Climate Policy in the Wide World

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- In combination with carbon cycle, every additional ton of a CO_2 emissions has an approximately constant and permanent effect on the global mean temperature (IPCC, 2021).
- The global mean temperature at time t is approximately proportional to over time cumulative global emissions. $T_t = \sigma_{CCR} \sum_{s=0}^{t} M_s$.

Cumulative emissions and Global Mean Temperature

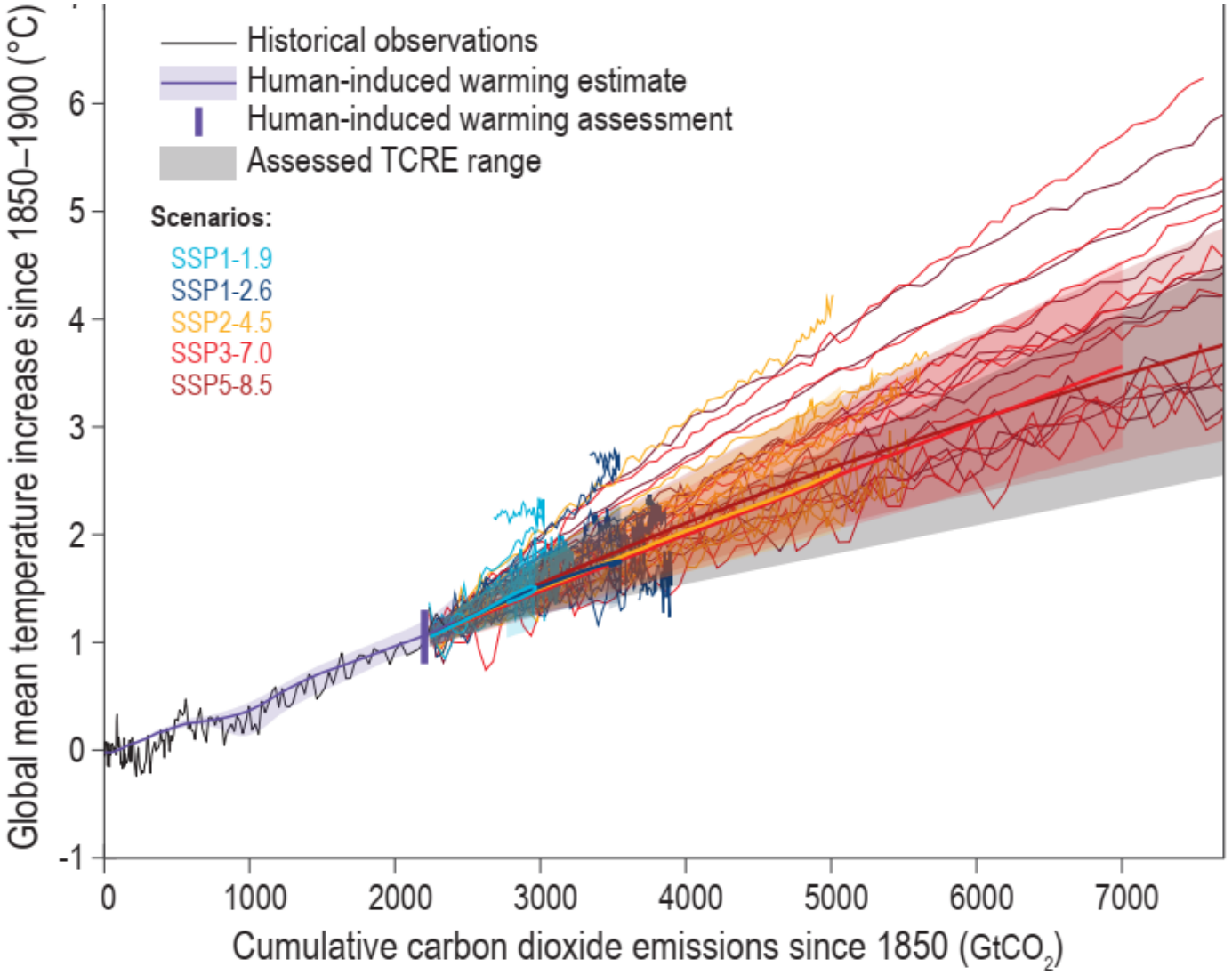

Figure: IPCC (2021), Physical Science Basis, Figure TS.18

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  - Equally large uncertainty regarding economic sensitivity to climate change, in particular in long-run.
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- Policy mistakes/failures inevitable. Important to find *robust polices*.

