Optimal Unilateral Carbon Policy

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- This paper: What's the best that a smaller coalition can do on its own?

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- Key effect known as *leakage*
  - increased emissions in a low-tax jurisdictions as carbon-intensive activities relocate
- Leakage potentially undermines the effectiveness of carbon policies

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- Huge literature estimating effects of border adjustments, mostly CGE models

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- Show that trade can *strengthen* the coalition's carbon policy by extending its reach

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- No border adjustment for exports of goods
- Instead, subsidize marginal exporters, per unit exported
  - expands the set of goods that the taxing region exports; expands carbon policy through trade

Outline

1. Model structure

2. Planner's problem

3. Optimal unilateral policy

4. Quantitative illustration

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- **Trade:** energy and services costlessly traded; goods traded subject to iceberg costs

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- Stylized analysis, but mimics some features of a big CGE model

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3. Released into the atmosphere through combustion by goods producer, or utilities generating electricity for them
4. Carbon is embodied in these goods, which are traded prior to being consumed
5. Carbon can be tracked all the way from its extraction to where the goods embodying the carbon are consumed

Carbon in the World

- Gigatonnes of CO_2 in 2015 (IEA and OECD $TECO_2$) with Home as the OECD

	Home	Foreign	Total
Home	$C_e^{HH} = 11.3$	$C_e^{HF} = 2.5$	$C_e = 13.8$
Foreign	$C_e^{FH} = 0.9$	$C_e^{FF} = 17.6$	$C_e^{\star} = 18.5$
Total	$G_e = 12.2$	$G_e^{\star} = 20.1$	$C_e^{W} = 32.3$
Extraction	$Q_e = 8.6$	$Q_e^{\star} = 23.7$	$Q_e^{W} = 32.3$

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- Home's welfare: quasi-linear to eliminate income effects

$$U = C_s + \eta^{1/\sigma} \frac{C_g^{(\sigma-1)/\sigma}}{(\sigma - 1)/\sigma} - \varphi(Q_e + Q_e^*)$$

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- Same form for Foreign preferences, but may have different parameters
  - for now assuming $\sigma^* \leq 1$

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- Normalize a unit of energy to be a unit of CO2 emissions

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- Cobb-Douglas production

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- Iceberg trade costs τ, τ^*

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- When we consider a decentralized equilibrium services are numeraire
    - leading to a common wage = 1

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- Recall the flow matrix

$$\begin{array}{cc|c} C_e^{HH} & C_e^{HF} & C_e \\ C_e^{FH} & C_e^{FF} & C_e^* \\ \hline G_e & G_e^* & C_e^W \end{array}$$

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Home’s Planning Problem

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- The planner seeks to maximize welfare in Home, by choosing

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- **Services:** quantity of services provided and consumed
- **Goods:**
  - quantity of goods produced in Home, for domestic consumption and for export
  - quantity of goods consumed in Home and imported
  - energy intensity of production for each of those three

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- Energy supply and demand elasticities in Foreign

$$\epsilon_S^* = \frac{dE^*(p_e)}{dp_e}\frac{p_e}{E^*} \qquad \epsilon_D^* = \alpha + (1-\alpha)\sigma^*$$

Constraints

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- Labor in Home

$$Q_s = L - \int_0^{E^{-1}(Q_e)} a dE(a) - \int_0^1 \left(l_j(z_j^y) y_j + \tau l_j(z_j^x) x_j \right) dj$$

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- Energy in Foreign

$$\int_0^1 e_j^*(z_j^*) y_j^* dj + \tau^* \int_0^1 e_j^*(z_j^m) m_j dj \leq Q_e^* + X_e$$

Solution Strategy

- Use labor and trade balance constraint to substitute out Home's provision and consumption of services
- Apply Lagrange multipliers λ_e, λ_e^* to the two energy constraints
- Solve by exploiting CDVW's idea
  - inner problem, for a particular good j
  - outer problem, for aggregates

