

Climate Change

Stanford Lunch Talk

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Level

(I am guessing that the level should be for finance researchers without much background in climate change.)

Warning: Presentation Coverage

- ▶ Covers many areas,
- ▶ Covers work of many other researchers,
- ▶ Covers textbook (my class), and
- ▶ Mentions my own research.

Too much!

- ▶ Many opinions, emotions, and misinformation about CC.
 - ▶ All of us know a little about pieces
 - ▶ Extreme intellectual hostilities, even for academia.
 - ▶ Distorted by ideology and politics, too.
 - ▶ I will miss many subtleties in my 60-min attempt.
 - ▶ I may have to cut some discussion short. Too much material.
Apologies in Advance. Talk to me over coffee.
 - ▶ But I do want to answer (tough) questions. Point of a seminar. Will tell you if I oversimplified, don't know, or disagree.
 - ▶ I am not trying to be brusque, but may have to.

Talk (and Textbook and Course) Outline

1. Climate Change Earth Science Background
2. Social Science Perspective
3. Technological Predictions

1. Climate Change

- ▶ I use data and predictions from the IPCC.
 - ▶ Reasonably good, despite some (reasonable) quibbles.
 - ▶ Like economics: Not everything is right, but it's better than the alternatives when talking about economics.
 - ▶ Not perfect. Some bias. In flux. Just like us!
 - ▶ Better than knee-jerk alternatives (JL?).
 - ▶ What would even be reasonable alternatives?
 - ▶ More than good enough for what my own points are.
 - ▶ (Interesting to argue details for other researchers.)
 - ▶ if a little better or worse, no problem for me.

- ▶ Earth has been heating up and will continue to do so.
 - ▶ Measurable current radiation imbalance.
 - ▶ Mean consensus: Think $\approx 2-3.5^{\circ}\text{C}$ by 2150 (1°C already).
 - ▶ baseline always difficult to keep straight. I use book.
 - ▶ More catastrophic scenarios, say up to $5^{\circ}\text{C}+$, possible.
 - ▶ domino effects, tipping points, etc.
 - ▶ low prob, but not far-left tail...probably.
 - ▶ Expected Mean Sea Level (MSL) Rise: $\approx 1-2$ feet.

- ▶ CC will be major problem in “marginal” regions.
 - ▶ (Change itself is costly [and, when slower, inevitable].)
 - ▶ exact locations unknown, but prbly not USA and Global North.
 - ▶ (CC is *not* the same as water shortages, species mass extinction, or biosystem collapse, though it can contribute to these.)

- ▶ Yes, Jonathan.
 - ▶ PS: I am not making up that countries will be hurt, but adopting the overwhelming scientific consensus here.
 - ▶ There is evidence that hotter years have depressed growth in hot countries. See below.
 - ▶ Nordhaus, Pindyck, etc. have signed on, too.
 - ▶ For my perspective, it is ok if it is less bad, but somewhat bad.

- ▶ Most paleo-evidence is irrelevant.
 - ▶ CO₂ was endogenous, except in some episodes.
- ▶ Recent 150 years, plus physics, identify current cause:
 - ▶ Humanity is running a ghg experiment — and it is working!
 - ▶ Isotopes strongly suggest fossil fuel drove increase in CO₂

- ▶ But it doesn't really matter much. If CC had been due to hotter sun, the important questions would be the same:

What should and can we do about CC now?

- ▶ My Focus: Mitigation. (Adaptation more important?!)

- ▶ Science: Lots of uncertainty about $\text{CO}_2 \rightarrow$ Temp (climate-sensitivity) coefficient.
 - ▶ Doubling of CO_2 increases global temp by how many $^\circ\text{C}$?
 - ▶ From 1 to 5, with consensus average about 2-3.
 - ▶ physics of GHG effect solo about 2.
 - ▶ Humanity has increased CO_2 by 50% (280 to 420 ppm).
 - ▶ Air CO_2 will go considerably higher (to 750-850ppm).
 - ▶ ...but never to Mars (think 95% air CO_2)
 - ▶ Temporary interlude: Earth will remove human CO_2 again (but temp interludes can kill lots of life);

