Introduction to the macroeconomics of climate change and IAMs

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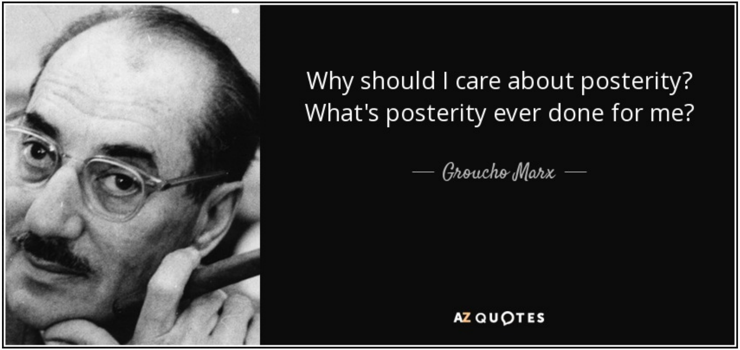
Motivation

- 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

Climate Change - the core problem



CO_2 emissions and global warming

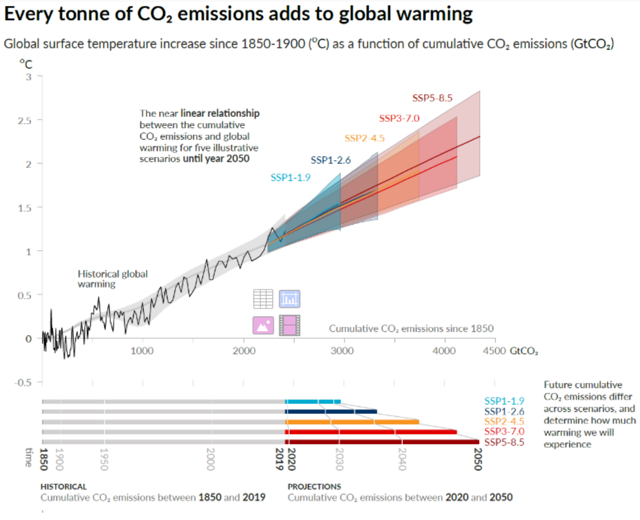


Figure SPM.10: **Near-linear relationship between cumulative CO2 emissions and the increase in global surface temperature.**

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.

Integrated assessment models (IAMs)

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

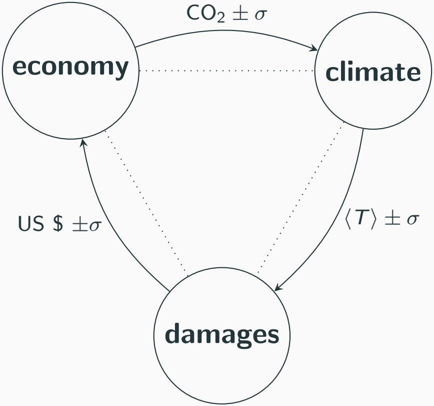


Figure 1: Stylized representation of an IAM.

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)

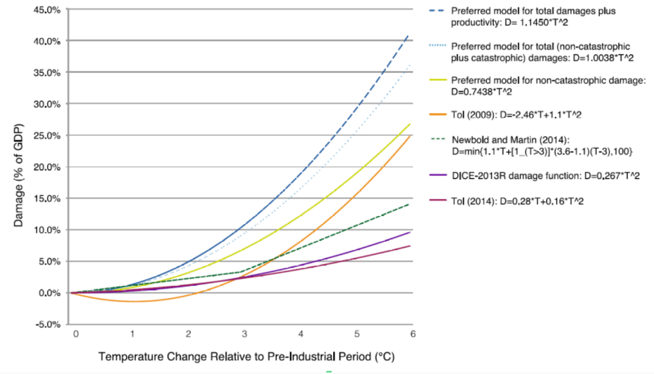


Figure 2: Burke, Hsiang, Miguel 2015 Nature. Econometric example with very high damages.

