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The Economic Geography of Climate Change

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Princeton University

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Princeton

01. Oct. 2020

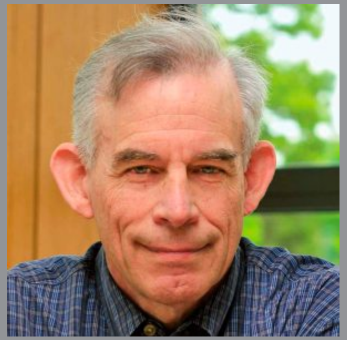
Every Thursday at 12:30 (New York Time)

- Previous

  - Jean Tirole
    "Public & Private Sphere
    and the Authentic Self"

  - Richard Zeckhauser
    "... on geo engineering"

- Upcoming



  - Chris Sims
    "How to worry about
    government debt"

  - Bengt Holmstrom
    "Seasonal COVID"

  - Esther Duflo (later)

Markus' intro on **Climate Change**

academy

- Malthusian approach vs.
  Innovation approach
  - Mitigation (reduce pollution)
  - Adaptation (dams/seawalls, migration, …)
  - Amelioration (geo engineering, …)

- Dynamic effects
  - Over 100 years – uncertainty : main driver is mean-reversion

- Planning certainty is key for innovation
  - Carbon tax **path**

Role of Risk/Uncertainty

1. About climate change **"Climate volatility"**
2. About **damage function** (of climate change)
3. About **policy** – and response to policy

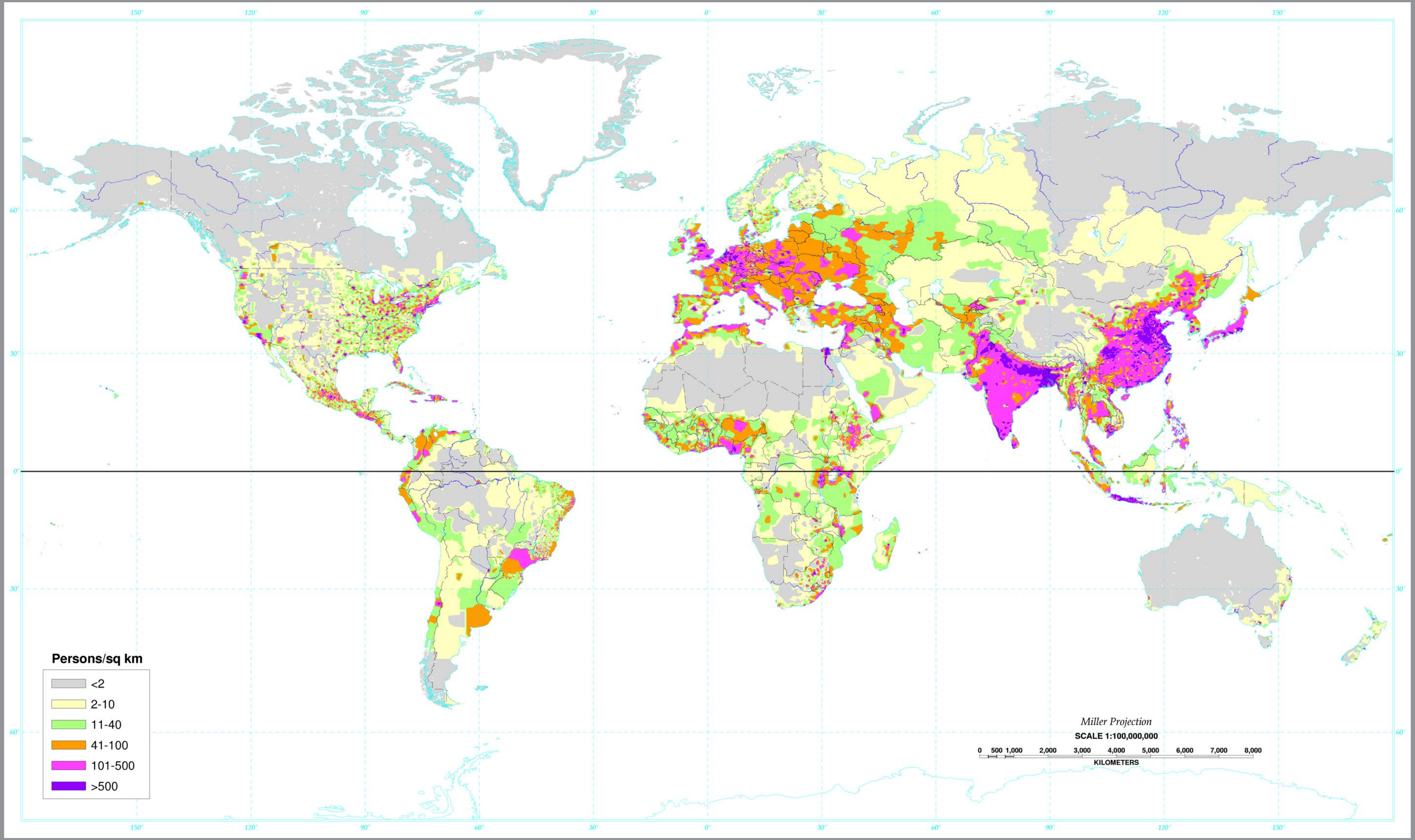
⇒ Makes remaining consumption more volatile too

- Uncertainty: **Future counts more, but delays action**

Time-Preference rate | Ramsey-term Intergenerational equality | Precautionary Motive | Lowers downside risk

- $$r = \underbrace{\rho + E[g_c] - Var[g_c]}_{\text{risk-free rate}} + \underbrace{Cov[g_c, g_{\text{benefit}}]}_{\text{risk premium} < 0}$$
- Long-run $Var[g_c]$ depends mostly on mean-reversion
  - Tipping points
- Communicate policy response (if, then …) to reduce uncertainty
  - Don't off-load risk to innovators and adopters

Migration as Adaptation Strategy?



Migration?

- Migration and Political Conflict
  - Canada approach – welcoming immigrants
    - Implicit social contract and migration
  - What will Russia do?

