

Pledge-and-Review Bargaining: from Kyoto to Paris

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- "Top-down" negotiations.
 - As in international trade negotiations, countries compared and referred to one another's contributions, and made conditional offers.

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- *-**The pledge-and-review strategy is completely inadequate.** Gollier and Tirole '15, The Economist*

Differences

Kyoto '97

- (1) "Top down" bargaining
- (2) $n=37$
- (3) Legally binding cuts
- (4) Chosen in the 1990s
- (5) 5y periods

Paris '15

- "Bottom up" pledges:
Nationally determined contributions
- $n=195$
- Not legally binding
- Chosen in the 2010s
- 5y periods

BARGAINING GAMES

Top-down Bargaining (Kyoto style)

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

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

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- 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:

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

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- Here, we analyze the consequence of the two different bargaining games.

- I. SIMPLE MODEL (UNDERGRADUATE)
- II. DYNAMIC GAME (GRADUATES)

I. SIMPLE MODEL (UNDERGRADUATE)

Model

- Assume utility is:

$$u_{i,t} = -a \sum_{j \in n} g_{j,t} - \frac{b}{2} (\bar{g}_{i,t} - g_{i,t})^2$$

$$v_{i,t} = \sum_{\tau=t}^{\infty} \delta^{\tau-t} u_{i,\tau}.$$

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- The (present-discounted) cost of emission is a , $g_{i,t}$ is i 's greenhouse-gas emission, $\bar{g}_{i,t}$ is i 's bliss point, b is the cost of deviating from the bliss point, and $\delta \in (0, 1)$ the discount factor.

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- First best

$$g_{i,t}^{FB} = \bar{g}_{i,t} - n \frac{a}{b}.$$

Bargaining

- Nash bargaining solution:

$$\begin{aligned}g_{i,t}^{eq} &= \arg \max_{g_{i,t}} \prod_{j \in M} (u_j - u_j^{BAU}) \\&= \arg \max_{g_{i,t}} \sum_{j \in M} (u_j - u_j^{BAU}) \\&= \bar{g}_{i,t} - m \frac{a}{b} .\end{aligned}$$

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- Pledge-and-review:

$$\begin{aligned}g_{i,t}^{eq} &= \arg \max_{x_i} u_i \prod_{j \in M \setminus i} u_j^w \\&= \arg \max u_i + w \sum_{j \in M \setminus i} (u_j - u_j^{BAU}) \\&= \bar{g}_{i,t} - \frac{a}{b} - w(m-1) \frac{a}{b}.\end{aligned}$$

Payoff for a participant

- One-period benefit from an insider is $u_{i,t}^M$, which is $-a \sum_j \bar{g}_{j,t}$ plus

$$\begin{aligned} & -\frac{a^2}{2b} (1 + w(m-1))^2 + cm(1 + w(m-1)) \frac{a}{b} + a(n-m) \frac{a}{b} \\ = & -\frac{a^2}{2b} \left[(1 + w(m-1))^2 - 2m(1 + w(m-1)) - 2(n-m) \right] \\ = & -\frac{a^2}{2b} \left[(1 + w(m-1))^2 - 2mw(m-1) - 2n \right] \\ = & -\frac{a^2}{2b} \left[1 + 2w(m-1) + (w(m-1))^2 - 2mw(m-1) - 2n \right] \\ = & -\frac{a^2}{2b} \left[1 - 2n - w(2-w)(m-1)^2 \right]. \end{aligned}$$

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- The optimal w is 1. Why?

Payoff for a free rider

- Payoff for a free rider is $u_{i,t}^{N \setminus M}$, which is:

$$\begin{aligned} & -\frac{a^2}{2b} + cm(1 + w(m-1))\frac{a}{b} + a(n-m)\frac{a}{b} - a\sum_j \bar{g}_{j,t} \\ = & -\frac{a^2}{2b} [1 - 2wm(m-1) - 2n] - a\sum_j \bar{g}_{j,t} \end{aligned}$$

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- It is easy to check that the payoff of a free-rider is always larger.
- Why?

Participation

- But if one of the m participants free ride, then m is reduced by 1, and the new free-rider only obtain:

$$u_{i,t}^F = -\frac{a^2}{2b} [1 - 2w(m-1)(m-2) - 2n] - a \sum_j \bar{g}_{j,t}.$$

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- By comparison, it is better to participate if:

$$\begin{aligned} u_{i,t}^M &\geq u_{i,t}^F \Leftrightarrow \\ -\frac{a^2}{2b} \left[(1 + w(m-1))^2 - 2mw(m-1) - 2n \right] &\geq \\ -\frac{a^2}{2b} [1 - 2w(m-1)(m-2) - 2n] &\Leftrightarrow \\ (1 + w(m-1))^2 - 1 &\leq \\ 2mw(m-1) - 2w(m-1)(m-2) &\Leftrightarrow \\ m &\leq 2/w + 1. \end{aligned}$$

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- What if $w = 1$? What if $w < 1$?