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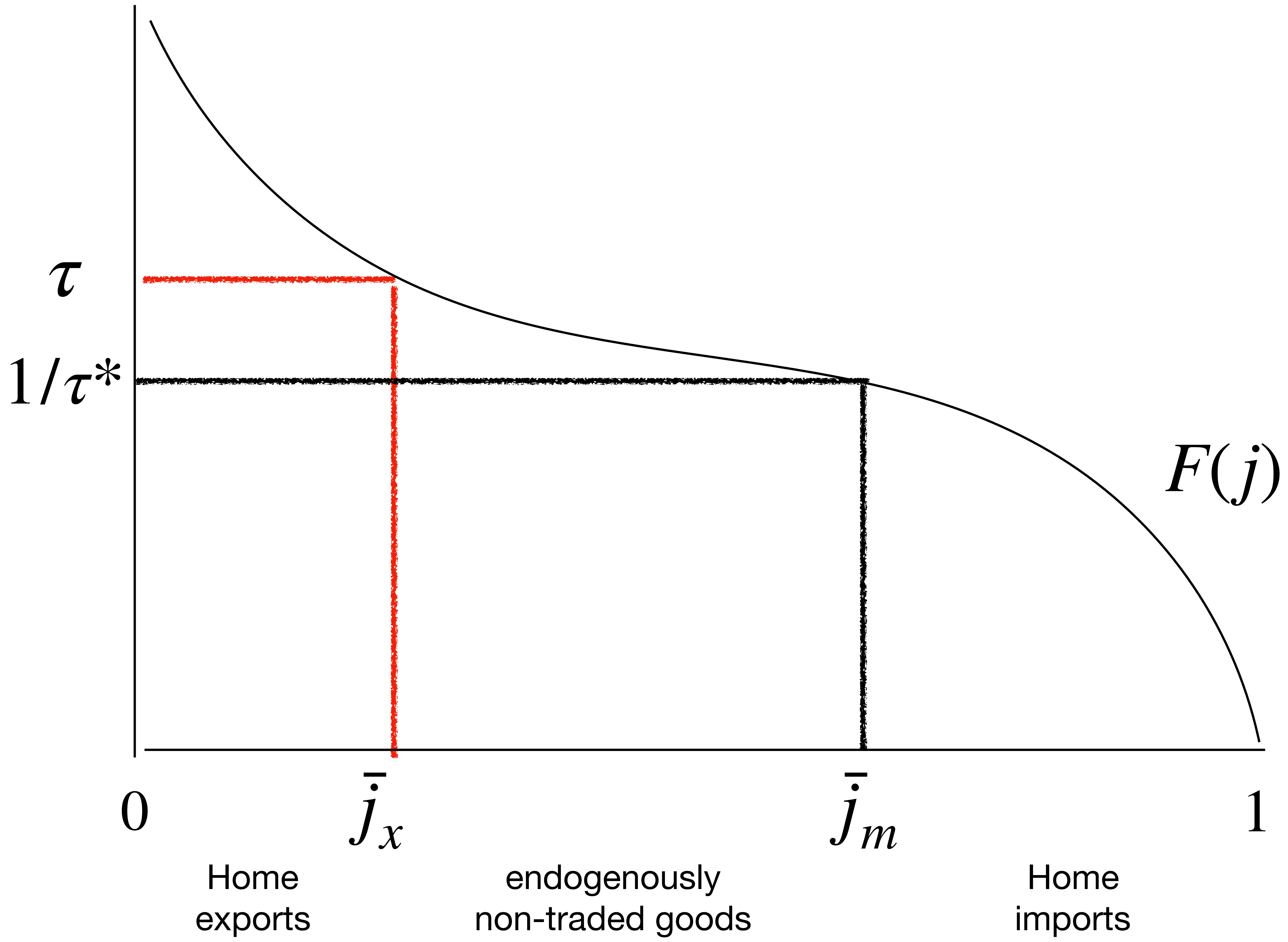
- Home expands its export margin
    - effectively expands its control of energy use in production
