The Economic Geography of Global Warming

José-Luis Cruz (Princeton University)

Esteban Rossi-Hansberg (Princeton University)

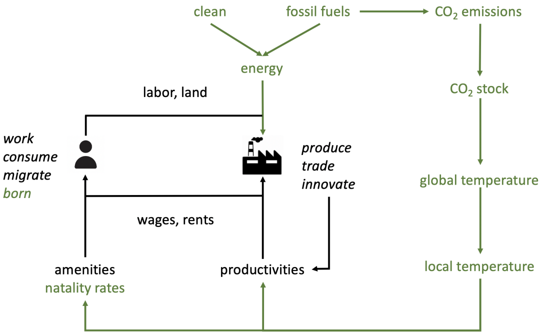
April 2021

An Economic Assessment Model

- Global warming is a **protracted**, **global**, phenomenon with **heterogeneous local effects**
- Standard climate models use loss functions relating aggregate economic outcomes to climate variables
  - Fail to incorporate behavioral responses, and therefore economic adaptation
  - Ignore the vast spatial heterogeneity in climate damages
- We propose and quantify a spatial and dynamic assessment model
  - Emphasizing the role of **economic adaptation through migration, trade, and innovation**

Model Characteristics

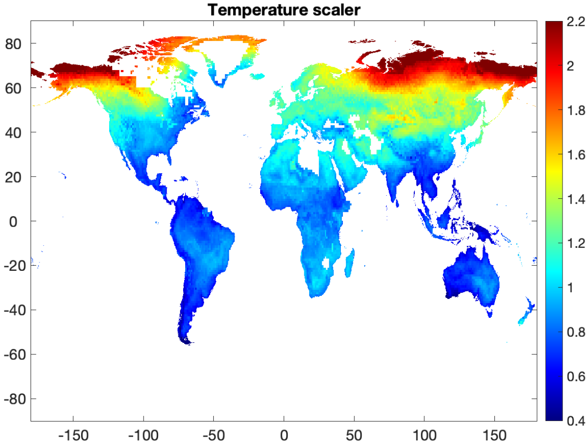
- We extend the spatial growth model in Desmet et al. (2018)
  - Add natality, energy, carbon cycle, and local temperature effect on amenities and productivities



  - Quantify using $1^\circ \times 1^\circ$ G-Econ data on population and income in 2000
  - Set trade and mobility frictions to match gravity and net migration flows
  - Natality depends on income and temperature

Local Temperature Down-scaling

- We let $T_{t+1}(r) = T_t(r) + g(r) \cdot (T_{t+1} - T_t)$
  - where $g(\cdot)$ is a function of latitude, longitude, elevation, distance to coast, distance to ocean, distance to water, vegetation density and albedo

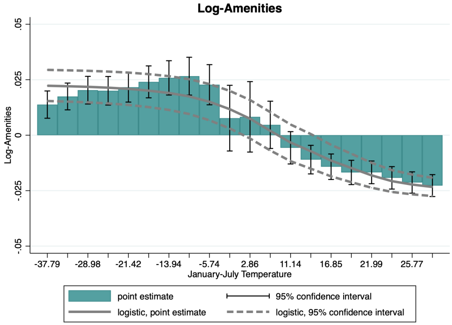


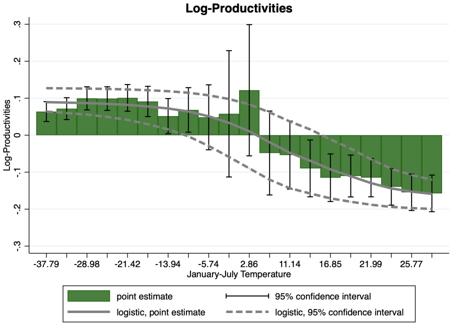
Damage Functions

- Invert fundamental amenities and productivities consistent with observed data (1990, 1995, 2000, 2005)
- Estimate damage function given by

$$\text{Log-Amenity}_t(r) = \sum_{j=1}^{J} \delta_j^b \cdot T_t(r) \cdot \mathbb{1}\{T_t(r) \in \mathcal{T}_j\} + \iota(r) + \iota_t(s_j) + \varepsilon_t(r)$$

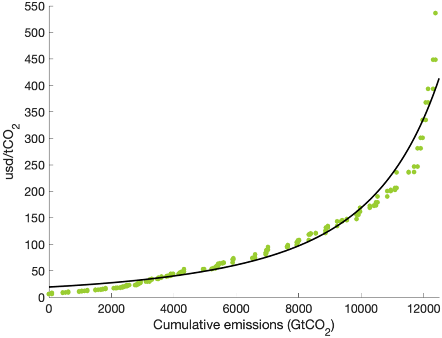
$$\text{Log-Productivity}_t(r) = \sum_{j=1}^{J} \delta_j^a \cdot T_t(r) \cdot \mathbb{1}\{T_t(r) \in \mathcal{T}_j\} + \delta^z \cdot Z(r) + \iota_t(s_j) + \varepsilon_t(r)$$





