Participation and Free Riding

ECON 4910

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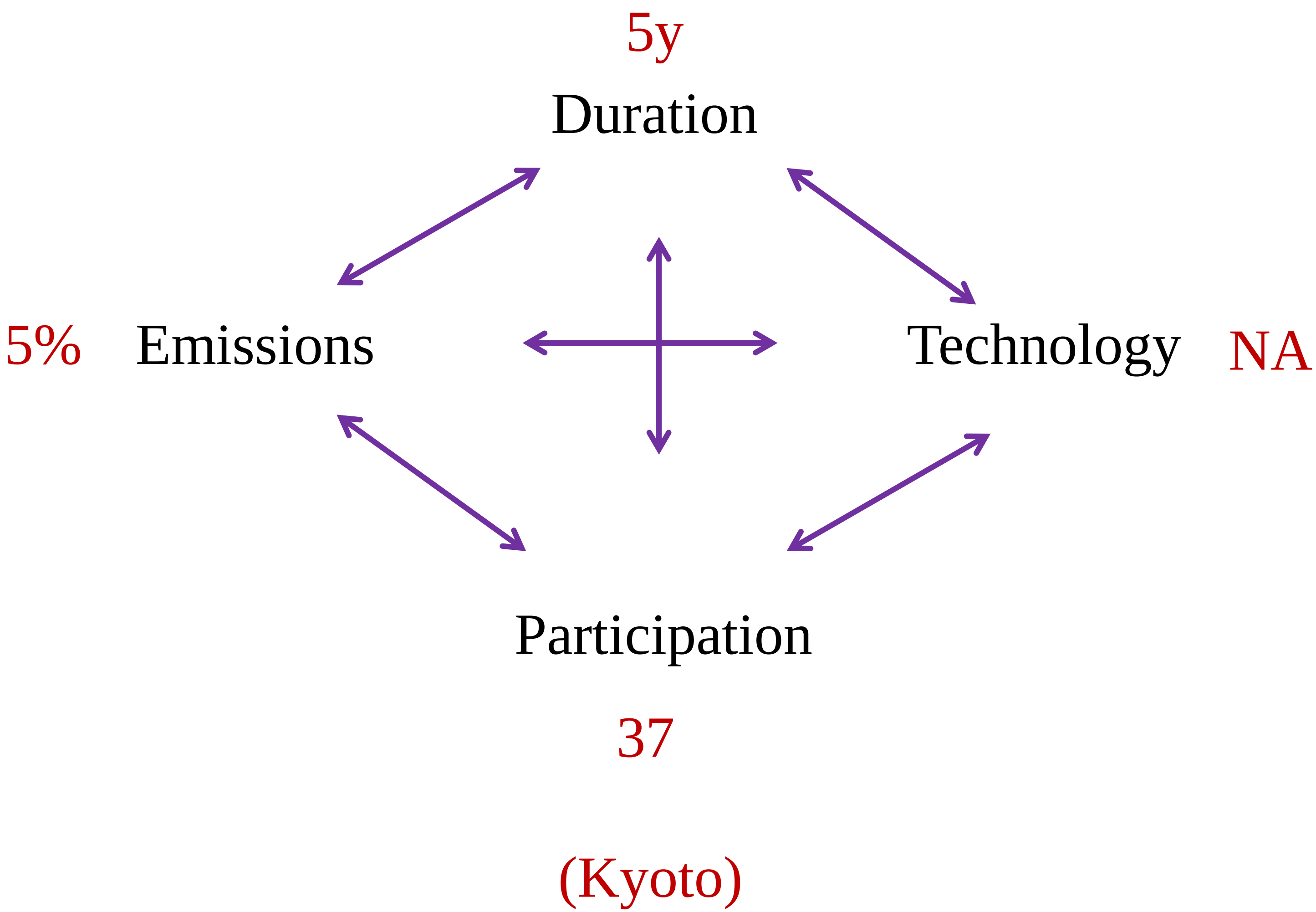
Relationships



Questions – and Preliminary Answers

1. Should one attempt to contract also on R&D?
   YES! (Last lecture, Buchholtz-Konrad, Beccherle-Tirole)

2. Is a long-term agreement better than a short-term one?
   YES! (Last lecture).

3. Is there a trade-off between width, depth, and length?
   YES ☹ (Barrett, Finus and Maus, Carraro, trade-literature)

4. Is the equilibrium coalition necessarily small?
   YES ☹ (Barrett, Carraro-Siniscalco, Hoel, Dixit-Olson)

Assumptions

(can be relaxed)

1. Countries are symmetric
2. Pollution is flow (stock depreciates after a period)
3. Technology depreciates after a period
4. Permits are non-tradable
5. Linear-quadratic utility functions