    - can even lead to cross-hauling if iceberg costs are low

Extensive Margin of Trade: No Policy



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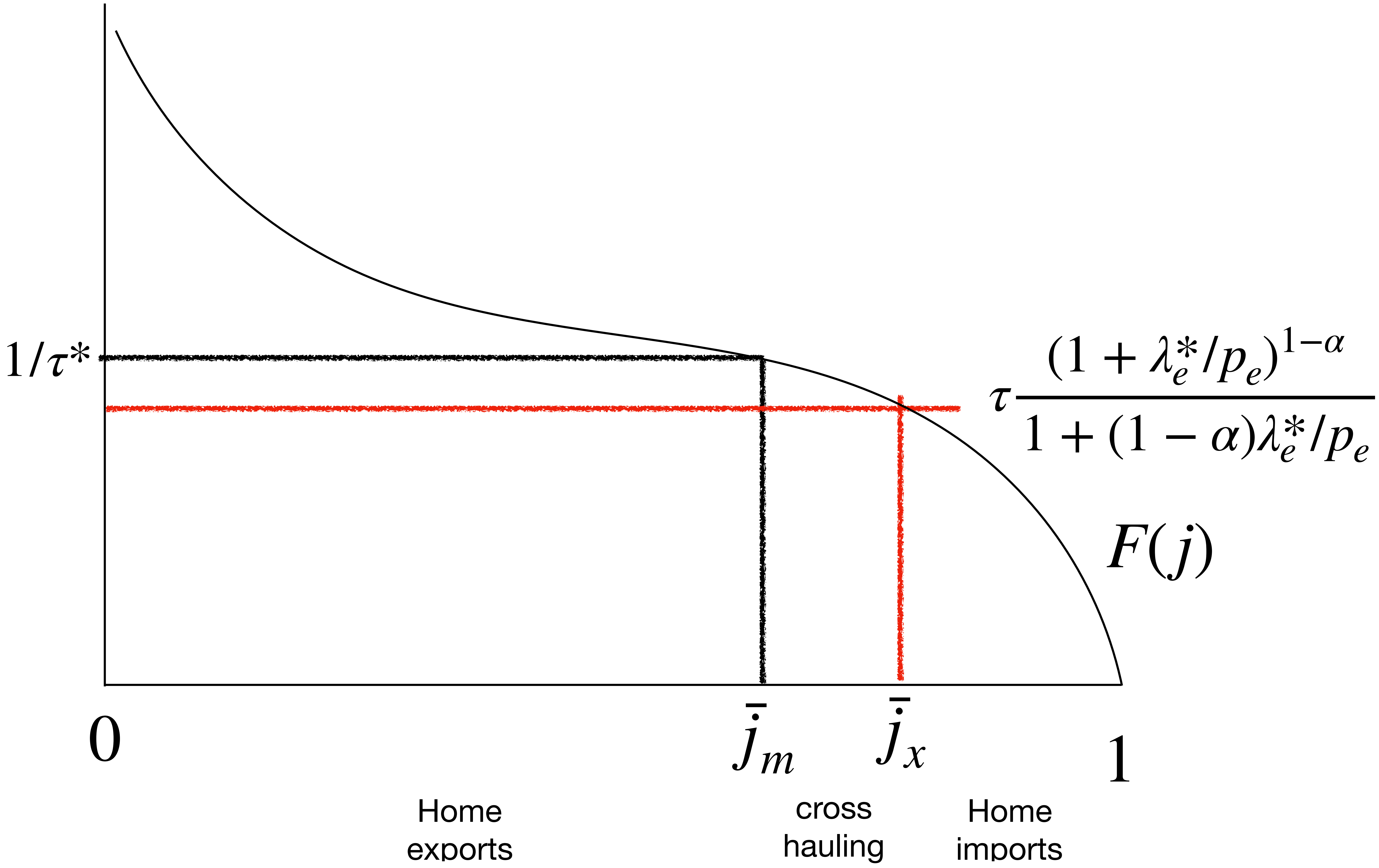

