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The role of financing externalities for negative emissions market design

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Introduction

- Standard economic analysis calls for full integration of CDR into a unified carbon market.

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- Several challenges to this notion (Edenhofer et al. 2024):
  - Political economy (MacLaren et al. 2019)
  - Inter-regional leakage (Franks et al. 2023)
  - Non permanance of removal (Kalkuhl et al. 2022)
  - Environmental externalities (Fuss et al. 2018)

Motivation

- Andreoni et al. 2024 finds an additional channel that might justify market separation.

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- Rents for CDR can emerge in a unified carbon market:
  - Frictions (quasi-rents)
  - Convexity in the removal cost curves
  - Heterogeneity of CDR options

Motivation

- Andreoni et al. 2024 finds an additional channel that might justify market separation.
- Rents for CDR can emerge in a unified carbon market.

- Rents cause inequality (Stiglitz, 2015) and erode the carbon market revenues base available for redistribution/green spending/fiscal reform (Van der Ploeg, 2023).

Research questions

RQ: Does these distributional concerns justify separation of markets (prices) for removal and emissions?

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Yes, under (relevant) second- or third- best conditions. Optimal price for CDR is reduced (by 30/50% in a EU calibrated model) relative to abatement if:

(a) the *double dividend* hypothesis applies

OR

(a) the social planner is inequality averse.

Methods

- Closed polluting economy (calibrated on the EU) with one emission and two removal sectors subject to a cumulative emission constraint compatible with net-zero by mid century.

$$E_b(t) = ci(t) * Y(t)$$

$$E(t) = E_b(t) - \sum_s E_{ar}(t, s)$$

$$\forall\, t^* \; s.t. \; t^* < 2150 \quad \sum_{t=2020} E(t) < E_{max}$$

Methods

- Convex, dynamic cost curves for emission reductions and Carbon Dioxide Removal (DAC and BECCS).

$$MC(t,s) = \sum_{i=0}^{4} a_i(t,s) * E_{ar}(t,s)^i$$

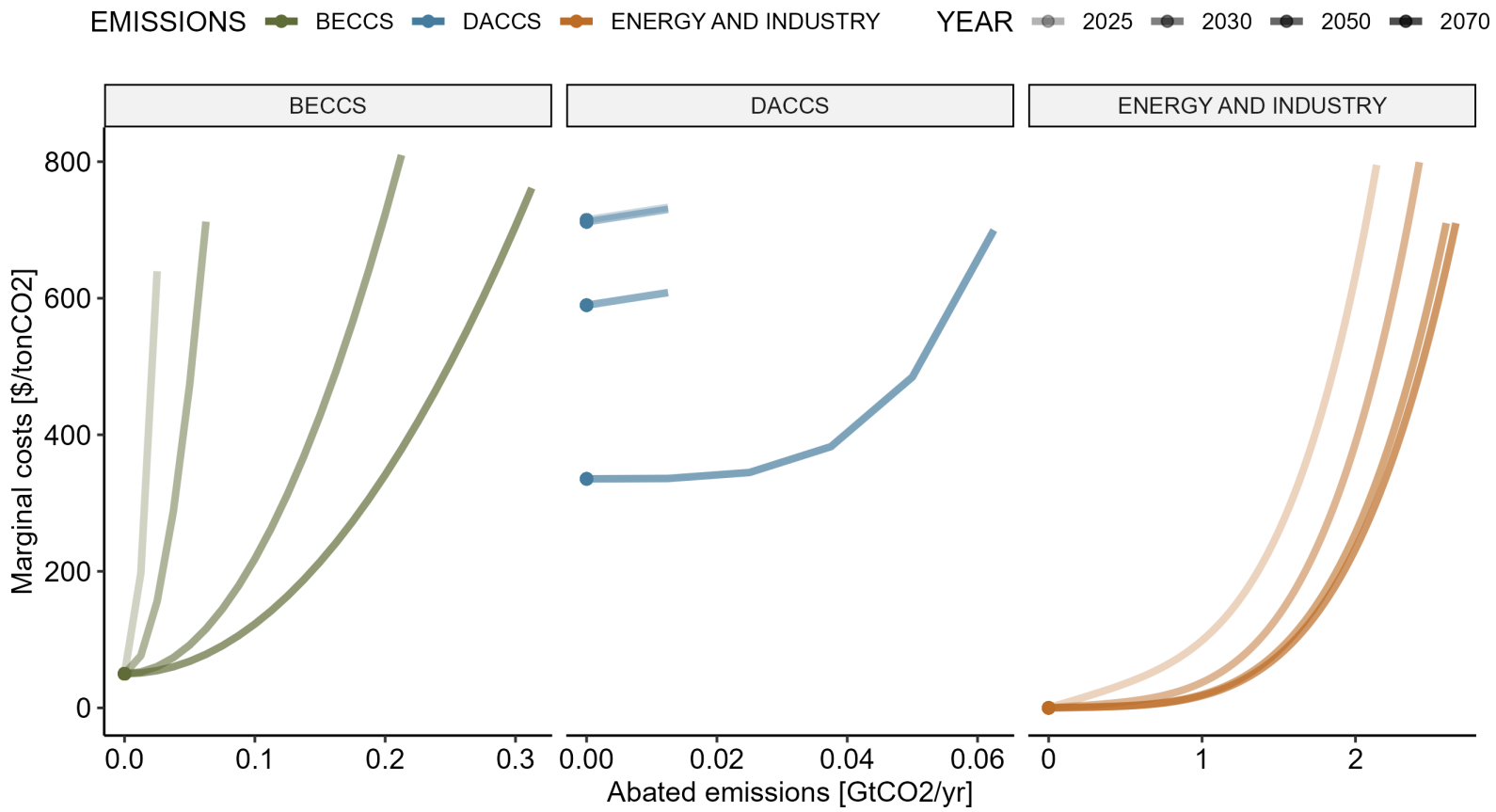
$$C(t,s) = \int_0^{E_{ar}} MC(t,s)$$

$$a_i(t,s) = \max\left(a_i(t_0,s) * \left(\frac{K_{rd}(t,s)}{K_{rd}(t_0,s)} \right)^{-\lambda_i(s)} , a_{i,min} \right)$$

$$K_{rd}(t,s) = \sum_{t^*=2020}^{t} \max(E_{ar}(t^*,s) - E_{ar}(t^*-1,s) * (1-\partial), 0)$$

Methods

- Convex, dynamic cost curves for emission reductions and CDR.



