# Virtual Seminar on Climate Economics

Federal Reserve Bank of San Francisco

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# Challenges when designing optimal climate policy

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October 7, 2021

# Preliminaries

- Today's presentation is a "policy" presentation.
- Based on policy and commentary work surrounding climate change:
  - "Climate change: time to act," with Christian Gollier, as part of the report *The major future economic challenges*, by Olivier Blanchard and Jean Tirole, 2021.
  - Comment on: "Climate Change Uncertainty Spillover in the Macroeconomy", for the 36th Annual Conference on Macroeconomics, 2021.
  - Comment on: "The Social Cost of Carbon: Advances in Long-Term Probabilistic Projections of Population, GDP, Emissions, and Discount Rates", Brookings Conference, Fall 2021, in preparation.

## Three main points of presentation

- We need to reconcile SCC and net-zero approaches to optimal climate policy for a more internally consistent narrative.
- Importance of uncertainty (*not the extent*) might be overstated for optimal policy in a constrained world.
- We are surely falling short and should plan accordingly.

# The need to reconcile prices and quantities

## Prices vs. quantities

- Two dual approaches to recommended action:
  - Social cost of carbon (prices) $\rightarrow$ imply emissions path
  - Net-zero targets (emissions path) $\rightarrow$ imply prices
- "Divide" in the approach: US vs. Europe, although targets (at least, via announcement) getting more traction in the US.
- Fixed targets often criticized as they seem less flexible.
- Prices criticized as they do not guarantee a temperature limit, and estimated prices tend to be very low ($\approx$ \$50).

## Uncertainty in prices vs. quantities

- Two approaches suffer from different sources of uncertainty in order to calibrate necessary market signals:
  - Prices. Focus on what the damages are from climate change given expected temperature increases.
  - Quantities. Focus on what the costs are of going to net zero.
- Unclear which source of uncertainty is largest!
- In equilibrium, there should be some internal consistency between the two, but **link often lacking**.

## Example: \$50 SCC

- Social cost of carbon can be computed: using general equilibrium model like DICE, or computing damages for an assumed path of emissions (Rennert et al, 2021).
- Problem: DICE model assumes reducing emissions is quite "easy".
- Predicted emissions reductions at this price → quite substantial.
- However, given what we know from "quantity approach," *extremely unlikely*.

- Can we combine the **two approaches**, even if just as a sanity check?

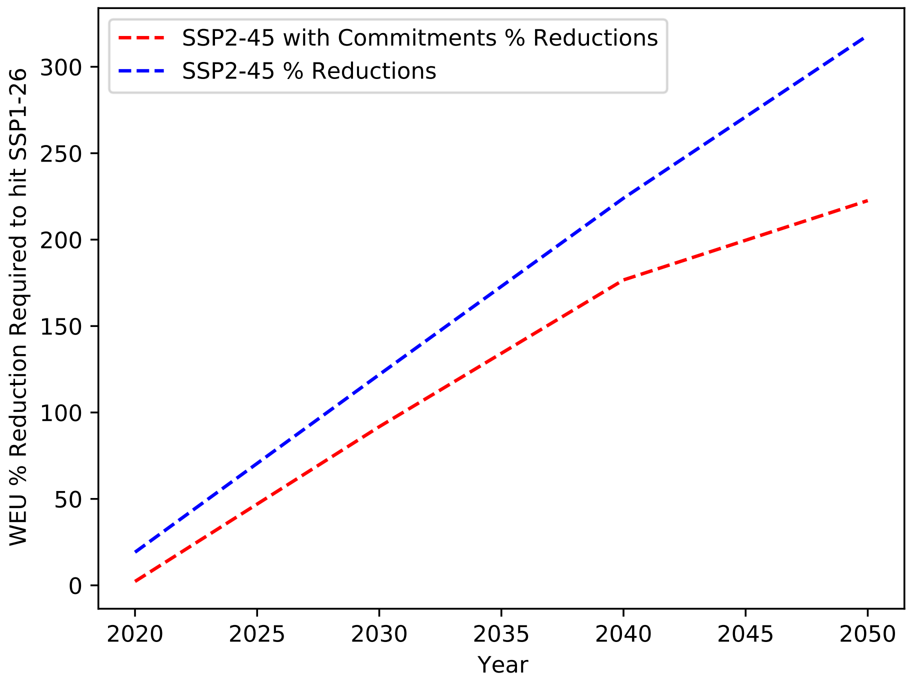
## Prices from the quantity approach *much* larger

**Table 2 – Shadow carbon price (in 2018 euros per metric ton of $CO_2$) in France implied by three different commissions**

| | Boiteux (2001) | Quinet 1 (2009) | Quinet 2 (2019) |
|---|---|---|---|
| 2010 | 32 | 32 | |
| 2020 | 43 | 56 | 69 |
| 2030 | 58 | 100 | 250 |
| 2050 | 104 | 250 | 775 |

*Source: France Stratégie*

# Even "net-zero" approaches inconsistent with claimed targets!




Note: Based on own simulations using annual emissions country level data (Gollier and Reguant, 2021).