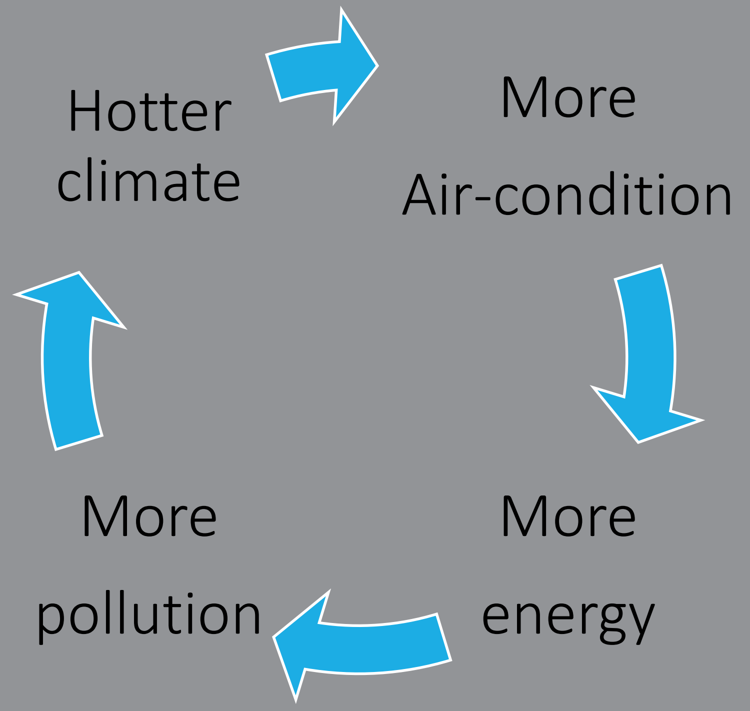
- Migration: shift or jump (depends on moving fixed costs)
  - Shift: everyone moves a bit to the north (push through land price)
  - Jump: people in areas under waters move
  - What's socially optimal? What is individually optimal?

- Migration and "Climate Volatility"
  - Move several times a year at short notice to escape storms?

2 Types of **Innovations – diabolic loop**

1. Innovation to reduce emissions

2. Innovation to better cope with different climate
   - The air conditioning diabolic loop



- Which innovation/adaptation is more likely?
- Which innovation will unregulated market economy pick?

Poll Results

1. What are the main mechanisms economies have to adapt to climate change?
   a. Technological innovations
   b. Mobility
   c. International trade

2. What are the best policies to combat climate change?
   a. Carbon taxes
   b. Clean energy subsidies
   c. Emission restrictions

3. Do you think international transfers to help countries confront the cost of climate change are need?
   a. Yes
   b. No

Thank you!

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The Economic Geography of Global Warming

José-Luis Cruz (Princeton University)

Esteban Rossi-Hansberg (Princeton University)

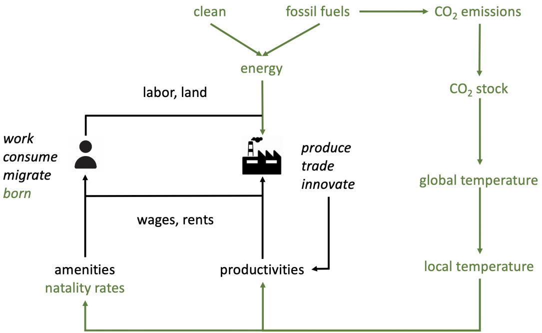
Markus' Academy, October 2020

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

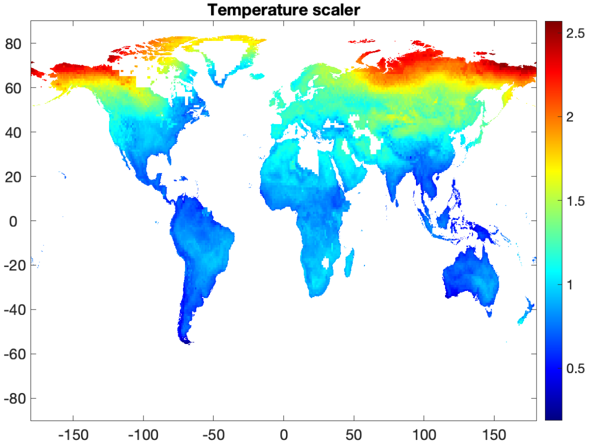
- We extend the spatial growth model in Desmet et al. (2018)
  - Add natality, energy, carbon cycle, and local temperature effect on amenities and productivities



  - 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 that 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

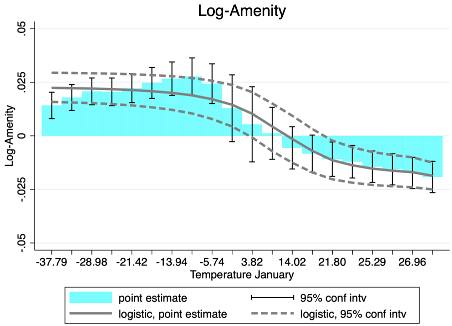


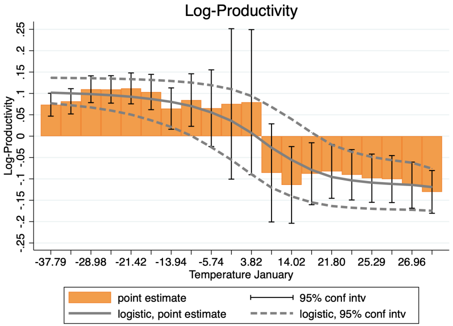
Damage Functions

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

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

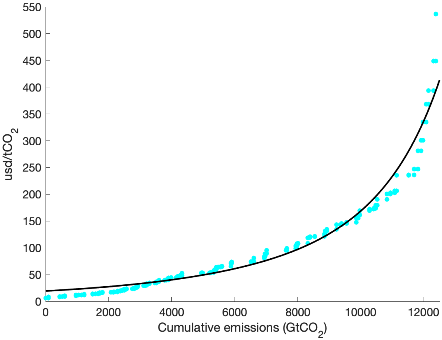
$$\text{Log-Productivity}_t(r) = \sum_{j=1}^{J} \delta_j^a \cdot T_t(r) \cdot \mathbb{1}\{T_t(r) \in \mathcal{T}_j\} + \delta^z \cdot Z(r) + \iota_t(s_j) + \varepsilon_t(r)$$





