A macroeconomist's thoughts on climate and climate policy

THE DANISH ENVIRONMENTAL
ECONOMIC CONFERENCE
2023

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Points of departure

- **Cumulative emissions** of CO_2 drive climate change, so the world eventually needs to become carbon neutral.
- Comparative advantage of economists is to describe **how** this can be done. Which polices are effective and which are not?
- Basically **nothing** of this is done by **IPCC.**
- Our **quantitative models** are very helpful, but used too little
- Today: useful **observations** as inputs to analysis and **tentative results**.

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1. Economy → climate

- CO_2 is like a blanket around Earth. More CO_2 makes **blanket thicker**.
- A highly **complicated** system of very many non-linear feedback mechanisms.
- Surprisingly, the total effect is a linear relation between **accumulated** CO_2 emissions and climate change.
- As long as we continue to emit, the temperature increases. When we stop, the temperature **stabilizes** at the level we then have reached.

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Climate change proportional to accumulated emissions

- Advanced Earth System Models agree that climate change is approximately **proportional** to stock of global **accumulated** emissions.

$$T_t^{Atm} = \sigma_{CCR} \sum_{s=0}^{t} EM_s$$

- Key mechanism: given a stock of accumulated emissions, **two forces** balance for a long time (hundreds of years):
  1. CO_2 slowly leaves the atmosphere reducing the greenhouse effect.
  2. Oceans slowly get warmer. Their cooling effect on atmosphere fades away.

$$\frac{dT_t^{Atm}}{dt} = \sigma_1 \left(\underbrace{\nu \ln CO_2^{ATM}}_{1.} - \kappa T_t^{Atm} - \underbrace{\sigma_2 \left(T_t^{Atm} - T_t^{Ocean} \right)}_{2.} \right)$$

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Accumulated emissions and global warming