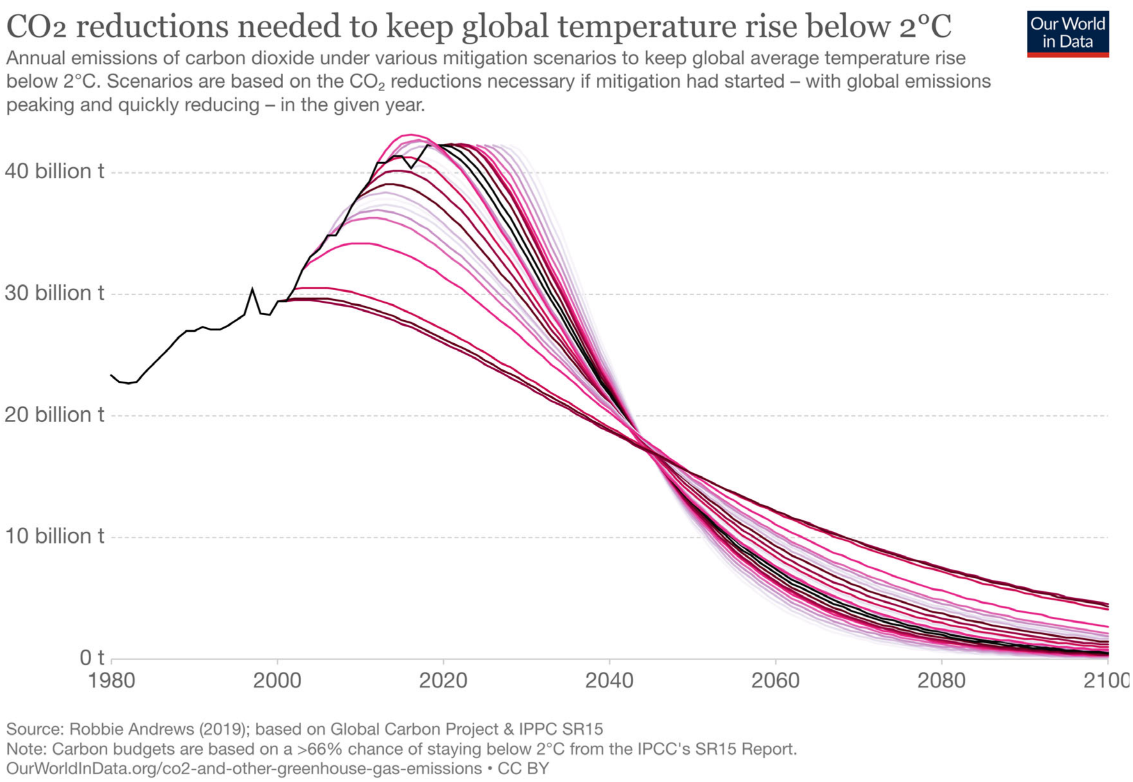
# Is uncertainty relevant for policy recommendations?