Methods

- A governement redistributes the residual revenues from the carbon market and tax revenues, net of CDR payments

PAYMENTS TO CDR SUBSIDIES

$$G(t) = \underbrace{P(t,e) * E_{res}(t)}_{\text{REVENUES FROM EMISSIONS}} + \underbrace{T(t)}_{\text{REVENUES FROM TAX VARIATION}} - P(t,r) * \sum_r E_{ar}(t,s) - \sum_s S(t,s) * E_{ar}(t,s)$$

$$P(t,m) = \min_{s\ if\ s \in m} \left(MC(t,s)\right)$$

$$S(t,s) = \max_{if\ s \in m} \left(MC(t,s) - P(t,m), 0\right)$$

Methods

- Decile-based microsimulation model, costs and revenues distributed to different households via elasticities as in Dennig et al. 2015, Andreoni et al. 2024.

$$Y(t,d) = Y_b(t) * q_b(t,d) - C(t,e) * w_{\xi_e}(t,e) - P(t,e) * E_{res}(t) * w_{\xi_e}(t,d) - T(t) * w_{\xi_t}(t,d) * MCPF_t + \sum_r \Pi(t,r) * w_{\xi_r}(t,d) + \mathrm{G}(t) * w_{\xi_g}(t,d)$$

$$w_\xi(t,d) = \frac{q_b(t,d)^\xi}{\sum_d q_b(t,d)^\xi}$$

- CDR PROFITS GO TO THE RICH ($\xi_r = 1.8$)
- INCOME TAX IS PROGRESSIVE ($\xi_t = 1.4$) AND DISTORTIVE ($MCPF_t > 1$)
- CARBON TAX ON EMISSIONS IS REGRESSIVE ($\xi_e = 0.8$)
- GOVERNMENT REDISTRIBUTION NEUTRAL OR EPC ($\xi_g = 0{,}1$)

Methods

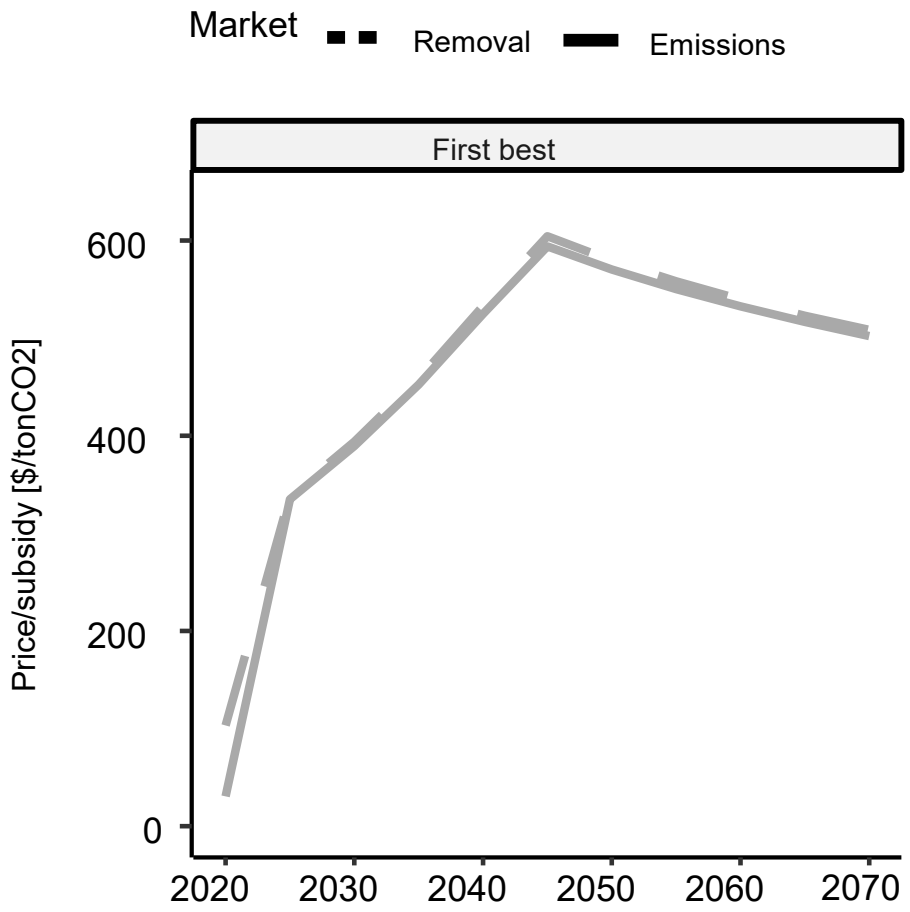
- Climate and fiscal policy thus affect the income distribution and the aggregate output. An inequality averse impact function captures the resulting equity-efficiency trade-off

$$Y_b(t) - Y(t) = \sum_s C(t,s) + T(t) * (MCPF_t - 1)$$

$$W = \sum_t \frac{1}{\delta^{t-t_0}} * \frac{\left(\sum_d \left(\frac{Y(t,d)}{pop(t,d)}\right)^{1-\varrho}\right)^{\frac{1-\eta}{1-\varrho}}}{1-\eta}$$

Results

- Numerical simulation with model calibrated on the European Union.
- Three policy settings:
  - **First best**, «unlimited» non distortive and progressive taxation. Textbook solution with uniform price for abatement and removal.