- ▶ Science Plus Econ: relatively better predictions of future CO₂ emission paths:
 - ▶ RCP 2.0 - 3.0 — some dreamers still believe possible.
 - ▶ RCP 4.0 - 6.0 — realistic range
 - ▶ +2°C to +2.5°C (above today, not preind)
 - ▶ subject to clean-E progress, econ growth, renunciation.
 - ▶ CC is coming. Action range is limited to about 0.5°C.
 - ▶ RCP 8.0 - 9.0 — almost surely no longer the future.
 - ▶ +3°C+
 - ▶ use only as (inferior) standin for “worse than expected” outcome
 - ▶ backward-looking, we are still on it (clean E is coming)

- ▶ Global climate change (even if 3-5°C)
 - ▶ will likely be bad for hundreds of millions of people,
 - ▶ but will likely only be nuisance for billions of other people.
 - ▶ CC is not even predicted to dent WW population growth or shrink per-person forecast income.
 - ▶ Nothing is certain, though.

- ▶ Unlikely that the world will end due to CC.
- ▶ No certainty that the world will *not* end due to CC.
 - ▶ extremely unlikely, though no one knows for sure.
 - ▶ credible scientists do not predict it
 - ▶ same for contagious epidemics, nuclear wars, supervolcanos, undetected major asteroids, etc.

- ▶ My own points are the same regardless of where CC outcome will end up between “nuisance” and “end of advanced civilizations.”
 - ▶ you are welcome to your own alternative POV
 - ▶ as long as you agree that fossil fuel (incl PM) emissions are now “harmful” on the margin.
 - ▶ (of course, also great benefits, but public goods problem.)
 - ▶ less energy is not (necessarily) a better alternative!
 - ▶ better alternatives are only now becoming available!
 - ▶ (Good evidence that global warming has been harmful *sofar* short-term in hot countries.)

▶ Posited Assumption:

- ▶ Fossil fuels have serious negative externalities (PM and GW)
- ▶ Socially, collectively, world parties burn too much FF now, relative to social coordinated optimum

Sidenote: My Own Current Empirical Work

- ▶ (Existing) Facts:
 - ▶ About 1°C avg WW warming in last 40 years.
 - ▶ Good year-to-year variation (but esp in North).
 - ▶ **Hotter years have been harmful to countries!**
 - ▶ (Adaptation could reduce future harm.)
- ▶ (Existing) Empirical Work:
 - ▶ All that mattered was poverty.
 - ▶ Geography was unimportant.
 - ▶ Shown only on margin, but also solo(!)
 - ▶ Arguably wrong specification.

(With Romain W:)

- ▶ **Weird Specification in earlier work**
 - ▶ Poorer countries have had a neg coef
 - ▶ Hotter countries (solo!) have had a pos coef
- ▶ **Correct Specification**
 - ▶ Hotter countries have *never* had a positive coef
- ▶ **Novel and Perhaps Worrisome: After year 2000**
 - ▶ Geography has become the dominant harm determinant.
 - ▶ Poverty has been carrying much little importance.
 - ▶ Inescapable harm?
 - ▶ (but long-term adaptation more related to wealth?)

Economic Bases

PS: WW emissions were caused by

- ▶ About 1/3 to 1/2 due to popgrowth.
- ▶ About 2/3 to 1/2 due to living standards.
 - ▶ not “luxury” (plastic bags), but “modern lifestyle”
 - ▶ think living to 80 years, motorized moving, sitting in a heated room, no fear of famines.
- ▶ (Efficiency grew nicely but not enough.)

Economic Workhorse Models

- ▶ Integrated Assessment Models (IAM)
- ▶ Nordhaus, Stern IAMS
 - ▶ seminal and great (but) sketch models.
 - ▶ CC is economically harmful. SCC (not /tC but /tCO₂).
 - ▶ Shadow price of emissions is \$30-\$50/tCO₂.
 - ▶ Add in CC uncertainty, shadow price is more like \$100 / tCO₂
 - ▶ convex damages
 - ▶ SCC should be rising in the future.
 - ▶ Some disagreement on discount rate etc. Too literal?
- ▶ Nordhaus: Climate Pacts?

Sidenote: Current IAMS Theory Work

- ▶ Uncertainty may **not** increase shadow price of emissions.
 - ▶ Geoengineering would almost surely make it possible to cheaply and quickly cool down planet.
 - ▶ not a perfect fix. A band-aid, but a very quick and effective one.
 - ▶ (moral hazard? would argue no.)
- ▶ **Real option:** the optimal choice may well be to wait and first see what the climate response coefficient to CO₂ is.
- ▶ Admittedly schizophrenic academic curiosity.

