International Climate Action: Bargaining, Participation, Compliance

Bård Harstad

Stanford GSB

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Outline

Kyoto and Paris*

0. Bargaining Procedures

1. Dynamic Climate Games

2. Participation vs. Free Riding

3. Compliance vs. Defection

4. Institutional Design

* The lecture notes were published in Economic Journal, 2023, in a paper with the title "Pledge-and-Review Bargaining: From Kyoto to Paris"

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

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

Differences

	Kyoto '97	**Paris '15**
(1)	"Top down" bargaining	"Bottom up" pledges: Nationally determined contributions
(2)	*n=37*	*n=195*
(3)	Legally binding cuts	Not legally binding
(4)	Chosen in the 1990s	Chosen in the 2010s
(5)	5y periods	5y periods

BARGAINING GAMES

Top-down Bargaining (Kyoto style)

- "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.

Bottop-up Bargaining (Pledge-and-Review)

- When i's contribution is nationally determined, lower weights are placed on the payoff of other countries:

$$\max_{\{g_i\}} \prod_{j \in N \setminus i} U_i U_j^w, \text{ where } w < 1.$$

  - With uncertainty, i may be worried that the agreement would not succeed unless contributions are acceptable. This can explain why $w > 0$.
  - A microfoundation for this bargaining outcome is presented in the "Pledge-and-Review Bargaining", Journal of Economic Theory (Harstad, 2023).
  - Here, we analyze the *consequence* of the two different bargaining games.
  - *Example E:* If $U_i = \alpha \sum_{j \neq i} x_j - \beta x_i^2/2 + \gamma$, then $x_i = w(n-1)\alpha/\beta$.

DYNAMIC CLIMATE GAMES

1. 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?
- 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.

Lemma

In equilibrium, the additional investment $y_{i,t}$, and $Y_{i,t}$, are both linear in x_i:

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

1. A Dynamic Game: Equilibrium

Lemma

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

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

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

1. A Dynamic Game: Equilibrium

Proposition

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

- Payoffs are maximized when $w = 1$:

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

- Welfare is lower when w is small.
- This supports the criticism of P&R.

2. PARTICIPATION

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- 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.*

- Note: x_i^* and $(n-1)w$ are invariant in w (intuition: then, the cost/benefit of participating is unchanged).
- Although $\partial x_i^*/\partial w = 0$, *aggregate* contributions decreases in w.
- Payoffs decrease in w:

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

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

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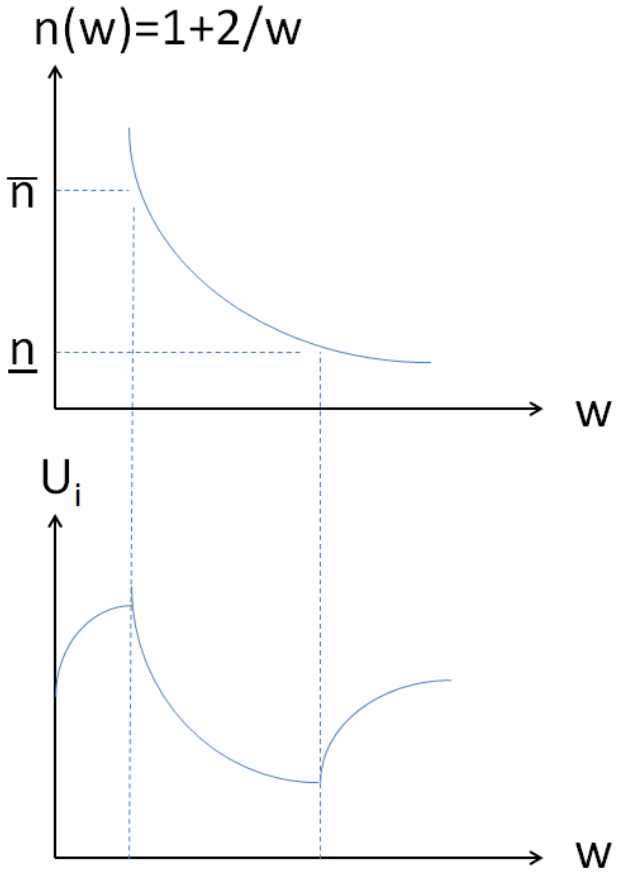
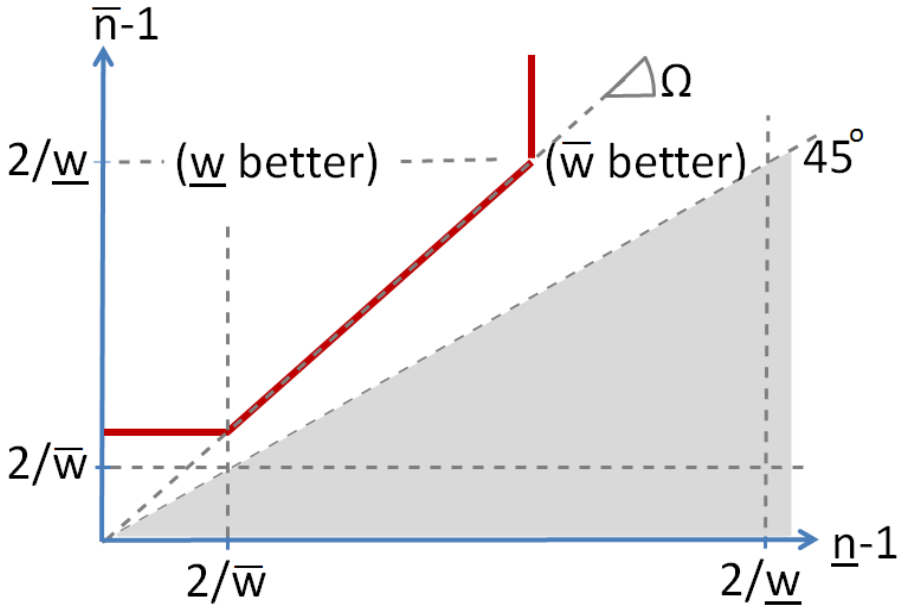
- The level of w depends on the bargaining game.
- With an exogenous n, it is optimal with $w = 1$.
- With an endogenous n, it is optimal with a small w
- There is a trade-off between broad-but-shallow and narrow-but-deep if
  - There are relatively few countries: $\overline{n} < n(w) = \overline{n}$,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

