

Introduction to the macroeconomics of climate change and IAMs

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Motivation

- The macroeconomics of climate change: the interdisciplinary domain that examines the aggregate economic determinants and consequences of climate change.
- Key contributions by **Nordhaus (1979)** (DICE and RICE) and **Stern (2006)** (Stern Review).
- It is a subset of the larger field of economics of climate change.
- Large (and growing!) field of research.
- It largely takes climate science as given (although it considers important uncertainties linked to it).
- But it considers the responses of economic agents to a changing environment, evaluates welfare, and attempts the design of optimal policies (or perhaps second-best policies).

Nordhaus and Stern



CO₂ emissions and global warming

Every tonne of CO₂ emissions adds to global warming

Global surface temperature increase since 1850-1900 (°C) as a function of cumulative CO₂ emissions (GtCO₂)

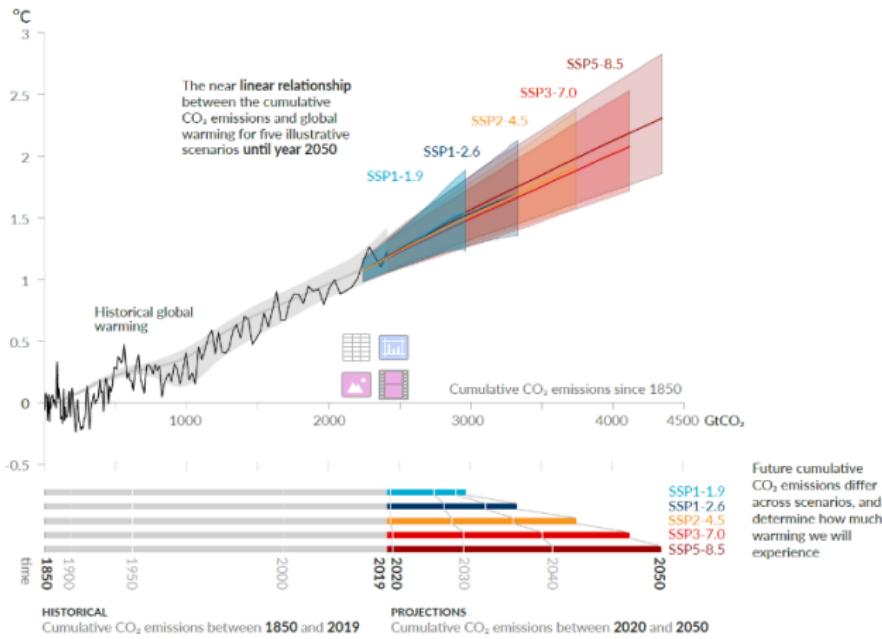


Figure SPM.10: Near-linear relationship between cumulative CO₂ emissions and the increase in global surface temperature.

Two caveats

- I will report results from standard welfare analysis (i.e., “applied utilitarianism”) in economics.
 - I have always had many issues with it, but today is not the moment to review them.
 - Often, those issues are merely academic, but here, it matters, e.g., what discount factor do we use?
- Since this is a (short) introductory talk, I will omit (most) references and sources. Please let me know if you want more info about them.
- One notable reference with more introductory details:
<https://phdmacrobook.org> (Chapter 23).

Some background

Five observations from Hassler et al. (2024)

1. A simple system of five difference equations describes the relation between emissions of CO₂ and global warming quite well, both qualitatively and quantitatively.
2. Global CO₂ emissions are not falling, but they are increasing at a lower rate than two decades ago. Both consumption- and production-based emissions have fallen in the EU and the U.S. over the last two decades, whereas the opposite is true for emissions in China and India.
3. Global warming is approximately proportional to the cumulative emissions of CO₂, in both the short and long run.
4. The amount of fossil fuel left in the ground is very large compared to the carbon budgets for 1.5°C and 2°C global warming. The amount of oil and gas with low extraction costs is of the same order of magnitude as these carbon budgets.
5. The frequency and intensity of key weather extremes increase with the global mean temperature. The predicted increase is gradual and approximately linear, but the uncertainty is very large.