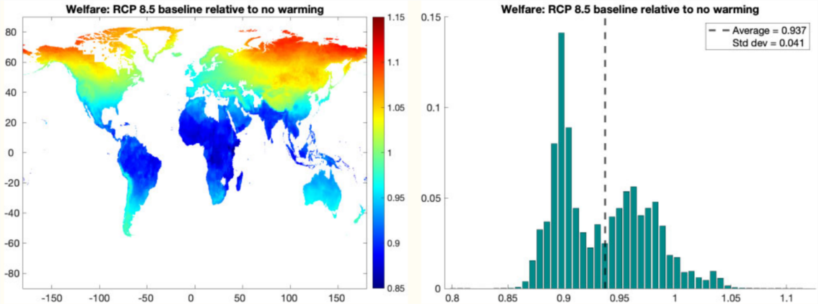


Figure 3: Welfare losses due to global warming

Spatial inequality: Welfare losses due to global warming

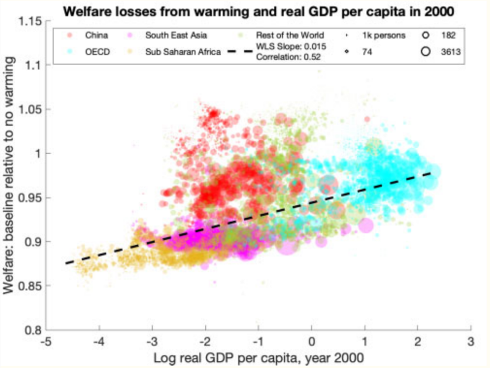


Figure 4: Welfare losses due to global warming

- 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

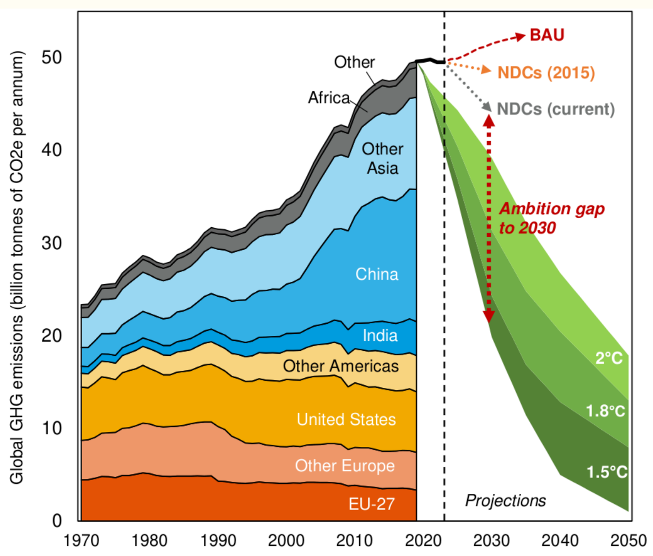
- Complex computation (see later today).
- Quality of climate emulators: Folini et al. (2024).
- Long-run impacts.
- Uncertainty:
    1. Precautionary behavior.
    2. Tail events.

Some policy implications

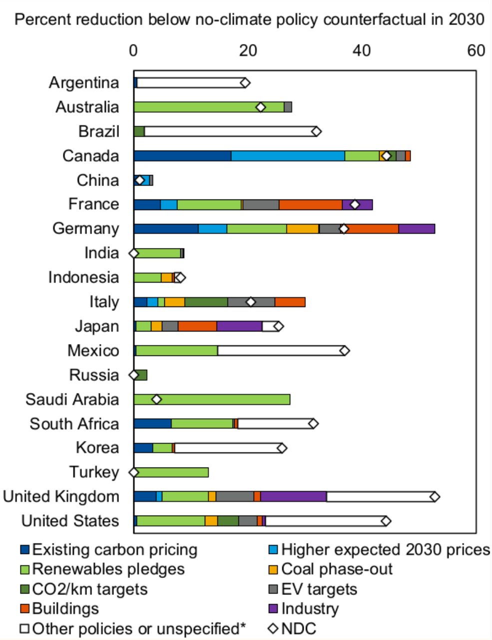
The situation

- 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



The challenges, I

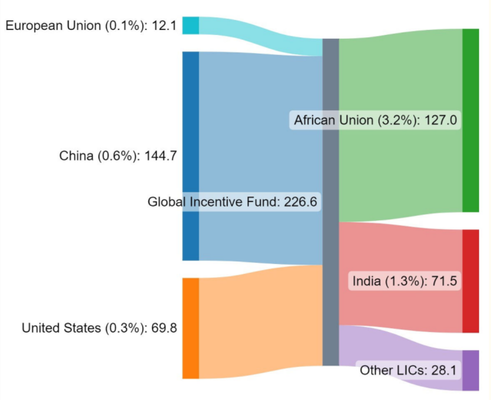
Large transition costs.

- "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.

The challenges, II

- 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?

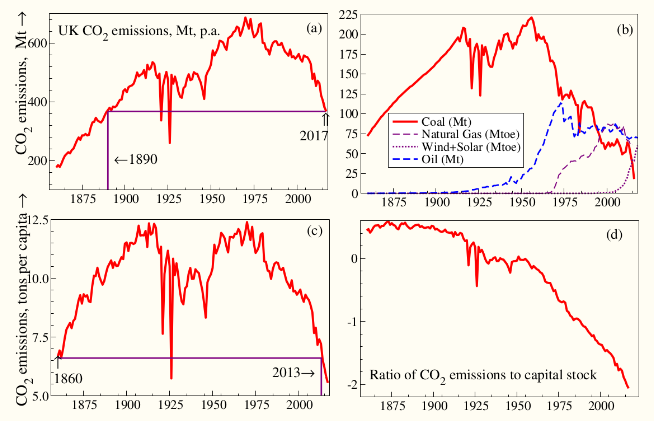
Fiscal Transfers if Revenue of a $25 per ton Global Carbon Tax is Shared on a per-capita basis (2030)



