Potsdam Institute for Climate Impact Research

Climate impacts on labor productivity and long-term economic growth

December 4, 2017

Leopoldina “Climate Science & Health: A Dialogue”

Ottmar Edenhofer, Anselm Schultes

Leibniz Gemeinschaft

Outline

1. Empirical methodology
2. Main findings
3. Implications for economic growth
4. Implications for the social cost of carbon

1. Empirics: Methodology

Objective: Finding dose-response functions for climate impacts

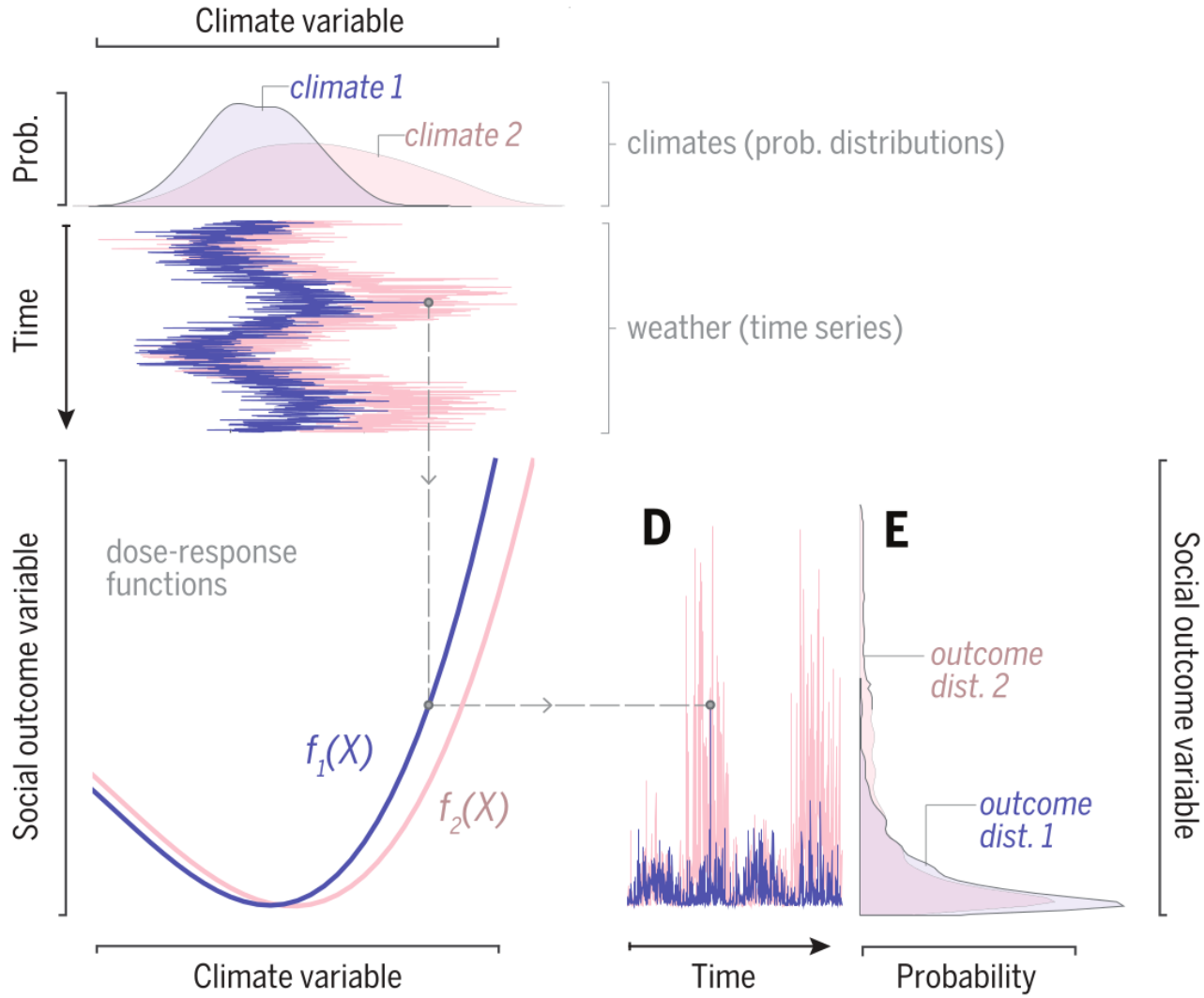


Figure from Carleton et al. (2016)

1. Empirics: Climate and wealth

Montesquieu (1748): “There are countries where the excess of heat … renders men so slothful and dispirited …”

- Cross-country studies: Warmer countries are poorer (Nordhaus 2006)

- Is this causal?
  → Establishing causality hard due to unobserved heterogeneity