Fossil and Clean Energy Costs

1. Fossil fuel extraction cost $f(\cdot)$

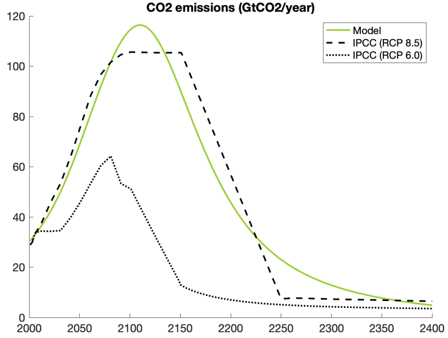


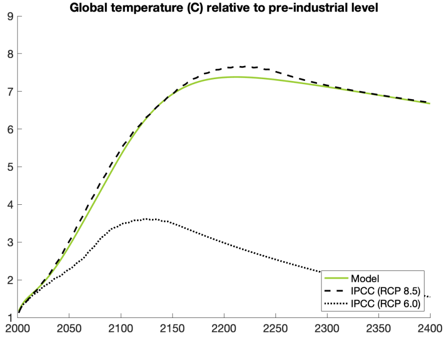
- ★ Data from Bauer et al. (2016)
- ★ Cost has asymptote at total CO_2 reserves

2. Set initial productivities to match fossil and clean energy use map

3. Set relative fossil and clean technology growth to match historical CO_2 emissions and clean energy use

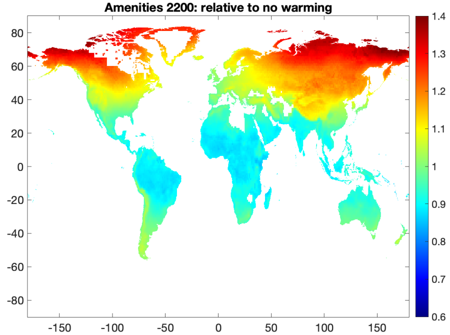
Baseline Scenario: CO2 Emissions and Global Temperature

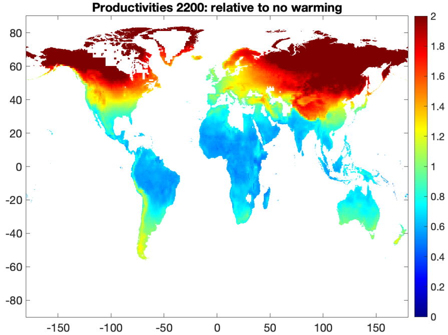




temperature

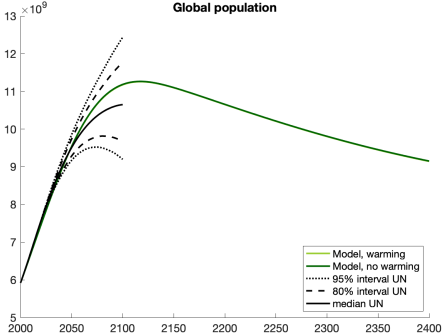
Baseline Scenario: Amenities and Productivities

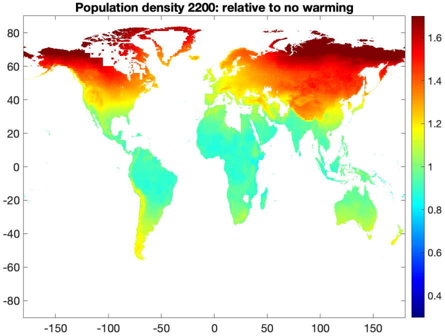




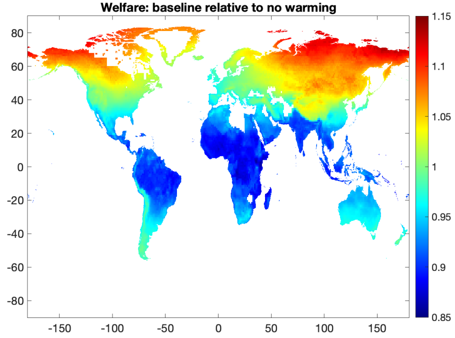
worst-scenario

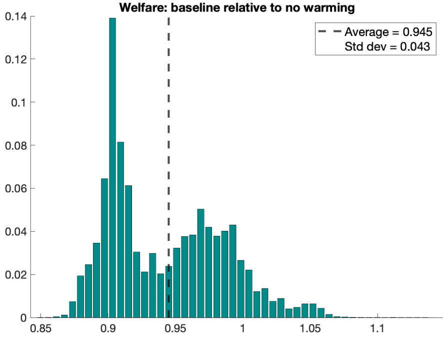
Baseline Scenario: Global and Local Population





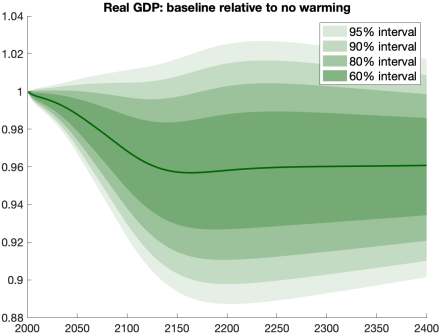
Baseline Scenario: Welfare Cost of Global Warming