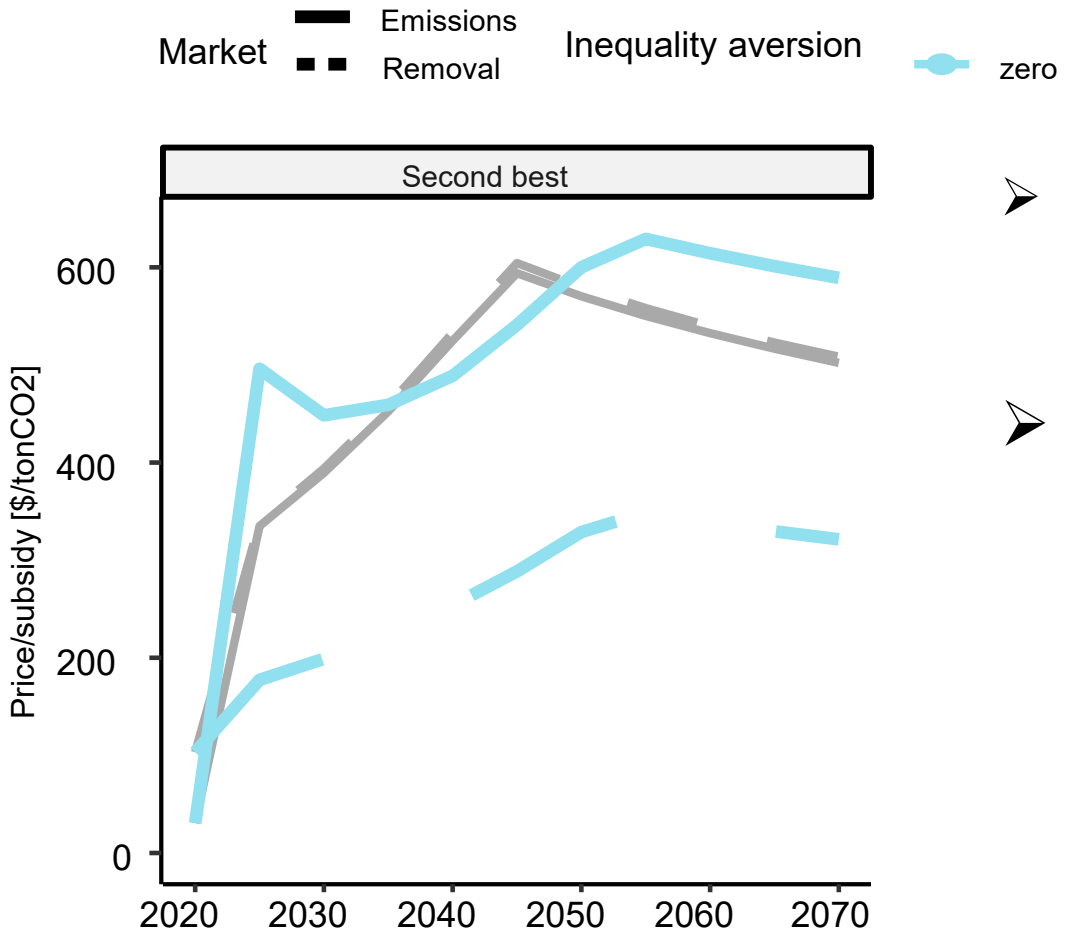


Results, second best

- Numerical simulation with model calibrated on the European Union
- Three policy settings:
  - First best, non distortive and progressive taxation. Single market.

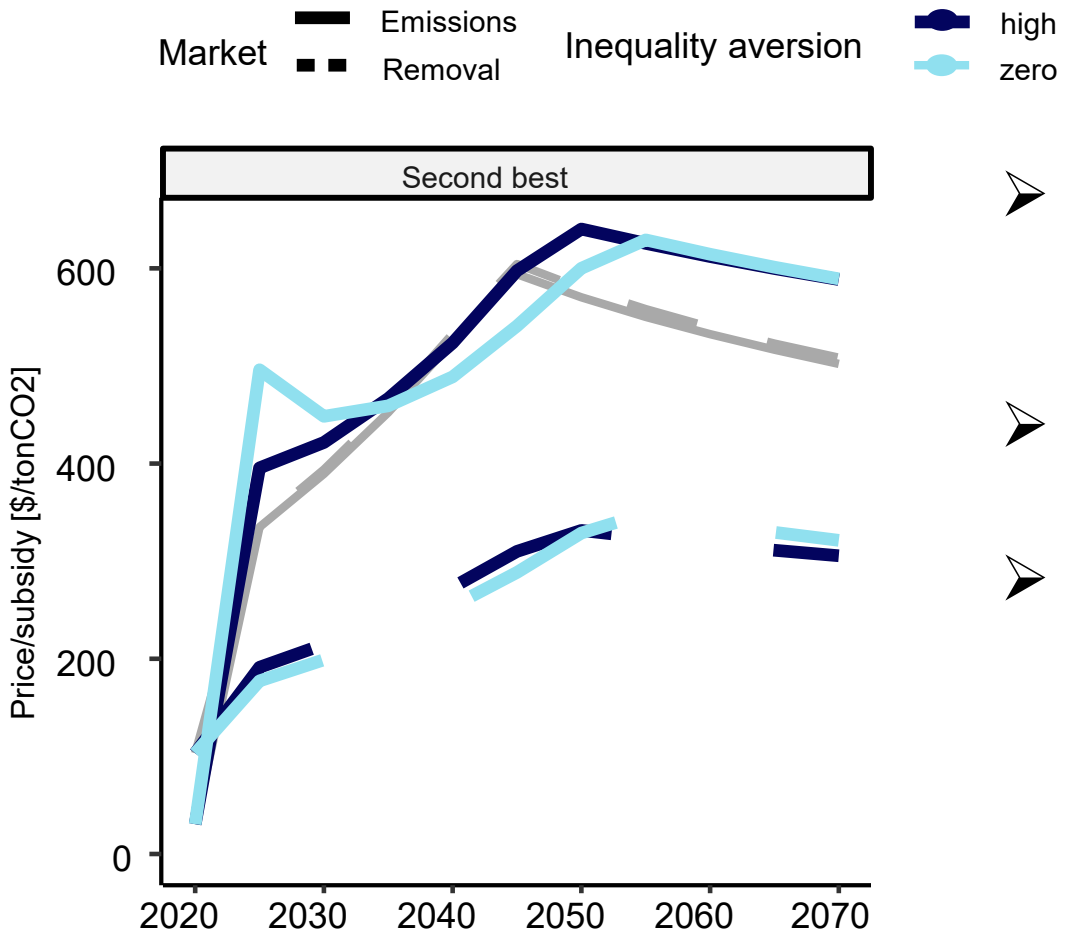
  - **Second best**, progressive but distortive taxation reform is available to the social planner. Double dividend hypothesis applies.

Results, second best



- «double dividend» opportunity arises to lower distortive taxes with carbon tax revenues.
- Price of CDR market is optimally halved.

