Which is the role of equity in climate policy pathways?

The status of integrating Justice/equity into IAMs

Dr. Panagiotis Fragkos, E3Modelling
PRISMA Summer School, Utrecht, July 10 2025

Contents

- Definition of justice and equity. Why does it matter for climate policy?
- How IAMs can represent inequalities and distributional impacts?
- Assessment of distributional impacts of climate policies and climate change based on various studies
- What is the role of redistributive policies towards ensuring both mitigation and just transition
- Way forward towards improving equity integration in IAMs and mitigation pathways

Equity and climate policies

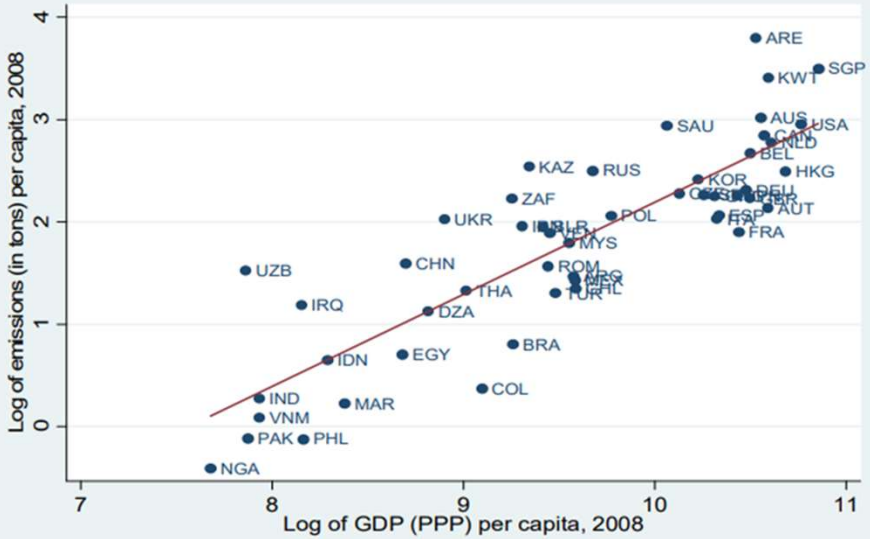
- Climate policies are needed for climate change mitigation, but they often lead to negative distributional impacts across countries, sectors, regions, and households

- Equity is very important for mitigation action due to:
  - Differences in (historical) contribution to CC
  - Differences in capability to reduce emissions
  - Different consequences of mitigation (within and across regions)
  - Different climate impacts across groups

- People do not accept solutions that are not considered 'just'
- Recognised in the Paris Agreement in the form Of "common but differentiated responsibilities"

Why include **equity** in climate Policy?

- Climate change is a global problem with unequal causes & consequences
- Equity is essential for:
  - Fairness in sharing mitigation/ adaptation burdens and benefits
  - Building trust & cooperation in international negotiations
  - Ensuring all countries have the right to sustainable development (esp low- income countries)



International Distribution of Emissions, 2018

The impacts of climate change are also very regressive

- Climate change causes rising temperatures, extreme weather, sea level rise, and biodiversity loss

- Impacts are **unevenly** distributed: poorer countries and vulnerable populations are hit the hardest

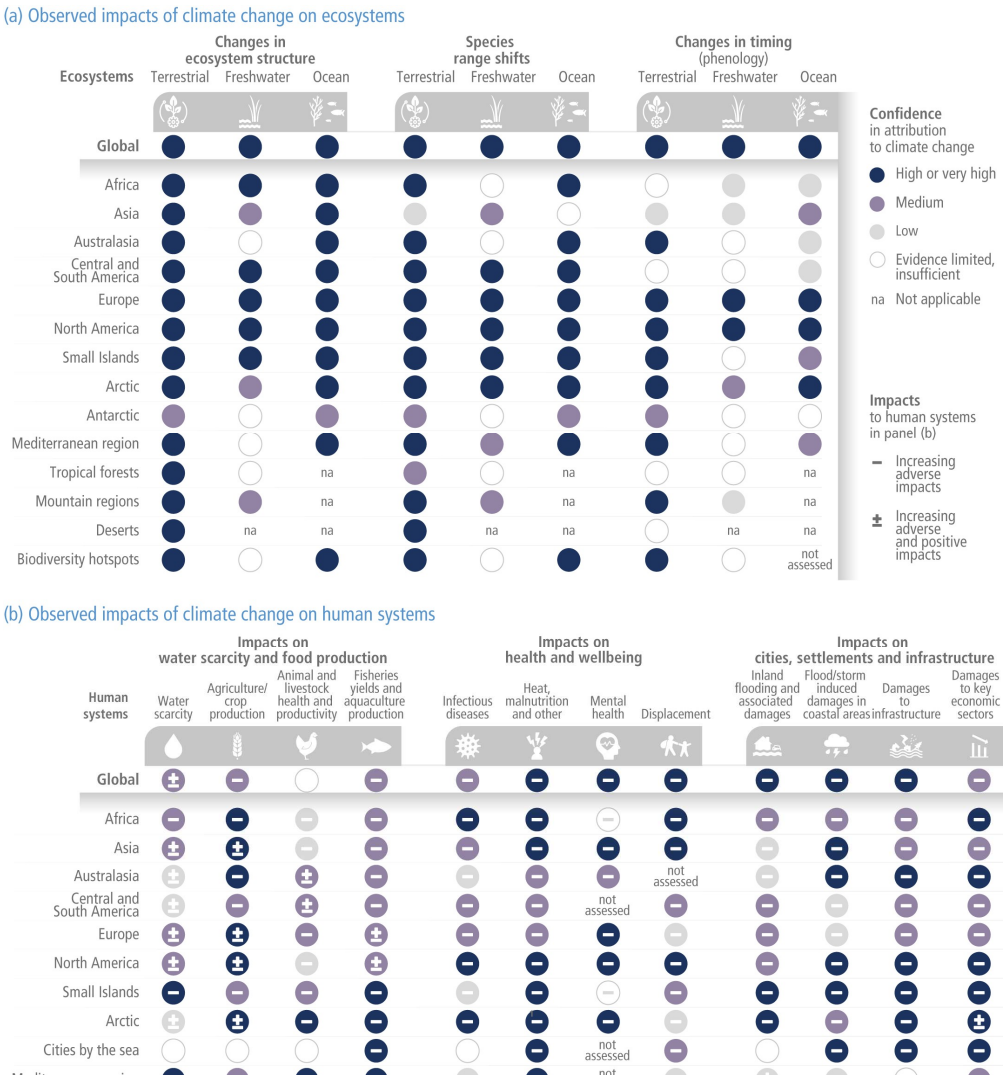


Figure SPM.2 in IPCC, 2022: Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-33, doi:10.1017/9781009325844.001.

Different forms of justice in climate policy

- **Distributional:** Distribution of impacts across groups, based on Responsibility, equality, capacity – cost-effective
- Procedural: Is the process fair and accessible for all?
- Corrective: How can we address historical injustices?
- Recognitional: What sensitivities (regional, cultural) are relevant to climate policy?
- Transitional: How should policies be sequenced to bring us closer to the ideal just state?

Justice considerations in climate research

Caroline Zimm, Kian Mintz-Woo, Elina Brutschin, Susanne Hanger-Kopp, Roman Hoffmann, Jarmo S. Kikstra, Michael Kuhn, Jihoon Min, Raya Muttarak, Shonali Pachauri, Omkar Patange, Keywan Riahi & Thomas Schinko

Nature Climate Change **14**, 22–30 (2024) | Cite this article

What is equity?

People
(social groups, income levels, generations)

Places
(countries, regions, localities)

Time
(intergenerational equity)

*In climate change: **equity**=Fairness in distributing responsibilities, costs & opportunities*

Key principles for equity in mitigation analysis

Equal per capita emissions: Everyone has an equal right to the atmosphere

Historic responsibility: Historical large emitters bear greater responsibility

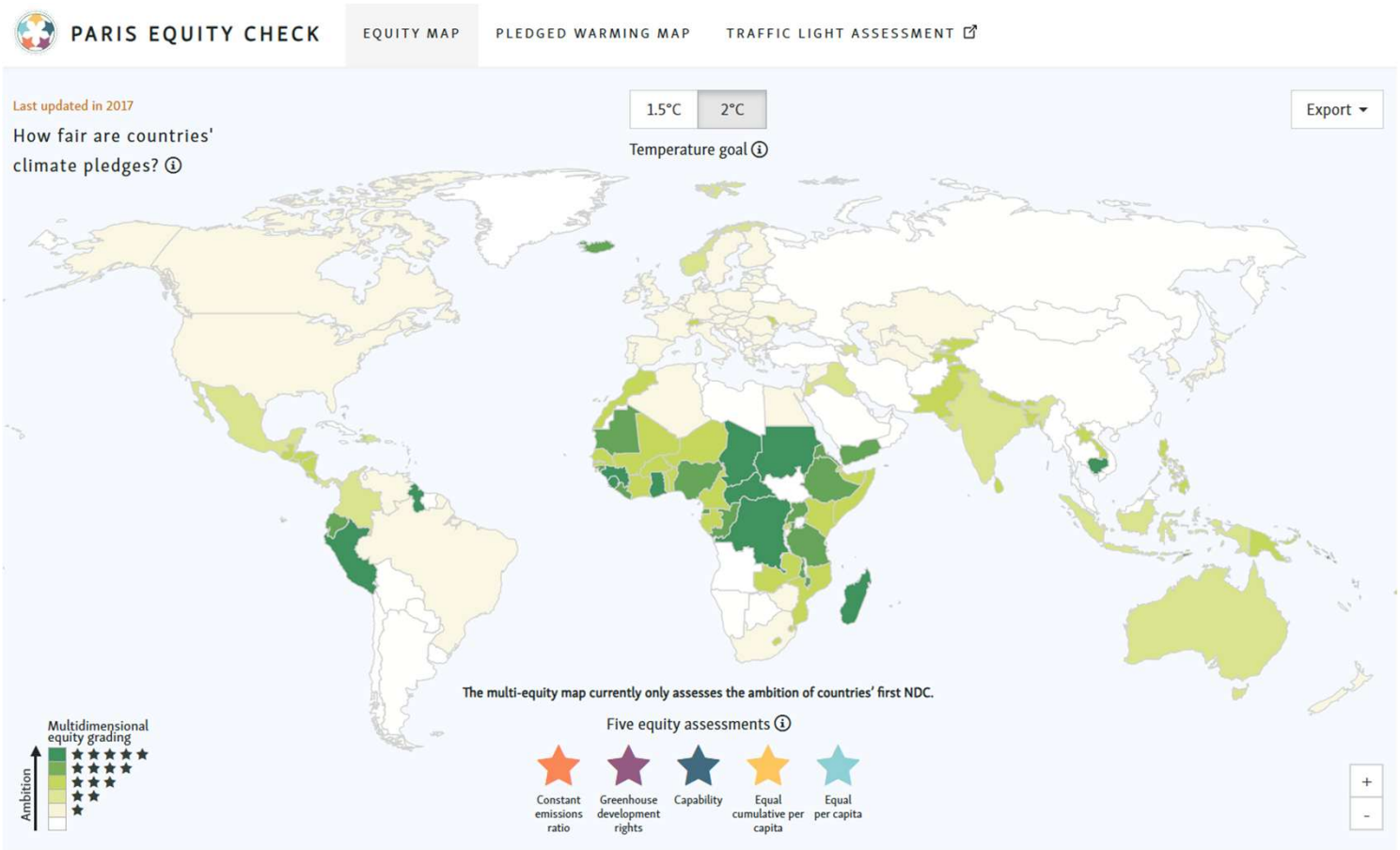
Ability to pay: Wealthier countries should shoulder more costs

Preserving development opportunities: Poorer countries need space to grow

Adjustment costs: Recognizes challenges of rapid transitions

Different equity principles lead to very different mitigation effort/emissions allocations across countries

Paris Equity Check | Equity Map - See Mark Dekker ppt



This Equity Map presents an assessment of countries' climate pledges under five visions of climate justice and for emissions pathways that are consistent with the Paris Agreement goals of limiting warming to 1.5 °C or well below 2 °C, and achieving net-zero greenhouse-gas emissions by the end of the century.

How IAMs have been used?

Typical application of IAMs

- ❑ Emission pathways to 1.5oC and 2oC
- ❑ Technology and energy transitions
- ❑ Policy cost analysis
- ❑ Global carbon budgets
- ❑ Climate finance needs and carbon pricing

IAMs help answer questions like:

- ❑ What is the least-cost way to reach net-zero by 2050?
- ❑ How much renewables are needed?
- ❑ What are the costs of delaying mitigation?

Why equity is important in climate mitigation?