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- **Export policy:**

    - expand export margin through subsidies (not the same as removing the tax on exporters)

    - exert market power by taxing exporters with strong comparative advantage

    - net cost of policy is Π_g

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- **CDVW reasoning:** tax the better exporters to exploit market power
  - but don't mess with the import margin
- **New reasoning:** subsidy applies to goods Home wouldn't export with no policy

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Calibration Strategy

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- Impose functional forms for extraction and comparative advantage
    - constant supply elasticities, ϵ_S, ϵ_S^* and constant trade elasticity θ

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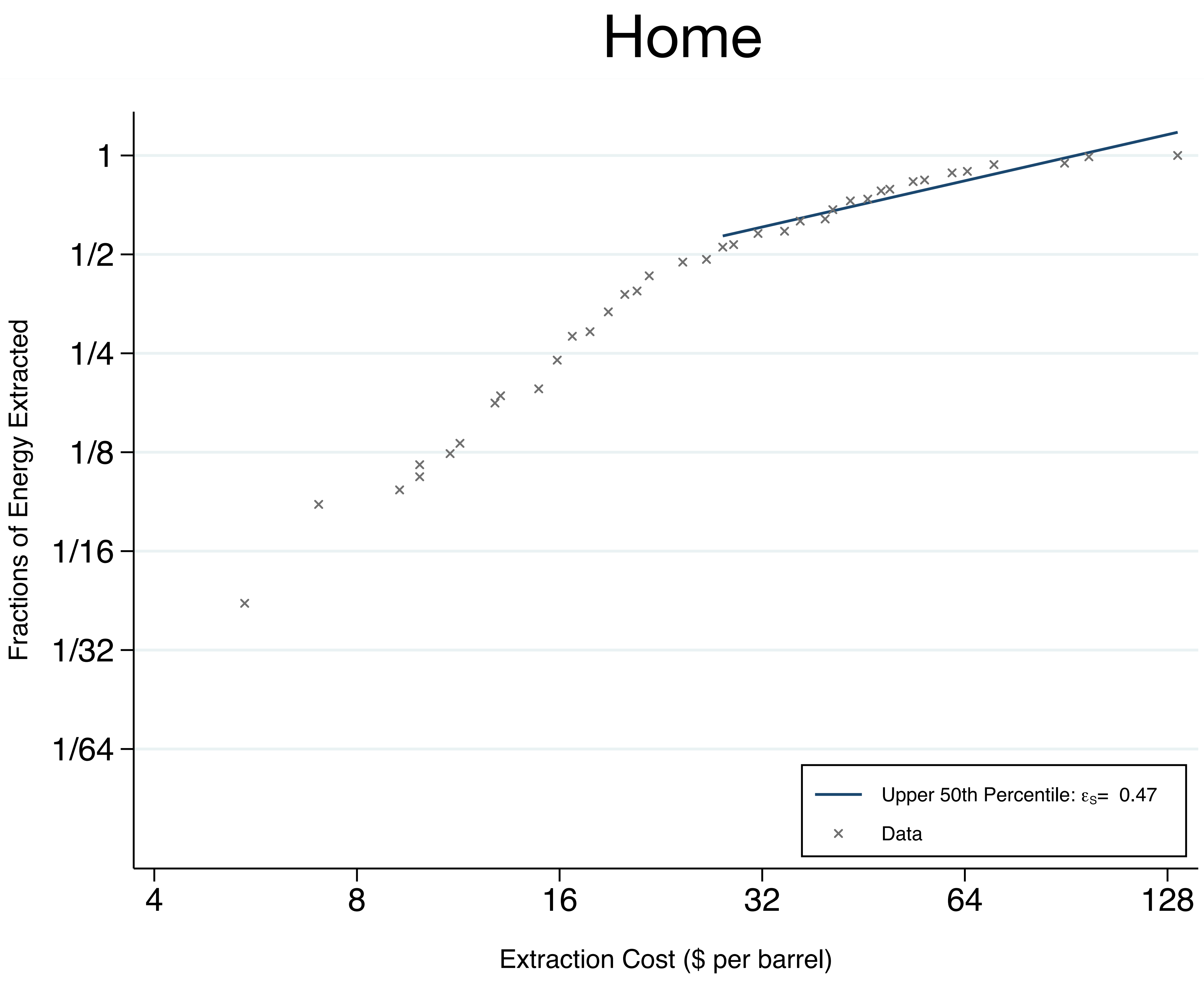
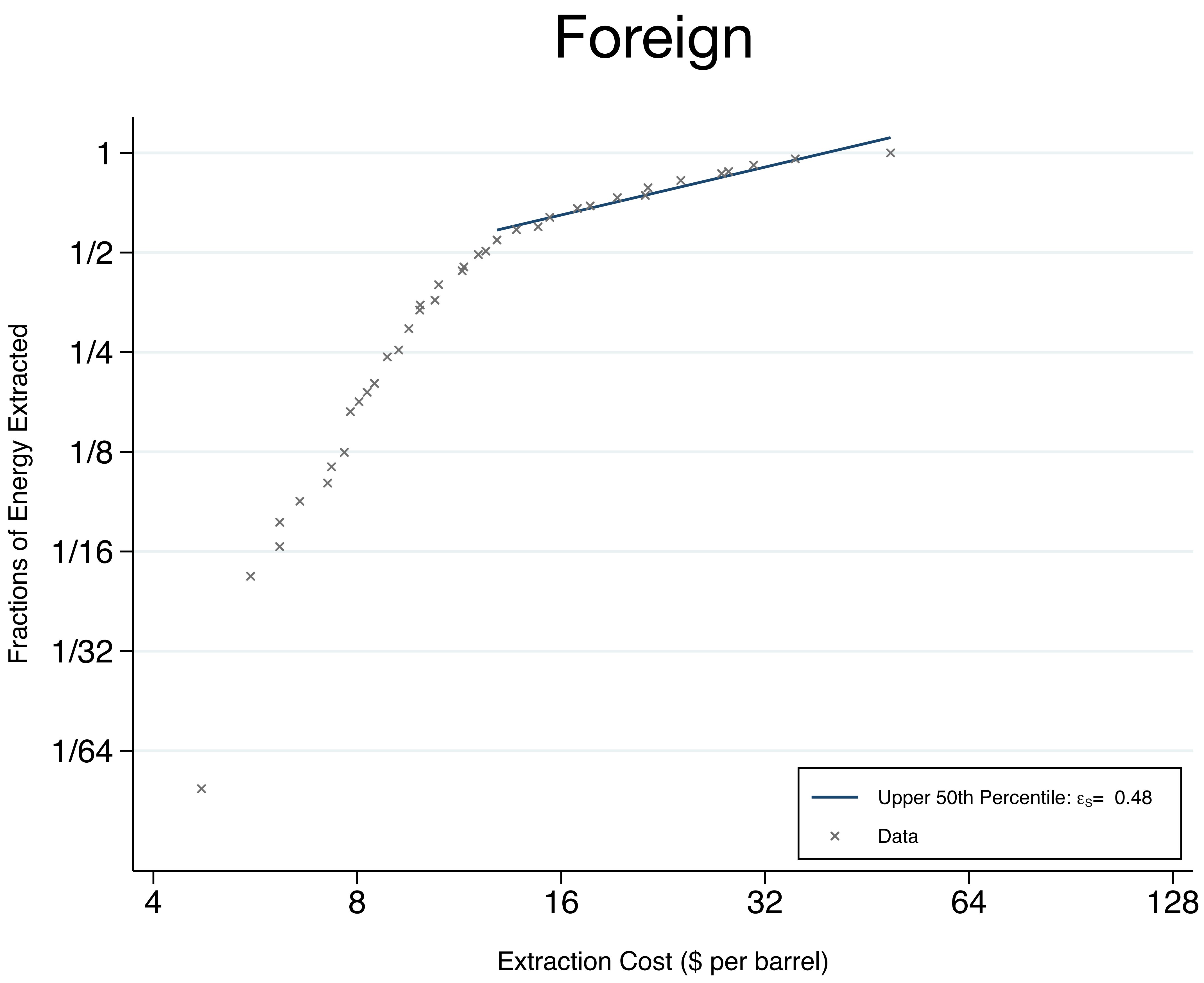
- Compute outcomes for a range of marginal damages, $\varphi \in [0,2]$
  - i.e. consider Home's marginal damages of up to twice the BAU energy price