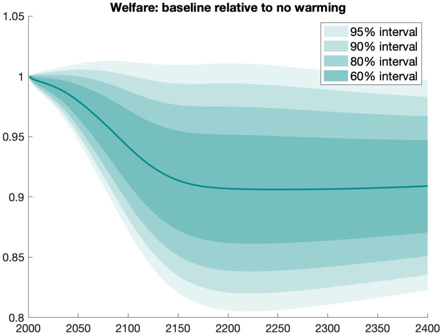




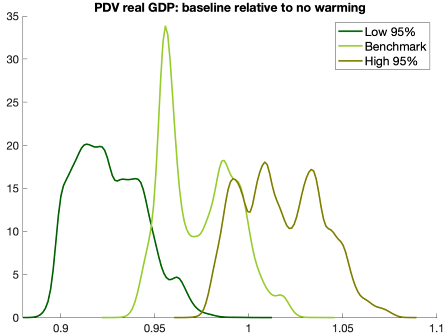
welfare, worst-scenario   real GDP, baseline   real GDP, worst-scenario

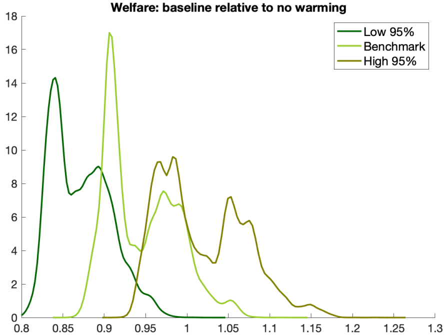
Baseline Scenario: Uncertainty about Damage Functions



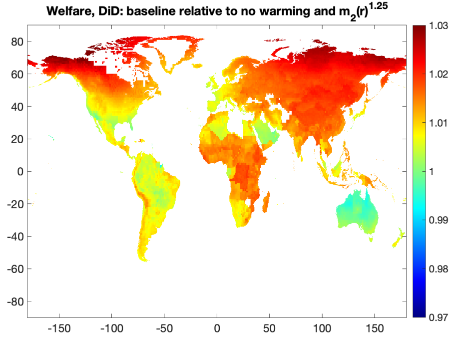


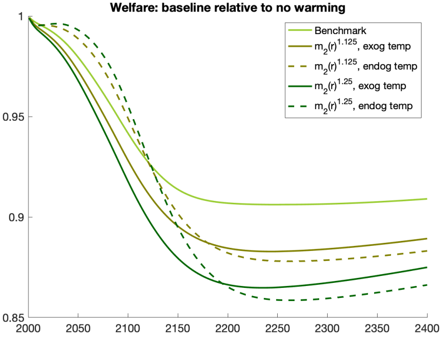
Baseline Scenario: Uncertainty about Damage Functions