Equity is crucial for achieving:

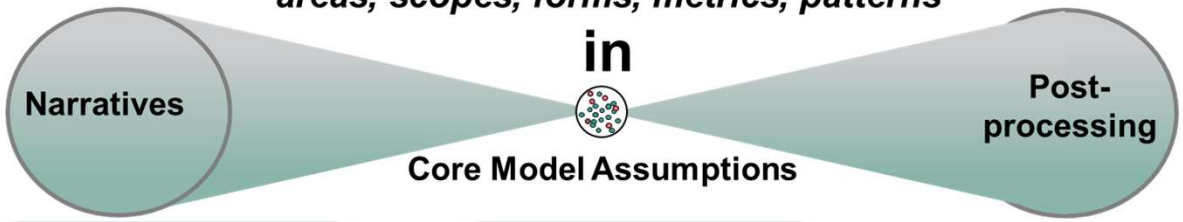
- ❑ Fair burden-sharing across countries
- ❑ Avoid regressive impacts in poorest and most vulnerable communities (energy poverty)
- ❑ Political legitimacy
- ❑ SDGs and just transition goals

IAMs while influential in policy, have historically centered on **cost efficiency**, **not fairness**

Justice Considerations

areas, scopes, forms, metrics, patterns

in



	Narratives	Core Model Assumptions	Post-processing
Work in progress	❖ SSPs ❖ SSP Extensions ❖ Demand-Driven Strategies ❖ Gender Inequality ❖ Fair Development Patterns ❖ Fast GDP/capita Convergence ❖ SDGs ❖ Societal Change	❖ Regionally Differentiated Carbon Prices ❖ Discount Rates ❖ Sustainability Constraints ❖ Effort Sharing ❖ Institutional Capacity for Climate Action	❖ Risk of Hunger ❖ DLE ❖ Unemployment ❖ Health Impacts ❖ Income Inequality ❖ Climate Impacts ❖ Financial Investment Needs ❖ Welfare ❖ Economic Impacts of Mitigation and Adaptation ❖ Land Use Implications
Outlook	❖ Transparent Assumptions & Context ❖ Development First ❖ Beyond Growth Narratives ❖ Convergence of Need Satisfiers ❖ Fair Effort Sharing Under Constraints ❖ Inequality Drivers ❖ Integrated Stakeholder Engagement	❖ Alternative Objective Functions ❖ Greater Heterogeneity of Actors ❖ Explicit Representation of Resource Needs ❖ Reserve Land for Nature ❖ Integrated Stakeholder Engagement	❖ Land-Based CDR Granularity ❖ Biodiversity and Ecosystem Health Metrics ❖ Climate Impacts ❖ Overshoot Burden Shift ❖ Multidimensional Wellbeing & Justice Metrics ❖ Integrated Stakeholder Engagement

Representing inequalities in IAMs

How central dimensions of inequality are represented in IAMs? How relevant are they for climate policies?

Variable	Gender	Age	Education	Settlement	Income	Family size	Health	Race	Religion
Scenarios quantified	SSPs, Ext. SSPs	SSPs	SSPs	SSPs	Ext. SSPs (Gini)	-	-	-	-
Endogenization in IAMs so far	-	low	-	-	medium	-	low	-	-
Relevance … general	***	***	***	**	***	**	**	**	*
… for climate policies	**	*	**	**	***	**		*	?
… for climate impacts	**	***	**	***	**	*	***	**	?

Representing inequalities in integrated assessment modeling of climate change

Johannes Emmerling[1,*] and Massimo Tavoni[1,2]

https://www.cell.com/one-earth/pdf/S2590-3322(21)00059-2.pdf

Current ways to assess equity

- **IAMs** traditionally use **representative agents**, hide within country differences (*representative-agent set up masks within-population disparities*)
  - Common modelling approaches include:
    - **Cost-benefit IAMs**: Use aggregate social welfare functions (e.g., RICE, FUND)
    - **Process-based IAMs**: Focus on energy/economic system dynamics (e.g., WITCH, GCAM, IMAGE)
- **Equity** represented via:
  - Country/regional disaggregation (e.g., RICE, FUND) **to capture between-country inequality**
  - Use of SSP scenarios providing exogenous Gini projections for inequality
  - Alternative welfare functions (*utilitarian vs prioritarian*) to weight impacts on the poor
  - Simplified revenue recycling schemes (lump-sum per capita transfers) but often without realistic targeting

Three modeling entry points and effect categories of inequality

Modeling as \ Effects of..	policies	impacts	SWF definitions
(exogenous) scenarios	n.a.	Through estimated damage functions	Alternative welfare metrics (Sen, multidimensional, subgroup, ...)
+ endogenous modeling	CGE/ABM/IAM with additional detail on consumption, production factor heterogeneity	ABM/CGE with households labour productivity, capital, assets, health	Include heterogeneity in the optimization criterion
+ considering interactions	ABM with interactions / network	ABM + spatial impact specification	- (challenging)

Challenges and Gaps in IAM Equity Modelling

Most IAMs use representative agents, masking heterogeneity

Narrow equity dimensions, focus mainly on income, neglect health, gender, race

Unrealistic policy assumptions, idealized universal schemes with no leakage

Damage functions ignore distributional impacts and adaptation gaps

IAMs lack integration of social dynamics & stakeholder input

Accounting for inequality in IAMs

Current generation of IAMs:

- ❑ Most IAMs still oversimplify or exclude inequality, relying on average consumer assumptions
- ❑ Including inequality changes climate policy outcomes
- ✓ often leads to higher social cost of carbon SCC
- ✓ may justify stronger climate action
- ✓ Would improve our understanding of how the costs and benefits of climate transition would be split across countries, sectors and households

Key motivation to include equity in IAMs:

1. **Moral & Impact concerns:** 1.5oC limit aims to protect vulnerable communities
2. **Trade-offs and inequality:** Costs and opportunities are unevenly distributed
3. **Political feasibility of ambitious mitigation:** Unfair pathways may face resistance and fail

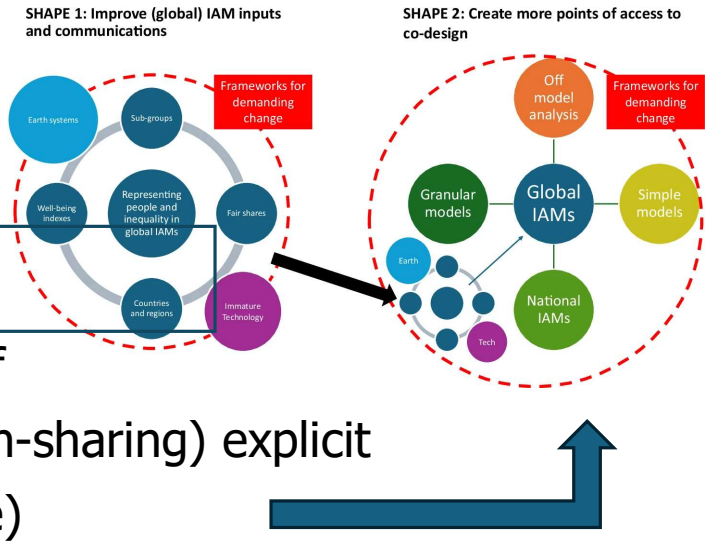
Redistributive policies matter:

- ❑ Recycling carbon revenues can reduce inequality if well-targeted
- ❑ Real-world limitations (e.g., in Sub-Saharan Africa) suggest that universal targets modelled in IAMs are unrealistic in the short term

Strategies to improve equity in IAMs

Ways Forward (Klinsky & Winkler, 2018):

- ❑Integrate adaptation/climate damage inequality
- ❑Use downscaling to increase context-sensitivity
- ❑Link IAMs with poverty/human development models
- ❑Apply equity weights or disaggregation in cost-benef
- ❑Make normative choices (e.g., discount rates, burden-sharing) explicit
- ❑Engage users in scenario framing (procedural justice)



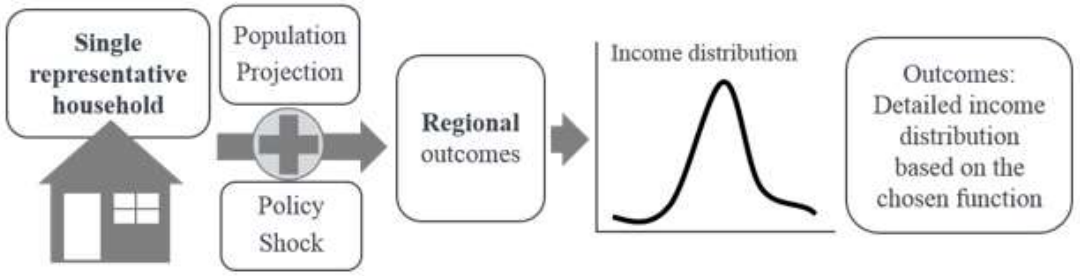
Expert perspectives on incorporating justice considerations into integrated assessment modelling

Tools & Innovations:

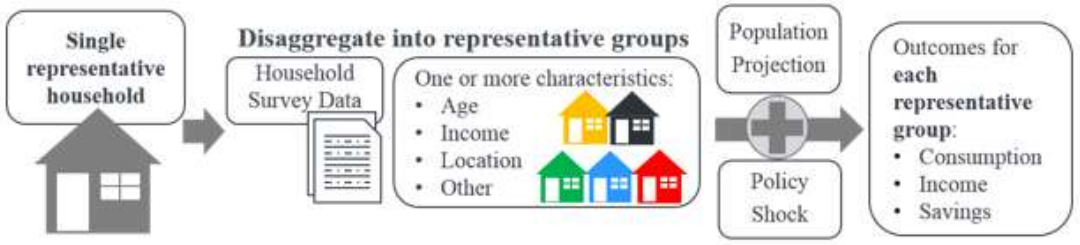
- ❑Link IAMs with household data
- ❑Equity weighted social cost of carbon
- ❑Effort sharing frameworks (e.g. per capita, capability)
- ❑Linking IAMs with microsimulation or CGE models

Assessing distributional impacts

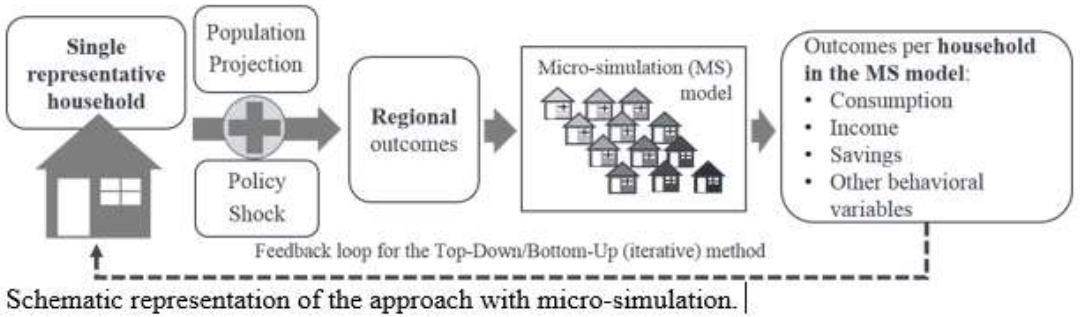
1) Direct modelling of income distribution based on base data
2) Disaggregate population into representative groups (i.e. income deciles)
3) Micro-simulation modelling coupled with IAMs



Schematic representation of direct modeling of income distribution..

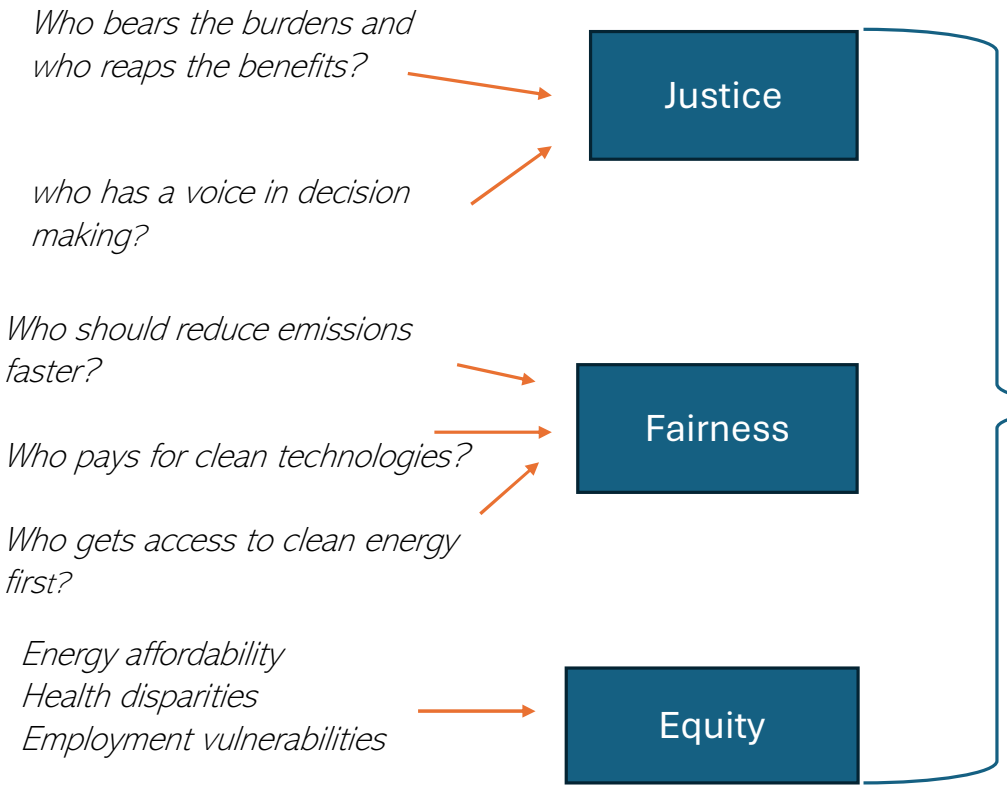


Schematic representation of the approach with multiple households.



Schematic representation of the approach with micro-simulation.