Fossil and Clean Energy Costs

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

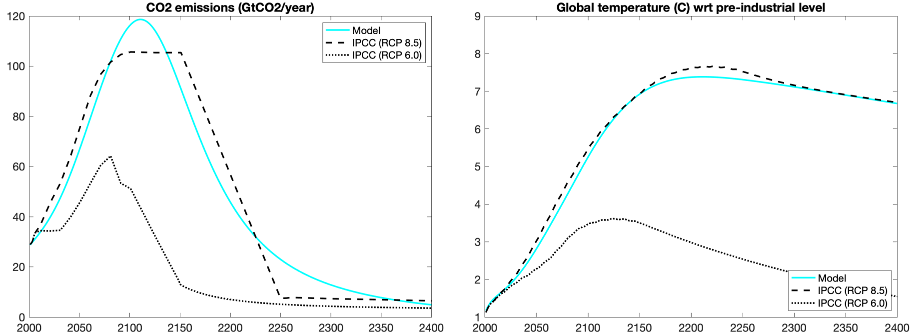


- ⋆ Data from Bauer et al. (2016)
- ⋆ Cost has asymptote at total CO_2 reserves

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

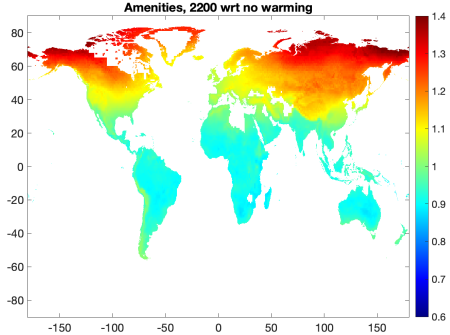
3. Set relative fossil and clean technology growth to match historical CO_2 emissions and clean energy use

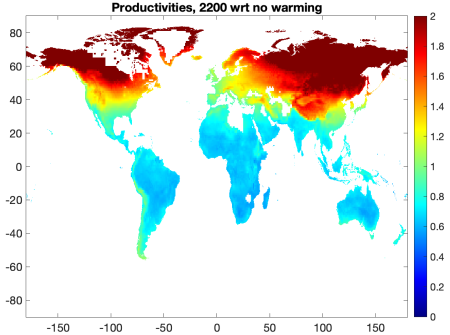
Baseline Scenario: CO2 Emissions and Global Temperature



temperature

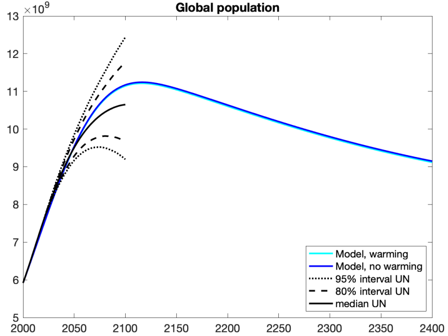
Baseline Scenario: Amenities and Productivities

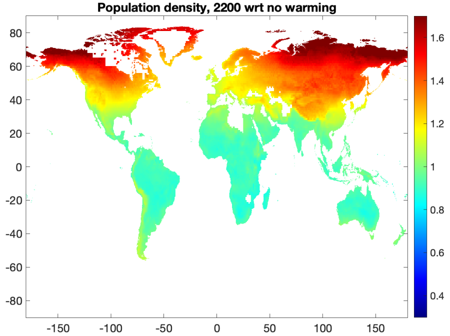




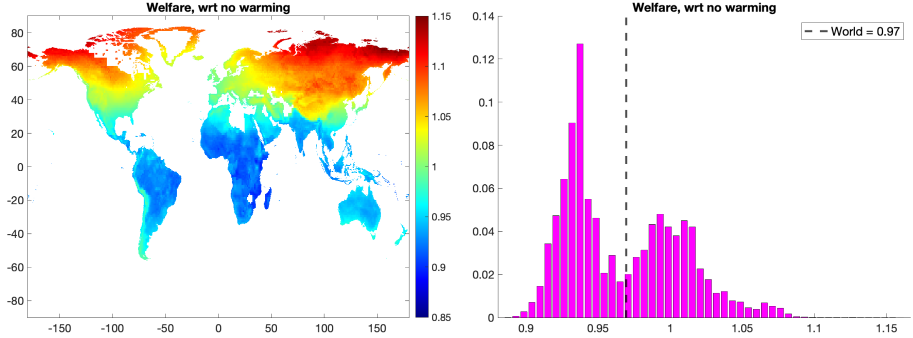
worst-case

Baseline Scenario: Global and Local Population



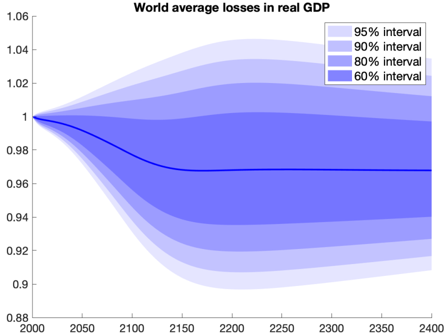


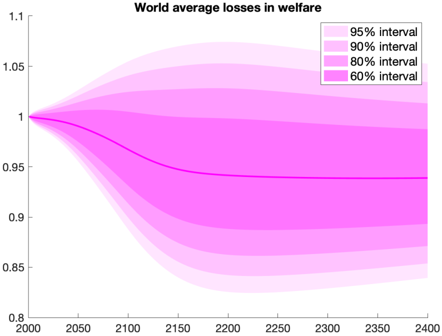
Baseline Scenario: Welfare Cost of Global Warming



