Shaping climate cooperation: The role of global environmental norms

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Presented at the 23rd Conference on Research on Economic Theory and Econometrics

CRETE 2025

June 7, 2025

Tinos island

I. Introduction: a. motivation

- Increased public awareness about the accelerating impacts of climate change and easy access to information about their government's environmental commitments relative to those of other nations, put pressure on governments to improve their behavior.

- Evidence indicating that countries enhancing their environmental performance are more likely to offer stable, low-risk, and ethically sound conditions for investment (Peiró-Signes et al. 2022, identified a positive and statistically significant correlation between the Environmental Performance Index (EPI) and the Country Risk Score (CRS)).

- Growing evidence indicating that international norms are spreading within regions and across the globe causing radical domestic policy shifts (Linos, 2011 in American Journal of Political Science; Dobbin, et al., 2007 in Annual Review of Sociology; Goodman and Jinks 2004 in *Duke Law Journal*).
- Specific examples of international norms shaping domestic policies: the introduction of mass public education (Schofer and Meyer 2005, *American Sociological Review*), the adoption of democracy and expansion of political rights (Gleditsch and Ward 2006 *International Organization*; Ramirez et al. 1997, *American Sociological Review*), the expansion of human rights (Goodman and Jinks 2012), the turn to environmentalism (Frank et al. 2000), the reform of state administrative structures (Finnemore 1993 *International Organization*; Lee and Strang 2006), and the adoption of liberalization policies (Simmons and Elkins 2004 *American Political Science Review*).

- Based on the above, we consider that a country that is able to exceed a given global environmental norm experiences a welfare increase (sense of pride, warm glow), while falling behind the norm decreases its welfare (sense of shame, loss of status).
- This assumption captures the sentiment of environmentally concerned citizens, who experience reduced utility when their country's emissions surpass the global standard, thereby influencing the nation's decision-making process.

- We employ the classic two-stage game model of international environmental agreements, in which countries in the 1st stage choose whether to join a coalition and in the 2nd stage choose their emissions

$$W_i(e_i) = B_i(e_i) - D(E), \; E = \sum_{i=1}^{n} e_i$$

- We incorporate into countries' welfare the effect of responding to the global environmental norm

$$W_i(e_i) = B_i(e_i) - C_i(\psi_i) - D(E), \;\; \psi_i = e_i - \hat{e}, \quad \text{where } \hat{e} \text{ is the norm}$$

- and examine the effect on countries choice of emissions and on the size of stable coalitions.

I. Introduction: c. literature review

- A growing body of literature incorporates ethical dimensions, moral behavior, and altruism into economic models to examine the stability of IEAs:
  - Finus and Maus (2008, *JPET*) consider the possibility that countries agree on modest instead of ambitious abatement targets. It is show that modesty increases participation and leads to more successful treaties.
  - Dernbach and Brown (2008, *Hofstra Law R.*) argue that nations must consider fairness and the interests of others to achieve effective global climate action.
  - Nyborg (2018, JEEM) and Bucholz et al. (2018, *JEBO*) introduce reciprocity into the model and find that if if reciprocity is sufficiently strong and widespread large and even the grand coalition is stable.
  - Daube and Ulph (2016, *ERE*), Ulph and Ulph (2024, *ERE*), Eichner and Pethig (2024b, *JEEM*) and Eichner and Pethig (2024a) introduce a Kantian perspective. It is show that emissions moralism does not enhance coalition size compared to purely self-interested countries, while membership moralism does.
  - Van der Pol et al. (2012, *Ecol. Econ.*), Schopf (2023, *ERE*) and Sacco (2024, *Dec. Econ. Fin.*) introduce altruism (in one or both stages of the game). In most cases, the size of stable coalition increases and always welfare improves.
  - Breton and Sbragia (2023, *Ecol. Econ.*) explore how self-image considerations influences IEA participation. They show that when countries value their reputation, stable agreements with meaningful participation can emerge, leading to lower emissions and higher welfare.