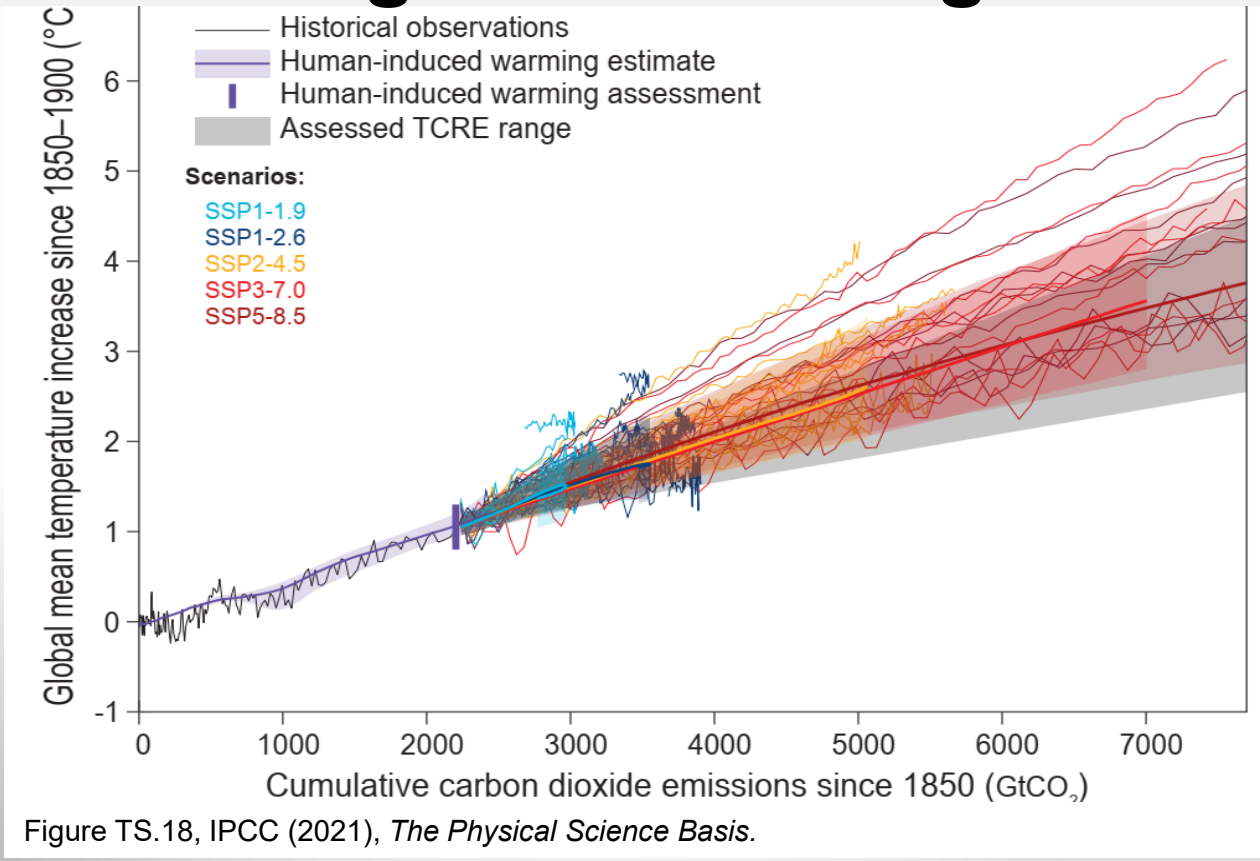

Figure TS.18, IPCC (2021), *The Physical Science Basis.*

Heavy precipitation events

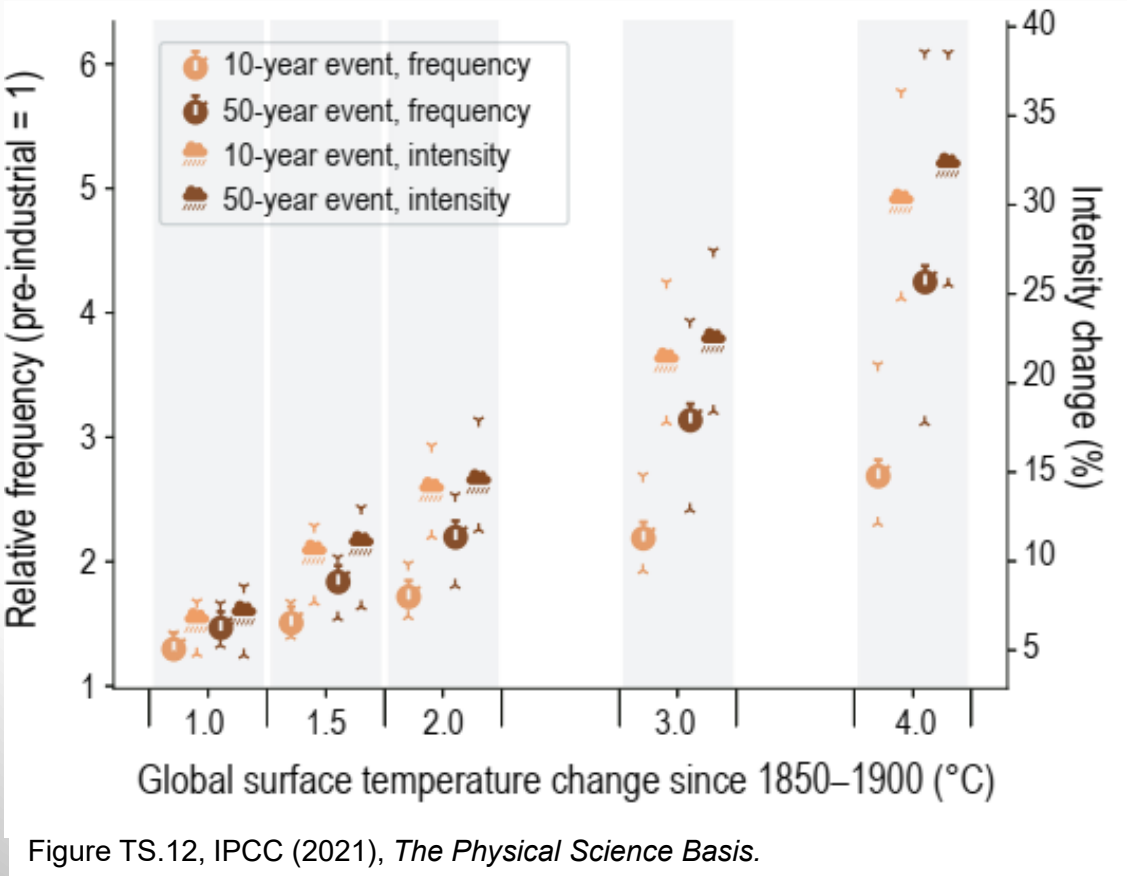

Figure TS.12, IPCC (2021), *The Physical Science Basis.*

Droughts

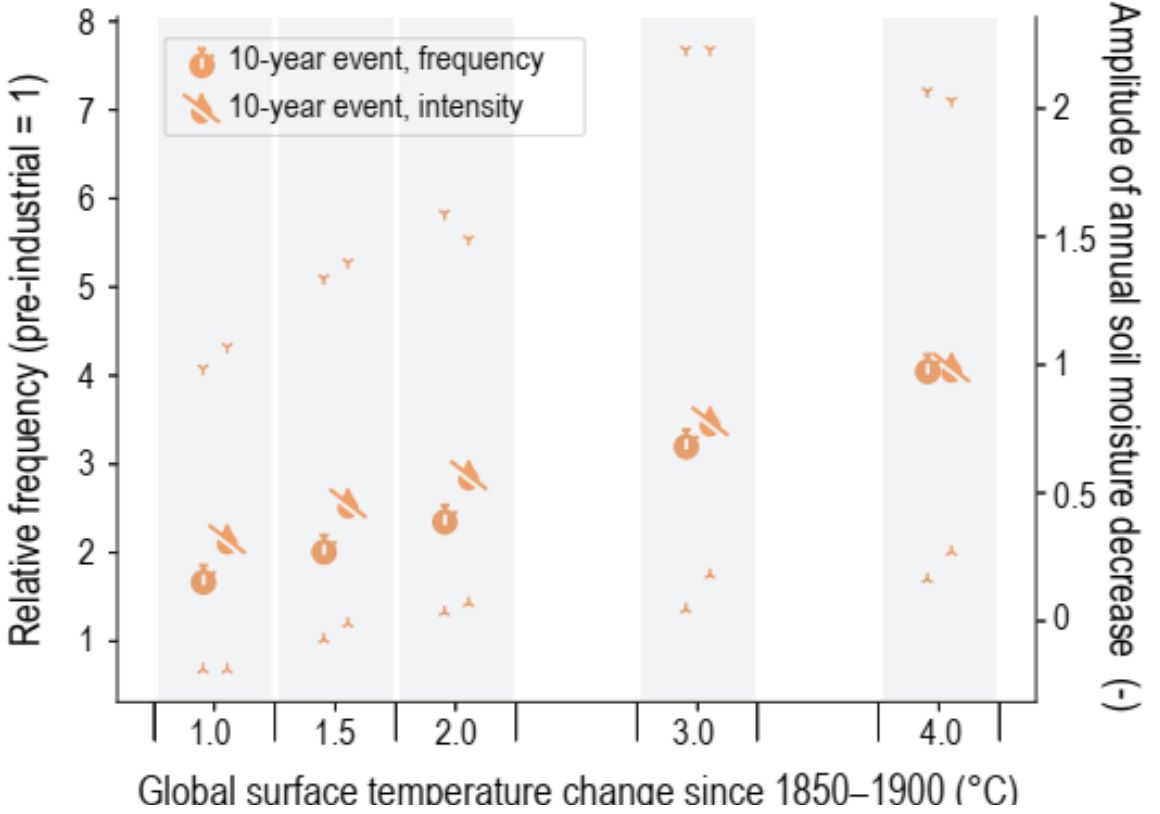

Figure TS.12, IPCC (2021), *The Physical Science Basis.*

Heat extremes

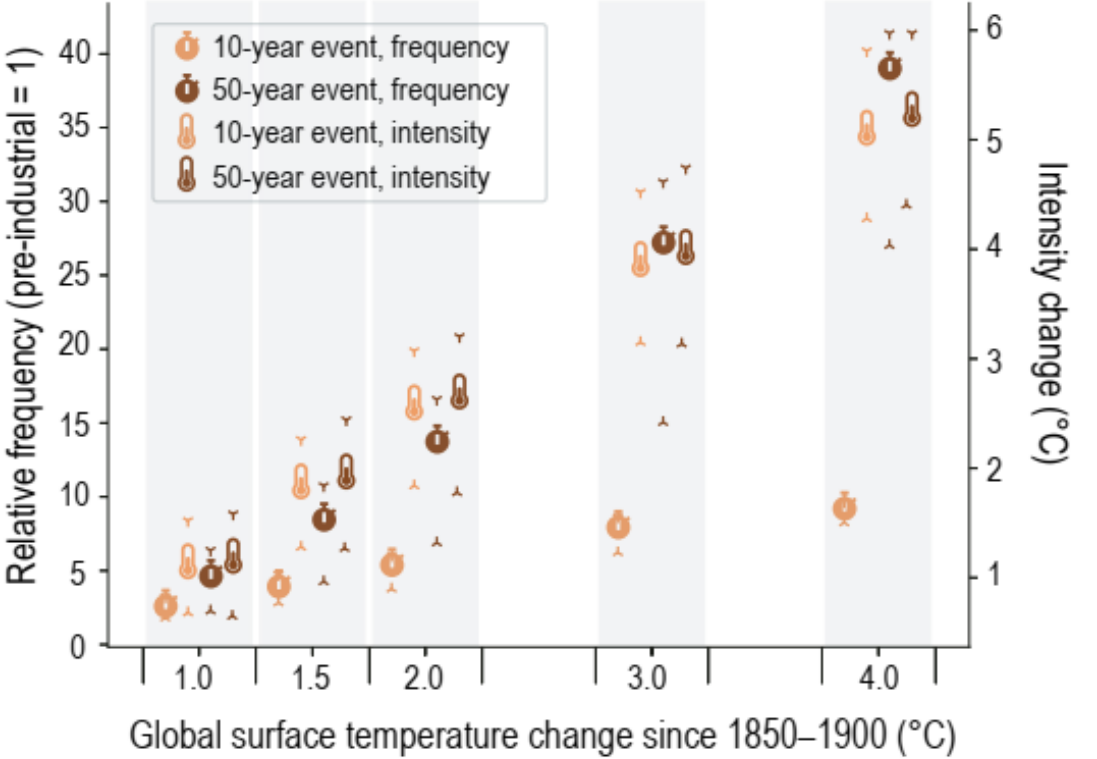

Figure TS.12, IPCC (2021), *The Physical Science Basis.*

Large uncertainty according to IPCC

- Current **human induced warming** likely between 0.8 and 1.3˚C. Includes uncertain cooling effect from aerosols between 0 and 0.8˚C.
- Linear coefficient on accumulated emissions likely 0.27-0.63 ˚C/TtCO_2
- Is this range **wide**? Yes!
- So far, we have emitted 2.4 TtCO_2. Doubling this yields **additional** global warming between 2.4*0.27=0.65 and 2.4*0.63=1.5˚C.
- Global **tipping points** dismissed by IPCC, but cannot logically be ruled out.

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2. Climate change → Economy

- **Bottom-up** vs **time-series** studies.
- Time-series studies **regress** growth on temperature with various controls.
- A much-used study is **Burke et al**., Nature 2015. Panel study where country growth us regressed on country specific temperature and temperature squared with globally common coefficients.
- $\Delta y_{i,t} = \beta_1 T_{i,t} + \beta_2 T_{i,t}^2 + \mu_i + \nu_t + \gamma_{1,i} t + \gamma_{2,i} t^2 + \varepsilon_{i,t}$
- Quantitative response at national level makes **no sense**.

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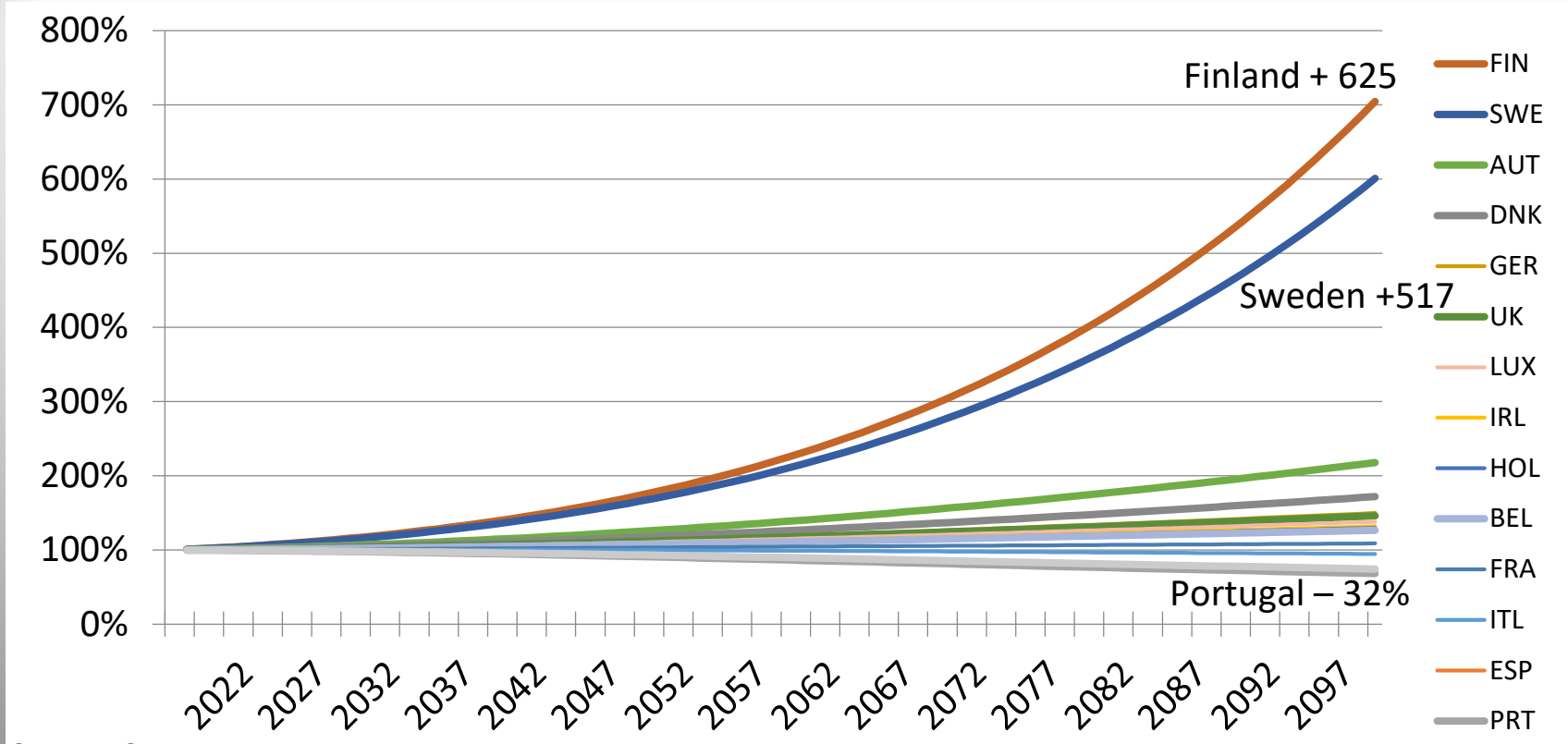
Effects of 2.5 degrees increase in Global Mean Temperature on GDP/capita in EU15