The "Standard" Participation Model

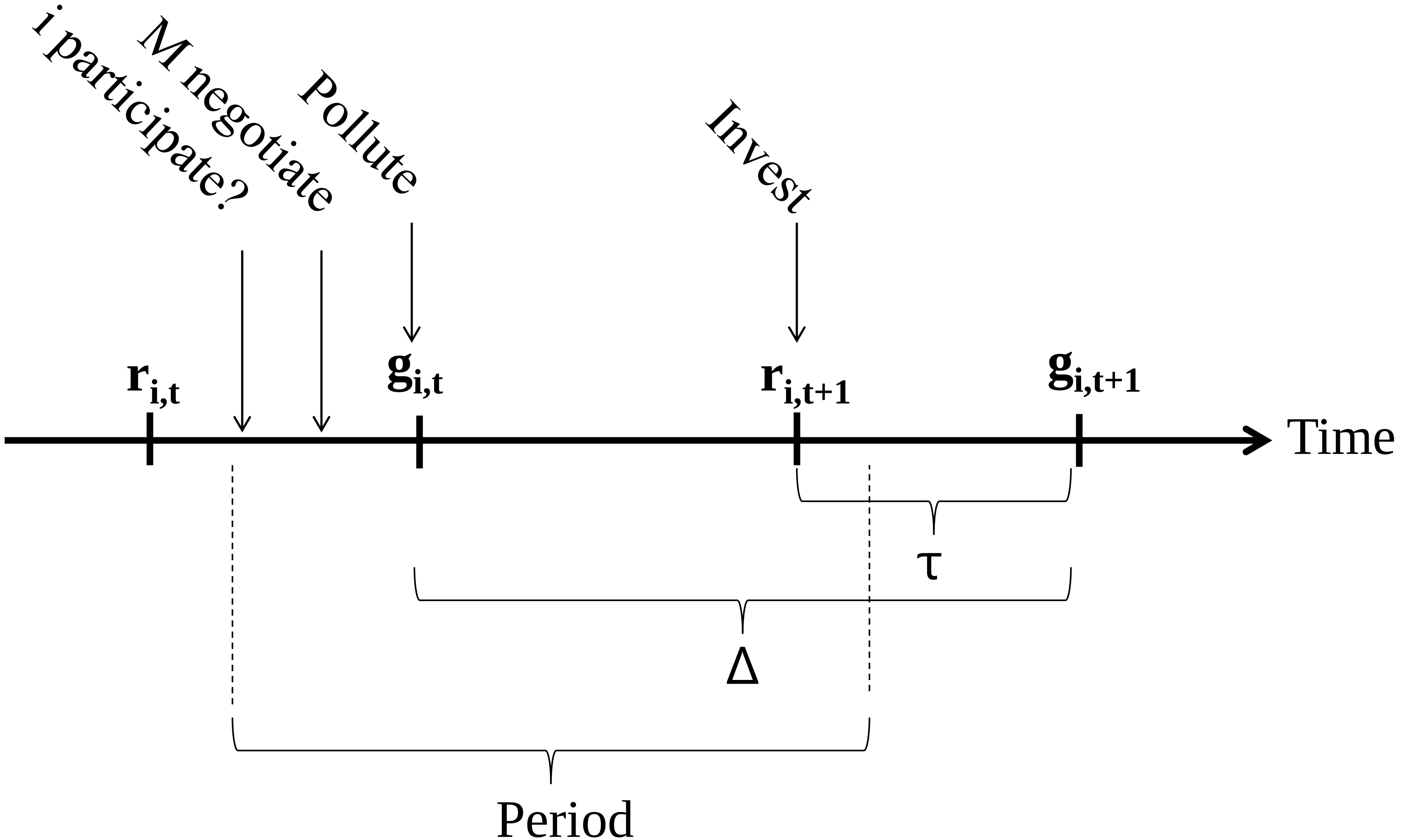
The linear-quadratic model (Barrett '05 for an overview):

Benefit $$B\left(g_{i,t}\right) = -\frac{b}{2}(\bar{y} - g_{i,t})^2,\ i \in N = \{1,\ldots,n\}$$

Costs $$u_{i,t} = B\left(g_{i,t}\right) - C\sum_{i\in N} g_{i,t}$$

Timing: (1) Participate, (2) pollute.
Internal stability: No participation should want to leave
External stability: No free-rider should want to join

A Dynamic Model: Timing



Model: Equations

A linear-quadratic model:

Benefit $$B\left(y_{i,t}\right) = -\frac{b}{2}(\bar{y} - y_{i,t})^2,\ i \in N = \{1,\ldots,n\}$$