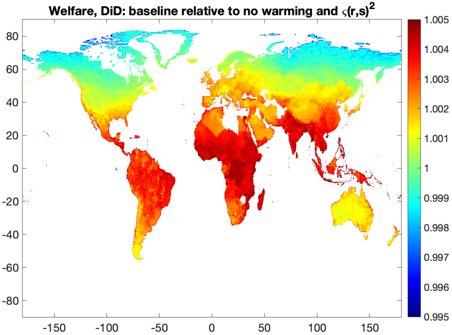
Adaptation: Migration

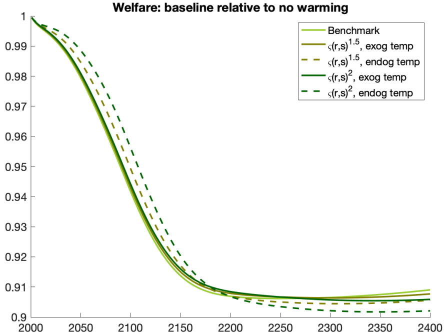




real GDP

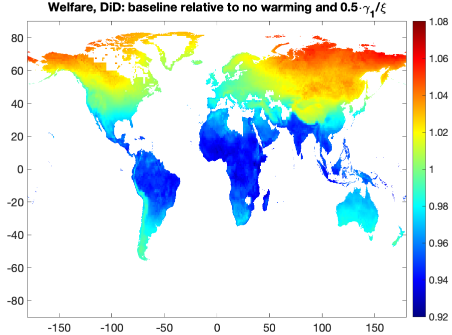
Adaptation: Trade

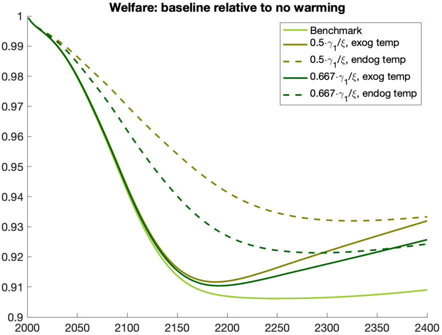




real GDP

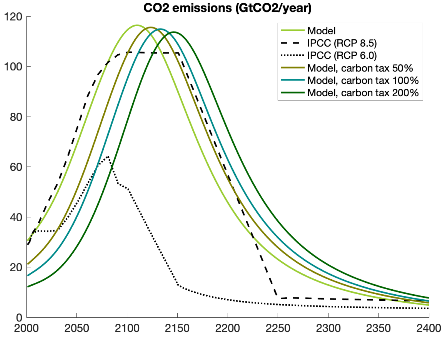
Adaptation: Innovation

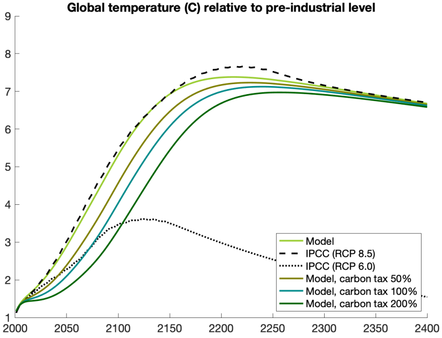




real GDP

Carbon Taxes

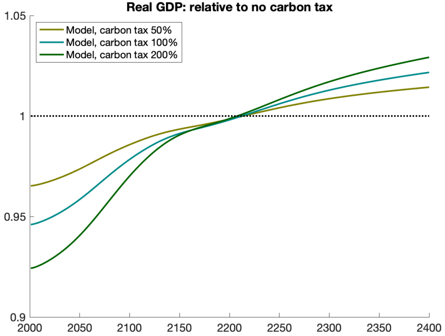


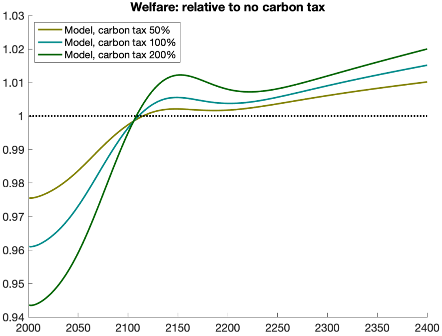


- Carbon tax of 50% equals 37 usd/tCO_2; similar to maximum in EU Emissions Trading Scheme
- Carbon tax of 200% equals 146 usd/tCO_2; similar to Swedish Tax

energy population

Carbon Taxes: Dynamic Effects

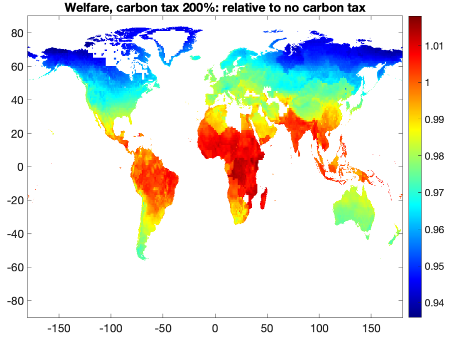


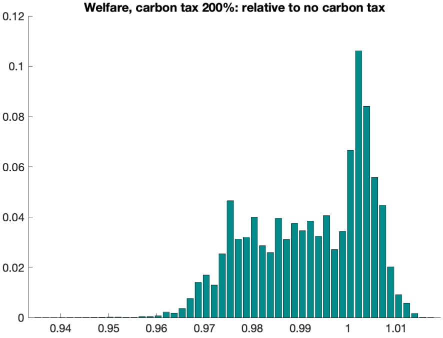


- Aggregate gains depend on discount factor and BGP growth rate

	PDV of real GDP			Welfare		
	BGP gr	β=0.965	β=0.969	BGP gr	β=0.965	β=0.969
τ=0%	3.043%	1	1	3.024%	1	1
τ=50%	3.048%	0.991	1.019	3.028%	0.997	1.016
τ=100%	3.050%	0.987	1.030	3.030%	0.995	1.024
τ=200%	3.053%	0.981	1.042	3.032%	0.993	1.033

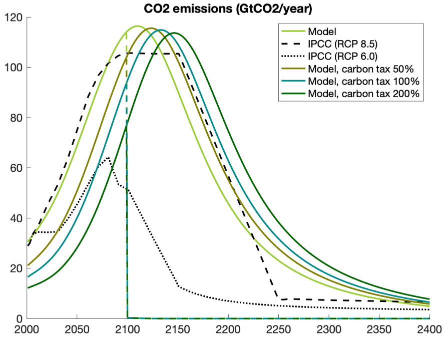
Carbon Taxes: Local Effects

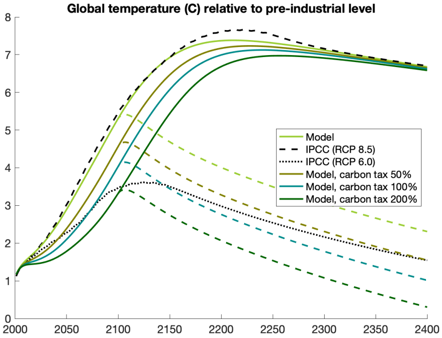




real GDP

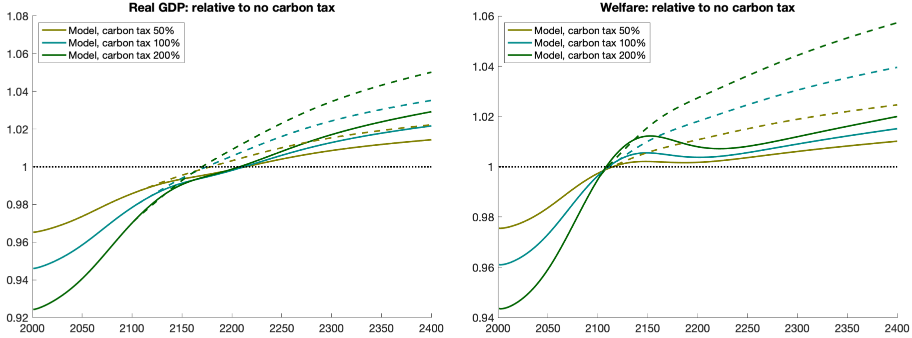
Carbon Taxes with Abatement





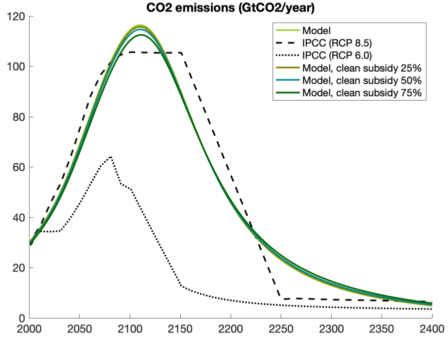
- Perfect and cost-less abatement technology in 2100
- With abatement, carbon tax not only **flattens the temperature curve** but reduces total emissions significantly

