A Just Green Transition:

Carbon pricing, income taxation and citizen dividends

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Conference in honour of the 65th birthday of our friend Helmuth Cremer

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Golden Rule: Price Carbon!

- Curbs demand for fossil fuel
- Encourages to leave more fossil fuel in crust of earth.
- Induces substitution from carbon-intensive (tar sands?, coal, crude oil) to less carbon-intensive fossil fuel (gas)
- Induces substitution away from fossil fuel to renewables and brings forward the carbon-free era.
- Boosts CCS and limits slash and burn of forests
- Boosts R&D into clean fuel alternatives and into energy-saving technology

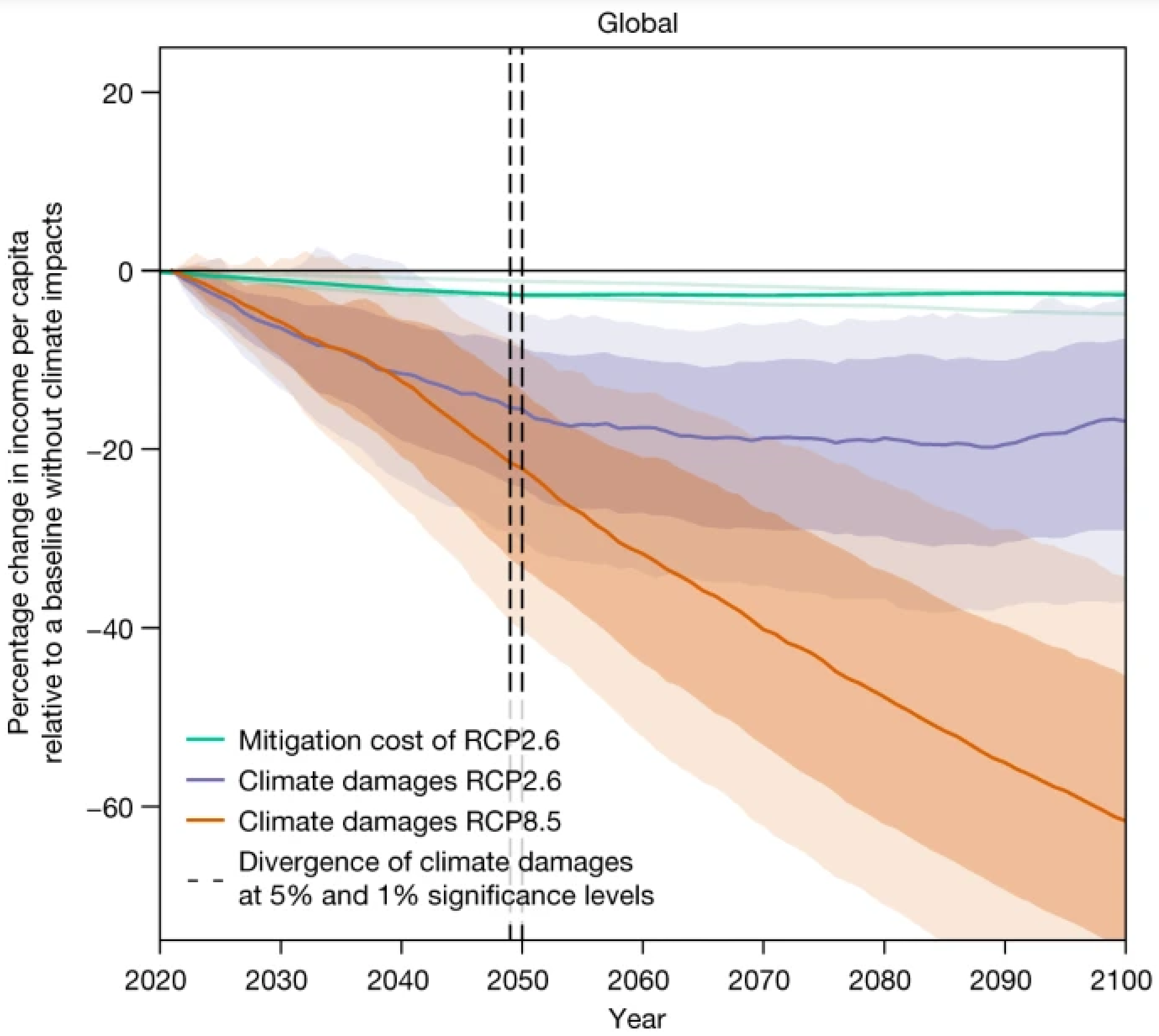
Supplementary policies

- Subsidies for green R&D to internalise technological spill-over effects and learning-by-doing effects in immature markets for renewables
- Green loans to overcome imperfect access to capital markets
- Subsidies to keep fossil fuel in the earth
- BTAs to avoid carbon leakage
- Compensate lower incomes for adverse effects of carbon pricing
- Etcetera

All other climate policies follow from the carbon price

- Success of green R&D depends crucially on the price of carbon
- Without a price of carbon, there is no market for carbon capture and sequestration
- Other instruments such as mandates have a shadow price which should equal the carbon price
- Efficiency requires that the explicit or implicit cost of reducing emissions by one ton must be the same for every type of policy instrument, in every sector, in every region, and if possible in every country

No brainer (Kotz et al., 2024, Nature)



Why Climate Policy is a Mess

1. Burning world's fossil fuel reserves is going on and on

- Emit 3.5 trillion tons of CO_2 if identified reserves of oil, gas and coal are burnt
- Carbon budget of 400 to 500 billion tons of CO_2 to say below 1.5 degrees Celsius would be exceeded by factor 7 $\Rightarrow$ temperature will rise easily above 1.5 degrees target
- See Carbon Tracker's new *Global Registry of Fossil Fuels* launched earlier this year!
- Guardian identified 200 'carbon bomb' projects that would each result in at least a billion tons of CO_2 over their lifetimes.
- Private equity firms, too, continue to pour billions of dollars into the sector

2. Worldwide fossil fuel subsidies are huge

- Fossil fuel subsidies are staggering $5.3 trillion a year (6.5% of world GDP) versus renewable subsidies of only $120 billion/year (FAD, IMF)

- No brainer: scrap these subsidies asap

- Like having “heating and air condition on at the same time”

- But dirty coal is consumed relatively more by the poor so need compensation for the poor (more difficult in countries with poorly developed tax systems)

3. Energy Charter Treaty (ECT)

- Fossil fuel investors have used ECT to sue states in investment arbitration, challenge climate measures, and claim tremendous amounts of compensation

- Not in line with Paris agreement to phase out fossil fuel rapidly: *totally outdated treaty*

- 2022 agreement: still an additional 10 years of investment protection and indefinite for non-contracting parties

4. Procrastination by policymakers

- Politicians procrastinate and prefer excessive subsidies over carbon pricing (in US with 2022 IRA and European Green Deal)

- Increases the risk of stranded financial assets

- Cost of litigation and compensation (ETC)

- Cost of inefficient green transition by doing too little upfront and having to do more upfront

- Induces Green Paradox: faster pumping to avoid capital losses, especially if supply of reserves does not react much to price of fossil fuel

4. International and intertemporal obstacles

- Leakage: if only some countries price CO2 emissions, other countries benefit from lower world price of oil
- Global emissions fall less: leakage due to tax shifting
- Need global carbon pricing deal including China and India
- Need “climate wall” around Europe (CBAM, BTA)
- “Climate clubs” may help too: due to increasing gains from trade, the more countries join, the more attractive it is for other countries to join (Nordhaus, 2015)
- Intertemporal hurdles: technology and self-enforcing climate treaties, so lock in green technologies to commit future governments (Harstad, 2021)

5. Obstacles due to policy failure and capture

- Lobbies for exceptions: ETS – grandfathering; if coal is excluded from tax or even subsidised; etc.
- Government picks winners & faces lobbies
- Subsidies tend to become addictive
- Bio-fuel mandate puts up land price $\Rightarrow$ food poverty
- Non-price controls are susceptible to capture: energy efficiency standards, mandatory sequestration, renewable mandates, etc.

6. Other obstacles to be overcome

- *Spatial needs:* need space for windmills, solar panels, hydrogen factories and CCS in the landscape, in the soil and on sea – huge challenge (NIMBY politics)

- *Climate scepticism:* cf. Pascal's wager about better to believe in God; costs of carbon pricing if sceptics are right are small, but costs of inaction if IPCC is right are huge $\Rightarrow$ max-min or min-max regret policies require ambitious carbon pricing

- *Behavioural distortions:* e.g., salience (Farhi and Gabaix, 2022) $\Rightarrow$ distorted carbon tax < SCC (FF-subsidies!) and distorted renewable subsidies higher

7.Hurdles to get political majorities
a/ Compensate current generations and poor, resource-rich countries

- Current generations must make sacrifices to curb global warming for future, perhaps much richer, generations $\rightarrow$ run up debt to give transfers and get intergenerational win-win outcome
- Give transfers to countries with lots of fossil reserves and to poor countries to ensure a uniform global carbon price
- Surprise: one can design a Pareto-improving green tax reform: an *intergenerational* and an *international* win-win!
- Kotlikoff et al. (2023) but need much more work with models where agents differ in income and wealth