The basic idea

- Use of integrated assessment models (IAM): how the economy and climate interact quantitatively.
- Three blocks: economy, climate, and damages.
- Nonlinear and stochastic dynamics.
- Uses:
 1. Positive analysis \Rightarrow future paths of variables of interest.
 2. Normative analysis \Rightarrow design of optimal policies.
 3. Counterfactuals \Rightarrow mitigation, changes in technology, ...

Stylized IAM

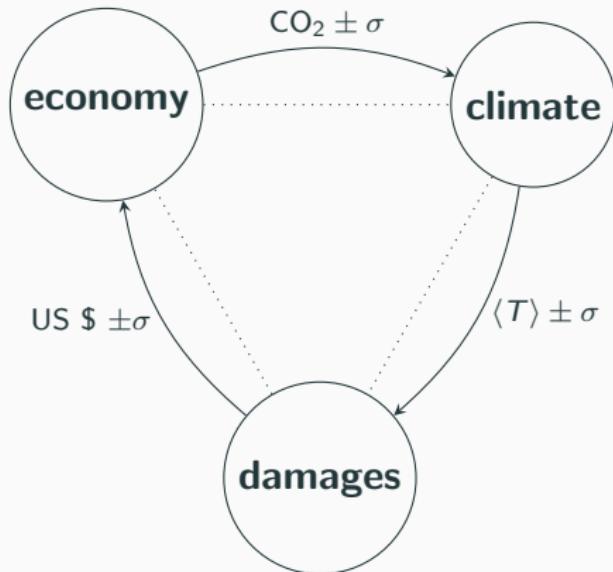


Figure 1: Stylized representation of an IAM.

A simple example

- Cruz and Rossi-Hansberg (2023).
- Average welfare losses of 6%.
- Large heterogeneity in climate damages across space: from welfare losses of 20% to gains of 11%.
- Large role of adaptation, particularly migration.
- Large disagreement across regions.
- See also Kotlikoff et. al (2023)

Damage functions (Howard & Sterner 2017)

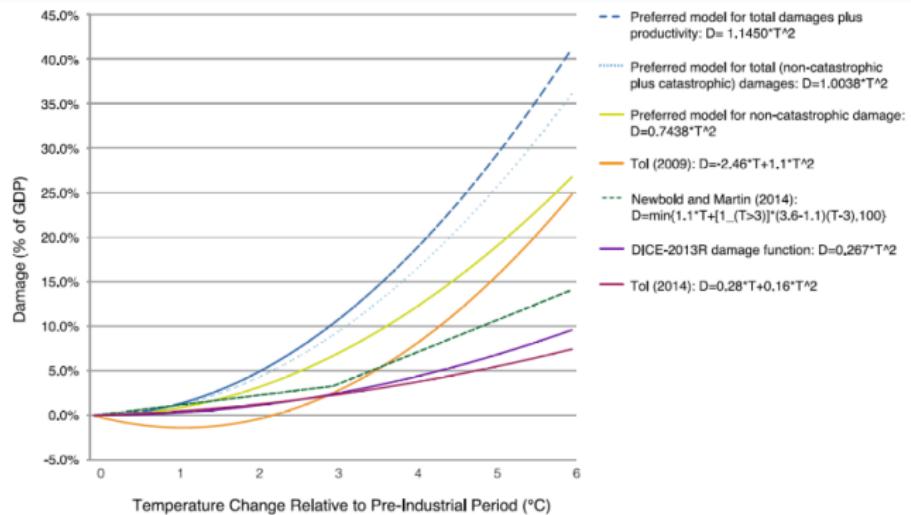


Figure 2: Burke, Hsiang, Miguel 2015 Nature. Econometric example with very high damages.