Linking Justice, Fairness, Equity with Just Transition

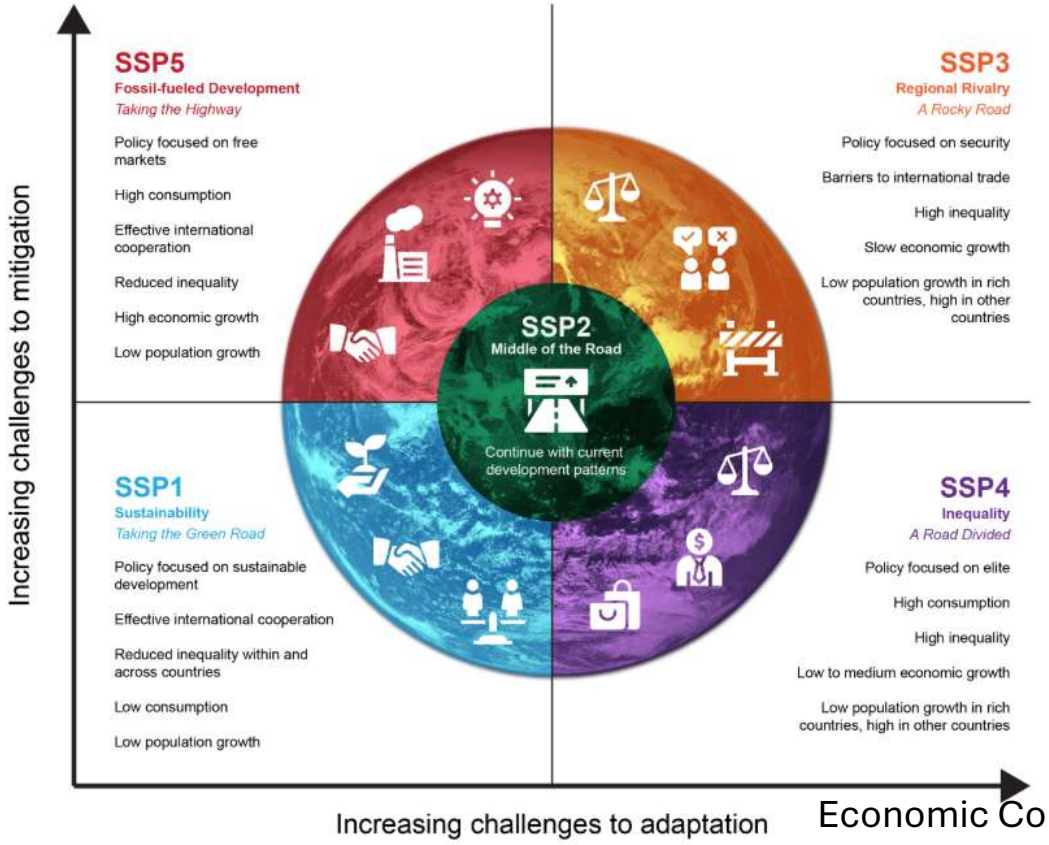


Just transition operationalises justice by ensuring no one is left behind

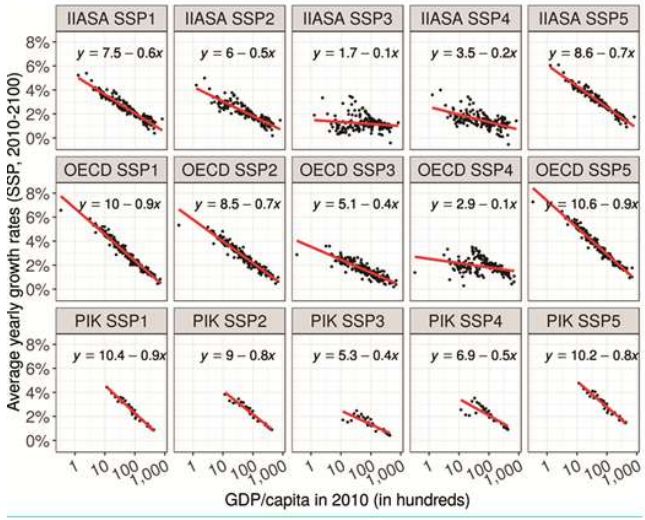
A Just transition ensures that: fairness guides the phasing out of fossil fuels

A Just transition embeds equity by tailoring policies to correct systemic disadvantages, prioritise vulnerable communities, & ensure inclusive benefits.

Equity in Shared Socioeconomic Pathways SSPs



- SSPs explore potential future developments and their impact on climate change, including the role of equity. SSP1 (Sustainability) envisions a world with low inequality and focus on sustainability, while SSP4 (Inequality) projects a future with high inequality, with different impacts across regions.



Economic Convergence Rate by Model and Growth Scenario in the SSP Framework. Global economic convergence in most SSPs, with the exception of SSP3 and SSP4 (rising inequalities)

Large disparities in households' expenditure on energy across and within EU countries

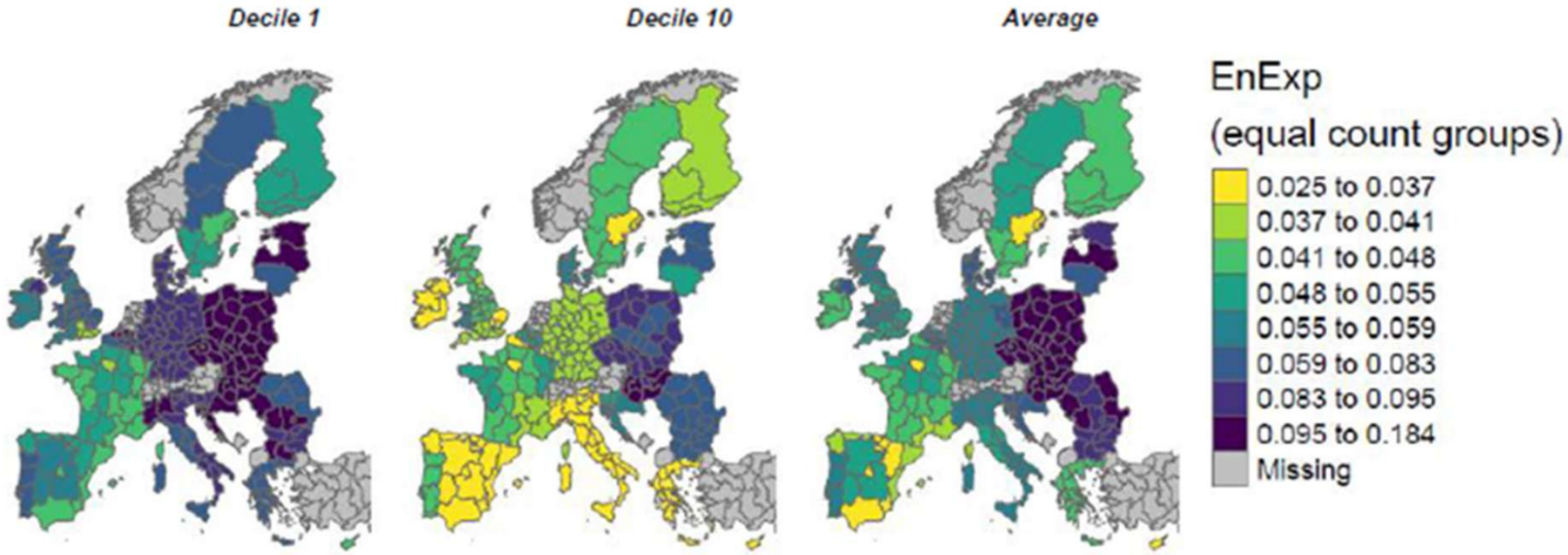
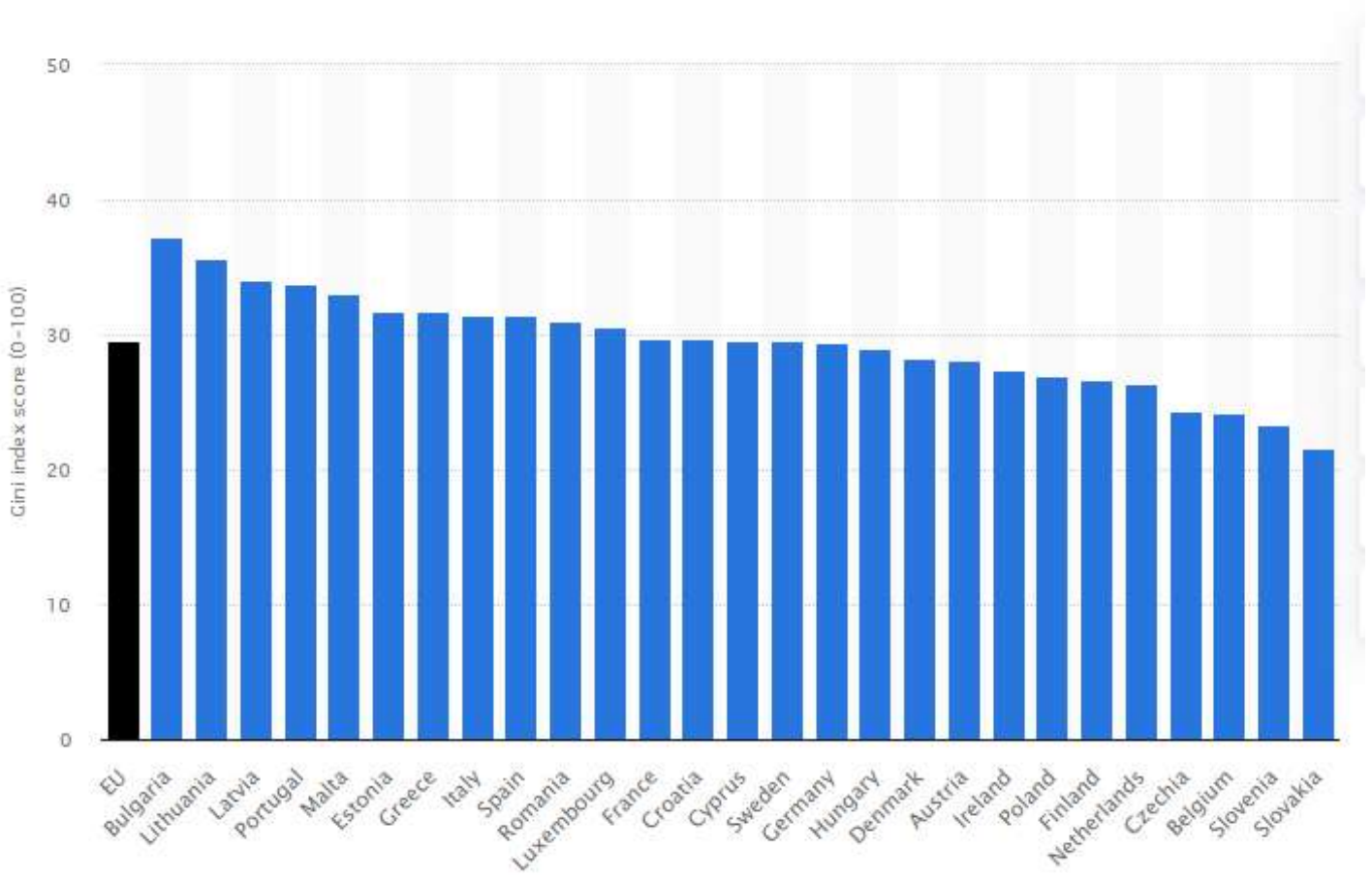


Figure 1. Average household expenditure on energy by income decile (lowest, highest and average) by NUTS1 regions across Europe.[31] CC BY 4.0

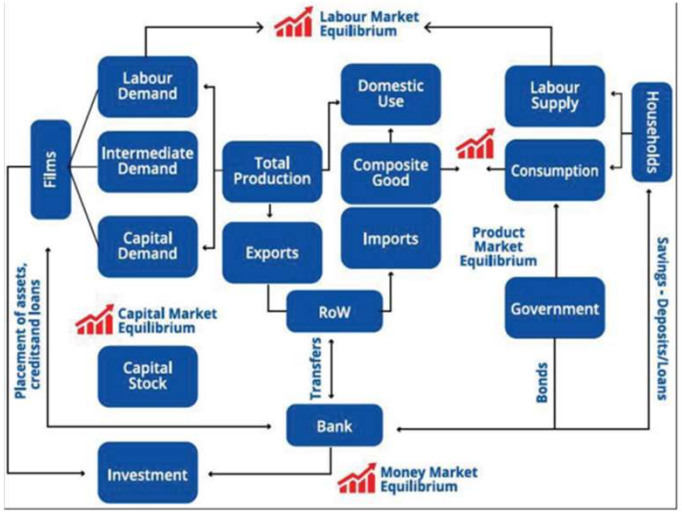
Indicators to measure income inequality

Indicator	Description/ relevance for inequality
Mean and median income by household	The median is the income level that divides the population into two groups of equal size. The use of the median corrects potential distortion that may be caused by the existence of extreme values.
Decile dispersion ratio	This measure presents the ratio of the average income of e.g. the richest 10 percent of the population divided by the average income of the poorest 10 percent. The indicator is vulnerable to extreme values and outliers.
S80/S20 income quintile share ratio	Comparing the income received by the top 20% of the population with the bottom 20% of the population.
Gini coefficient	based on the Lorenz curve, that compares the distribution of income with the uniform distribution that represents equality. It represents the extent to which income distribution differs between an equal distribution (Gini 0) and perfect inequality (Gini 1).
Atkinson index	This index is based on the Gini index and includes a sensitivity parameter, which can range from 0 (meaning indifference about the nature of the income distribution), to infinity (where the focus is on the lowest income group).
At risk poverty rate	The share of people with an equivalised disposable income below the at-risk-of-poverty threshold, which is set at 60% of median equivalised disposable income.
Severely and materially deprived	The indicator measures the share of population that cannot afford three or four of the nine items listed in a reference year.