Results, second best

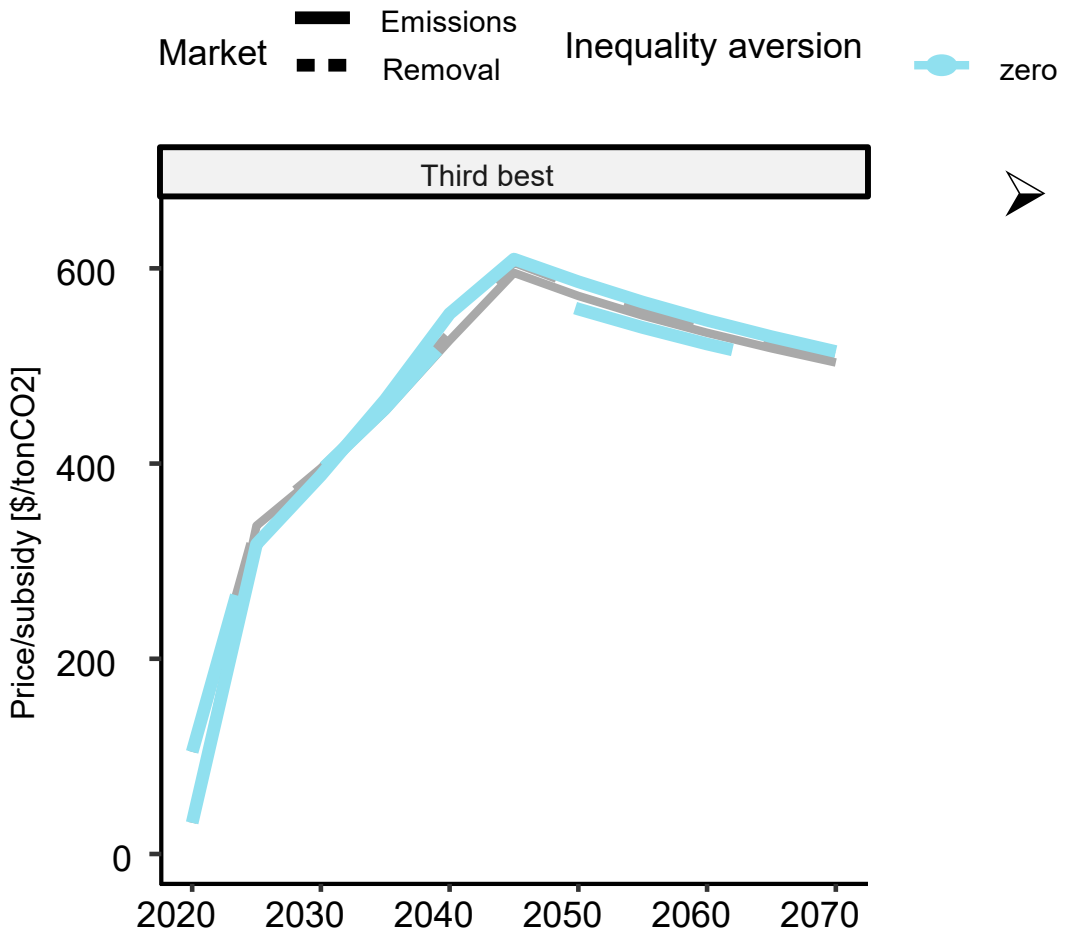


- «double dividend» opportunity arises to lower distortive taxes with carbon tax revenues.
- Price of CDR market is optimally halved.
- This dynamic is driven from cost-efficiency and largely indipendent from inequality aversion.

Results, third best

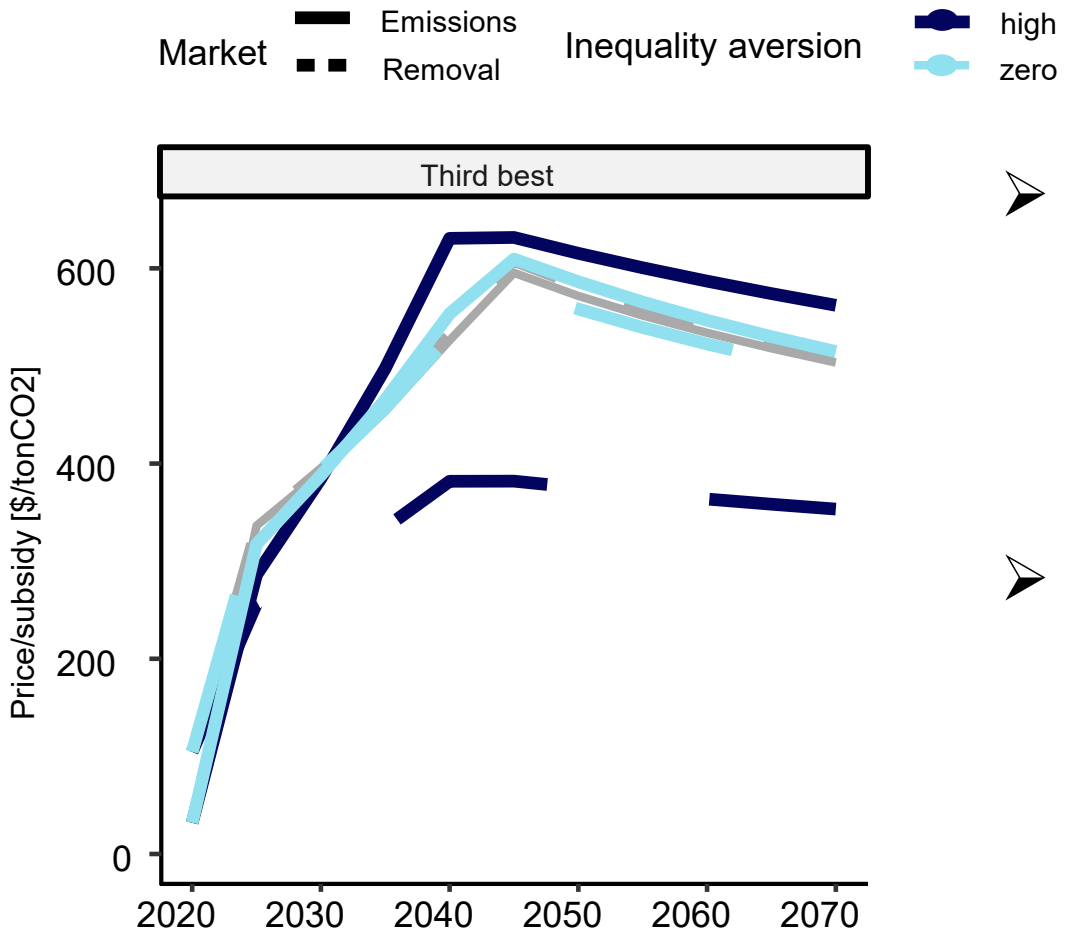
- Numerical simulation with model calibrated on the European Union.
- Three policy settings:
  - First best, non distortive and progressive taxation. Single market.
  - Second best, distortive taxation. Double dividend.
  - **Third best**, no fiscal policy available (e.g. climate and fiscal policy are not designed by the same authority). Same fiscal setting as Andreoni et al. 2024

Results, third best



- With no inequality aversion, the inequality increase due to financing CDR is not relevant to the social planner. Cost-efficient solution is mantained.