II. The model

- Notation
  - n identical countries $N=\{1, \ldots, n\}$
  - e_i : country i's emissions, $e_i>0$ and $E = \sum_{i \in N} e_i$
  - $B_i(e_i)$: country i's benefits from emissions
  - $\hat{e} = E/n$: global environmental norm
  - $\psi_i(e_i,\hat{e}) = e_i - \hat{e}$: country i's deviation from the norm
  - $C_i(\psi_i)$: effect on country i's welfare from deviation from the norm
  - D(E): country i's damage from aggregate emissions
  - $w(e_i,\psi_i)$: country i's welfare function
- Country i's welfare is,

$$W(e_i,\psi_i) = B(e_i) - C(\psi_i) - D(E)$$

$B(0)=0,\ B'\geq 0$ and $B''<0$

$D(0)=0,\ D'(NE)>0,\ D''(NE)>0$

$C(0)=0,\ C'(\psi_i)>0,\ C''(\psi_i)>0$

II. The model

- Modeling IEAs as a non-cooperative one-shot, two-stage game*:
  - 1st stage: participation choice (yes/no)
  - 2nd stage: choice of emissions level

- We assume that a single coalition forms, comprising a subset of s countries.
- In the 1st stage, To determine the size of the stable coalition, we apply the internal and external stability criteria originally proposed by D'Aspremont et al. (1983)

$$w_s(s^*) \geq w_{ns}(s^* - 1), \quad w_s(s^* + 1) \leq w_{ns}(s^*)$$

- In the 2nd stage signatories maximize collective welfare, while nonsignatories maximize their own welfare. We examine the Nash and the Stackelberg case (with the coalition acting as a leader).
  - e_s , e_{ns} : signatory and nonsignatory country's emissions
  - $\hat{e} = [se_s + (n-s)e_{ns}]/n$: global environmental norm

* Critical assumption: each country upon withdrawing from the agreement assumes that the agreement will remain intact (myopic behavior)

III. Nash equilibrium

- Second stage: signatories and nonsignatories choose *e* :
- Nonsignatories' choice: $\max_{e_{ns}} W(e_{ns}, \psi_{ns}) = B(e_{ns}) - C(\psi_{ns}) - D(E)$
- First order conditions:

$$\frac{\partial B(e_{ns})}{\partial e_{ns}} = \frac{\partial C(\psi_{ns})}{\partial \psi_{ns}} \frac{\partial \psi_{ns}}{\partial e_{ns}} + \frac{\partial D(E)}{\partial E} \frac{\partial E}{\partial e_{ns}}$$

- Signatories' choice: $\max_{e_{ns}} sW(e_{ns}, \psi_{ns}) = s\{B(e_{ns}) - C(\psi_{ns}) - D(E)\}$
- First order conditions:

$$\frac{\partial B(e_s)}{\partial e_s} = \frac{\partial C(\psi_s)}{\partial \psi_s} \frac{\partial \psi_s}{\partial e_s} + \frac{\partial D(E)}{\partial E} \frac{\partial E}{\partial e_s}$$

- Recall that: $\psi_i = e_i - \hat{e}, \;\; \hat{e} = \frac{E}{n}, \;\; \frac{\partial E}{\partial e_{ns}} = 1 \;\; \& \;\; \frac{\partial E}{\partial e_s} = s$
- And thus, $\frac{\partial \psi_{ns}}{\partial e_{ns}} = 1 - \frac{1}{n} > 0, \;\; \frac{\partial E}{\partial e_s} = 1 - \frac{s}{n} > 0$. Also, $\frac{\partial C(\psi_i)}{\partial \psi_i} > 0$
- Therefore, all countries, *s* and *ns* reduce their emissions relative to a scenario without global norm considerations.

- First stage: size of coalition
- We define the critical coalition size at which $e_s = e_{ns}$:
  - Assuming symmetric countries the first order condition are equal if:

$$\left(1-\frac{1}{n}\right)C' + D' = \left(1-\frac{s}{n}\right)C' + sD' \Rightarrow \left(D' - \frac{1}{n}C'\right)(s-1) = 0$$

  - Given that, $nD' > C'$ then, the condition holds only for $s=1$. Thus, we get the usual result that $e_s = e_{ns}$ iff $s^{min} = 1$.