Calibration of Energy Supply Elasticity





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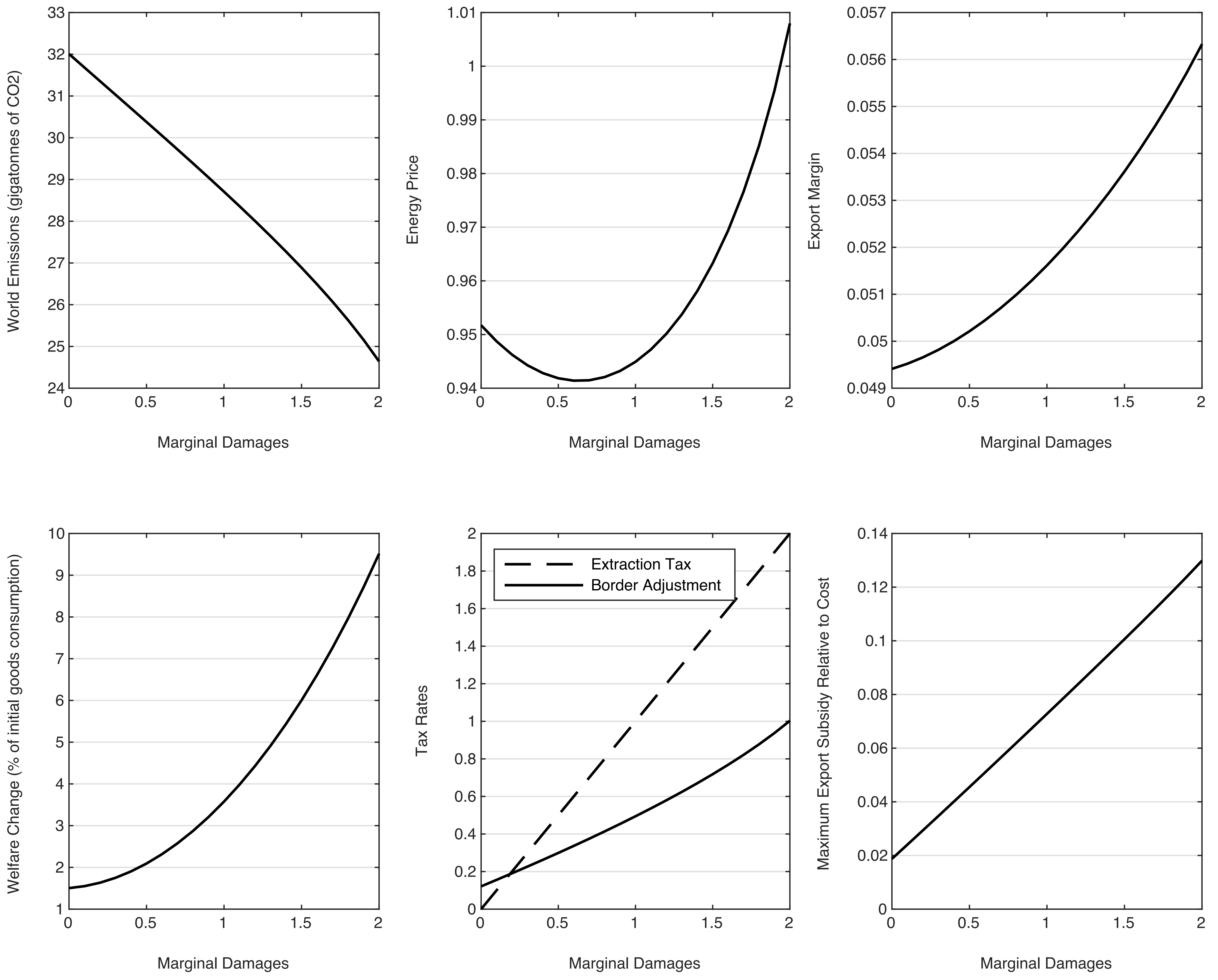
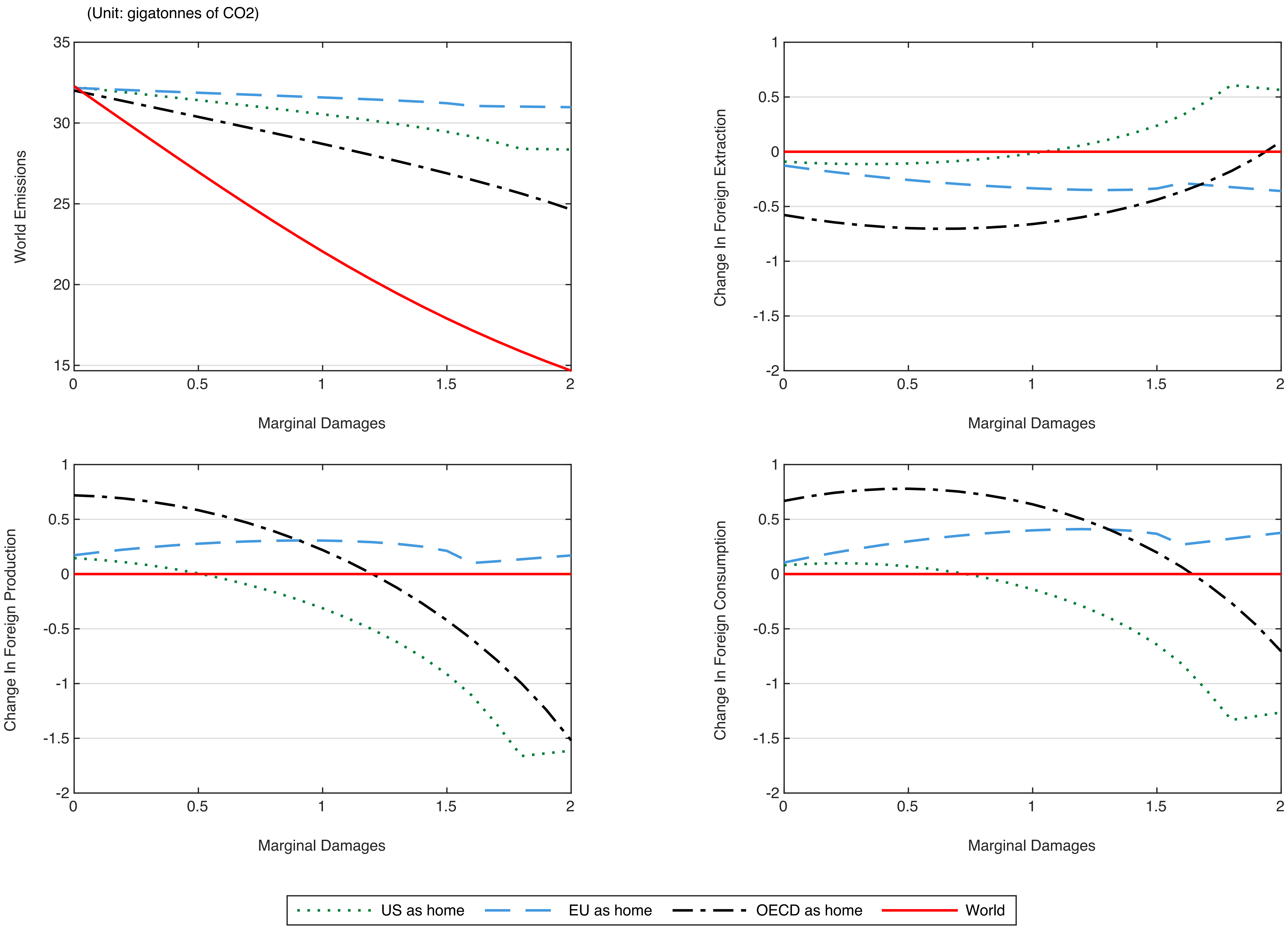
Optimal Policy for the OECD