Results, third best



- With no inequality aversion, the inequality increase due to financing CDR is not relevant to the social planner. Cost-efficient solution is mantained.
- If the planner is inequality averse, price of CDR is reduced to reduce rents to CDR and inequality.

Conclusions

- Significant rents in a net-zero cabron market are a possibility
- Rents might justify market separation to control CDR prices by up to 50%.
- Rents are higher the lower the availability of CDR.
- More research is needed to study the «shape» of the cost curves for removal.

Thank you!

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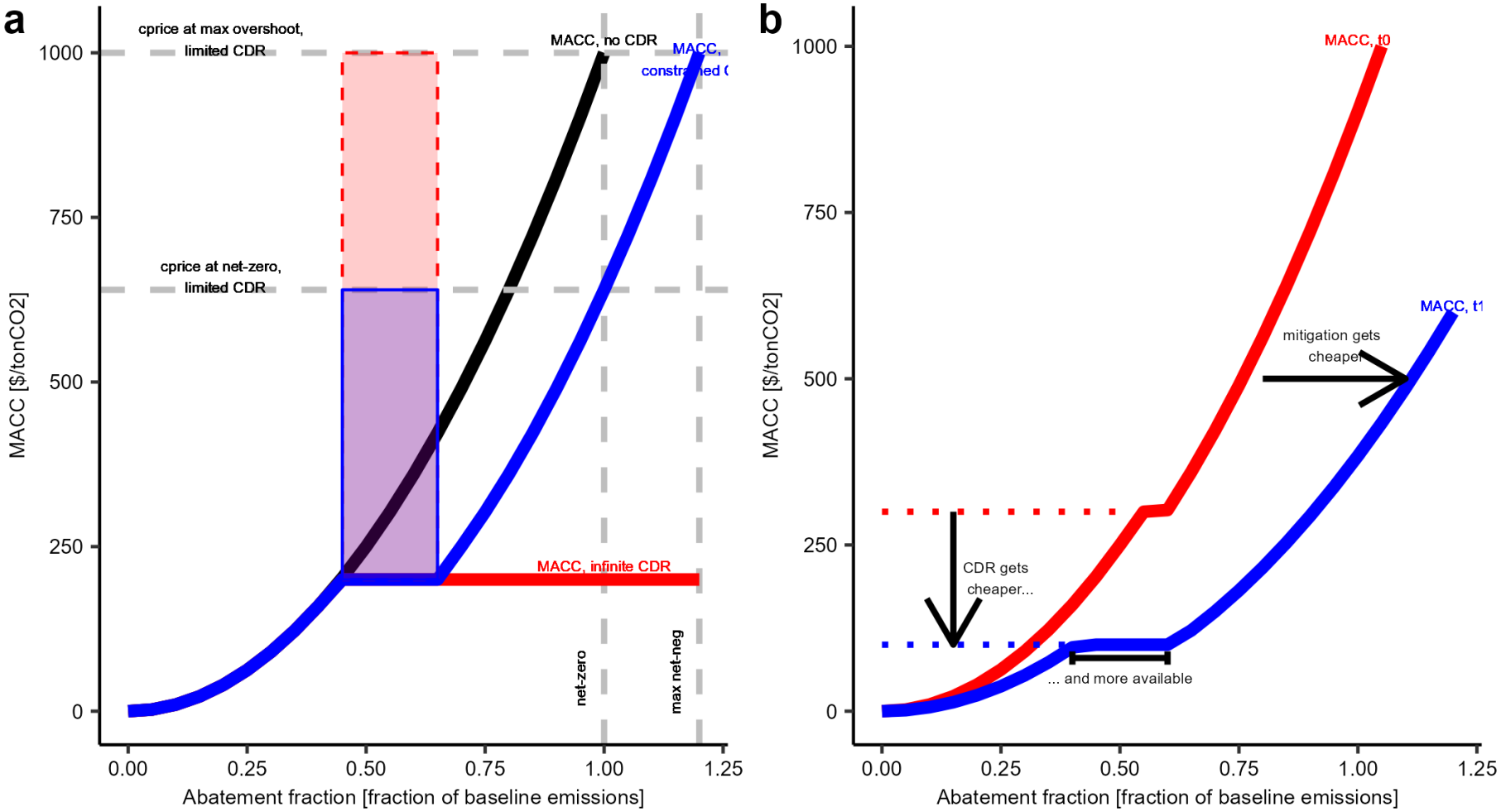
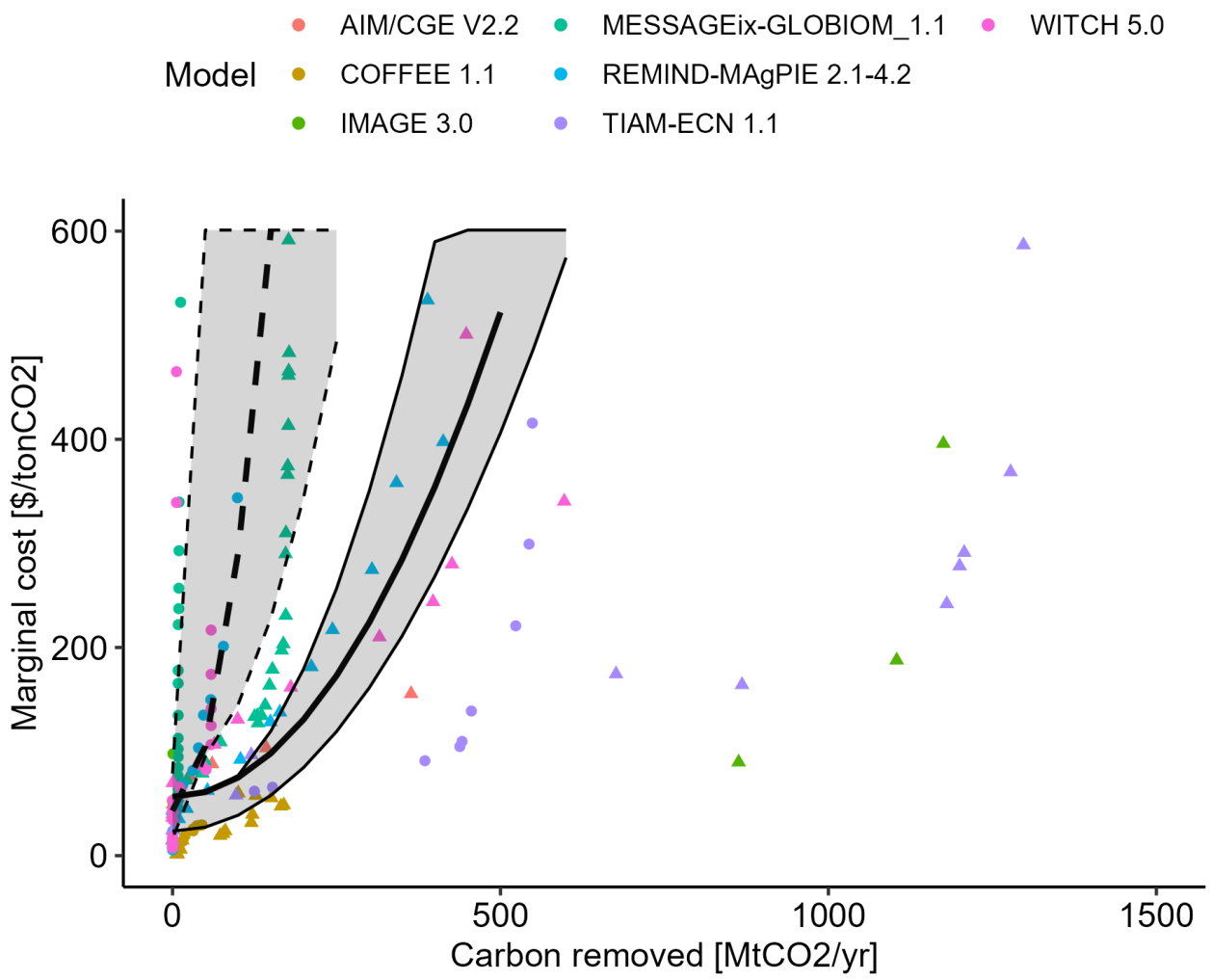
Chapter I: macc curves



