POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Towards a better representation of inequality and sustainable development in IAMs

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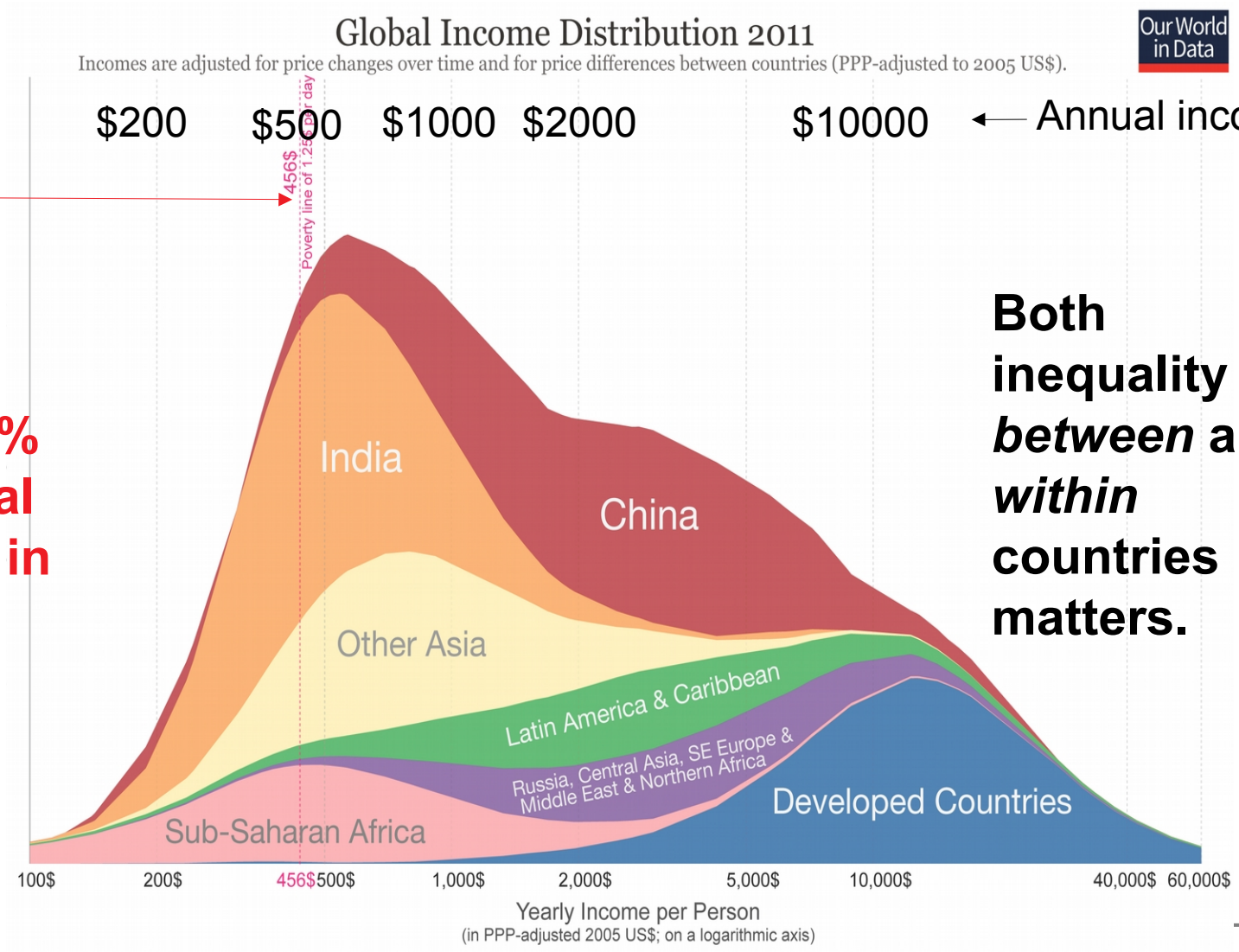
+ the REMIND & MAgPIE teams

ENGAGE Final Workshop 2019

Global distribution of income



Absolute poverty line: $ 1.25 / day (2005 PPP)

Approx. 10% of the global population in absolute poverty.

Both inequality *between* and *within* countries matters.

source: Lakner and Milanovic (2015) – *Global Income Distribution: From the Fall of the Berlin Wall to the Great Recession*, World Bank Economic Review.

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Inequality in IAMs

Layers of inequality & current modelling status:

- between generations (discounting)
- within generations, between countries (country groups)
- within generations, within countries (income distribution)

Steps towards representing inequality:

1) **Ex-post analysis (today):**
   - distributional effects of mitigation costs / damages
   - connection to SDGs

2) Represent income distribution in IAMs (“work in progress”)

3) Energy + food demand scenarios by income group

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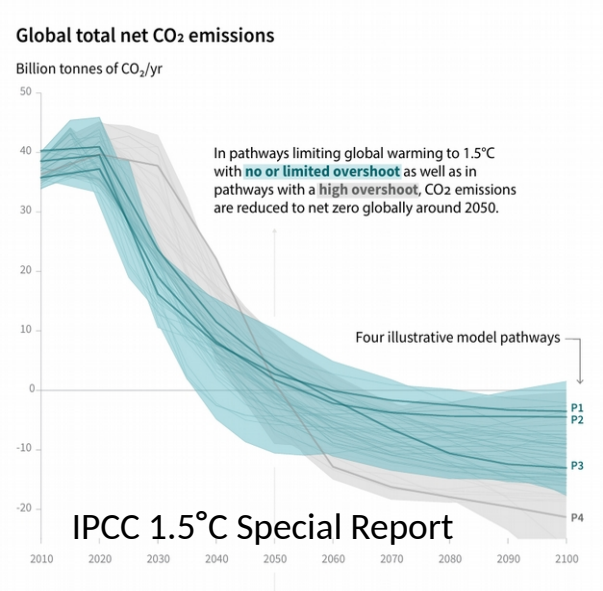
Climate change, inequality & sustainable development



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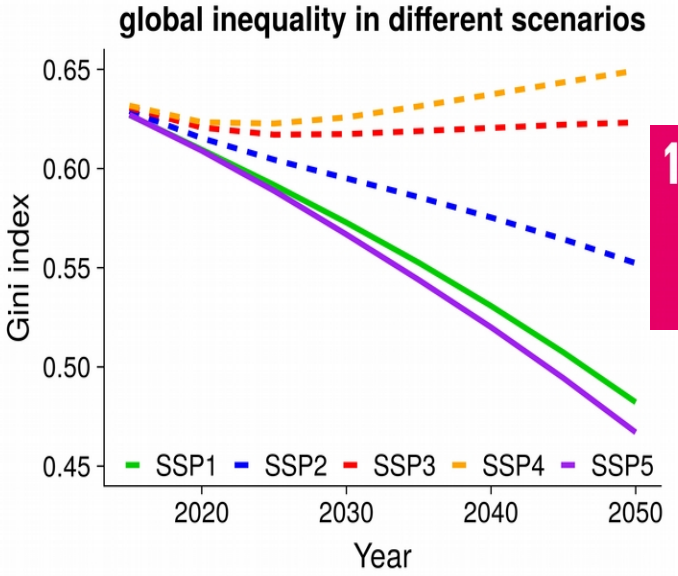

Carbon price vs. energy access

Climate impacts & bioenergy vs. food prices

mitigation costs & climate impacts as poverty trap

+ many more

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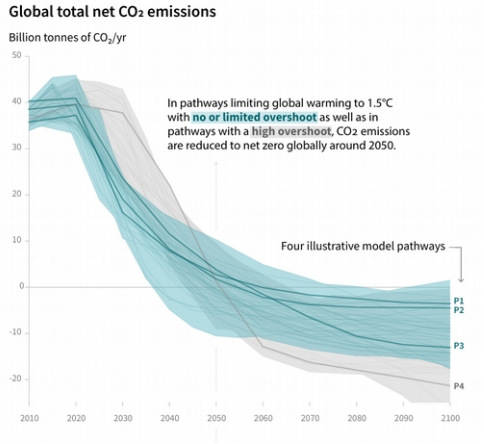
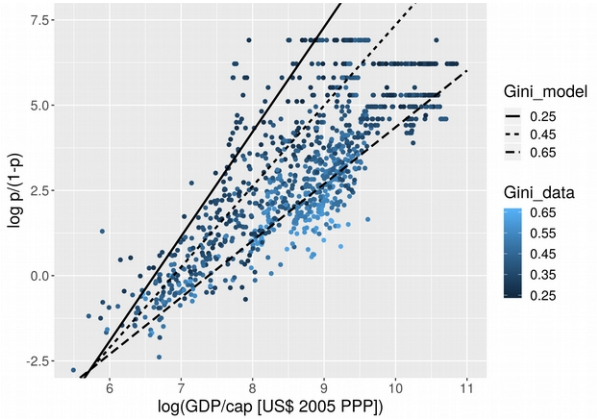
Sustainable Development Pathways?

Mitigation pathways & sustainable development

Mitigation pathways → **Income distribution** → **SDG indicators**





- Economic growth
- Energy and food prices
  → *regressive*
- Carbon price revenue
  → *progressive*

Change in distribution of *real* income, i.e. after increased energy/food expenditures and revenue recycling

Income/cap & Gini are key drivers for:
- poverty rates
- energy access
- food security
- ...

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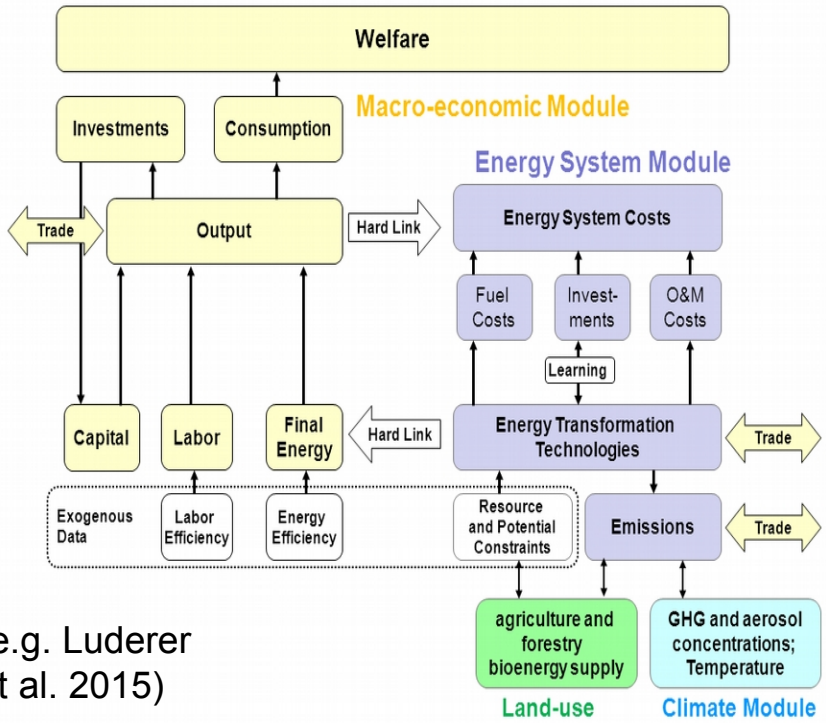
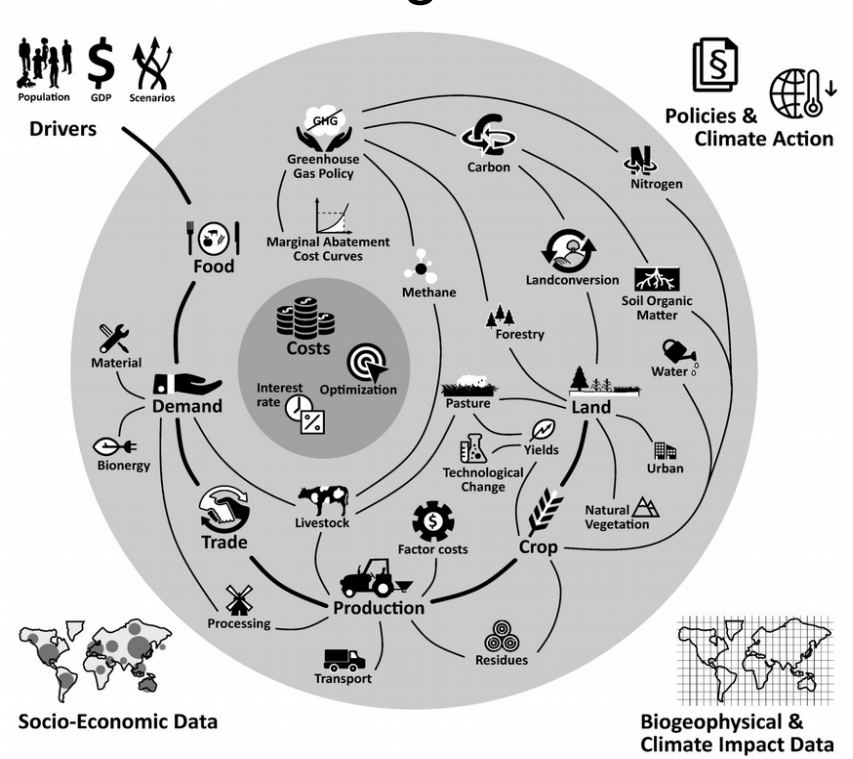
REMIND/MAgPIE modelling framework

REMIND



(e.g. Luderer et al. 2015)

MAgPIE



(Dietrich et al. 2018)