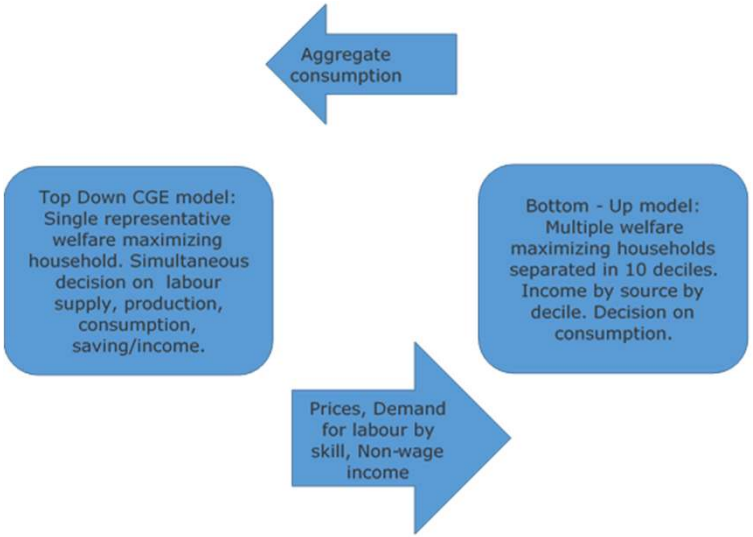
Gini coefficient of EU countries



Study: Distributional impacts of EU net-zero policies



GEM-E3 model capturing both the demand and supply-side impacts



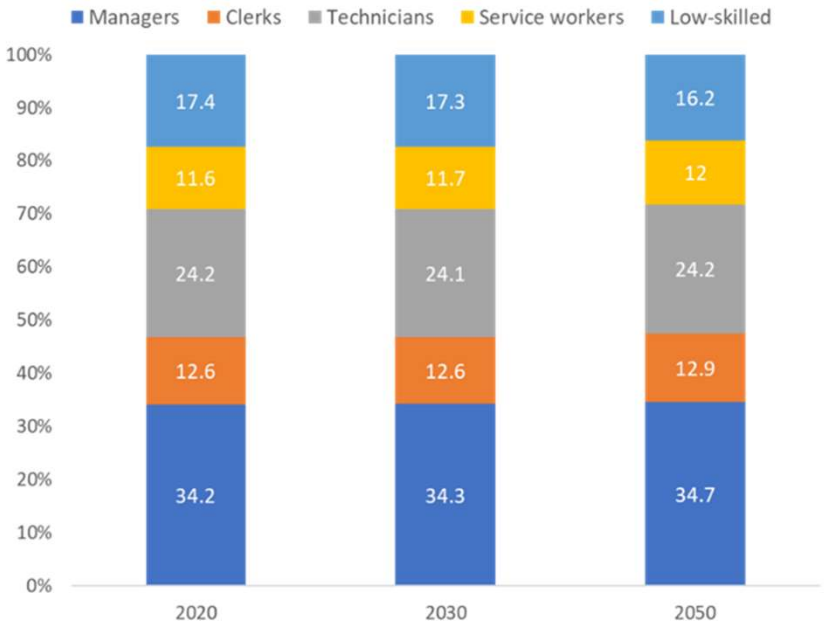
Methodology to model the impacts on 10 income deciles (income, consumption)

Three scenarios simulated

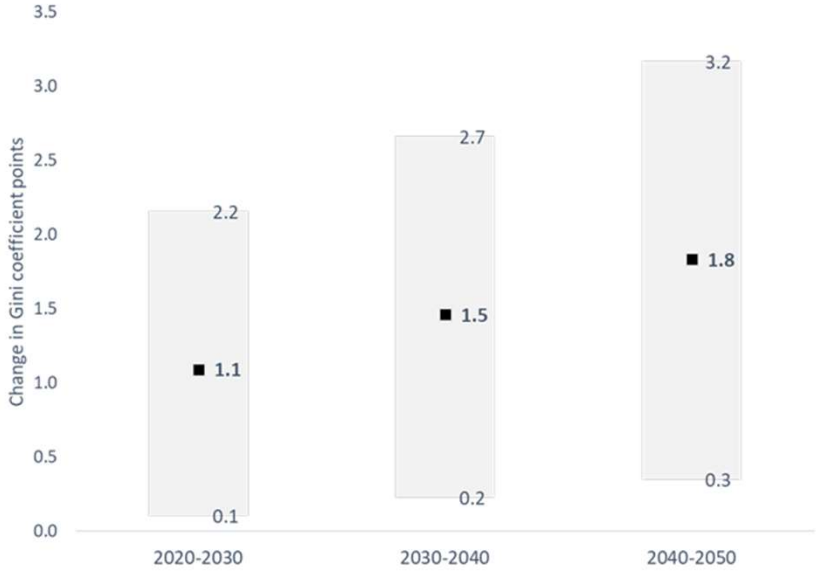
- Current Climate Policies
- EU Net zero by 2050
- EU net zero with lump-sum transfer to households

The Reference scenario

Composition of EU labour value added by skill



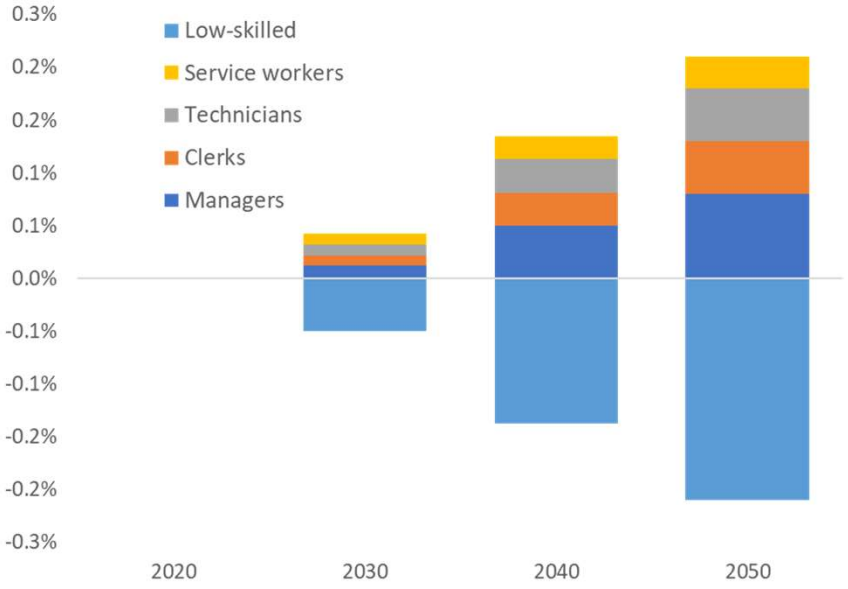
Increase in inequality across all EU countries by 2050



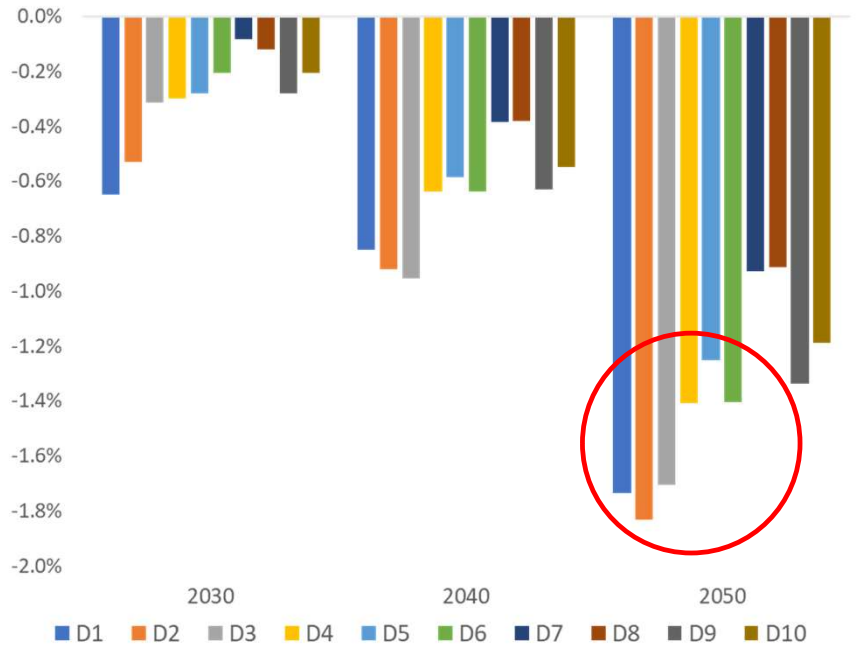
Increase in inequality (S80/S20 index) across all EU countries

Distributional impacts of the net-zero

Changes in the composition of EU labour value: Towards higher skills !

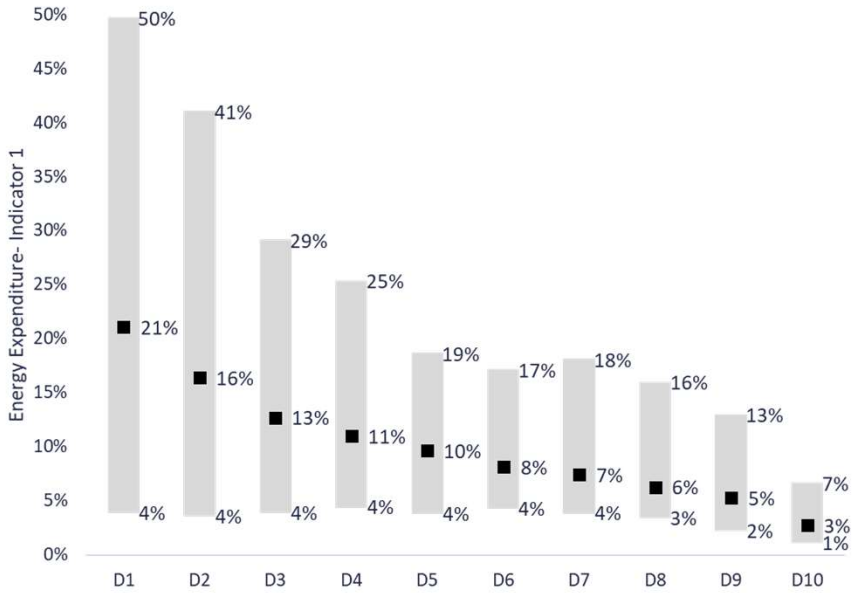


Changes in income per EU decile group relative to Reference: <u>Regressive impacts of mitigation</u>

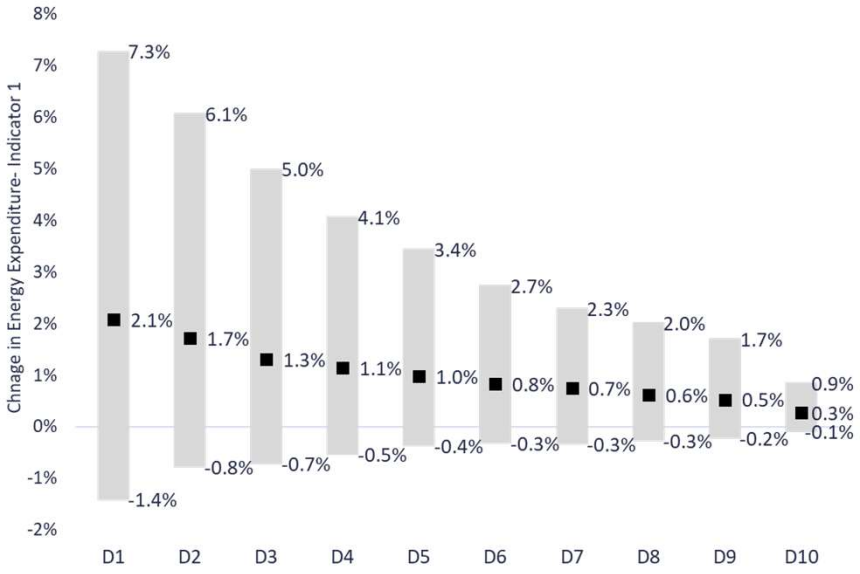


Impacts on households' energy expenditure

Energy expenditure as a share of income across Member States by decile in 2050 in Reference