Textbook

- ▶ (Some emphasis on different perspective now.)

Textbook: Really?

- ▶ Problem is not about what “we” *should* do.
 - ▶ Most current debate is irrelevant to CC.
 - ▶ Angels on the heads of pins.
 - ▶ (even Lomborg and Koonin.)
- ▶ Problem is also not about ethical considerations
 - ▶ development today vs less climate change tomorrow.
 - ▶ book still explains the ethics, no time here.
- ▶ Problem is about what “we” *will* (and *can*) do.
 - ▶ No solutions, but better or worse approaches/remedies.
 - ▶ Realistic does not mean nihilistic.

Main Point

- ▶ Realism is primarily about self-interest, with only 2nd- and 3rd-order sacrifices viable, on worldwide basis.
- ▶ Even economists often get upset when I lay out the evidence and talk about self-interest
 - ▶ What if the world comes to an end?
 - ▶ How can I be so callous?
 - ▶ Seems bizarre — self-interest is at core of our discipline.
 - ▶ (A few economists have an extreme opposite reaction.)

Easy Blurps For Non-Economist Relatives

1. Countries have militaries for the same reason why they will not decarbonize.
2. Arguing about whether a nuclear war will kill 1 or 5 billion people is irrelevant.
3. Arguing about the optimal world choice is irrelevant.
4. Arguing about what can realistically be done *asap* to reduce the probability of nuclear war may not be ideal but it is the only relevant discussion.

Too obvious?

1. CC No Longer an OECD Problem

2050-2100	OECD	Not OECD
Population	12%	88%
GDP	50%	50%
Energy	30%	70%
Emissions	28%	72%

Fact 1. No Longer an OECD Problem

- ▶ 2/3 of emissions today are non-OECD. 3/4 soon.
- ▶ It's not about luxury consumption.
 - ▶ “We” are no longer starring players.
 - ▶ USA is ultimately not primarily causing Δ CO₂ in air.
 - ▶ India now matters more. (China matters, but is done.)
 - ▶ If Africa were to develop, much worse. (Pop growth.)
- ▶ Climate activists' main focus on shooting ourselves in the foot has little chance to curb CC.
 - ▶ they should not care so much about OECD and ESG and ...

Fact 2. Humanity is not the BORG.

- ▶ (Worldwide SCC is never applicable to us.)
 - ▶ Req: 1 mo rent (worldwide), 3-6 mos if OECD alone.
 - ▶ “Who” is often left badly vague even in talks.

SCC is practically irrelevant.

- ▶ There will be no climate pacts.
- ▶ There will be no (WW) consumption renunciation.
- ▶ There will be no generational commitments.

Need It More Obvious?

Spend all military expenses on CC instead?

- ▶ Discuss any more obvious dreams / absurdities?
- ▶ I know of no free-rideable treaty with major sacrifices ever voluntarily widely (WW?) adopted?
 - ▶ painful implementation is not babble at COPs
 - ▶ Montreal Ozone is *not* it.

Revealed Preference

As of 2020s, three decades by now:

- ▶ World can suck out at $< \$10/\text{tCO}_2$ *on the margin* today. Who is volunteering to pay?
- ▶ Spending a lot more today due to concern about going beyond the margin seems sysiphean.
 - ▶ some research funding for better ideas seems ok
- ▶ Who wants to pay to suck out China's and India's increasing GDP emissions?

- ▶ Which developed country voters will say “it was our fault, let’s transfer tens of billions of dollars to other countries?”
 - ▶ Who cares about the small EU?
 - ▶ And even EU doesn’t really do it much, either.
- ▶ Which other country voters will say “it was their fault, but they are now cutting back, so we shouldn’t emit, either?”

Hopeless Economic Misanalysis (IMHO)

- ▶ Everything renunciation related.
 - ▶ Carbon Footprints.
 - ▶ Belt-Tightening in OECD.
 - ▶ Plastic straws are wealthy salon insights.
 - ▶ (PS: I am not against reducing plastic straws.)
 - ▶ United Nations COP conferences
 - ▶ The Montreal Ozone Protocol is not an analogy.

WW Renunciation is not going to happen.