Bioenergy price

CO_2 price, bioenergy demand

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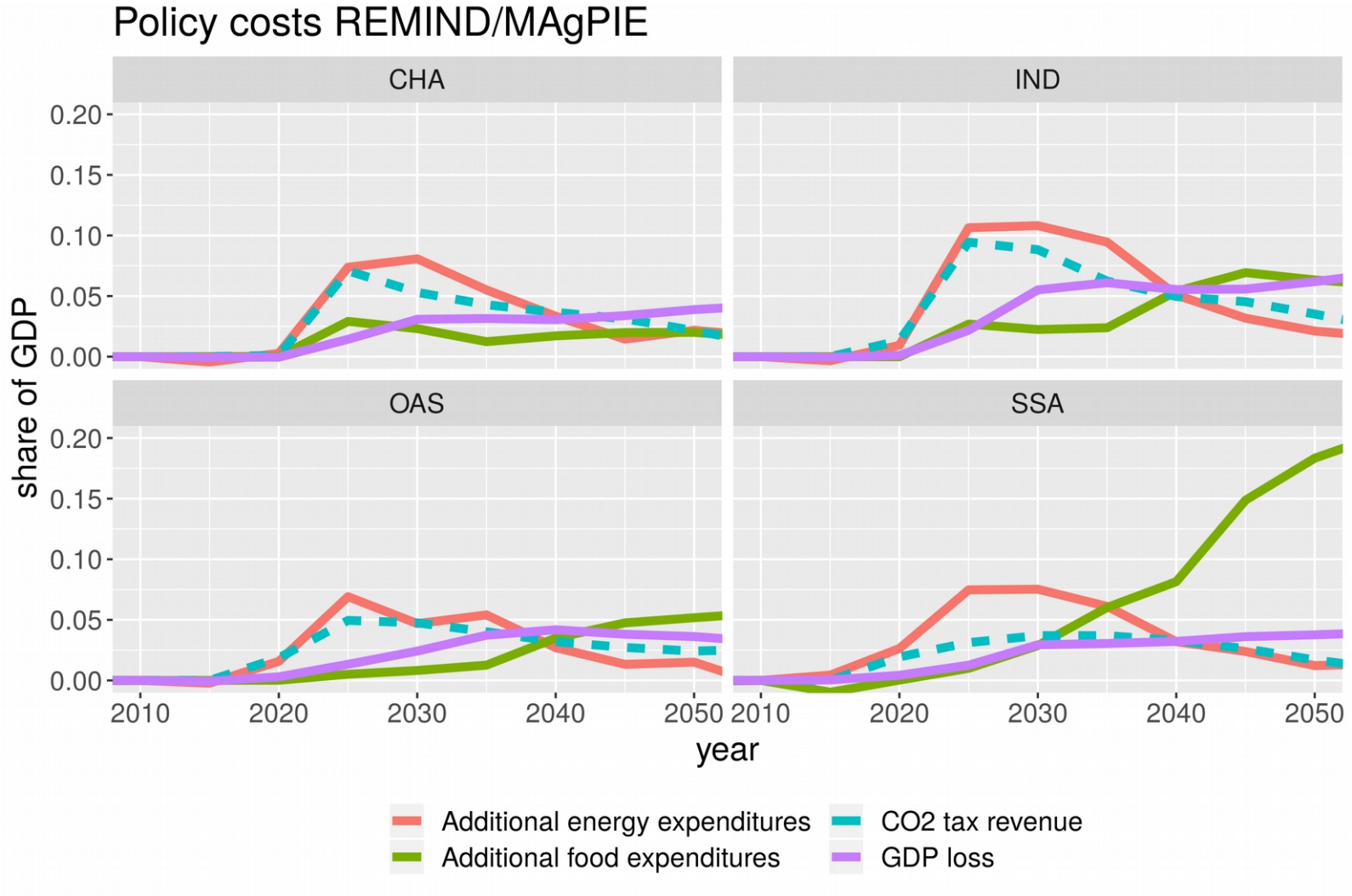
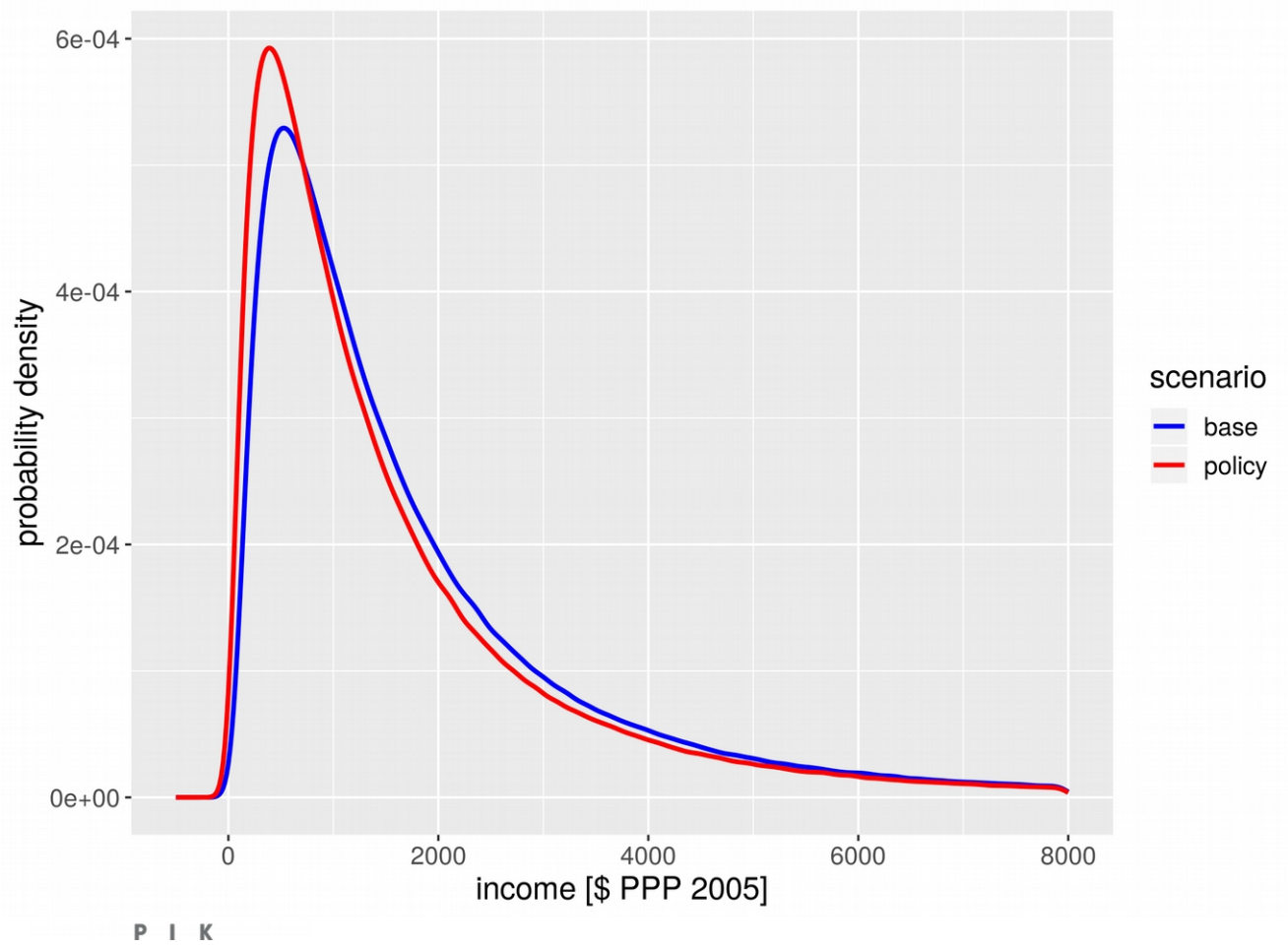
Example scenario: SSP2 1.5°C



NB: Here for a globally uniform carbon price. Results will depend on burden sharing regime.

Distributional effects – “real income” approach

Increased energy/food expenditures reduce real income; effect stronger for low-income groups.



- Food / energy expenditures:

$$exp. \propto y^{\alpha}$$

- income elasticity α here: α = 0.8 for energy, α = 0.5 for food
- Recycling of carbon price revenue
- Compute “real income” Gini from distribution of (y – exp. + rev.rec.)

Linking income and Gini to SDG objectives

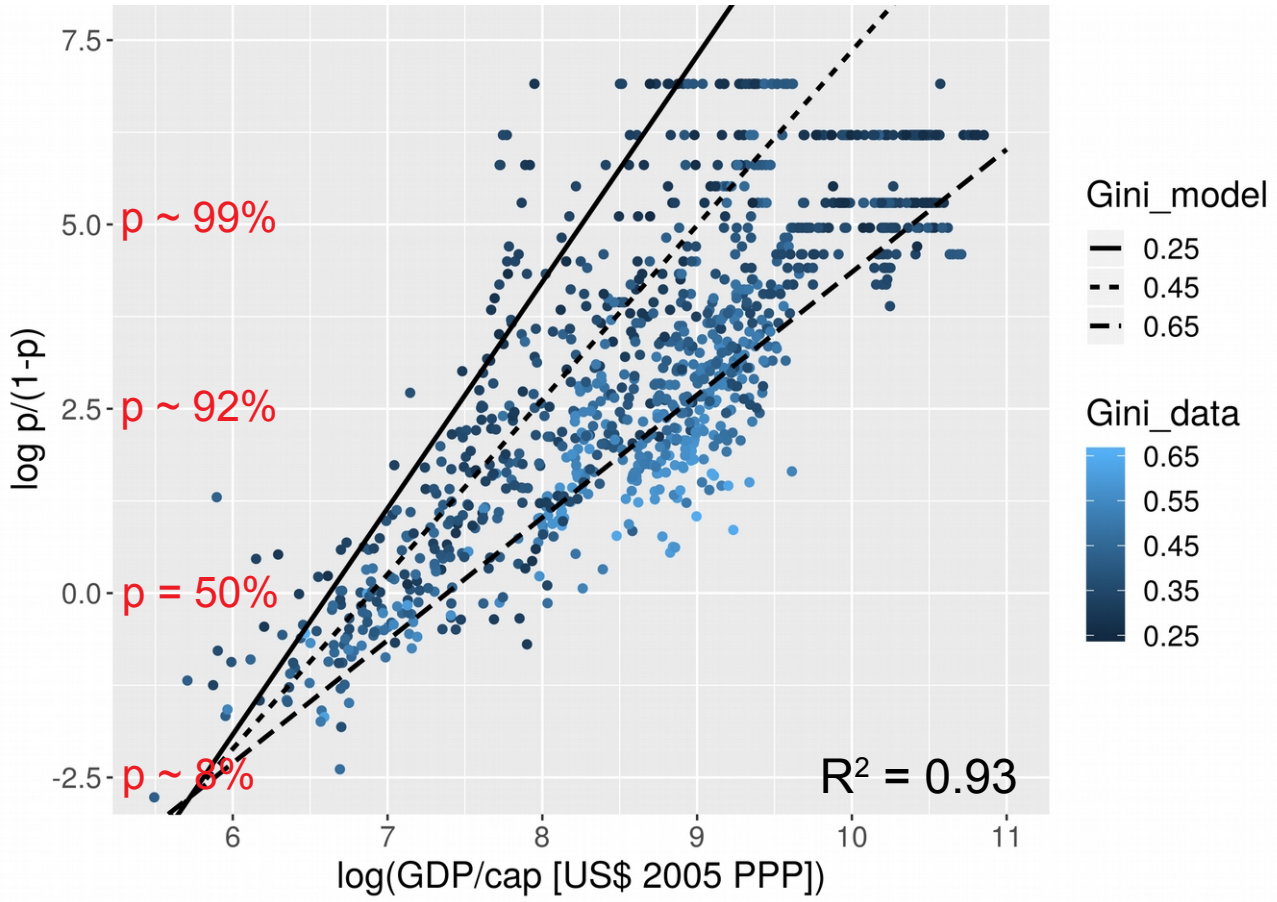
Logistic regression model for SDG objectives (x = GDP/cap., G = Gini):

$$\log \frac{p_{it}}{1-p_{it}} = \beta_0 + \beta_1 \log x_{it} + \beta_2 G_{it} + \beta_3 \log x_{it} \times G_{it} + \mu_i + \epsilon_{it}$$

Example: poverty threshold of $1.90/day

→ p_{it} = fraction *above* poverty line

decreasing poverty



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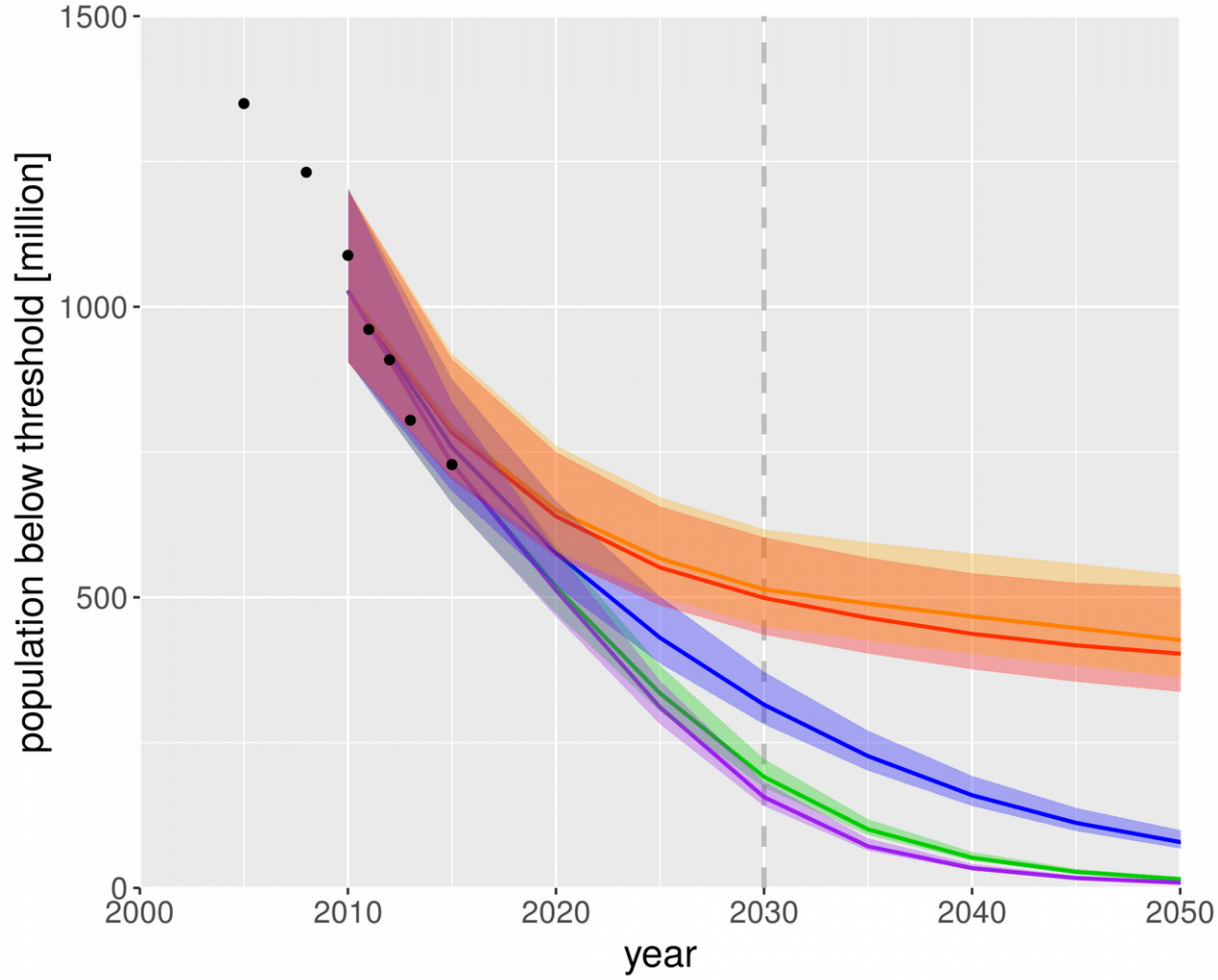
Projections for SDG 1 (SSP Baselines)