Source: Own calculations based on Burke et al. 2015 estimates.

A good bottom-up study for EU
damages without adaptation

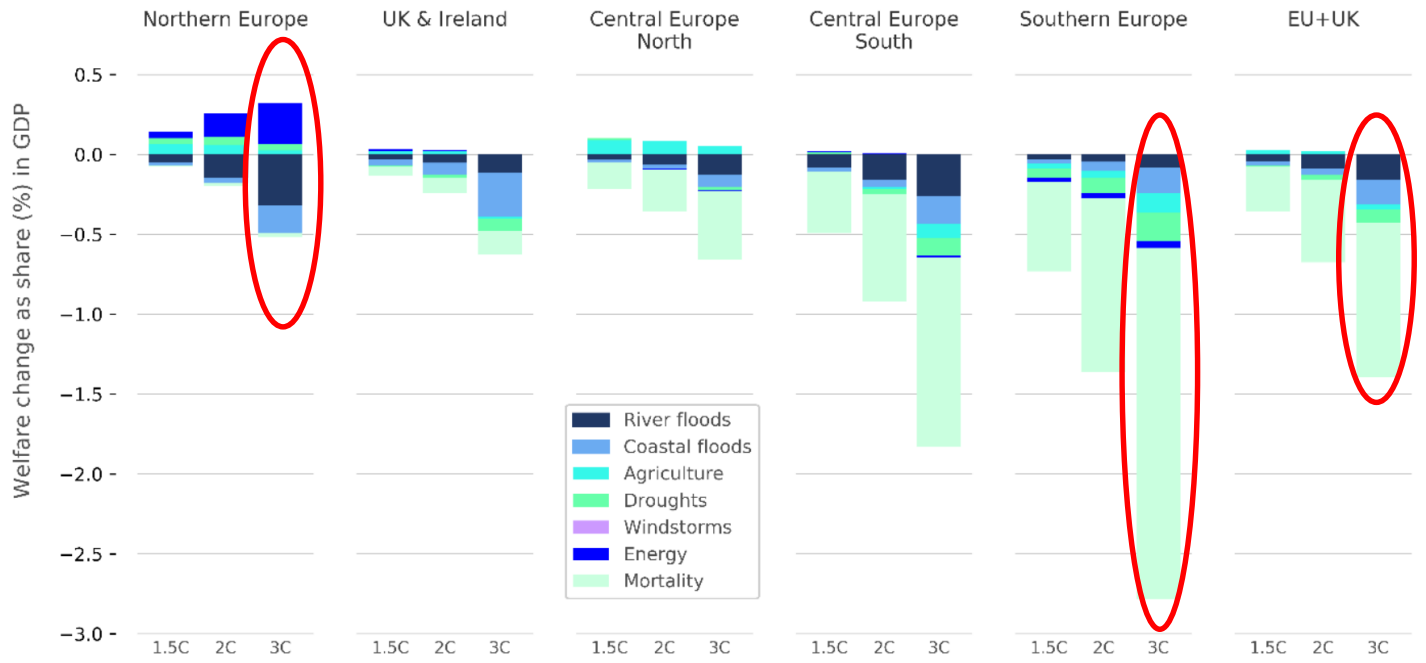


Figure 31. Welfare loss (% of GDP) from considered climate impacts at warming levels for the EU and the UK, and for macro regions (see Approach). The results represent change in welfare if warming levels would act upon current economy, compared to current economy under present climate.

Källa: EU Commission, 2020, JRC Peseta IV report

Conclusions about climate and economy interaction

- Best credible guess that the effects on human welfare are non-trivial but **limited on average** – equivalent to a few percent of income at 2°C and perhaps 5-10% at 3°C. Substantially less in Europe.
- Cannot rule out much more damaging scenarios. Bad things not in the **data**.
- Uncertainty is **Knightian.** Traditional CB calculations of **Social Cost of Carbon** not convincing.
- Not learning fast enough for **"wait and see"** to be a good strategy.
- Is there a **robust** policy? **Quantitative models** are useful to answer this. Stiglitz and Pindyck are wrong!

A quantitative global climate-economy model

- A semi-analytical global **neo-classical growth model** with 8 regions (Hassler et al. 2021a).
- Augmented with a simple 5-equation model of **carbon cycle and climate** known to well replicate dynamics of most advanced Earth System Models (Follini et al., 2022).
- **Energy** from oil, coal, fracking and green.
- Useful for analyzing **quantitative implications** of different assumptions and scenarios.

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Tentative model results

1. Global (or regional) **carbon tax** (a price on emissions) is a potent policy tool.
2. Smooth transition to climate neutrality at 2050 can be accomplished at fairly small cost and with acceptable carbon tax expenditures.
3. An ambitious climate policy is a robust: it offers cheap "insurance" against high sensitivities of climate to emissions and damages to climate change.
4. All regions of the world must participate. Compensating for significant-size regions failing to phase out fossil fuel is very costly, or outright impossible.
5. Subsidies to green energy are not likely to outcompete fossil energy.

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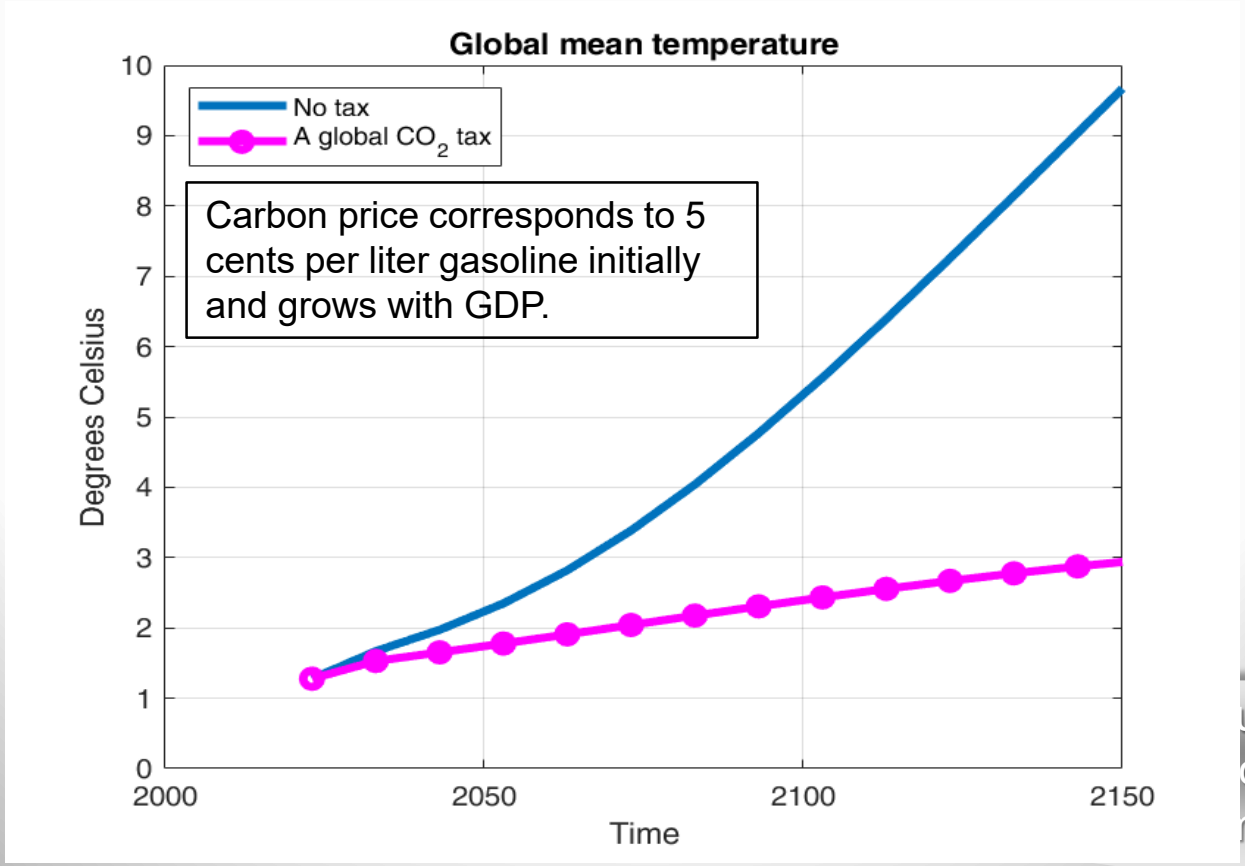
Modest carbon price effective



