Climate Justice:

Historical Accountability vs. International Paretianism

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July 17, 2023

Intro

UNFCCC, 1992

“The Parties should protect the climate system for the benefit of present and future generations of human kind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.” (United Nations, 1992, Principle 1 in Article 3).

Fair international protocols for the abatement of GHG emissions (B.-G. Ju, M. Kim, S. Kim, J.D. Moreno-Ternero, 2021, *Energy Economics*)

- formulates normative principles, pertaining to countries' population, emission history, and current and future emissions, as axioms for allocation rules.
    - Historical Accountability
    - History Independence
    - Equal Treatment of per capita Equals
    - Other axioms

- Combinations of those axioms characterize equal per capita rules or equal per emissions rules, with or without historical accountability.

Results (Ju et al., 2021)

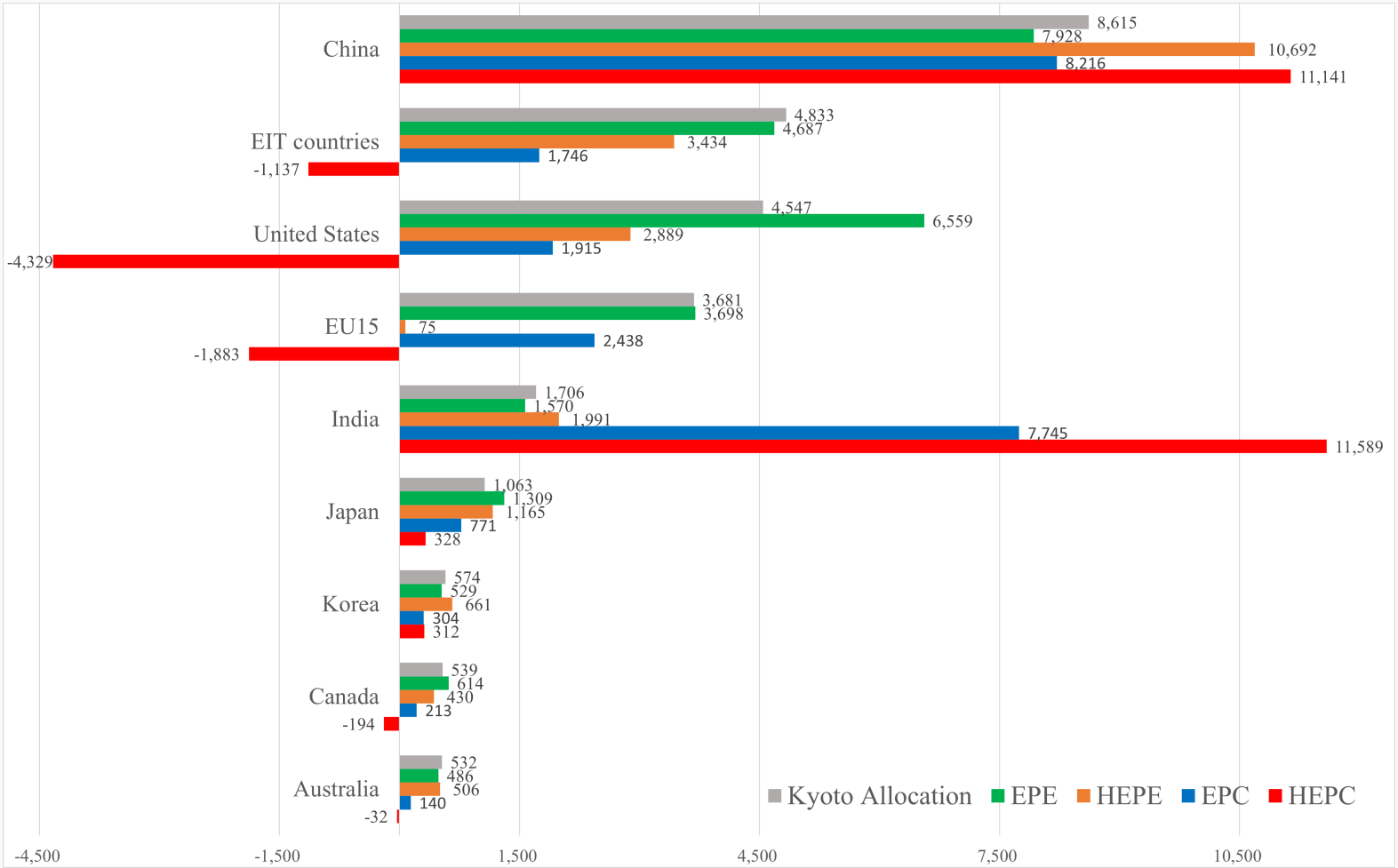
Table 1
Axioms and rules.

