Suboptimal Climate Policy

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Economics applied to climate change

The problem of climate change is trivial!

- Humans cause warming as a *byproduct* of economic activity.
- This is a classic case of a *pure externality*.
- 100 years ago an economist figured out what to do in such cases (Pigou, 1920): apply a tax equal to the total marginal "externality damage" the polluter is otherwise not paying for. I.e., markets need some help in correcting the pricing.
- No research since has quibbled with this basic insight.
- Carbon spreads super-quickly in atmosphere: damage identical regardless of where it is emitted $\Rightarrow$ global tax!
- Thousands of (famous) economists have signed a petition urging the adoption of a carbon tax.

Given this, is there nothing interesting left for us to work on?

A resounding NO

Important things to do for many parts of economics.

Here my focus: macro. Message: develop and USE integrated assessment models (IAMs, a la Nordhaus):

- Policymakers seem reluctant to just go for a carbon tax. So let's consider policies that are closer to implementation—compare them and inform.
- This task is what economists know how to do: we are experts on understanding how markets operate and how different regulations/taxes act.

Note: the idea is to analyze *suboptimal policy*

- to be distinguished from "second-best" policy;
- we are pushing for quantitative analysis, for example computing how much more certain policy packages hurt our welfare (than, say, a global carbon tax) if the goal is to limit warming by x degrees by 2200.

Contribution here, in concrete terms, I

Methodological: we offer a framework—an IAM—for quantitative analysis of policy, designed so that it can be built upon further. Key features:

- it is decentralized;
- it is rich enough to be taken seriously: it can be used address important questions;
- it allows significant heterogeneity; and
- it builds entirely on "modern macro".

We use the framework to ask three quantitative questions.

Contribution here, in concrete terms, II

The three questions:

1. What if the right *kind* of policy is used but *at the wrong level*?
    - Highly relevant question as there is much uncertainty both about the climate conditional on emissions and about damages.
    - We compare a global carbon tax that turns out to be (much) too high ex post to one that is (much) too low ex post.
    - Insight: the former error is not very costly but the latter is.
2. What if we use a particular form of bad policy design: different carbon tax rates around the world?
    - Can be super-costly (we look at different concrete cases).
3. What if we can promote green energy instead of taxing carbon?
    - Very likely very bad idea.

People, preferences, technology, nature

- discrete, infinite time, one final good
- r regions
    - $r-1$ regions consume but do not produce oil
    - 1 region produces but does not consume oil
- within each region, representative agent
- output in each region
    - C-D in capital, labor, energy composite
    - energy composite nested CES in oil(s), other fossil, green
    - TFP incorporates damages from changed climate
- capital accumulation neoclassical
- fuels produced with constant marginal costs in terms of output (oil at zero), vary across fuels and regions
- exogenous technical change (in various parts)
- climate/carbon cycle modules: (roughly) as in Nordhaus

Markets, policies

- perfect competition everywhere (implies only oil gives "rents")
- restrictions: the only between-country trade involves oil (rule out intertemporal trade)
- governments' actions
    - *local*, i.e., no interregional transfers
    - run balanced budgets
    - tax fossil energy sector
    - rebate in proportion to incomes

Comments

Some potentially important things abstracted from in this model:

- intertemporal trade between countries (competitive everywhere, implies only oil gives “rents”)
- endogenous technology (e.g., R&D into green)
- uncertainty
- nonlinearities (e.g., tipping points in damages or natural-science part)

These can be useful additions but much can be said without them.

Addition of these elements “straightforward” (especially for doing positive analysis); basic model super-easy to solve.

(If time: comment on the merits of “really complicated models”.)

Some key equations, economics

$$\sum_{t=0}^{\infty} \beta^t \log(C_{i,t})$$

$$E_{i,t} = \left(\lambda_1 O_{i,t}^{\rho} + \sum_{j=2}^{n} \lambda_j e_{j,i,t}^{\rho} \right)^{\frac{1}{\rho}} \quad ; \quad O_{i,t} \equiv \widetilde{I} \left(\lambda_1^{oil} e_{1,i,t}^{\rho_h} + \sum_{j=1}^{I} \lambda_{j+1}^{oil} e_{n+j,i,t}^{\rho_h} \right)$$

$$C_{i,t} + K_{i,t+1} = A_{i,t} L_{i,t}^{1-\alpha-\nu} K_{i,t}^{\alpha} E_{i,t}^{\nu} - p_{1,t} e_{1,i,t} - \sum_{j=2}^{n+I} p_{j,i,t} e_{j,i,t}$$