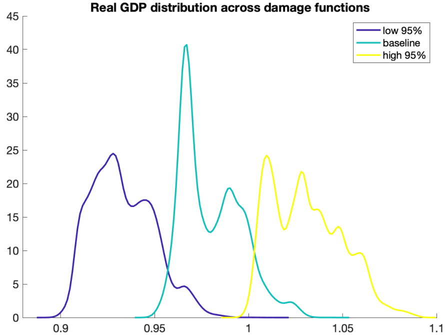
welfare, worst-case   real GDP, baseline   real GDP, worst-case

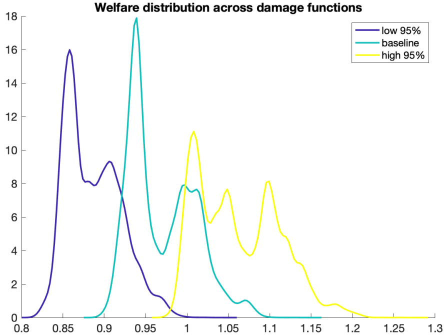
Baseline Scenario: Uncertainty about Damage Functions



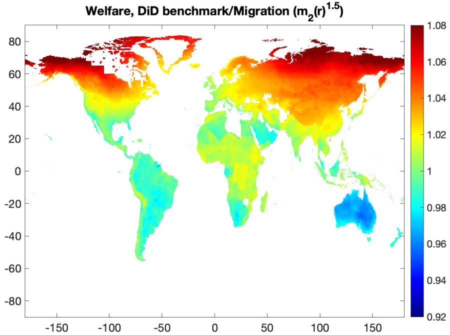


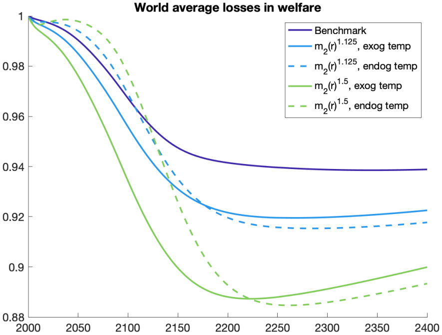
Baseline Scenario: Uncertainty about Damage Functions





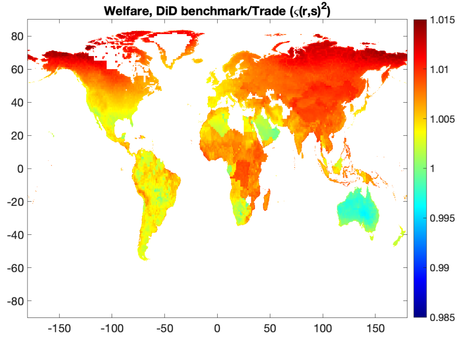
Adaptation: Migration

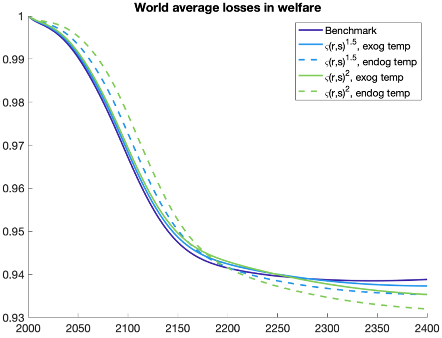




real GDP

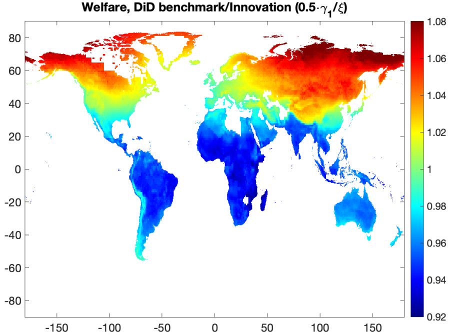
Adaptation: Trade

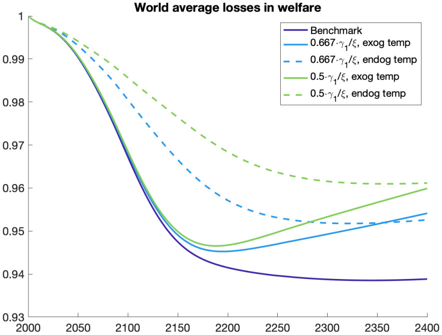




real GDP

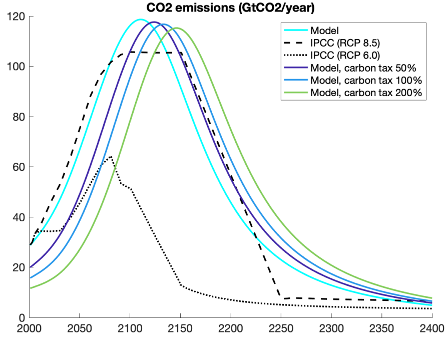
Adaptation: Innovation

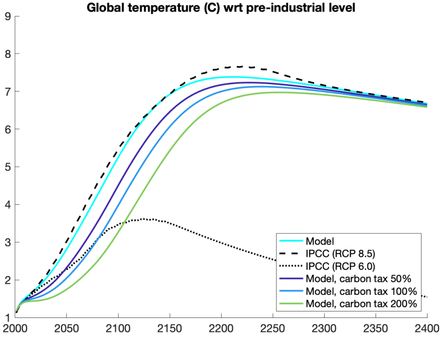




real GDP

Carbon Taxes

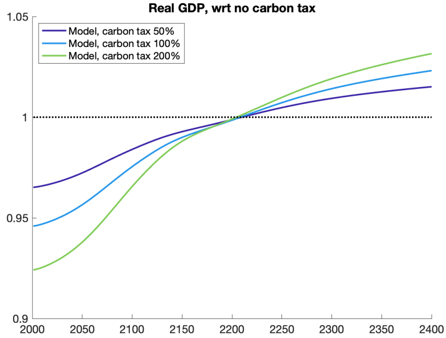


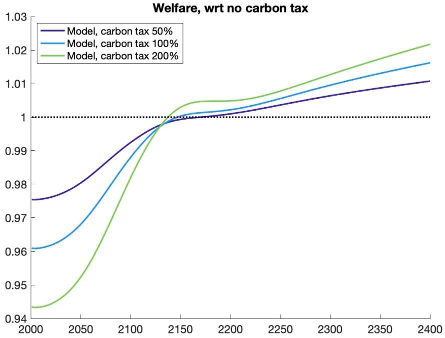


- Carbon tax of 50% equals 37 usd/tCO_2; similar to maximum in EU Emissions Trading Scheme
- Carbon tax of 200% equals 146 usd/tCO_2; similar to Swedish Tax