Modesty may pay

- When this binds, this also implies

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- Q: What is the preferred w ? Why?

Full participation

- If $w = \underline{w}$ is so small that everyone participates, then $u_{i,t}^M$ is:

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- Again, for a given n , it is optimal with $\underline{w} = 1$.

Choice of bargaining game

- This $\underline{w} < \bar{w}$ (with full participation) is better than $\bar{w}$ iff

$$1 - 2n - \underline{w} (2 - \underline{w}) (n - 1)^2 < 5 - \frac{8}{\bar{w}} - 2n \Leftrightarrow$$

$$\underline{w} (2 - \underline{w}) (n - 1)^2 > \frac{4}{\bar{w}} - 2 \Leftrightarrow$$

$$n > 1 + \sqrt{\frac{4}{\bar{w}} - 2 - \underline{w} (2 - \underline{w})}.$$

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- Can this shed light on Paris vs. Kyoto?

- Payoff in BAU:

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- Comply? The compliance constraint is:

$$\begin{aligned} -\frac{a^2}{2b} \left[(1 + w(m-1))^2 - 2mw(m-1) - 2n \right] &\geq \\ -\frac{a^2}{2b} \left((1 - 2n - 2w(m-1)^2) (1 - \delta) - \delta \frac{a^2}{2b} [1 - 2n] \right) &\Leftrightarrow \\ -\left[(1 + w(m-1))^2 - 2mw(m-1) - 2n \right] &\geq \\ -\left((1 - 2n - 2w(m-1)^2) (1 - \delta) - \delta [1 - 2n] \right) &\Leftrightarrow \end{aligned}$$

Compliance (continues...)

$$\begin{aligned} - \left[(w(m-1))^2 + 2w(m-1) - 2mw(m-1) \right] &\geq \\ &- \left(-2w(m-1)^2 \right) (1-\delta) \Leftrightarrow \\ - \left[(w(m-1))^2 - 2w(m-1)^2 \right] &\geq \\ 2w(m-1)^2 (1-\delta) &\Leftrightarrow \\ w(2-w)(m-1)^2 &\geq \\ 2w(m-1)^2 (1-\delta) &\Leftrightarrow \\ (2-w) &\geq 2(1-\delta). \end{aligned}$$

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- What are the roles of the various parameters? Why?
- What happens if this inequality does not hold?

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	Kyoto '97	Paris '15	Results
(1)	"Top down" Comparable cuts	"Bottom up" pledges: Nationally determined	Smaller w under Paris?
(2)	$n=37$	$n=195$	✓ $n'(w) < 0$, so $x'(w) < 0$, $y'(w) < 0$
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II. DYNAMIC GAME (GRADUATES)

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$$u_{i,t} = -a \sum_{j \in N} g_{j,t} - \frac{b}{2} (B_{i,t} - [g_{i,t} + R_{i,t}])^2 - \frac{c}{2} r_{i,t}^2, \text{ where}$$

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

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

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

1. A Dynamic Game: Investments

Lemma

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

$$y_{i,t} = x_i \left(k_1 m_1^{t-1} [1 - m_1] - k_2 m_2^{t-1} [m_2 - 1] \right) \text{ and}$$

$$Y_{i,t} = x_i \left(1 - k_1 m_1^{t-1} - k_2 m_2^{t-1} \right), \text{ where}$$

$$m_1 \equiv \frac{1}{2} \left(\frac{1}{\delta} + 1 + \frac{b}{c} \right) - \frac{1}{2} \sqrt{\left(\frac{1}{\delta} + 1 + \frac{b}{c} \right)^2 - \frac{4}{\delta}} \in (0, 1),$$

$$m_2 \equiv \frac{1}{2} \left(\frac{1}{\delta} + 1 + \frac{b}{c} \right) + \frac{1}{2} \sqrt{\left(\frac{1}{\delta} + 1 + \frac{b}{c} \right)^2 - \frac{4}{\delta}} > 1,$$

$$k_1 \equiv \frac{m_2^{T-1} (m_2 - 1)}{m_1^{T-1} (1 - m_1) + m_2^{T-1} (m_2 - 1)} \in (0, 1), \text{ and}$$