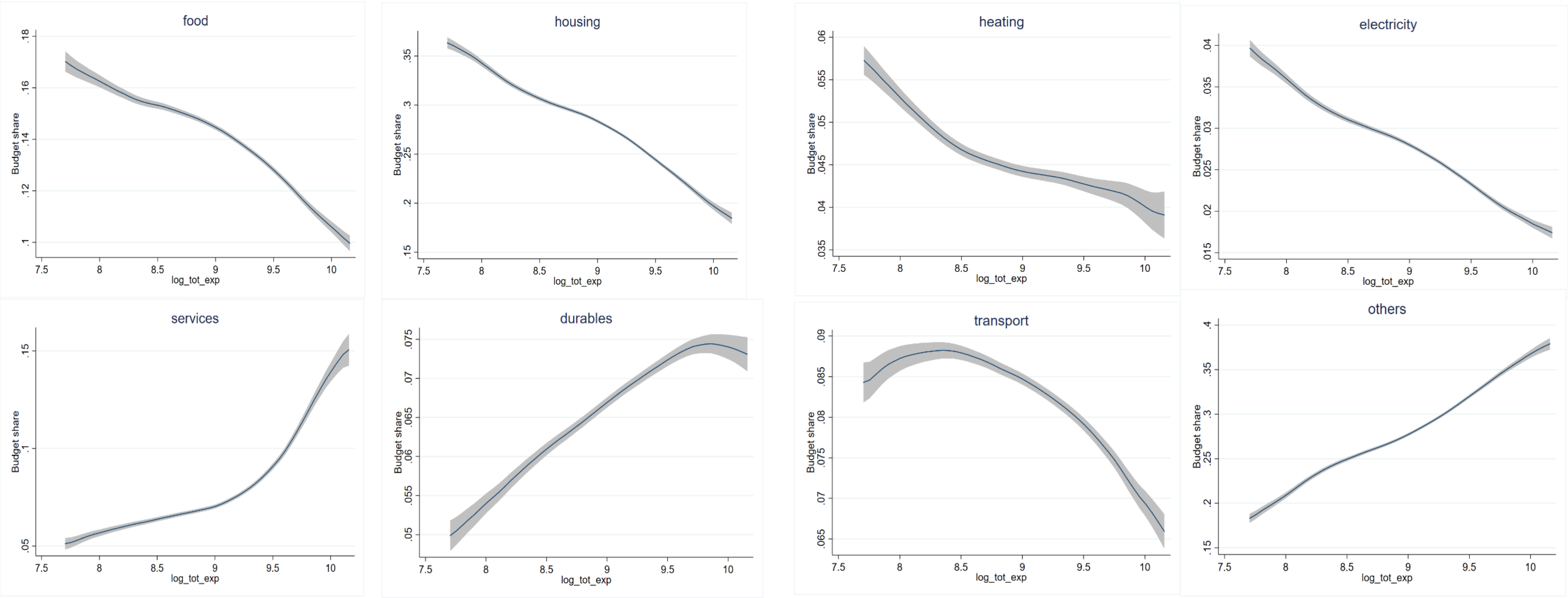
b/ Compensate adverse effects on income distribution

- Replace fossil fuel (e.g., electricity) subsidies with general tax deductions for the poor: more efficient way to redistribute incomes
- When pricing carbon, gain popular support
- Avoid “Yellow Vests”: use revenues from carbon tax to lower income tax and hand out *carbon dividends* to get it politically across the line *in the most efficient manner*
- Majority support if half of revenue is used to lower income taxes and boost economic activity and the tax base and other half of revenue is handed out as carbon dividends

Motivation

- Great policy ambition (EU's -55% by 2030, carbon neutrality by 2050) which will require pricing all users of fossil fuels. However, wider distributional considerations are largely absent.
- Green tax reform is unpopular, because it hurts typically the poor most. Many proposals of *carbon-tax-cum-dividend* (CTCD) try to "maximise fairness and political viability" of climate policy, since it benefits the poor disproportionally and lowers inequality.
- Horowitz et al. (2017) find for the US that 70% better off if revenue from $49/tCO2 is rebated at $583 p.p.
- But is such a CTCD policy feasible (political economy of carbon pricing) once effects on labour supply and the tax base and nonlinear Engel curves are taken account of? What about horizontal equity? The double dividend of a greener policy and lower income inequality suggests that a CTCD policy is politically viable and superior to other forms of carbon tax schemes.

Motivation Nonlinear Engel curves



Outline

- We explore the distributional effects of carbon pricing in policy trade-offs.
- Demand for consumption goods varies non-linearly with income.
  - We estimate an EASI demand system (Lewbel and Pendakur, 2009) from German household data to capture the effects of carbon pricing and estimate a labour supply schedule using wage data and the German income tax schedule.
- We match emissions data with households’ consumption bundles.
  - We study the effects of carbon damages of €50/tCO2 under various recycling options.
  - We allow optimal carbon pricing as function of inequality aversion.
- (We compare this to LES systems with linear Engel curves.)
- Vertical equity more important than horizontal equity. The rural/urban divide is secondary in our study.

Previous Literature

- **Double Dividend** – mostly homogenous agent approach. Using carbon tax revenue to cut taxes on labour does not necessarily boost employment.

  Bovenberg and de Mooij (1994), Bovenberg and van der Ploeg (1994, 1998); Goulder (1995), Parry (1995), Bovenberg (1999), Jacobs and the Mooij (2015)

- **Pigou and Mirrlees:** Cremer, Gahvari and Ledoux (1998, 2003), Jacobs and the Mooij (2015)

- **Incidence of carbon taxes and revenue recycling** – lifecycle perspective, general equilibrium, OLG

  e.g. Poterba (1991), Metcalf (1999), West and Williams (2004), Bento et al. (2009), Grainger and Kohlstad (2010), Rausch et al. (2011), Flues and Thomas (2015), Williams et al. (2015), Rausch and Schwarz (2016), Berry (2019), Pizer and Sexton (2019)
  explicitly on CTCD: Treasury (2017), Klenert et al. (2018), Carattini (2018, 2019), Cronin et al. (2019), Edenhofer et al. (2019); Anderson et al. (2019)

- **Non-linear Engel curves:** Lewbel and Pendakur (2009), Tovar and Wölfing (2018), Jacobs and van der Ploeg (2019), van der Ploeg et al. (2021)

Households: wage income, taxes and transfers

- Households choose hours l_h and consumption $\vec{x}_h$ to maximize utility, with the disutility of labor parameter φ_h and the uniform Frisch elasticity ε_h

$$V_h = v_h(\vec{q}_h, z_h) - \varphi_h \frac{l_h^{1+1/\varepsilon_h}}{1+1/\varepsilon_h},$$

- We use Heathcote income tax schedule with parameters λ_0, λ_1, so household budget constraint is

$$z_h = \vec{q}_h' \vec{x}_h \; = \; \lambda_0 (W_h l_h + \overline{z}_h)^{1-\lambda_1} + s_h - \sigma_h.$$

- Households provide l_h units of labour and receives a gross wage W_h and a uniform lump-sum transfer s_h from the government (“climate dividend”). They may also receive other exogenous income $\bar{z}_h$. Income is spent on consumption z_h and (exogenous) saving σ_h.
- Households are subject to a nonlinear average income tax schedule proxied by the Heathcote function $t_{\mathrm{h}}^{\mathrm{A}} = \max\left(0{,}1 - \lambda_0 (W_h l_h + \overline{z}_h)^{-\lambda_1}\right)$.

Households: labour supply

- Individual households take taxes and transfers and aggregate emissions as exogenous. Maximisation gives labour supply function for household h as

$$l_h = \left(\frac{1}{\phi_h} \frac{(1 - t_h^M) W_h}{P_h^M} \right)^{\varepsilon^F}$$

where $P_h^M \equiv dz_h / dv_h$ denotes the marginal cost of utility for household h.

- A tax on carbon, $\tau > 0$, increases CPI, lowers the real wage and thus curbs labour supply.
- Using some of the carbon tax revenue to lower the marginal income tax rate, the fall in labour supply is mitigated.
- Rebating carbon tax revenue via lump-sum transfers has no additional effects on labour supply, since due to the quasi-linear nature of the utility function there are no income effects in labour supply.

Households: EASI commodity demand

- The Exact Affine Stone Index (EASI) demand system put forward by Lewbel and Pendakur (2009) is very flexible and allows for non-homothetic preferences and nonlinear Engel curves with underlying preferences that are not of the Gorman polar form.

- Our sample consists of *H* households and the population weight for household h is N_h. Each household consumes *I* commodities has *K* characteristics. For EASI demand, the budget shares are

$$\omega_{hi} = \sum_{r=0}^{R} b_{ir} log(v_h)^r + \sum_{i=1}^{I} a_{ij}\log(q_{hi}) + \sum_{k=1}^{K} [d_{ik} z_{hk} \log(v_h) + g_{ik} z_{hk}],$$

with z_{hk} household characteristic k for household h. Importantly, the right-hand side includes a sum of various powers of the log of indirect utility, which itself follows from

$$\log(v_h) = \log(z_h) - \sum_{j=1}^{I} \omega_{hj} \log(q_{hj}) + \frac{1}{2}\sum_{i=1}^{I}\sum_{j=1}^{I} a_{ij}\log(q_{hi})\log(q_{hj})$$

where the a_{ij} are the estimated compensated price effects in commodity demand.

- These equations are functions of total expenditure z_h and consumer prices $\vec{q}_h$ (and of household attributes).

Firms

- Firms pass all price increases on unmitigated emissions due to the carbon tax on to the consumer. Consumer prices are thus

$$q_i = p_i + \tau(1 - a_i)\bar{e}_i.$$

- Firm *i* maximises profits $q_i x_i - W l_i - \kappa_{0i} {a_i}^{\kappa_1} p_i x_i - \tau(1 - a_i)\bar{e}_i x_i$ subject to $x_i = B_i \, l_i$ and taking the wage W and price q_i as given.

$$W = p_i(1 - \kappa_{0i} {a_i}^{\kappa_{1i}})B_i \qquad\qquad a_i = (\tau/\bar{\tau}_i)^{1/(\kappa_1 - 1)}$$

A higher carbon tax τ decreases the wage *W* and increases the abatement rate a_i.

- Aggregate emissions in the economy are $A \equiv \sum_{h=1}^{H} N_h \sum_{i=1}^{I} e_{hi} x_{hi}(\vec{q}_h, z_h)$.
- Backstop is \$500/tCO2 (DICE-2016R) and cost of full abatement 14.96% of output.