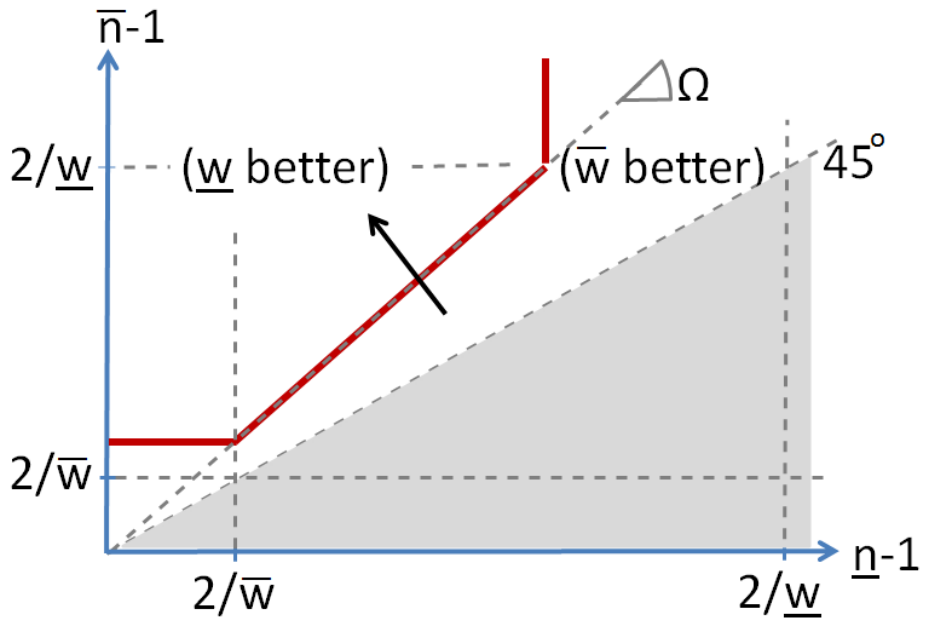
4. Institutional Design



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

- *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. COMPLIANCE

3. Compliance

- 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 incentive 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)

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(3)	Legally binding	Not legally binding	✓Self-enforcing if w
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THE CONTRACT TERMS

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)

- Trade-off, and the optimal T^*, independent of w and n:

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

Conclusion

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(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	✓ $T'(n)=T'(w)=0$

Literature (incomplete)

1. Nash Bargaining Solution (in Nash '50, Kalai '77)
   - Nash demand game provides a noncooperative solution (Nash '53, Binmore '87), also with strategic uncertainty (Carlsson '91, Andersson et al. '17, Abreu and Pearce '15 Abreu and Gul (2000) kambe 2000 Binmore 87).
   - Alternating offer bargaining provides another (Rubinstein '82, Binmore et al. '86, Kawamori '14)
   - **Here:** Pledge-and-review provides an asymmetric (and inefficient) NBS.
2. Dynamic games with emissions, negotiations, and technology
   - Some early models by Dutta and Radner '04, '06, '09, and own work assume efficient negotiations to study contract design and renegotiation (Harstad '12), hold-up problems and international trade (Harstad '15), or compliance (Harstad et al., '18).
   - **This lecture** studies the consequence of the bargaining game.
3. Participation
   - Small coalitions ($n^*=3$) predicted by Hoel '92, Barrett '94, Carraro and Siniscalco '93
   - Battaglini and Harstad '15 predict larger coalitions when the participants can decide on the period length. (This effect is abstracted from here.)
   - **This lecture** generalizes results on the trade-off between depth and breadth (f.ex. Finus and Maus '08), provides a foundation for "modesty" in bargaining, and discusses implications for investments and period length.

Robustness

1. Pledging to invest (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 ($T^* = \infty$)
6. Firms may invest ($T^* = 1$)
7. The timing of T can be after/in between
8. Multiple participation stages
9. Multiple bargaining choice stages
10. Limited punishments

Conclusion

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