Number of people in absolute poverty (global)

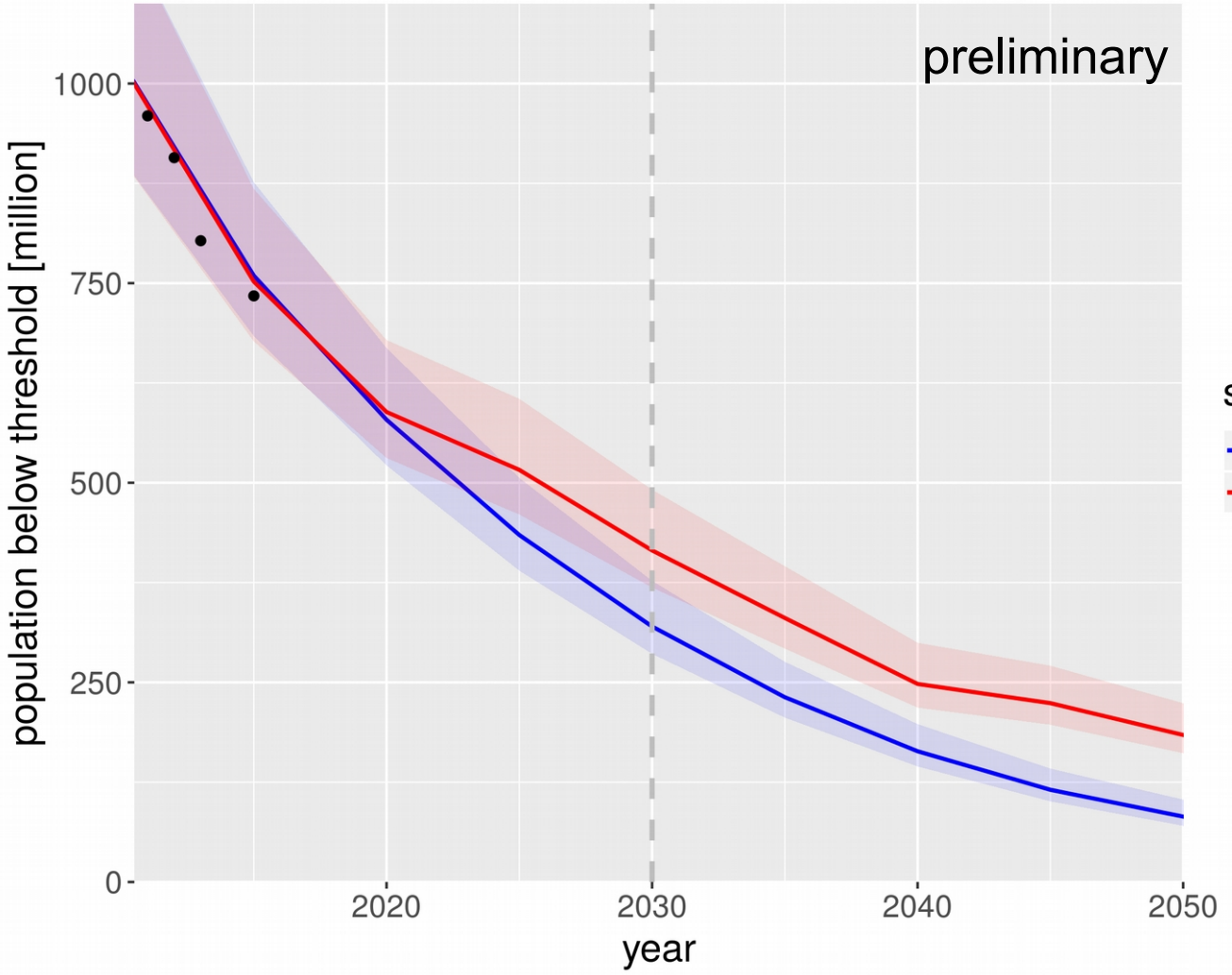


Baseline SSP Gini scenarios: Rao et al. 2018

SDG 1 not even reached in SSP1 & SSP5 baselines.

Projections for SDG 1: Mitigation scenario (SSP2 – 1.5°C)

Number of people in absolute poverty (global):

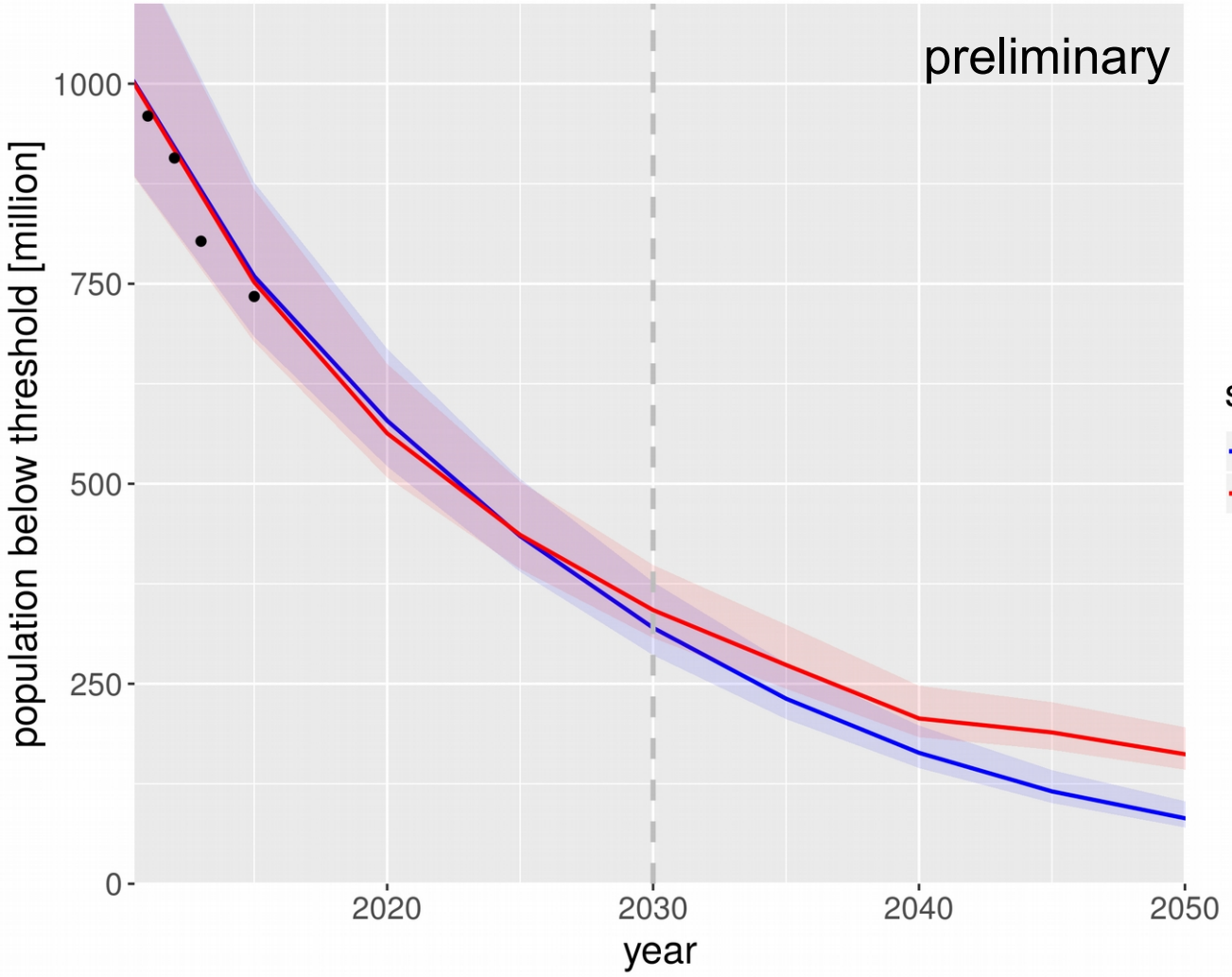


Without pro-gressive use of carbon price revenue

reduced rate of poverty reduction (+ 95 million people in 2030)

Projections for SDG 1: Mitigation scenario (SSP2 – 1.5°C)

Number of people in absolute poverty (global):



With lump-sum transfer of carbon price revenue

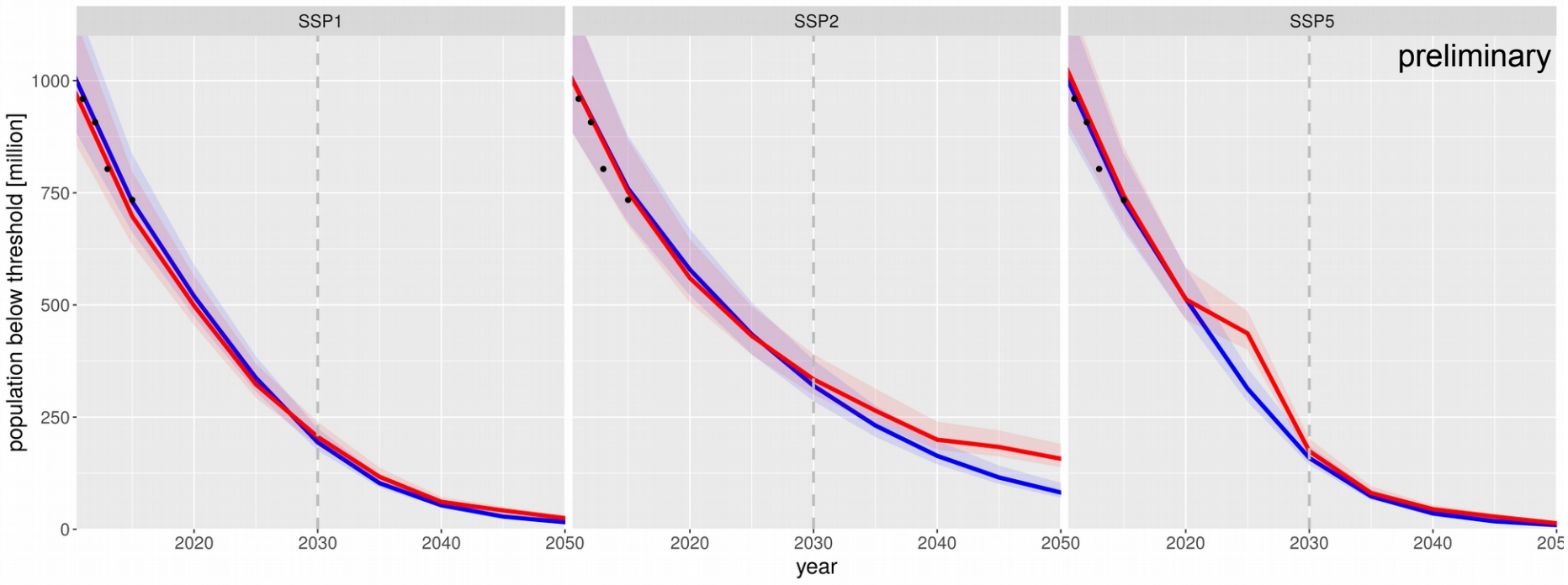
Effect mostly compensated from domestic revenues

Projections for SDG 1: different SSPs – 1.5°C

SSP1: low baseline poverty, low mitigation pressure

SSP2: middle of the road scenario

SSP5: lowest baseline poverty,high mitigation pressure



SDG "side-effect" of mitigation depends on socioeconomic baseline

More research questions for this framework

- other SDG dimensions: energy access, food security, ...
- Co-benefits & trade-offs of different mitigation options (e.g. BECCS limit, demand-side, …)
- How to design burden sharing schemes (differentiated carbon prices + transfers) to minimize negative side-effects?
- Which other policies are required to go from a **mitigation pathway** to a **sustainable development pathway?**
- SDG side-effects **of impacts vs. mitigation**

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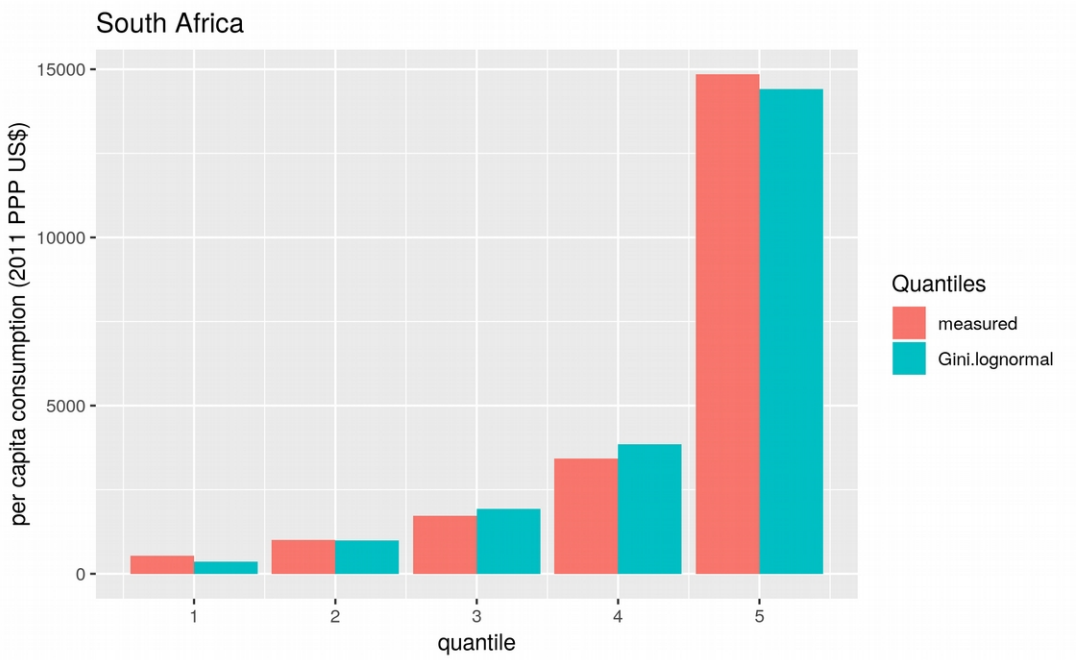
Outlook: integrating inequality into IAMs

So far most IAMs include temporal and regional inequality, but not inequality within countries/regions.