## Uncertain climate, uncertain climate policy?

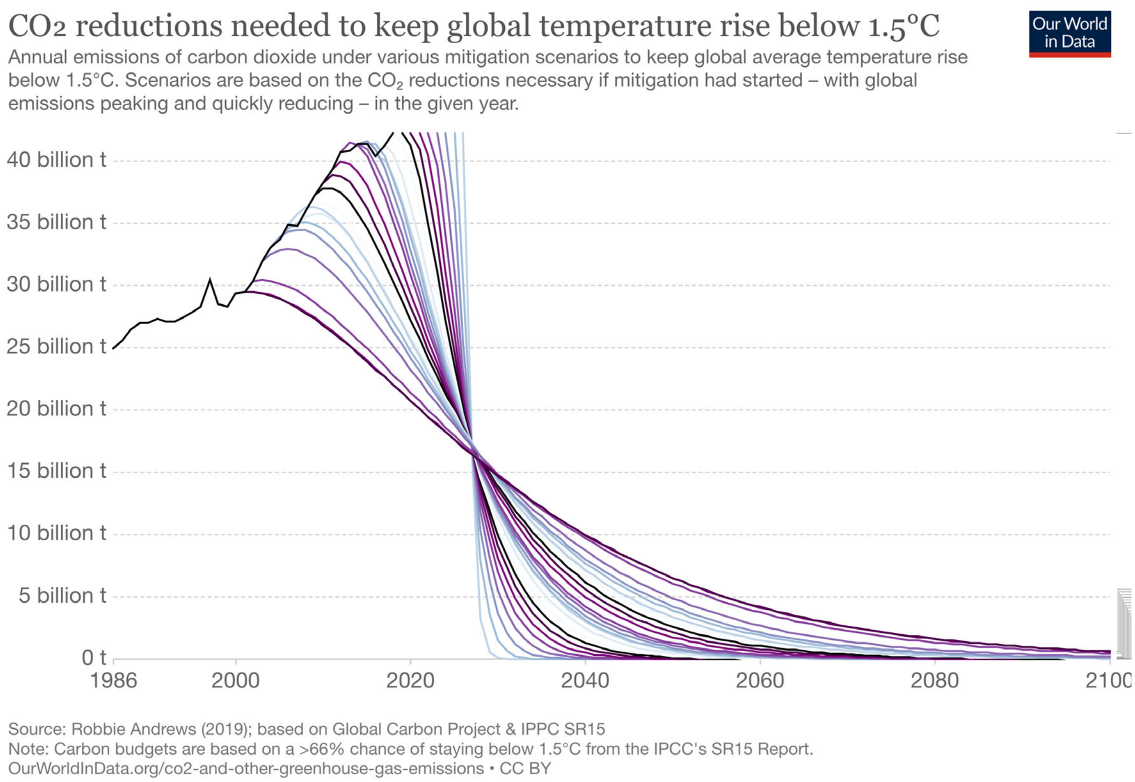
- Economists, engineers, and climate modelers explore optimal climate policy using stylized models (e.g., DICE, PAGE, etc.).
- Uncertainty along several dimensions: climate impacts via carbon and temperature dynamics (scenarios/stochastic), economic damages, innovation, population growth, tipping points.
- Early literature emphasized "value of waiting."
- Recent literature more focused on the "value of immediate action" (fat tails, tipping points, risk aversion, ambiguity aversion).

- **Major outcome of interest**: recommended emissions path and/or recommended carbon price path.

# Limited progress along recommended pathways



# Necessary actions become unrealistic



## A (somewhat provocative) question

- Does climate uncertainty matter from a policy recommendation point of view?
- Should our recommendations change substantially depending on what benchmark we take?
- Why or why not?

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- **Point**: Climate uncertainty matters to inform necessary steps. However, emissions reductions likely constrained for range scenarios.

$$\underbrace{E^{constrained}}_{\substack{\text{Feasible} \\ \text{policy ambition}}} > \underbrace{E^{*}}_{\substack{\text{Recommended policy} \\ \text{under wide range} \\ \text{of uncertainty outcomes}}}$$

## Implications for modeling

- Important to focus on how to **move the needle** on what is politically feasible (even unilaterally).
- Important to better capture **policy risks** in addition to other sources of uncertainty: leakage, bitcoin mining, etc.
- Important to consider "fat tails" in **political economy** outcomes.
- Important for policy portfolio: need to **strengthen negative emissions technologies**.