energy population

Carbon Taxes: Dynamic Effects

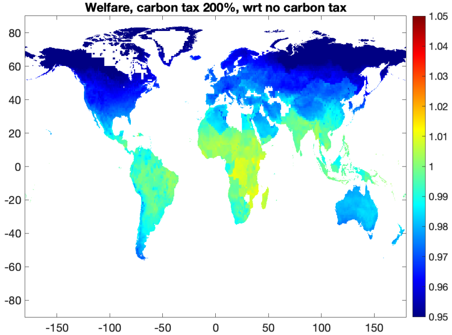


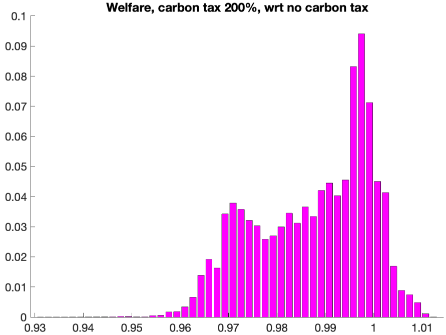


- Aggregate gains depend on discount factor and BGP growth rate

	Real GDP			Welfare		
	BGP gr	β=0.965	β=0.969	BGP gr	β=0.965	β=0.969
τ=0%	3.050%	1	1	3.011%	1	1
τ=50%	3.054%	0.991	1.020	3.015%	0.995	1.014
τ=100%	3.057%	0.986	1.032	3.017%	0.992	1.022
τ=200%	3.060%	0.980	1.046	3.019%	0.988	1.030

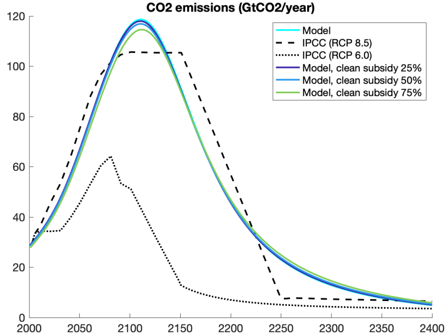
Carbon Taxes: Local Effects

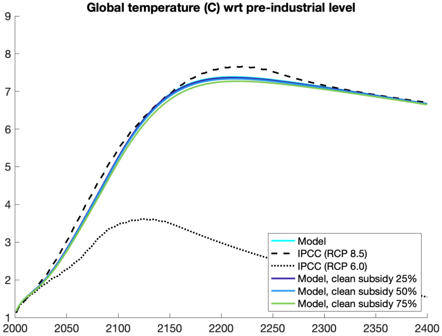




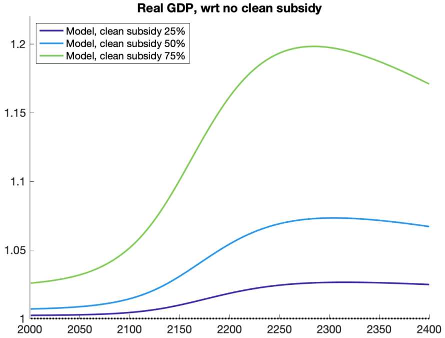
real GDP real income

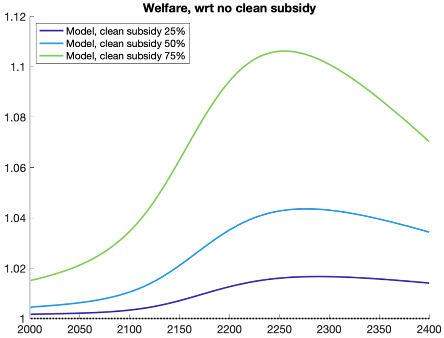
Clean Energy Subsidies





Clean Energy Subsidies: Dynamic Effects

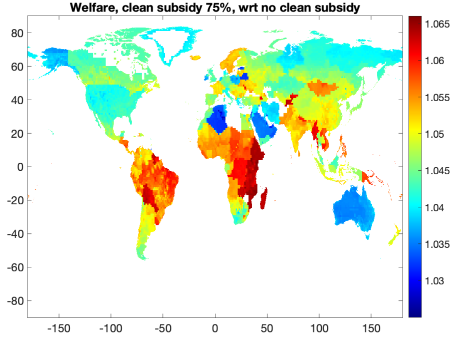


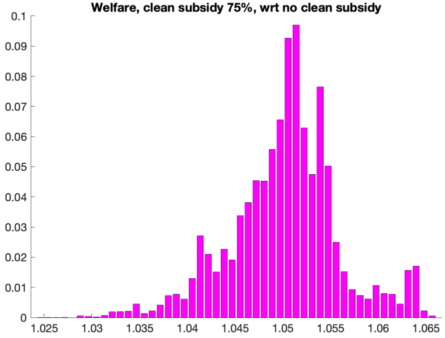


- Aggregate gains depend on discount factor and BGP growth rate

	Real GDP			Welfare		
	BGP gr	β=0.965	β=0.969	BGP gr	β=0.965	β=0.969
s=0%	3.050%	1	1	3.011%	1	1
s=25%	3.047%	1.011	1.008	3.007%	1.007	1.002
s=50%	3.040%	1.033	1.020	2.999%	1.020	1.000
s=75%	3.018%	1.095	1.039	2.976%	1.051	0.984