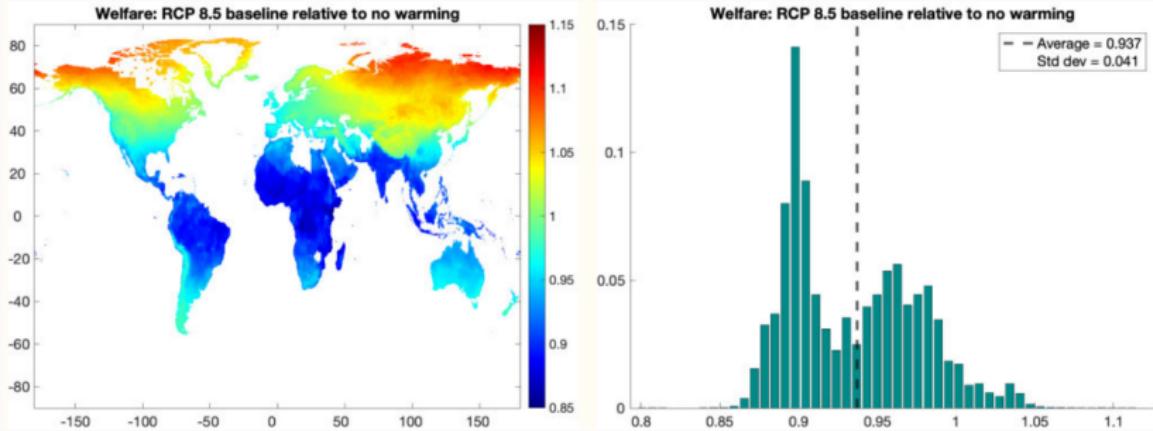


Figure 3: Welfare losses due to global warming

Spatial inequality: Welfare losses due to global warming

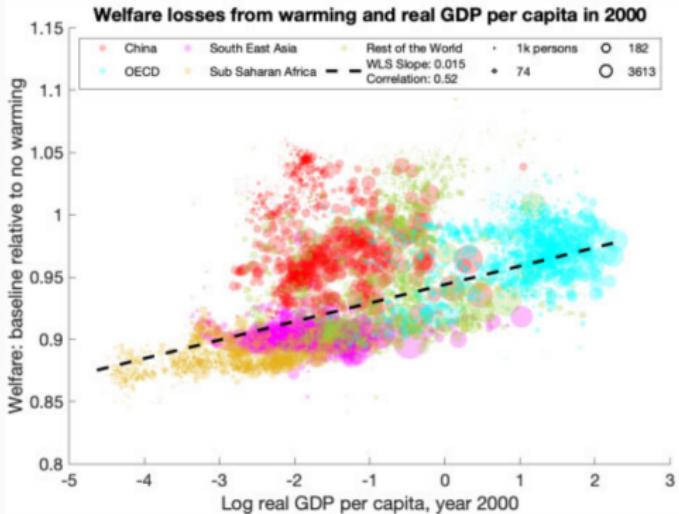


Figure 4: Welfare losses due to global warming

- The figure presents scatterplots of the local welfare losses from global warming versus local real GDP per capita in the year 2000. The colors indicate different areas of the world, and the size of each dot also represents the population of the cell in 2000. The dashed black lines present the population-weighted linear relationship.
- The world's poorest regions, mainly in Sub-Saharan Africa and South East Asia, are expected to undergo the highest warming losses.
- OECD countries, with initially high income, are much less affected.

