# Conditional Pledges in International Negotiations on a Climate Agreement – How Far Can They Carry?

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# Motivation

- At the COP 15 in Copenhagen, and in the subsequently signed Copenhagen agreement, the EU made their pledges conditional on abatement in the rest of the world.
- Such conditional pledges constitute an additional incentive for other countries to take GHG emissions abatement serious and abate more.
- How far can this approach to the negotiations possibly carry?

# Related work and own approach

I combine 'matching' with questions of coalition formation (different approach than Buchholz, Cornes and Rübbelke 2012[1]).

- Coalition regions match non-coalition regions (increase coalition abatement proportionally to non-coalition abatement).
- Non-coalition regions do not match back and react rationally to matching.
- Which coalitions are stable?[2] Could Europe get other regions to join?

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[1] Wolfgang Buchholz, Richard C. Cornes and Dirk T. G. Rübbelke (2012). *Potentially Harmful International Cooperation on Global Public Good Provision*. SSRN Scholarly Paper ID 2133157. Rochester, NY: Social Science Research Network.

[2] Michael Finus and Bianca Rundshagen (2001). *Endogenous Coalition Formation in Global Pollution Control*. SSRN Scholarly Paper ID 278511. Rochester, NY: Social Science Research Network.

# Model: Assumptions

- Coalition and non-coalition regions are assumed to be perfectly informed about climate impacts.
- Non-coalition regions act rationally when trading off abatement cost against benefits, taking into account that their abatement will be matched by coalition regions.
- Coalition regions are undecided on the extent to which they want to internalize each others benefits from abatement.
  - Coalition can credibly announce a range of abatement levels.

# Game

1. Coalition announces unconditional abatement level and matching rates.
2. Non-coalition, facing matching rate, decides on abatement level.
3. Coalition observes non-coalition abatement and tops up its unconditional abatement.

Anticipating outcomes in stages 2 and 3,

- the coalition announces smallest possible unconditional contribution (it has to be credible),
- chooses to match all non-coalition regions with same rate, and
- chooses the rate such that the outcome in stages 2 and 3 maximize coalition welfare.

# Stylized facts about costs and benefits of abatement

Motivated by the behavior of the RICE integrated assessment model (Nordhaus 2010)[3], I posit stylized facts:

- Climate impacts on intertemporal utility differ by region
- Constant marginal impacts of one period's emissions
- Marginal abatement cost has form $c_r(a) = \gamma_r a^{\epsilon}$ with region specific cost factor $\gamma_r$

[3] William D. Nordhaus (2010). "Economic aspects of global warming in a post-Copenhagen environment". In: *Proceedings of the National Academy of Sciences* 107.26, pp. 11721–11726.

# System of equations

Indices: $r$ (regions), $c$ (coalition), $nc$ (non-coalition)

F.O.C. $a_{nc}$ : $$\gamma_{nc} a_{nc}^{\epsilon} = (1 + \mu_C)\beta_{nc}$$

Maximum $\mu_c$ : $$\sum_{c} (a_c - \underline{a}_c) = \mu_C \sum_{nc} (a_{nc} - \underline{a}_{nc})$$

F.O.C. $a_c$ : $$\gamma_c a_c^{\epsilon} = \left(1 + \frac{\mathrm{d}\mu_c}{\mathrm{d}a_c} \sum_{nc} \frac{\partial a_{nc}}{\partial \mu_c}\right) \sum_{c} \beta_c,$$

where $\underline{a}_r$ solves $\gamma_r a_r^{\epsilon} = \beta_r$.

