Pledge-and-Review Bargaining

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The 1997 Kyoto Protocol

- 37 committed countries.
- Reducing emissions by 5% (on average)
- "Legally binding" emission cuts.
- 5 year commitment period(s).
- Tech/investments decided on noncooperatively.
- "Top-down" negotiations.
  - As in international trade negotiations, countries compared and referred to one another's contributions, and made conditional offers.

The 2015 Paris Agreement

- -*Instead of pursuing a [Kyoto-style] top-down agreement with mandated targets, [the organizers] have asked every country to submit a national plan that lays out how and by how much they plan to reduce emissions in the years ahead*, The New York Times
- Paris Agreement (Art. 4.2): -*Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve.*
- -*Now, instead of setting commitments through centralized bargaining, the Paris approach sets countries free to make their own*, Victor '17
- -*The Paris talks were a bit like a potluck dinner, where guests bring what they can*, The New Yorker
- -*Many governments will be tempted to use the vagueness of the Paris Agreement, and the discretion that it permits, to limit the scope or intensity of their proposed actions*, Keohane and Oppenheimer '16
- -*The pledge-and-review strategy is completely inadequate.* Gollier and Tirole '15, The Economist

Introduction

	Outline	**Paris '15**
(1)	Pledge bargaining a (general) model	"Bottom up" pledges: Nationally determined contributions
(2)	Participation	*n=195*
(3)	(Self)Enforcement	Not legally binding
(4)	Institutional design	Chosen in the 2010s
(5)	Terms of contract	5y periods

A THEORY OF PLEDGE-AND-REVIEW BARGAINING

1. A Theory of Pledge-and-Review Bargaining: Benchmark

- "Top-down" negotiations, standard/conditional bargaining, often approximated by the Nash Bargaining Solution(NBS):

$$\max_{\{g_i\}} \prod_{j \in N} U_j \left(g_i, \mathbf{g}^*_{-i} \right)$$

  - Here, g_i is i's emission, and U_i is i's utility (relative to "business as usual" BAU).
  - Axiomitized by Nash '50
  - *Nash demand game* provides a noncooperative solution (Nash '53, Binmore '87, Kambe '00, Abreu and Gul '00)
  - *Alternating offer bargaining* provides another (Rubinstein '82, Binmore et al. '86), even with many parties (Khrishna and Serrano '96, Kawamori '14, Britz et al. '10, Okada '10, Laruelle and Valenciano '08)
- This approximation no longer justifiable for the Paris Agreement.

1. A Theory of Pledge-and-Review Bargaining

1. Each party i simultaneously pledges to cut emission (g_i) by $x_i \equiv g_i^{BAU} - g_i$. ontribute $x_i \in \mathbb{R}_+$.
2. The parties decides whether to accept $\mathbf{x} \equiv \{x_1, ..., x_n\}$.
   - If every party accepts, each i receives the payoff $U_i(\mathbf{x})$.
   - If at least one party declines, the game restarts after delay Δ.

- With no uncertainty, the equilibrium is simply $x_i = 0$.
- With uncertain willingness to accept/reject, $x_i > 0$.

1. A Theory of Pledge-and-Review Bargaining: Result

Theorem

If $\mathbf{x}^*$ *is a nontrivial locally perfect equilibrium, for every* $i \in N$*:*

$$x_i^* = \arg\max_{x_i} \prod_{j \in N \setminus i} U_i U_j^w, \text{ where}$$

$$w = f(0) \in \left[0, \frac{1}{2}\right]$$

- Here, $f(\cdot)$ is the single-peaked pdf of an "uncertainty parameter".
- Recent lab experiments confirm $w > 0$ even without my exact assumptions on the uncertainty (Lippert and Tremewan, just accepted in *GEB*).
- In contrast, standard bargaining games implement the NBS, in which $w = 1$.
- *Example E:* If $U_i = \alpha \sum_{j \neq i} x_j - \beta x_i^2/2 + \gamma$, then $x_i = w(n-1)\alpha/\beta$.