Lognormal vs. measured quantiles

Representing inequality:

→ assume lognormal income distribution (σ ↔ Gini)

→ standard isoelastic utility function (inequality aversion η)

→ analytically calculate social welfare function with inequality

→ effects of impacts/mitigation through moments of distribution (instead of quantiles)

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Summary

- A better modelling of inequality is required both on the impacts and mitigation side

- Distributional questions are at the core of many SDG objectives

- First step: Ex-post analysis of mitigation pathways
  → effects on income distribution
  → connection to other SDG objectives
  → Example: SDG 1 – zero poverty
  → mitigation pathway vs. sustainable development pathway

- Next levels: impacts and inequality,
  endogenously model income distribution within IAMs

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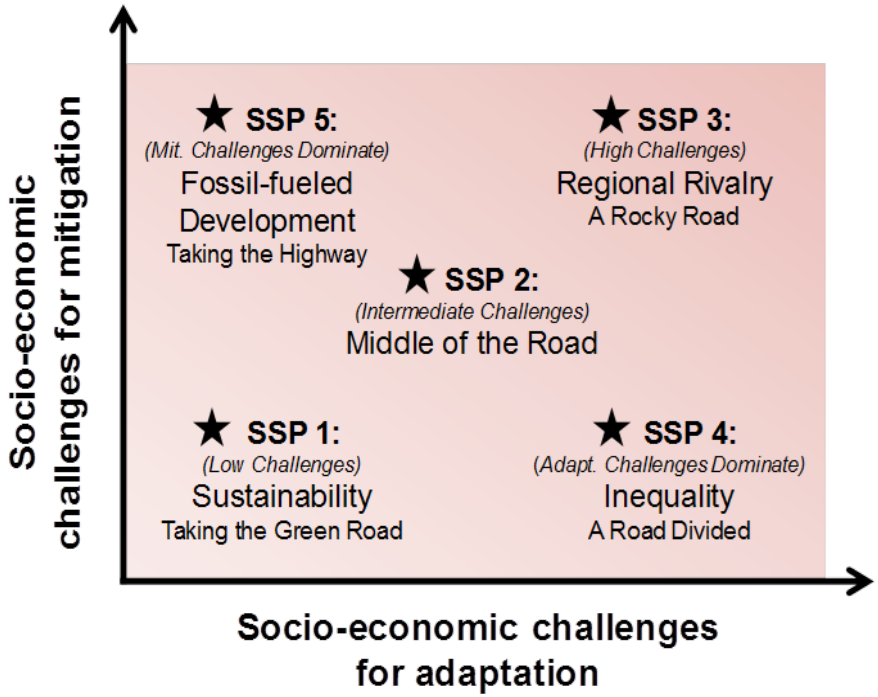
Scenarios for socio-economic drivers

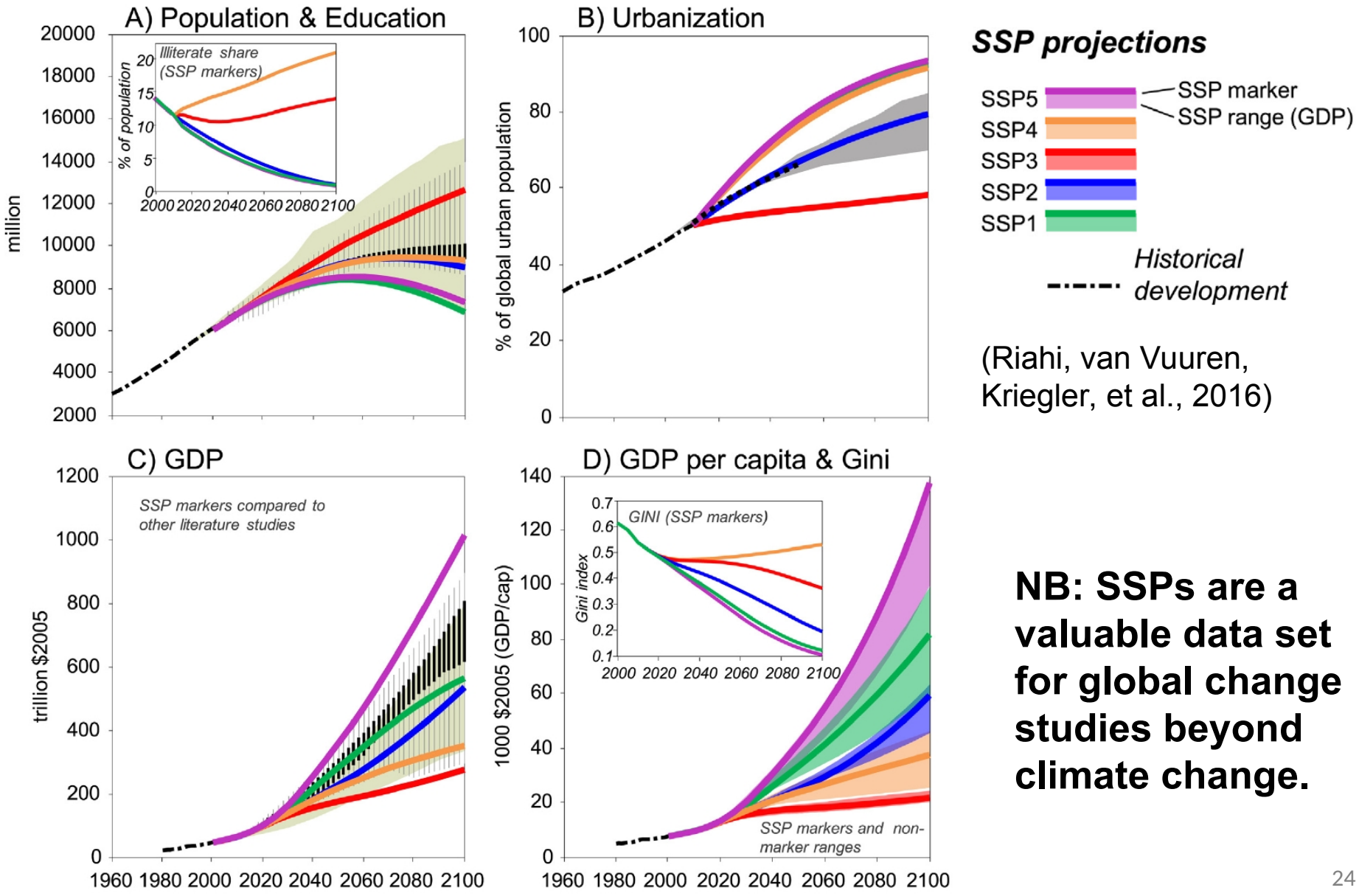
Cannot predict socio-economic drivers (population, GDP,...) reliably until 2100 → work with **scenarios** (narratives, not predictions!)

Shared socio-economic pathways (SSPs):



O'Neill, Kriegler et al., 2017

Shared Socioeconomic Pathways



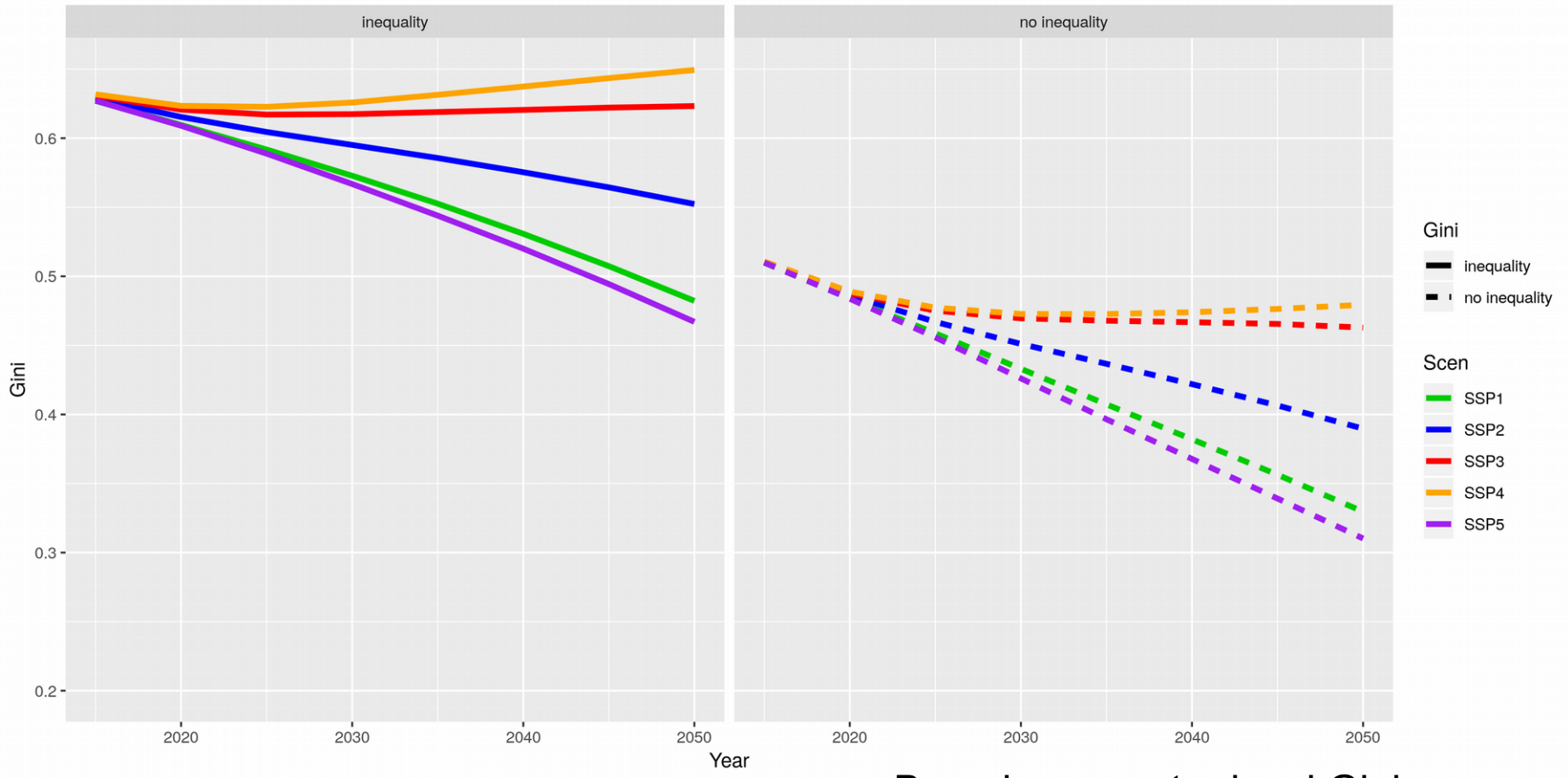
(Riahi, van Vuuren, Kriegler, et al., 2016)

NB: SSPs are a valuable data set for global change studies beyond climate change.