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5. Proof of concept at this stage.

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- Labor, capital and domestically produced fuels freely mobile across the regions in a country but cannot move across countries.
- Consumers decide how much to consume and to save in next periods capital stock.
- Some countries are classified as producers of conventional oil. Citizens there only decide how much oil to sell to the rest of the world.

The economy: markets and taxes.

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- There is a frictionless international market for (conventional) oil.
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- Each country has an exogenous carbon tax on emissions that is rebated back as a negative income tax.

The economy: energy supply

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- In conventional oil producing countries, oil in extracted costlessly from a reserve with a fixed initial size.

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- p_{jt} is the perfect price index of energy services, A_{jt} $\equiv \left(\sum_{i=1} \left(\hat{A}_{ijt} N_{jt}^{\varphi_j - 1} \right)^{\frac{1}{1-\varphi_j}} \right)^{1-\varphi_j}$ a convex weighted average of regional TFPs and k_{jt} the per capita capital stock.

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- Net aggregate country output becomes a Cobb-Douglas in labor and capital!

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- With population growth, supply remains completely inelastic and independent of future prices. The share saved, s_{jt} satisfies:

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- A higher population growth implies larger weight on future per capita consumption. A temporarily higher population growth implies oil supply converges to $1-\beta$ from below.

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- Savings converge to $\beta\alpha\frac{\varphi_j}{1-\nu_j\varphi_j}$ from above.

Emission and carbon circulation

- Global emissions M_t are the sum of all uses of coal, conventional oil and fracked oil (measured in GtC). This enters into a 3-reservoir (atmosphere S_t, biosphere+surface ocean S_t^U, and deep ocean S_t^L) linear carbon cycle model.

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- Idea is that flows are proportional to size of source reservoir:

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\begin{aligned}
S_t - S_{t-1} &= -\phi_{12} S_{t-1} + \phi_{21} S_{t-1}^U + M_{t-1} && (1)\\
S_t^U - S_{t-1}^U &= \phi_{12} S_{t-1} - (\phi_{21} + \phi_{23}) S_{t-1}^U + \phi_{32} S_{t-1}^L && (2)\\
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- The carbon cycle model determines a path of the size of the atmospheric carbon reservoir, i.e., the atmospheric CO_2 concentration (note that 1 GtC corresponds to 0.47 ppm CO_2).

Climate

- We use the two-temperature (T_t, T_t^L) energy budget model:

$$\begin{aligned} T_t - T_{t-1} &= \sigma_1 \left(\frac{\chi}{\ln 2} \ln \left(\frac{S_{t-1}}{S_0} \right) - \kappa T_{t-1} - \sigma_2 \left(T_{t-1} - T_{t-1}^L \right) \right) \\ T_t^L - T_{t-1}^L &= \sigma_3 \left(T_{t-1} - T_{t-1}^L \right) \end{aligned}$$