The stable coalition size is the lower integer satisfying the internal and external stability conditions

w_i illustrates indirect welfare

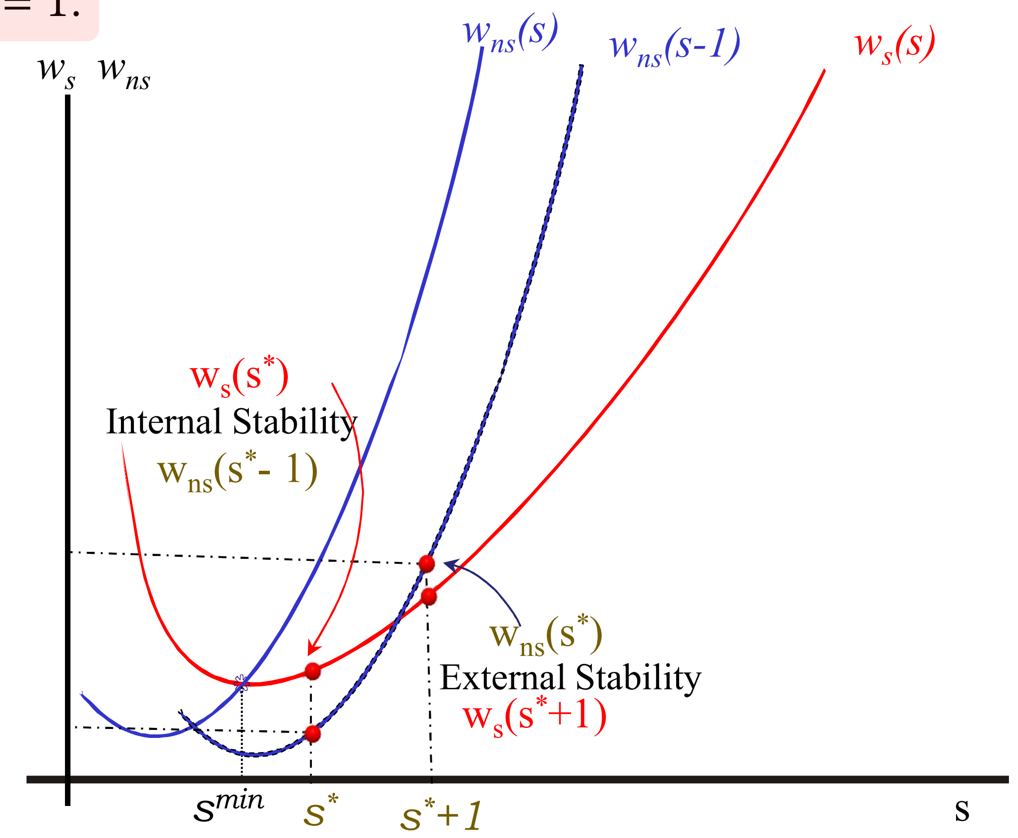
At $s^{min} = 1$: $w_s(s^{min}) = w_{ns}(s^{min})$

At s=s^*: $w_s(s^*) > w_{ns}(s^* - 1)$ (internal)

At $s^* + 1$: $w_s(s^* + 1) < w_{ns}(s^*)$ (external)

Thus, s^* is the size of stable coalition

Using general functional forms, determining the exact value of the stable coalition size s^* is analytically intractable.



Proposition 1: (i) In a simultaneous game, when countries take into account their position relative to a global environmental norm, they choose lower emission levels compared to a scenario where they do not consider the norm. (ii) Assuming completely symmetric countries and defining the global norm as the average level of emissions, global norm considerations do not improve the size of stable coalition. Despite lower overall emissions, the incentive structure underlying coalition formation remains unchanged, and the free-rider problem persists.

- Different sensitivity to the global norm
  - Assuming $C_s' \neq C_{ns}'$, $e_s = e_{ns}$ if:

$$n(s-1)D' = (n-1)C_{ns}' - (n-s)C_s' \Rightarrow s^{min} = 1 - \left(\frac{n-1}{n}\right)\frac{C_s' - C_{ns}'}{D' - \frac{1}{n}C_s'} = 0$$

- Given that, $nD' > C'$ then, larger stable coalitions become possible only in the very unrealistic case that non-signatories are more sensitive to the global norm than signatories, $C_s' < C_{ns}'$.

IV. Leadership equilibrium

- Second stage: signatories and nonsignatories choose *e* :
- Nonsignatories:
- Differentiating the first order condition $\mathrm{B}' = \left(1 - \frac{1}{n}\right) C' + D'$ yields the slope of the reaction function:

$$\frac{\partial e_{ns}^*(e_s)}{\partial(e_s)} = -\frac{s[n^2 D''(E) - (n-1)C''(\psi_{ns})]}{n^2[(n-s)D''(E) - B''(e_{ns})] + s(n-1)C''(\psi_{ns})} < 0$$

- Signatories' and nonsignatories' emissions decisions are strategic substitutes
- When global norm considerations are introduced (C′′<0) the slope of the reaction function increases $\left|\frac{\partial e_{ns}^*(e_s)}{\partial(e_s)}\right|_{C''<0} > \left|\frac{\partial e_{ns}^*(e_s)}{\partial(e_s)}\right|_{C''=0}$.