Conclusion on (1)

	Kyoto '97	**Paris '15**	**Results**
(1)	"Top down" Comparable cuts	"Bottom up" pledges: Nationally determined	Asymmetric NBS with weights w=f(0)$<\frac{1}{2}$
(2)	n=37	n=195	
(3)	Legally binding	Not legally binding	
(4)	Chosen in the 1990s	Chosen in the 2010s	
(5)	5y period 2007-2012	5y periods	

PLEDGE-AND-REVIEW BARGAINING: FROM KYOTO TO PARIS

A Dynamic Game

- Article 4-9: *-Each Party shall communicate a nationally determined contribution every five years*
- -*The idea is that this short time frame would give countries the opportunity to regularly capture scientific and technological developments in their official targets* (CarbonBrief)
- Will the parties have *incentives* to develop such technologies?
- We'll now draw on the literature on dynamic games in climate/environmental economics.
  - Especially Dutta and Radner (2004, 2009, ...)
  - and my own earlier papers, which investigated how emission caps influence technology investments (Harstad, 2012) and how investments influence one's bargaining power (2016).
- The following model is novel in that it permits long-lasting technologies.

A Dynamic Game: Model

- Assume utility is linear in emissions, quadratic in energy consumption from fossils ($g_{i,t}$) + renewables ($R_{i,t}$), and quadratic investment cost:

$$\begin{aligned} u_{i,t} &= -a\sum_{j\in N} g_{j,t} - \frac{b}{2}\left(B_{i,t} - [g_{i,t} + R_{i,t}]\right)^2 - \frac{c}{2}r_{i,t}^2, \text{ where} \\ R_{i,t+1} &= R_{i,t} + r_{i,t}. \end{aligned}$$

- The "business as usual" (BAU/MPE) is

$$g_{i,t}^{BAU} = B_{i,t} - R_{i,t} - \frac{a}{b} \text{ and } r_{i,t}^{BAU} = \frac{\delta}{1-\delta}\frac{a}{c}.$$

- The pledge $x_i \equiv g_{i,t}^{BAU} - g_{i,t}$ commits i for T periods.

A Dynamic Game: Investments

Lemma

In equilibrium, the additional investment $y_{i,t}$ is linear in x_i:

$$
\begin{aligned}
y_{i,t} &= x_i \left(k_1 m_1^{t-1} \left[1 - m_1 \right] - k_2 m_2^{t-1} \left[m_2 - 1 \right] \right), \text{ where} \\
m_1 &\equiv \frac{1}{2}\left(\frac{1}{\delta} + 1 + \frac{b}{c} \right) - \frac{1}{2}\sqrt{\left(\frac{1}{\delta} + 1 + \frac{b}{c} \right)^2 - \frac{4}{\delta}} \in (0,1), \\
m_2 &\equiv \frac{1}{2}\left(\frac{1}{\delta} + 1 + \frac{b}{c} \right) + \frac{1}{2}\sqrt{\left(\frac{1}{\delta} + 1 + \frac{b}{c} \right)^2 - \frac{4}{\delta}} > 1, \\
k_1 &\equiv \frac{m_2^{T-1}\left(m_2 - 1 \right)}{m_1^{T-1}\left(1 - m_1 \right) + m_2^{T-1}\left(m_2 - 1 \right)} \in (0,1), \text{ and} \\
k_2 &\equiv \frac{m_1^{T-1}\left(1 - m_1 \right)}{m_1^{T-1}\left(1 - m_1 \right) + m_2^{T-1}\left(m_2 - 1 \right)} = 1 - k_1 \in (0,1).
\end{aligned}
$$

A Dynamic Game: Equilibrium

Lemma

Party i's continuation value, relative to BAU, is as in Example E:

$$
\begin{aligned}
U_i(\mathbf{x}) &= \alpha \sum_{j \neq i} x_j - \frac{\beta}{2} x_i^2 + \gamma, \quad \textit{where} \qquad (E) \\
\alpha &\equiv \frac{a}{1-\delta}\left[1 - \delta^T\left(k_1 m_1^{T-1} + k_2 m_2^{T-1}\right)\right], \\
\beta &\equiv \sum_{t=1}^{T} \delta^{t-1}\left[b\left(k_1 m_1^{t-1} + k_2 m_2^{t-1}\right)^2\right] \\
&\quad + \sum_{t=1}^{T} \delta^{t-1}\left[c\left(k_1 m_1^{t-1}\left[1 - m_1\right] - k_2 m_2^{t-1}\left[m_2 - 1\right]\right)^2\right], \\
\gamma &\equiv \delta^T U_i(\mathbf{x}^*).
\end{aligned}
$$

- From the theorem, $x_i^* = w(n-1)\alpha/\beta$.