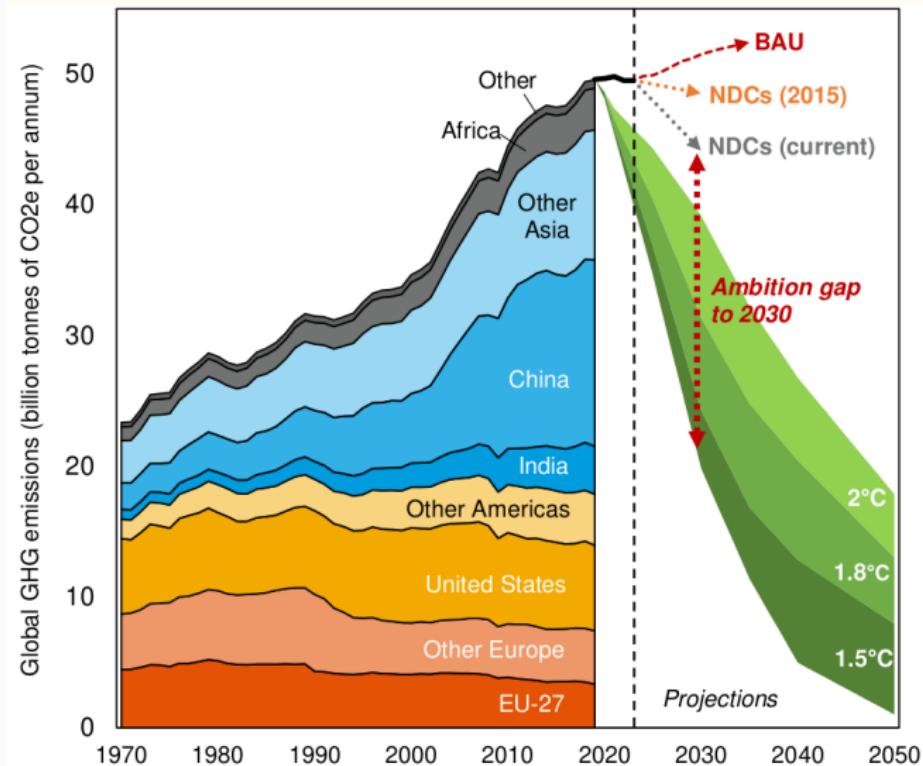
Task to complete

- Complex computation (see later today).
- Quality of climate emulators: Folini et al. (2024).
- Long-run impacts.
- Uncertainty:
 1. Precautionary behavior.
 2. Tail events.

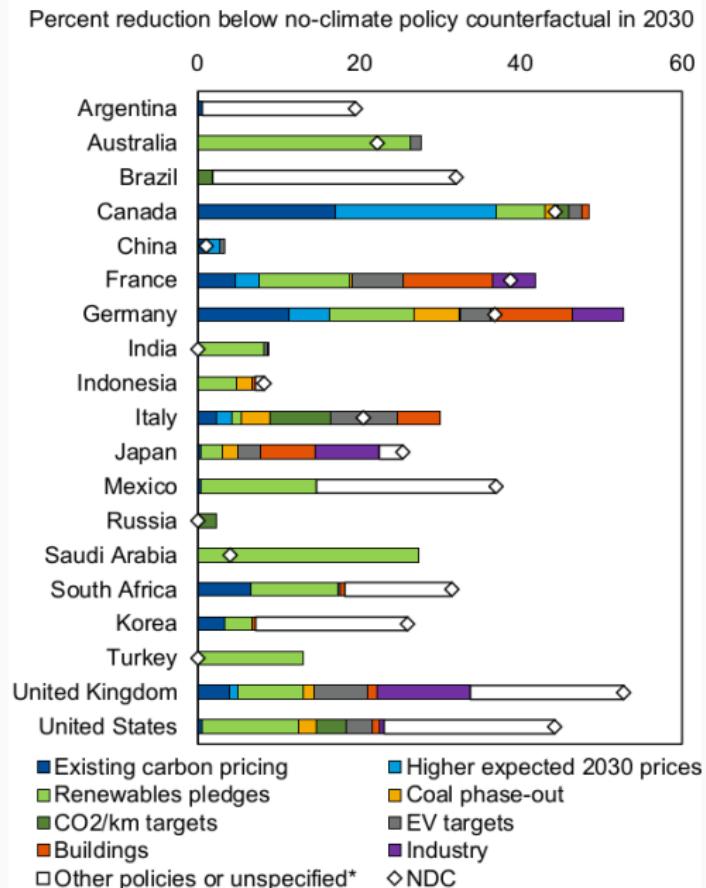
The situation

- The 2015 Paris Agreement required limiting global warming to “well below 2°C.”
- Current efforts are far from the goal.
- Particularly serious from China and India.