Clean Energy Subsidies: Local Effects





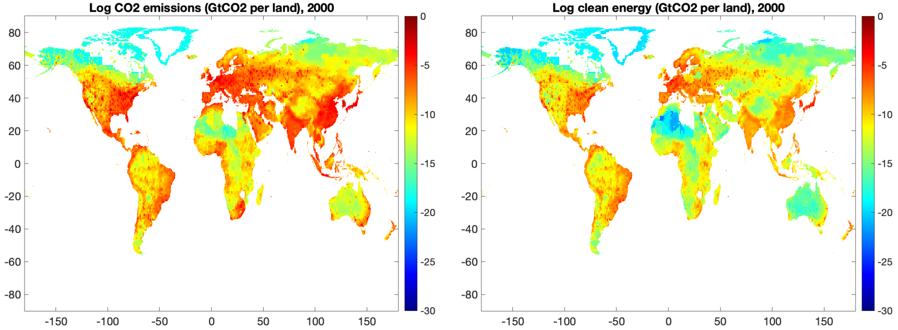
real GDP real income

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 10% to gains of 15%
  - On average, welfare losses of 3%
  - Large role of adaptation, particularly migration
- Carbon taxes create trade-off between present and future benefit
  - Large disagreement across regions

Thank You

Estimation: Energy



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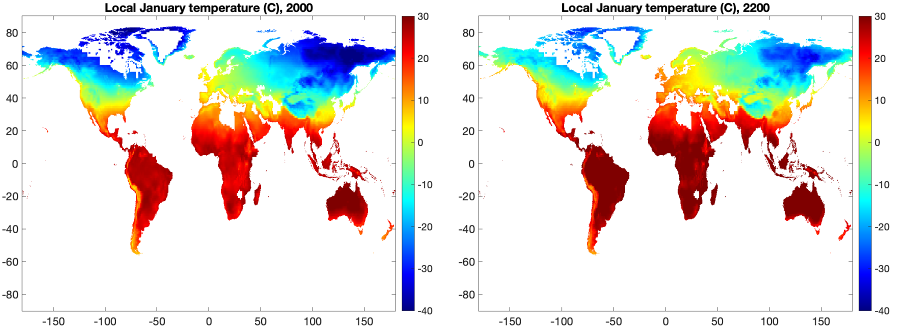
Estimation: Temperature



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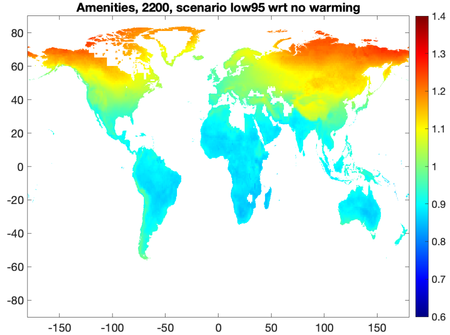
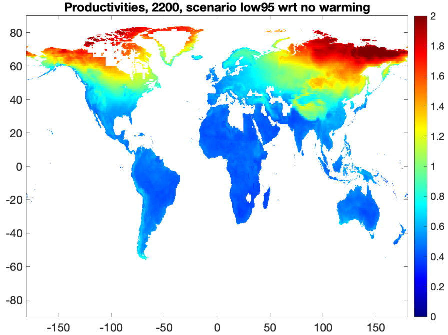
Amenities and Productivities





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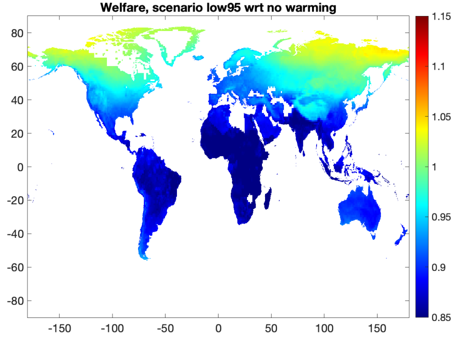
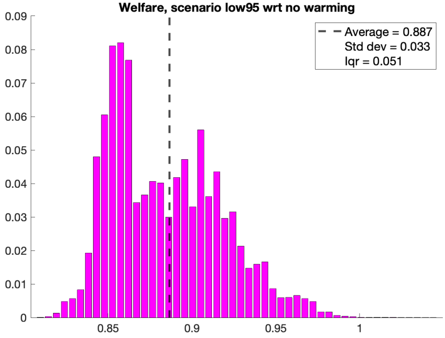
Welfare Cost of Global Warming





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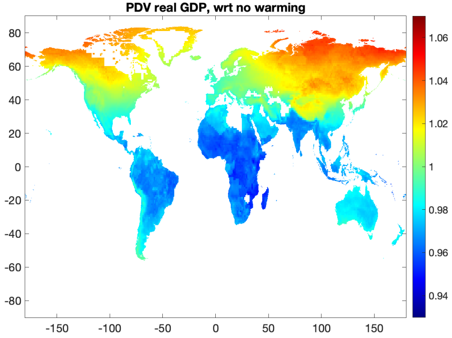
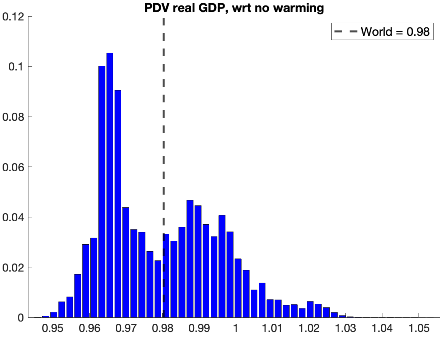
Baseline Scenario: Real GDP Cost of Global Warming





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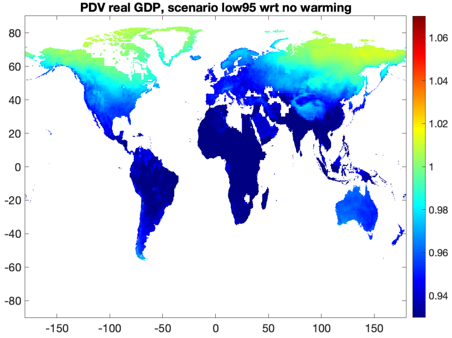
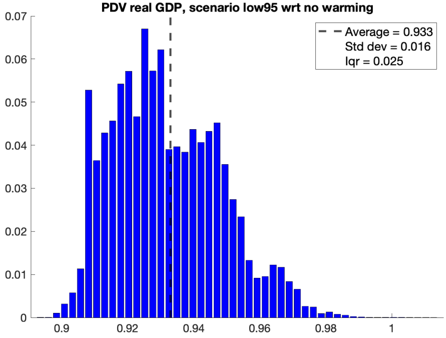
Real GDP Cost of Global Warming