## Just out: related concerns and constructive suggestions

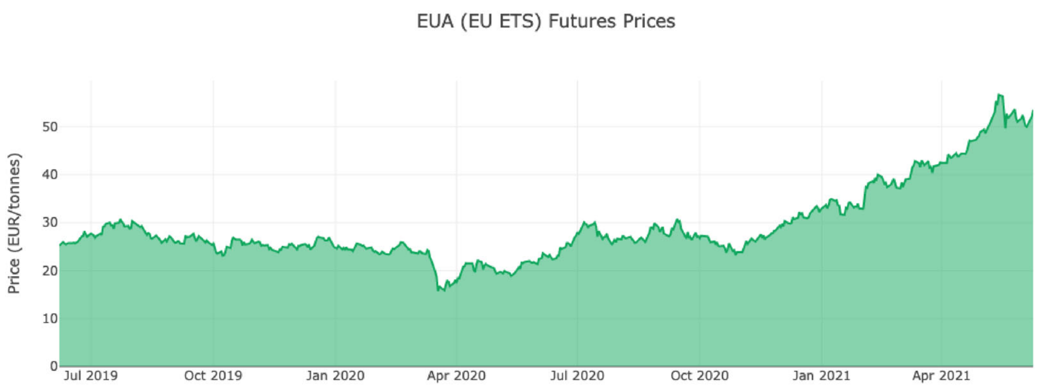
COMMENT | 08 June 2021

# Climate policy models need to get real about people – here's how

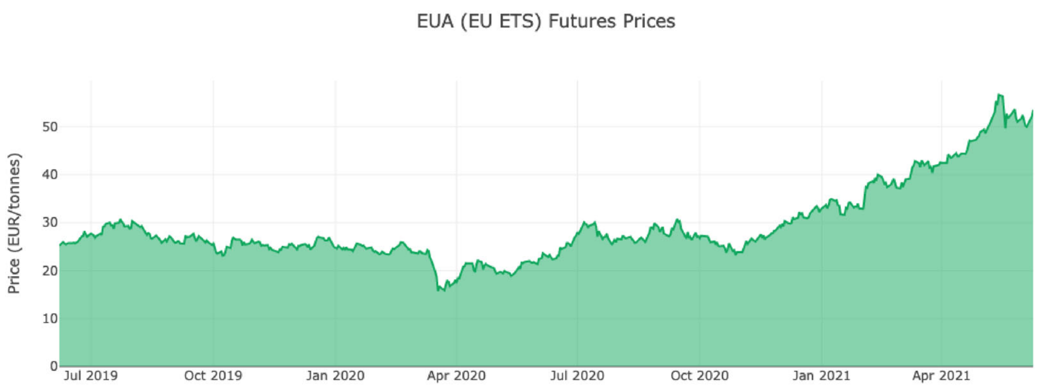
To predict how society and political systems might actually respond to warming, upgrade integrated assessment models.

Wei Peng, Gokul Iyer, Valentina Bosetti, Vaibhav Chaturvedi, James Edmonds, Allen A. Fawcett, Stéphane Hallegatte, David G. Victor, Detlef van Vuuren & John Weyant

# The tension: An example from EU ETS



# The tension: An example from EU ETS




- Finally prices at levels IAMs would consider a good *start*.
- Yet, partial coverage and leakage likely to lead to backlash (exacerbated by extreme gas prices).
- Needs to be addressed via full coverage of emissions and border adjustments, but political risk (domestic and int'l) looms large.

# To illustrate the discussion

- (Very) Simple model of climate change based on Barnett, Brock, and Hansen (BBH 2019, BBH 2021).
- The difficulty of "compartamentalizing" uncertainty, economic modeling, and political feasibility.
- The role of political economy constraints.
- Re-framing the uncertainty problem: what is politically feasible?

## Model (based on BBH 2021)

- AK model, $C_t + I_t = \alpha K$.
- Utility, $U_t = (C_t/N_t)^{1-\kappa}(E_t)^\kappa$
- $\kappa = 0.032, \alpha = 0.115$.

- Emissions $E_t$ have a zero price but contribute to climate change (cake-eating problem) via damages $N_t$.

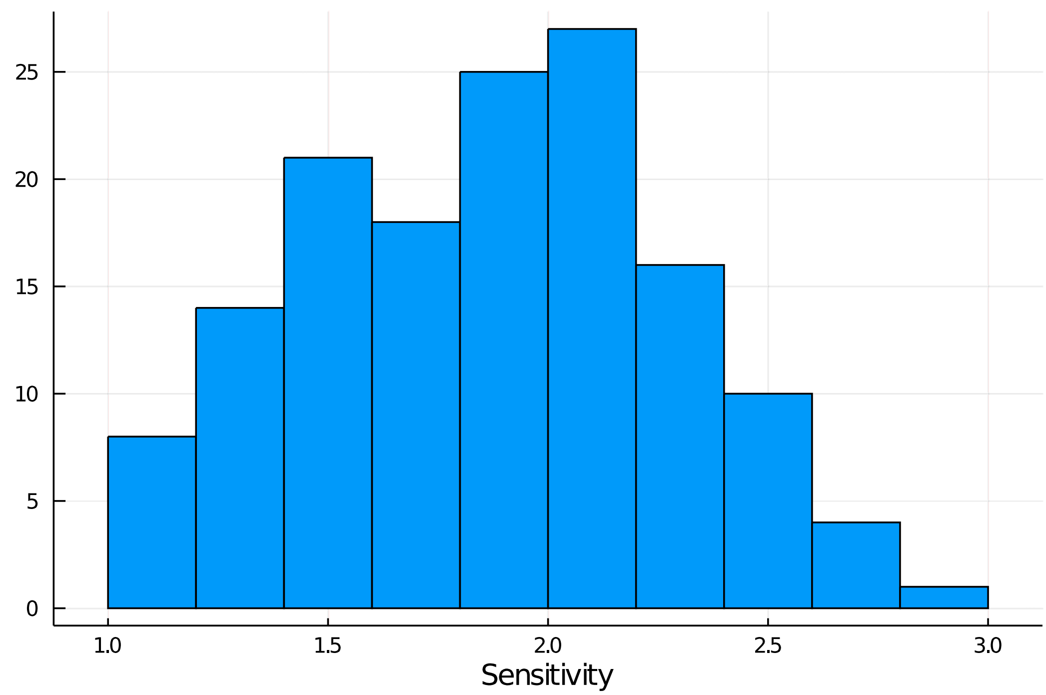
## Climate sensitivities

- Climate damages articulated via impact of emissions on temperatures (stock pollutant).
- Use of Matthews approximation and Joos et al. (2013) and Geoffroy et al. (2013) pulse experiments.
- Increase in temperature linear with emissions:

$$Y_{t+1} = Y_t + \zeta_t E_t.$$

- Temperature increases in turn generate damages, $N_t(Y_t)$.