Axioms\Rules	HEPC	EPC	HEPE	EPE
Historical Accountability	$Y^{(1)}$	N	$Y^{(3)}$	N
History Independence	N	$Y^{(2)}$	N	$Y^{(4)}$
Equal Treatment of per-capita Equals	$Y^{(1)}$	$Y^{(2)}$	N	N
Irrelevance of Excessive per-capita Emissions	$Y^{(1)}$	$Y^{(2)}$	N	N
Claim Upper Bound	N	N	$Y^{(3)}$	$Y^{(4)}$
History Lower Bound	Y	N	$Y^{(3)}$	N
Resource Additivity	$Y^{(1)}$	$Y^{(2)}$	$Y^{(3)}$	$Y^{(4)}$

Note: '$Y^{(k)}$' ('N', respectively) in each cell means that the rule in the corresponding column satisfies (does not satisfy) the axoim in the corresponding row, where the superscript $k = 1, 2, 3$, and 4 means the axiom is used in Theorem k that characterizes the rule.

Application (Ju et al., 2021)

- Fair allocation rules (equal per capita rules with or wihout historical accountablity) are in stark contrast with the Kyoto protocol.

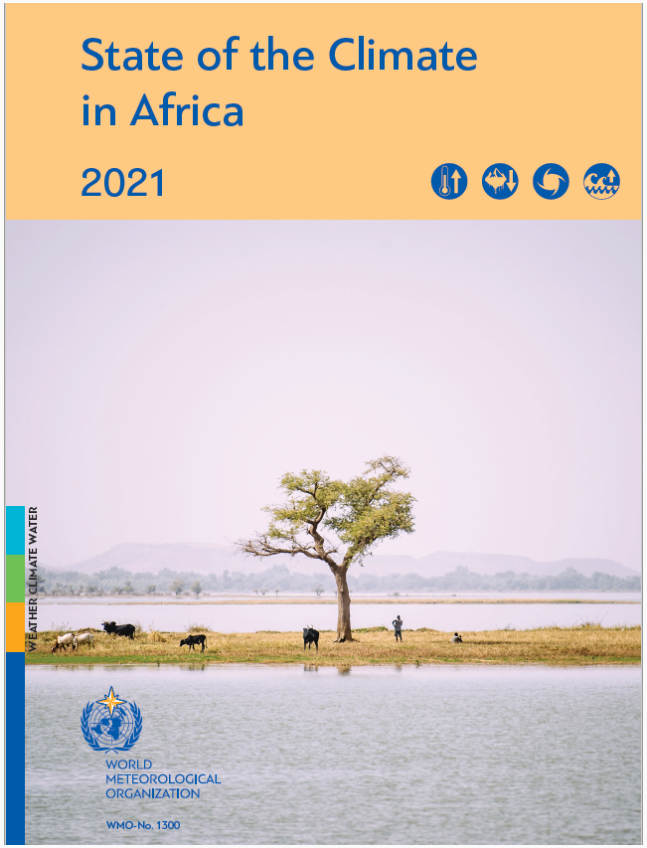


Limitations (Ju et al., 2021)

- No account of differentiated climate risks across countries.
- No account of differentiated economic needs of emission allowances.
- No account of differentiated abatement costs.

