Empirical evidence on the aggregate impacts of warming

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But how do these effects aggregate?

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Two approaches to generate an aggregate "damage function"

- **Bottom up**: convert micro estimates to \$, add them up somehow
- 2 Top down: let economy do adding up for you, study effect on economic aggregates (e.g. GDP)

Damage functions we have known



- Pindyck (JEL, 2013): "The damage functions used in most IAMs are completely made up, with no theoretical or empirical foundation."
- Revesz, Arrow, Goulder et al (*Nature*, 2014): "The models should be revised more frequently to accommodate scientific developments."

Burke et al Nature (2015, 2018)

Approach: study effect of temperature on aggregate economic outcomes using country-level data (165 countries, 50 years).

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Goals:

- Identify causal effect of temperature on economic aggregates
- Empirically evaluate some conventional wisdoms:
 - Temperature has level effects, not growth effects
 - 2 Wealth insulates you from the effects of climate
 - 3 Ag is sensitive to climate, but other sectors aren't
 - 4 We've become less sensitive over time

Last half-century: global non-linear response



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Differences over space or time?



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Empirical climate damages

Now run the world forward



Can this be right??

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Some common complaints:

- Not convinced growth rates are affected
- We can't trust national accounts data from lots of places
- You're still leaving out a lot of bad stuff

Let's try it with subnational output data

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11,669 districts, n=162,256 total district-year obs

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Empirical climate damages

Pooled response, all districts



Pooled response, all districts



Estimated optimum is \sim 5C (compare 13C in Burke et al 2015, 2018).

Implies that most of world harmed by warming



Growth effects?

Since DJO 2012, estimate distributed lag models, add up lags. (Can also estimate a "long difference")



Conclusions

In Non-linear effect of temperature on historical output

- No strong evidence that structure of economy mitigates these effects
- No clear evidence of adaptation over time
- Similar response in national and subnational data, and strong evidence for growth effects
- a High likelihood of substantial losses under future climate change
 - Loss estimates are much larger than in existing damage functions, 5-10x
 - This is just from taking historical aggregate data seriously
- **We ignore or downplay large aggregate impacts at our peril**, even if we can't fully explain or understand them.
 - They are robustly "in" the data
 - Micro-founded estimates that do not match macro "moments" should be treated with care