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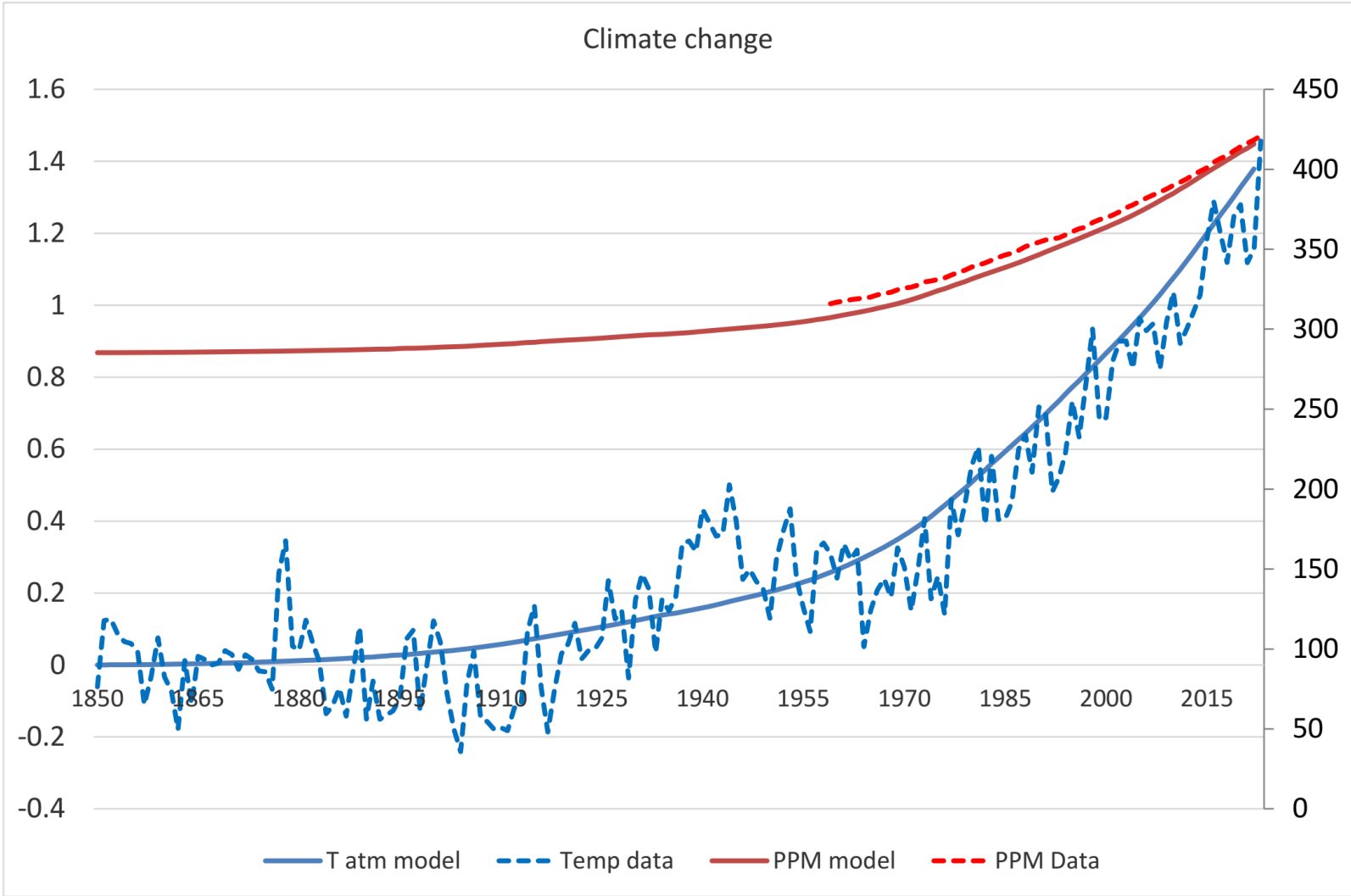
- Together, the carbon cycle and climate model well replicates historic data as well as simulations of difference future scenarios from Earth System Models.