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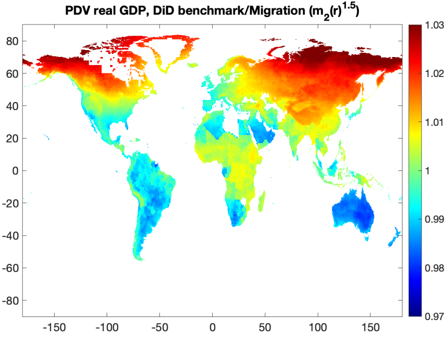
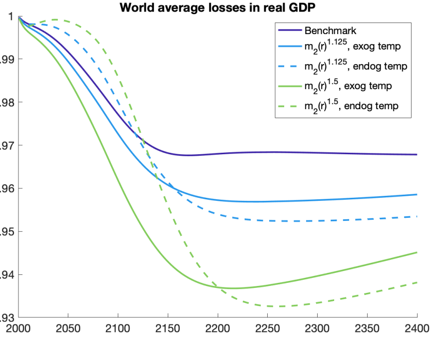
Adaptation: Migration and Real GDP





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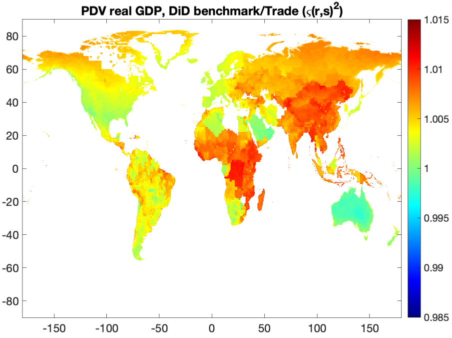
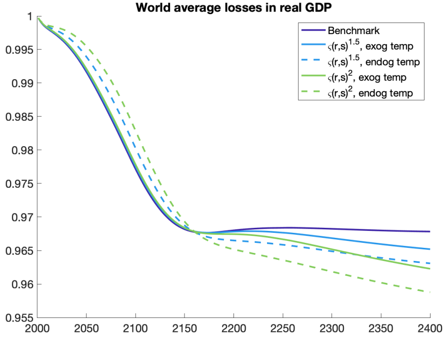
Adaptation: Trade and Real GDP





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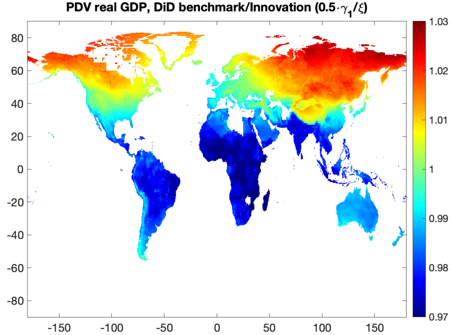
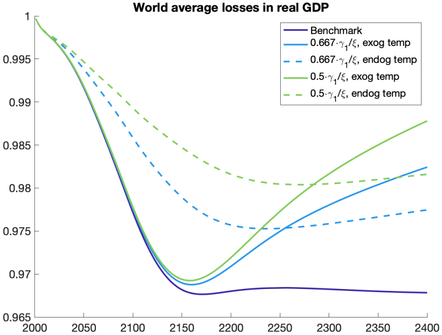
Adaptation: Innovation and Real GDP





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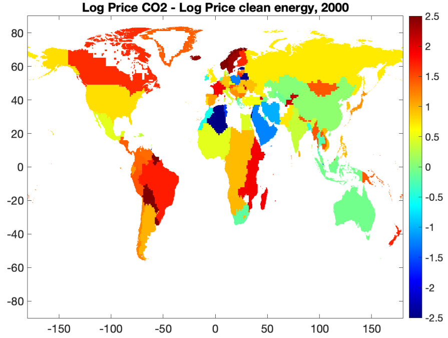
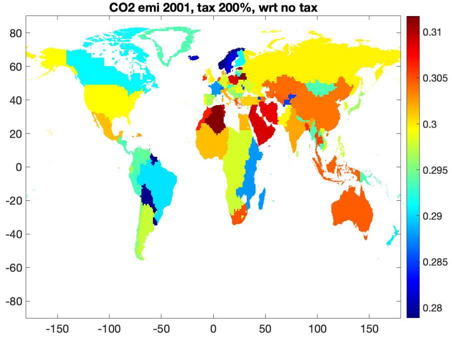
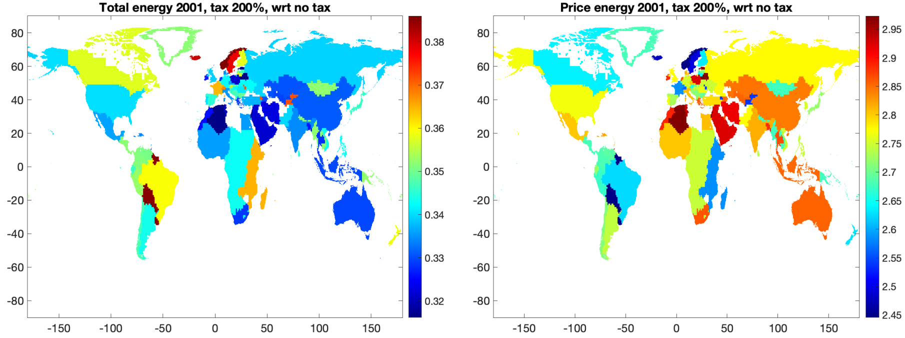
Carbon Taxes: Energy Price