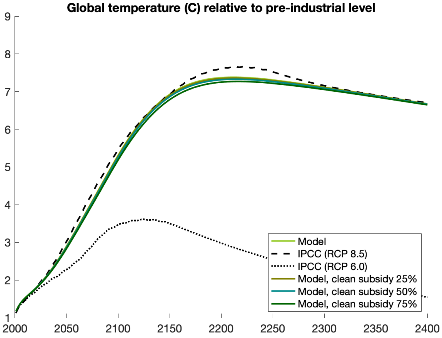
Carbon Taxes and Abatement: Dynamic Effects



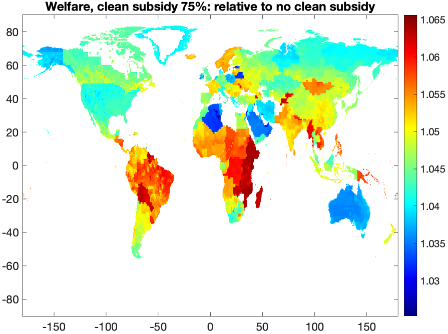
- With abatement, carbon tax results in same current cost but much larger welfare gains in the future
  - For $\tau = 200\%$ and $\beta = 0.969$, **welfare gains from carbon tax double**

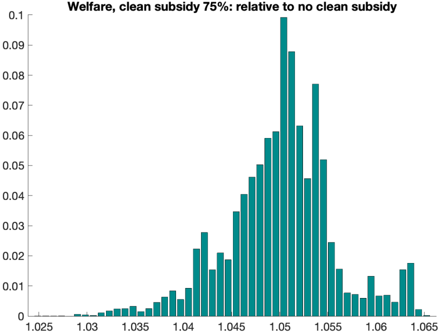
Clean Energy Subsidies





Clean Energy Subsidies: Local Effects





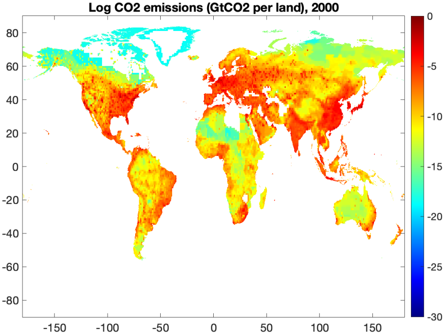
dynamic effects   real GDP

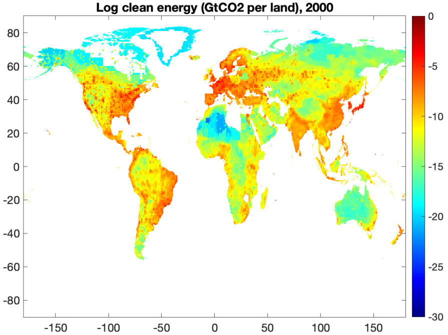
Conclusions

- We develop an economic spatial growth model of global warming
  - Accounts for **adaptation through trade, migration, innovation**
- Estimate impact of temperature on fundamentals
  - Heterogeneous spatial effect of temperature for amenities and productivities
- Large heterogeneity in climate damages over space
  - From welfare losses of 15% to gains of 14%
  - On average, welfare losses of 6%
  - **Large role of adaptation, particularly migration**
- Carbon taxes create trade-off between present and future benefit
  - Large disagreement across regions
  - **Highly effective only in combination with future abatement technology**