Emission $$g_{i,t} = y_{i,t} - r_{i,t}$$

Utility $$u_{i,t} = B\left(y_{i,t}\right) - C\sum_{i\in N} g_{i,t} - \delta \frac{k}{2} r_{i,t+1}^2$$

$$\delta \equiv e^{-\rho\Delta}$$

$$k \equiv e^{\rho\tau}\,\overline{k} \Rightarrow \delta k = e^{-\rho(\Delta-\tau)}\,\overline{k}$$

Equilibria: Markov-perfect

Preliminaries

Preferences rewritten. If:

$$d_{i,t} \equiv \bar{y} - y_{i,t} \Leftrightarrow g_{i,t} = \bar{y} - d_{i,t} - r_{i,t}$$

$$v_{i,1} \equiv \sum_{t=1}^{\infty} \delta^{t-1} \hat{u}_{i,t}, where$$

$$\hat{u}_{i,t} = -\frac{b}{2} d_{i,t}^2 - C \sum_{j \in N} \left(\bar{y} - d_{j,t} - \delta r_{j,t+1} \right) - \delta \frac{k}{2} r_{i,t+1}^2$$

So, **no** past action is «payoff relevant»

… **except** whether commitments have been made…

=> Simple to use **Markov-perfect equilibria**

First Best

Concave&symmetric welfare f.

$$r_{i,t} = n\frac{C}{k}$$

$$d_{i,t} = n\frac{C}{b} \Leftrightarrow$$

$$g_{i,t} = \bar{y} - n\frac{C}{k} - n\frac{C}{b}$$

$$\frac{d_{i,t}}{r_{i,t}} = \frac{k}{b} \equiv x$$

Business as Usual

If nothing is contractible

$$r_{i,t} = \frac{C}{k}$$

$$d_{i,t} = \frac{C}{b} \Leftrightarrow$$

$$g_{i,t} = \bar{y} - \frac{C}{k} - \frac{C}{b}$$

$$\frac{d_{i,t}}{r_{i,t}} = \frac{k}{b} \equiv x$$

Nonparticipants always act this way

	Complete Contracts	Incomplete Contracts
Depth:	*for a given m and T…*	$r_{i,t} = \frac{b(\bar{y} - g_{i,t})}{b+k}, t \leq T, r_{i,T+1} = \frac{C}{k}$
	$r_{i,t} = m\frac{C}{k}$	$g_{i,t} = \bar{y} - m\frac{C}{k} - m\frac{C}{b} \Rightarrow$
	$d_{i,t} = m\frac{C}{b} \Rightarrow$	$r_{i,t} = m\frac{C}{k} > r_{i,T+1} = \frac{C}{k} \Rightarrow$
	$g_{i,t} = \bar{y} - m\frac{C}{k} - m\frac{C}{b}$	$d_{i,t} = m\frac{C}{b}$
	$\frac{d_{i,t}}{r_{i,t}} = \frac{k}{b} \equiv x$	$\frac{d_{i,t}}{r_{i,t}} = \frac{k}{b} \equiv x$
Length:	$T(m) = \infty$ if $m \geq m^*$	$T(m) = \infty$ if $m \geq \hat{m} < m^*$
	$T(m) = 1$ if $m < m^*$	$T(m) = 1$ if $m \leq \hat{m} < m^*$
Width:	***m* = {2,3}***	**Larger; *m*=n* possible**

Intuition

Participate? $m = m^*$ $\Rightarrow$ $T = \infty$ $\Rightarrow$ $r = m(C/k)$

$\succcurlyeq$ *IFF* $m^* \leq \overline{m}_I \equiv \begin{Bmatrix} 3+\frac{2\delta}{x-\delta} \text{ if } x > \delta \\ \infty \text{ if } x \leq \delta \end{Bmatrix}$

