The Macroeconomic Impact of Climate Change: Global vs. Local Temperature

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Discussion

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Cowles Summer Conference on Macroeconomics

June 2024

Outline

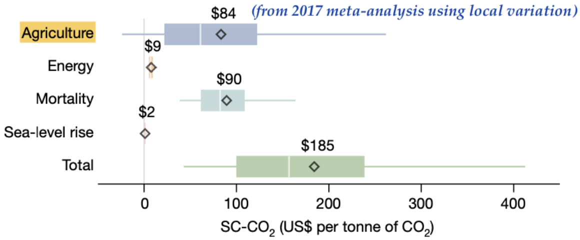
Background & Recap

Social cost of carbon (SCC): Crucial summary measure of climate damages

- Used formally in U.S. policymaking since 2010 for required regulatory cost-benefit analysis
- Most recent interagency working group estimate: $51 per ton of CO2
- Influential 2022 assessment [Rennert et al., *Science*]: $185/ton
- **This paper: $1,056/ton**. Important (30% of global GDP!), and with a nice paper to back it up.

Why? Climate damages depend on global, not local, temperature changes

- Widely accepted in climate science lit. . .but not incorporated into estimates of economic damages



The Micro-to-Macro Problem

[Nakamura & Steinsson 2014, 2018; Chodorow-Reich 2020; Moll 2021; Wolf 2023; . . .]

- For region i, log output growth y_{it}, local temp. τ_{it}, global temp $\mathcal{T}_t = \frac{1}{N}\sum_{i=1}^{N} \tau_{it}$:

$$y_{it} = \alpha + \beta\tau_{it} + \theta\mathcal{T}_t + \varepsilon_{it}$$

- Local variation identifies β, but true aggregate effect is $\beta + \theta$: $\mathcal{Y}_t = \alpha + (\beta + \theta)\mathcal{T}_t$
  - As a matter of intellectual history, interesting that the climate lit. started with local variation
- Standard problem: **GE spillovers on outcome variable**
  - $\theta < 0$ if, e.g., input prices increase with other countries' temperature
  - $\theta > 0$ if, e.g., global temp. shocks generate investments in adaptation with positive spillovers
- Additional problem here for **treatment variable: agg. shock is not equivalent to sum of local shocks**
  - Temp. is reduced-form proxy for true climate shock (incl. extreme weather events)
  - True climate shock ≈ 0 given local temp. change, but $\gg 0$ given equivalent global temp. change
  - Similar to a case where monetary policy responds to aggregate fiscal shock

Outline

What to Make of the Time-Series Evidence

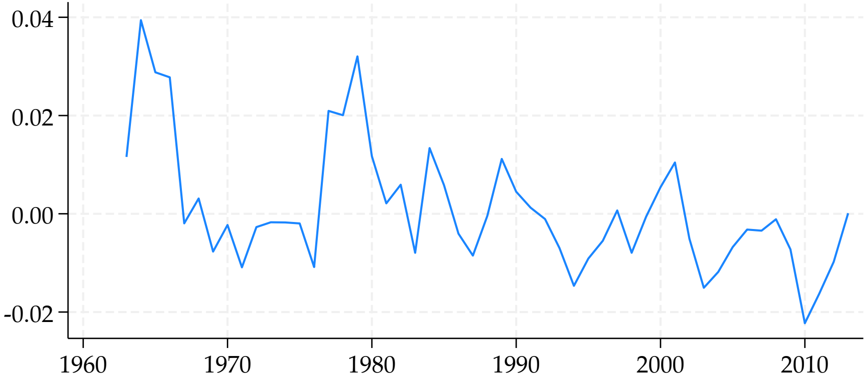
- Aggregate temp. shock (forecast error for global temp.) is likely exogenous
  - Is it predictable given shock construction? Probably not in this sample, but don't have much to say
- But time-series exercise still sacrifices identifying variation & statistical power relative to local exercise
- Key questions:
  1. **Can we trust that the estimates aren't due to noise?**
  2. Can we trust that the estimated effects are useful out of sample?
- Simple to replicate and extend baseline time-series estimation exercise
  - Global temp. $\mathcal{T}_t$ from NOAA; temp. shock $\widehat{\mathcal{T}}_t$ as residual from regression on 2 most recent values of $\mathcal{T}_t$ as of $t-2$ [Hamilton 2018]; real GDP per capita from Penn World Table, aggregated globally
  - Given short sample (1960–2019) and moderate forecasting horizon (max. effect at $h = 6$ years), important to examine influential observations
  - I do so in a simple jackknife (leave-one-out) exercise: dropping one t at a time, reestimate θ in in

$$y_{t+6} - y_{t-1} = \alpha + \theta \widehat{\mathcal{T}}_t + \underbrace{\left(\widehat{\mathcal{T}}_{t-1}, \widehat{\mathcal{T}}_{t-2}, \Delta y_{t-1}, \Delta y_{t-2}, \{\mathbb{1}(\text{recession})\}_{t,t-1,t-2}\right)'}_{x_t'} \beta + \varepsilon_{t+6}$$