Government

- The government uses revenues from the labour income tax and carbon tax, τ, to finance the exogenous public revenue requirement, R, and total lump-sum transfers, s.
- The government budget constraint is

$$\sum_{h=1}^{H} N_h\left[W_h l_h + \bar{z}_h - \lambda_0 (W_h l_h + \bar{z}_h)^{1-\lambda_1}\right] + \tau A = R + \sum_{h=1}^{H} N_h s_h \,.$$

- The government chooses policy $\{\lambda_0, \lambda_1, \tau, s\}$ subject to the budget constraint and the additional “third-best” constraint for incremental tax reform

$$0 \leq \sum_{h=1}^{H} N_h s_h \leq \tau A \quad \text{and} \quad \tau \geq 0.$$

Social welfare

- The government chooses policy to evaluate social welfare, using weights $\omega_h N_h$ with $\sum_{h=1}^{H} \omega_h N_h = 1$

$$\Omega = \sum_{h=1}^{H} \omega_h N_h (V_h - \psi_h A)$$

- We allow for equity concerns via weights that decline with income,

$$\omega_h = \omega_0 (z_h + \sigma_h)^{-\eta}$$

with $\eta > 0$ the coefficient of relative inequality aversion (cf. Atkinson, 1970).

Utilitarian weights correspond to $\eta = 0$ and maxi-min weights correspond to $\eta \to \infty$. These weights can be interpreted as a generalisation of the marginal social welfare weights derived from a more conventional social welfare function.

Private welfare changes

- We compute welfare changes for each household using equivalent variations (EV).
- With baseline ($\tau = s_h = 0,\ \lambda_0 = \lambda_0^0,$ and $\lambda_1 = \lambda_1^0$) expenditure is $E_h(\vec{p}_h, v_h^0)$.
- With policy package $\Theta\{\tau, s_1, .., s_H, \lambda_0, \lambda_1\}$, the new utility level is v_h^1.

$$EV_h \equiv E_h(\vec{p}_h, v_h^1) - E_h(\vec{p}_h, v_h^0)$$

- Note that many studies use the expenditure changes of the pre-policy consumption bundle as a welfare measure (e.g. Cornin et al., 2019; Feindt et al., 2021) without taking budget constraints into account.

Social welfare changes

- Social can be decomposed into terms capturing efficiency, equity, and emissions:

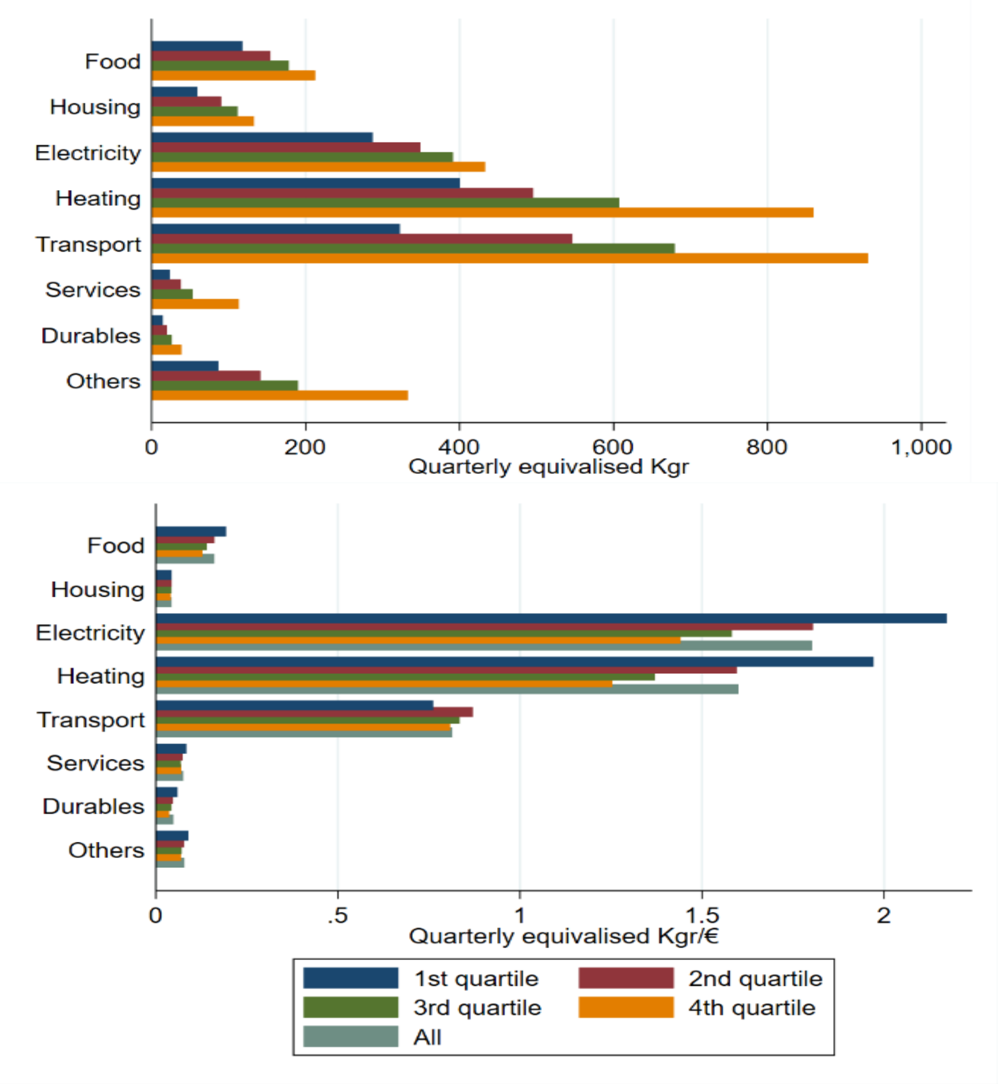
$$\Omega = \sum_{h=1}^{H} \omega_h N_h (V_h - \psi_h A) = \underbrace{\sum_{h=1}^{H} \omega^U N_h V_h}_{efficiency,\, \boldsymbol{X}} + \underbrace{\sum_{h=1}^{H} (\omega_h - \omega^U) N_h V_h}_{equity,\, \boldsymbol{Y}} + \underbrace{\sum_{h=1}^{H} -\omega_h N_h \psi_h A}_{emissions,\, \boldsymbol{Z}}$$

- Social welfare changes relative to baseline and the corresponding changes in efficiency, equity, and emissions can be expressed as:

$$(\Omega - \Omega^0)/\Omega^0 = (\mathrm{X} - \mathrm{X}^0)/\Omega^0 + (\mathrm{Y} - \mathrm{Y}^0)/\Omega^0 + (\mathrm{Z} - \mathrm{Z}^0)/\Omega^0$$

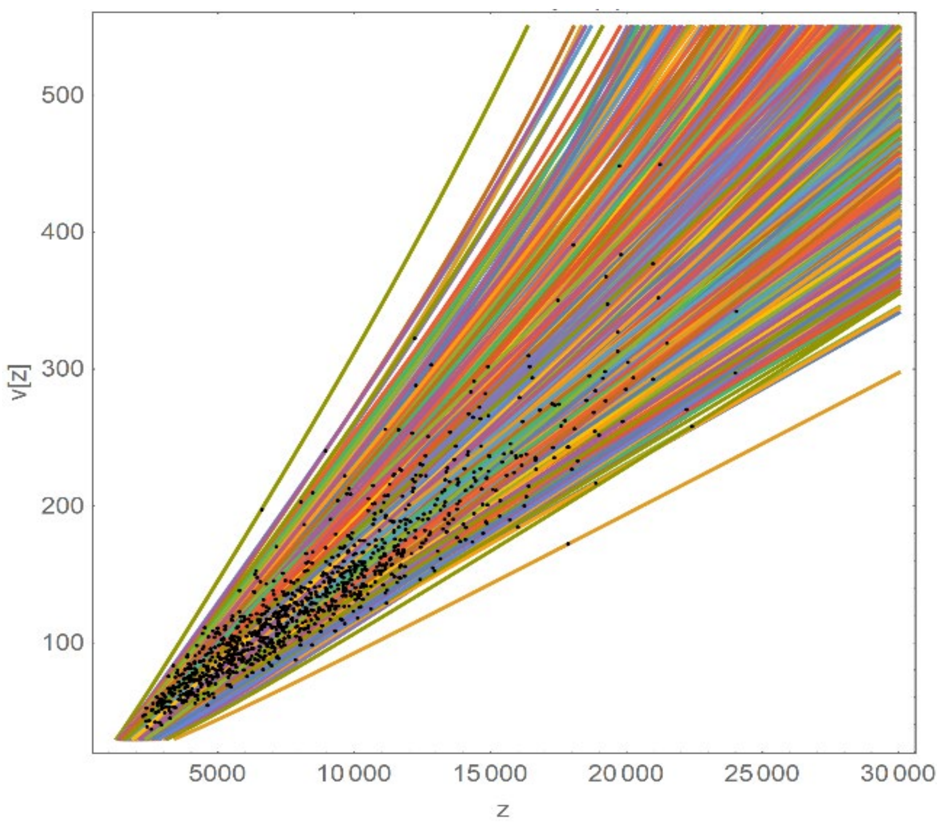
Emissions (kg CO2) and intensities (kg CO2/€)

- Overall emissions increase with income (richer household have a larger footprint), but emissions intensity falls with income. This suggests that transferring one Euro from a poor to a rich household would decrease overall emissions.
- Footprint data is provided by the German Central Statistical Office following the COICOP classification and are estimated using an input-output approach. We allow for direct and/or indirect emissions.