Motivation

State of the Climate in Africa 2021



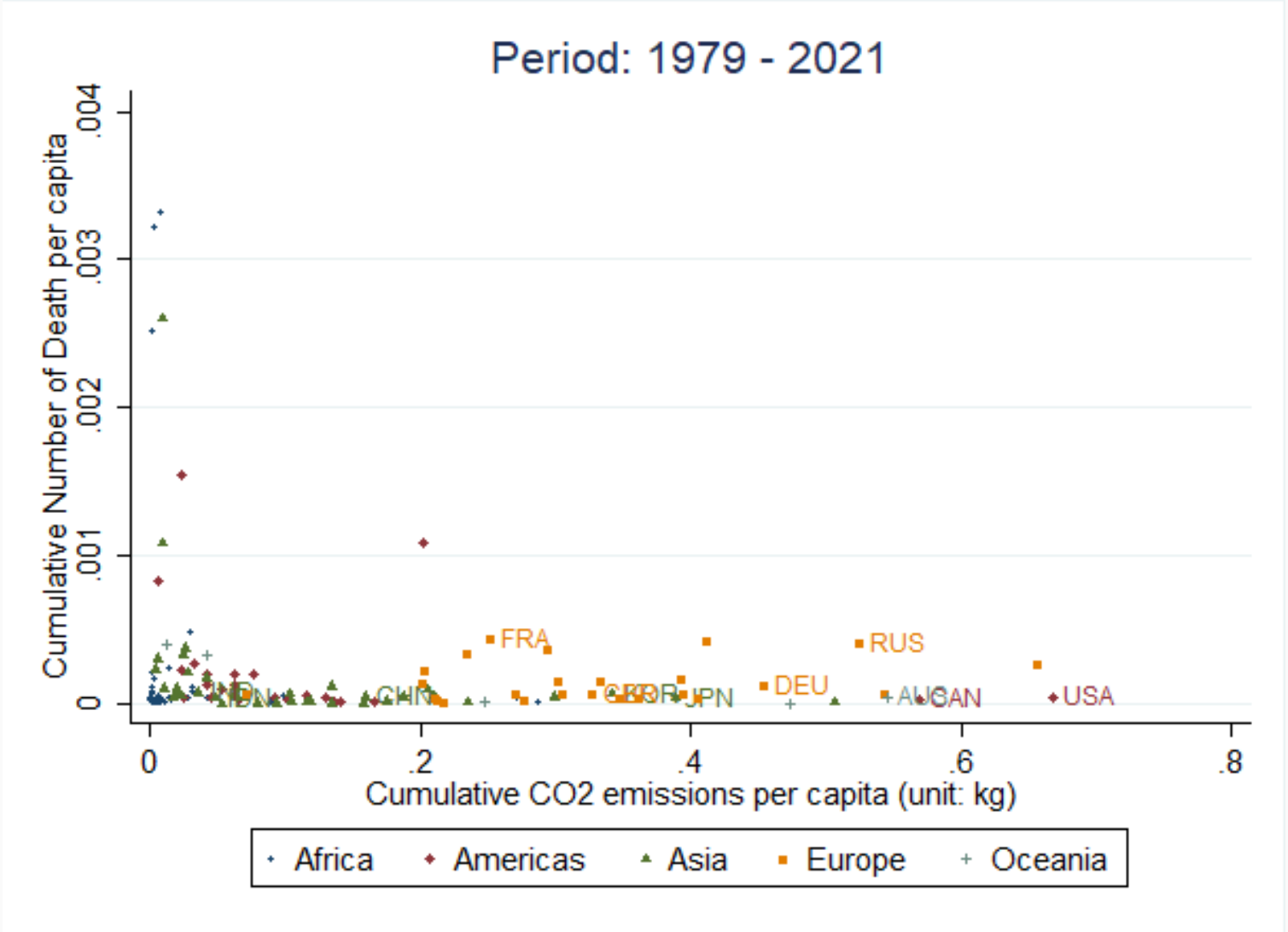
- This report shows how extreme weather and climate change are undermining human health and safety, food and water security, and socio-economic development in Africa.

State of the Climate in Africa 2021 (2/2)

- With a special focus on water, high water stress is estimated to affect about 250 million people on the continent and displace up to 700 million individuals by 2030.
    - Four out of five African countries are unlikely to have sustainably managed water resources by 2030.