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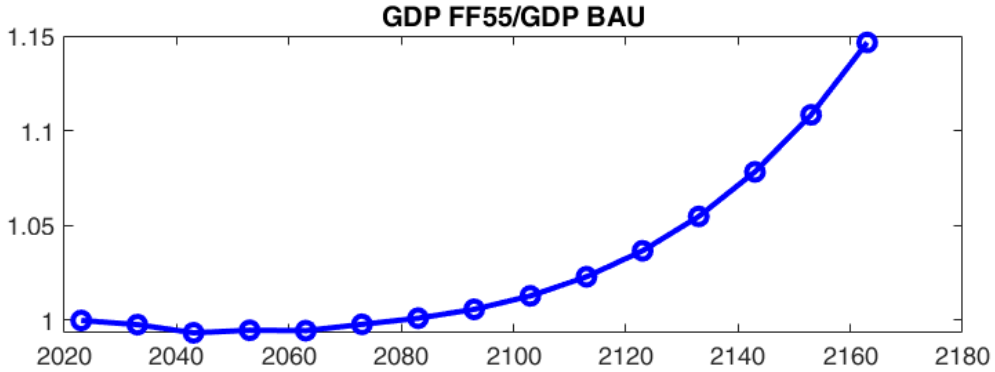
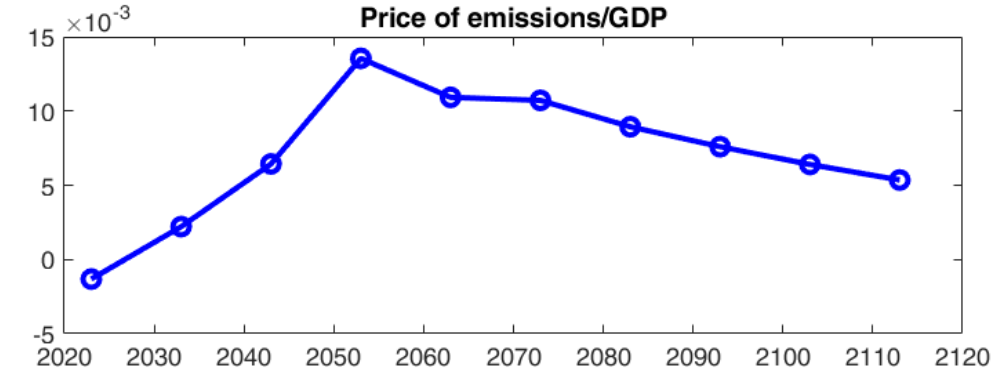
Climate neutrality by 2050





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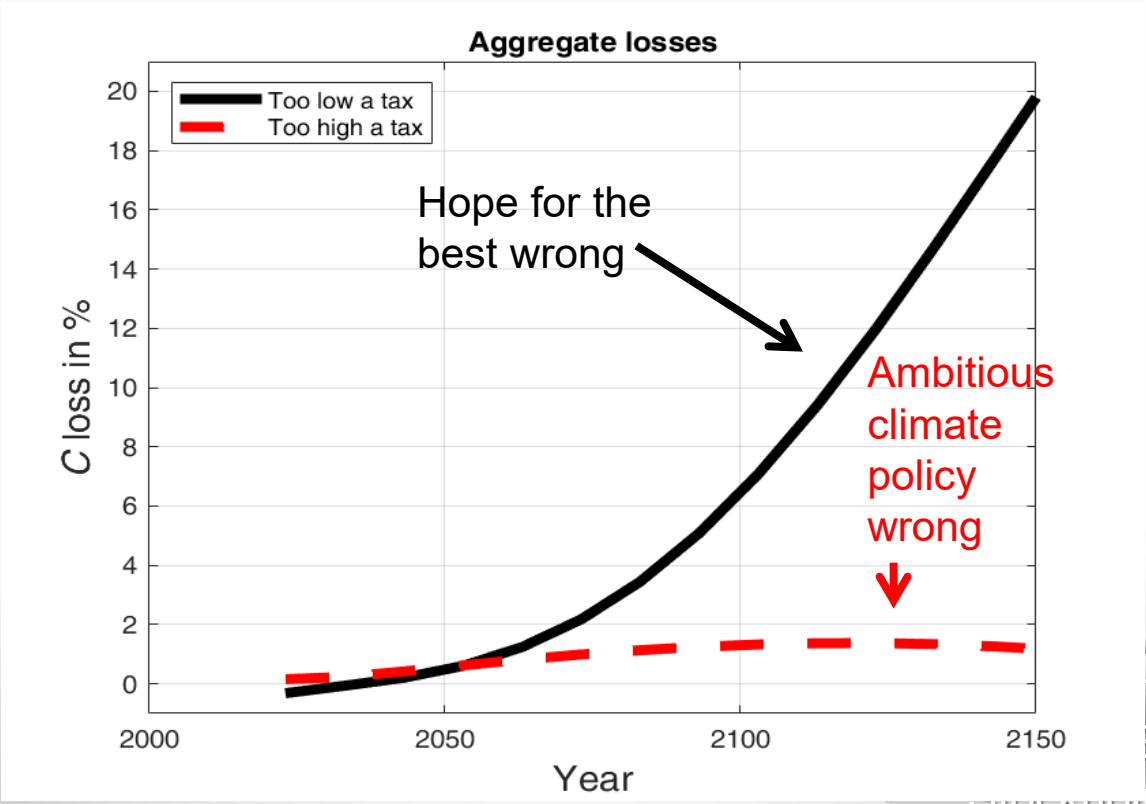
Costs of policy mistakes



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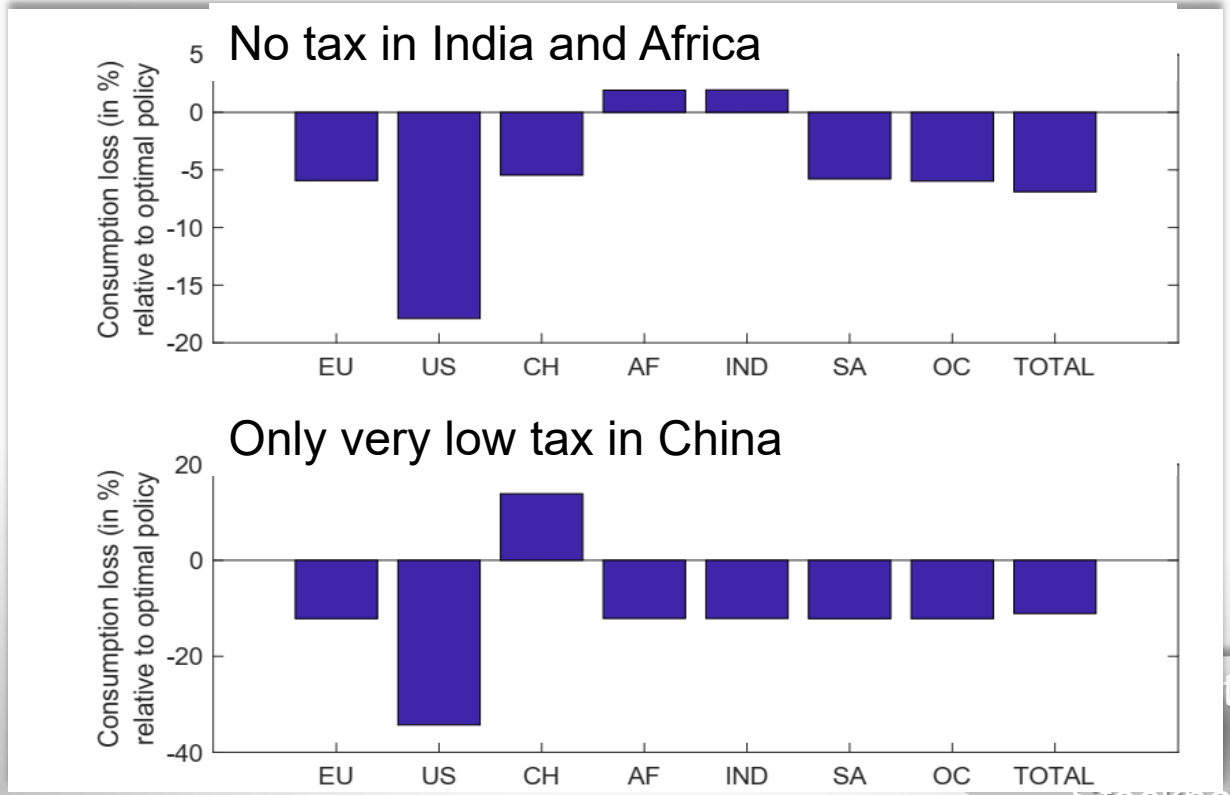
Costs of making up for climate laggards