- ▶ or at least we shouldn't count on it.

Top Choices

Must have a chance to be implementable

- ▶ Of course, even the best remedies will not happen without resistance by incumbents,
- ▶ but *The Force* should or could ultimately prevail!
 - ▶ Economics is *The Force*.
 - ▶ But this is “cosmic.” Government is everywhere, esp in energy (for good reasons). Ever difficult balance.

1+2: Realistic Remedies

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 - ▶ Not all places are the same.

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4. Must be able to sustain majority support.
5. Needs to work for 6-7 billion people in China, India, other Asia, and Africa.
 - ▶ Who cares about Sweden?
 - ▶ USA? CA?? UC??? Palo Alto????

Quick Abbreviated Tour of Tech

Ask Me About Details Over Coffee
(or correct my facts if wrong)

Rem 1. Clean Energy is Tantalizingly Close

Viable useful activism: subsid clean energy innovation

- ▶ But like all government X, difficult and conflicted.
- ▶ International opportunities to innovators.
- ▶ Clean E is (**cosmically**) tantalizingly close
 - ▶ please stop “net-zero” stupidity.
 - ▶ net-10% is good enough and much cheaper.

Clean Energy is about more than CC

Fossil fuels are nasty stuff.

- ▶ Kill millions with particle emissions,
- ▶ but it's they are why you (and G Thunberg) expect to live to 80, and sit in this nice room.
- ▶ FF time is passing. Would be good to speed up demise with R&D into clean E.

Estimates are from 3 years ago, long-term predictions

Electricity Generation in 2050:

- ▶ 1 MWh of Dirty/Nuclear Energy: \$50-\$100/MWh
 - ▶ nuclear, too, even outside the US and Germany
 - ▶ would love better nuclear, (too,) but ...
- ▶ What do you think clean energy cost is expected to be?

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- ▶ What do you think clean energy cost is expected to be?
- ▶ 1 MWh of clean energy in 30 years: \$15-\$20/MWh
 - ▶ but only when nature cooperates,
 - ▶ ...and that ain't enough.

- ▶ Storage is the Problem
- ▶ Right now, storage cost is close to \$200/MWh.
 - ▶ Situation seems almost absurd for day-to-day experience.
 - ▶ Imagine if oil cost \$1/barrel to burn now, but \$10 / barrel to store until 8pm.
 - ▶ Imagine if dinner cost \$1 to eat now, but \$10 to pack.
- ▶ Help subsidize how to store 1 MWh for <\$100/MWh and then let capitalist competition do its job.
 - ▶ ok, still needs grid coordination fixes.
 - ▶ plus, nothing about energy can be pure free markets.

Fossil Fuels for Electricity Plus

- ▶ **NatGas:** Most competitive fossil fuel for Elec and Heat.
 - ▶ Yet, solar PV is already becoming cheaper than NatGas fuel for existing plants in the United States. *Wow!*
 - ▶ ...and this was before 2022 (and Ukraine)!

- ▶ **Coal:** No entrepreneur in the OECD has built a new electricity coal plant in decades.
 - ▶ Ironically, coal is no longer a capitalist outcome!
 - ▶ Coal is heavy to schlepp and expensive to clean up.
 - ▶ Coal now lives off unions and government regulation.
 - ▶ China (India) are building massive new plants now.
 - ▶ Nothing in E is without government involvement!

▶ **Oil**

- ▶ will probably be uncompetitive in grid-adjacent ground transport soon
- ▶ niche: long-term off-grid transport, chemical products, etc.

(Good Question: Will FF remain the cheapest heat source.)

- ▶ PS: Please don't Believe Propaganda and Dogma.
 - ▶ I don't have time to dispell many here. (See book.)
 - ▶ (Who cares if windmills are buried later?)
 - ▶ (Who cares if solar PV needs size of Massachusetts?)
 - ▶ (Who cares if capitalists get richer?)
 - ▶ (Who *really* cares about the poor on Bangladesh's coast? Not a callous statement but a genuine question.)