# Climate sensitivities histogram




Source: BBH (2021), using several models and uncertainty scenarios from Joos et al. (2013).

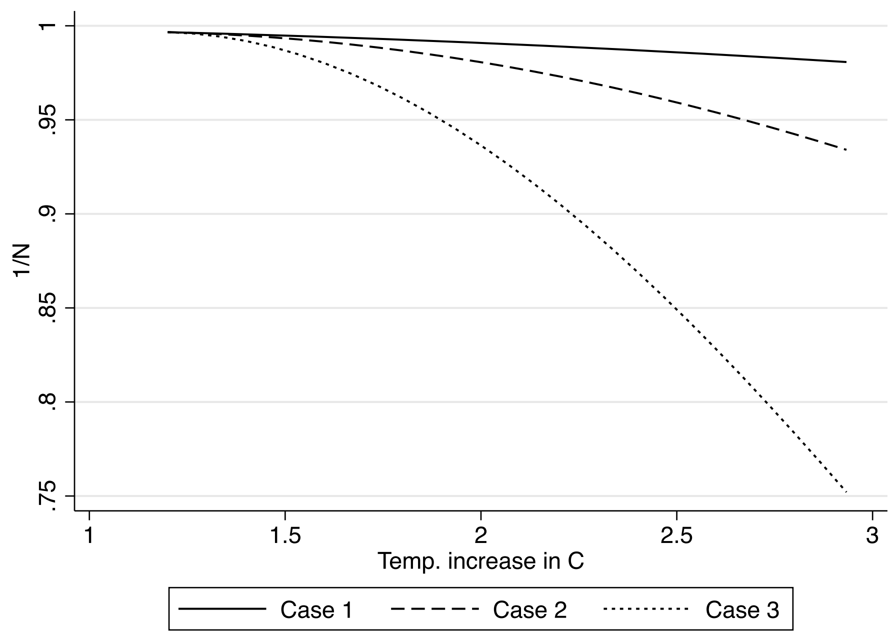
## Economic damages

- Economic damages evaluated via scenarios.

$$log(N_t) = \gamma_1^s Y_t + \gamma_2^s Y_t^2/2.0 + \gamma_3^s (Y_t - Y_0)^2.$$

- For simplicity, consider 3 scenarios (almost no damages, medium, and large damages).
- BBH consider almost no damages until temperature reaches 1.5-2 degrees, here a more gradual assumption $Y_0 = 1.2$ degrees (simplifies modeling and still allows for range of impacts).
- Weights: $1/3$ each. With ambiguity aversion, BBH show can reframe problem *as if* more weight to extreme scenario (e.g., [0.1, 0.35, 0.55] towards high damage).

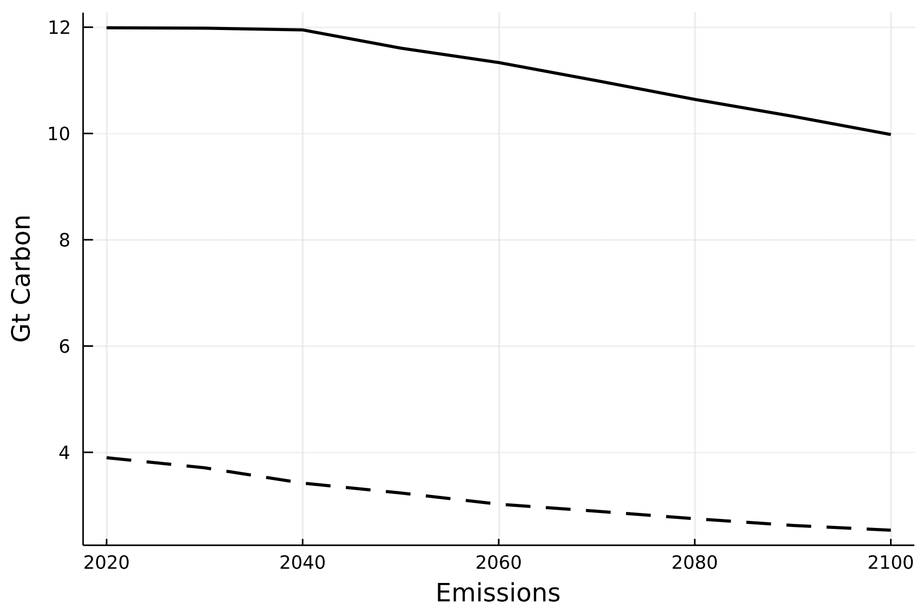
# Economic damages




Source: Own elaboration based on BBH model. Case 1 is a scenario with almost no climate damages, Case 2 is a relatively optimistic scenario, and Case 3 is a case with substantial climate impacts.