Thank You

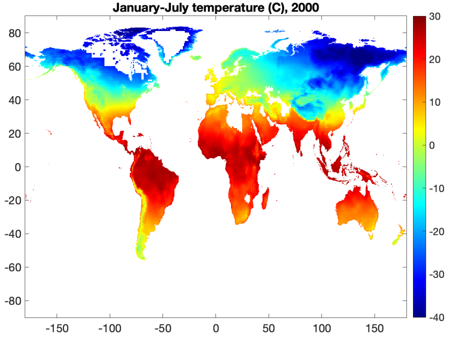
Estimation: Energy

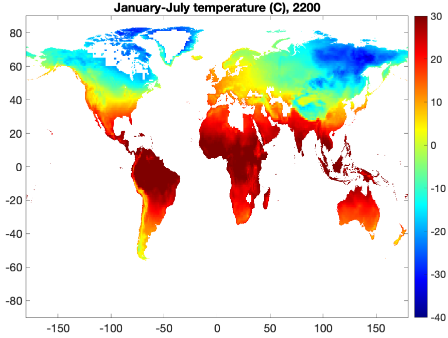




back

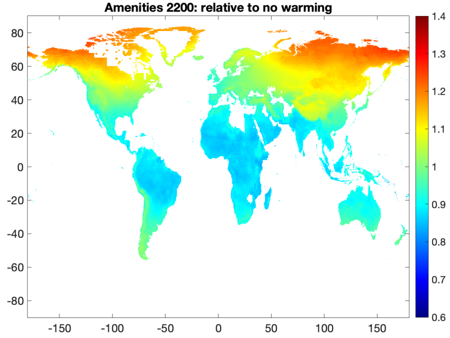
Estimation: Temperature

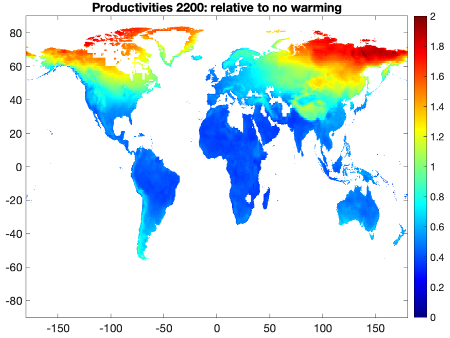




back

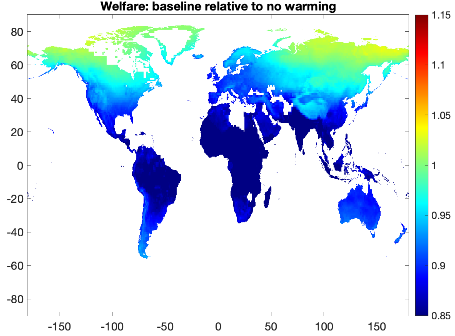
Worst-Scenario: Amenities and Productivities

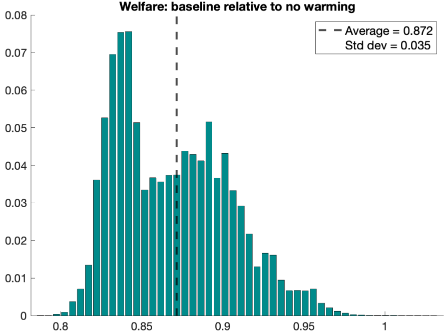




back

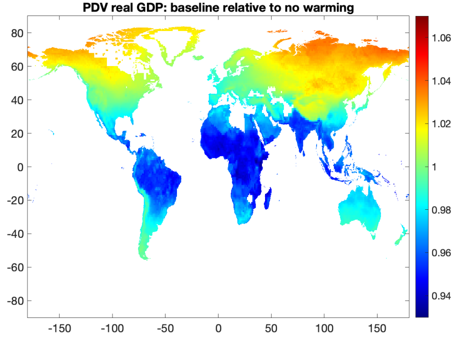
Worst-Scenario: Welfare Cost of Global Warming

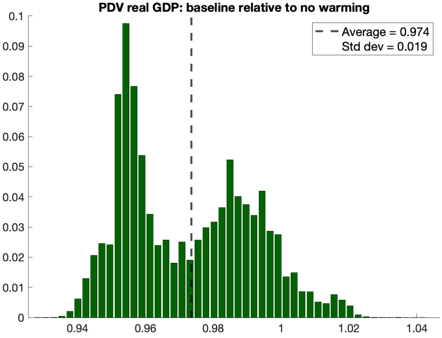




back

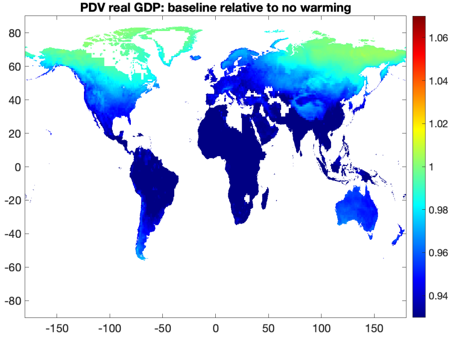
Baseline Scenario: Real GDP Cost of Global Warming

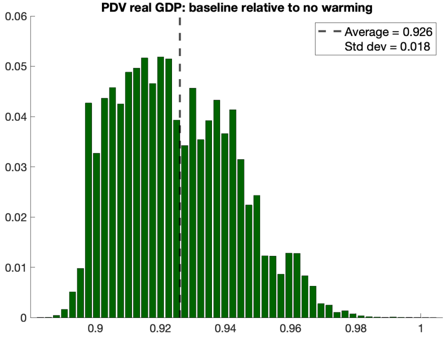




back

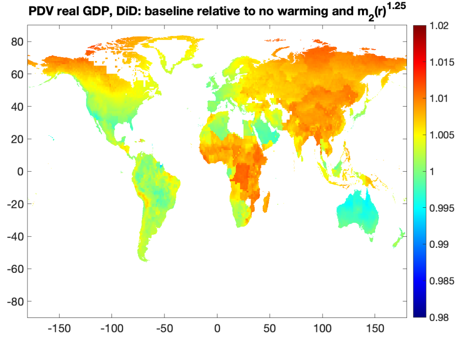
Worst-Scenario: Real GDP Cost of Global Warming