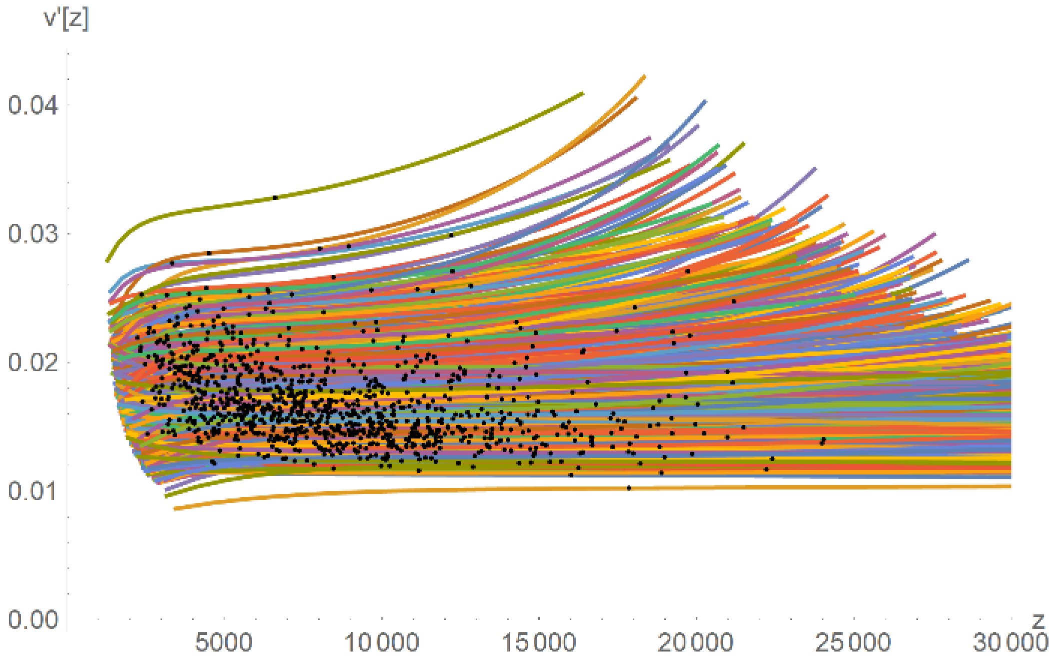


Estimation of household demand

Indirect utility

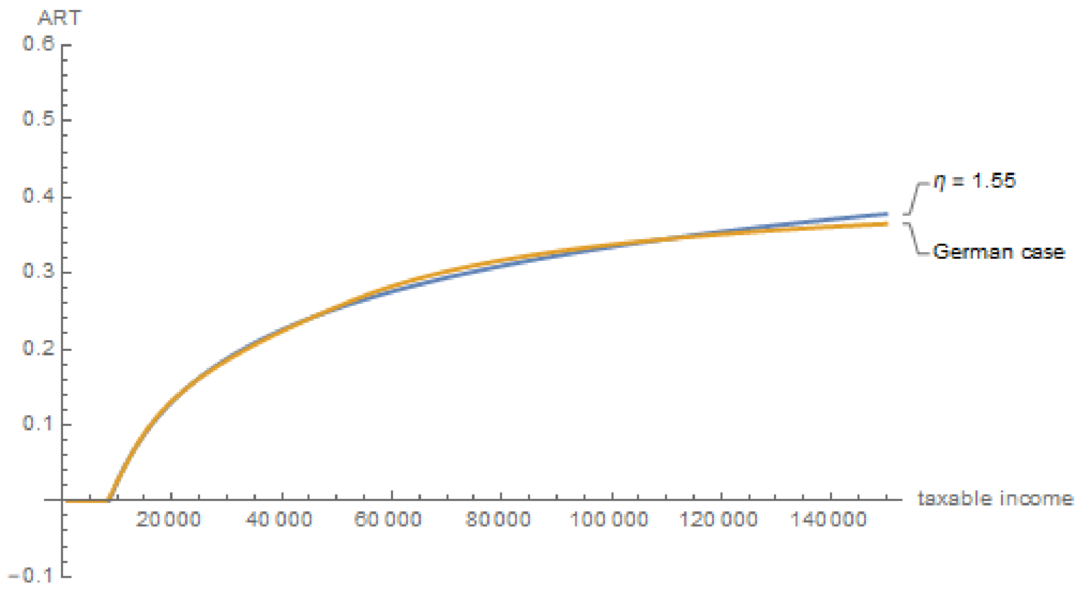


Marginal indirect utility

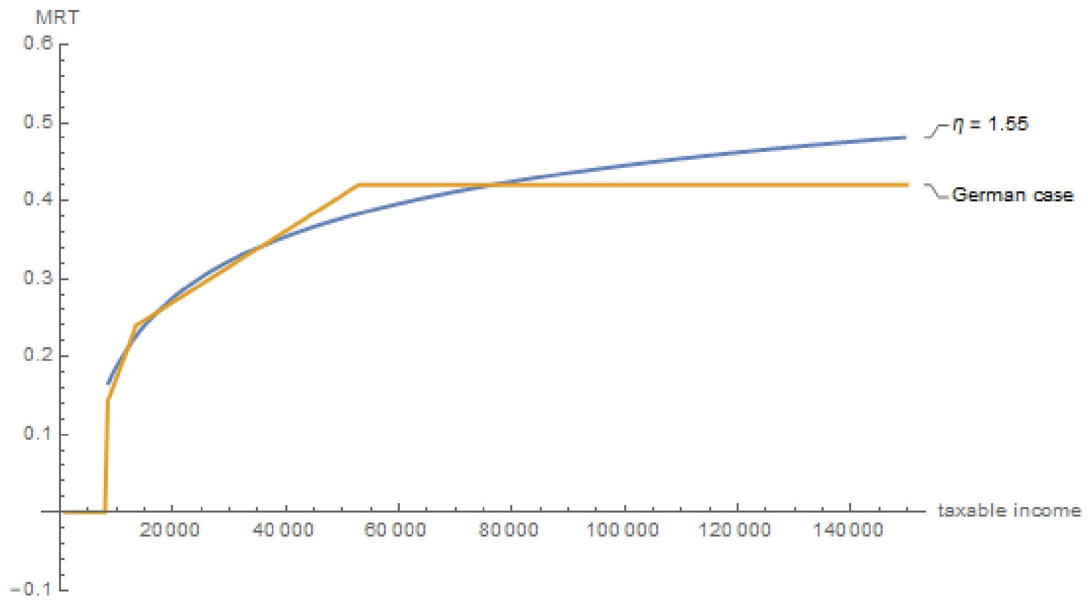


Approximation of tax system

Average income tax



Marginal income tax



First set of policy experiments

We consider three scenarios:

- *<u>Levy a given carbon tax and rebate all revenue as climate dividend</u>*

set carbon tax and disburse climate dividend finance but keep income tax schedule fixed

- *<u>Levy a given carbon tax and use all revenue for lowering income taxes</u>*

- *<u>Levy a given carbon tax and use revenue for dividend and lowering income taxes</u>*

Set carbon tax to damage coefficients (Pigouvian tax) of €0, €50, €100 per tCO_2.

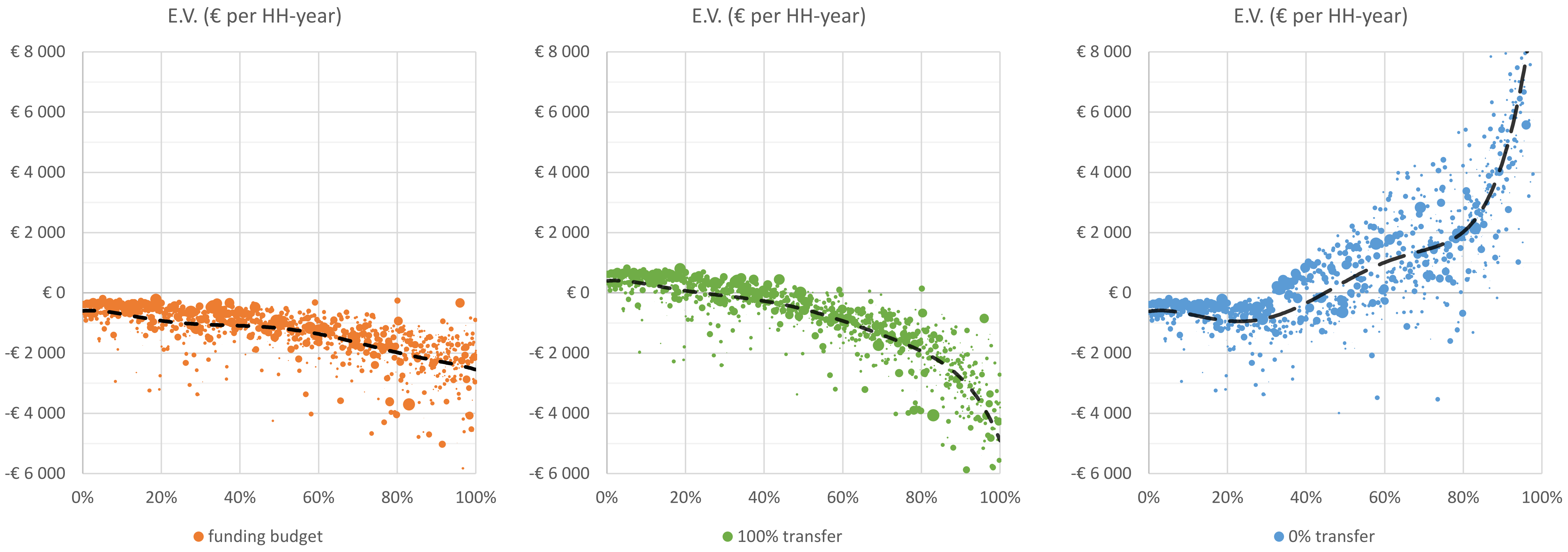
Taxing carbon and how to spend it

	Carbon tax, π (€ / tCO_2)	Transfers, s (€ per year)	Tax factor, λ (%)
Status-quo	-	-	0%
(i) General expenditure	€ 50	-	-
(ii) Lump-sum transfer	€ 50	€ 443 [€ 456]	-
(iii) Income tax reduction	€ 50	-	11% [12%]

- A carbon tax of €50/tCO2 can finance a transfer of €443 or a uniform reduction of income taxes of 10% if demand is of EASI type. Alternatively, policymakers could also choose a combination of these policy instruments to maximise welfare.
- Note that recycling as 100% as transfers would require an increase in income taxes because carbon taxes lower the incentive to work.