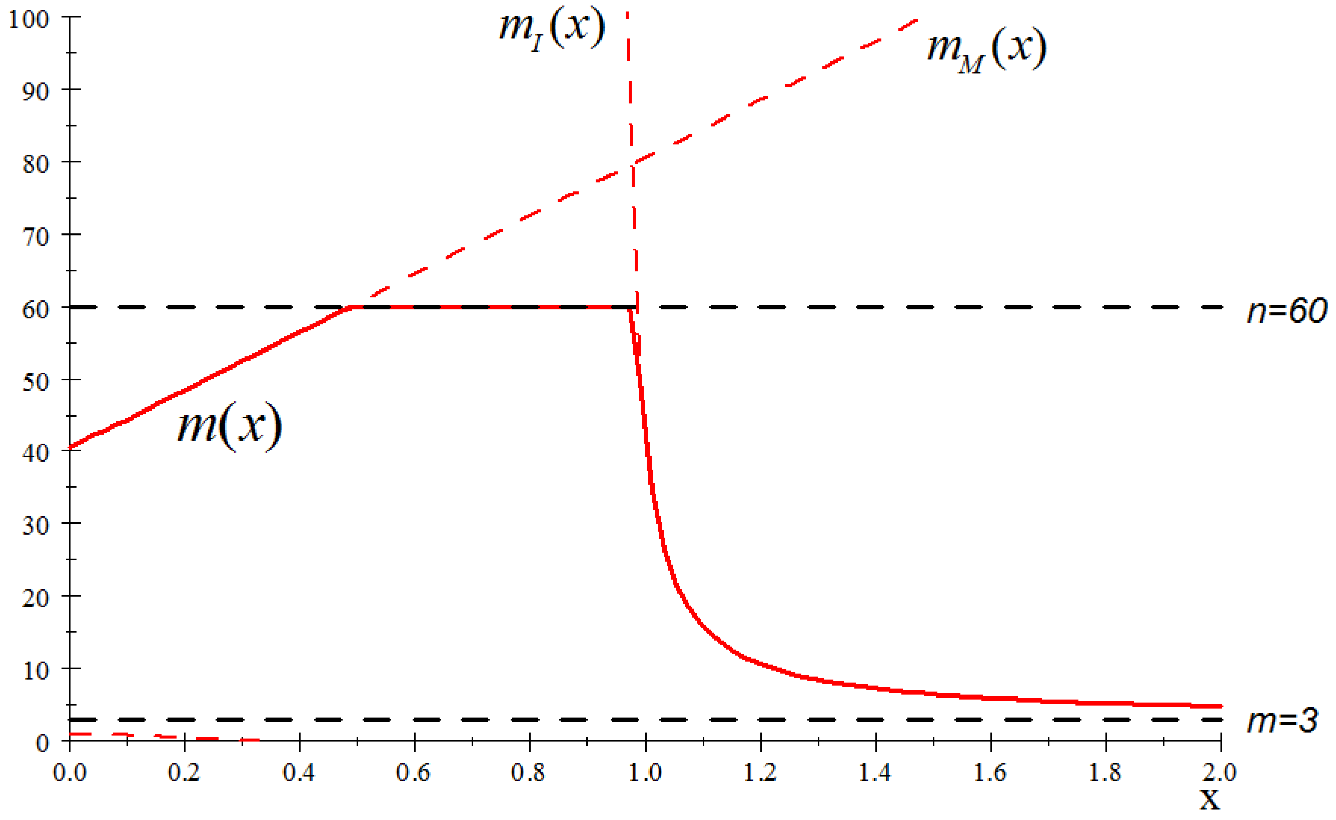
Deviate? $m = m^*\text{-}1$ $\Rightarrow$ $T = 1$ $\Rightarrow$ $r = C/k$

IFF $m^* - 1 \leq \hat{m} \Leftrightarrow m^* \leq \overline{m}_M$, *where*

$$\overline{m}_M \equiv 1 + \frac{1}{1 - \sqrt{\frac{x+\delta}{x+1}}}.$$

Proposition: *m^* is an equilibrium iff:*

$m^* \leq \min\{\overline{m}_I, \overline{m}_M, n\} = n \rightarrow$ ***FB*** *iff $\delta\uparrow$ and x moderate*



The key variable is: $x=k/b$

Bottom line

The hold-up problem can be beneficial and a credible out-of-equilibrium threat, materialized if a participant deviates, investments are noncontractible, and T is endogenous

Participation: Lessons

1. If countries can opt out, there is a strong incentive to free-ride
2. In static linear-quadratic models, only 3 (!) countries want to participate in equilibrium
3. This conclusion continues to hold even if we add:
   a) Green technology or
   b) Many periods
4. But the coalition can be much larger if:
   a) Contracts are incomplete *and*
   b) Duration is endogenous
5. The hold-up problem can then be *beneficial*: it is materialized only if few countries participate, since only a large coalition prefers to lock in the participants, and this (credible) threat can motivate many more countries to participate.
6. There are thus also good equilibria in Kyoto-style games where countries negotiate emissions, but not investments.

Dynamic Games in Environmental Economics

Lessons

Emissions ↔ Investments

1. Recent theory on repeated games, dynamic games, and contract theory can be used to analyze environmental issues.
2. In business as usual, countries may invest strategically little, to motivate others to invest more and pollute less later.
3. In repeated games, countries may want to require over-investments in technology to ensure compliance.
4. With commitments, emission quotas should be small to motivate investments.
5. Investments will be strategically small before bargaining
6. This can make short-term agreements costly.
7. Only a large coalition prefers to lock in for the long run.
8. This *can* motivate free-riders to participate.