5 times higher CO_2-tax in all other regions

20 times higher CO_2-tax in all other regions

Tentative results

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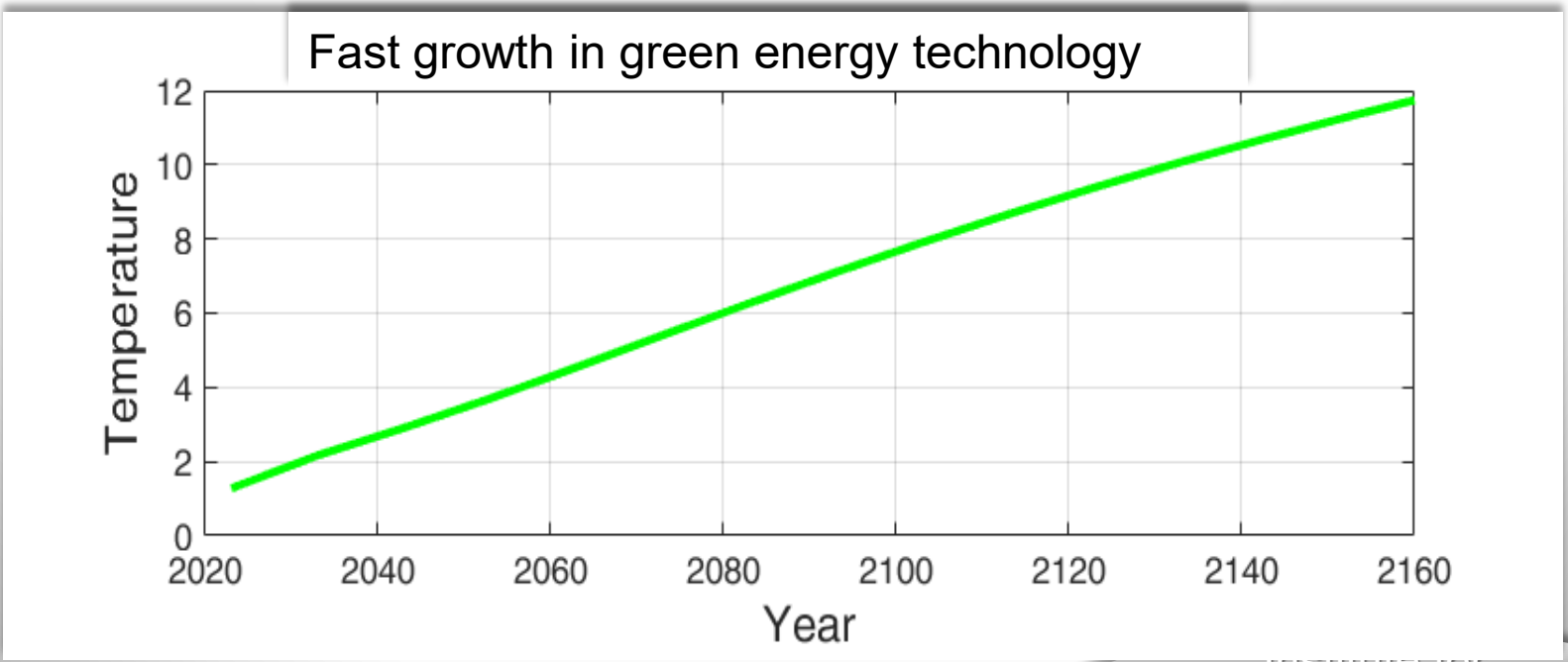
Green subsidies not effective



Climate policy

- In our model, **only one market failure** – the climate externality. In reality, many frictions. Requires broad policy interventions.
- **Three complementary** policy areas with different aims:

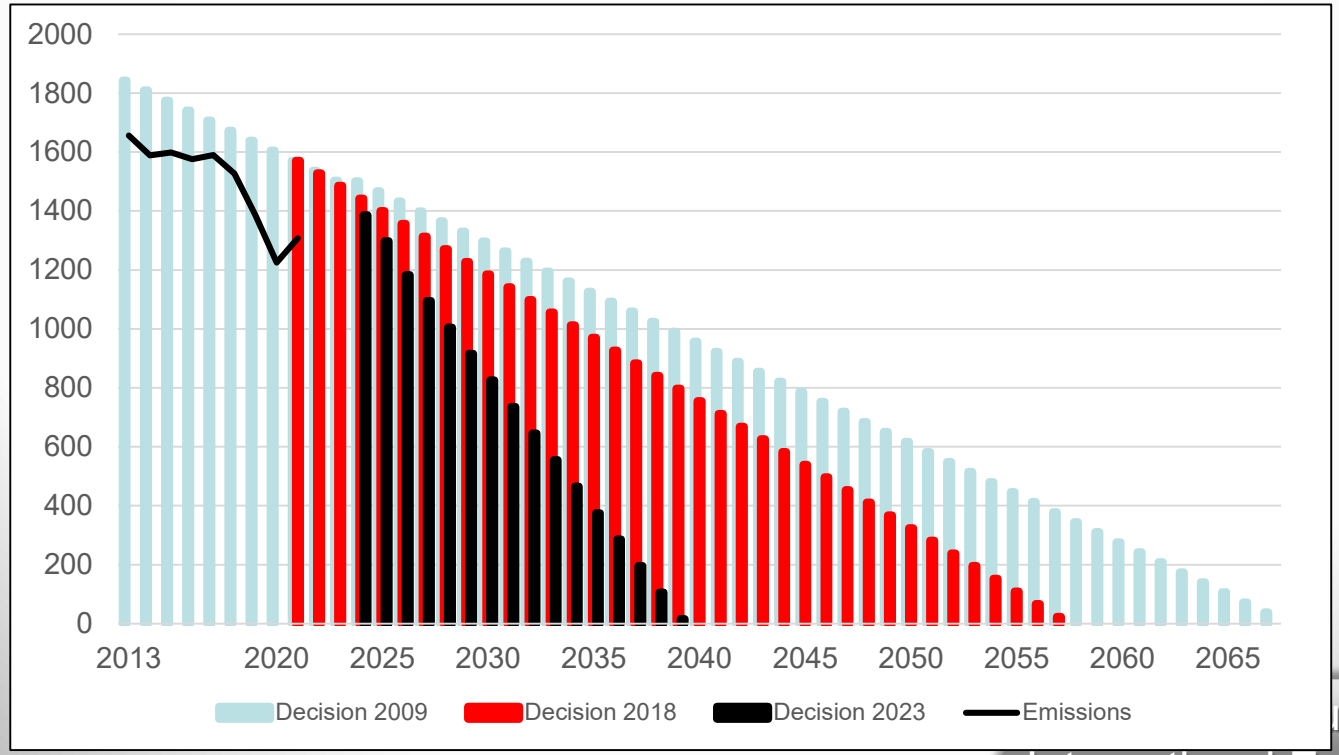
1. Directly **curbing** emissions. (Cap and trade, taxes, bans)
2. Overcome **other frictions** so that transition to climate neutrality forced by policy area 1 becomes economically, socially and politically acceptable (R&D, transfers, industrial policy, ….).
3. Inducing **rest of world** to participate. (Trade policy, technological and financial transfers)

EU now does what is required in policy area 1!

- Recent agreement to implement **emission trading** for almost all CO_2 emissions.
- If rules are not changed -- no more allowances distributed after 2039 (EU ETS) and 2042 (EU ETS II). Ban on fossil cars from 2035.
- Gives practically **full control** over almost all future CO_2 emissions in union. Accumulated CO_2 emissions to 2050 around 30 Gt. 70 ton per EU citizen.
- Around 70 ton per world citizen gives 560 $GtCO_2$. IPCC global carbon budget for 1.5˚C 420 Gt and for 2 ˚C 1150 Gt. Consistent with **Paris agreement** ambition.
- Still some possibility to opt out from EU ETS II. Hopefully not used.