The opportunities

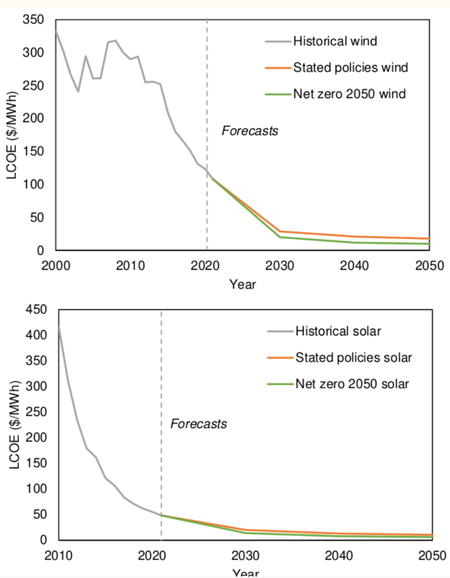
- Human ingenuity plus the power of incentives is extremely powerful.
- In fact, technology has progressed faster than expected.
- Levelized Cost of Energy (LCOE) from state-of-the-art utility-range solar is probably now lower than any alternative (\$24 MWh).
- Fast developments in syngas and carbon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

Emissions



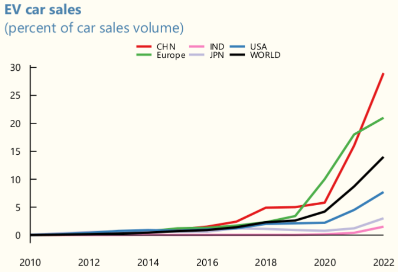
UK CO_2 emissions, Mt, p.a.
(a)
CO_2 emissions, Mt →
600
400
200
←1890
2017
1875
1900
1925
1950
1975
2000
(b)
225
200
175
150
125
100
75
50
25
0
Coal (Mt)
Natural Gas (Mtoe)
Wind+Solar (Mtoe)
Oil (Mt)
(c)
CO_2 emissions, tons per capita →
12.5
10.0
7.5
5.0
1860
2013→
(d)
0
-1
-2
Ratio of CO_2 emissions to capital stock

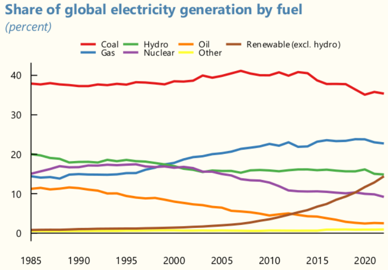
LCOE



350
300
250
200
150
100
50
0
LCOE ($/MWh)
2000
2010
2020
2030
2040
2050
Year
Historical wind
Stated policies wind
Net zero 2050 wind
Forecasts
450
400
350
300
250
200
150
100
50
0
LCOE ($/MWh)
2010
2020
2030
2040
2050
Year
Historical solar
Stated policies solar
Net zero 2050 solar
Forecasts

EV car sales and electricity

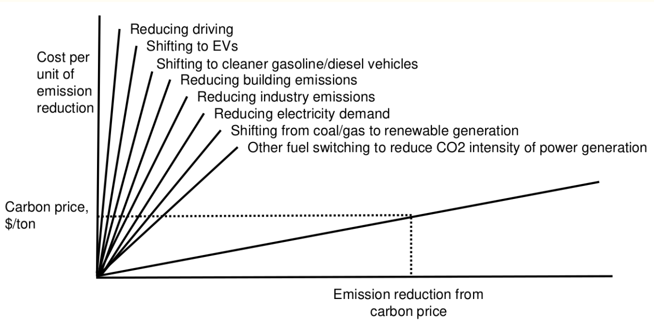




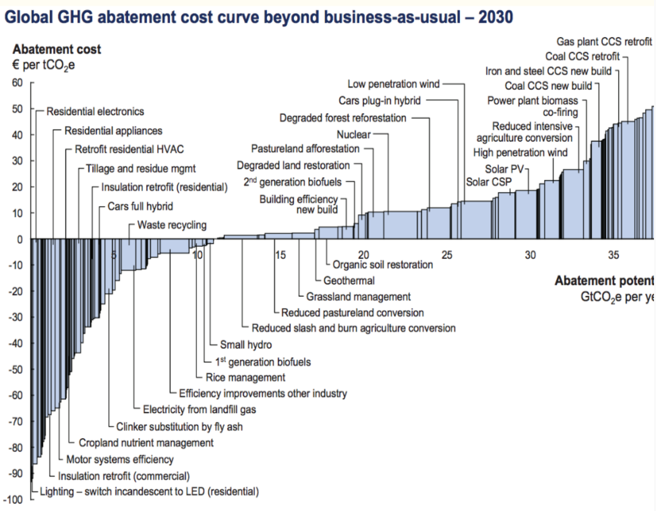
The policy balance, I

- 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



The policy balance, II

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.

The policy balance, III

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

The policy balance, IV

- 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 useful.

The policy balance, V

- 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.