A Dynamic Game: Equilibrium

Proposition

- *A smaller w reduces contributions, investments, and welfare.*

- Payoffs are maximized when $w = 1$:

$$U_i\left(\mathbf{x}^*\right) = \frac{\alpha^2}{\beta\left(1-\delta^T\right)}\left(n-1\right)^2 w\left(1-\frac{w}{2}\right)$$

- Supports criticism of P&R.

2. PARTICIPATION

2. Participation

- The participation stage is standard (d'Aspremont et al., 1983, Hoel '92, Carraro and Siniscalco '93, Barrett '94):
  - Each $i \in \{1, ..., \overline{n}\}$ decides simultaneously whether to participate.
  - The participants continue by playing the game above.
  - The nonparticipating parties find it optimal to contribute $x_i = 0$.
- Every pure-strategy equilibrium is characterized by the same number n^* of participating parties.
  - The 'standard' result is $n^* = 3$ (when $w = 1$)
  - Exceptions (Finus and Maus '08, Karp and Simon '12, Battaglini and Harstad '15)

2. Participation: Result 2

Proposition

- *The equilibrium coalition size is larger if w is small:*

$$n(w) = \lfloor 1 + 2/w \rfloor \approx 1 + 2/w$$

- *Proposition 1 is reversed: A smaller w increases aggregate contributions, investments, and welfare:*

$$U_i^* = \frac{4\alpha^2}{\beta\left(1-\delta^T\right)}\left(\frac{1}{w}-\frac{1}{2}\right).$$

- Note: x_i^* and $(n-1)w$ are invariant in w (since, then, the cost/benefit of participating is unchanged).

Conclusion on (2)

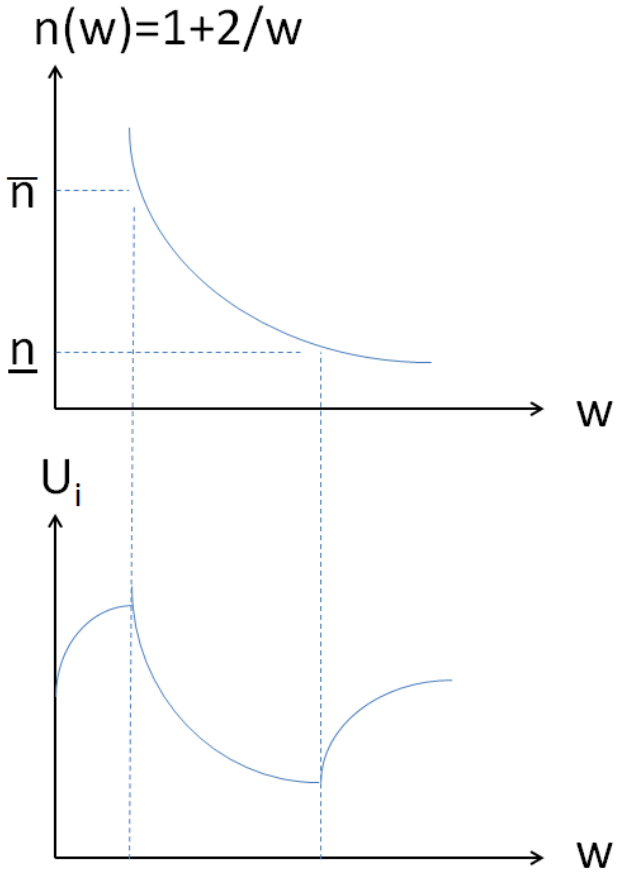
	Kyoto '97	**Paris '15**	**Results**
(1)	"Top down" Comparable cuts	"Bottom up" pledges: Nationally determined	Asymmetric NBS with weights $w=f(0)<\frac{1}{2}$
(2)	n=37	n=195	✓ $n'(w)<0$, so $x'(w)<0$, $y'(w)<0$
(3)	Legally binding	Not legally binding	
(4)	Chosen in the 1990s	Chosen in the 2010s	
(5)	5y period 2007-2012	5y periods	