# Model output under rational expectations

Reductions substantial even including baseline of almost no climate impacts in expectations.

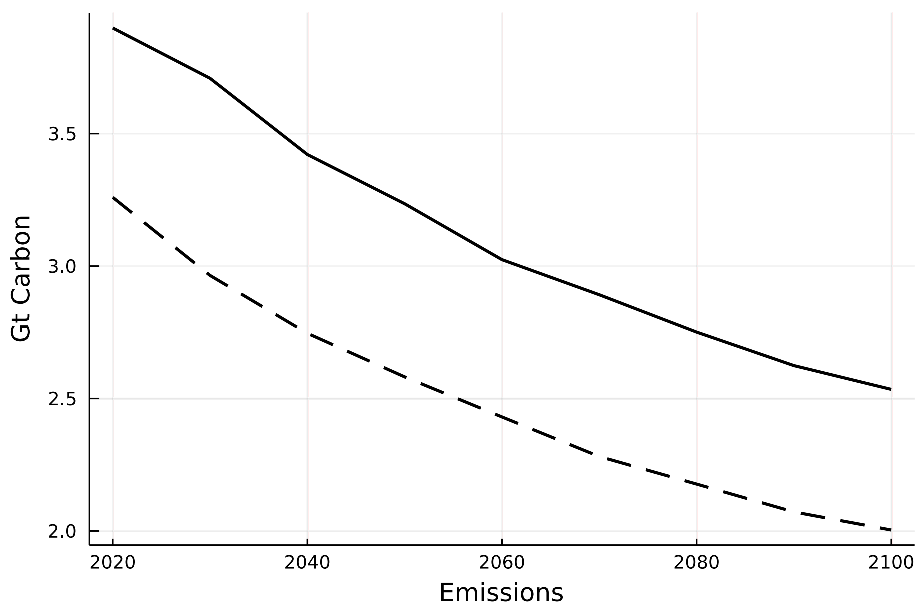


# Workings of the model

- Model is **highly stylized**.
- **Most optimal pathways will maintain temperature below 2** (or 2.5) in 2100 in line with current demands.
- In spite of no abatement or innovation, climate problem can be resolved at very low cost (probably not accurate!).
- Reductions occur suddenly and keep decreasing over time.
- Uncertainty matters, but emissions levels low under all circumstances **as long as some bad outcomes are considered**.

# Ambiguity aversion makes planner more conservative

Ambiguity aversion on economic outcomes does increase targets, but even without it, they remain low.



# Adding realistic concerns

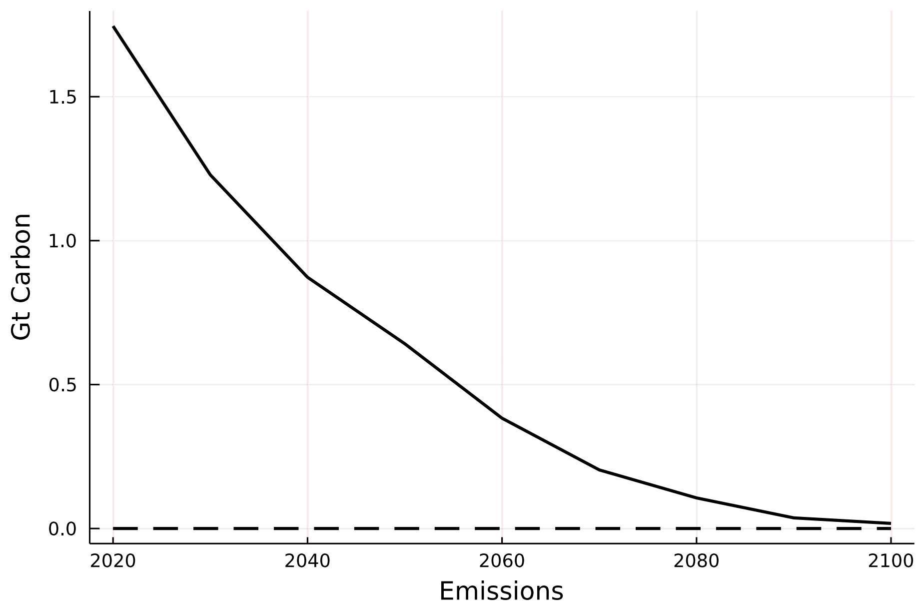
- Model as built is extremely simple.
- Political and economic feasibility as embedded either in the problem constraints or the production function.
  - **Leakage in emissions**: always above a certain threshold $\underline{E_t}$.
  - **Costly transition**: at most 40% *global* reduction every 10 years, starting at 45 Gt CO2.
  - **"Leontieff" considerations**: cannot substitute emissions as easily.