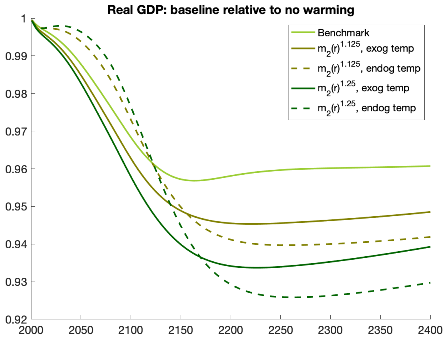




back

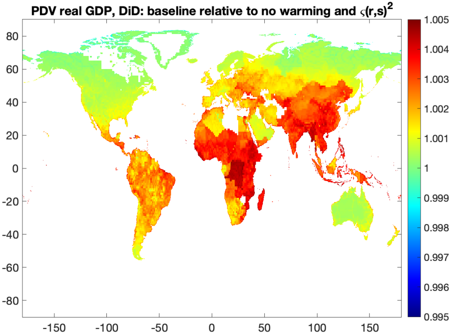
Adaptation: Migration and Real GDP

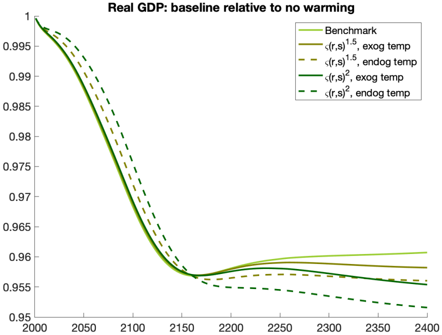




back

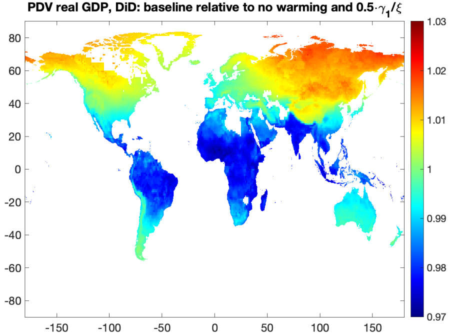
Adaptation: Trade and Real GDP

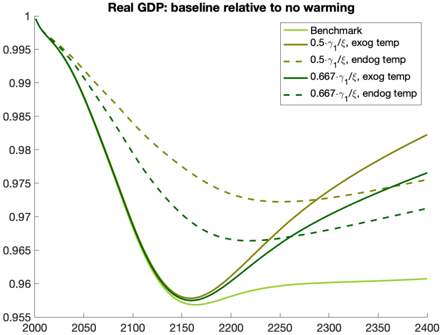




back

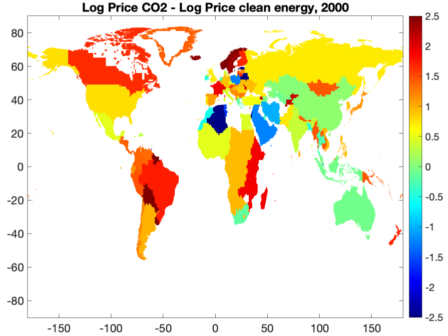
Adaptation: Innovation and Real GDP

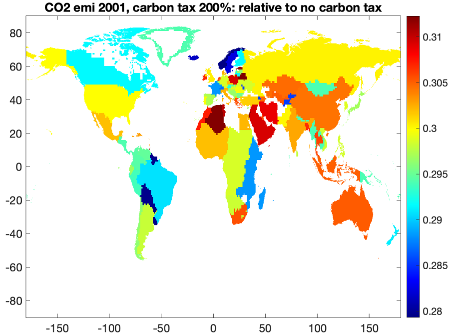




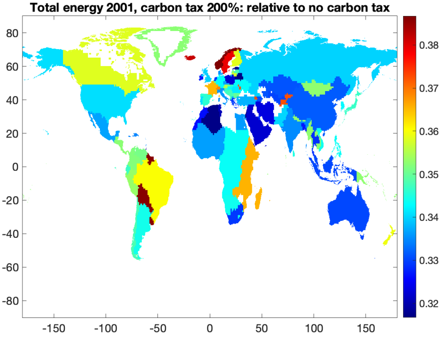
back

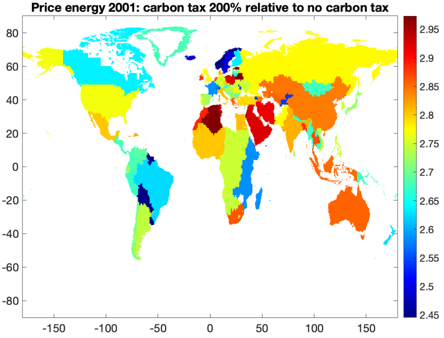
Carbon Taxes: Energy Price





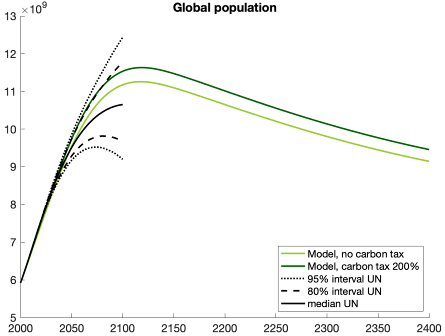
Carbon Taxes: Energy Price

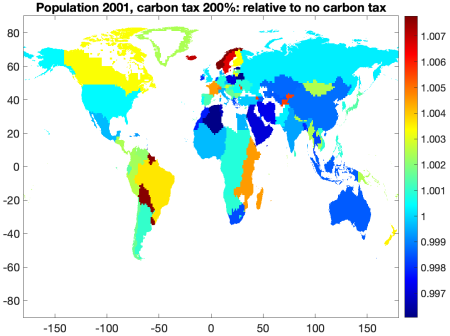




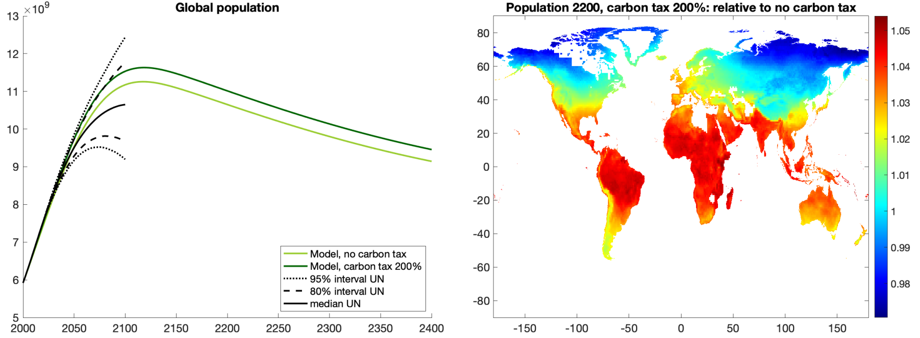