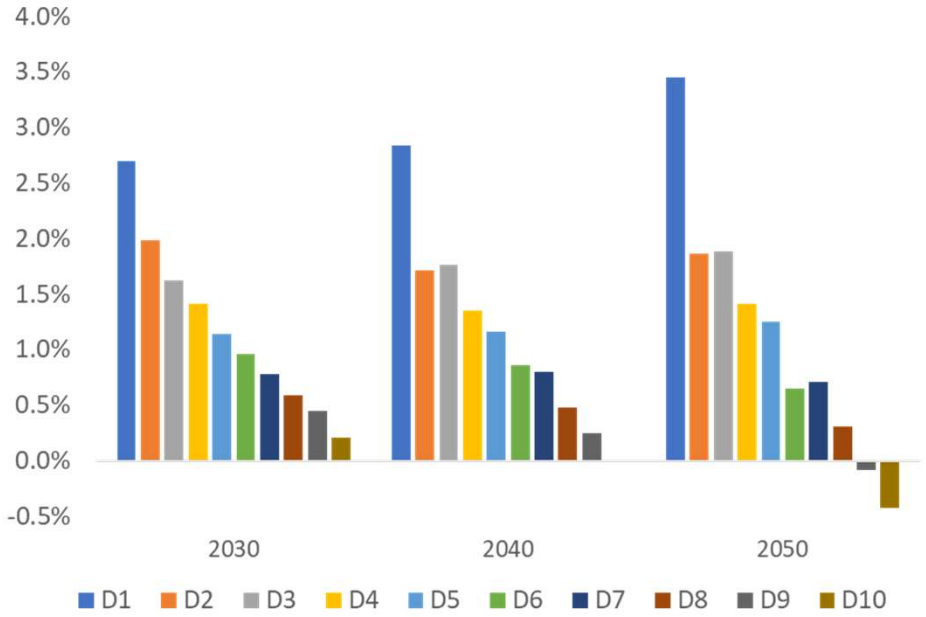


Changes in Energy expenditure Indicator across Member States by income relative to Reference

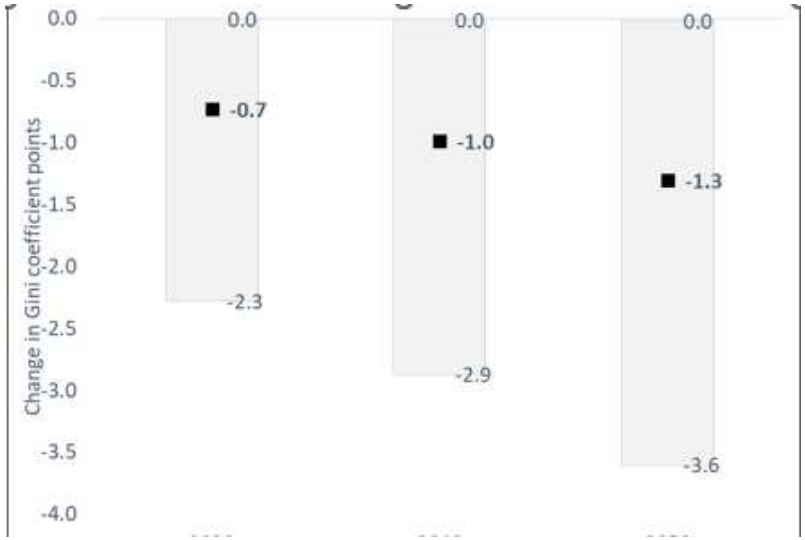


What happens if carbon revenues are given back to households?

Higher income esp. for low-income deciles



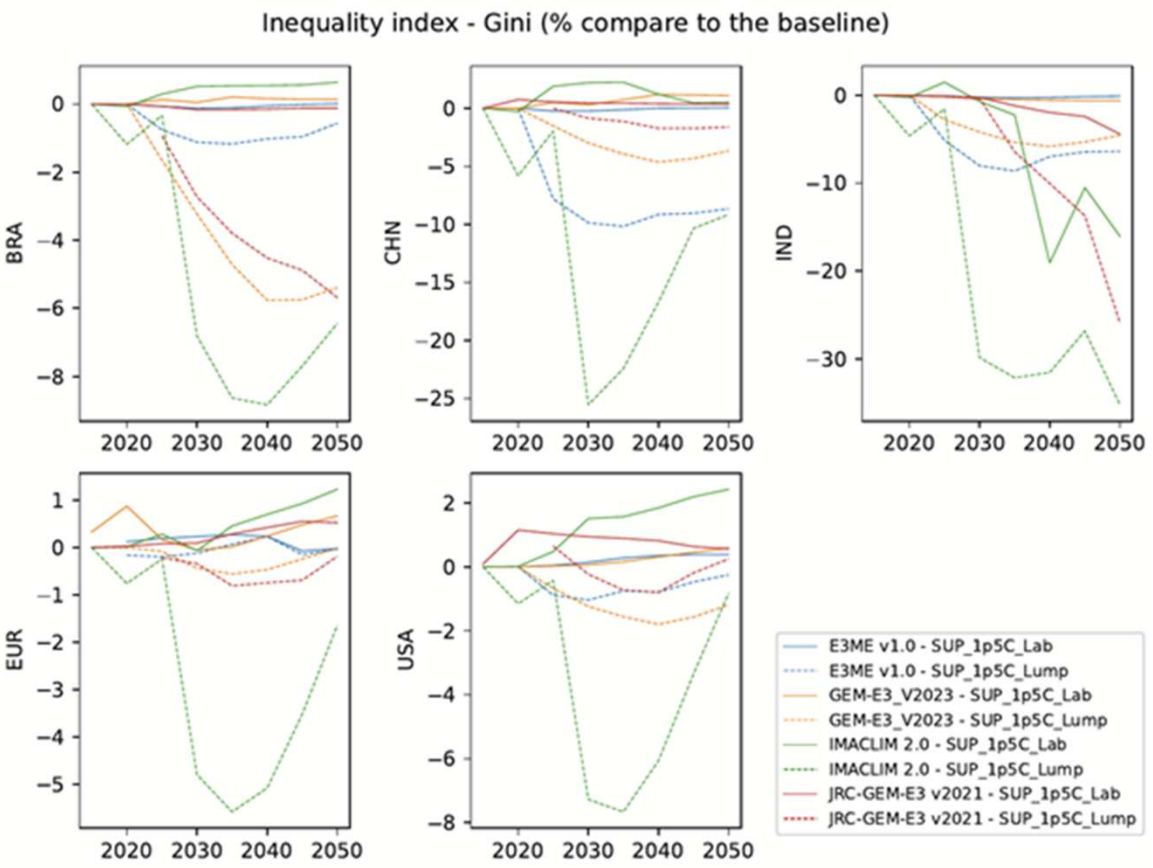
Gini coefficient declines – improved equity



The EU can achieve deep decarbonization and improved societal equity !

Are these results robust to different models & countries?

- Use 4 leading macro economic models
- Comparison of two recycling schemes of carbon revenues:
  - ➢ Reducing labor taxes / subsidizing labor (direct support to employment)
  - ➢ Lump-sum transfers to households (direct reduction of income inequality)
- Progressive outcomes from the lump-sum transfer policy with large Gini index improvements
- Strongest results in China and India, due to higher carbon revenues
- Trade-offs between equity and efficiency that need to be balanced

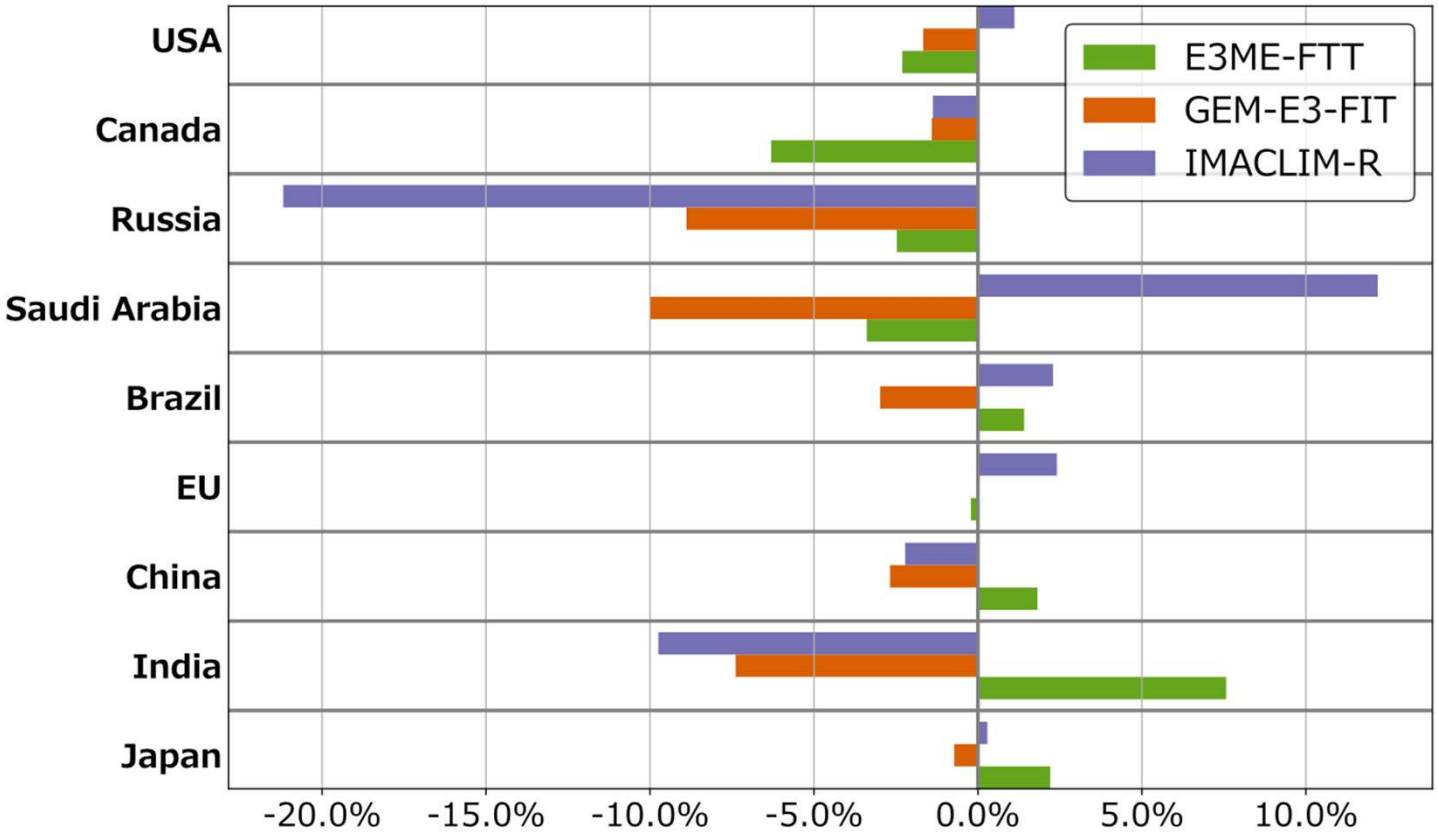


Large distributional impacts across sectors

Winners	Losers	Not clear
• Electricity supply • Renewables • Construction • Manufacturing for renewable goods	• Coal • Oil and gas extraction • Gas distribution • Refineries • Land transport • Air transport • Energy intensive industries	• Services (depend on outcomes of revenue recycling) • Agriculture (biofuels) • Other industries

C Lynch, Y Simsek, JF Mercure, P Fragkos, J Lefèvre... - Economic Systems Research, 2024

Regional disparities: GDP impacts of 1.5C



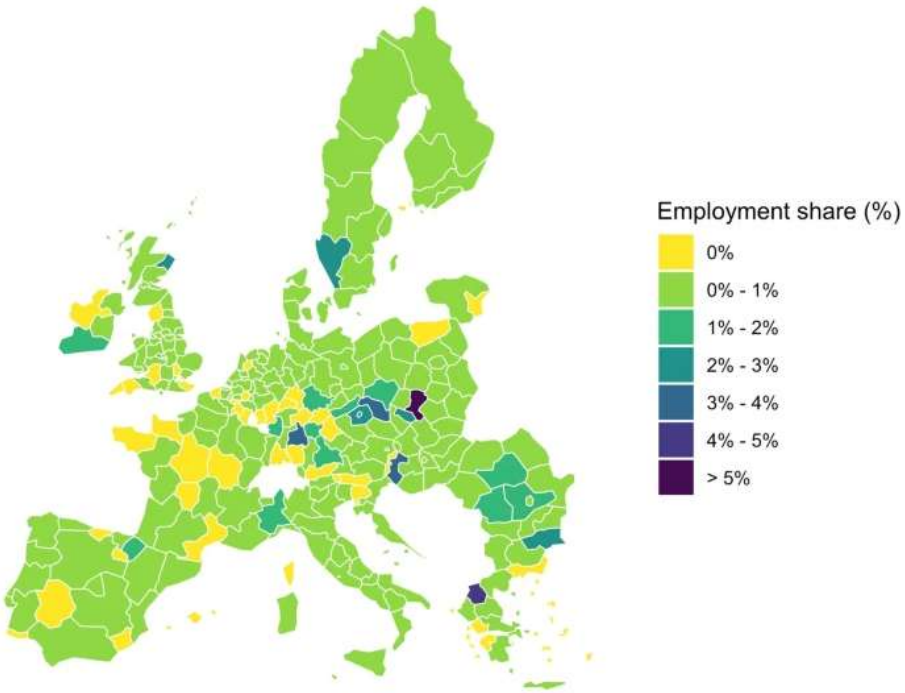
Major determinants:

1) Carbon intensity of GDP
2) Role in fossil fuel trade
3) Economic structure
4) RES potentials