Inequality under the SSPs: global Gini coefficient

Within-country inequality:

included not included



Based on country-level Gini scenarios by Rao et al., 2018

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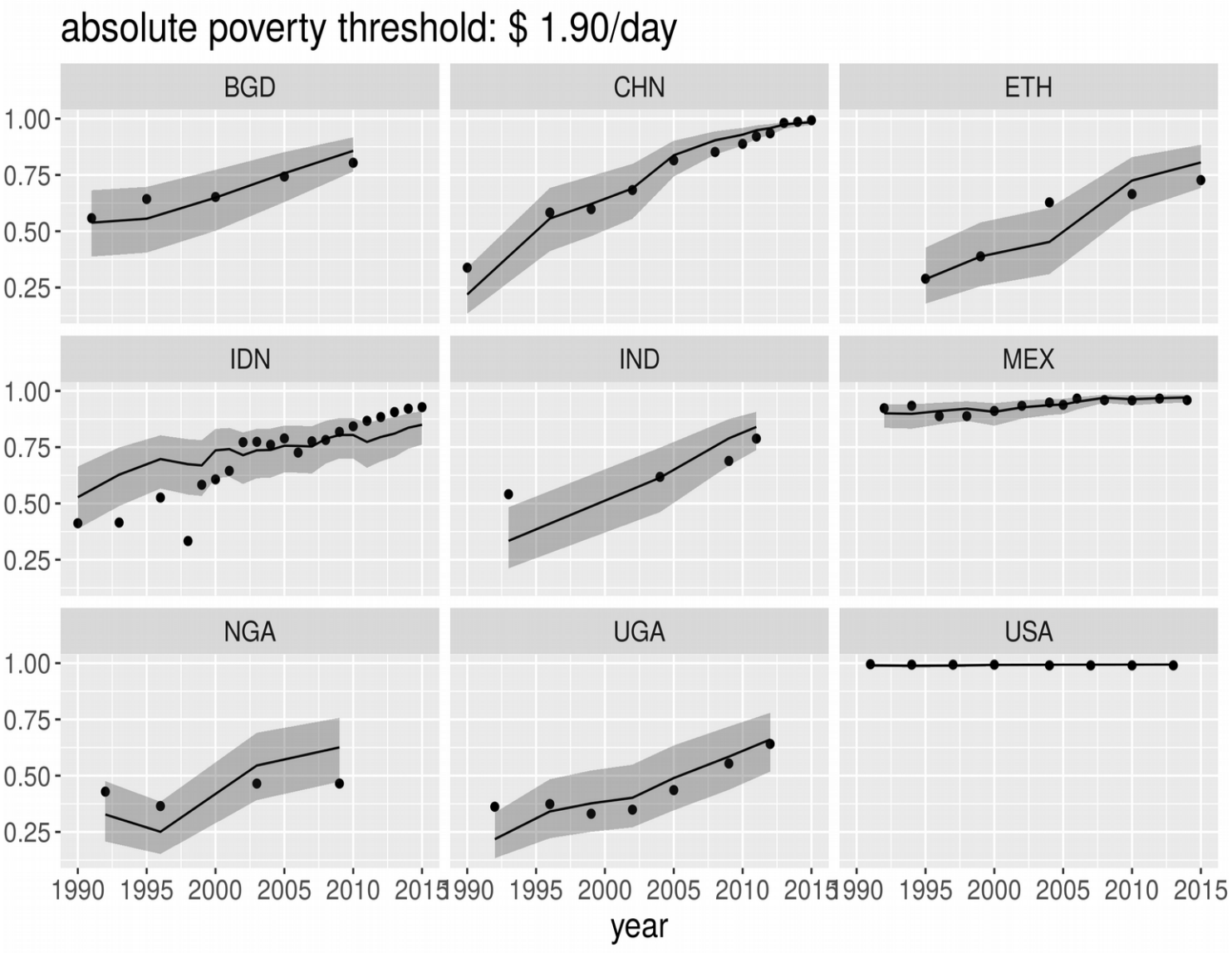
Linking income and Gini to SDG objectives

Fraction of population *above* the poverty line



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Linking income and Gini to SDG objectives

Logistic regression for fraction of population above the poverty line:

Coefficients:

	Estimate	Std Error	t value	Pr(>|t|)
(Intercept)	-27.543020	1.916208	-14.374	< 2e-16 ***
log(gdppcap)	3.946146	0.229753	17.176	< 2e-16 ***
Gini	20.095888	4.509789	4.456	9.37e-06 ***
log(gdppcap):Gini	-3.510272	0.562928	-6.236	6.83e-10 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5583 on 924 degrees of freedom
Multiple R-squared: 0.94, Adjusted R-squared: 0.9312
F-statistic: 107.2 on 135 and 924 DF, p-value: < 2.2e-16

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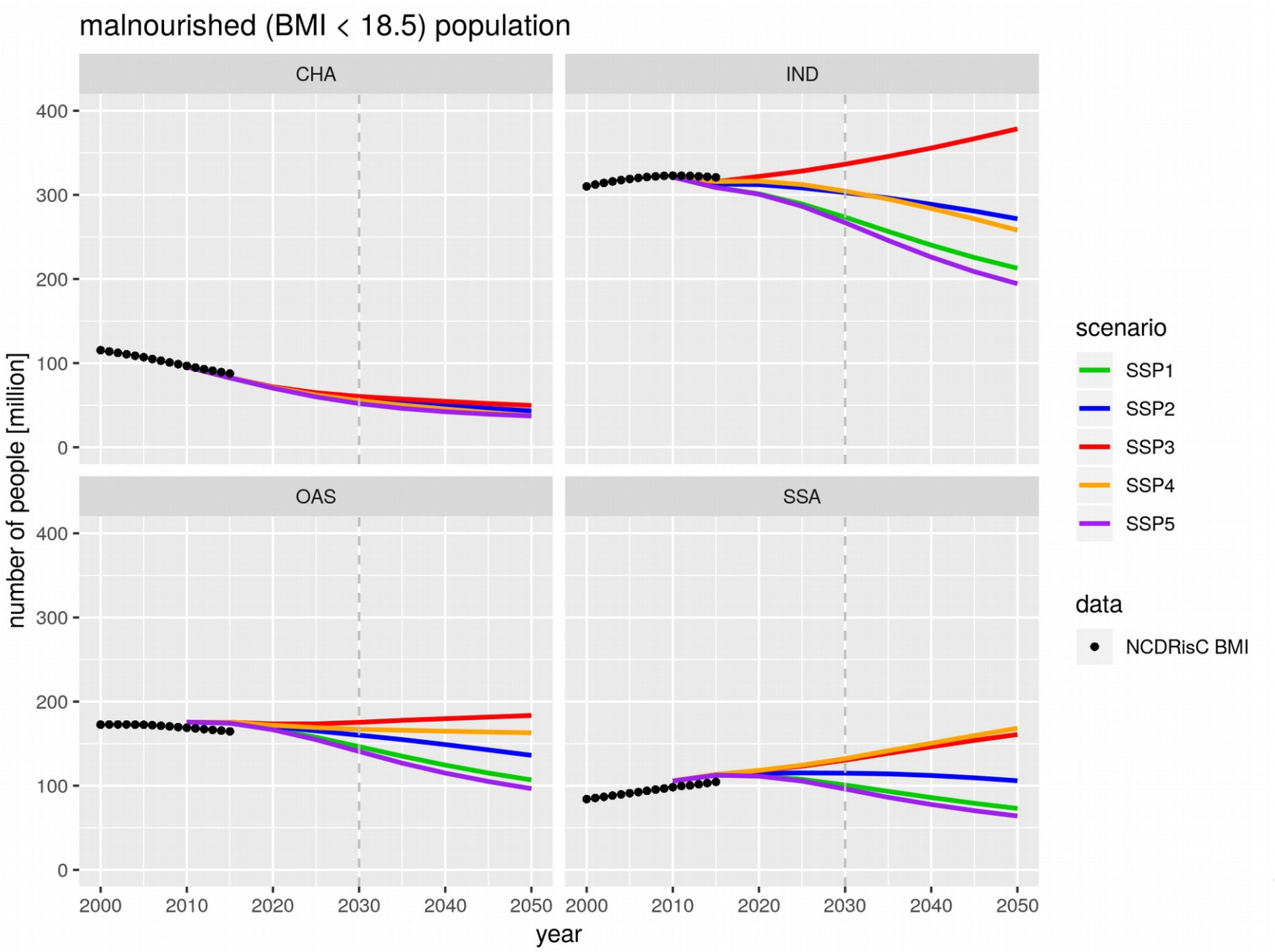
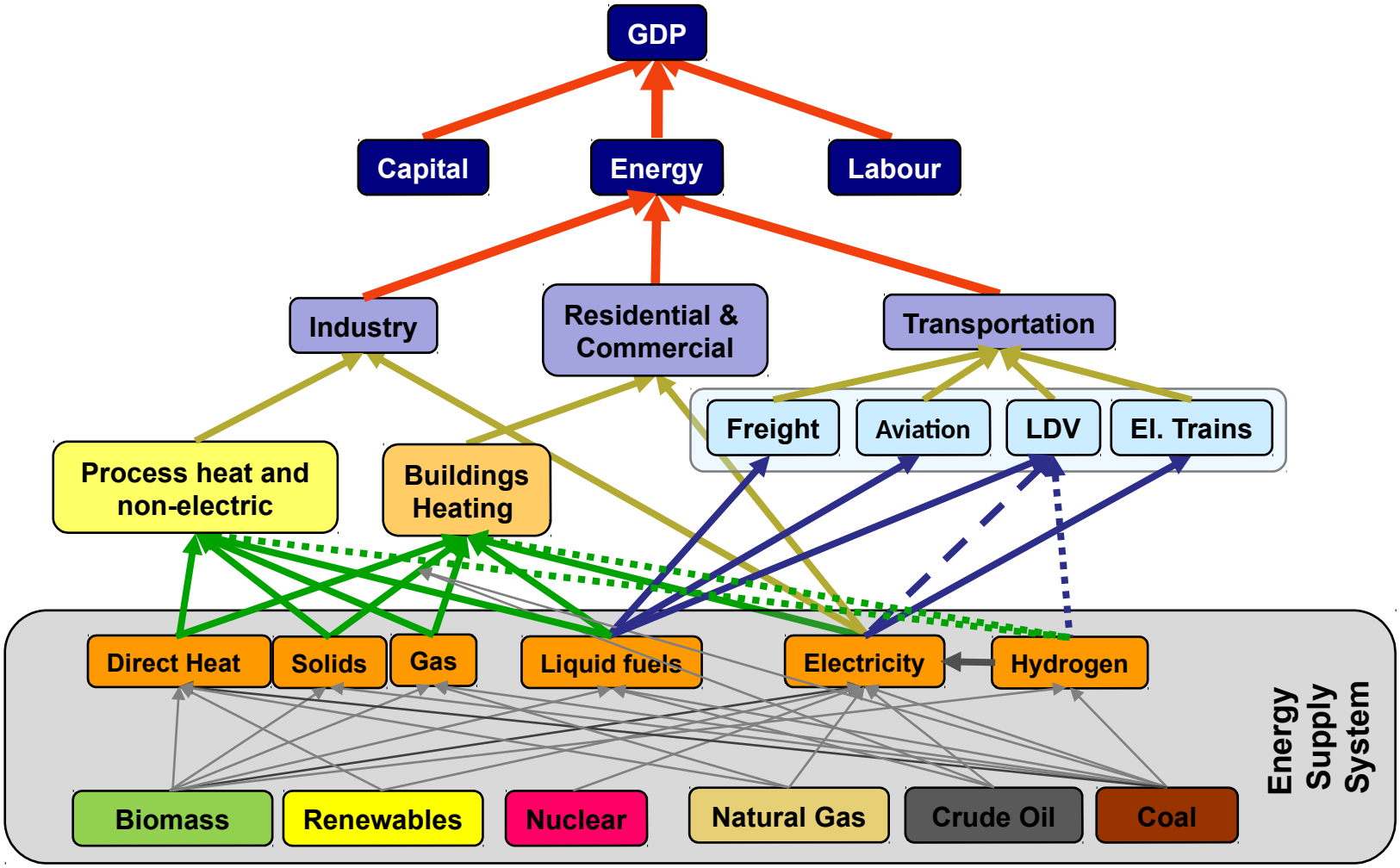
Example: SDG2 – zero hunger