Little Mass



Unlikely Solutions

- ▶ *Current* nuclear tech is niche, at best.
 - ▶ Safety, spent fuel, proliferation, mass production.
 - ▶ Regulatory and public hostility
 - ▶ BUT it's *not* mostly about US regulatory hostility.
 - ▶ See France, USSR, China, Ukraine, Korea, Japan, Mexico, etc.
 - ▶ Even already-built plants still incur \$40-\$50/MWh marginal cost! They are now often closing down early at \$50/MWh.
 - ▶ It's mostly about cost competitiveness (NatGas, E-Storage)
 - ▶ Promising: FOAK in Wyoming (big subsidies!). Pebble-bed reactor. Small reactors. etc. R&D = good. Install = bad.

- ▶ Hydrogen seems outright stupid as E-storage.
 - ▶ Had real hope and excitement, but
 - ▶ even if cost declines by factor of 3, NatGas dominates
 - ▶ even if electricity were free, H is not competitive to NatGas.
 - ▶ badly corrosive on transport, too.
 - ▶ Whatever El will cost, batteries and heat storage are/will likely store El much cheaper for output as El or Ht
 - ▶ Future niche for hydrogen only in long-range transport.
 - ▶ Possible niche with epsilon E in very long run. Who knows.

- ▶ Industrial CO₂ sequestration is outright stupid.
 - ▶ Only P.R. and “stupid government regulations” arbitrage.
 - ▶ see below for cheaper better seq alternatives

Rem 2. Regional Fossil Fuel Taxes

- ▶ (Viable in many places!)
- ▶ “This stuff kills your parents and children!”
- ▶ It makes spending outdoors less desirable.
 - ▶ Clean air is a luxury good.
 - ▶ Very visible and noticeable.
 - ▶ Would you prefer 5% more income if you had to suffer Beijing-like smog and air? Not me. Not most.
 - ▶ Still tough to implement. See Delhi.

Rem 3. Smart Regreening (Everywhere)

- ▶ Timber is valuable. Also, hemp, seaweed, etc.
 - ▶ Wood and bamboo are amazing materials. At half price...
- ▶ Available cultivatable land is abundant worldwide.
 - ▶ But it's not in the Amazon and Indonesia.
 - ▶ Gvnmts could lease out land with credits for CO₂.
- ▶ Think \$10/tCO₂ *on the margin* for 1t/CO₂.
 - ▶ \$30/tCO₂ not for 50 GtCO₂/Yr, but for 5 GtCO₂/Yr.
 - ▶ Who cares about 30 years from now? **Care about Now!**
 - ▶ “Growing smartly” is super low-hanging fruit.
 - ▶ Failure is indicative of world coordination & commitment.

4. Many Other Cheap Improvements (OECD)

- ▶ Time-of-Day Pricing
 - ▶ Big problem is 6-10pm. So make electricity near free when it's sunny, and signal this over the networks.
 - ▶ Great for poorer energy-conscious consumers.
 - ▶ Crazy Time-of-Day Plans in many places.
- ▶ Improve Electrical Grid.
 - ▶ Logistical and regulatory nightmare.
- ▶ Concierge Service for Government Permits
 - ▶ 10 years to start a low-impact mine?
 - ▶ Almost impossible for many entrants.

PLEASE ENVIRONMENTALISM: STOP STUPID

- ▶ Universities: Invest in clean-energy research chairs and labs. Reduce vehicle electrification efforts and ESG.
- ▶ Economists: Stop focus and hope on SCC.
- ▶ Companies: Commercialize E-gen and E-storage tech.
- ▶ Activists: Promote clean air standards worldwide. Drop anti-capitalist attitudes. Work with it.
- ▶ Government: Price El. Improve El-Grid. Coordinate. Reduce Red Tape (faster, not laxer). Lease out land.

Apologies on Wish List

- ▶ Ignores realist hindrances:
 - ▶ admittedly hypocritical (“world as it is”)
 - ▶ but more feasible
- ▶ Hindrance Examples:
 - ▶ Investors and activists need to swear allegiance to ESG.
 - ▶ Necessary PR and useful customer marketing.
 - ▶ Politicians may need to hold coalitions together.
 - ▶ University administrators fear cancellation.
 - ▶ Activists want to go to the pub with like-minded.

Thanks

- ▶ Thanks for listening to me.
- ▶ I did not hope to convince you, but
- ▶ to get you to reflect on what environmentalists are doing and could be doing.
- ▶ Much more detail and backup in our free textbook.

- ▶ Resources
 - ▶ <http://climate-change.world/>
 - ▶ <https://www.climate-change.world/home/16-cribsheet.html>