EU ETS 1 – new emission allowances

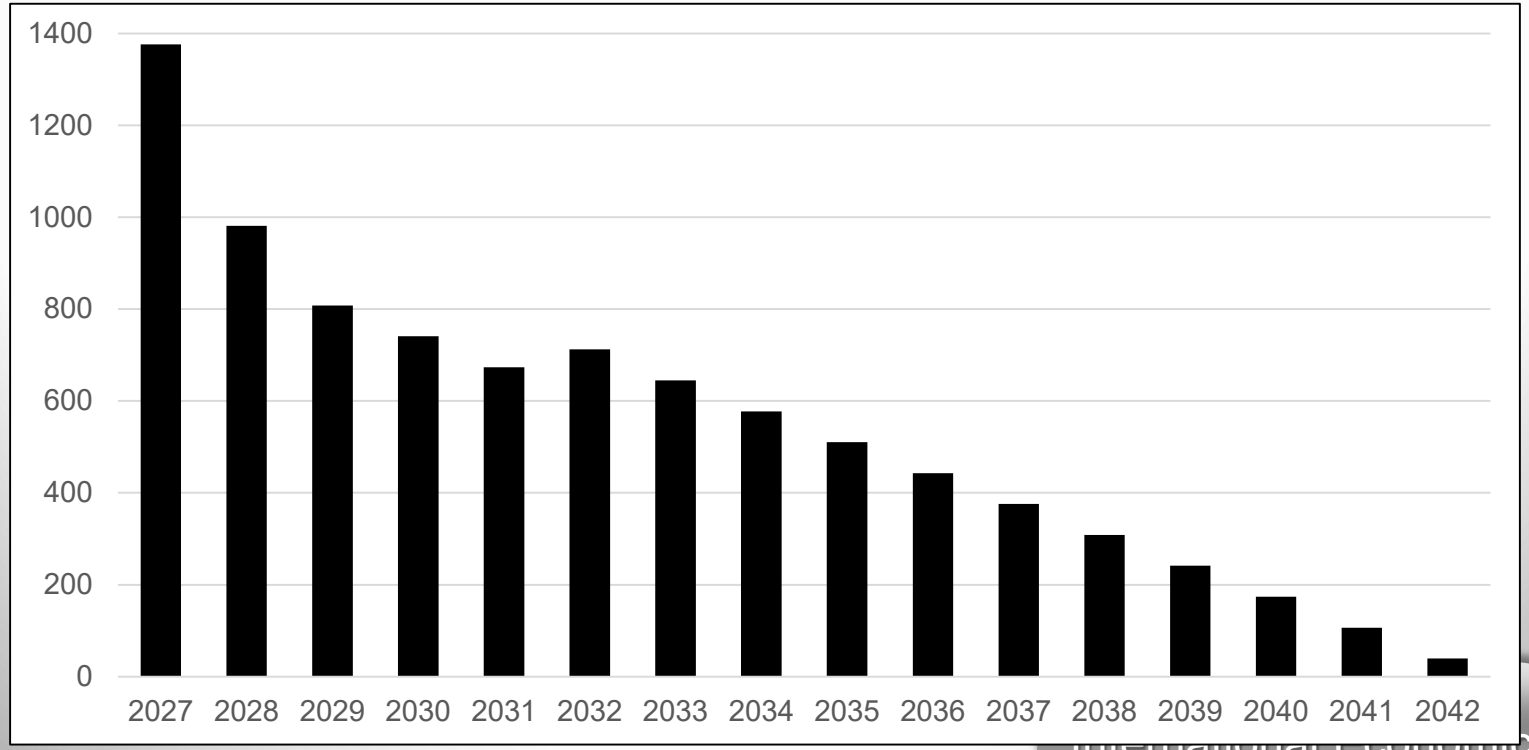
Million tons



Source: ”Temperaturhöjning i klimatpolitiken”, ESO-report 2023:7

EU ETS 2 – new emission allowances

Million tons



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- **International fairness** requires financial, institutional and technological transfers, not that we give poor countries a larger CO_2 budget!

Effort Sharing Regulation

- EU is doing **enough** at the union level to phase out CO_2,
- In addition, **Effort Sharing Regulation** requires emissions reduction outside of EU ETS II or Nordic countries. Minus 50% in 2030 relative to 2005.
- To reduce divergent emission prices in union, various **flexibility mechanisms** allowed, paying for reductions in other countries, moving emission allowances from EU ETS II and LULUCF.
- These flexibilities should be **used**!
- No need for other **national emission targets**. EU has caught up here!

National Policies in the Nordics

- EU ETS I and II covers basically all CO_2 emissions, but policy tools providing economic incentives in **agriculture** and **LULUCF** still missing. Should be fixed by national policy.
- Key **challenge** for national policy are in area 2 and 3.
- National policies must focus on making the transition politically, economically and socially **acceptable**. Much more important than aiming (marginally) higher than EU as whole in setting emission targets.
- We should also engage bilaterally and with EU to **hep transition** in **developing** world, particularly Africa.

Conclusions

- A transition to climate neutrality over 3 decades is likely **a robust policy** – a cheap insurance.
- Economics research should be **focused** on analyzing this **claim**. Higher policy relevance than calculating social cost of carbon under speculative assumptions and extreme scenarios.
- EU is **doing what is required** under policy area 1 – forces a phase out of fossil emissions of CO_2 with EU ETS I and II.
- The Nordics should now be **frontrunners** in showing that it is possible to thrive also when the Fit-for-55 rules are in place. Growth and social cohesion must not and cannot be sacrificed!

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I remain optimistic!

Literature

- The Macroeconomics of Climate Change: Starting Points, Tentative Results, and a Way Forward, preliminary report for Peterson Institute of International Economics, http://hassler-j.iies.su.se/PAPERS/PIIE_HKO.pdf
- ”Swedish Policy for Global Climate”, SNS Economic Policy Council Report 2020:2020. https://www.sns.se/artiklar/sns-economic-policy-council-report-2020-swedish-policy-for-global-climate/
- “Suboptimal climate policy”, *Journal of the European Economic Association*, Hassler, Krusell, Olovsson, http://hassler-j.iies.su.se/PAPERS/suboptimal_CO2.pdf
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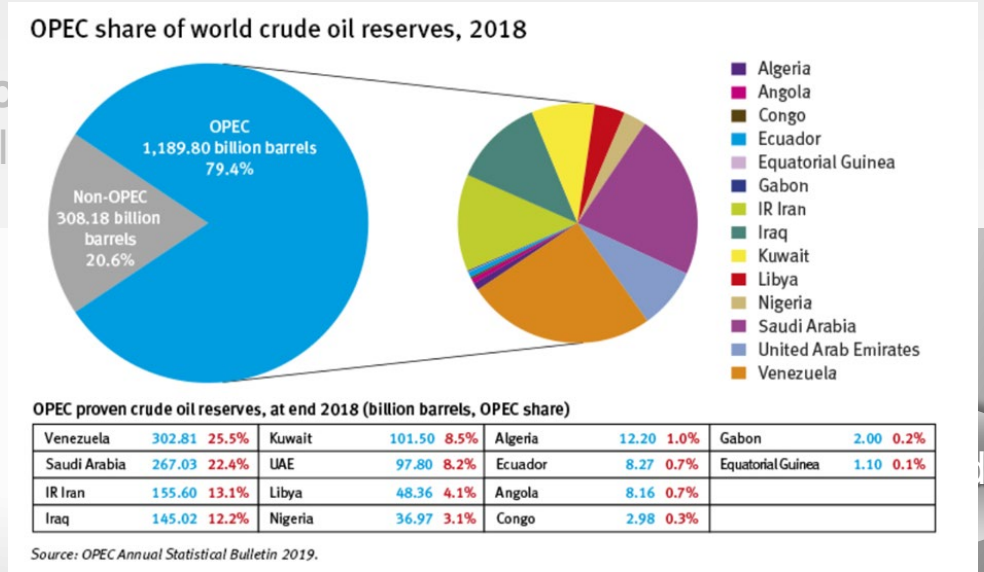
- “Mitigating Climate Change”, *World Economic Outlook*, Oct 2020, https://www.imf.org/-/media/Files/Publications/WEO/2020/October/English/ch3.ashx
- ”Net Zero by 2050”, IEA, https://www.iea.org/reports/net-zero-by-2050
- ” Stranded fossil-fuel assets translate to major losses for investors in advanced economies”, Semieniuk, *Nature Climate Change, 2022.*

EXTRA SLIDES

Using the proportionality result

- **Carbon budgets** can be calculated.
- Sizes of different **fossil reservoirs** can be interpreted.
- A barrel is 1/7.33 tons. Carbon content 85%. Burning a ton carbon gives 3.67 tons CO_2. 1190/7.33*0.85*3.67=500 $GtCO_2$. Gives 0.13-0.33 increase in global mean temperature.
- So OPEC (conventional) oil is **no** most non-conventional fossil fuel



OPEC proven crude oil reserves, at end 2018 (billion barrels, OPEC share)

Venezuela	302.81 25.5%	Kuwait	101.50 8.5%	Algeria	12.20 1.0%	Gabon	2.00 0.2%
Saudi Arabia	267.03 22.4%	UAE	97.80 8.2%	Ecuador	8.27 0.7%	Equatorial Guinea	1.10 0.1%
IR Iran	155.60 13.1%	Libya	48.36 4.1%	Angola	8.16 0.7%		
Iraq	145.02 12.2%	Nigeria	36.97 3.1%	Congo	2.98 0.3%		

Source: OPEC Annual Statistical Bulletin 2019.

2. Climate change → Economy

- **Bottom-up** vs **time-series** studies.
- Time-series studies **regresses** growth on temperature with various controls.
- A much-used study is **Burke et al**., Nature 2015. Panel study where country growth us regressed on country specific temperature and temperature squared with globally common coefficients.