Influential Observations

- Recall baseline $\widehat{\theta} \approx -0.11$ (s.e.: 0.05)
- Calculate 3-year moving sum effect of leaving out year t obs. when forecasting $t+6$ output
  (positive = closer to 0 without these observations)

Effect of Dropping Given Years on Estimated Output Effects of Temperature



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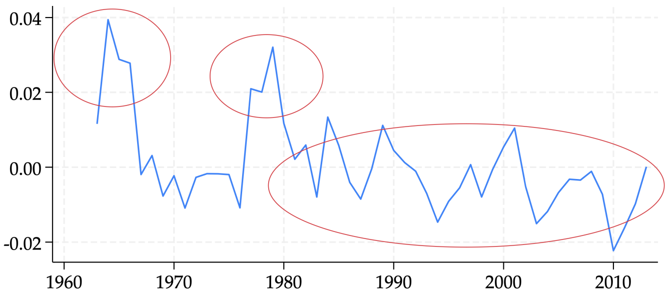
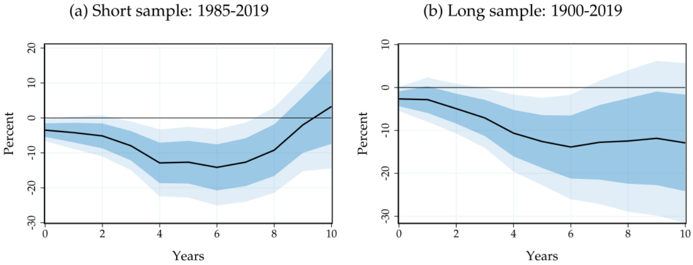


- Big negative temp. shock predicts continued global boom in late 60s; positive temp. shock predicts early-80s recession. Effects estimated using only post-80 agg. data ~50% smaller, but still there.
- Don't want to include *leads* of recession indicators to strip this out, but may want other controls

Influential Observations: Less Influential in Panel Setting

- Authors do a nice set of follow-up exercises, including estimating average local effects of global temp. shocks in panel of countries to get more power
- In this setting, post-1980s effect is still strong (no decline in estimated effect)

Figure 6: Sensitivity of the Average Effect of Global Temperature Shocks



- Panel structure also allows for richer estimation of effects of temp. shocks on extreme weather events, and on investment, capital, and TFP. Extreme heat & precipitation effects peak at 2 years, but investment & TFP effects take at least 4 years to hit peak. Worth examining further.
- Upshot: Not positive headline magnitudes are airtight, but paper moves my own view in its direction.

Outline

1. Background & Recap

2. Time-Series Evidence

3. Structural Interpretation

Are These Estimates Useful Out of Sample?

- Some discussion of the paper has focused on whether the estimated damage functions and model-implied SCC are really structural, given potential adaptation
- But recall that one *benefit* of considering global temp. is to be able to study possible adaptation

$$y_{it} = \alpha + \beta \tau_{it} + \theta \mathcal{T}_t + \varepsilon_{it}$$

  - $\theta < 0$ if, e.g., input prices increase with other countries' temperature
  - $\theta > 0$ if, e.g., global temp. shocks generate investments in adaptation with positive spillovers
- Main question is whether existing sample contains adaptation response that will apply going forward
  - I think of this as a problem of potential nonlinearity (e.g., bigger adaptation response as temp. rises)
- Worth studying further, but past work is suggestive. One relevant case: Moscona & Sastry (*QJE*, 2023)

> We find that innovation has redirected since the mid-twentieth century toward crops with increasing exposure to extreme temperatures. Moreover, this effect is driven by types of agricultural technology most related to environmental adaptation. We next show that U.S. counties' exposure to induced innovation significantly dampens the local economic damage from extreme temperatures. Combining these estimates with the model, we find that directed innovation has offset 20% of potential losses in U.S. agricultural land value due to damaging climate trends since 1960 and that innovation could offset 13% of projected damage by 2100. These

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- More generally, Sims (1986):

"There is no logical inconsistency between a world of competitive markets and rational people and a world in which the best forecasting models are VAR models. [...] In any empirical study there will be debatable questions about identification — questions that will leave us more or less uncomfortable about applying the conclusions. The [structural] rational expectations framework raises such issues from a different angle, but it cannot avoid them."

Final Notes

- Estimates come with inherent uncertainty
- If we view potential climate damages as uncertain (currently absent from the paper's model), the paper increases my view of the probability of tail-like outcomes. . .
- . . .bringing us closer to Weitzman's (2009) "Dismal Theorem"
  - When the distribution of possible consumption damages has a tail probability that approaches 0 more slowly than exponentially, the social cost of carbon becomes **arbitrarily large**
- Overall, very clear, well-executed, thought-provoking paper on first-order question

Thank you!