## Main result of the exercise

- Adding realistic policy constraints to the model makes the optimal pathway equal under substantially different forms of uncertainty.
- **Corner solution**: politically viable solution falls short of optimal efforts under a wide range of modeling choices.

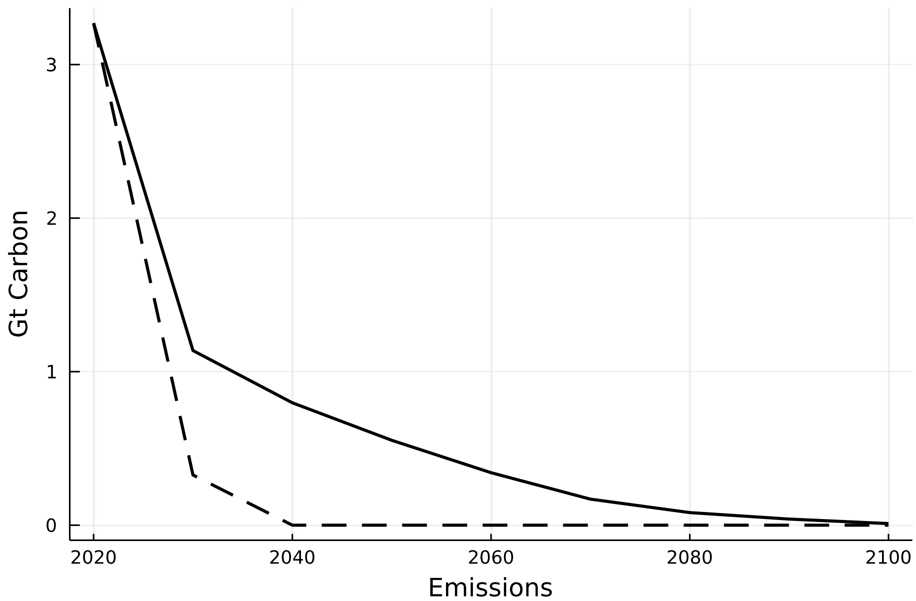
# Medium vs. extreme case under constraints

Substantial leakage leads to net zero (for complying countries) quickly (as quickly as now!). Effective carbon prices inefficiently low.



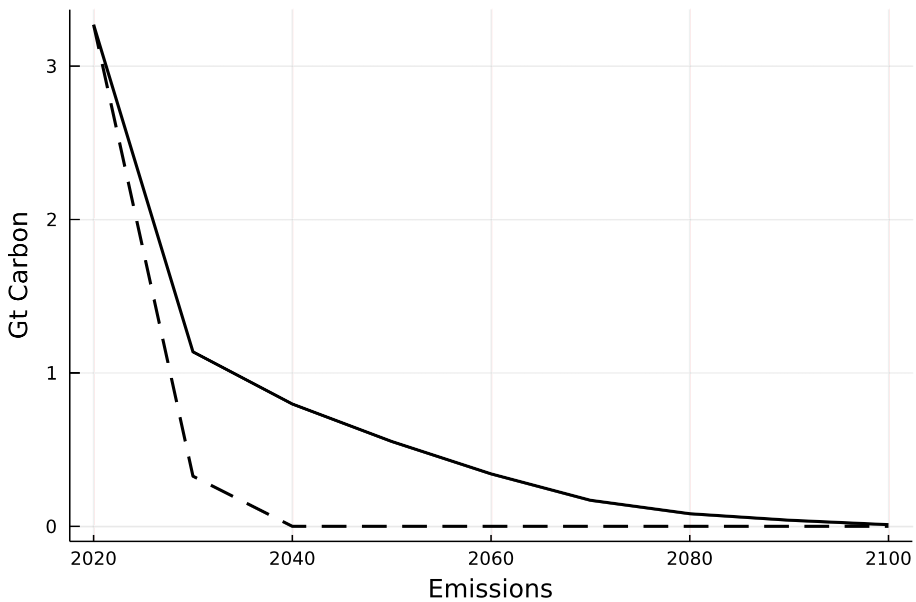
# Medium vs. extreme case under constraints

Coupled with gradual constraints, optimal policy becomes virtually the same for quite different scenarios.