- Signatories first order condition:

$$B' - C' = \left(D' - \frac{1}{n} C_s'\right)\left[s + (n-s)\frac{\partial e_{ns}^*(e_s)}{\partial(e_s)}\right]$$

- While sensitivity to the global norm induces nonsignatories to decrease emissions, the reverse might be the case for signatories, who—acting as leaders—anticipate that their increased emissions incentivize nonsignatories to further reduce their emissions. If this indirect, leadership effect outweighs the direct effect of responding to the global norm, then an increase in sensitivity could induce signatories to increase their emissions

IV. Leadership equilibrium

- First stage: size of coalition

- We define the critical coalition size at which $e_s = e_{ns}$:
  - Assuming symmetric countries the first order condition are equal if:

$$\left(D' - \frac{1}{n}C'\right)\left[s + (n-s)\frac{\partial e_{ns}^*(e_s)}{\partial(e_s)}\right] = D' - \frac{1}{n}C' \Rightarrow \left(D' - \frac{1}{n}C'\right)\left[\underbrace{(s-1)}_{\text{damage internalization effect}} + \underbrace{(n-s)\frac{\partial e_{ns}^*(e_s)}{\partial(e_s)}}_{\text{Leadership effect}}\right] = 0$$

  - Given that, $nD' > C'$, the condition holds only for the critical coalition size,

$$s^{min} = \frac{nD'' - B''}{D'' - B'' + \left(\frac{n-1}{n}\right)^2 C''}$$

Given that $C'' < 0 \xrightarrow{\text{yields}} s^{min}(C'' < 0) > s^{min}(C'' = 0)$. Stronger norm concerns among non-signatories enhance the coalition's leadership effectiveness, making participation in emission reduction efforts more attractive. As a consequence, the critical coalition size required for emissions alignment increases, supporting the formation of larger stable coalitions.

Proposition 2: (i) When the coalition assumes a leadership role, the size of the stable coalition increases if countries are sensitive to the global environmental norm. (ii) Normative considerations results in lower aggregate emissions compared to a scenario in which countries act solely out of economic self-interest. (iii) For a given coalition size, an increase in sensitivity to the global norm can lead to higher emissions by signatories. This increase is offset by a larger reduction in emissions by non-signatories, leading to a net decline in global emissions.

- Different sensitivity to the global norm
  - Assuming $C_s' \neq C_{ns}'$, $e_s = e_{ns}$ if:

$$s^{min} = \frac{n^2(1-\Xi)\left(nD''-B''\right)}{n^2[(1-\Xi)D''-B'']+(n-1)[n-(1-\Xi)]C_{ns}''}$$

  where, $\Xi = {}^{(C_s'-C_{ns}')}\!/_{(nD'-C_s')} < 1$.

- Given that, $\frac{\partial s^{min}}{\partial \Xi} < 0$, if $C_s' > C_{ns}'$ the critical coalition size, s^{min}, declines, while it increases in the unrealistic case that $C_s' < C_{ns}'$. If signatories are more (less) sensitive to the global norm, the critical size of the coalition decreases (increases).

V. Quadratic functions: Nash equilibrium

Notation

$$w_i = b\left[ae_i - \frac{e_i^2}{2}\right] - \delta\left[a\psi_i - \frac{\psi_i^2}{2}\right] - \frac{c}{2}E^2 \qquad E = \sum_{i\in N} e_i = se_s + (n-s)e_{ns}$$

- Nonsignatories and signatories reaction functions,

$$e_{ns}^*(e_s) = a\frac{\Phi_{ns}}{\Omega_{ns}} - \frac{\Psi_{ns}}{\Omega_{ns}}se_s\,, \qquad e_s^*(e_{ns}) = a\frac{\Phi_s}{\Omega_s} - \frac{\Psi_s}{\Omega_s}(n-s)e_{ns}$$

where $\Phi_{ns} = b - \frac{n-1}{n}\delta_{ns} > 0,\ \ \Phi_{ns} = b - \frac{n-1}{n^2}\delta_{ns} > 0,\ \ \Omega_{ns} = b + (n-s)c - \frac{s(n-1)}{n^2}\delta_s > 0$

and $\Phi_s = b - \frac{n-s}{n}\delta_s > 0,\ \ \Phi_s = b - \frac{n-s}{n^2}\delta_s > 0,\ \ \Omega_s = b + s^2c - \left(\frac{n-s}{n}\right)^2\delta_s > 0$

