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 γ_r

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[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)

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

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

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

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: $1/n$
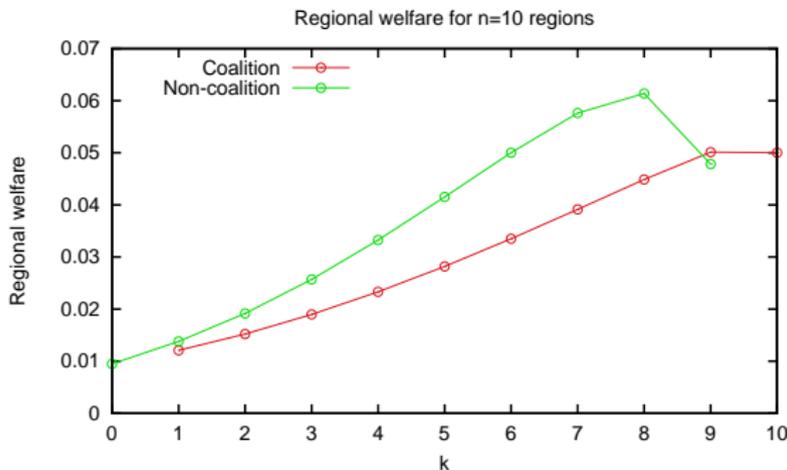
Abatement cost: $c(a_r) = n\gamma a_r^2/2$

Marginal abatement cost: $mc(a_r) = n\gamma a_r$,

where global abatement A is the sum of all regional abatement a_r.
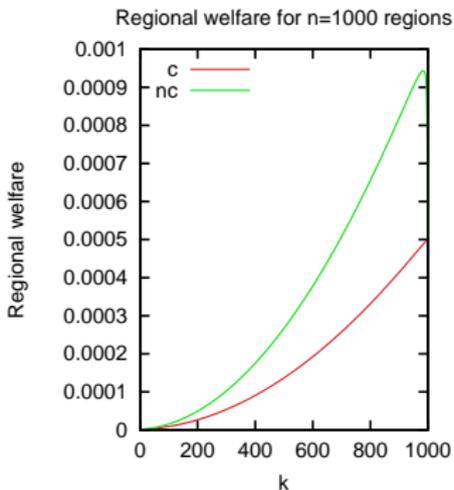
Stability of coalitions
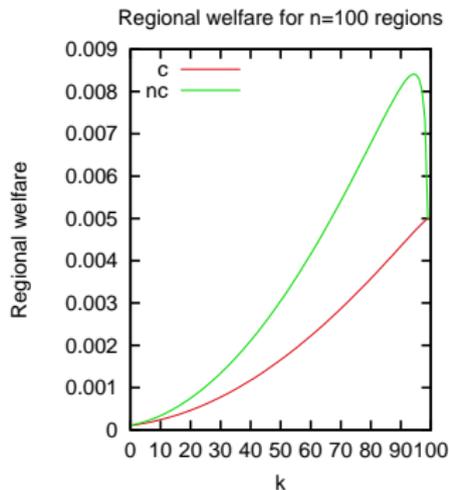
Welfare considers costs and benefits of abatement:

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

Regional welfare for n=10 regions

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

Stability of coalitions
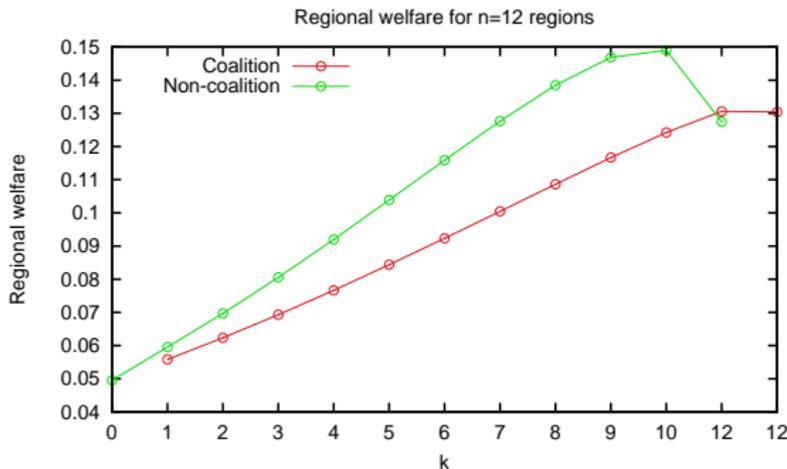

Regional welfare for n=100 regions

Regional welfare for n=1000 regions

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):

Regional welfare for n=12 regions

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

Asymmetry: coefficients from RICE

	β_r	γ_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.

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.
- If the EU was a stable coalition, it 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

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

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

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

◄ Equations

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

$$= \frac{\alpha}{\sum_{nc} A_{nc} + m_c \alpha}.$$

To find α, 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

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