CO2 Concentration and Global temperatures 1850-2023



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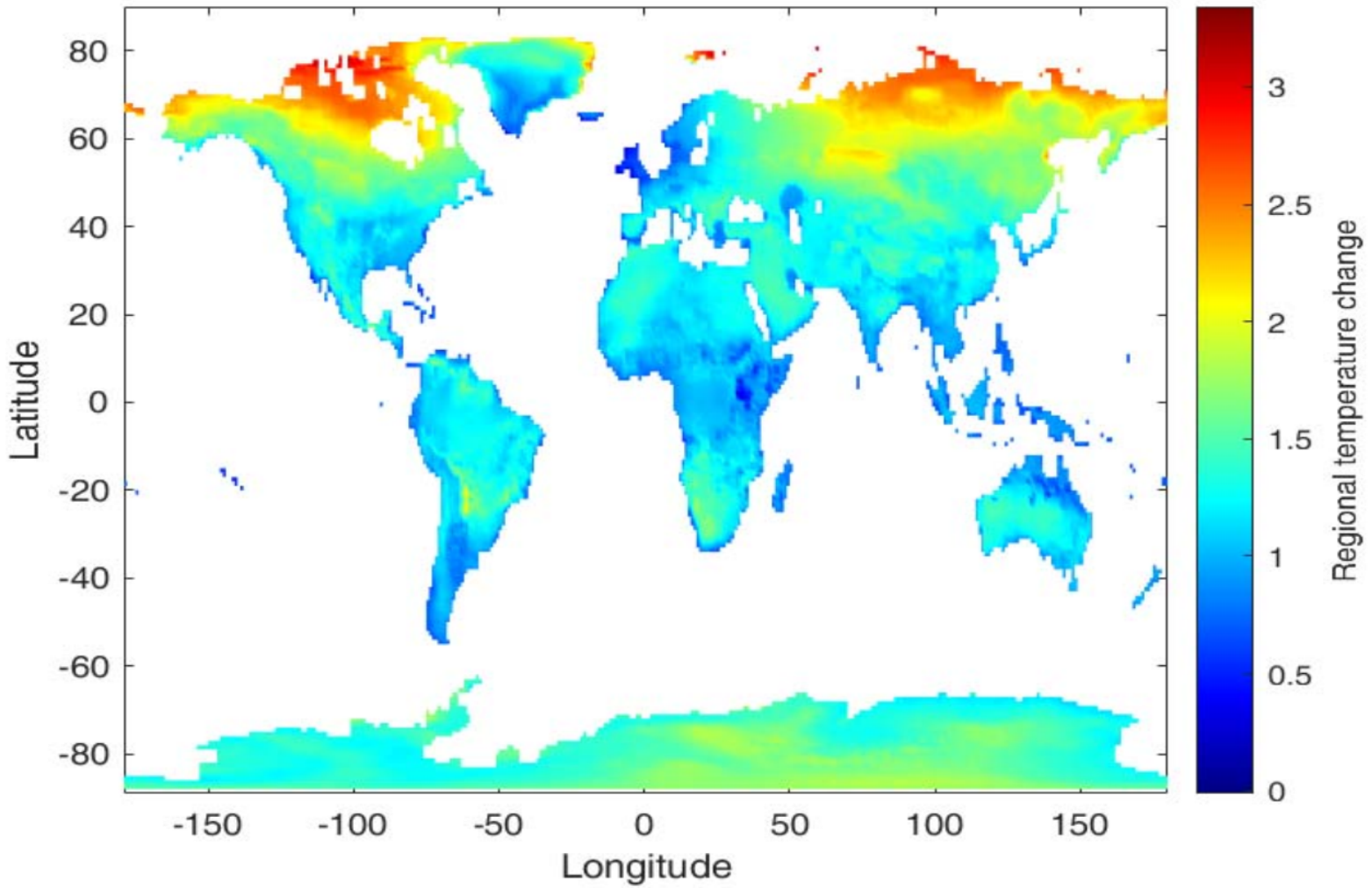
Sensitivity to Global Mean Temperature change