# Matching coalitions with symmetric regions

Benefits and costs are equally spread over $n$ regions

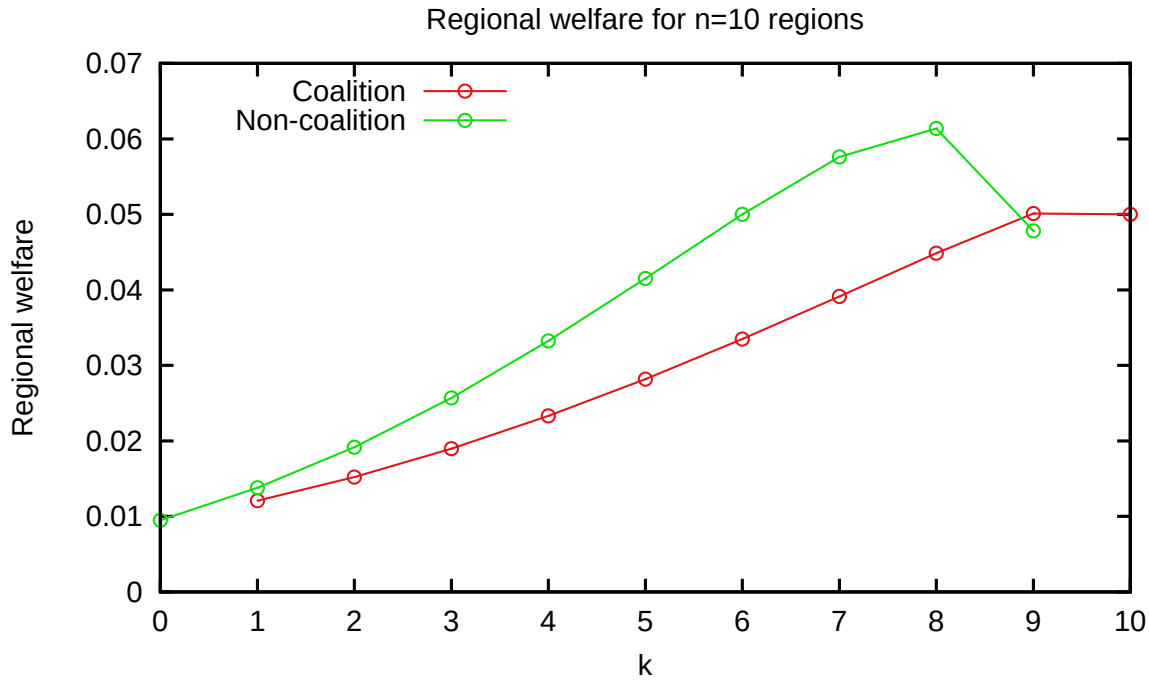
| | |
|---|---|
| Global | Marginal benefits: 1 |
| | Abatement cost: $C(A) = \gamma A^2/2$ |
| | Marginal abatement cost: $MC(A) = \gamma A$; |
| Regional | Marginal benefits: $1/n$ |
| | Abatement cost: $c(a_r) = n\gamma a_r^2/2$ |
| | Marginal abatement cost: $mc(a_r) = n\gamma a_r$, |

where global abatement $A$ is the sum of all regional abatement $a_r$.

# Stability of coalitions

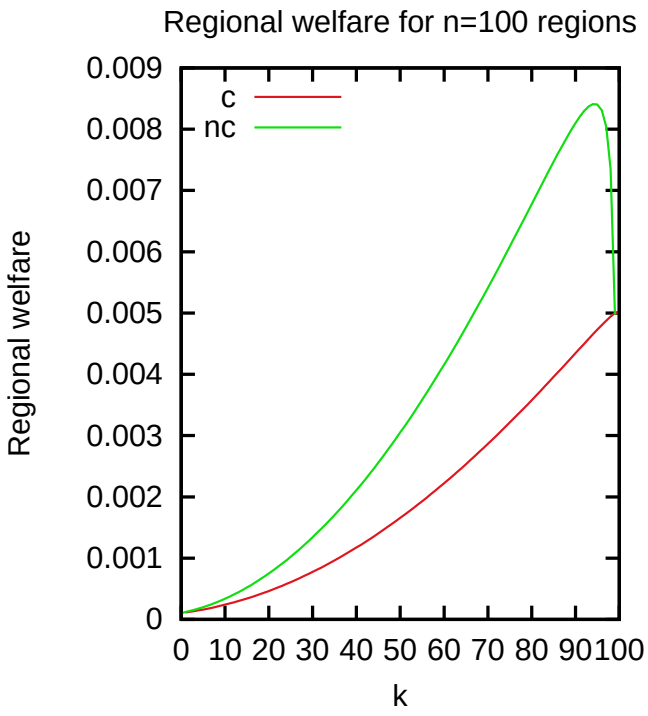
Welfare considers costs and benefits of abatement:

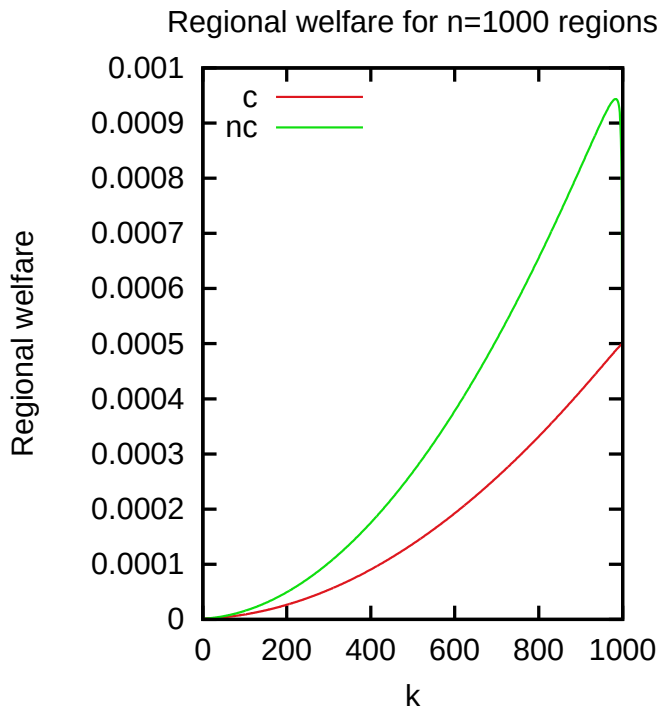
$$w_r = -c(a_r) + A_{\text{global}} = -n\gamma a_r^2/2 + A_{\text{global}}$$




Coalitions of size 1,2, and 10 are stable.

# Stability of coalitions

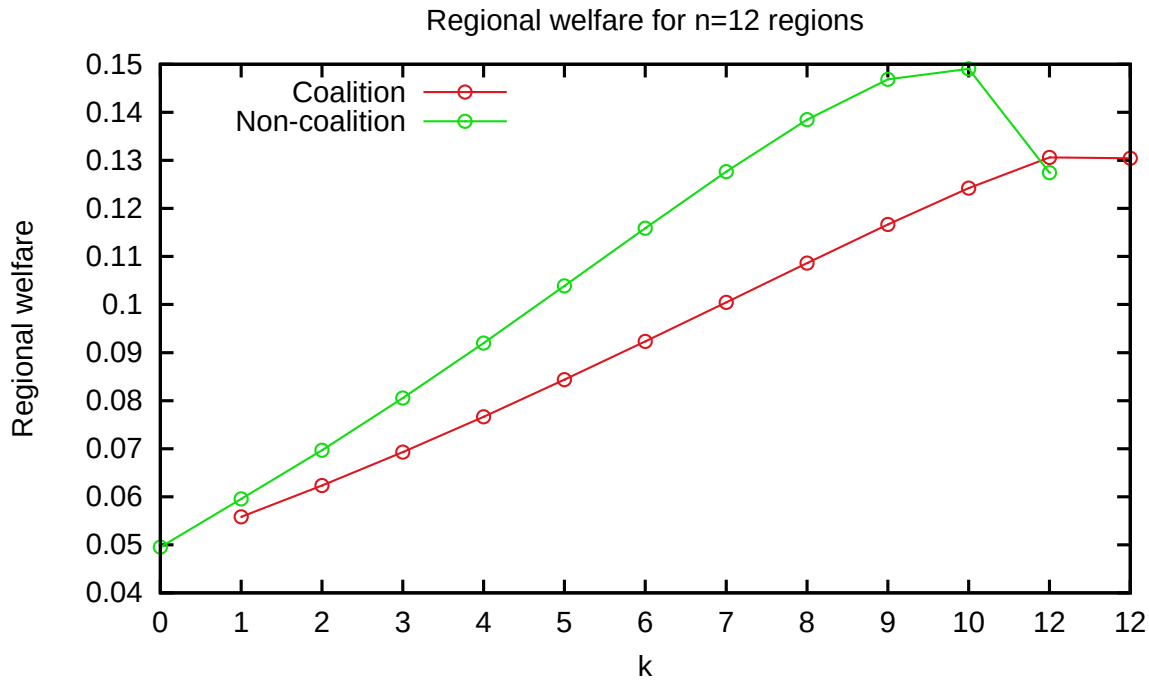



Coalitions of size 1,2, and n=100 or n=1000 are stable.

# Welfare comparison: RICE case

If regions in the RICE world were symmetric ($\epsilon$ = 2.8 instead of 2):




Coalitions of size 1,2, and n=12 are stable.