$$R_{t+1} = R_t - \sum_{i=2}^{r} e_{1,i,t}, \text{ s.t. } R_t \geq 0$$

Some key equations, natural sciences

$$A_{i,t} = \exp\left(z_{i,t} - \gamma_{i,t} S_{t-1}\right)$$

$$S_t = \sum_{s=0}^{\infty} (1 - d_s) \sum_{i=2}^{r} M_{i,t-s} \quad \text{with} \quad M_{i,t} = \sum_{j=1}^{n+l} g_j e_{j,i,t}$$

$$T_t = T_{t-1} + \sigma_1 \left(\frac{\eta}{\ln 2} \ln\left(\frac{S_{t-1}}{S_0}\right) - \kappa T_{t-1} - \sigma_2 \left(T_{t-1} - T_{t-1}^L \right) \right)$$

$$T_t^L = T_{t-1}^L + \sigma_3 \left(T_{t-1} - T_{t-1}^L \right)$$

Theoretical characterization

$$R_{t+1} = \beta R_t \qquad K_{i,t+1} = \frac{\alpha\beta}{1-\nu}\left(1+\Gamma_{i,t}\right)\hat{Y}_{i,t}$$

$$\hat{Y}_{i,t} = (1-\nu)\,A_{i,t}L_{i,t}^{1-\alpha-\nu}K_{i,t}^{\alpha}E_{i,t}^{\nu}$$

$$E_{i,t} = \left(\nu\frac{e^{\left(z_{i,t}-\gamma_{i,t}s_{t-1}\right)}L_{i,t}^{1-\alpha-\nu}K_{i,t}^{\alpha}}{P_{t,i}}\right)^{\frac{1}{1-\nu}}$$

$$P_{i,t} = \left(\lambda_1^{\frac{1}{1-\rho}}\left(P_{i,t}^{O}\right)^{\frac{\rho}{\rho-1}} + \sum_{j=2}^{n}\lambda_j^{\frac{1}{1-\rho}}\hat{p}_{j,i,t}^{\frac{\rho}{\rho-1}}\right)^{\frac{\rho-1}{\rho}}$$

Theoretical characterization, cont'd

$$P_{i,t}^{O} = \widetilde{I}^{-1} \left(\left(\lambda_1^{oil}\right)^{\frac{1}{1-\rho_h}} \hat{p}_{1,i,t}^{\frac{\rho_h}{\rho_h-1}} + \sum_{j=1}^{I} \left(\lambda_{j+1}^{oil}\right)^{\frac{1}{1-\rho_h}} \hat{p}_{n+j,i,t}^{\frac{\rho_h}{\rho_h-1}} \right)^{\frac{\rho_h-1}{\rho_h}}$$

$$O_{i,t} = \left(\lambda_1 \frac{P_{i,t}}{P_{i,t}^{O}}\right)^{\frac{1}{1-\rho}} E_{i,t}$$

$$e_{j,i,t} = \frac{O_{i,t}}{\widetilde{I}} \left(\widetilde{I}\lambda_j^{oil} \frac{P_{i,t}^{O}}{\hat{p}_{j,i,t}}\right)^{\frac{1}{1-\rho_h}}, \quad j \in \{1, n+1, \ldots n+I\}$$

$$e_{j,i,t} = \left(\lambda_j \frac{P_{t,i}}{\hat{p}_{j,i,t}}\right)^{\frac{1}{1-\rho}} E_{i,t}, \quad j \in \{2, ..., n\}$$

Numerical solution

- Find path for oil prices such that

  $$\sum_{i=2}^{r} e_{1,i,t} = (1-\beta)\, R_t$$

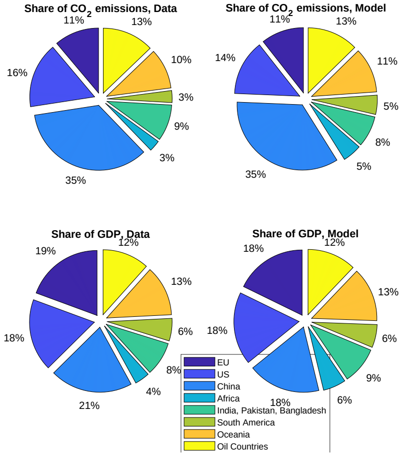
  at all points in time. Each period is solved in isolation.
- In experiments where we target a temperature at a certain date, iterations on paths.

Calibration

Everything calibrated to data (except some features that are assumed common across regions).