Different Taxing Coalitions



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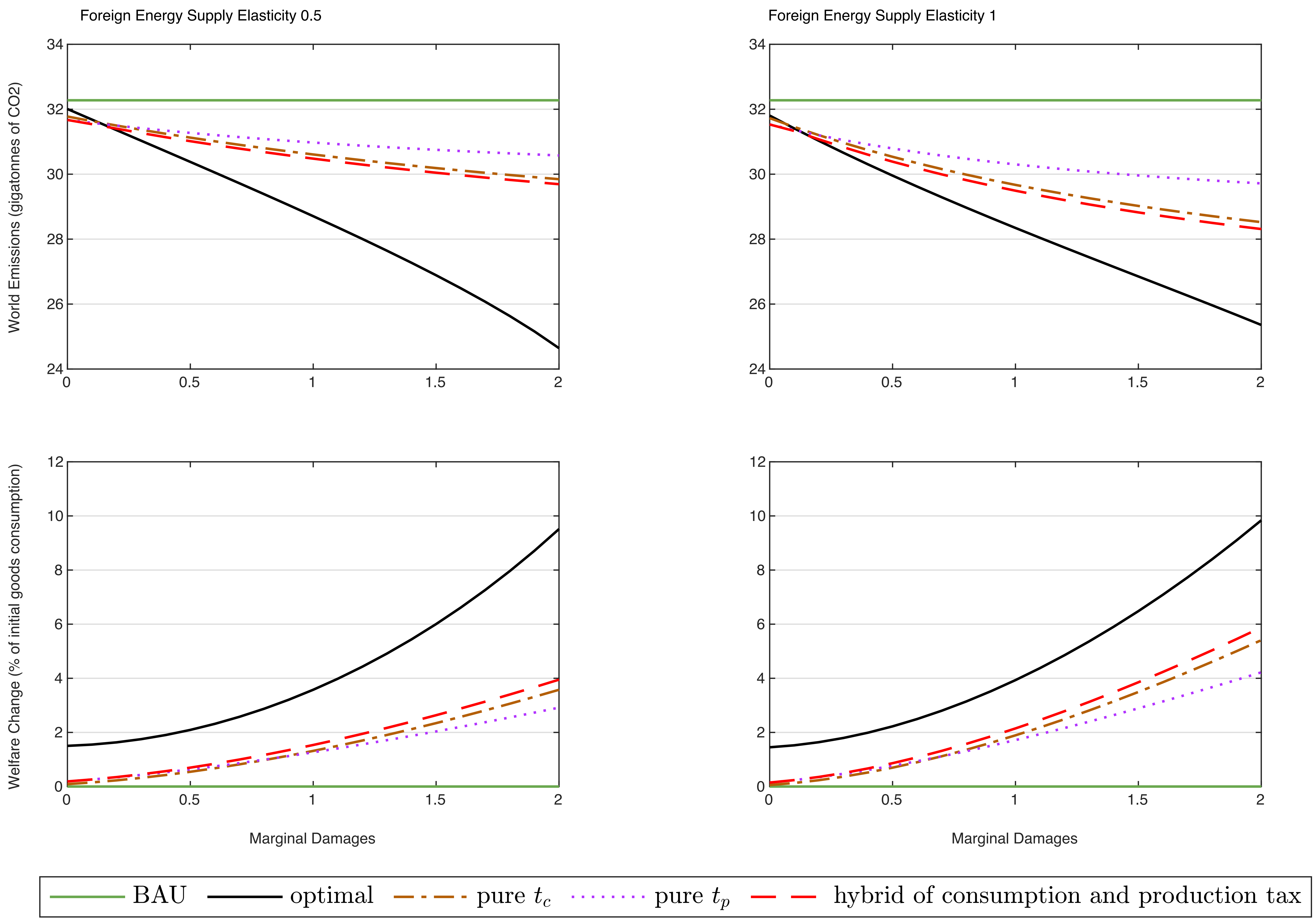
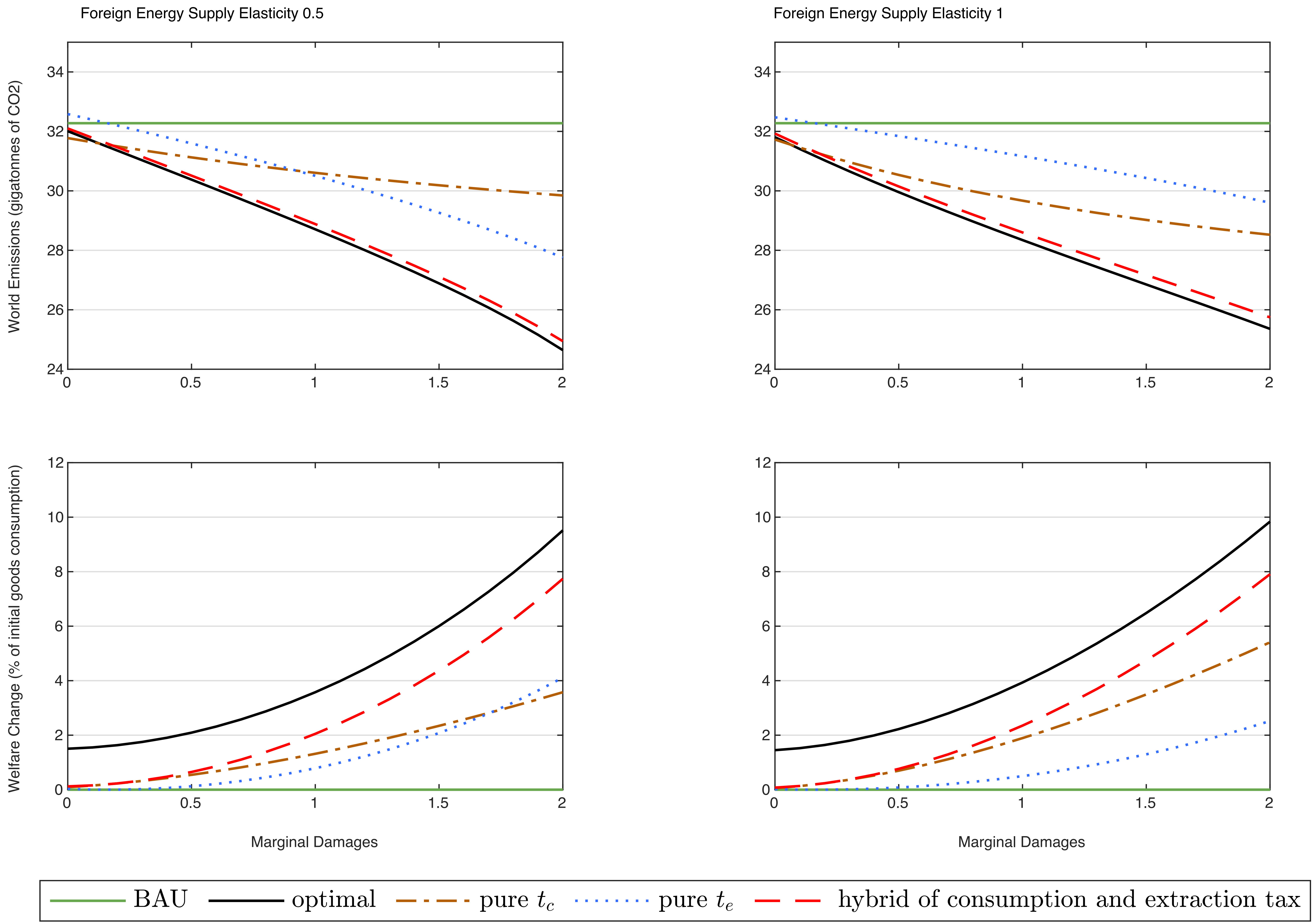
- We can also solve numerically for an optimal pure production tax as well as an optimal hybrid of consumption and production tax