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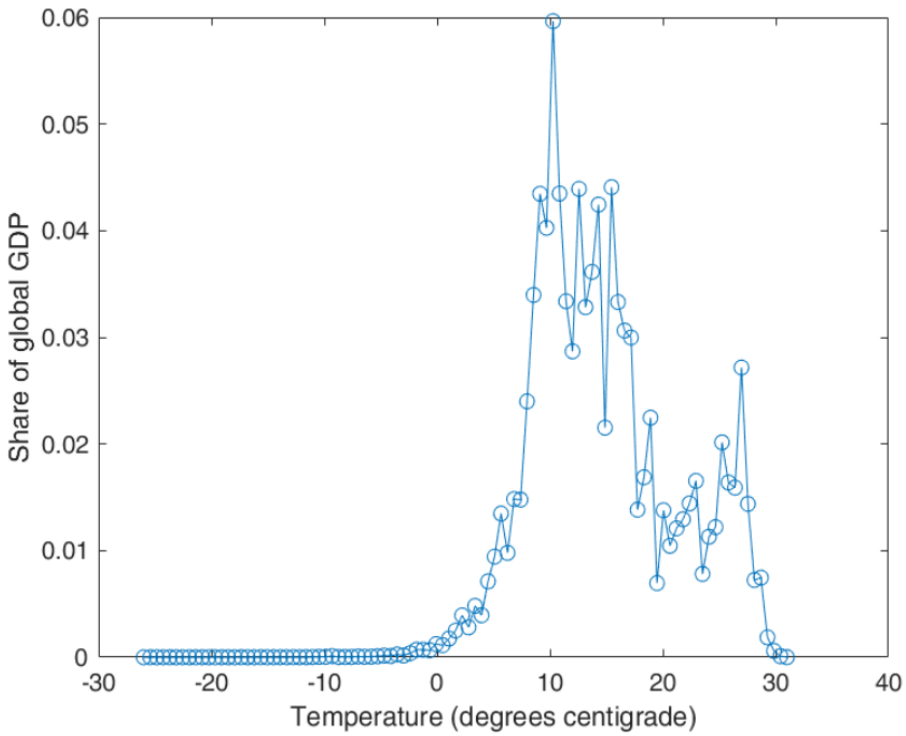
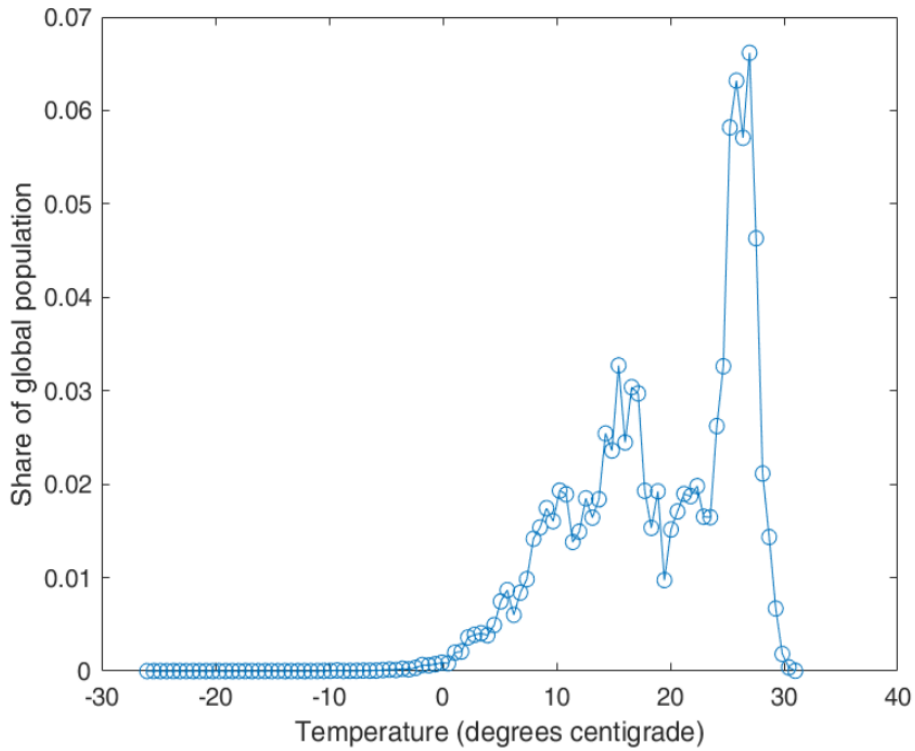
- Using our model, we can back out regional TFP in 2005.