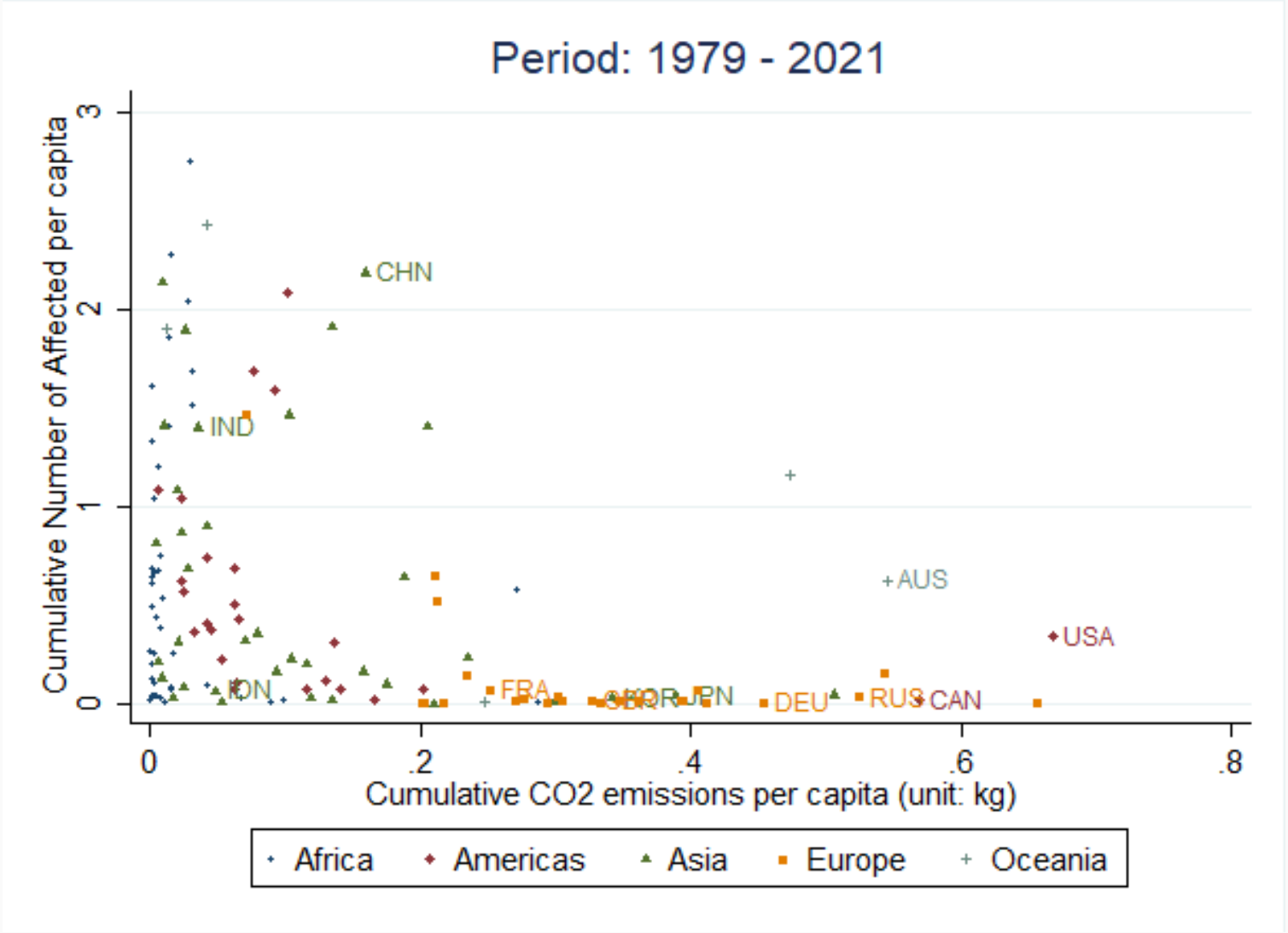
- However, Africa accounts for only about two to three percent of global GHG emissions.

Damage from the Climate Crisis: Death and Missing



Cumulative CO2 emissions per capita = (Σ CO2 emissions) / 2021 population
Cumulative Number of Death per capita = (Σ Death) / 2021 population
(Source: Emergency Events Database by Center for Research on the Epidemiology of Disasters & CAIT)

Damage from the Climate Crisis: Affected



Cumulative CO2 emissions per capita = (Σ CO2 emissions) / 2021 population
Cumulative Number of Affected per capita = (Σ Affected) / 2021 population
(Source: Emergency Events Database by Center for Research on the Epidemiology of Disasters & CAIT)

Motivation I: Damage from the Climate Change

- All countries and all generations involved with GHG emissions are responsible for the damage due to climate change, independently of the regions or generations.
    - A representative example of negative externalities across countries and **generations**.