Chapter II: methods and scenarios



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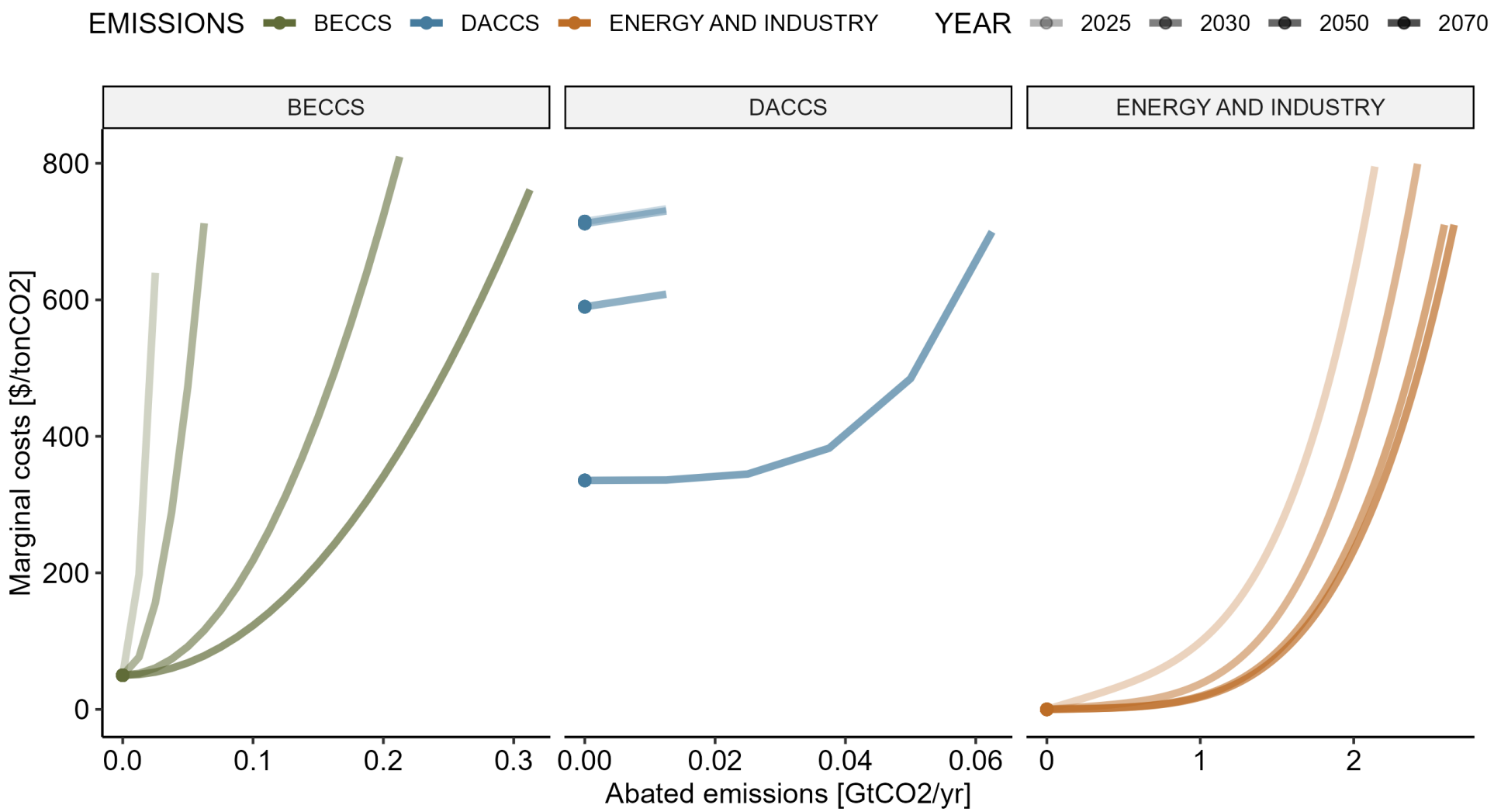