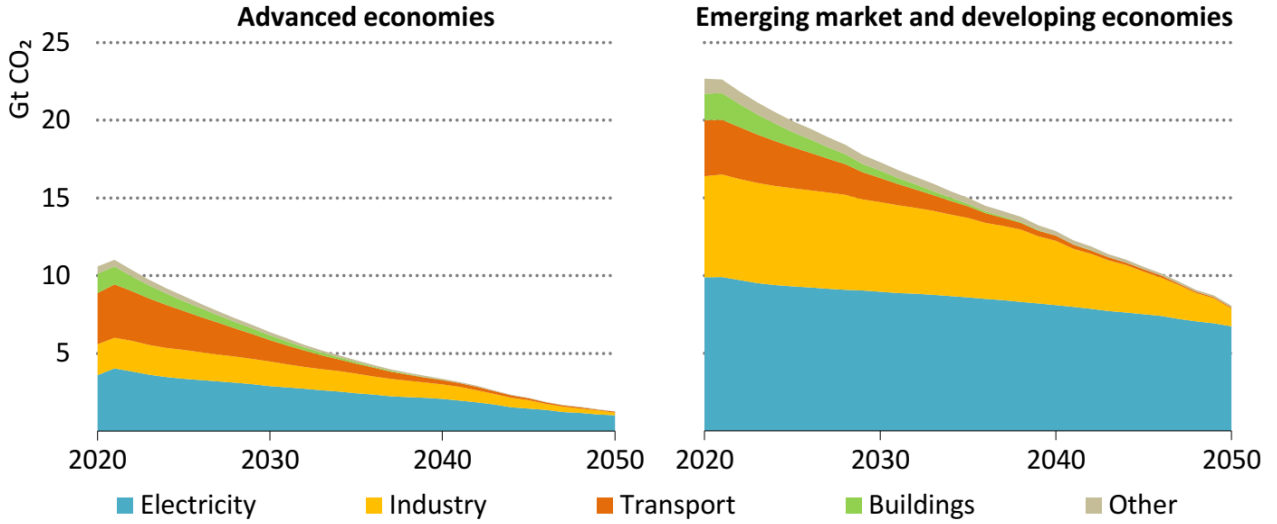
$$\Delta y_{i,t} = \beta_1 T_{i,t} + \beta_2 T_{i,t}^2 + \mu_i + \nu_t + \gamma_1 t + \gamma_2 t^2 + \varepsilon_{it}$$

- Finds **positive** effects on growth in cold countries and **negative** in hot.
- Quantitative response makes **no sense**. Forgot convergence forces.

Challenge 1 –stranded assets

- Existing **infrastructure** emits 200 $GtCO_2$ too much relative to a 1.5 ˚C target over economic lifetime. 0.05-0.13 ˚C additional warming. Stranded assets mostly c
- Limited asset r
US$ 1 trillion (S

Figure 1.9 ▷ Emissions from existing infrastructure by sector and region

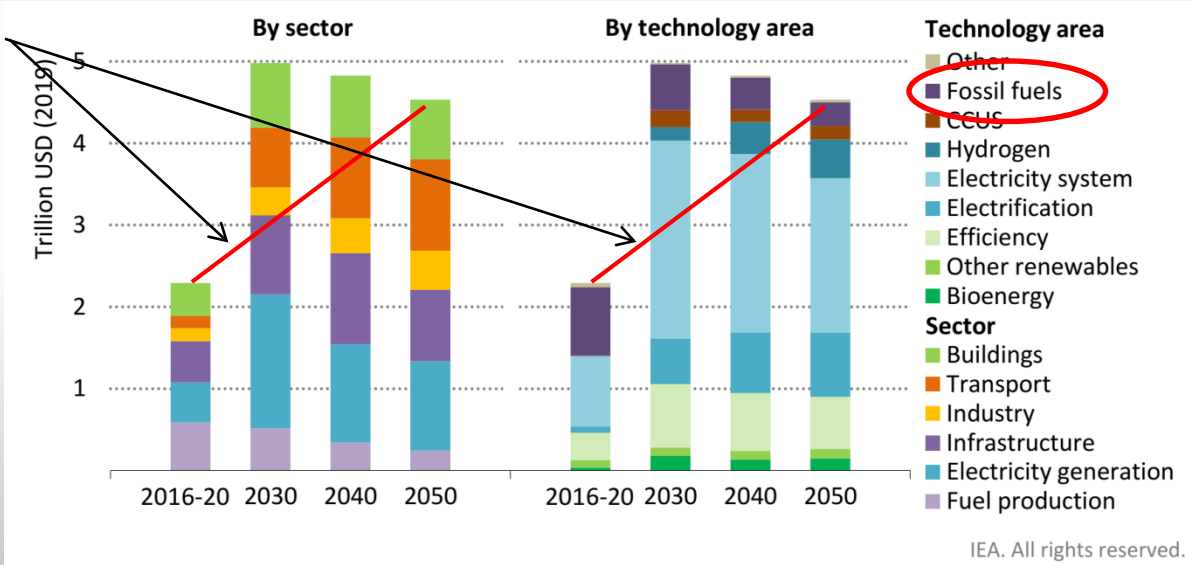


IEA, 2021, Net Zero By 2050.

Challenge 2 – capital investments

- Higher capital investments required for NZ50. 1% higher investment share.2020-50. Peak 2030, 2% higher. Back to the level of 1970-99. Changes in neutral rates can be calculated.

GDP



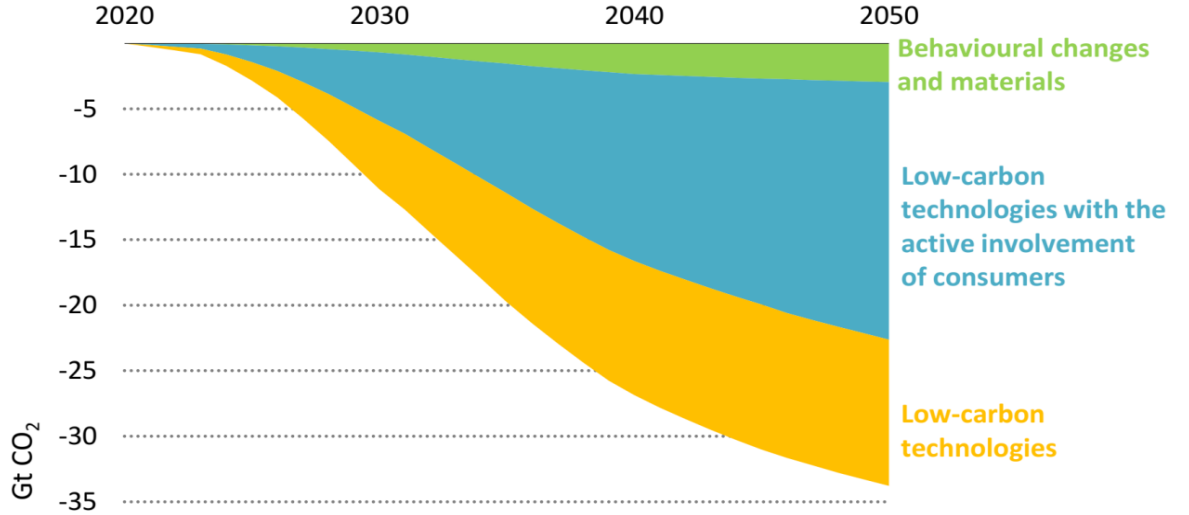
Capital investment in energy rises from 2.5% of GDP in recent years to 4.5% by 2030; the

IEA, 2021, Net Zero By 2050.

Challenge 3: changed lifestyle

- Fundamental changes in lifestyle not the key mechanism.

Figure 2.14 ▷ Role of technology and behavioural change in emissions reductions in the NZE