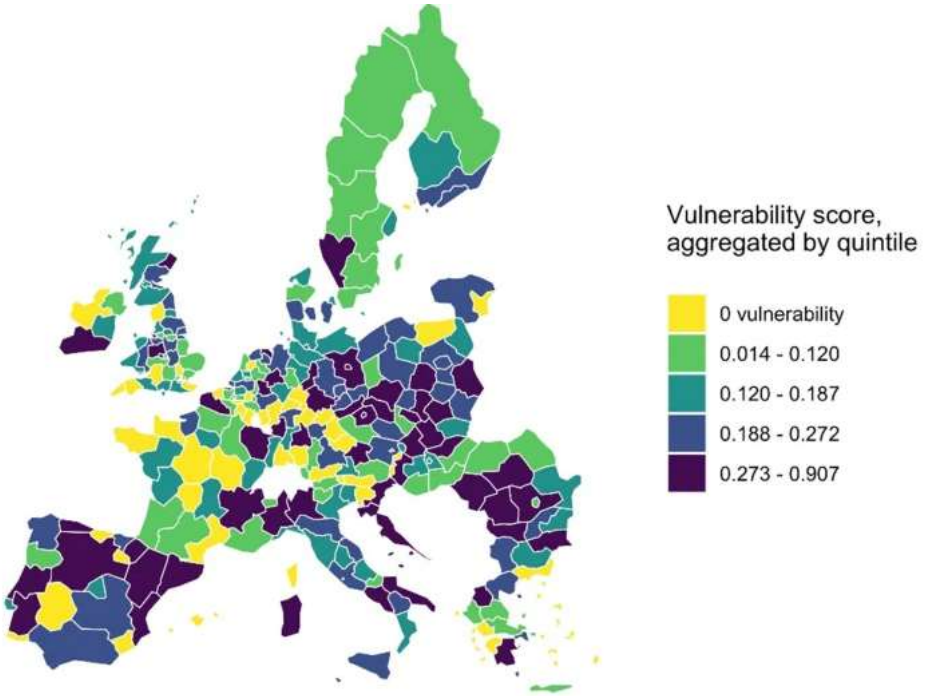
C Lynch, Y Simsek, JF Mercure, P Fragkos, J Lefèvre... - Economic Systems Research, 2024

Sub-national impacts of carbon pricing

share of employment in high-carbon sectors in 2022



Vulnerability of EU NUTS-2 regions in net-zero scenario

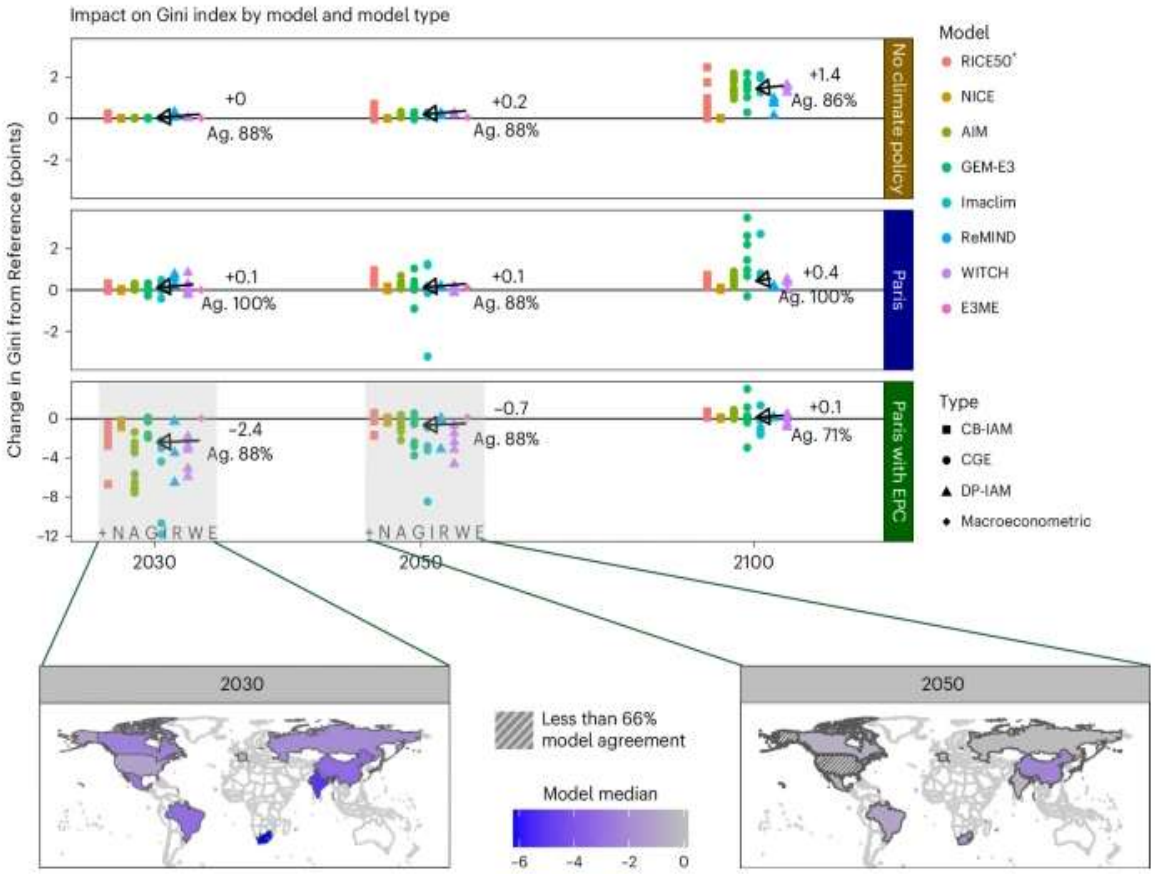


McDowall, W., Reinauer, T., Fragkos, P. et al. Mapping regional vulnerability in Europe's energy transition: development and application of an indicator to assess declining employment in four carbon-intensive industries. Climatic Change 176, 7 (2023). https://doi.org/10.1007/s10584-022-03478-w

A multi-model assessment of inequality and climate change

- Use 8 leading IAMs to assess the distributional impacts of climate policy & climate change
- By 2100, climate impacts will increase inequality by 1.4 points of the Gini index on average.
- The 1.5 °C scenario reduces long-term inequality increase by two-thirds but increases it slightly in the short term.
- Equal per-capita redistribution can offset the short-term effect, lowering the Gini index by almost two points.

Fig. 1: Change in Gini index from the Reference scenario without climate impacts.



https://www.nature.com/articles/s41558-024-02151-7

Share of consumption per decile in various countries

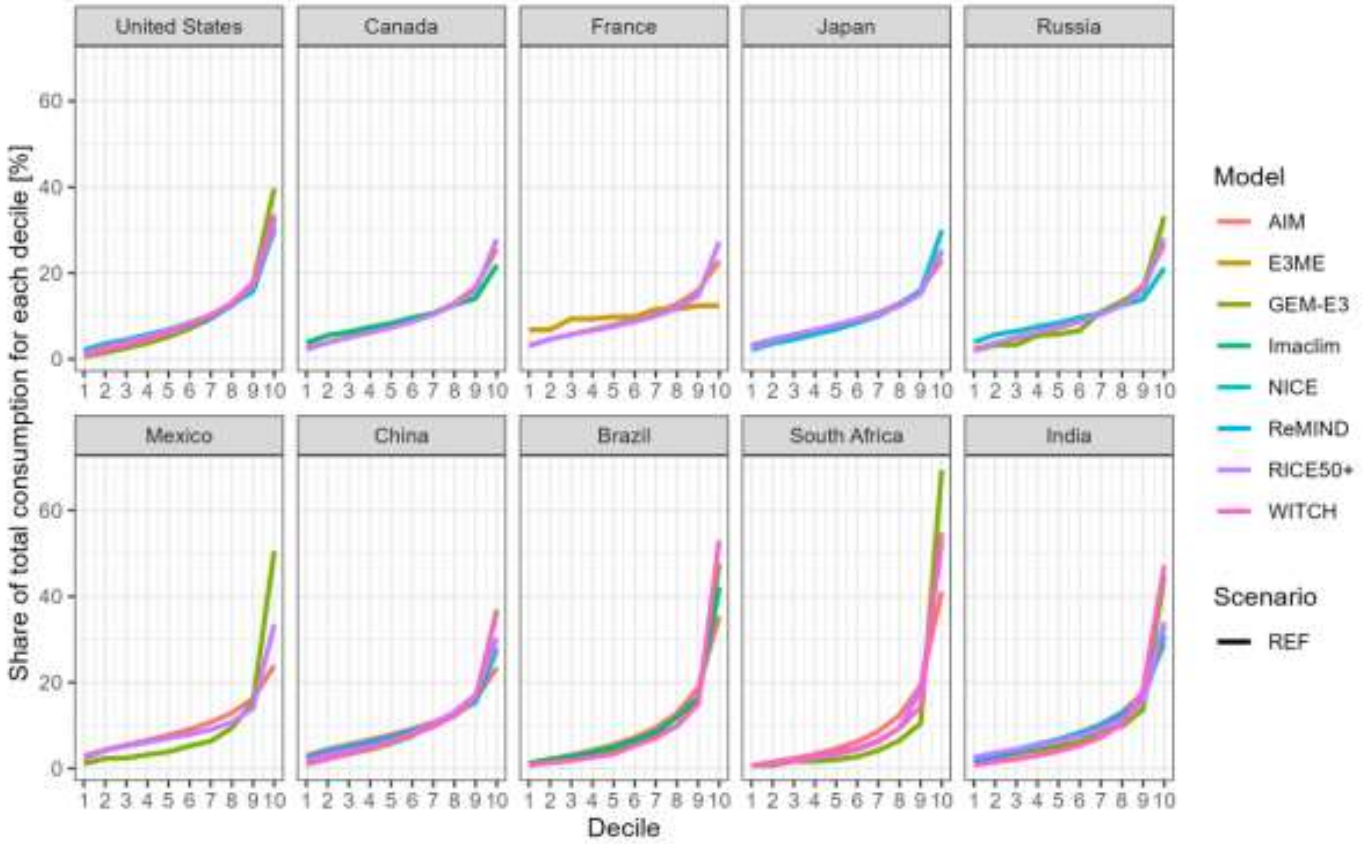
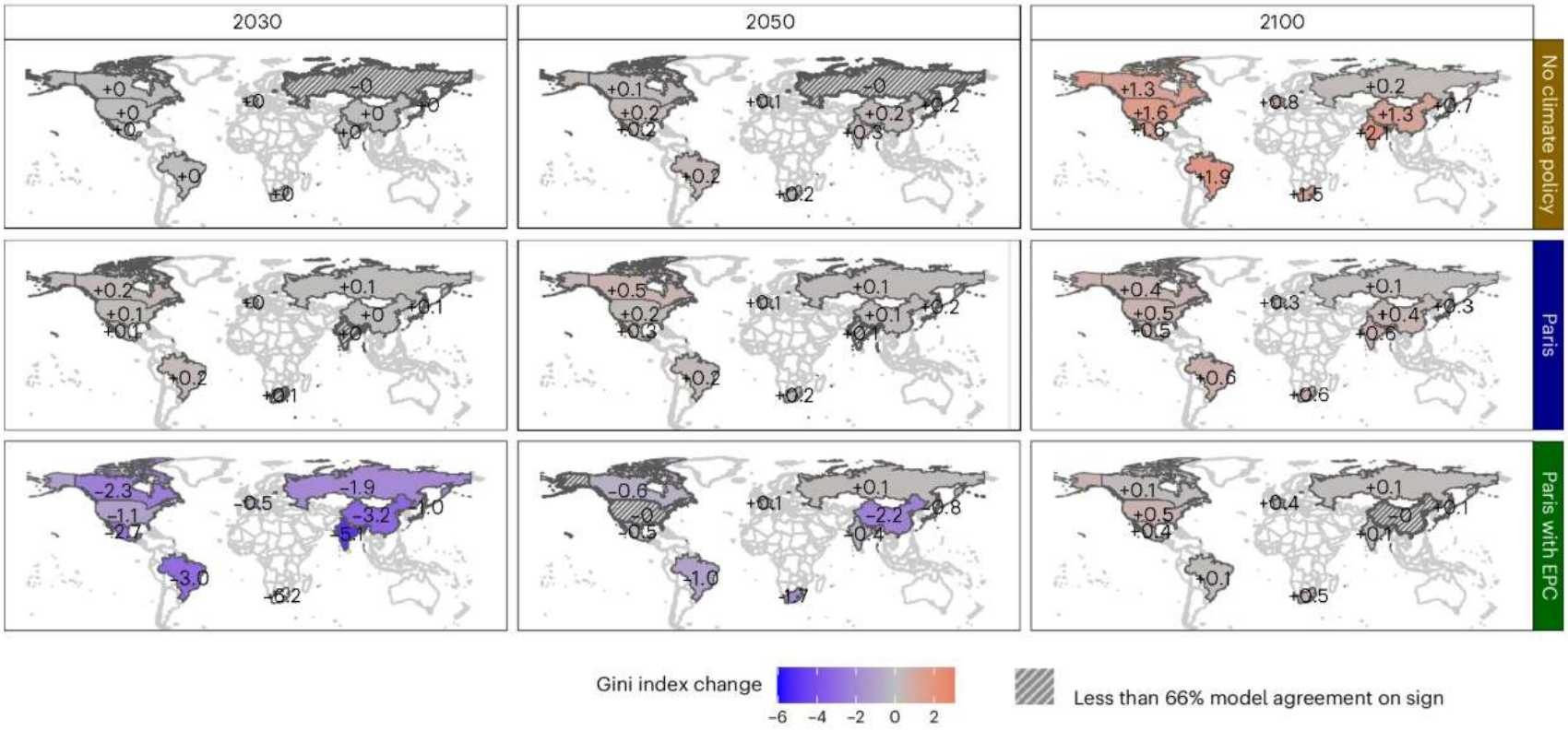
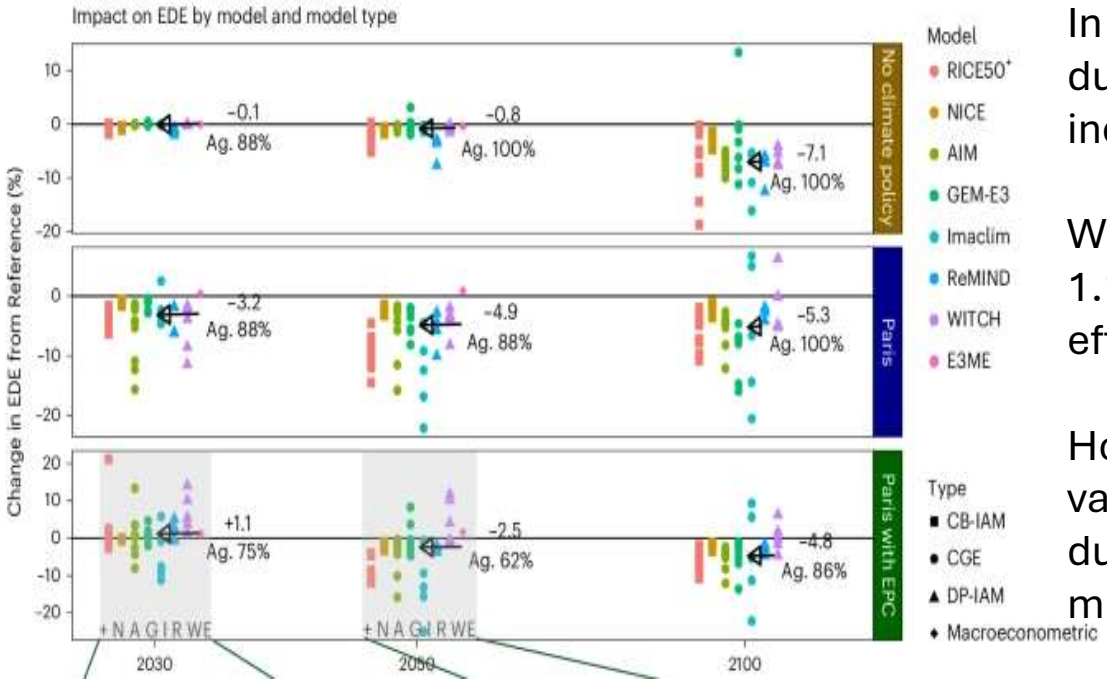