- Solving the above,

$$e_{ns}^{N*} = a\frac{\Phi_s\Omega_{ns} - (n-s)\Psi_s\Phi_{ns}}{\Omega_s\Omega_{ns} - s(n-s)\Psi_s\Psi_{ns}}\,, \qquad e_s^{N*} = a\frac{\Phi_{ns}\Omega_s - s\Psi_{ns}\Phi_s}{\Omega_s\Omega_{ns} - s(n-s)\Psi_s\Psi_{ns}}$$

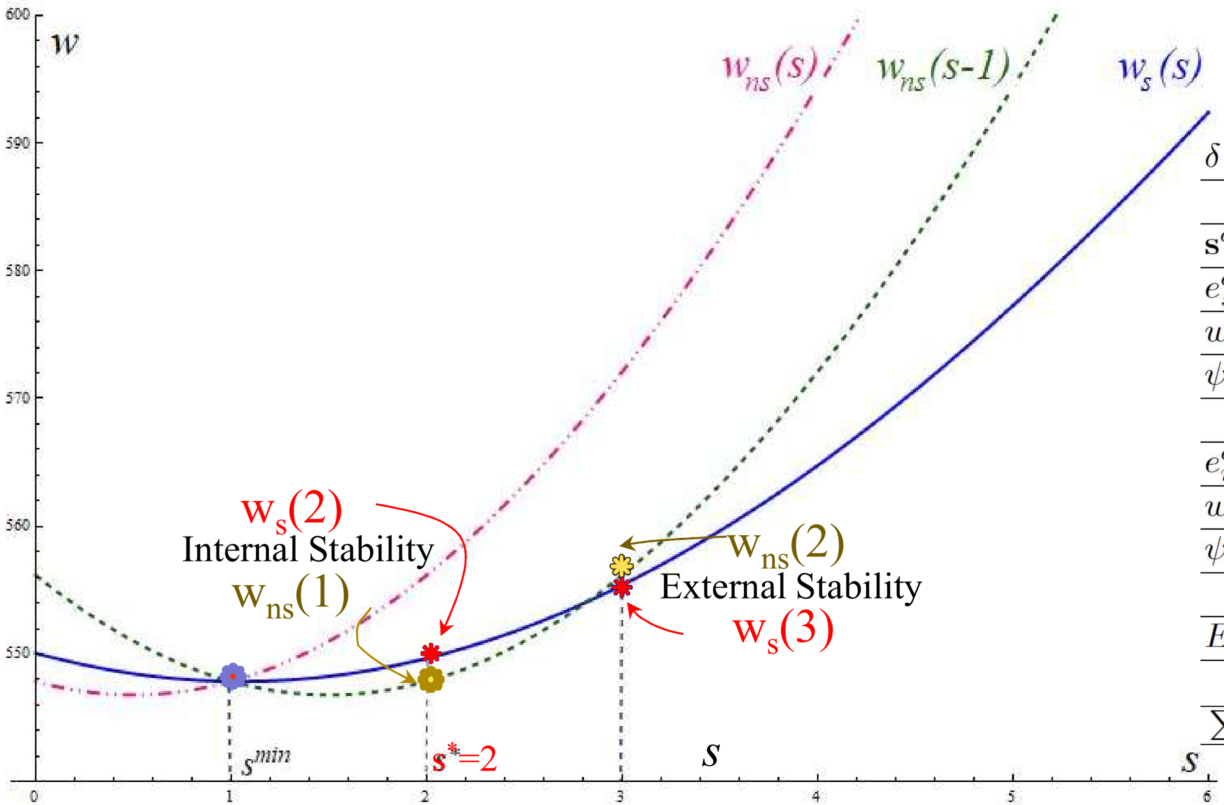
- The critical coalition size at which $e_{ns}^{N*} = e_s^{N*}$, is,

$s^{min} = 1 - \left(\frac{n-1}{n}\right)\frac{a(\delta_s - \delta_{ns})}{nce_N - \frac{a}{n}\delta_s}$, $\qquad e_N = a\frac{b - \left(\frac{n-1}{n}\right)\delta_{ns}}{b + nc - \delta_{ns}}$ is the emissions at the Nash

Numerical simulations

We use the following parameter values: *n=10, a=10, b=20, c=0.1,* $\delta_s = \delta_{ns} = \delta = 0.1$

A coalition of two countries is both internally and externally stable, as illustrated in the graph. As soon as the smallest coalition forms, free-riding incentives dominate, leading to non-signatories consistently enjoying higher welfare than signatories in larger coalitions.