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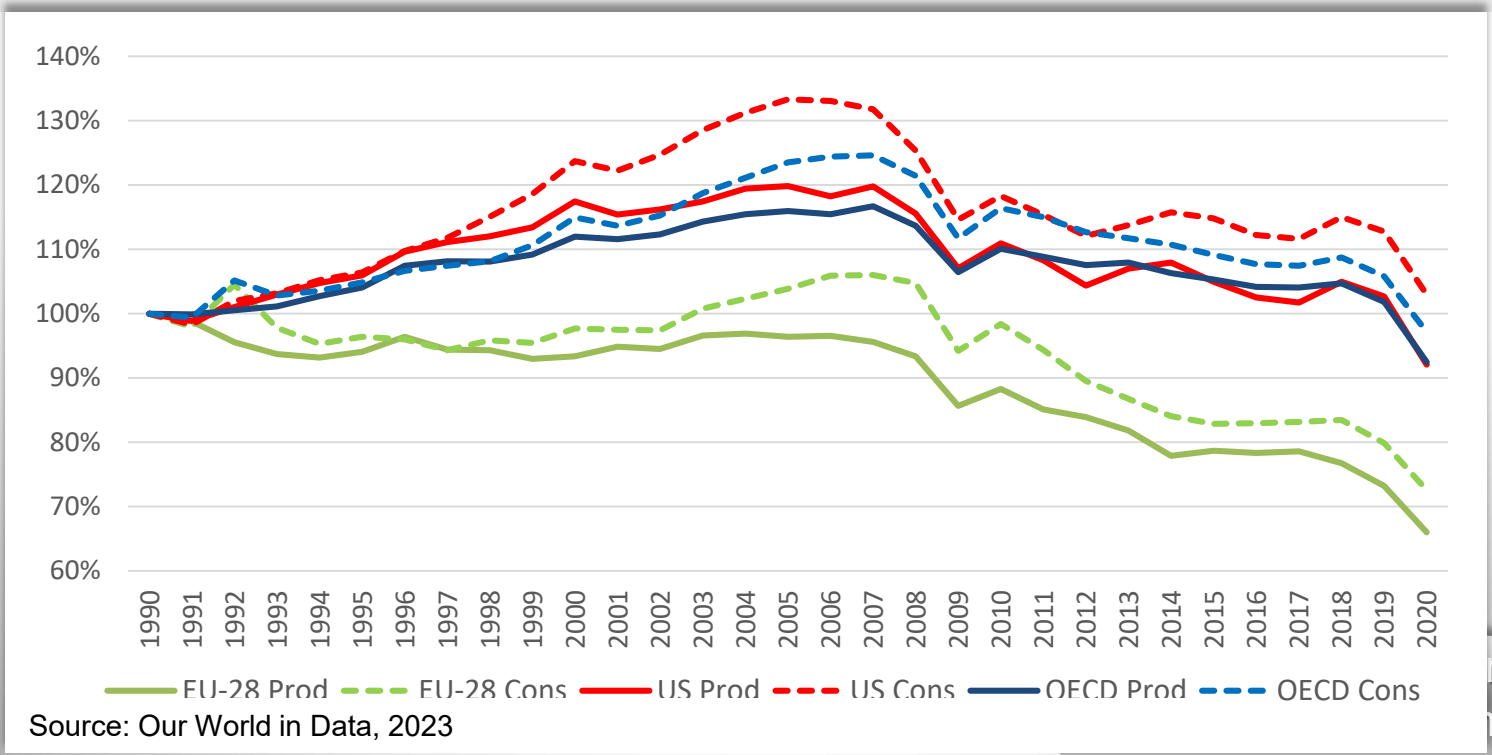
Production- and consumption based emissions



Source: Our World in Data, 2023

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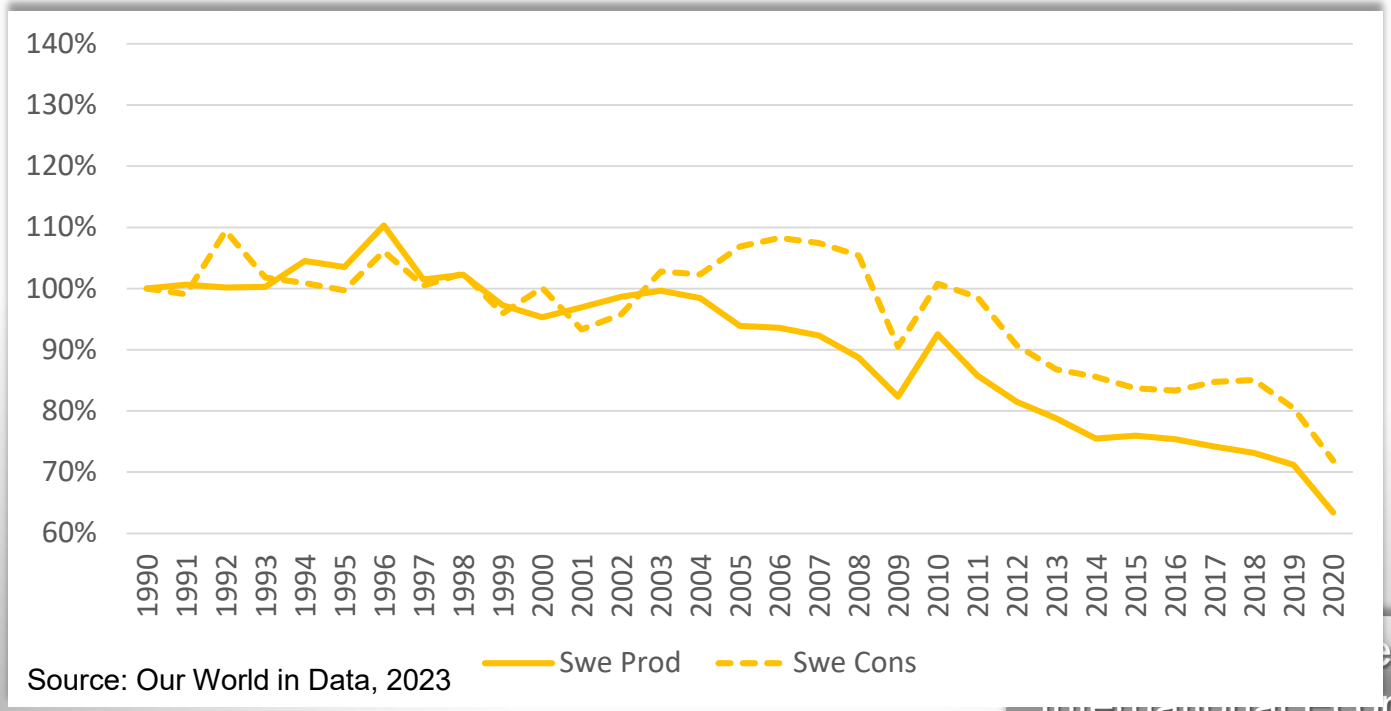

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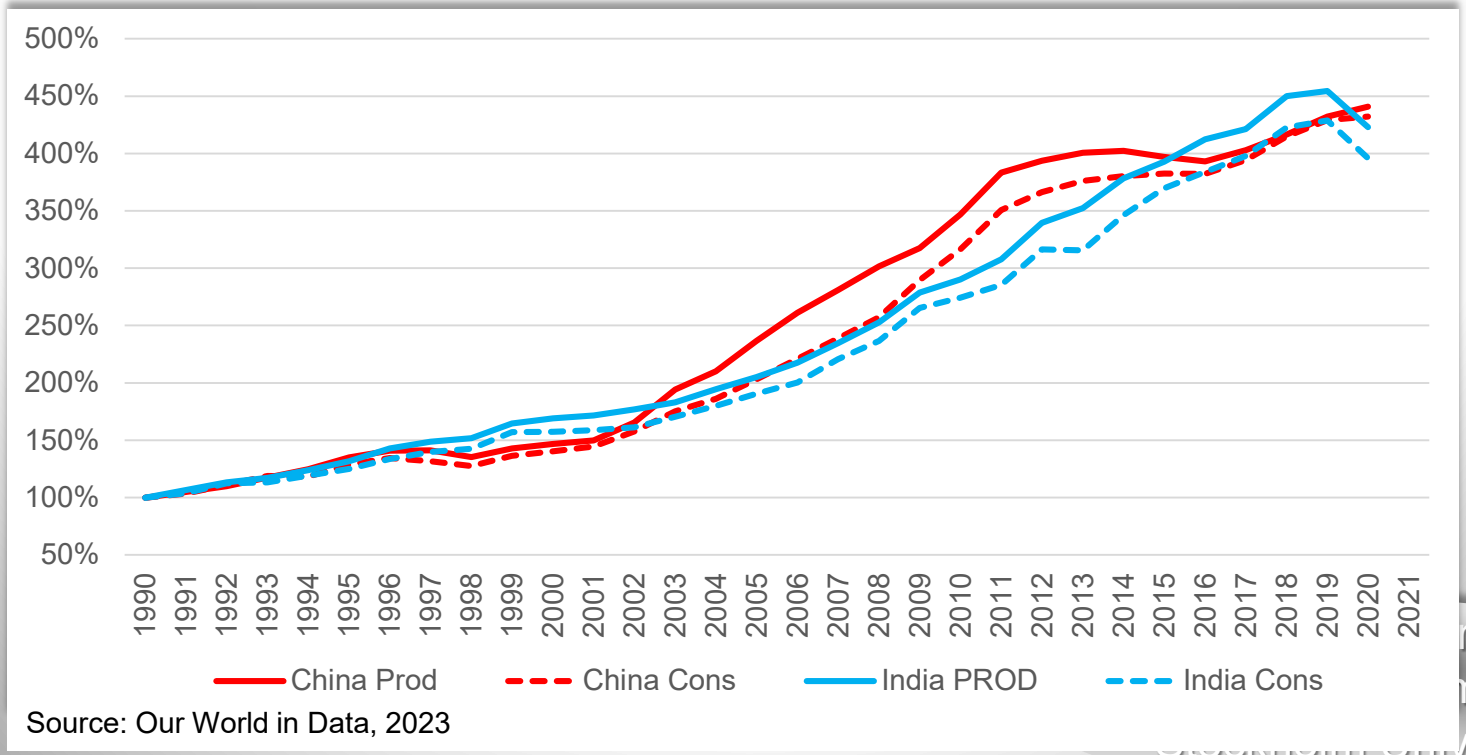

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