Distributional effects

Equivalent variations for different recycling regimes

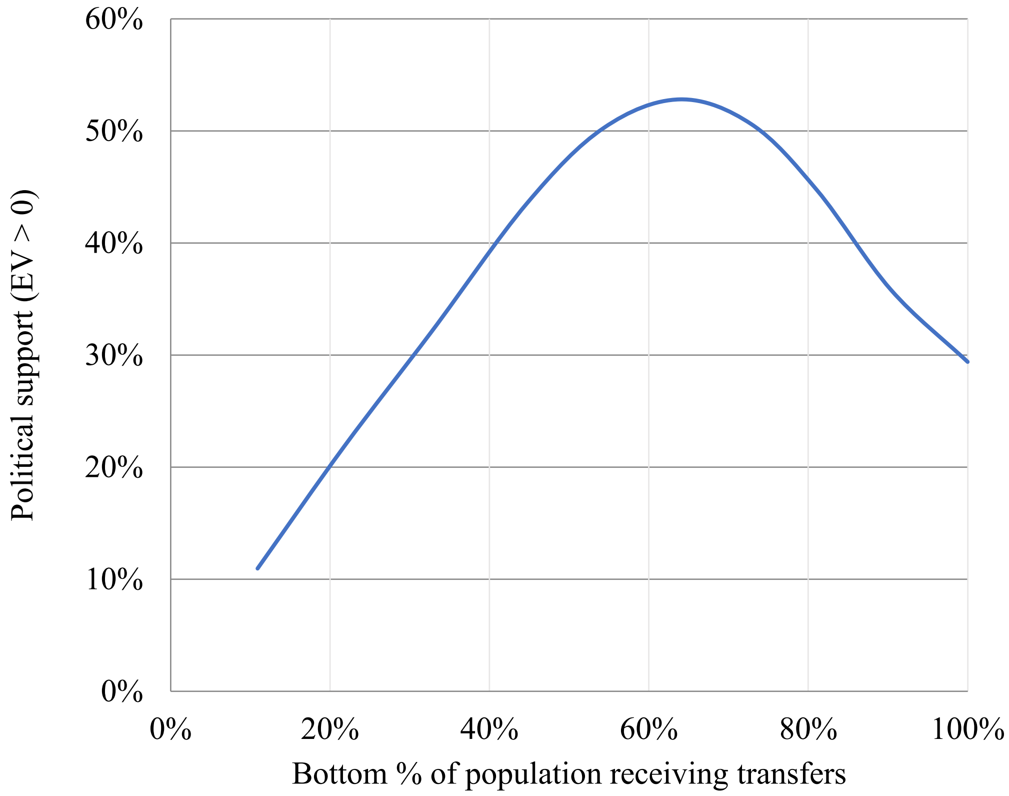


Political arithmetic of carbon pricing

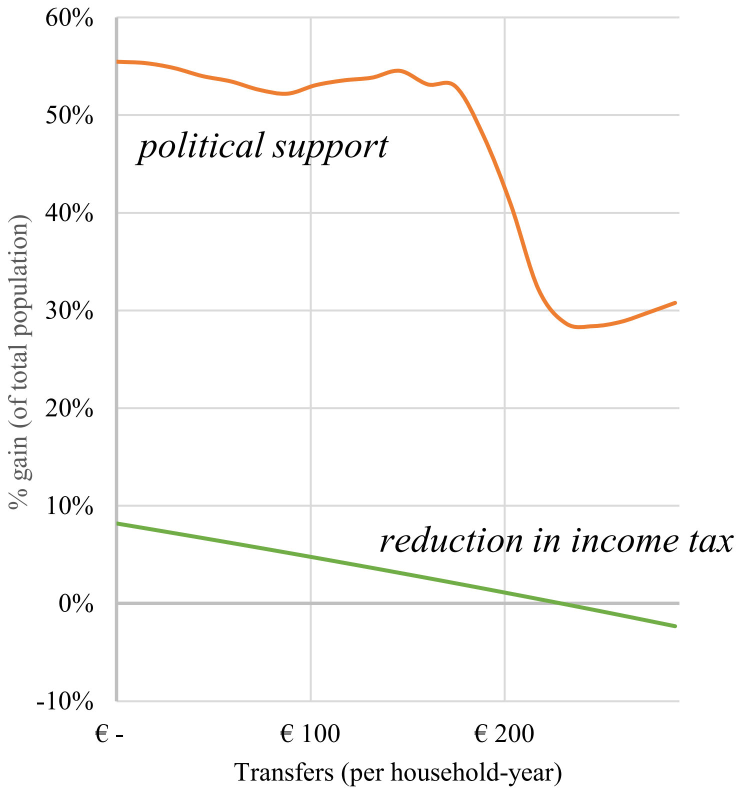
Transfers can be targeted such that only the lower end of the income distribution is eligible.

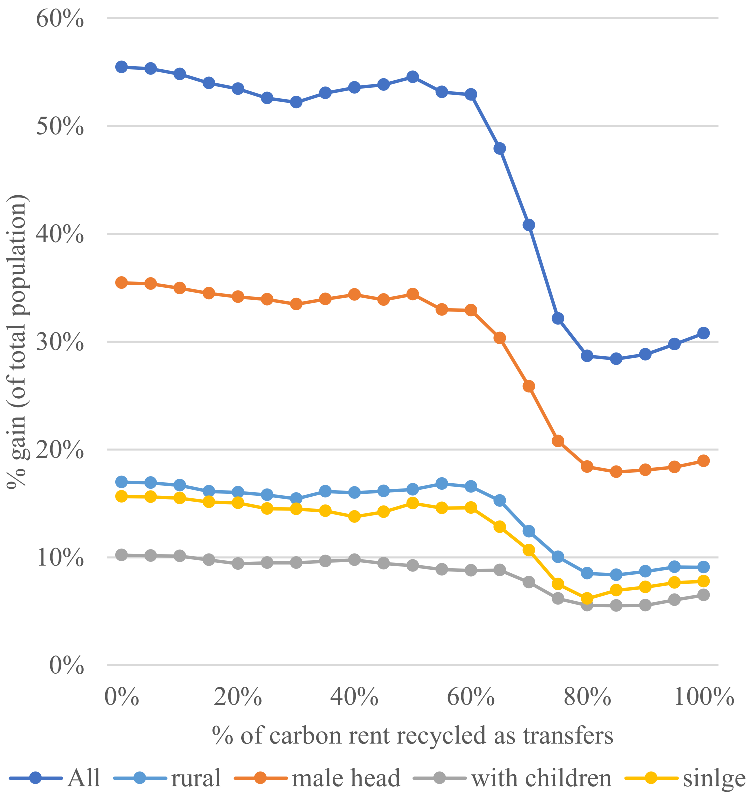
As more people become eligible, transfers fall.
If all households are eligible, transfers amount to €443 per year as in previous slide.

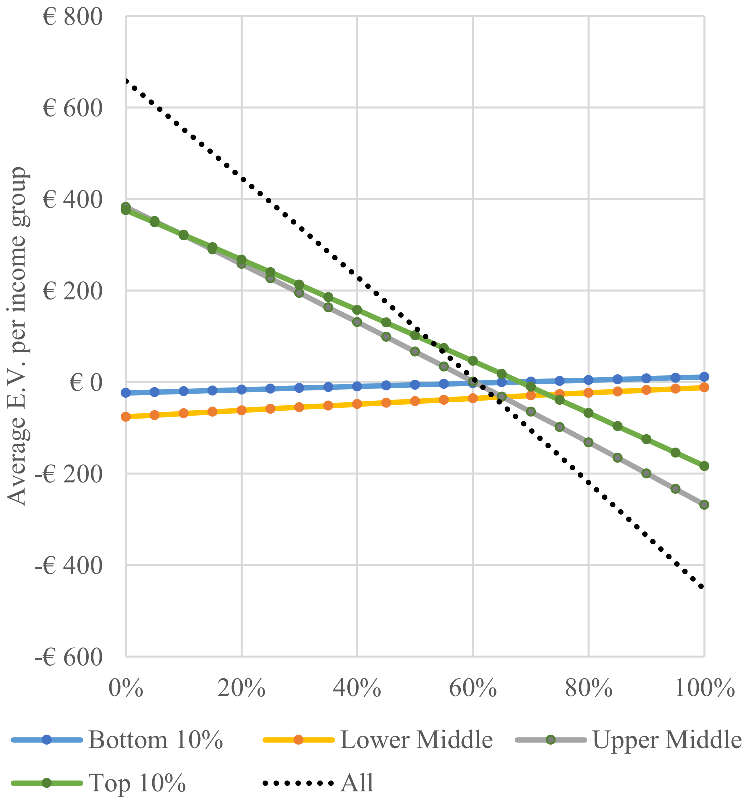
Political support increases linearly initially as all transfers are large enough to make all eligible households better off. This linear trend breaks at around 50% and support peaks when 65% of households receive transfers.