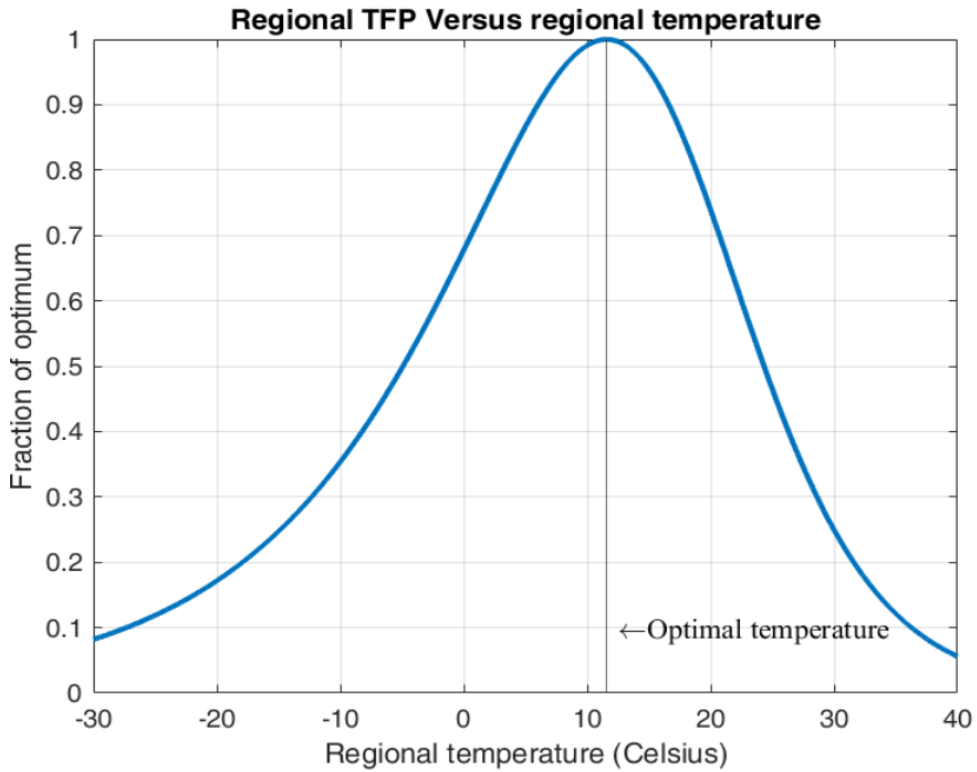
GDP and Population vs. temperature





Temperature and TFP

- Combine calculated regional TFP and average regional temperature 1980-2008 to calibrate relation between local temperature and TFP. $D(T_{ijt}) = \exp(\kappa_1 T_{ijt}) \left(1 + \exp(\kappa_2 (T_{ijt} - \kappa_3))\right)^{\frac{-\kappa_4}{\kappa_2}}$ (Cruz and Rossi-Hansberg, 2021).



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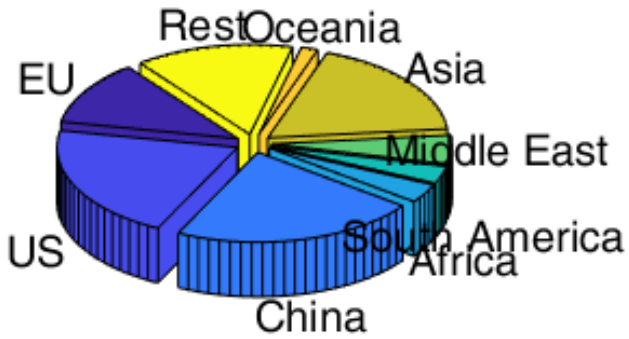
- Calibrate to output and GDP in 2005 and distribution of emissions across countries.

Initial GDP and emissions

Share of Emissions, Data 2005



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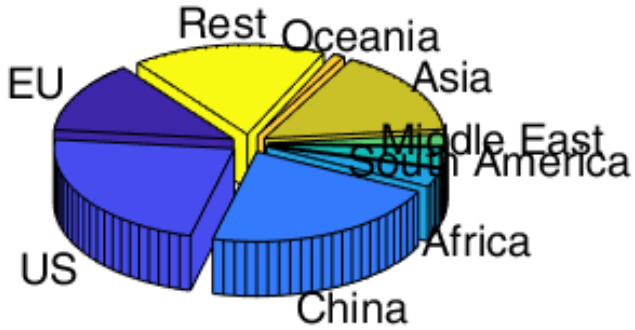

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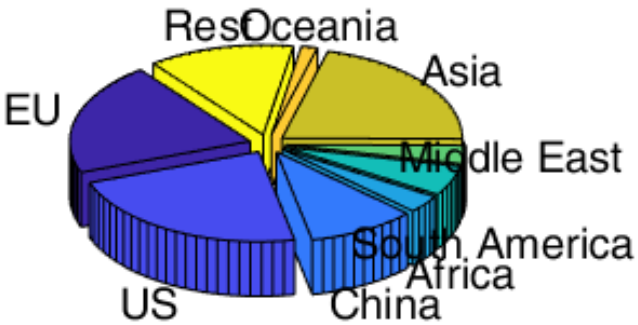