δ	0	0.10	0.50	0.90
		Signatories		
$\mathbf{s}^{c*}$	2	2	2	2
e_s^{c*}	9.06	9.02	8.87	8.72
w_s^{c*}	546.10	549.67	563.40	576.28
ψ_s^{c*}	−0.38	−0.37	−0.36	−0.339
		Non-signatories		
e_{ns}^{c*}	9.53	9.49	9.32	9.15
w_{ns}^{c*}	552.78	556.17	569.22	581.46
ψ_{ns}^{c*}	0.094	0.093	0.089	0.084
		Aggregate emissions		
E^{c*}	94.34	93.92	92.27	90.61
		Total welfare		
$\sum_{i=1}^{n} w_i^{c*}$	5514	5549	5681	5804

V. Quadratic functions: Leadership equilibrium

- Nonsignatories' $e_{ns}(e_s)$

$$e_{ns}^{*}(e_s) = a\frac{\Phi_{ns}}{\Omega_{ns}} - \frac{\Psi_{ns}}{\Omega_{ns}} s e_s \ ,$$

where $\frac{\partial e_{ns}^{*}(e_s)}{\partial e_s} < 0$ and $\frac{\partial}{\partial \delta_{ns}}\left|\frac{\partial e_{ns}^{*}(e_s)}{\partial e_s}\right| > 0$ the more sensitive nonsignatories are to the global environmental norm, the more responsive they are to changes in the emissions of signatories

- Solving signatories collective maximization problem yields,

$$e_s^{l*} = a\frac{\Phi_s^l \Omega_{ns} - (n-s)\Psi_s^l \Phi_{ns}}{\Omega_s^l \Omega_{ns} - s(n-s)\Psi_s^l \Psi_{ns}}$$

and substituting to the nonsignatories reaction function,

$$e_{ns}^{l*} = a\frac{\Phi_{ns}\Omega_s^l - (n-s)\Psi_{ns}\Phi_s^l}{\Omega_s^l \Omega_{ns} - s(n-s)\Psi_s^l \Psi_{ns}}$$