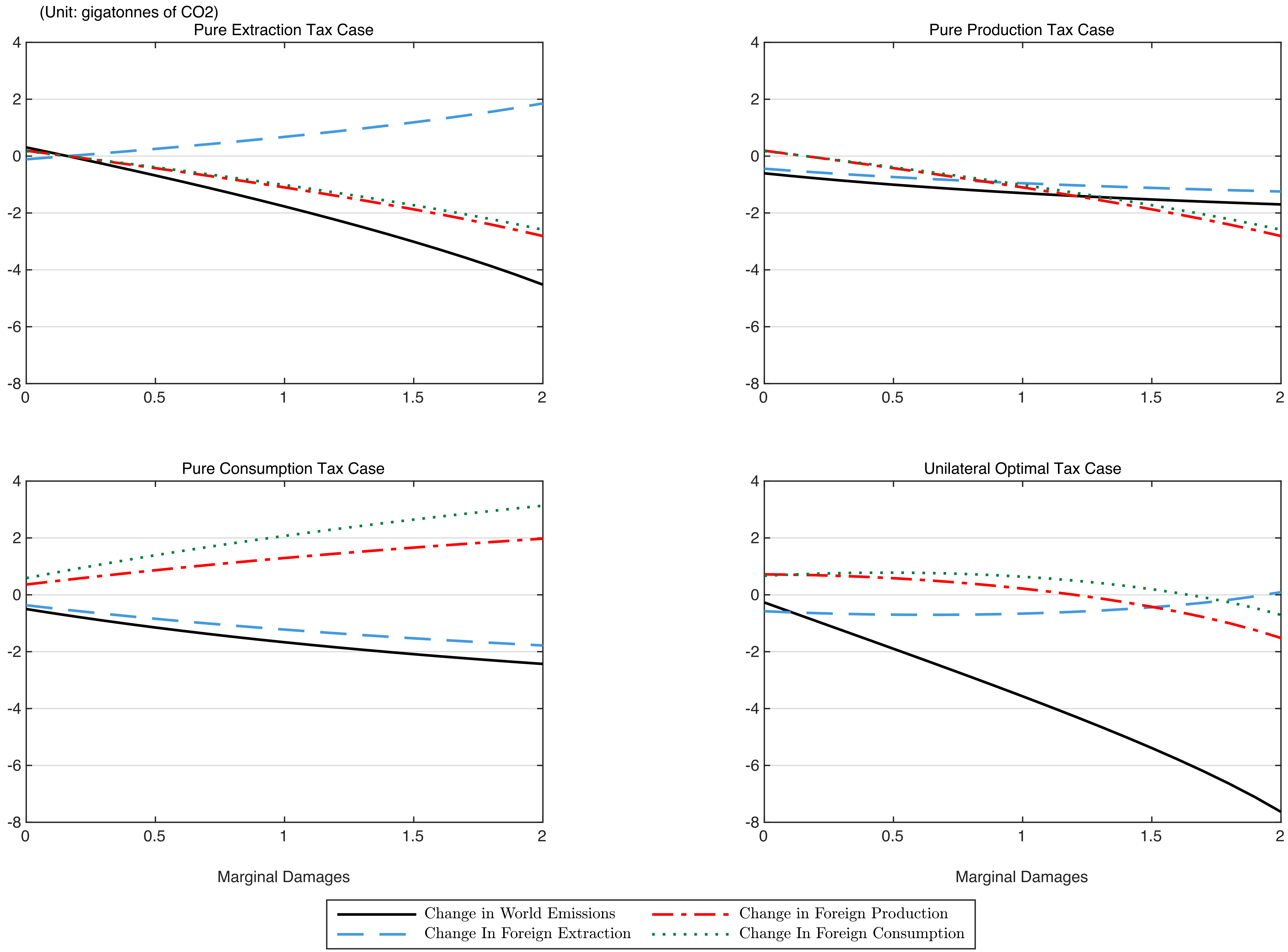
Production and Consumption Taxes



Extraction and Consumption Taxes



Leakage with Different Taxes



Conclusions

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- Readily accommodates extensions, such as renewable energy
- Directions to explore
  - many countries as in EK (2002) or recently Farid and Lashkaripour (2020)
  - dynamics as in Golosov, Hassler, Krusell, and Tsyvinsky (2014)