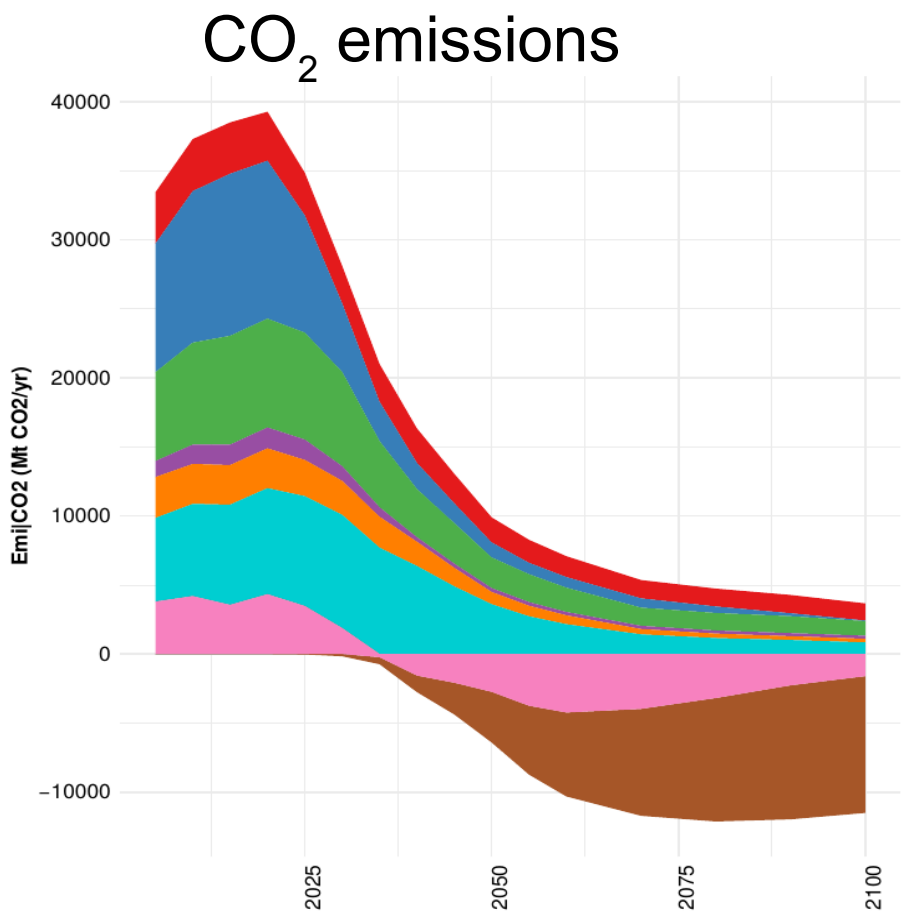


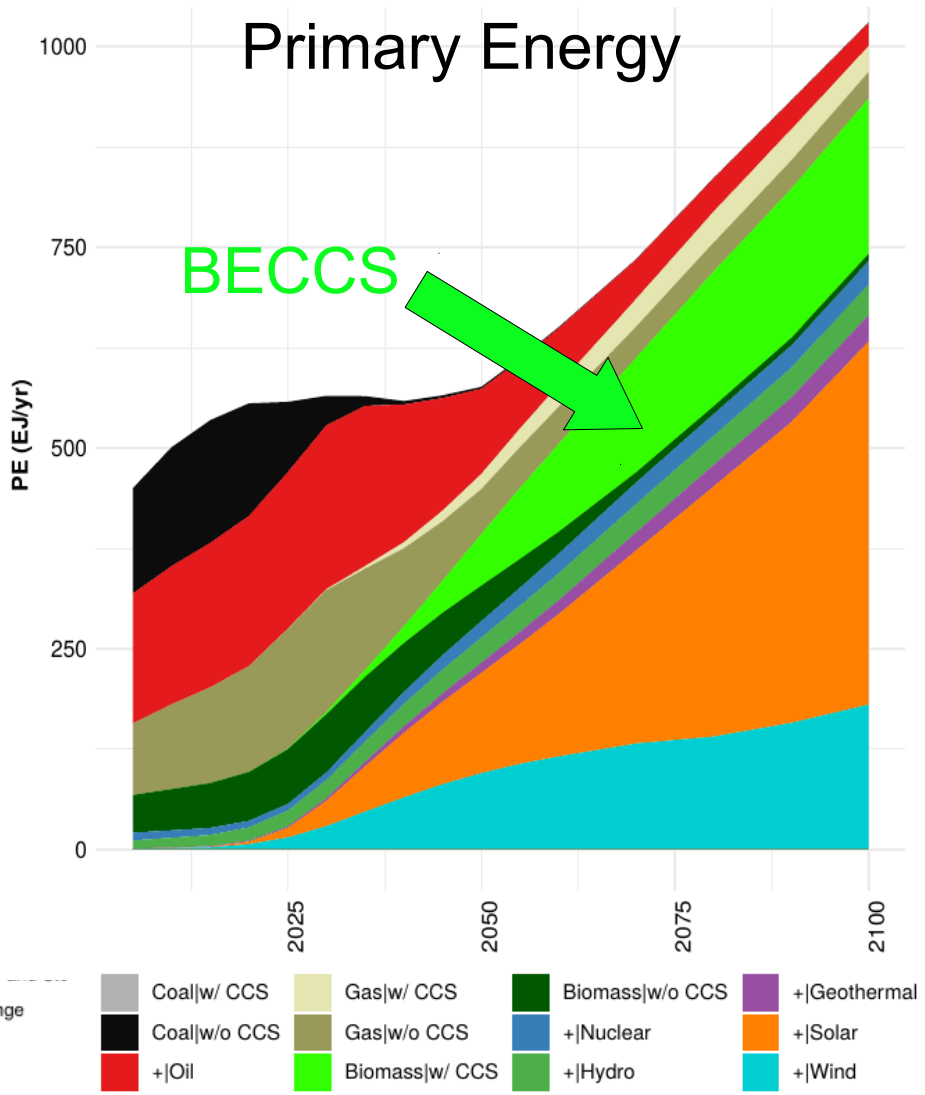
REMIND energy sector



(Graphic: Jessica Strefler, PIK)

Example scenario: SSP2 – 1.5°C





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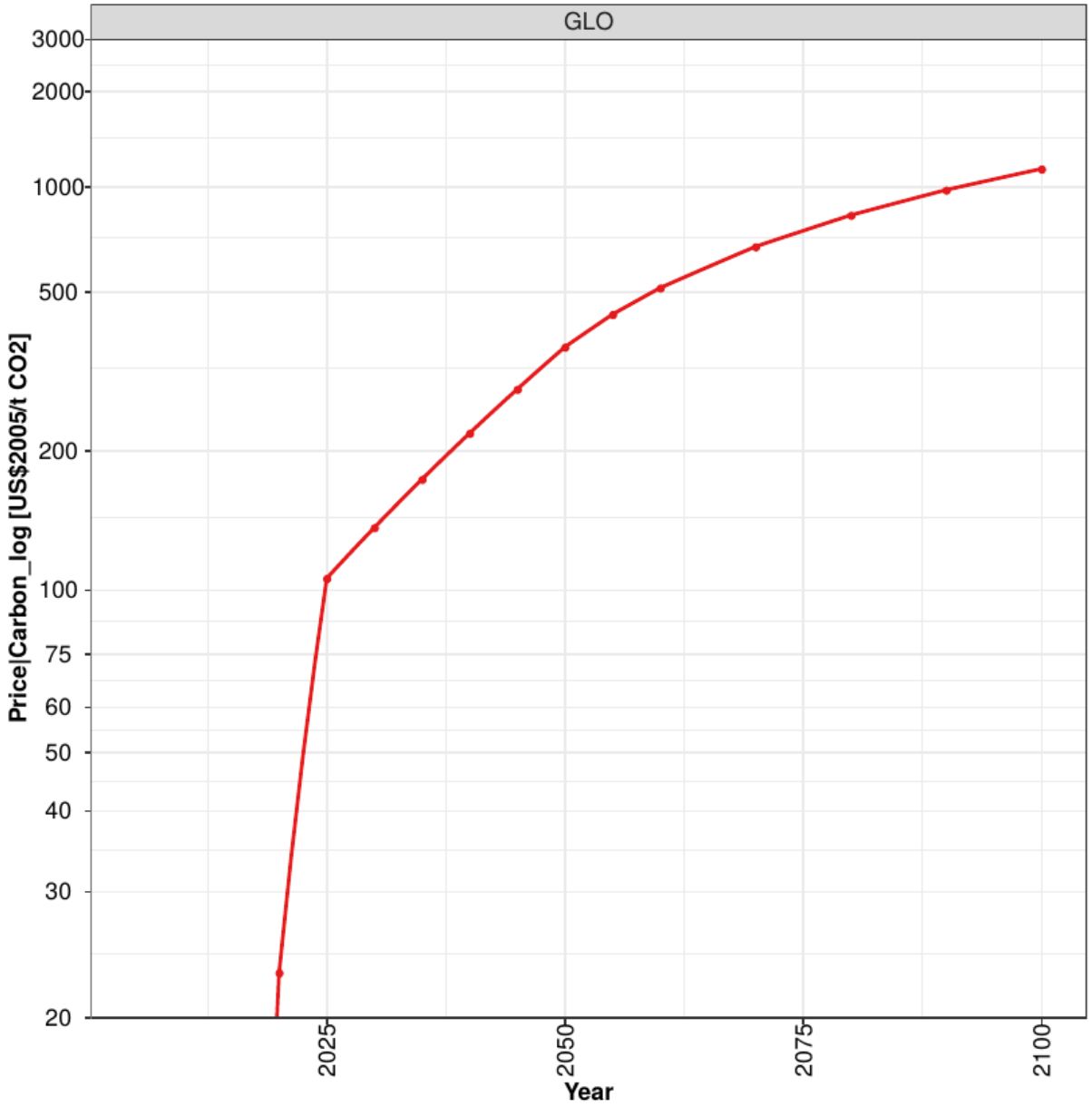
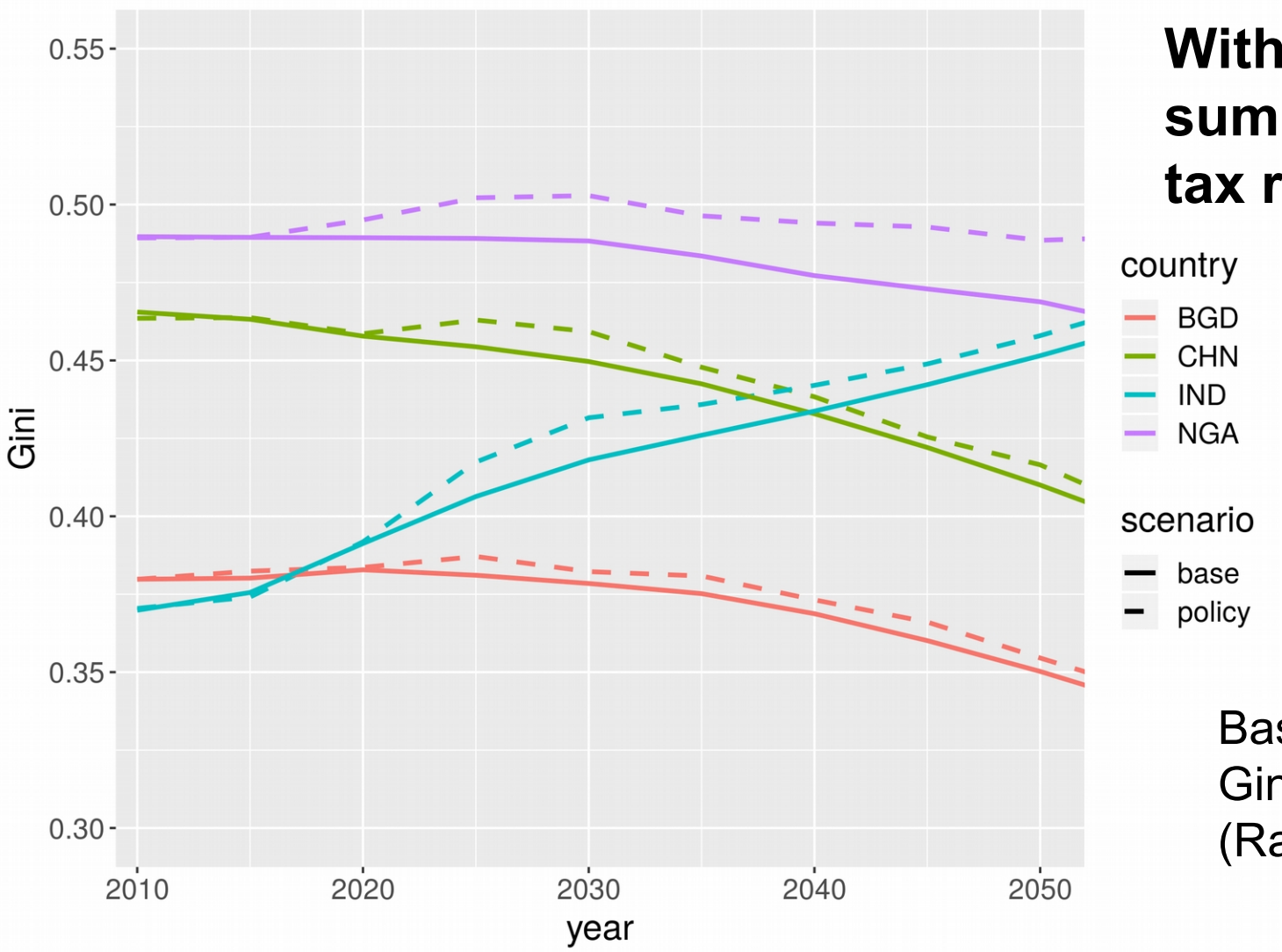


Distributional effects – “real income” Gini

At country-level (assuming equal GDP/capita loss within region):



Without lump-sum transfer of tax revenues

Baseline: SSP Gini scenarios (Rao et al. 2018)