Global GHG emissions



Percent reduction below no-climate policy counterfactual in 2030

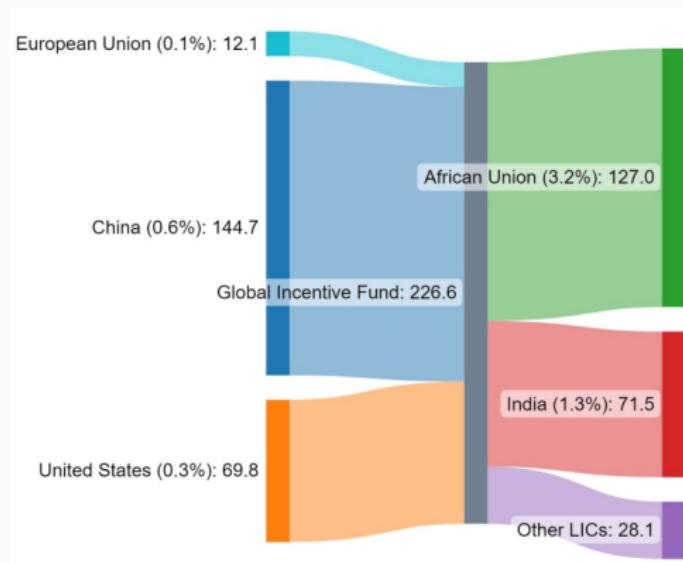


Large transition costs.

- “The worst economic argument ever”
- The de-carbonization of the economy will create many “green” jobs, “green” investments,...
- Every job “created” (or investment required) is a cost for society, not a benefit.
- Which technology would you choose?
 1. A net-zero technology that would generate all the energy we need on earth, with an investment cost of \$1, and that only requires one worker to operate.
 2. A net-zero technology that would generate all the energy we need on earth, with an investment cost of \$1 trillion, and that requires ten million workers to operate?
- More in general, no, de-carbonization will not increase economic growth. Let's be honest with the public.

- Large re-distributional effects: reallocation of production across space and sectors.
- Large free-riders problems.
- Border adjustments.
- Limited fiscal space.
- Geopolitical fragmentation.
- Higher interest rates?

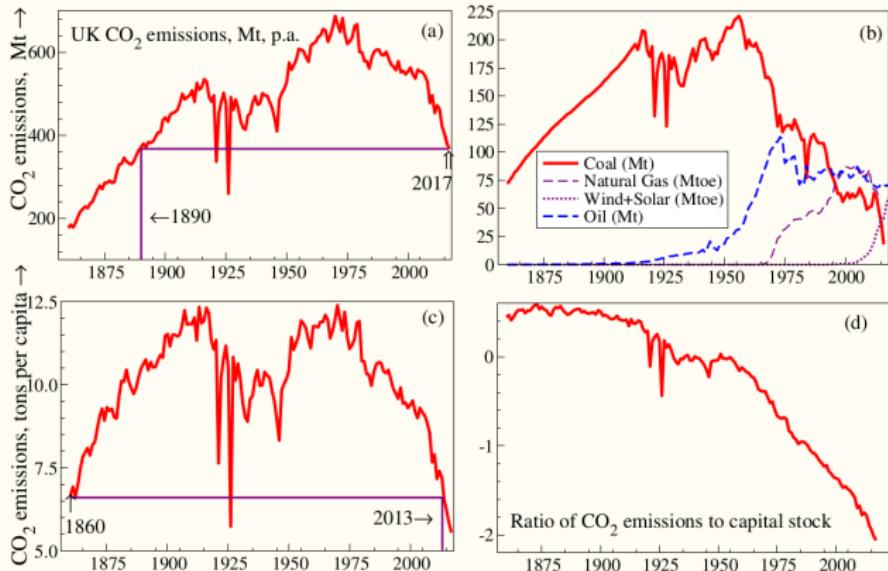
Fiscal Transfers if Revenue of a \$25 per ton Global Carbon Tax is Shared on a per-capita basis (2030)

