



(2.3) Long-Term Agreements: The Optimal Time Horizon

Proposition

- 1 R_i decreases before the next bargaining stage

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Proposition

- 1 R_i decreases before the next bargaining stage
- 2 To encourage R&D, optimally $g_i - g_i^*$ decreases over time

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- ① R_i decreases before the next bargaining stage
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- R&D $\downarrow$ before next bargaining stage
- $U \downarrow$, particularly if underinvestment (and e) is large

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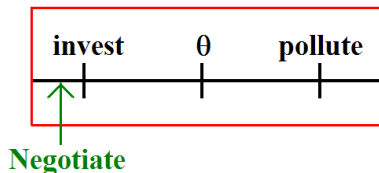
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 - 2.O.C. holds when 1.O.C. does

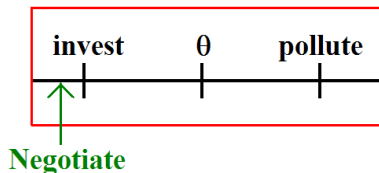
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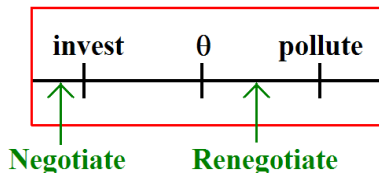
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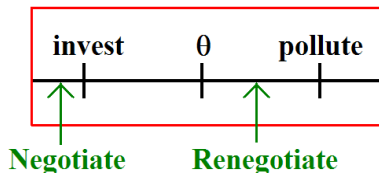
- For long-term agreements, $g_i < E g_i^*$ to encourage R&D
- This is clearly not renegotiation proof

(2.4) Long-Term Agreements with Renegotiation



- With renegotiation, $g_i < E g_i^*$ cannot hold ex post

(2.4) Long-Term Agreements with Renegotiation



- With renegotiation, $g_i < E g_i^*$ cannot hold ex post
- Harder to encourage R&D?

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- ② *The optimal agreement is more ambitious for large e , δ and n*

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- To avoid this, i invests to increase R_i and thus its bargaining power, particularly if g_i^{de} is small

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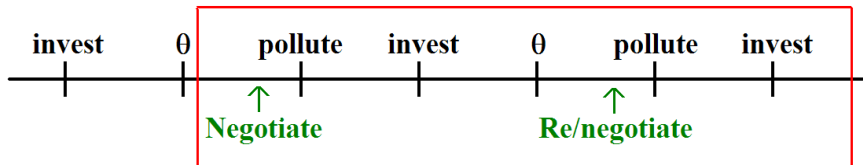
- ① *The outcome is first-best*
- ② *The optimal agreement is more ambitious for large e , δ and n*

• *Intuition:*

- After renegotiation, g_i is set at its *first best* level
- If $g_i^{de} < E g_i^*$, countries renegotiate to a *less* ambitious deal
- A small R_i makes i "desperate" and it has little bargaining power
- To avoid this, i invests to increase R_i and thus its bargaining power, particularly if g_i^{de} is small
- To exploit this effect, set (if Q):

$$g_i^{de} = E g_i^* (R^{de}) - \frac{K}{bD} \left[\frac{en}{D - en} + \delta (1 - d_R) \right]$$

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- For two-period agreements, in every period:
 - Negotiate a new ambitious agreement
 - Renegotiate the old ambitious agreement
 - Time-inconsistent? No, first best!

(3) Trade Policies

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- Thus, trade and short-term climate treaties are *complements*
 - The ambition levels of trade and climate treaties are *substitutes*

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 - Anticipating this, participation may increase

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 - First-best possible by ambitious agreement with renegotiation