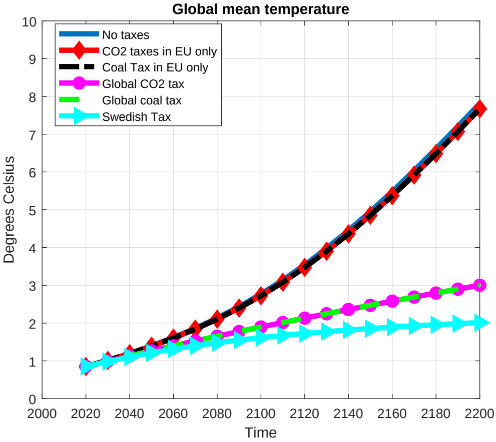
- 8 oil-consuming regions: Europe, the U.S., China, South America, India, Africa, “Oceania”; oil-producing region comprises OPEC and Russia
- energy:
  - oil (incl. natural gas), fracking; coal and green
  - fracking only in U.S.
  - energy elasticities calibrated to values from meta study (Stern, 2012): 0.95 except between oil and fracking output (10)
  - relative prices of fuels same across regions, match data
- TFPs in rich world grow at common rate, fast-growing and some convergence in rest
- initial capital stocks calibrated so that MPK_is equal at time 0
- initial stock of oil and energy production parameters set to match uses and emissions

Outputs and emissions



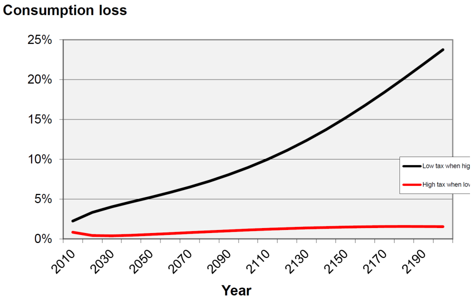
Shows our calibrated matches the key regional features.

Before we start, a few basic points



- It's all about coal (taxing oil or not makes no difference).
- A modest (EU-ETS level) tax helps a lot, if global.
- The lack of action (or only EU action or not taxing coal) leads to huge warming.

Suboptimal policy I: right kind of tax, wrong level

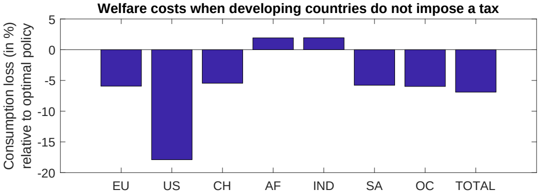


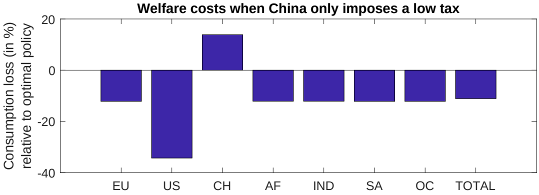
Black: global carbon tax based on most optimistic scenario for warming and damages in range given by IPCC, but reality turns out at other end of spectrum (very high warming and damages). Red: reverse.

Logic: (explain verbally).
Message: high tax excellent precautionary instrument.

Suboptimal policy II: non-uniform carbon tax

Target 2.6° heating by 2165, let Africa and India (1st graph) and China partially (2nd) off the hook; losses relative to uniform tax.



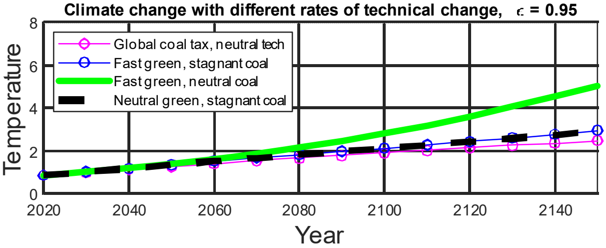


⇒ (i) non-uniform very bad idea; (ii) China crucial.

Suboptimal policy III: green energy push, no fossil tax

The Pigou tax implements the optimum ⇒ no green subsidy needed. But suppose there is no Pigou tax.

Feed in higher exogenous green productivity growth (+ 2%/year). Substitutability green-fossil: 0.95 (similar results for 2).



Doesn't help the climate! Lower coal productivity growth helps—like a tax. Green subsidy NOT good Pigou-tax substitute.

Summary remarks

There are productive ways for macroeconomics to be helpful in the area of climate change.

In particular, a stripped-down IAM is used to obtain quantitative answers: a cost-benefit evaluation of bad, but realistic, policies.

Some of the answers were very surprising to us:

- best available estimates suggest the policy errors are highly asymmetric, leading one to favor a high tax on carbon
- it's very costly not to be able to use a global tax (or equivalent)—letting some off the hook is very expensive
- to push for green *instead of* taxing coal is very ineffective and hazardous for the climate.

It's easy to take our analysis further.