Figure S3: Consumption share for income deciles across countries in 2050

Change in Gini index with respect to the Reference scenario by country (median of models)



Welfare impacts of scenarios



In the Reference, welfare losses reach 7.1% by 2100 as climate risks reduce economic growth and increase inequality.

In the Paris scenario, welfare decreases early on due to higher policy costs and a small increase in inequality, stabilizing around 5% after 2050

With compensatory transfers, welfare increases by 1.1% on average in the short term, as redistribution effect overcompensates for GDP loss.

However, the benefits of compensatory measures vanish after 2050, when carbon revenues dry up due to emissions reaching net zero, while mitigation costs remain substantial.

Nonetheless, in the long term the welfare gains from maintaining global warming <2 °C are still dominant.

The case of India: Climate Policy, Inequality & revenue recycling

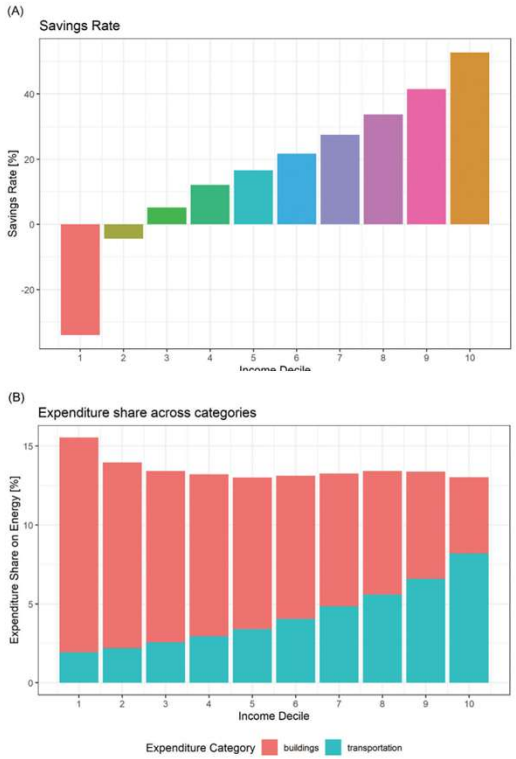


FIGURE 11.2 Saving rate (Figure 11.2A) and expenditure shares (Figure 11.2B) across deciles in the survey year 2011

What?

- Assessed how carbon taxation affects income groups in India
- Compared 2 revenue recycling schemes:

✓ Per capita redistribution (universal)

✓ Targeted distribution (based on existing BLP-style programs)

How?

* Linked a global IAM (WITCH) with a household-level model

* Used Indian real world data

Run 2 scenarios:
1) a **BAU**—3.2OC warming by 2100
2) a **carbon tax** scenario:
US $30/tCO2 (rising 5%/year, 1.8oC warming)

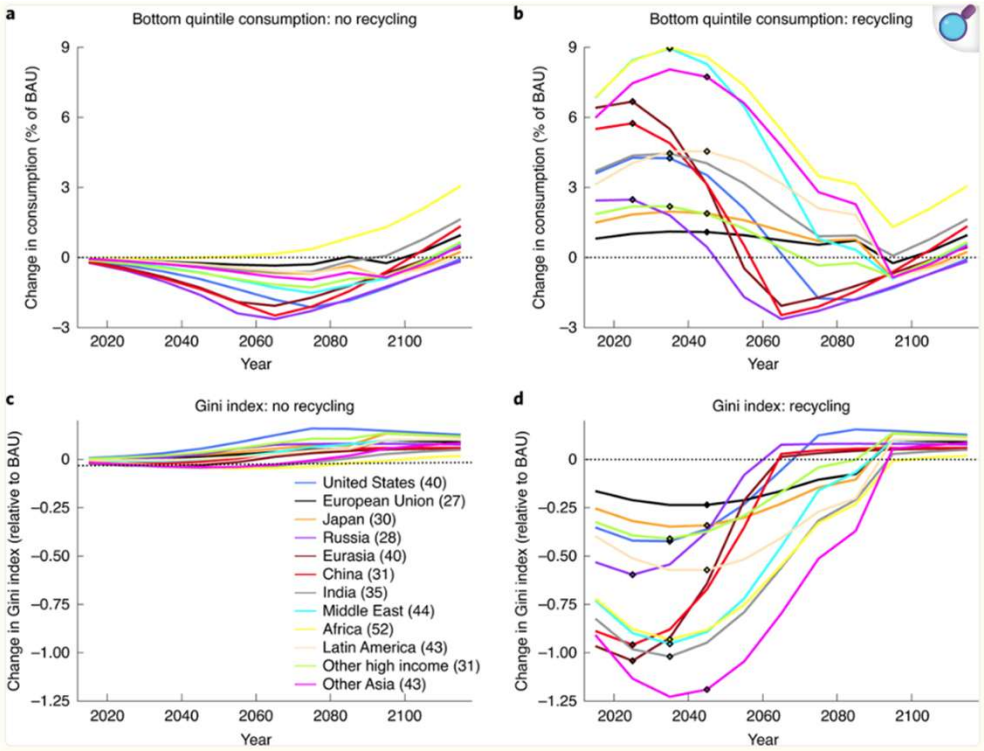
Key outcome

Without transfers:

- ❑ Poorest loose ~2,5% consumption, richest ~1,5%
- ❑ Universal transfers: progressive effect, reduce inequality
- ❑ Targeted transfers suffer from leakage and exclusion—underperformance
- ❑ Carbon pricing in India can reduce emissions and inequality, but only if revenue is redistributed effectively

Modelling the Interaction Between Climate Mitigation and Income Inequa

Climate action with revenue recycling has benefits for poverty, inequality and well-being



Trade-offs between climate action, poverty alleviation and inequality turn into synergies with an equal per capita carbon dividend.

https://pmc.ncbi.nlm.nih.gov/articles/PMC11244949/

What: Nested Inequalities Climate Economy (NICE) model adds household quintiles to RICE

How: Assigns income, Gini and mitigation costs across quintiles without redistribution

Outcome:

- Including inequality increases the social cost of carbon (SCC)
- Calls for more stringent climate action when equity is factored in
- Shows equity and efficiency should be balanced

Remaining gaps & Future research

- Limited representation of inequality within countries
- Procedural justice often ignored
- Few IAMs integrate social resistance, trust, or political feasibility

Conclusion & Next steps

Integrating equity into IAMs is ethically & politically fundamental

- IAMs are powerful but incomplete without justice lenses
- Better equity integration improves legitimacy, feasibility, public trust and policy relevance of IAM-based analyses
- Future IAMs development must:
  - Recognize diverse users and vulnerable groups
  - Be transparent about assumptions
  - Connect with political realities and justice frameworks

We cannot model a fair future without embedding fairness in our models

Thank you for your attention

Any questions ?

Panagiotis Fragkos,
panagiotis.fragkos@ricardo.com

Navigating the black box of fair national emissions targets

Table 1 | Key dimensions of setting a fair national emissions target

Physical + social uncertainties	Global strategies	Equity considerations
Epistemic/scientific	*Political*	*Normative*
Climate sensitivity	Temperature target and overshoot	Allocation principle (responsibility, capability or equality)
GDP projections	Global timing of action	Detailed normative parameters (for example, discounting of historical emissions)
Population projections	Global negative emissions	
	Global non-CO_2 reductions	

Note that elements could be argued to be part of various dimensions, but this partitioning is merely used for presentation purposes later in the paper.

What?

Quantified fair emissions allocations across various fairness principles.

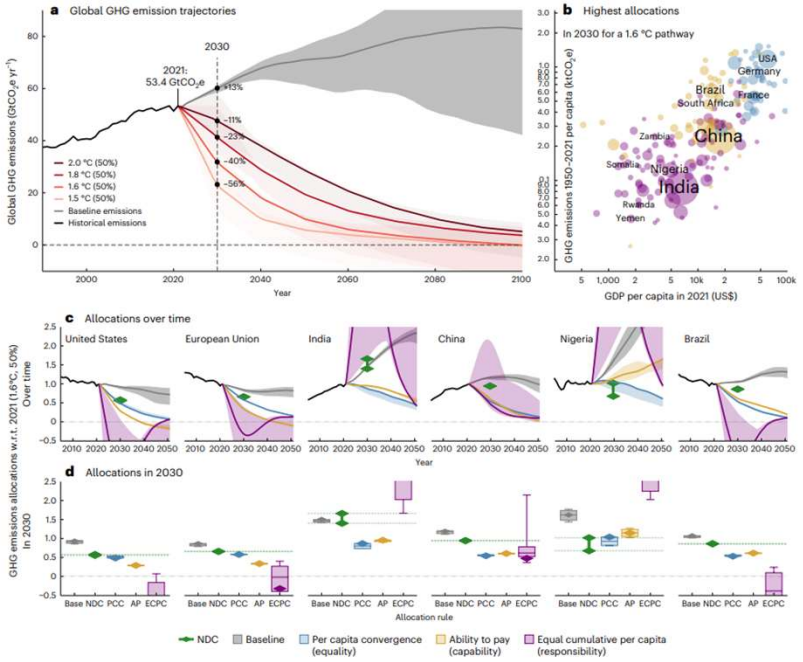
How?

Used three key allocation rules:

- capability (ability to pay),
- responsibility (equal cumulative per capita), and
- equality (per capita convergence).

Compared these allocations to current Nationally Determined Contributions (NDCs) and cost-optimal pathways

Incorporated a wide range of parameters and uncertainties, including physical, social, and normative factors.



https://doi.org/10.1038/s41558-025-02361-7

Outcome:

- Found that fairness-based allocations are typically lower than NDC projections for most countries.
- Identified substantial gaps between fair allocations and current NDCs, especially for high-income countries.
- Highlighted the need for increased domestic mitigation and international finance to meet fair targets.

6 elements for assessing equity (Ideal conditions)

- What would we ideally want to know?