4. INSTITUTIONAL DESIGN

4. Institutional Design

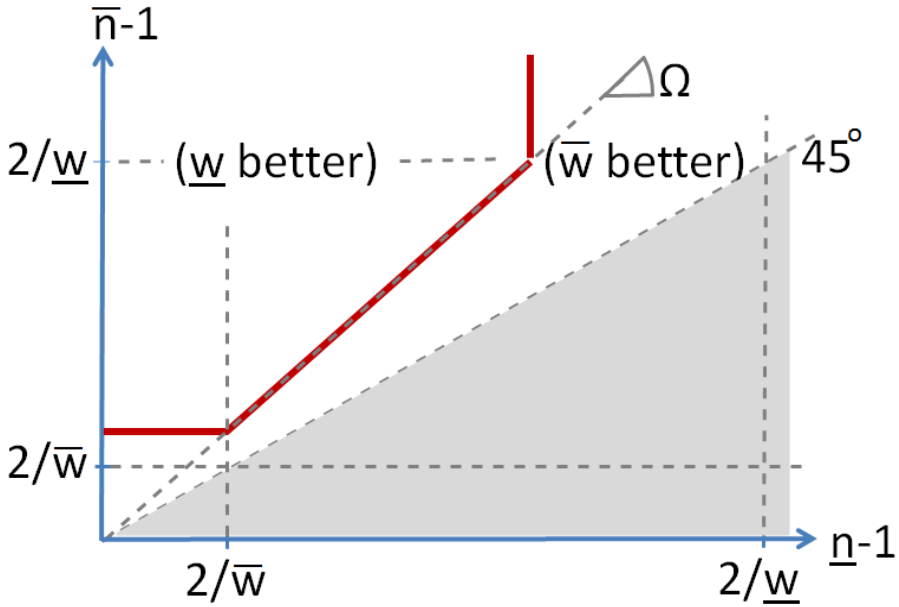
- The level of w depends on the bargaining game.
- With an exogenous n, it is optimal with $w = 1$.
- With an endogenous n, it is optimal with a small w
- There is a trade-off between broad-but-shallow and narrow-but-deep if
  - There are relatively few countries: $\overline{n} < n(w) = \overline{n}$, or
  - There is a large number $\underline{n}$ of 'committed' parties (or minimum participation requirement)

4. Institutional Design



- *If $\underline{n}$ is small and $\overline{n}$ large, then it is better with $\underline{w} < \overline{w}$ (so, pledge-and-review is better than top-down negotiations)*

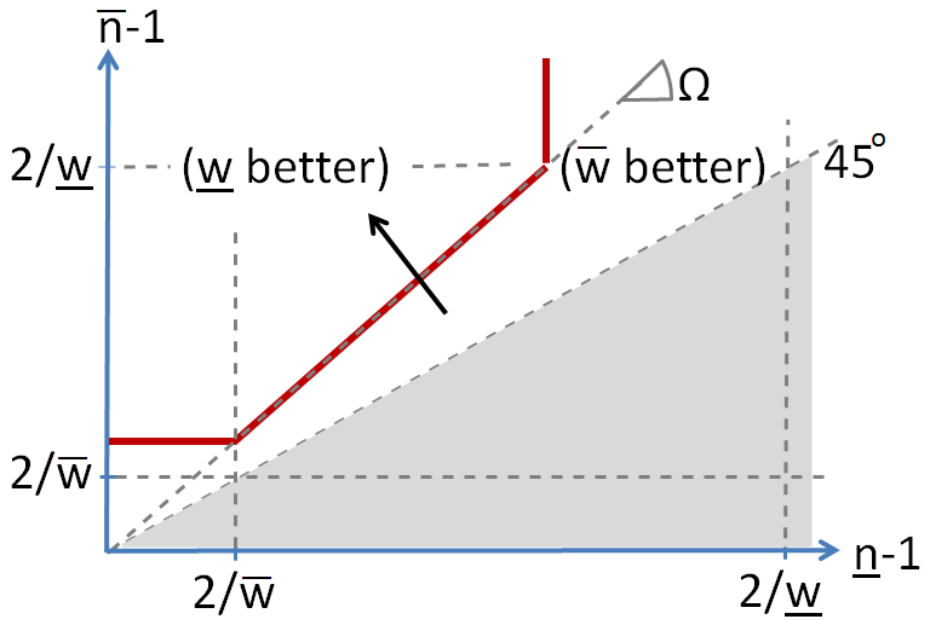
4. Institutional Design



$$\Omega \equiv \sqrt{\frac{\overline{w}\left(1-\overline{w}/2\right)}{\underline{w}\left(1-\underline{w}/2\right)}} \in \left(1, \frac{\overline{w}}{\underline{w}}\right)$$