back

Carbon Taxes: Population



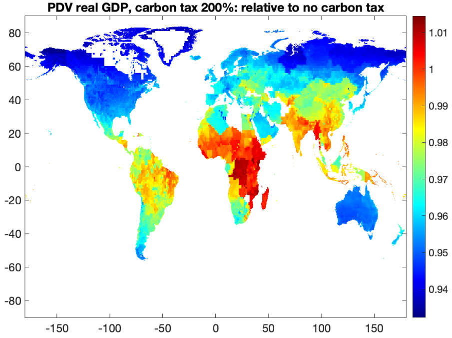


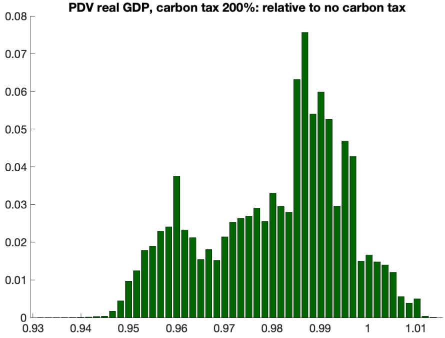
Carbon Taxes: Population



back

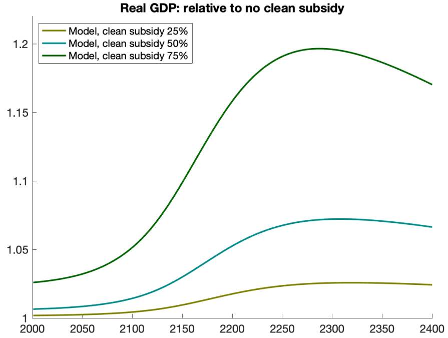
Carbon Taxes: Local Real GDP

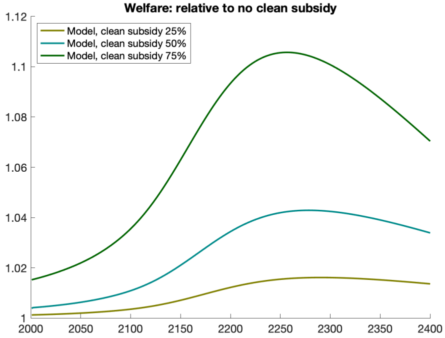




back

Clean Energy Subsidies: Dynamic Effects

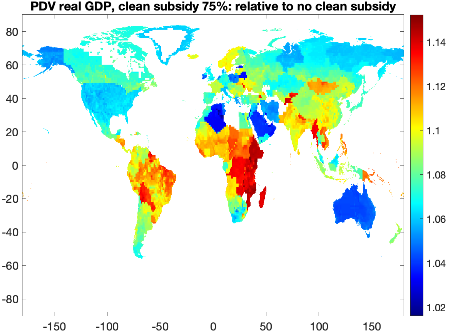


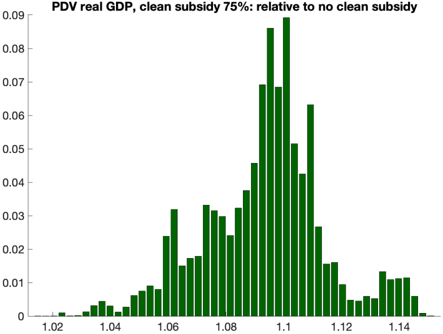


	PDV of real GDP			Welfare		
	BGP gr	β=0.965	β=0.969	BGP gr	β=0.965	β=0.969
s=0%	3.043%	1	1	3.024%	1	1
s=25%	3.040%	1.011	1.009	3.020%	1.007	1.000
s=50%	3.034%	1.032	1.021	3.012%	1.020	0.996
s=75%	3.012%	1.094	1.044	2.989%	1.050	0.975

back

Clean Energy Subsidies: Local Real GDP





back