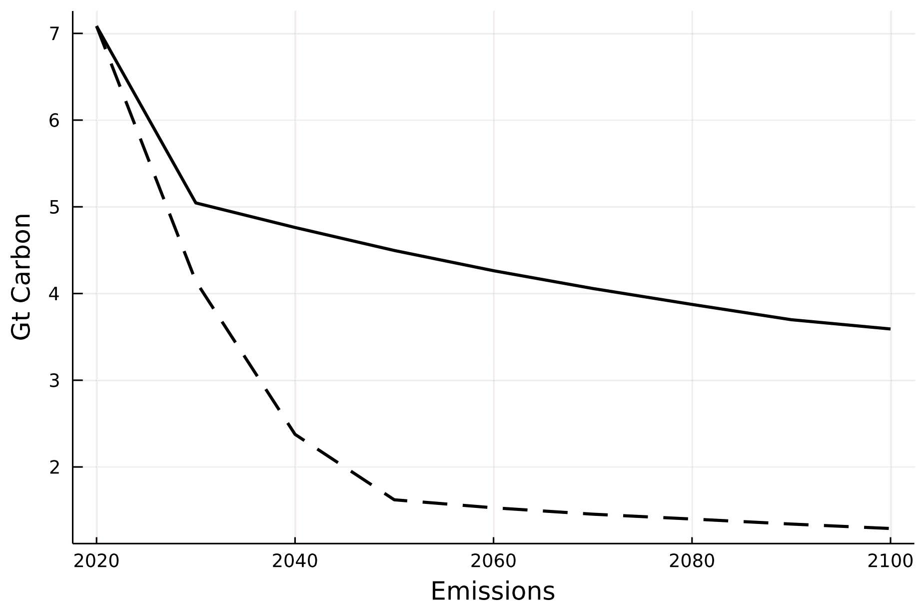
## Medium vs. extreme case under constraints

Leontieff constrains and gradual adoption lead to similar bottlenecks, even absent leakage.



# Medium vs. extreme case under constraints

Without leakage or Leontieff constraints, outcomes still very similar for short-run strategy (binding).



## Discussion

- Lots of efforts in the profession in the **sensitivity** of our recommendations to uncertainty (climate damages, innovation, economic assumptions, etc.).
- Uncertainty probably even much larger than what we tend to assume (model specification, tipping points, extrapolation).
- However, recommendations at this point, given **lack of action** and the limitations on the feasible set, should align with the scientific community: no matter what we do, we will fall short.
- Focus on **how to expand the set of possibilities**, and minimize costs but without limiting the extent of reductions.

As we surely fail

## The need for skepticism about golden bullets

- Adoption of more extensive/aggressive carbon pricing and explicit targets should be **welcomed**, but not a complete solution to the climate problem.
- Lack of incentives to fulfill promises, leakage (across countries, unkown sources, large value in the fossil fuel industry, etc.
- Even if recommendations were **applied by the book** (which I hope they are), they still **do not solve the long-term problem**!

# A battery of policies from Macron report

1. **Stronger carbon pricing**: including all fossil fuels (taxed at source), with carbon border tax adjustments, and more transparent price adjustment mechanisms. With transparent redistribution. Critical to induce innovation and change.
2. **Targeted innovation policy**: to mitigate the global failures of carbon pricing (see next slide).
3. **Bans and standards**: more popular, perceived as more equitable in the presence of income inequality, e.g., car bans, short flights, public funding of fossil fuel infrastructure, new fossil fuel exploration.
4. **Keeping an eye on leaks**: in carbon pricing, in agricultural policy, in foreign aid policies.
5. **Intermediate targets important**: even if they are not necessarily efficient, they seem important to deal with the political economy challenges of climate policy.
6. Better **imperfect action** than no action.

## R&D Policy

- Not credible to expect (or wait for) all countries to contribute.
- Different stages of development, natural resource endowments, preferences.
- Cooperation has failed for decades and has delayed efforts.
- Ambitious R&D int'l "prizes" with high stakes for direct air capture and other credible **negative emissions technologies**.
- Subsidies to other techs should be focused on **technologies that make fossil fuels economically irrelevant**.
- It is the only *incentive compatible* strategy.
  - Example: renewables + batteries > fossil fuels, crucial for the African continent.

## Adaptation

- We need to **plan for extreme events** and shortages (energy, water, food).
- Tendency to minimize their role, but they are becoming frequent and can be devastating even in advanced economies.
- Impacts will be **extremely unequal**, within and across societies.
- It can backfire against climate policy itself.

- Need to take into account resilience benefits, e.g., building envelopes protect against extremes in the presence of system failure, urban infrastructure to reduce asphalt and increase trees, etc. but **harder to price**.

## Conclusions

- Political constraints blur the importance of **climate and economic uncertainty** and emphasize robustness of current targets (due to lack of ambition).
- **Political constraints** are likely to bind when compared to optimal pathways.
- "Net zero" statements, given policy uncertainty, are reasonable **even under optimistic assumptions**. Important to convey: a robust policy.
- There is high value in enlarging the set of what is **politically feasible** and to minimize costs subject to feasibility constraints.
- Still, we need to prepare for policies that can **partially alleviate** the lack of success.