Distributional effects – “real income” Gini

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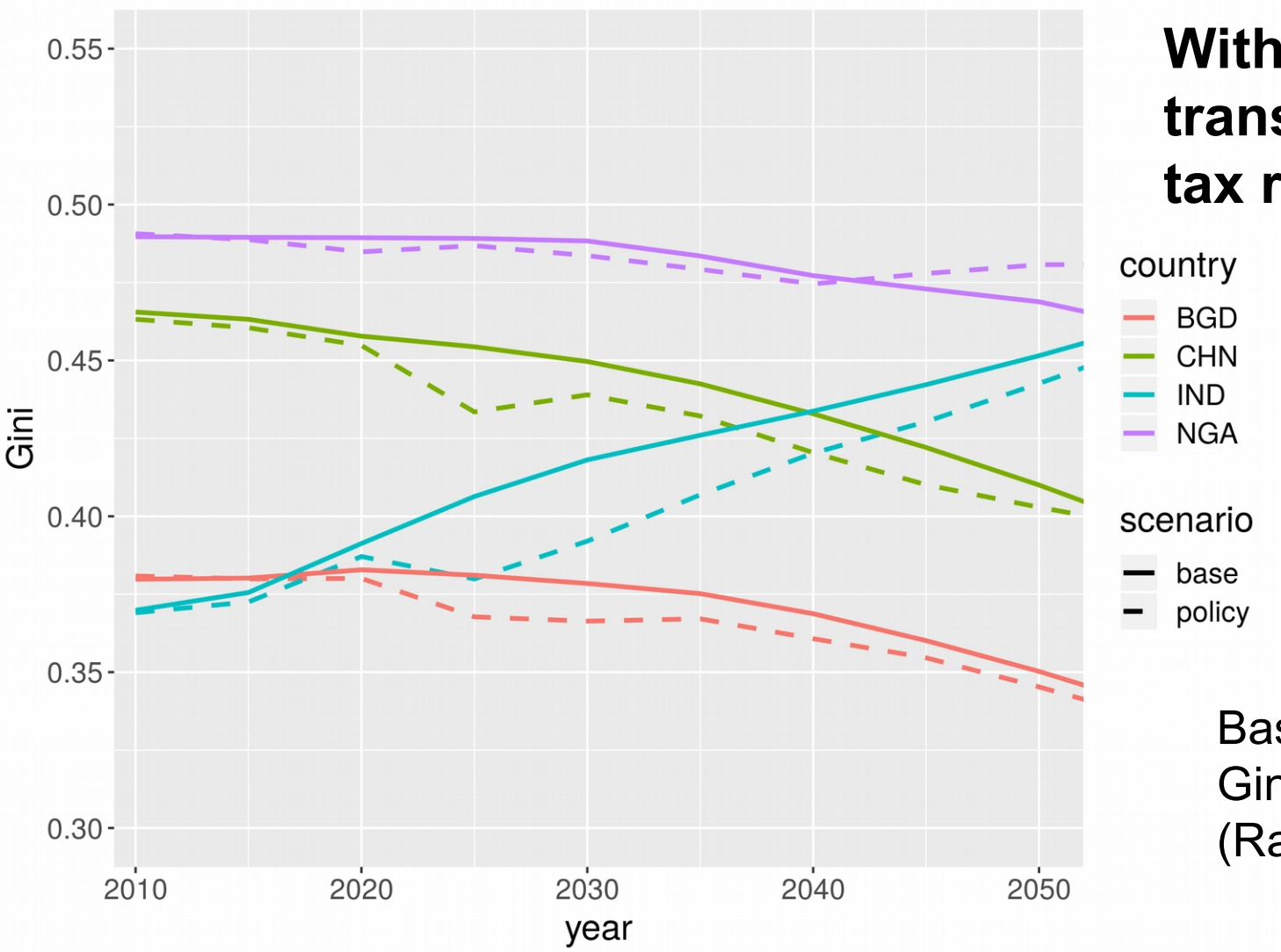
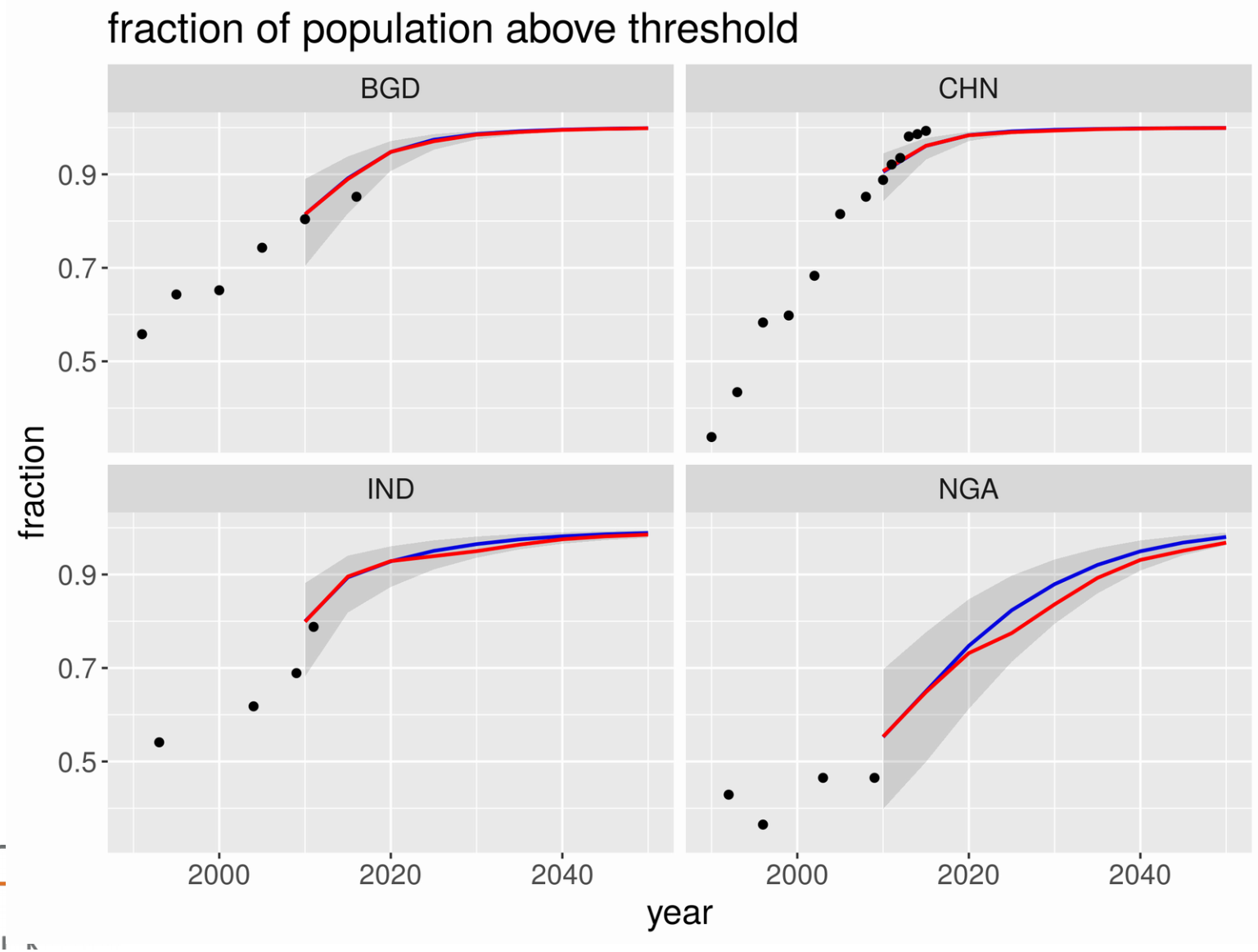


With lump-sum transfer of full tax revenues

Baseline: SSP Gini scenarios (Rao et al. 2018)

Projections with mitigation effect included (SSP2 – 1.5°C)



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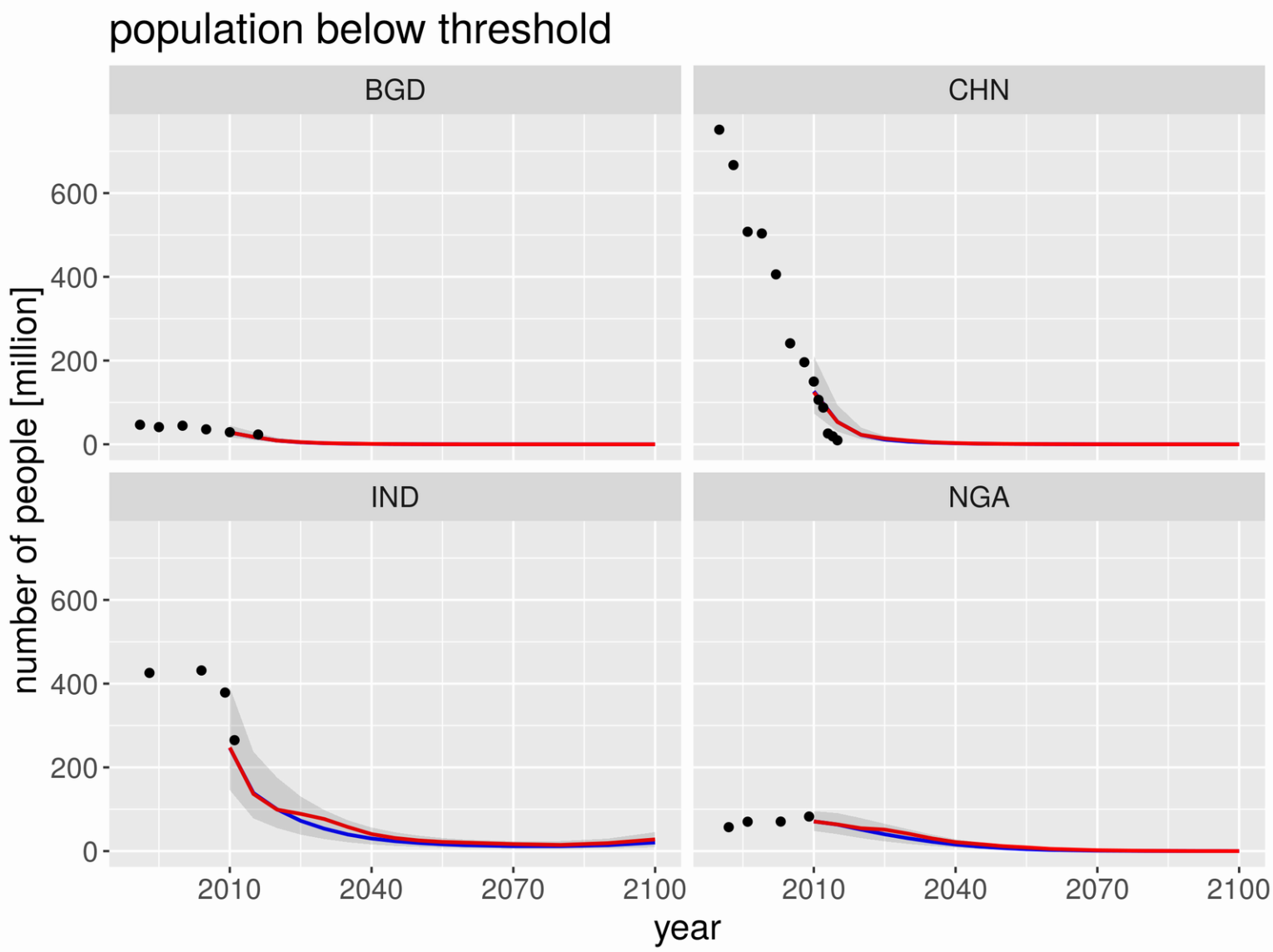
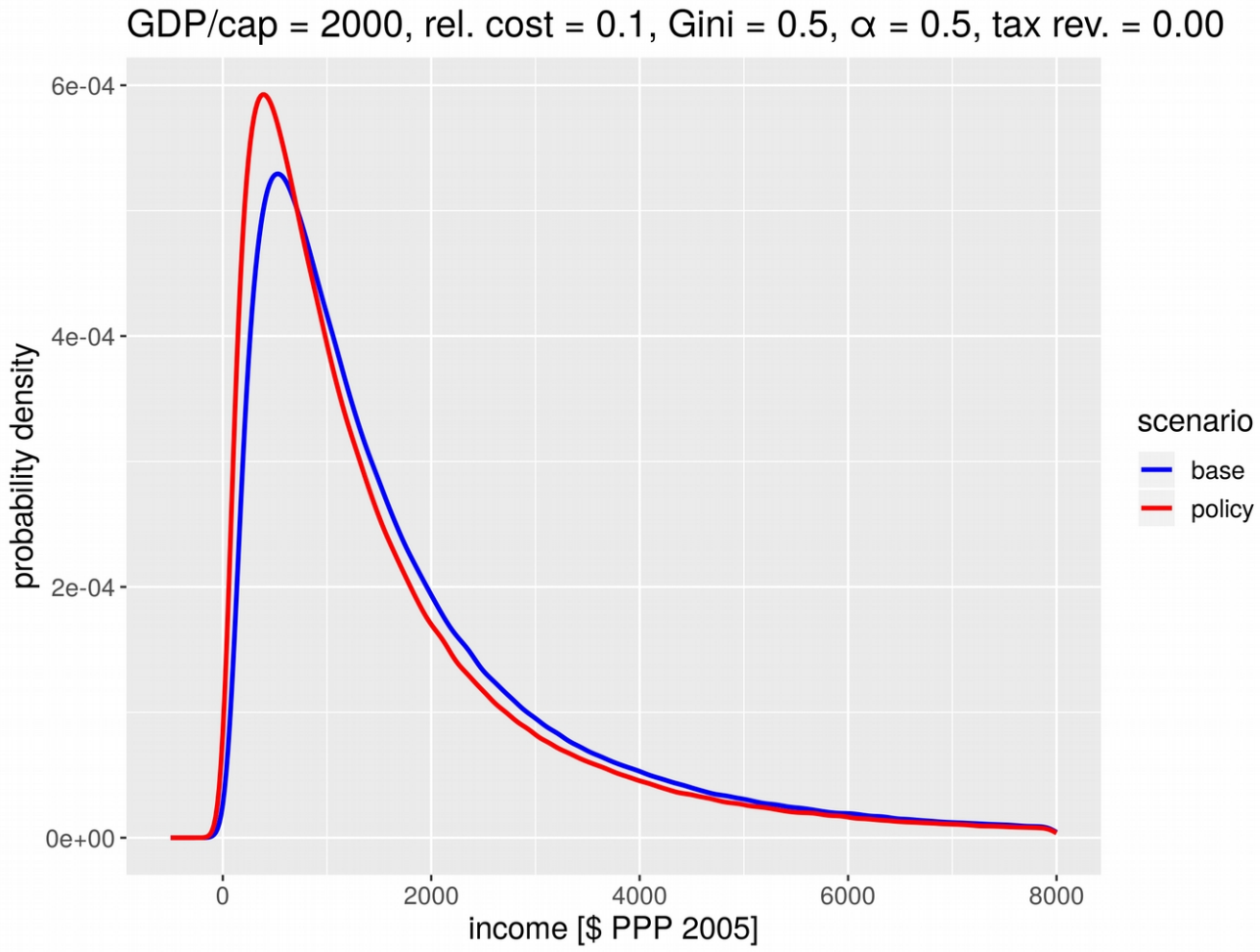


Distributional effects – “real income” approach

Increased energy/food expenditures reduce real income;
effect stronger for low-income groups.