Political arithmetic of carbon pricing





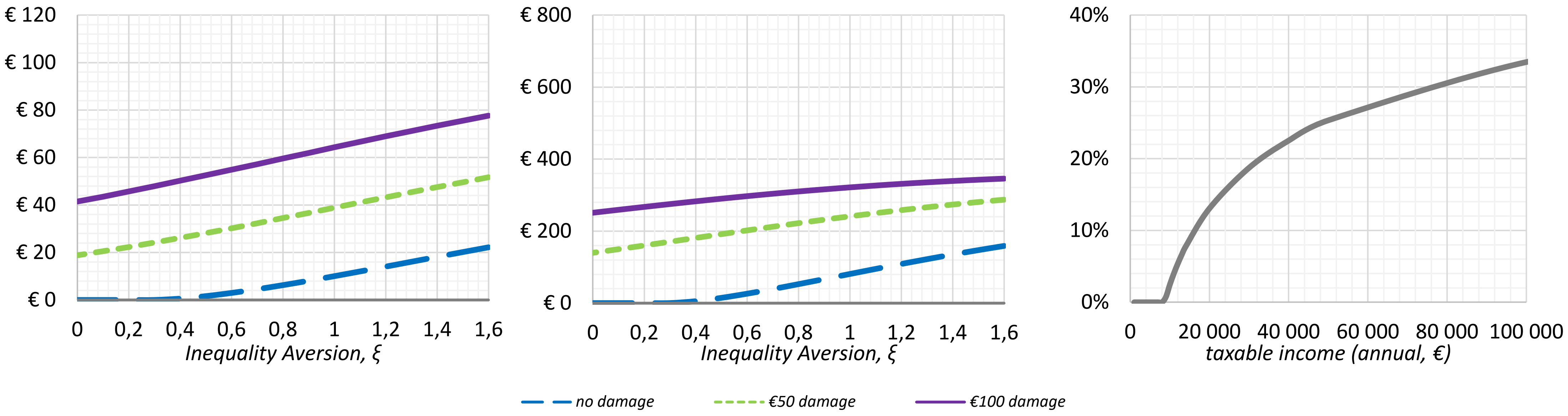


Second set of policy experiments

- Now optimize the carbon tax, so do not take it as given
- Use carbon tax revenue to finance climate dividend as before and now to potentially change both level and progressivity of income taxes by varying λ_0 and λ_1.
- Three scenarios for optimal recycling of carbon tax revenue: (i)-(iii)
- Show effects of three different damages (social costs of carbon)
- Show effect of inequality aversion

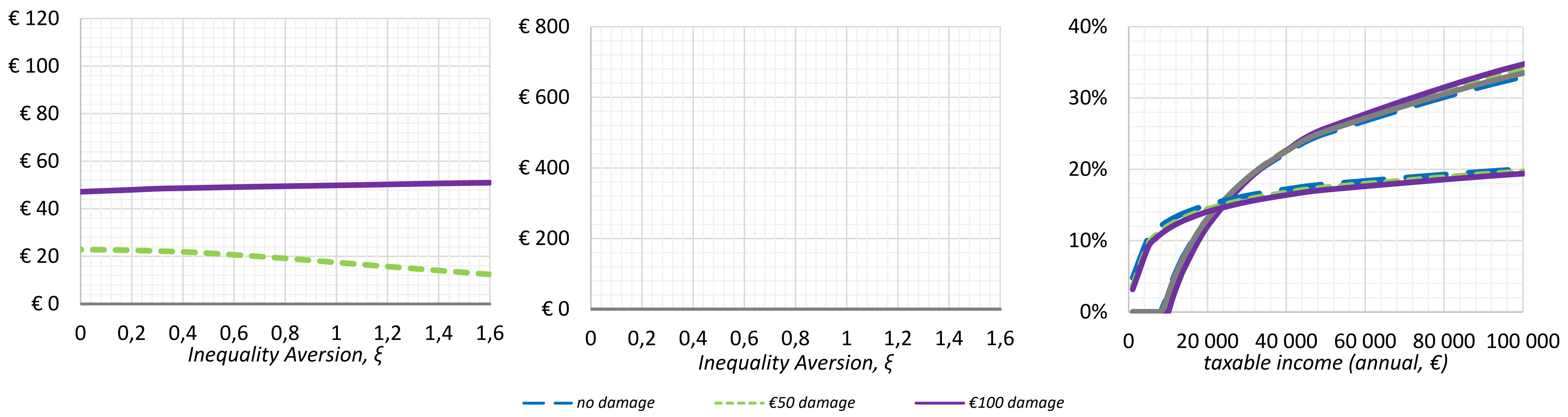
(i) Optimal carbon tax and climate dividend

Carbon tax (€/tCO2)	Climate dividend (€, annual)	Average income tax



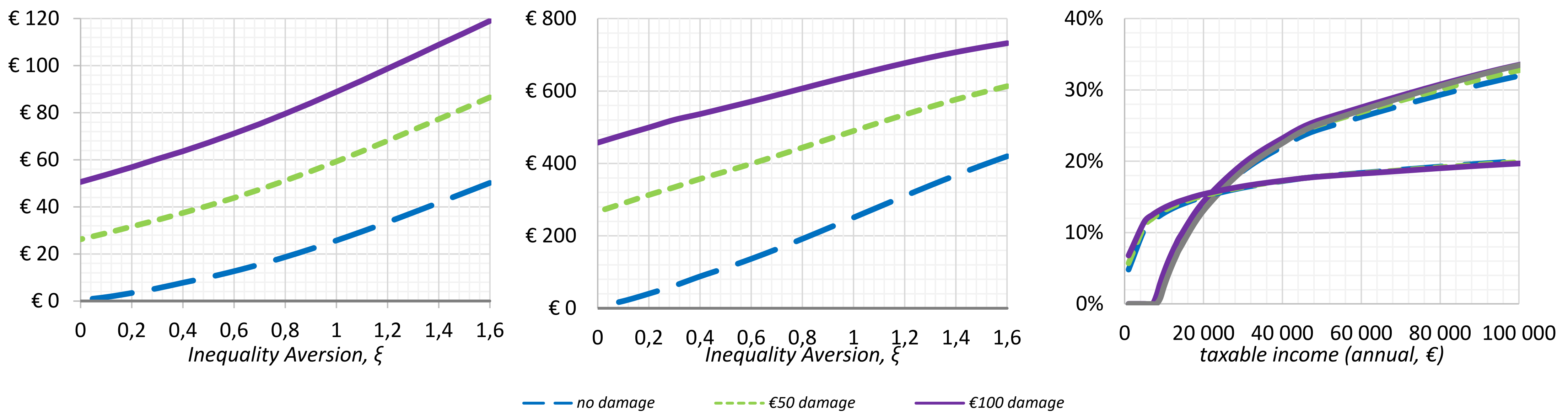
(ii) Optimal carbon tax and income tax reform

Carbon tax (€/tCO2)	Climate dividend (€, annual)	Average income tax



(iii) Third-best optimal carbon tax reform

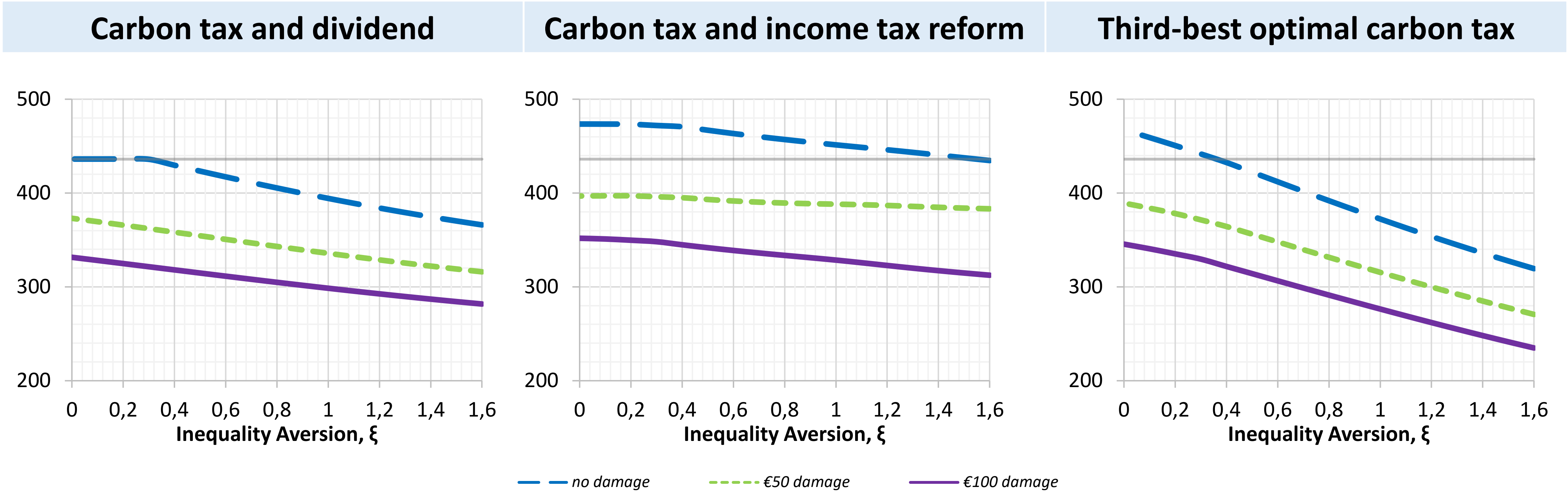
Carbon tax (€/tCO2)	Climate dividend (€, annual)	Average income tax