- Underdeveloped countries with little or no responsibilities may be affected more significantly than developed countries with most responsibilities.
- What is a fair treaty to deal with the climate emergency?
- How much burden should be placed on countries with 'differentiated responsibilities and respective capabilities'(UNFCCC)?

Motivation II: International Paretianism

- Posner and Weisbach (2010): Fair burden sharing needs to take into account both benefits and costs of a treaty for all parties involved. They proposes that
- "A treaty satisfes what we call International Paretianism if it advances the interests of all states that join it, so that no state is made worse off." [p.347 in Weibach and Posner 2013]
    - They claim IP is a precondition for the global implementation of the treaty.
    - "Although IP might seem obvious, it rules out nearly all the major proposals advanced for a climate treaty." (Weisbach and Posner, 2013)
- Can we find fair allocation rules satisfying IP?
- IP vs. historical accountability?

Model

Model

- A global society N of n countries.
- Each country $i \in N$ is characterized by
  - h_i: the amount of historical emissions
  - c_i: the amount of current and future (BAU) emissions
  - d_i: the damage from meteorological disasters caused by climate change
  - a_i: the cost of abating one unit of pollutant
  - ν_i: the population of country i
- $\overline{h} \equiv \Sigma_{i \in N} h_i$, $\overline{c} \equiv \Sigma_{i \in N} c_i$, and $\overline{d} \equiv \Sigma_{i \in N} d_i$.
- E: the amount of target emissions.
- $E - \overline{h}$: the amount of allowable emissions.

Model (2/4)

- Emission rights have economic values.
  - γ_i^A: country i's economic value per unit emission under the agreement of emission reduction
  - γ_i^D: country i's economic value per unit emission without the agreement of emission reduction
  - $\gamma_i^D < \gamma_i^A$, $\gamma \equiv ((\gamma_i^D)_{i \in N}, (\gamma_i^A)_{i \in N})$

- The benefit from emitting one unit of pollutant is the sum of the gain from emitting and the gain from not incurring the cost of reducing pollutant emissions.
  - $(\gamma_i^D + a_i)c_i$: country i's benefit without the agreement

- If the level of BAU emissions is maintained, the damage that each country suffers at least as large as the benefit that each country obtains from the BAU emissions.
  - $d_i \geq (\gamma_i^D + a_i)c_i$

Model (3/4)

- d_i/γ_i^A: country i's damage measured in equivalent units of emissions under international agreement
- $(d_i - \gamma_i^D c_i)/\gamma_i^A$: country i's net damage measured in equivalent units of emissions under international agreement
- $(\gamma_i^D c_i - d_i) - (-c_i \cdot a_i) = (\gamma_i^D + a_i)c_i - d_i$: the disagreement net benefit above the full reduction net benefit
  - $\gamma_i^A \cdot 0 - c_i \cdot a_i = -c_i \cdot a_i$: full reduction net benefits
- $b_i^D = [(\gamma_i^D + a_i)c_i - d_i]/(\gamma_i^A + a_i)$: country i's disagreement net benefit

Model (4/4)

- We consider the problem of allocating $E - \overline{h}$ to the countries, denoted by $P = (h, c, d, a, \gamma, E)$.

- Let $\mathcal{P} \equiv \{(h, c, d, a, \gamma, \nu, E) \in \mathbb{R}_+^{7n+1}$: for all $i \in N, c_i > 0, d_i > 0, a_i > 0, \overline{h} + \overline{c} \geq E$, and $d_i \geq (\gamma_i^D + a_i)c_i\}$ be the set of all these problems.

- An allocation rule $f : \mathcal{P} \to \mathbb{R}^n$ is a function associating a single allocation $x \in \mathbb{R}$ with each problem $P \in \mathcal{P}$.

Allocation Rules

(Historical) Equal Per Capita rule (Ju et al. 2021)

Equal Per Capita rule (f_i^{EPC})(Singer 2002)

For each $(h, c, d, a, \gamma, \nu, E) \in \mathcal{P}$ and each $i \in N$,

$$f_i^{EPC}(h, c, d, a, \gamma, \nu, E) = \frac{\nu_i}{\bar{\nu}_j}(E - \bar{h}).$$

Historical Equal Per Capita rule (f_i^{HEPC})(Neumayer 2000; Ju et al. 2021)