- Start with lognormal income distribution
- Distribute costs as food / energy expenditures:
  $exp. \propto y^{\alpha}$
- uncertain parameter: income elasticity α
  here: α = 0.8 for energy, α = 0.5 for food
- Compute “real income” Gini from distribution of (income - costs)

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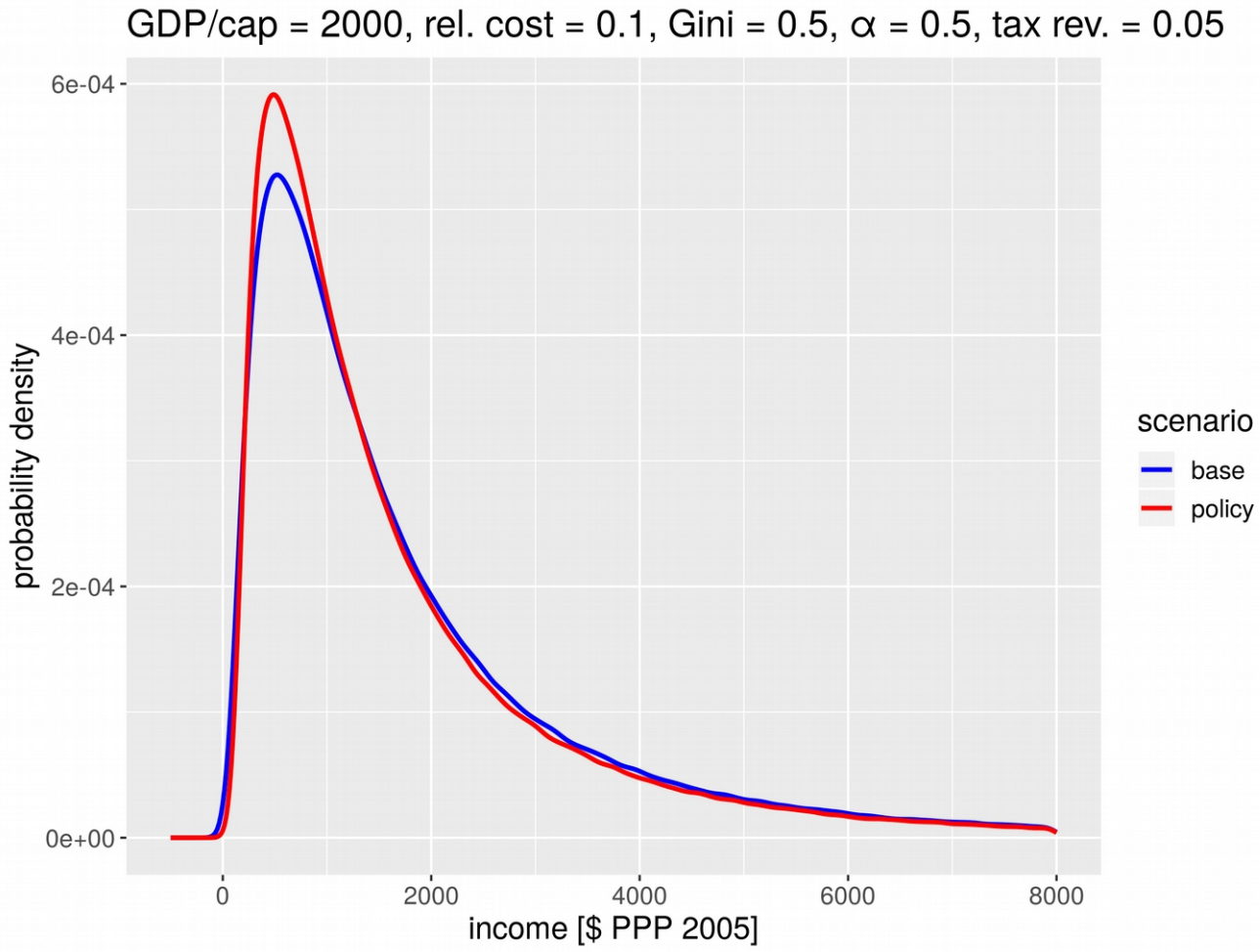

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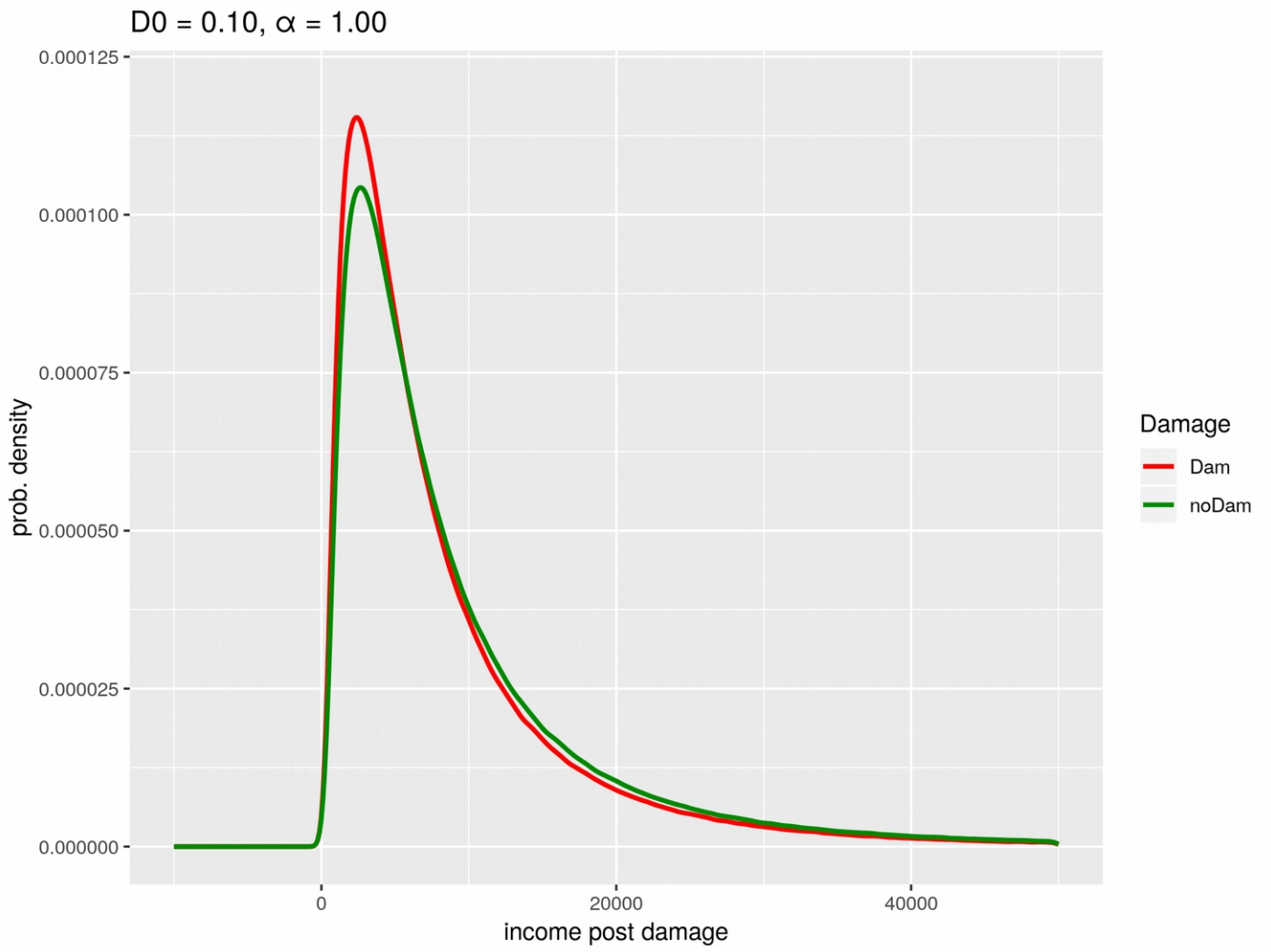
Toy model for distributional effects

Total damage = 10% of GDP, damage ~ income$^{\alpha}$



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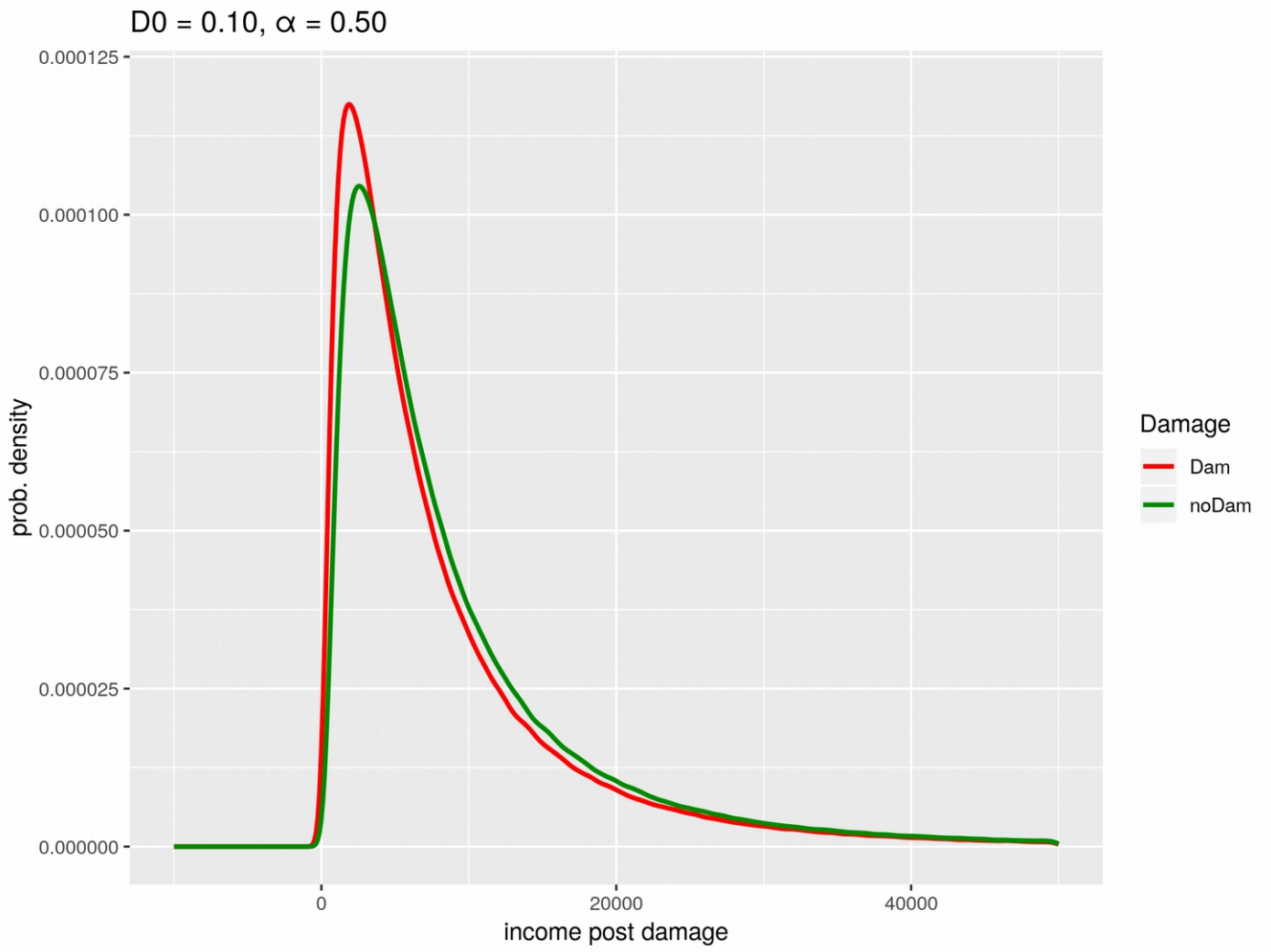

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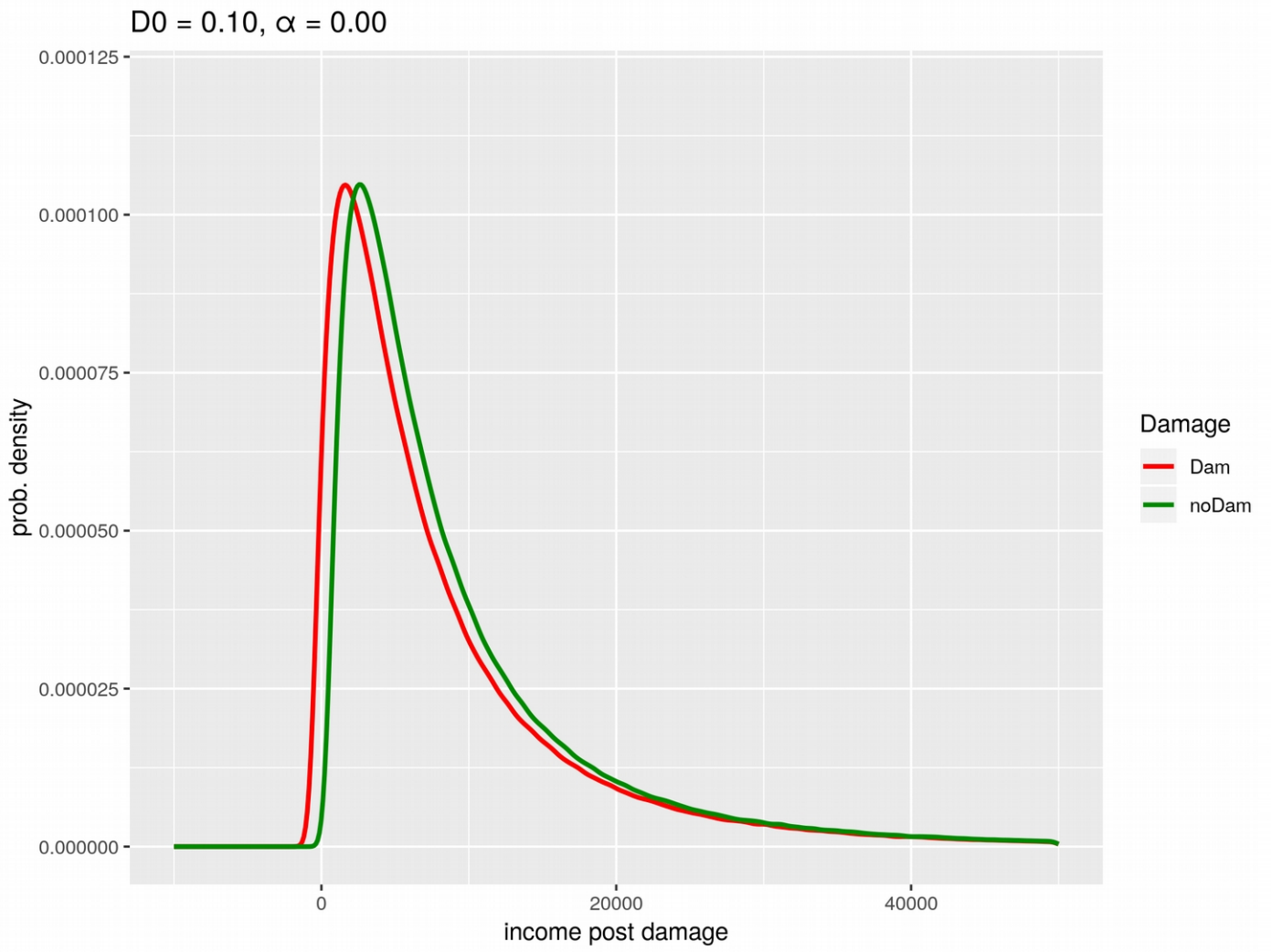

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