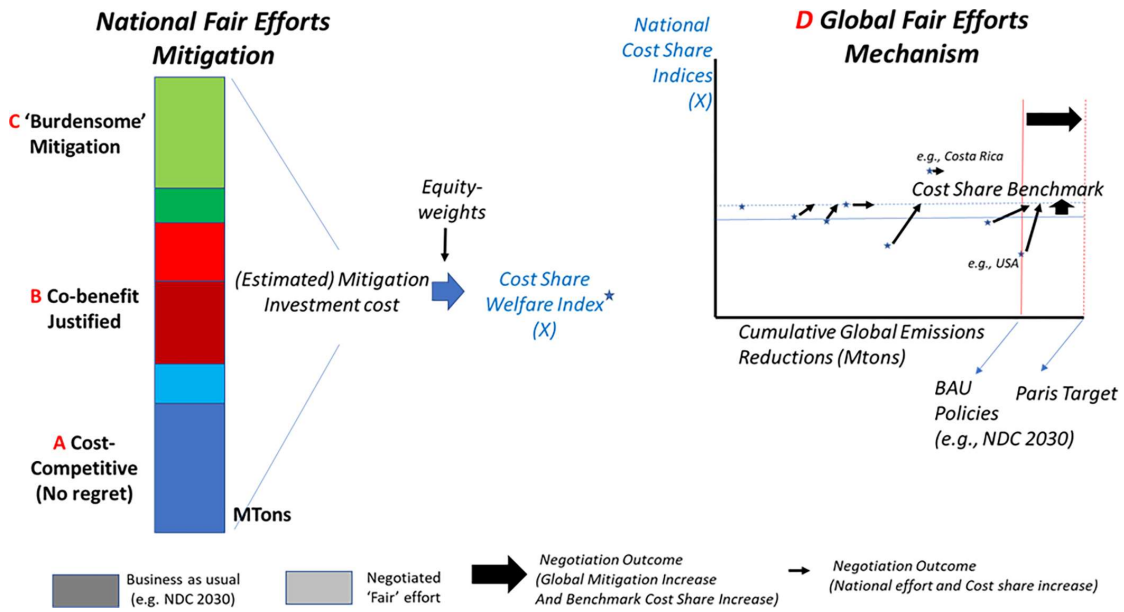
1. Impacts & Loss	Assess climate impacts, adaptation needs, and losses
2. Context sensitivity	Reflect national/local socio-economic conditions
3. Compare mitigation & adaptation costs	Evaluate trade-offs between action areas
4. Human development	Track poverty, access, development co-benefits
5. Inequality dynamics	Represent income/wealth distribution effects
6. Normative transparency	Be clear about fairness assumptions and end-users

Current IAM limitations on equity

Element	Current limitation
1. Impacts & Loss	Often omit adaptation/loss and damage entirely
2. Context sensitivity	Global models mask local disparities
3. Compare mitigation & adaptation costs	Few models compare mitigation vs adaptation effort
4. Human development	Development indicators underrepresented
5. Inequality dynamics	Inequality rarely modelled dynamically
6. Normative transparency	Normative assumptions often implicit or opaque

- Assess climate impacts, adaptation needs, and losses
- Reflect national/local socio-economic conditions
- Evaluate trade-offs between action areas
- Track poverty, access, development co-benefits
- Represent income/wealth distribution effects
- Be clear about fairness assumptions and end-users

How is equity currently represented in studies?



Global equity assessment of NDCs

What?

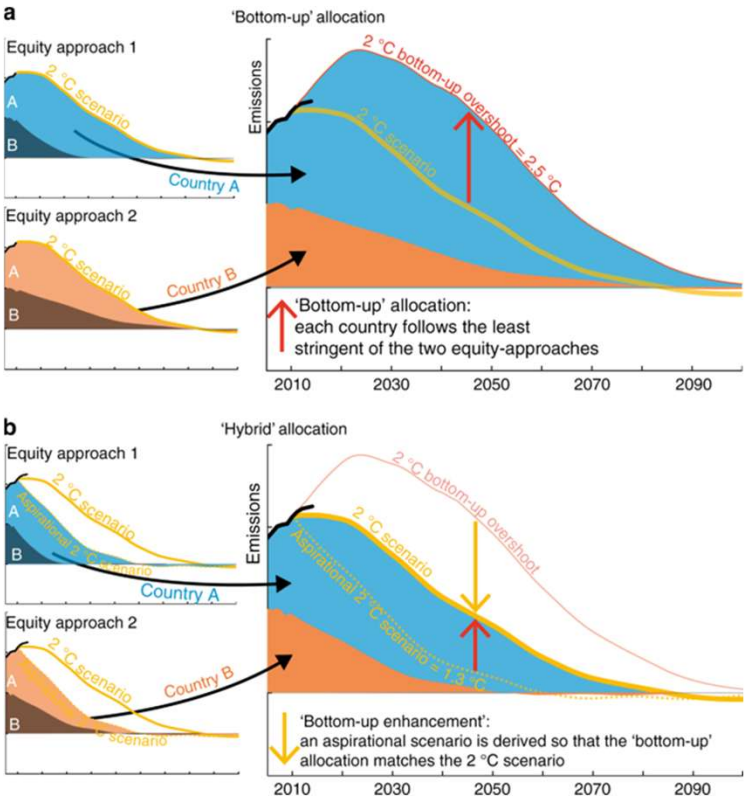
Assessed pledges via 5 equity frameworks:

- **CAP -**Capability to Pay
- **EPC-Equal** per capita emissions
- **CPC**: Cumulative per capita historical responsibility
- **GDR**: Greenhouse development Rights (capability +responsibility + development needs)
- **CER** -Constant Emissions Ratio

How?

Countries pick the least stringent equity model, outcomes simulated using MAGICC model

Hybrid equity approach (CBDR-RC inspired): Mix of 3 equity principles (CAP, EPC, CPC) to create a fairer benchmark for evaluating NDCs. GDR and CER were excluded due to high uncertainty & lack of consensus



Schematic description of the bottom-up and hybrid allocations of global emissions scenarios. **a** Under the bottom-up allocation, each country adopts the least-stringent equity approach. As a result of this self-interested allocation, the targeted 2 °C scenario is overshot. **b** An aspirational scenario is created so that its overshoot under the bottom-up allocation matches the originally targeted 2 °C scenario. Each country individually adopts the least-stringent equity approach of the aspirational scenario in order to collectively achieve the originally targeted 2 °C scenario

Outcome:

- ❑ Emissions pledges aligned with countries' self-interest leads to ~2,3oC warming
- ❑ Uniform and ambitious equity benchmarks required to stay within 1,5-2oC limits

*Robiou du Pont, Y., Meinshausen, M. Warming assessment of the bottom-up Paris Agreement emissions pledges. Nat Commun **9**, 4810 (2018). https://doi.org/10.1038/s41467-018-07223-9*

Equity is more important for the social cost of methane than climate uncertainty EZ1

What?
Equity considerations are more crucial than **climate uncertainty** when determining the social cost of methane.

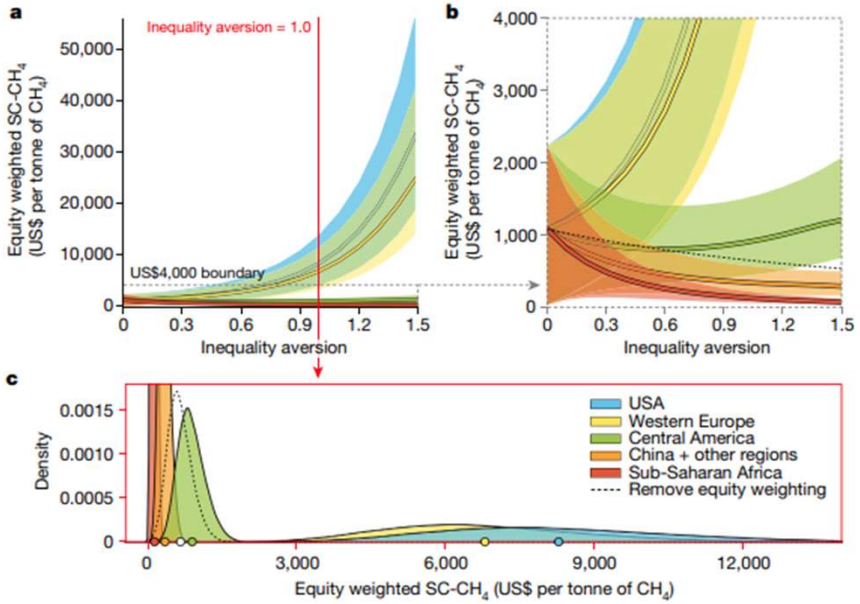
How?

1. Model Coupling: Integrated the Simple Nonlinear Earth System Model (SNEASY) with methane cycle components from four models: FAIR, FUND, Hector, and MAGICC.

2. Calibration: Calibrated models using historical data (1850-2017) for atmospheric CO2, methane concentrations, global surface temperature, ocean heat content, and carbon flux.

3. Scenario Analysis: Ran simulations under high-emissions (RCP 8.5) and low-emissions (RCP 2.6) scenarios.

4. Equity Weighting: Applied equity weighting to account for income disparities across regions, using a social welfare function framework.



https://doi.org/10.1038/s41586-021-03386-6

Outcome:

- Fou EZ2 hat higher inequality aversion values significantly increase the SC-CH4 estimates for high-income regions (e.g., USA) and decrease them for low-income regions (e.g., sub-Saharan Africa).
- Demonstrated that equity weighting leads to substantial variations in SC-CH4 estimates, highlighting the importance of considering equity in climate policy.
- Identified that without equity weighting, the SC-CH4 estimates are more uniform across regions, underscoring the role of equity in differentiating the social costs of methane emissions.

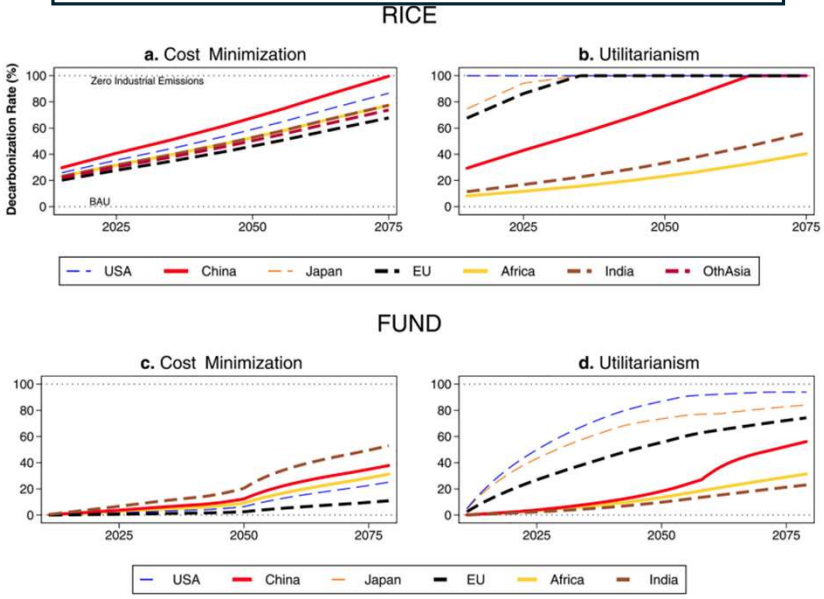
EZ1 The study demonstrates that equity considerations can lead to substantial variations in the social cost of methane, emphasizing the importance of incorporating equity in climate policy decisions.
Zisarou, Eleftheria; 2025-07-06T09:41:12.567

EZ2 Equity-Weighted SC-CH4: The social cost of methane (SC-CH4) varies significantly based on equity considerations.
Regional Differences:
High-Income Regions: For example, the USA has an equity-weighted SC-CH4 of $8,290 per tonne of CH4.
Low-Income Regions: Sub-Saharan Africa has a much lower equity-weighted SC-CH4 of $134 per tonne of CH4.
Impact of Inequality Aversion:
Higher Inequality Aversion ($\eta = 1.5$): The SC-CH4 for the USA increases dramatically to $34,100 per tonne, while for Sub-Saharan Africa, it decreases to $70 per tonne.
Uncertainties: The spread in SC-CH4 estimates increases with higher inequality aversion, highlighting the sensitivity of these estimates to equity considerations.
Zisarou, Eleftheria; 2025-07-06T09:42:12.980

Utilitarian benchmarks for emissions and pledges promote equity, climate and development

What?

To explore and demonstrate the benefits of using a **utilitarian optimization approach** in climate-economy models, as opposed to traditional cost-minimization strategies



Nat Clim Chang. 2021 October ; 11(10): 827–833. doi:10.1038/s41558-021-01130-6

EZ1

How?

1. - **Utilitarian Benchmark**: Implemented in two leading climate-economy models (RICE and FUND).

2.Optimization Framework: Utilitarian benchmark computed using a transparent optimization framework.

3.Comparison: Compared utilitarian optimization with cost minimization approaches.

4.Data Sources: Historical emissions, initial nationally determined contributions (NDCs), and future emissions projections.

*** Used the same discounting parameters and utilitarian objective function as in the RICE model.*

*** Assumed regional carbon taxes can go no higher than $5000/ton CO2.*

Outcome:

1. **Equity and Development**: Utilitarian optimization features better outcomes for human development and equity.

2.Climate Impact: Lower peak temperatures under utilitarianism due to reduced human development costs of global mitigation.

3.Policy Implications: Utilitarian benchmarks offer a promising alternative for future climate equity discussions.

EZ1 they aim to prove:

Equity in Emissions Allocation: The study suggests that a utilitarian approach, which considers the overall well-being and development of all regions, allows for a more equitable distribution of emissions. This is particularly beneficial for developing regions.

Human Development Outcomes: By prioritizing human development, the utilitarian approach can lead to better outcomes in terms of health, education, and economic growth, especially in less developed areas.

Climate Impact: The study aims to show that this approach can still achieve significant climate mitigation, potentially leading to lower peak global temperatures.

Policy Implications: The findings suggest that utilitarian benchmarks could be a valuable tool for policymakers, offering a balanced way to address both climate goals and human development needs.

Zisarou, Eleftheria; 2025-07-06T09:30:41.250