Sources and uses of government funds

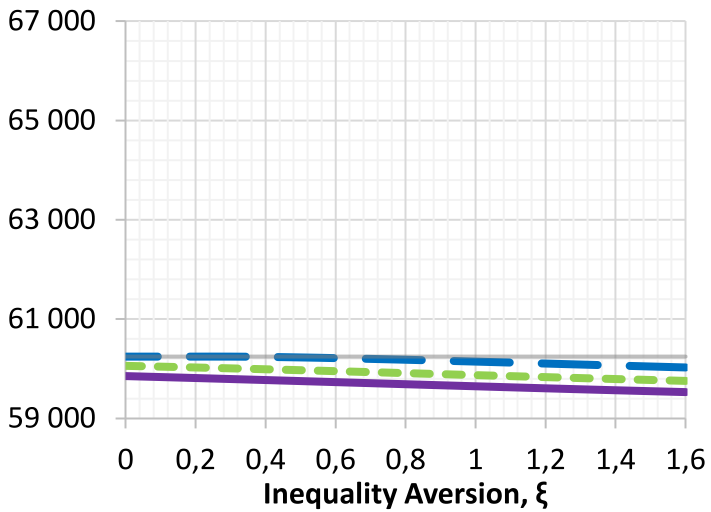
	Inequality Aversion, η	Climate dividend	Carbon tax revenue	Dividend, % carbon tax revenue	Income tax revenue	Government expenditure
Baseline	N/A	€ 0	€ 0	0%	€ 7,550	€ 7,550
Carbon tax and dividend	0	€ 251	€ 360	70%	€ 7,441	€ 7,550
	1.6	€ 346	€ 573	60%	€ 7,323	€ 7,550
Carbon tax and income tax reform	0	€ 0	€ 435	0%	€ 7,115	€ 7,550
	1.6	€ 0	€ 417	0%	€ 7,133	€ 7,550
Constrained optimal policies	0	€ 458	€ 458	100%	€ 7,550	€ 7,550
	1.6	€ 732	€ 732	100%	€ 7,550	€ 7,550

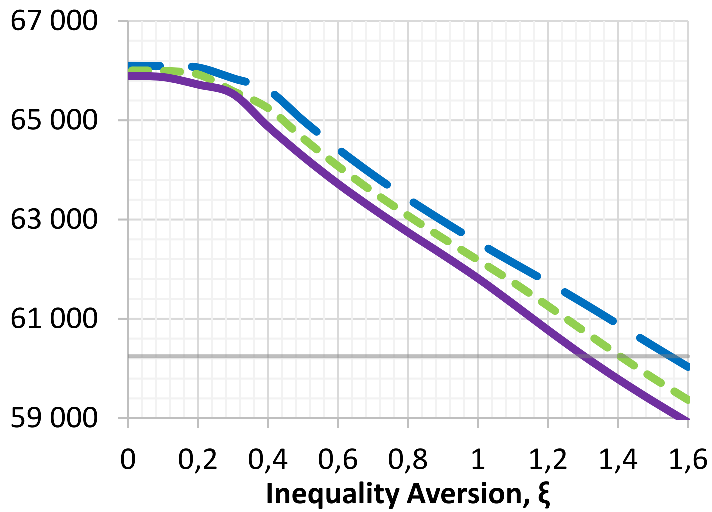
Environment (emissions, annual $MtCO_2$)

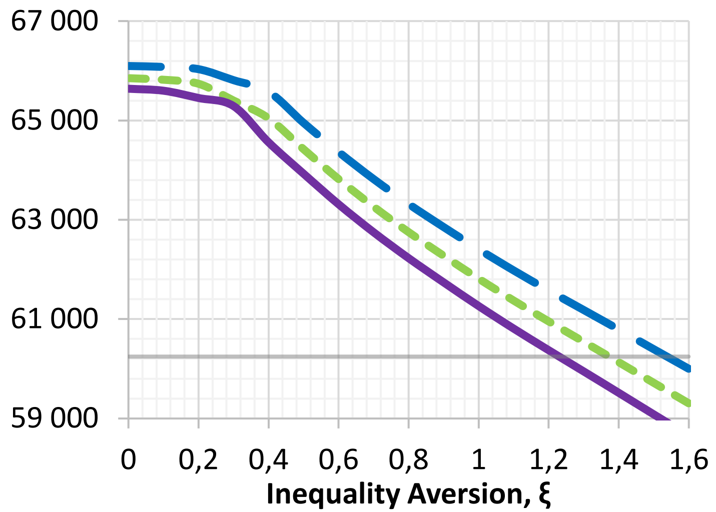


Efficiency (hours worked, annual million)

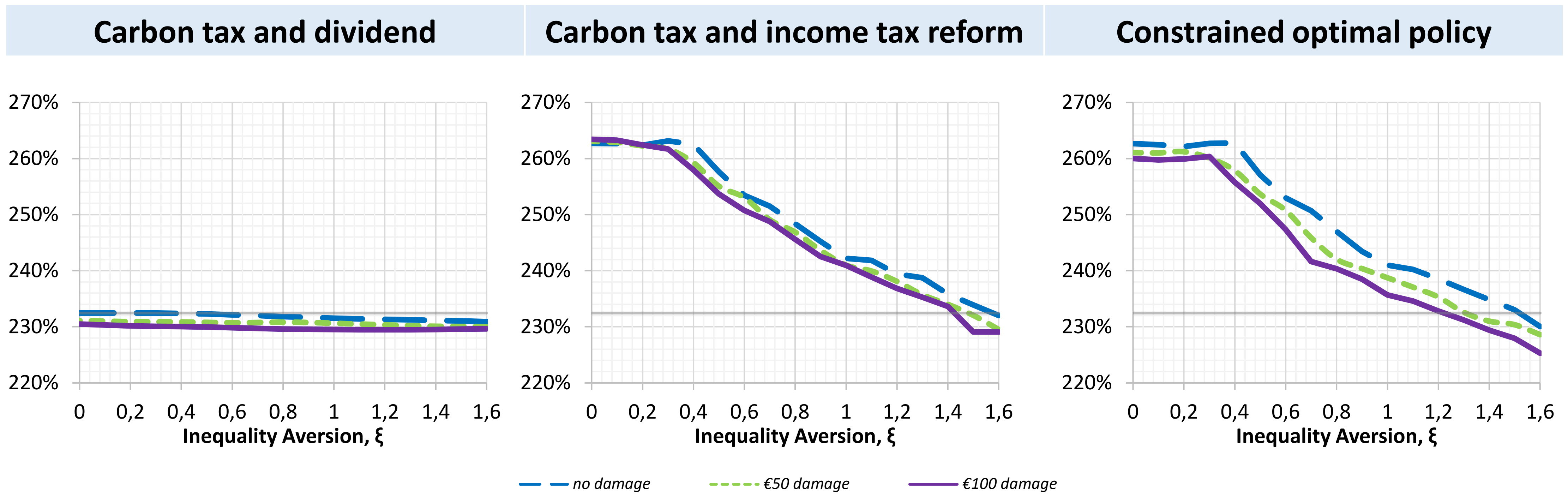
Carbon tax and dividend	Carbon tax and income tax reform	Third-best optimal carbon tax