For each $(h, c, d, a, \gamma, \nu, E) \in \mathcal{P}$ and each $i \in N$,

$$f_i^{HEPC}(h, c, d, a, \gamma, \nu, E) = \frac{\nu_i}{\bar{\nu}}\left(E - \bar{h}\right) + \nu_i\left(\frac{\bar{h}}{\bar{\nu}} - \frac{h_i}{\nu_i}\right).$$

(Historical) Equal Per Damage rule

Equal Per Damage rule (f_i^{EPD})
For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,

$$f_i^{EPD}(h, c, d, a, \gamma, E) = \frac{d_i/\gamma_i^A}{\sum d_j/\gamma_j^A}(E - \bar{h}).$$

Historical Equal Per Damage rule (f_i^{HEPD})
For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,

$$\begin{aligned} f_i^{HEPD}(h, c, d, a, \gamma, E) =& \frac{d_i/\gamma_i^A}{\sum d_j/\gamma_j^A}(E - \bar{h}) + \frac{d_i}{\gamma_i^A}\left(\frac{\bar{h}}{\sum d_j/\gamma_j^A} - \frac{h_i}{d_i/\gamma_i^A}\right) \\ =& \frac{d_i/\gamma_i^A}{\sum d_j/\gamma_j^A}E - h_i. \end{aligned}$$

More favorable to countries with high damage than EPC or HEPC in Ju et al. (2021)! No penalty for large BAU emissions.

(Historical) Equal Per Net Damage rule

Equal Per Net Damage rule (f_i^{EPND})
For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,

$$f_i^{EPND}(h, c, d, a, \gamma, E) = \frac{(d_i - \gamma_i^D c_i)/\gamma_i^A}{\sum(d_j - \gamma_j^D c_j)/\gamma_j^A}(E - \bar{h}).$$

Historical Equal Per Net Damage rule (f_i^{HEPND})
For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,

$$\begin{aligned} f_i^{HEPND}(h, c, d, a, \gamma, E) =& \frac{(d_i - \gamma_i^D c_i)/\gamma_i^A}{\sum(d_j - \gamma_j^D c_j)/\gamma_j^A}(E - \bar{h}) + \frac{d_i - \gamma_i^D c_i}{\gamma_i^A}\left(\frac{\bar{h}}{\sum(d_j - \gamma_j^D c_j} \right. \\ =& \frac{(d_i - \gamma_i^D c_i)/\gamma_i^A}{\sum(d_j - \gamma_j^D c_j)/\gamma_j^A}E - h_i. \end{aligned}$$

More favorable to countries with high "net" damage than EPC or HEPC in Ju et al. (2021)! Penalty for large BAU emissions.

Equal Per Disagreement Net Benefit rule

Equal Per Disagreement Net Benefit rule (f_i^{EPDNB})

For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,

$$f_i^{EPDNB}(h, c, d, a, \gamma, E) = \frac{b_i^D/(\gamma_i^A + a_i)}{\sum b_j^D/(\gamma_j^A + a_j)}(E - \bar{h}),$$

where $b_i^D = [(\gamma_i^D + a_i)c_i - d_i]/(\gamma_i^A + a_i)$ (country i's disagreement net benefit).

Axioms

Historical Accountability & History Independence

Historical Accountability (HA)

For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,

$$f_i(h, c, d, a, \gamma, E) = f_i((0, h_{-i}), c, d, \gamma, E) - h_i.$$

History Independence (HI)

For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $(h', c', d', a', \gamma', E') \in \mathcal{P}$, if $E - \overline{h} = E' - \overline{h}'$ and $(c, d, a, \gamma) = (c', d', a', \gamma')$, then,

$$f_i(h, c, d, a, \gamma, E) = f_i(h', c', d', a', \gamma', E').$$

International Paretianism

A treaty satisfes what we call International Paretianism if it advances the interests of all states that join it, so that no state is made worse off. [p.347 in Weibach and Posner 2013]

The status-quo is the outcome without international treaty, or the disagreement outcome where BAU emissions are maintained in all countries.

International Paretianism (IP)

For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,
if $E - \overline{h} \geq \sum b_j^D$,

$$\gamma_i^A f_i(h, c, d, a, \gamma, E) - a_i(c_i - f_i(h, c, d, a, \gamma, E)) \geq \gamma_i^D c_i - d_i.$$

- When $E - \overline{h} = \sum f_j < \sum b_j^D$, no allocation can meet the requirement.