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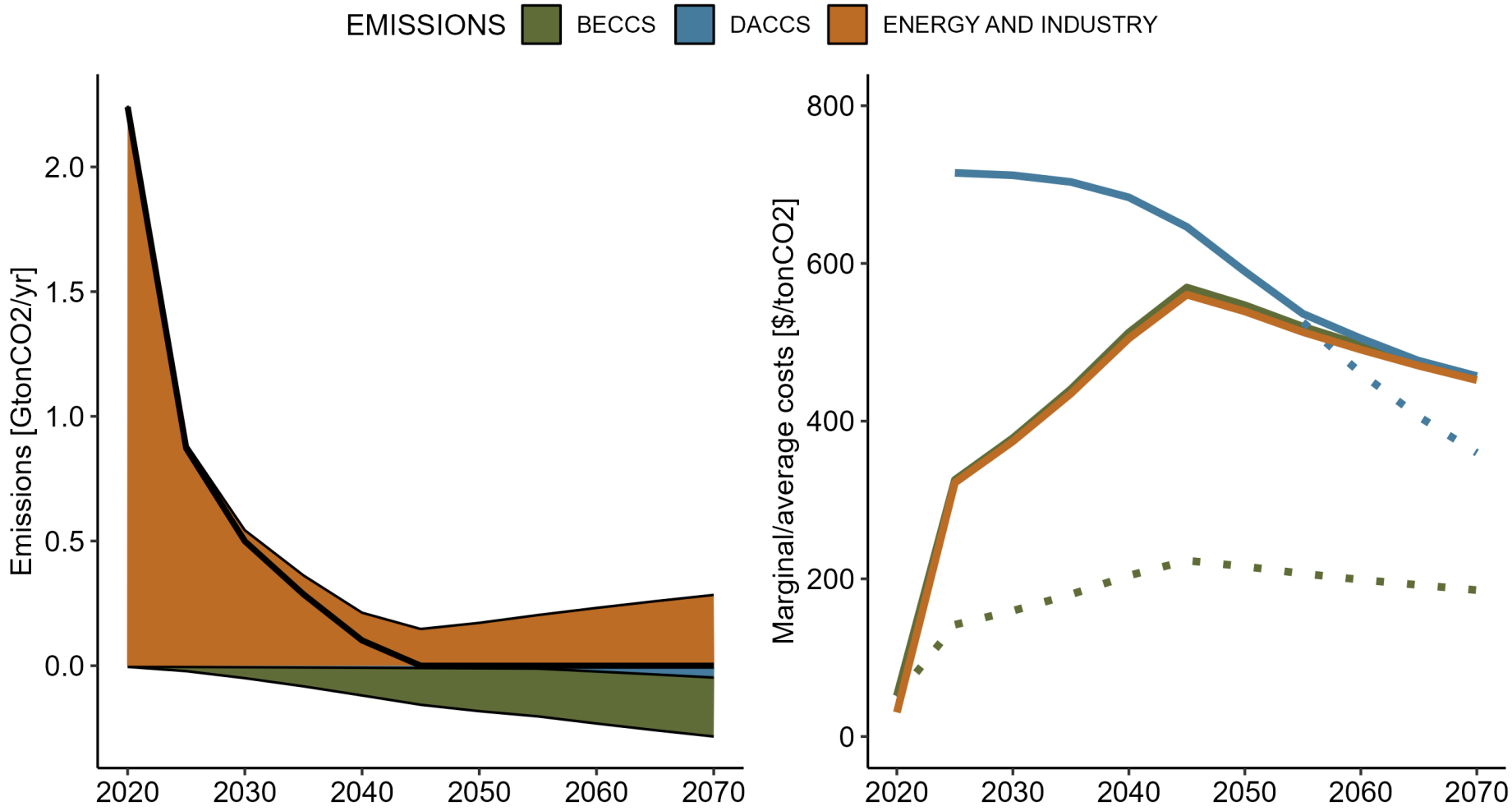
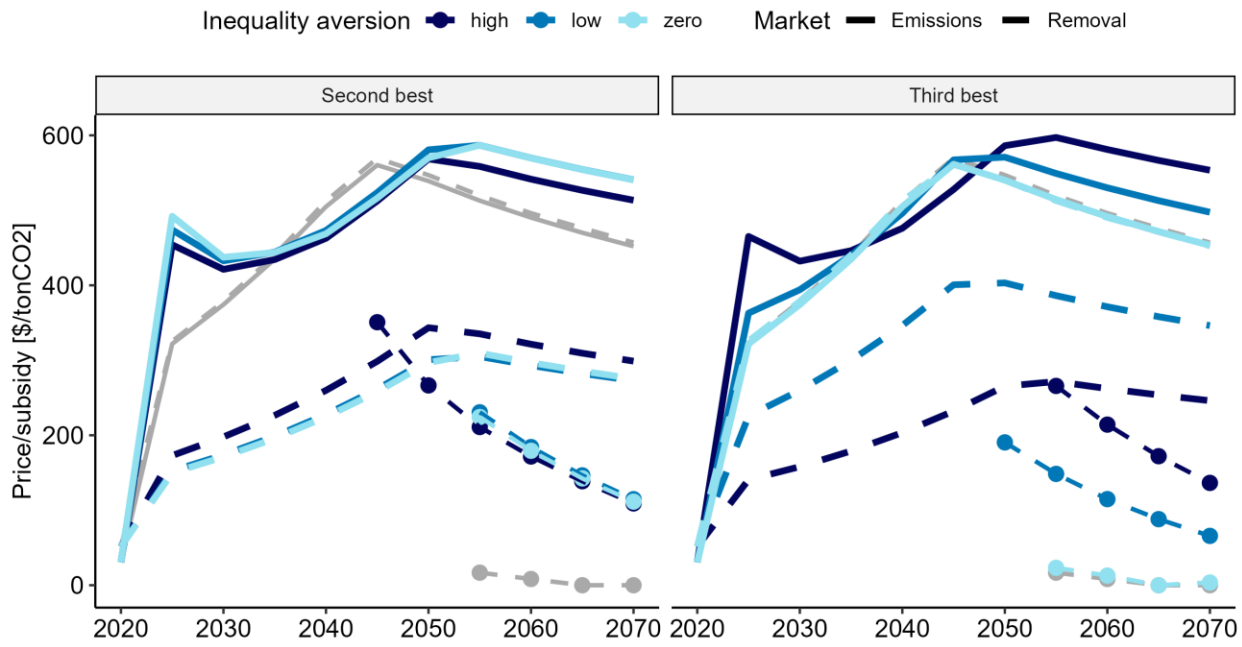
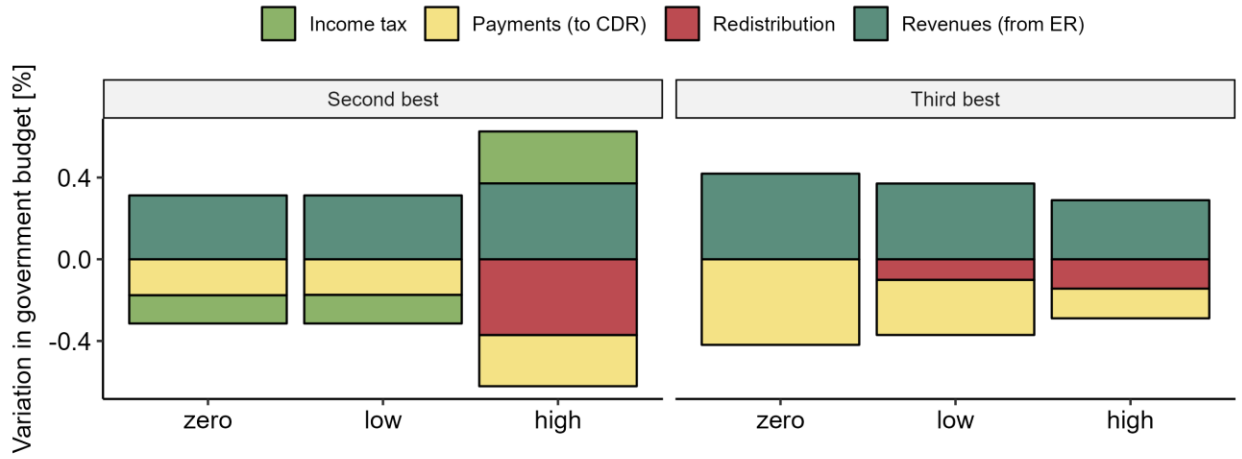