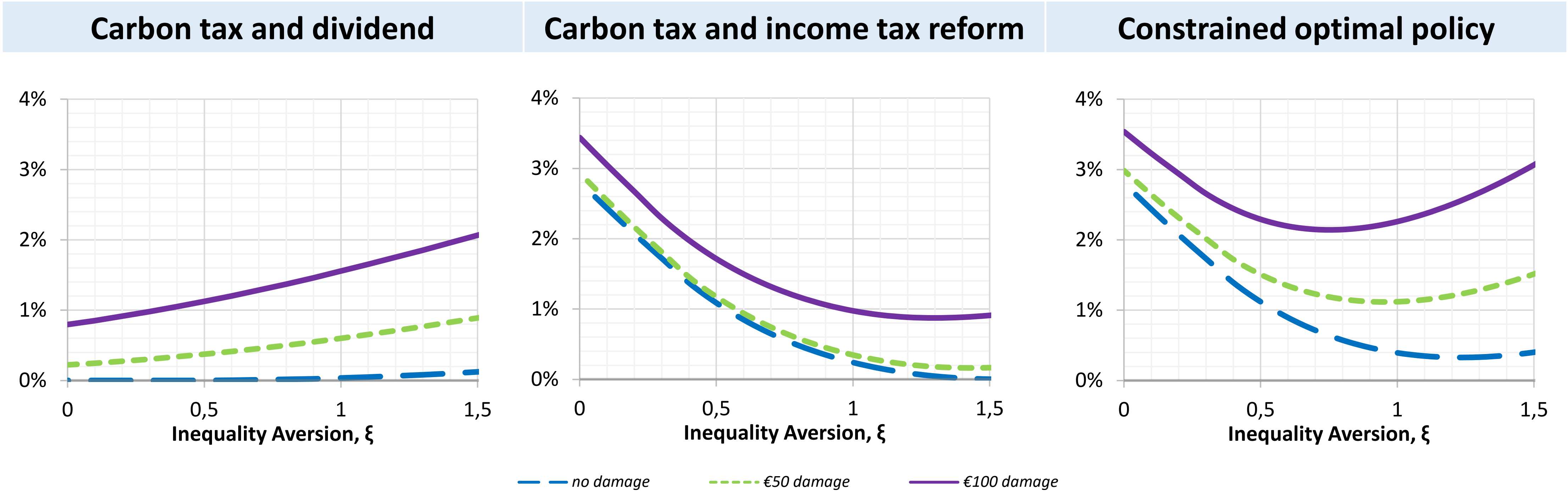


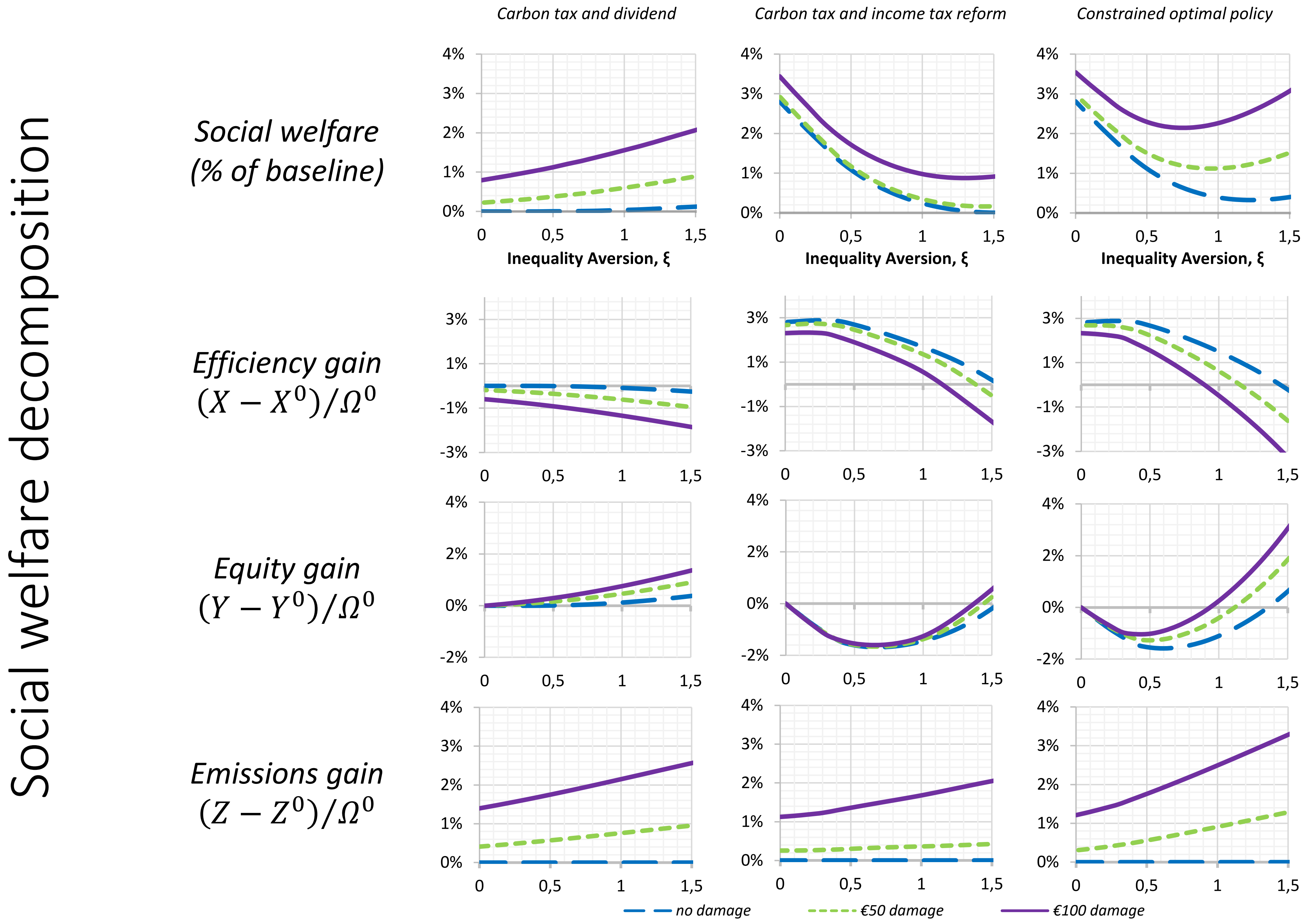


Equity (Q80/Q20 expenditure)



Social welfare (% relative to baseline)

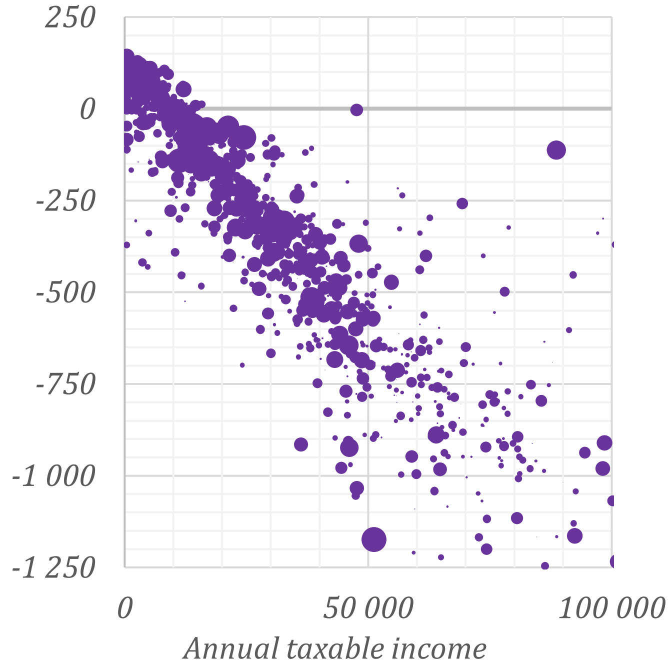


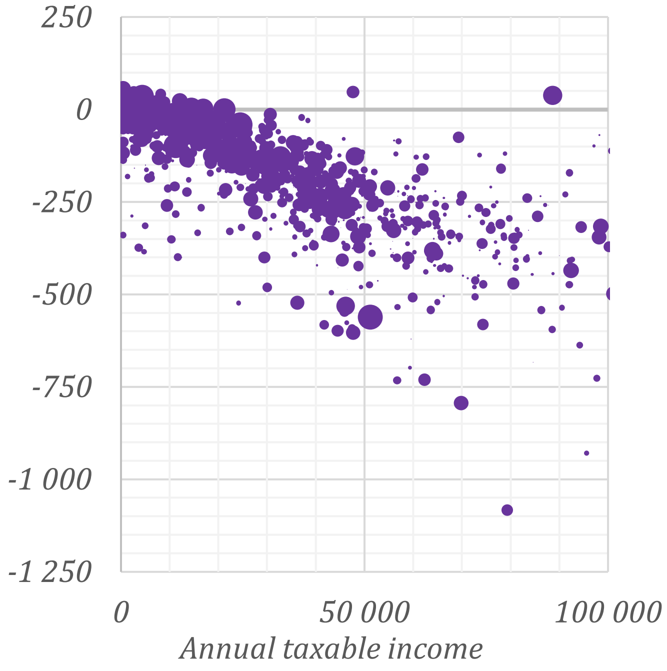


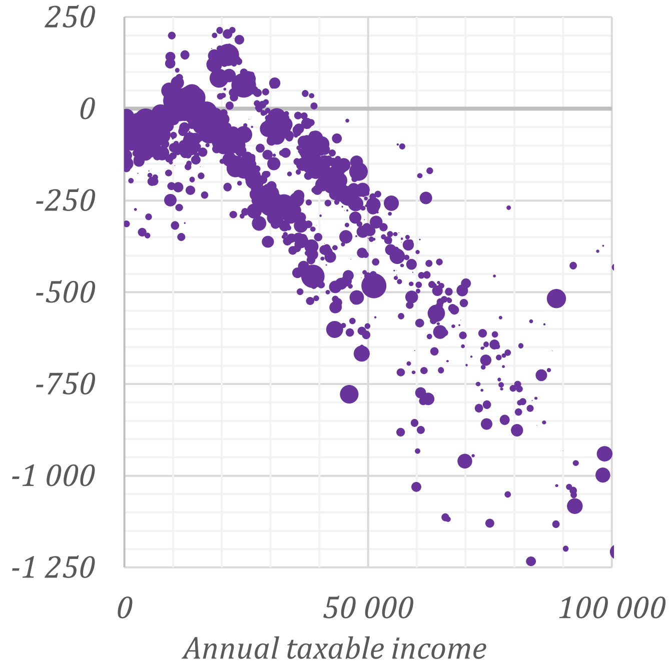
Social welfare decomposition
Carbon tax and dividend
Carbon tax and income tax reform
Constrained optimal policy
Social welfare
(% of baseline)
Efficiency gain
$(X - X^0)/\Omega^0$
Equity gain
$(Y - Y^0)/\Omega^0$
Emissions gain
$(Z - Z^0)/\Omega^0$
4%
3%
2%
1%
0%
-1%
-2%
-3%
0
0,5
1
1,5
Inequality Aversion, ξ
no damage
€50 damage
€100 damage

Private welfare (EV, baseline *ξ*, *€100/tCO$_2$*)

Carbon tax and dividend	Carbon tax and income tax reform	Constrained optimal policy







Conclusions

- Straightforward policy recommendation to fight climate change is to price carbon.
- Carbon taxation faces political hurdles, e.g. due to its adverse impact on poorer household
- Demand for consumption goods varies non-linearly with income. Demand varies with income. Carbon emissions increase in expenditure, but carbon intensity of consumption falls.
- Disbursing tax income as climate dividends put forward as solution. But double dividend literature argues that better use might be to lower other distortions in economy.
- We build an estimated model to understand the efficiency, equity, and environment trade-offs faced by policy makers.
- Higher aversion to inequality increases carbon taxes but the government consistently prefers to disburse carbon taxes as dividends, rather than lowering existing distortions.
- Carbon taxes are mostly set below the Pigouvian level.
- Private welfare effects across households are mostly negative due to cost of climate policy (on wages and via increased utility cost of consumption).

Issues to be considered

- Behavioural
  - The effectiveness of carbon taxes is often underestimated.
  - Salience of carbon taxes: leads to lower values of carbon taxes and excessive subsidies for renewable energies (cf. Farhi and Gabaix, AER, 2020)
  - The effects on the own budget are often overestimated.
  - The regressivity of the tax (i.e. effects on poorer households) is overestimated.
  - The tax is classified as harmful to the economy.
  - The intended use of the CO2 tax is critically questioned.
- Political
  - Climate policy is rarely an isolated issue. Acceptability strongly correlated with ideological position.
  - Policies frequently create winners / losers and we implement them nonetheless.

Fiscal costs of climate policy in macro framework

- **Barrage (2020):** big welfare gains from carbon taxation (33%) even taking account of fiscal impacts; second-best carbon pricing lower; high adaptation spending and high MCPF if no mitigation
- **Fried (2022):** OLG with Heathcote et al. tax function
  - Ramsey approach to optimal fiscal policy
  - Most efficient form of rebating carbon taxes is via increasing progressivity of income taxes, not lump sums
- **Douenne, Hummel and Pedroni (2024):** heterogenous agents discrete-time model with emissions and climate
  - Second-best carbon tax path is lower
- **Benmir, Rezai, Roman and vd Ploeg (2024):** heterogenous agents, continuous-time Achdou et al. framework with idiosyncratic income shocks so match wealth and income distributions. Consider third-best carbon tax reform.