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1. A Dynamic Game: Equilibrium

Lemma

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

$$U_i(\mathbf{x}) = \alpha \sum_{j \neq i} x_j - \frac{\beta}{2} x_i^2 + \gamma, \quad \text{where} \quad (E)$$

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

$$\beta \equiv \sum_{t=1}^T \delta^{t-1} \left[b \left(k_1 m_1^{t-1} + k_2 m_2^{t-1} \right)^2 \right] \\ + \sum_{t=1}^T \delta^{t-1} \left[c \left(k_1 m_1^{t-1} [1 - m_1] - k_2 m_2^{t-1} [m_2 - 1] \right)^2 \right], \quad (1)$$

$$\gamma \equiv \delta^T U_i(\mathbf{x}^*).$$

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

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 - Exceptions (Finus and Maus '08, Karp and Simon '12, Battaglini and Harstad '15)

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- Payoffs decrease in w :

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

Conclusion on (2)

Kyoto '97

(1) "Top down"
Comparable cuts

(2) $n=37$

(3) Legally binding

(4) Chosen in the 1990s

(5) 5y period 2007-2012

Paris '15

"Bottom up" pledges:
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5y periods

Results

Asymmetric NBS with
weights $w=f(0)<\frac{1}{2}$

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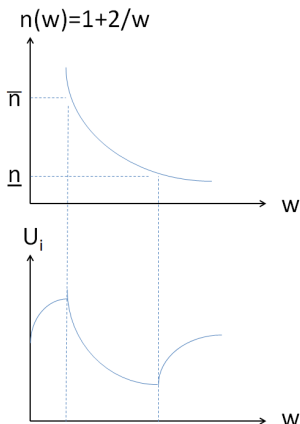
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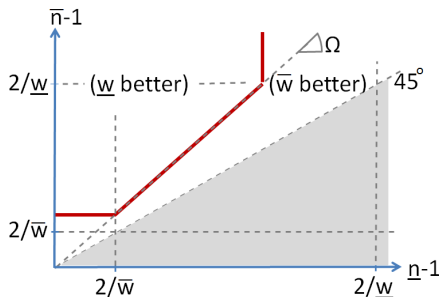
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 - There is a large number $\underline{n}$ of 'committed' parties (or minimum participation requirement)

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

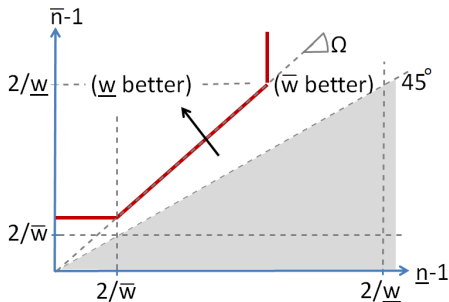
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$$\Omega \equiv \sqrt{\frac{\bar{w}(1 - \bar{w}/2)}{\underline{w}(1 - \underline{w}/2)}} \in \left(1, \frac{\bar{w}}{\underline{w}}\right)$$

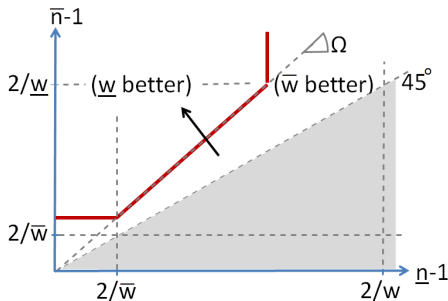
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- A number of [Kyoto] countries (Belarus, Canada, Japan, New Zealand, Russia, the United States, and Ukraine) decided not to participate in the 2nd period (IPCC '14). So, $\underline{n} \downarrow$

Conclusion on (4)

Kyoto '97

Paris '15

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- | | | | |
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5. THE CONTRACT TERMS

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

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

Conclusion

Kyoto '97

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Results

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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 paper** studies bargaining inefficiency's foundation and consequences.

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 paper** 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.

- ➊ Pledging to invest (T^* becomes irrelevant)
 - ➋ Pledging on emission taxes
 - ➌ Pledging both investments and emission taxes
 - ➍ Pledging investments and contributions
 - ➎ Pledging a path of contributions ($T^* = \infty$)
 - ➏ Firms may invest ($T^* = 1$)
 - ➐ The timing of T can be after/in between
 - ➑ Multiple participation stages
 - ➒ Multiple bargaining choice stages
 - ➓ Limited punishments
- **All results continue to hold.**