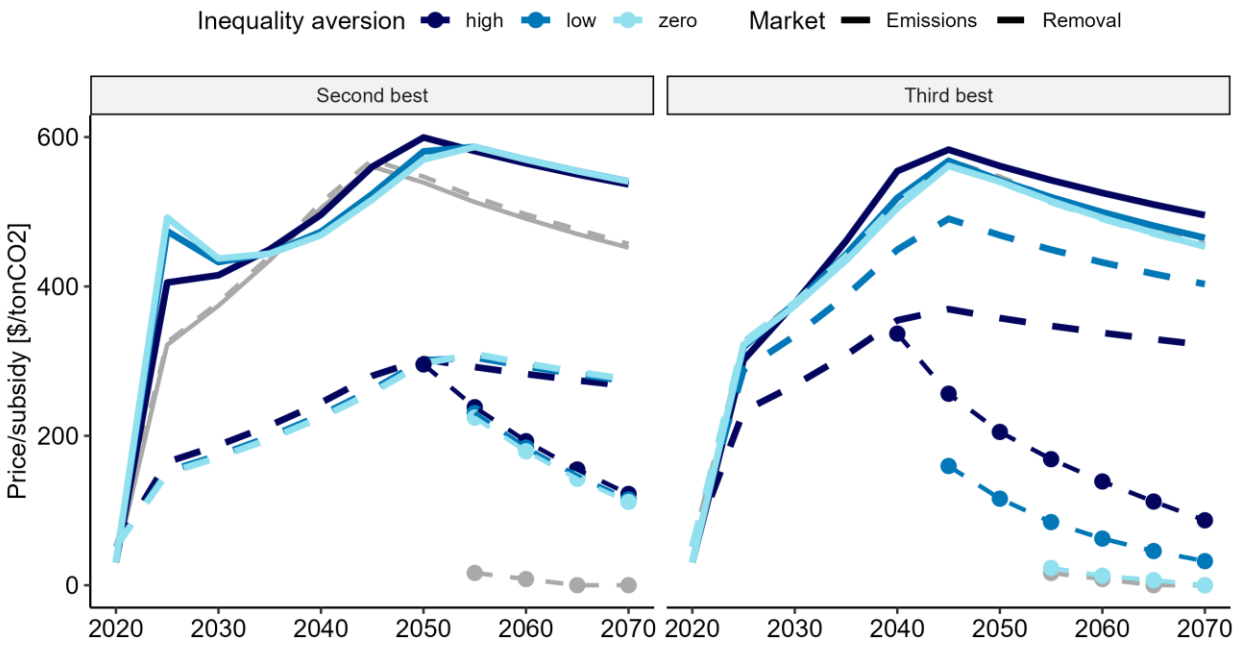
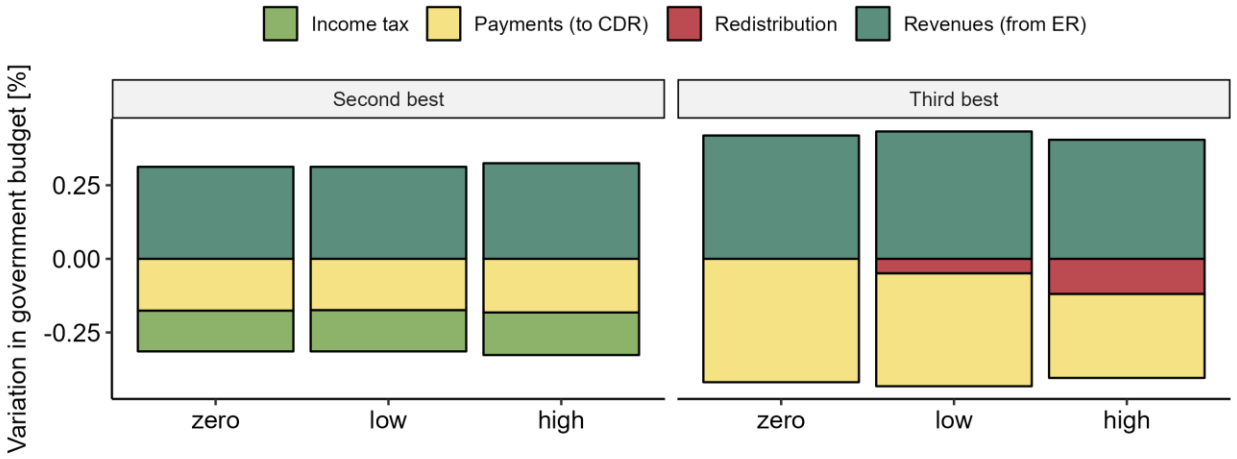


Chapter II: results









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