Carbon Taxes: Energy Price



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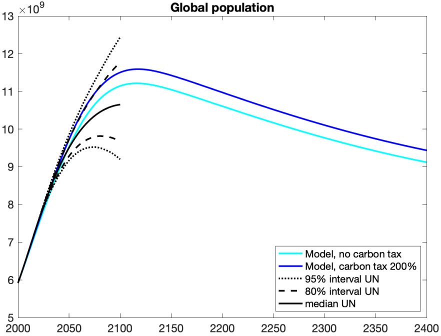
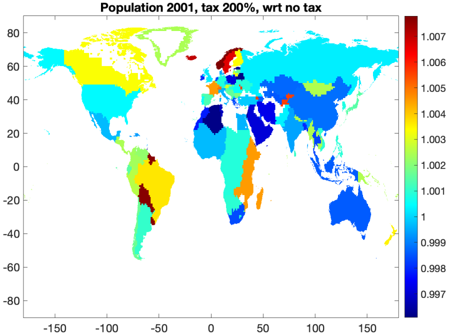
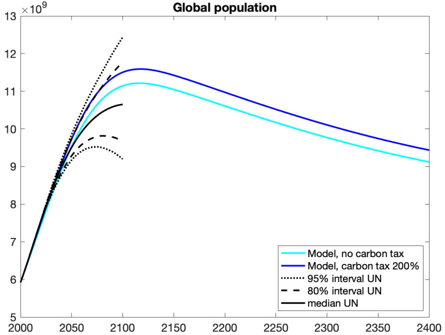
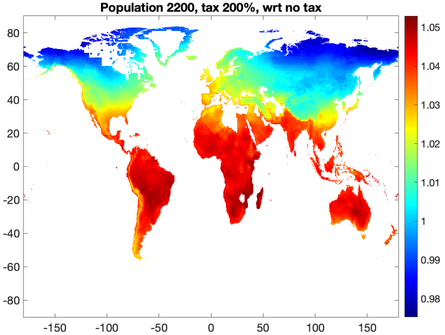
Carbon Taxes: Population





Carbon Taxes: Population





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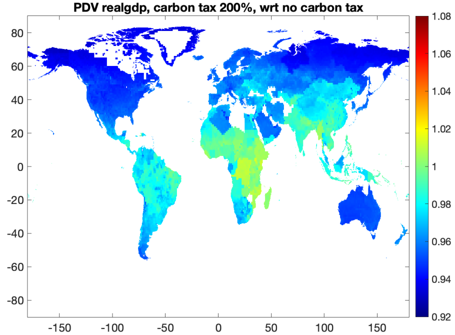
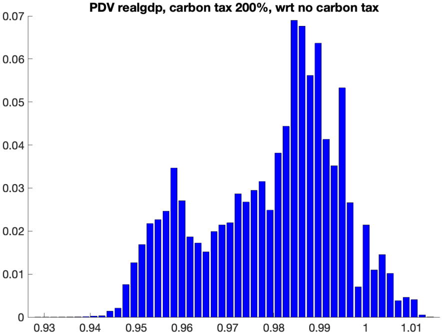
Carbon Taxes: Local Real GDP





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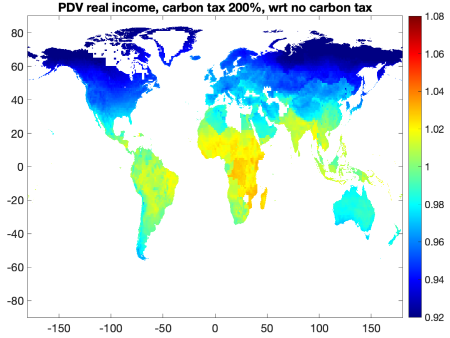
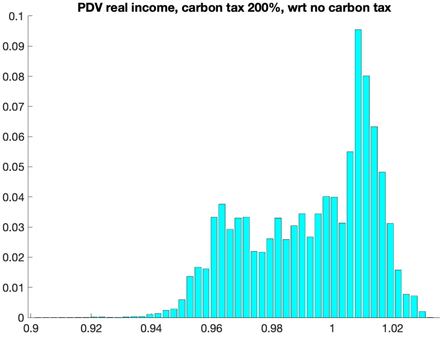
Carbon Taxes: Local Real Income





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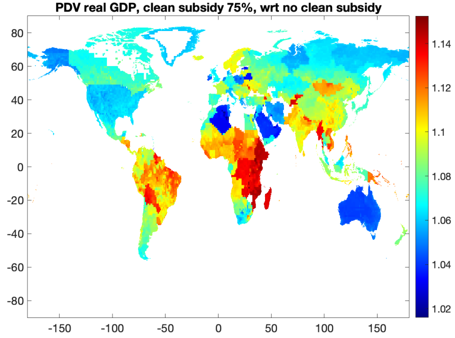
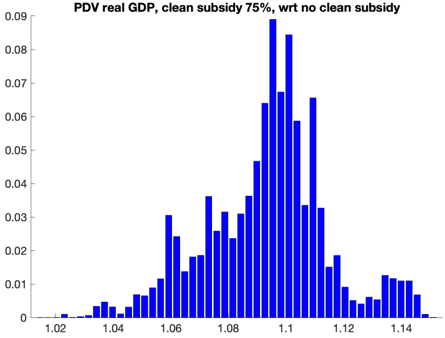
Clean Energy Subsidies: Local Real GDP





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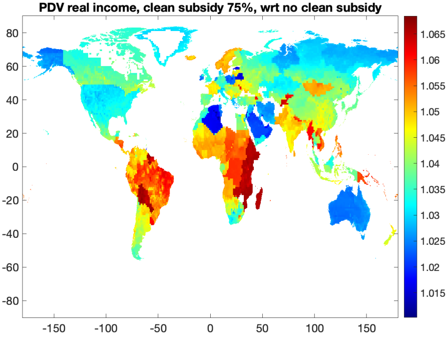
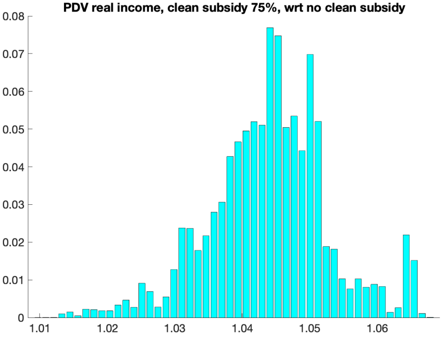
Clean Energy Subsidies: Local Real Income





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