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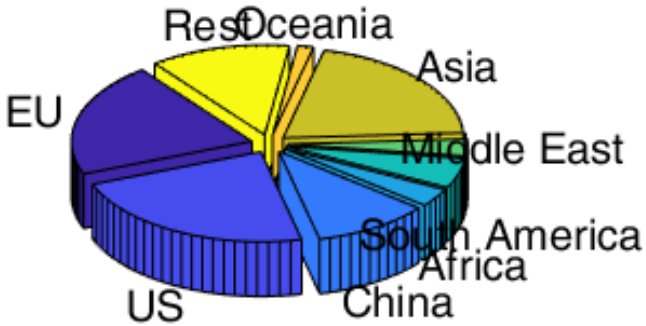
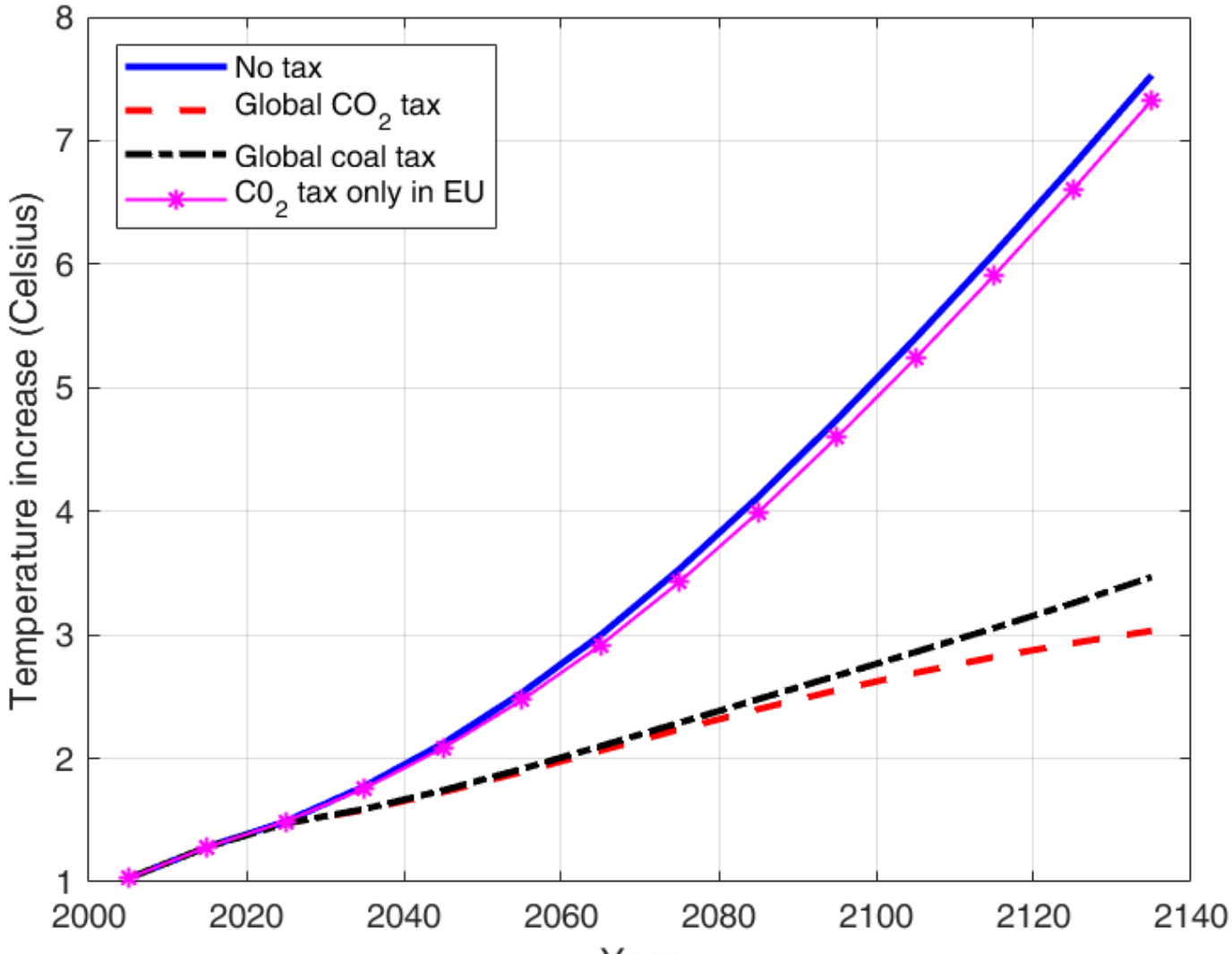
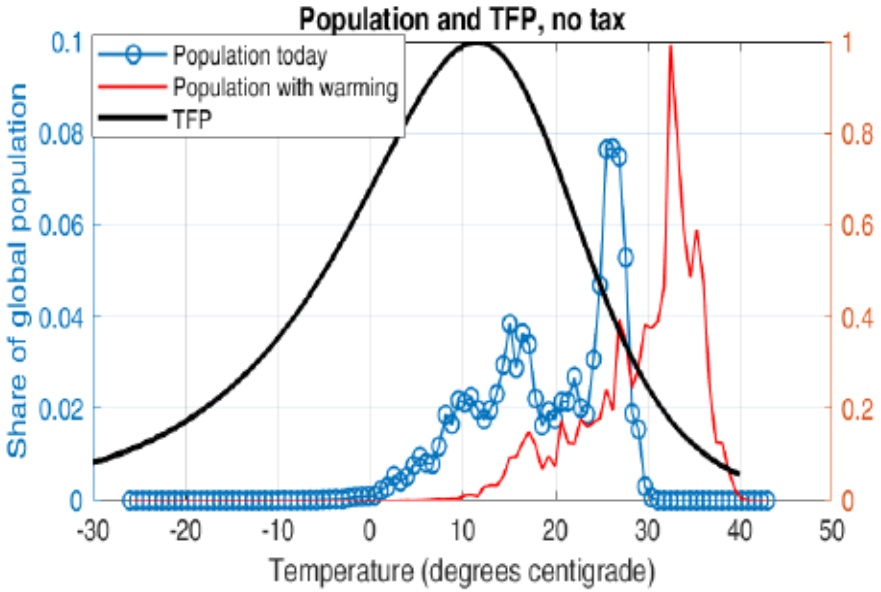