Other Axioms(1/3)

Damage Upper Bound (DUB)

For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$, if $E \leq \sum d_i/\gamma_i^A$

$$f_i(h, c, d, a, \gamma, E) \leq d_i/\gamma_i^A.$$

Net Damage Upper Bound (NDUB)

For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$, if $E \leq \sum(d_i - \gamma_i^D c_i)/\gamma_i^A$,

$$f_i(h, c, d, a, \gamma, E) \leq (d_i - \gamma_i^D c_i)/\gamma_i^A.$$

Other Axioms (2/3)

History Lower Bound (HLB)

For each $(h, c, d, a, \gamma, E) \in \mathcal{P}$ and each $i \in N$,

$$f_i(h, c, d, a, \gamma, E) \geq -h_i.$$

Historical accoubtability(HA) implies history lower bound(HLB).

Resource Additivity (RA)

For all $h, h' \in \mathbb{R}_+^N$, all $E, E' \in \mathbb{R}_+$ and all (c, d, a, γ) with $(h, c, d, a, \gamma, E), (h', c, d, a, \gamma, E'), (h + h', c, d, a, \gamma, E + E') \in \mathcal{P}$,

$$f(h + h', c, d, a, \gamma, E + E') = f(h, c, d, a, \gamma, E) + f(h', c, d, a, \gamma, E').$$

Other Axioms (3/3)

Equal Treatment.(ET) For each $(h, c, \nu, E) \in \mathcal{P}$ and each pair $i, j \in N$, if $h_i/\nu_i = h_j/\nu_j$, $c_i/\nu_i = c_j/\nu_j$, $d_i/\nu_i = d_j/\nu_j$ and $(a_i, \gamma_i) = (a_j, \gamma_j)$, then

$$f_i(h, c, \nu, E)/\nu_i = f_j(h, c, \nu, E)/\nu_j.$$

Strong Equal Treatment.(SET) For each $(h, c, \nu, E) \in \mathcal{P}$ and each pair $i, j \in N$, if $h_i/\nu_i = h_j/\nu_j$ and $c_i/\nu_i = c_j/\nu_j$,

then

$$f_i(h, c, \nu, E)/\nu_i = f_j(h, c, \nu, E)/\nu_j.$$

Independence of Irrelevant BAU Emissions.(IIE) For each $(h, c, \nu, E) \in \mathcal{P}$, each $i \in N$ and each $c_i' > 0$, if $c_i/\nu_i \geq E - \bar{h}$ and $c_i'/\nu_i \geq E - \bar{h}$, then

$$f(h, c, \nu, E) = f(h, (c_i', c_{-i}), \nu, E).$$

Results

Results

Theorem 1

A rule satisfies *history independence*, *damage upper bound*, and *resource additivity* if and only if it is **equal per damage rule**.

Theorem 2

A rule satisfies *history lower bound* (or *historical accountability*), *damage upper bound*, and *resource additivity* if and only if it is **historical equal per damage rule**.

Results (2/3)

Theorem 3

A rule satisfies *history independence*, *net damage upper bound*, and *resource additivity* if and only if it is **equal per net damage rule**.

Theorem 4

A rule satisfies *history lower bound* (or *historical accountability*), *net damage upper bound*, and *resource additivity* if and only if it is **historical equal per net damage rule**.

Results (3/3)

Theorem 5

A rule satisfies *history independence*, *international paretianism*, and *resource additivity* if and only if it is **equal per disagreement net benefit rule**.

Theorem 6

There is no rule satisfying both *historical accountability* and *international paretianism*.

Conclusion

- We consider both cost and benefit of a climate agreement, taking into account differential damages from the risk of climate disaster under no agreement as well as differential abatement costs and economic values of emissions across countries.
- International Paretianism, as proposed by Posner and Weisbach (2010), requires that any treaty must advance the interests of all states that join it, so that no state is made worse off.
- Incorporating all relevant cost and benefit, we find supports for more drastic redistribution in favor of developing countries with large potential climate damages and little BAU emissions (in the early stage of economic development) than previous proposals in the literature (EPC, HEPC, etc).
- International Paretianism is not compatible with Historical Accountability. It is not compatible with strong equal treatment properties as proposed by Singer or other scholars (e.g. EPC); but it is compatible with milder version of equal treatment

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