- The critical coalition size at which $e_{ns}^{l*} = e_s^{l*}$, is,

$$s^{min} = \frac{b + nc}{b + c - \left(\frac{n-1}{n}\right)^2 \delta}$$

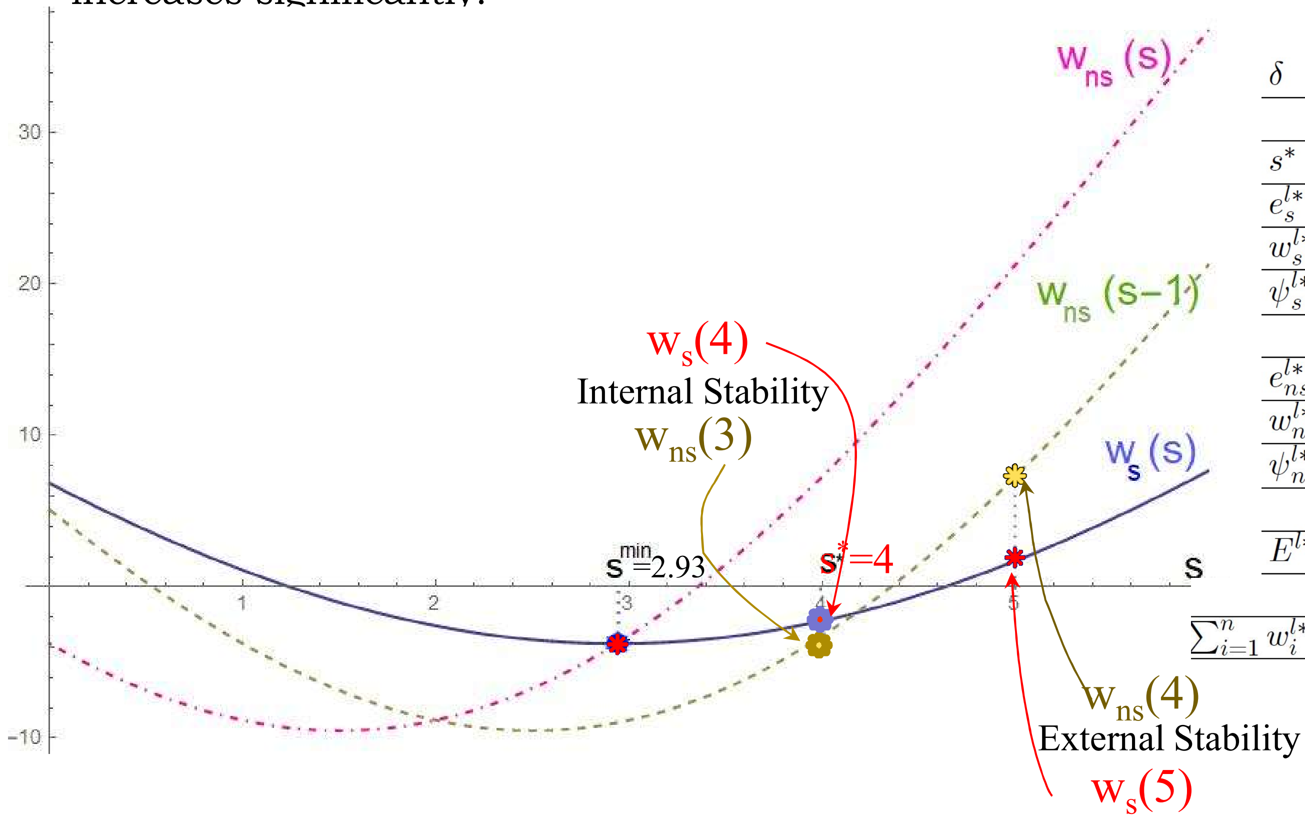
which is increasing in δ.

Numerical simulations

We use the following parameter values: *n=10, a=10, b=6, c=0.39999,* $\delta_s = \delta_{ns} = \delta = 3.7$ (we use the same parameter values as in D&S, 2006, which find $s^*=3$). A coalition of four ($s^*=4$) countries is both internally and externally stable, as illustrated in the graph.

As the level of sensitivity, δ, increases from 0 to 2, and the stable coalition size remain the same ($s^*=3$), emissions of the signatories slightly increase, while that of nonsignatories decrease significantly.

As the level of sensitivity, δ, increases from 0 to 2, total emissions decrease and aggregate welfare increases significantly.



δ	0	0.5	1	2	3.7
Signatories					
s^*	3	3	3	3	4
e_s^{l*}	2.73	2.75	2.77	2.78	1.83
w_s^{l*}	-427	-347	-274	-148	-2.26
ψ_s^{l*}	-2.60	-2.26	-1.91	-1.20	-0.83
Non-signatories					
e_{ns}^{l*}	6.45	5.98	5.50	4.50	3.01
w_{ns}^{l*}	-306	-256	-207	-118	7.26
ψ_{ns}^{l*}	1.1	1.0	0.8	0.5	0.36
Aggregate Emissions					
E^{l*}	53.3	50.1	46.8	39.8	26.62
Total Welfare					
$\sum_{i=1}^{n} w_i^{l*}$	-3425	-2832	-2272	-1273	44.02

V. Epilogue

- Conclusions
  - We incorporate into the pure materialistic welfare function a normative consideration in the form of a global environmental norm: Countries face moral costs when exceeding this norm and moral benefits when they outperform the norm.
  - Specifically, we define the norm as the global average level of emissions, thereby capturing the idea that countries care about their relative environmental standing.

  - Results:
  - In the simultaneous-move game, sensitivity to the global norm does not reduce free-riding incentives and thus the size of stable coalition remains very small (except in the unrealistic case that nonsignatories are more sensitive than signatories)
  - In the leadership game, sensitivity to the global norm makes nonsignatories more responsive to signatories choices, increasing thus coalition's power, leading to larger stable coalitions.
  - In both the simultaneous and the leadership game, aggregate emissions decrease, much more in the latter, and global welfare improves significantly.

Thank you for your attention

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