- *If $\underline{n}$ is small and $\overline{n}$ large, then it is better with $\underline{w} < \overline{w}$ (so, pledge-and-review is better than top-down negotiations)*

4. Institutional Design



- Emerging economies are now more relevant for climate policy, so $\overline{n} \uparrow$
- *-A number of [Kyoto] countries (Belarus, Canada, Japan, New Zealand, Russia, the United States, and Ukraine) decided not to participate in the 2nd period* (IPCC '14). So, $\underline{n} \downarrow$

Conclusion on (4)

	Kyoto '97	**Paris '15**	**Results**
(1)	"Top down" Comparable cuts	"Bottom up" pledges: Nationally determined	Asymmetric NBS with weights $w=f(0)<\frac{1}{2}$
(2)	n=37	n=195	✓ $n'(w)<0$, so $x'(w)<0$, $y'(w)<0$
(3)	Legally binding	Not legally binding	↓
(4)	Chosen in the 1990s	Chosen in the 2010s	✓Due to development
(5)	5y period 2007-2012	5y periods	

3. (SELF)ENFORCEMENT

3. (Self)Enforcement

- Since there is no world government, the treaty must be self-enforcing
- Suppose that if one party "defects", cooperation breaks down from next period on
- If w is small:
  - the cost of contributing is small (for fixed n)
  - the cost of defection is large (endogenous n)
  - the compliance constraint is more likely to hold:

$$w \leq 2 - 2\left[1 - \delta\left(k_1 m_1 + k_2 m_2\right)\right] \frac{a\left(1 - \delta^T\right)}{\alpha\left(1 - \delta\right)}$$

- What if w is large? IPCC '14: *a more legally binding commitment ... signals a greater seriousness by states ... These factors increase the costs of violation (through enforcement and sanctions at international and domestic scales, the loss of mutual cooperation by others, and the loss of reputation and credibility in future negotiations).*

Conclusion on (3)

	Kyoto '97	**Paris '15**	**Results**
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(2)	n=37	n=195	✓ $n'(w)<0$, so $x'(w)<0$, $y'(w)<0$
(3)	Legally binding	Not legally binding	✓Self-enforcing if w ↓
(4)	Chosen in the 1990s	Chosen in the 2010s	✓Due to development
(5)	5y period 2007-2012	5y periods	

5. THE CONTRACT TERMS

5. Contract Terms: Length of the Commitment Period

- The optimal **period length** solves the following trade-off:

1. With a **larger** T, pledges will not reflect recent advancements in technology (Harris and Holmstrom '87).
2. With a **smaller** T, investments are low because of the next approaching hold-up problem (Beccherle and Tirole '11, Harstad '16)

- This trade-off, and the optimal T^*, are independent of w and n:

$$T^* = \arg\max_T \frac{\alpha^2}{\beta\left(1-\delta^T\right)}.$$

Conclusion: From Kyoto to Paris

	Kyoto '97	**Paris '15**	**Results**
(1)	"Top down" Comparable cuts	"Bottom up" pledges: Nationally determined	Asymmetric NBS with weights $w=f(0)<\frac{1}{2}$
(2)	$n=37$	$n=195$	✓ $n'(w)<0$, so $x'(w)<0$, $y'(w)<0$
(3)	Legally binding	Not legally binding	✓Self-enforcing if $w \downarrow$
(4)	Chosen in the 1990s	Chosen in the 2010s	✓Due to development
(5)	5y period 2007-2012	5y periods	✓ $T'(n)=T'(w)=0$

Robustness

1. Pledging to invest (then, T^* becomes irrelevant)
2. Pledging on emission taxes
3. Pledging both investments and emission taxes
4. Pledging investments and contributions
5. Pledging a path of contributions (then, $T^* = \infty$)
6. Firms may invest (then, $T^* = 1$)
7. Timing: The decision on T can be after/in-between
8. Multiple participation stages
9. Multiple bargaining choice stages
10. Limited punishments

- **All propositions continue to hold.**