# Asymmetry: coefficients from RICE

| | $\beta_r$ | $\gamma_r$ |
|---|---|---|
| China | 0.062 | 0.128 |
| US | 0.039 | 0.452 |
| EU | 0.048 | 1.702 |
| Middle East | 0.041 | 1.767 |
| India | 0.048 | 2.371 |
| Other Asia | 0.043 | 3.306 |
| Russia | 0.004 | 3.388 |
| OHI | 0.015 | 3.642 |
| Latin America | 0.027 | 4.854 |
| Japan | 0.009 | 9.514 |
| Eurasia | 0.003 | 9.884 |
| Africa | 0.045 | 16.757 |

# Stability of coalitions

## Internal stability

No coalition region would prefer leaving the coalition.

## Expandability

Expansion of coalition benefits the candidate region, and makes no coalition region worse off.

# Results with 12 regions – Stability

| Size | # of coalitions | Internal stability | | Expandability | |
|---|---|---|---|---|---|
| | | no matching | matching | no matching | matching |
| 1 | 12 | 12 | 12 | 11 | 12 |
| 2 | 66 | 14 | 23 | 23 | 45 |
| 3 | 220 | | 1 | 21 | 50 |
| 4 | 495 | | | 13 | 22 |
| 5 | 792 | | | 2 | 3 |
| 6 | 924 | | | | |
| 7 | 792 | | | | |
| 8 | 495 | | | | |
| 9 | 220 | | | | |
| 10 | 66 | | | | |
| 11 | 12 | | | | |
| 12 | 1 | | | | |

# Results with all countries – Abatement

| Coalition | Abatement (GtC) | Abatement w/o matching (GtC) |
|---|---|---|
| EU | 0.478 | 0.374 |
| EU+China | 0.617 | |
| EU+US | 0.591 | |
| EU+India | 0.553 | |

Adding another partner is never in everybody's interest:

- Both India and China would be willing to join a EU+US coalition, but the US would then prefer to leave.
- Only India would like to join the EU+China coalition, but again, China would want to leave the resulting coalition.
- No further country would like to join a EU+India coalition.

Welfare maximizing global abatement would be 1.5 GtC!

# Discussion of *results*

- Big coalitions tend to be unattractive for marginal regions.
- Size of political units helps effectiveness of matching.
- Asymmetry
  - has ambiguous effect on internal stability, and boosts expandability,
  - makes the full coalition unstable.
- Viewed as a stable coalition, the EU could attract another big nation to the coalition.
- Matching and expanding the coalition could increase global abatement by at least 50 percent.

# Discussion of *framework*

- Would it be rational for some non-coalition regions to build one or several coalitions themselves?
  - If the world is partitioned into coalitions, reciprocal matching could lead to an Pareto efficient abatement level.
- My analysis only looks at one time period. “Deals across generations” would be hard to conceptualize but might change some results.

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$$\frac{\sum_{nc} \mathrm{d}A_{nc}}{\mathrm{d}A_c}$$

Zero unconditional abatement implies

$$\begin{aligned}\mathrm{d}A_c &= \mathrm{d}m_c \sum_{nc} A_{nc} + m_c \sum_{nc} \mathrm{d}A_{nc} \\ &= \mathrm{d}m_c \left( \sum_{nc} A_{nc} + m_c \underbrace{\sum_{nc} \frac{\partial A_{nc}}{\partial m_c}}_{=:\alpha} \right).\end{aligned}$$

The increase in $m_c$ that can be afforded due to a unit increase in $\mathrm{d}A_c$ therefore is

$$\frac{\mathrm{d}m_c}{\mathrm{d}A_c} = \frac{1}{\sum_{nc} A_{nc} + m_c \alpha}$$

and the increase in non-coalition abatement due to this will be

$$\sum_{nc} \frac{\mathrm{d}A_{nc}}{\mathrm{d}A_c} = \sum_{nc} \frac{\partial A_{nc}}{\partial m_c} \frac{\mathrm{d}m_c}{\mathrm{d}A_c} = \frac{\alpha}{\sum_{nc} A_{nc} + m_c \alpha}.$$

To find $\alpha$, totally differentiate $MC_{nc}(A_{nc}) = MB_{nc}(1 + \sum_c m_c)$:

$$\frac{\partial MC_{nc}(A_{nc})}{\partial A_{nc}} \mathrm{d}A_{nc} = MB_{nc} \mathrm{d}m_c$$

to obtain

$$\frac{\mathrm{d}A_{nc}}{\mathrm{d}m_c} = \frac{MB_{nc}}{\frac{\partial MC_{nc}(A_{nc})}{\partial A_{nc}}}.$$

◂ Equations