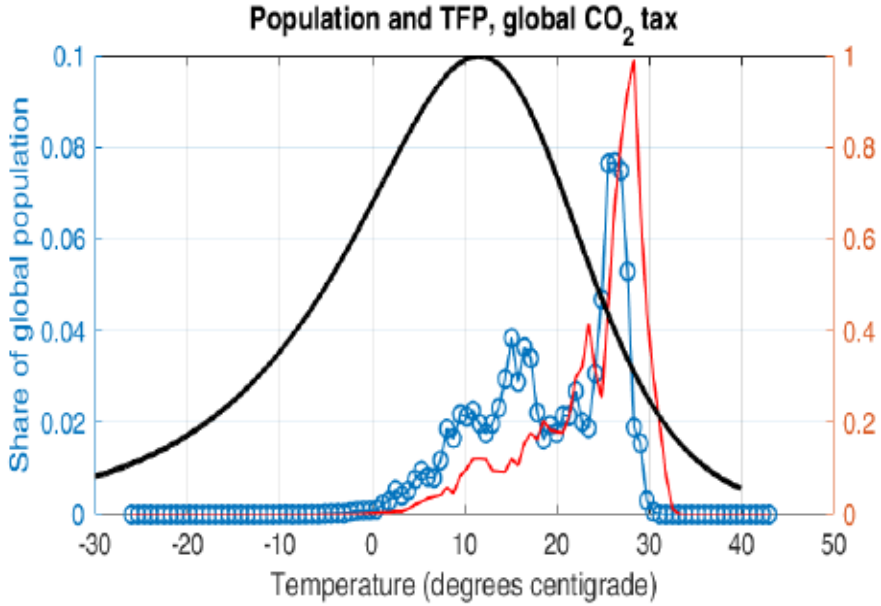
Experiment: A modest tax

- Effect of a modest CO_2 tax of USD \$20/ton CO_2 at the initial date that grows at the rate of world GDP.



Experiment: A modest uniform tax





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4. Introduce short-run frictions, in particular in energy sector.

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- Stern and Stiglitz are wrong!