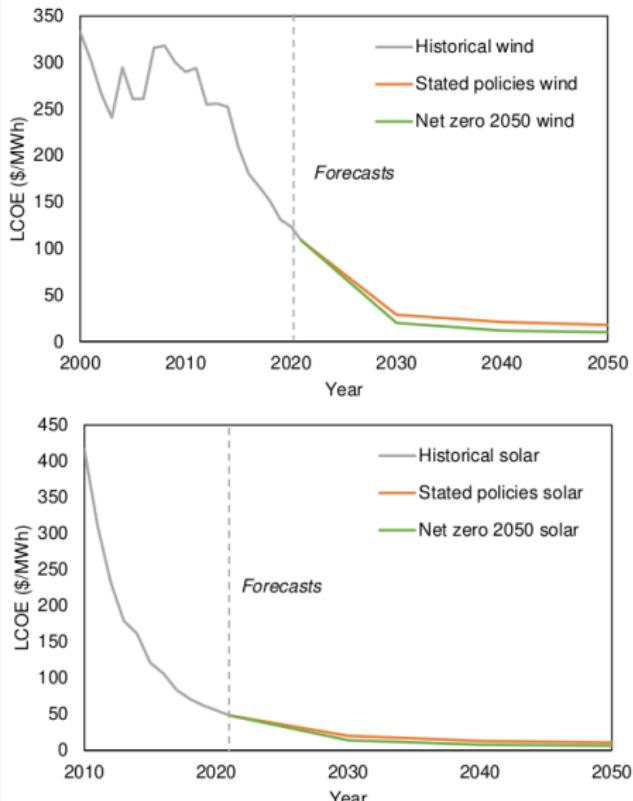


The opportunities

- Human ingenuity plus the power of incentives is extremely powerful.
- In fact, technology has progressed faster than expected.
- Levelized Cost of Energy (LCOE) from state-of-the-art utility-range solar is probably now lower than any alternative (\$24 MWh).
- Fast developments in syngas and carbon capture.
- Network externalities (van der Ploeg and Venables, 2022).
- Incredibly fast drop in global fertility.

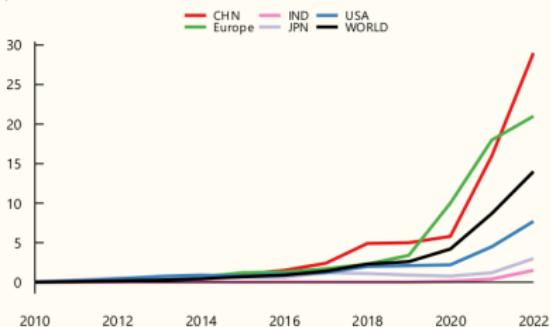
Emissions



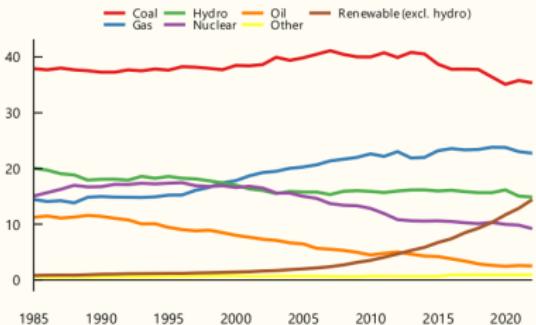


EV car sales and electricity

EV car sales
(percent of car sales volume)

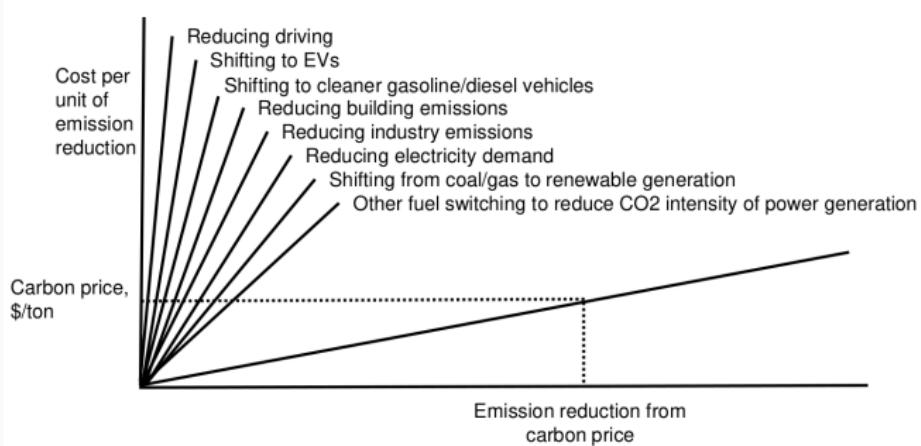


Share of global electricity generation by fuel
(percent)



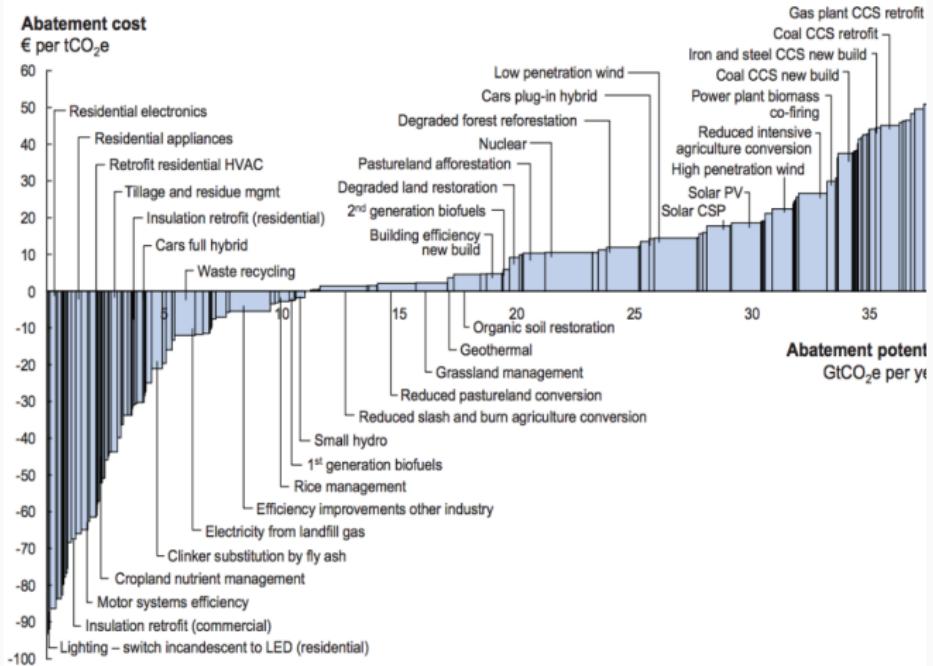
- How do we ensure that the opportunities dominate the challenges?
- Economists have traditionally defended carbon tax and technology-agnostic subsidies.
- Carbon tax: Golosov et al. (2014).
 1. Tax proportional to current GDP, damage parameter, and duration of carbon in the atmosphere.
 2. Independent of technology, future output, alternative energy, carbon capture, uncertainty, ...
 3. Also, rather robust to the mistake of being “pessimistic.”
 4. A global carbon tax of around \$100/tc will probably get most of what we need.
 5. But even a carbon tax of around \$25/tc will make a considerable difference.
- See, also, Kotlikoff et al. (2023).

Cost effectiveness



GHG abatement cost

Global GHG abatement cost curve beyond business-as-usual – 2030



Why technology-agnostic subsidies?

- Technological progress is directed.
- But also unknown.
- Not an idle worry:
 - If we had let nuclear energy develop in the 1970s, we would not be here.
 - Personally, I assess letting the nuclear technology train pass as one of the largest mistakes humanity has ever made.

Political-economy considerations make optimal policies rather difficult to implement.

- Large range of alternative policies:
 1. Reduction emissions.
 2. Mitigation (and geoengineering?).
 3. R&D.
- Unfortunately, most policies selected by governments are too expensive for the results they yield or even counterproductive (e.g., IRA).
- What about Sinn's Green Paradox?

Sabotage



- Most lifestyle changes (e.g., less flying and eating less meat) are at best useless, at worst counterproductive.
- Effect on total net global emissions is minuscule: not even a rounding error!
- Large negative welfare effects and alienate voters.
- Nonetheless, better information (e.g., how to re-design houses to reduce electricity consumption with minimal effects on welfare) and solving network effects have proven to be useful.

- Using monetary policy/central banks/financial regulation for climate change is a tricky issue (mandate).
- Extremely costly (Abiry et al. (2022)).
- It might be the end of the independence of central banks.
- There is plenty of capital out there without the need for “green bonds” or similar.
- The same goes for ESG. Most of it is greenwashing, and the rest is kidnapping shareholders for private political goals.

Concluding remarks

- From a purely technological perspective, the problem of climate change has been fixed.
- We have the technology (either already existing or in the short-run pipeline) to achieve net zero at a reasonable cost.
- And, no, we do not need to do crazy things (like all going vegan) or jeopardize monetary policy.
- Now the issue is merely of political economy: who will pay the bill?
- Of course, this is both optimistic and pessimistic.
- Think about Argentina: we perfectly know what has been wrong with it since 1945, and yet, little progress has been made.