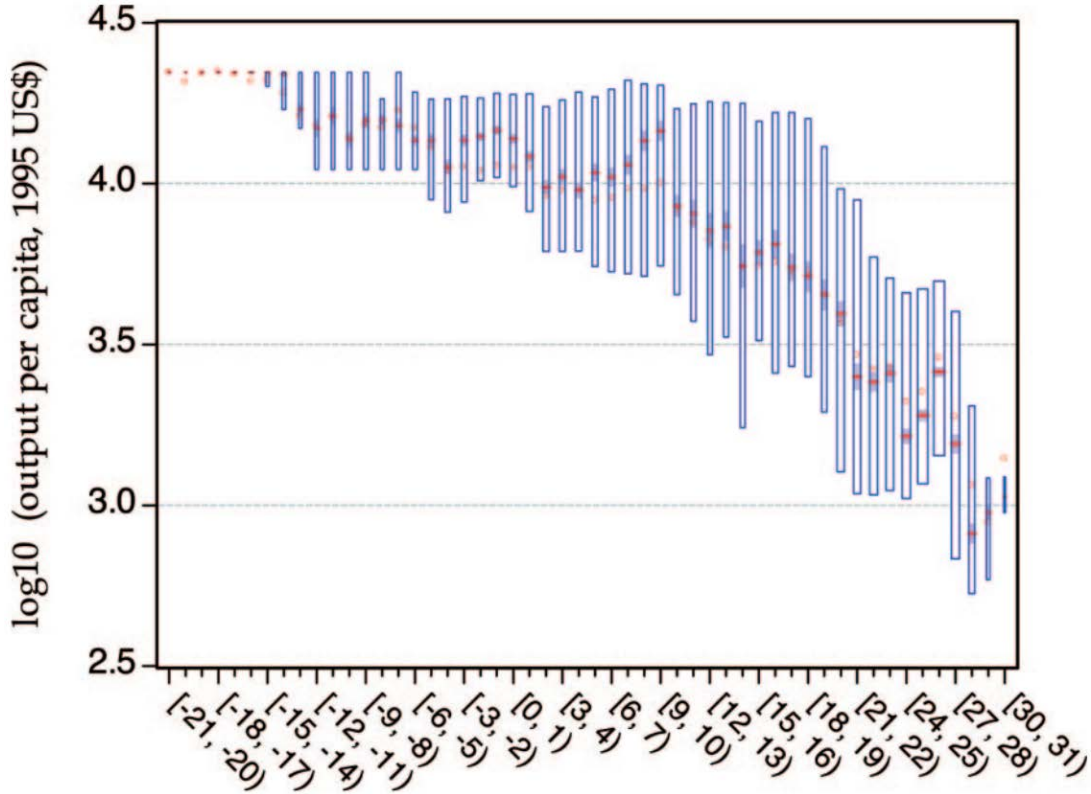


Figure from Nordhaus (2006)

1. Empirics: Causality

- Identification of characteristic social responses (micro level)
- Panel methods allow for causal identification
- Societies may or may not recover and adapt over time
- Response to weather not sufficient to know climate impacts
  → Adaptation

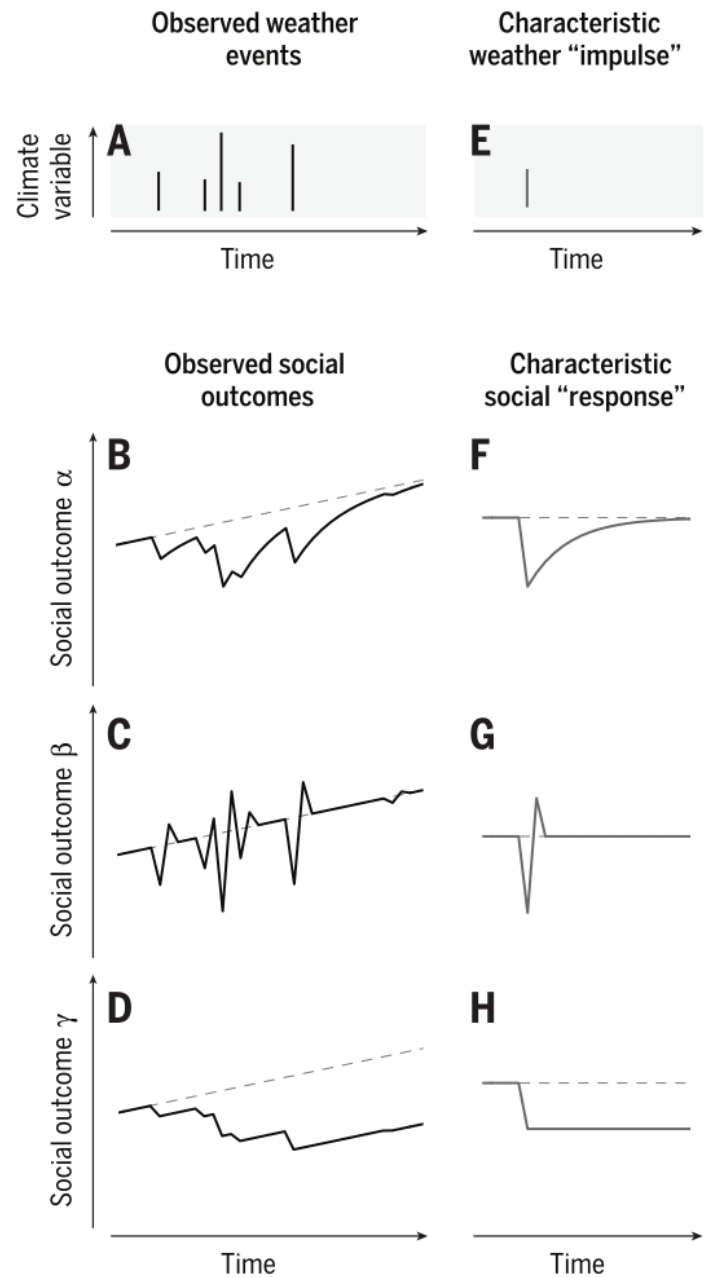
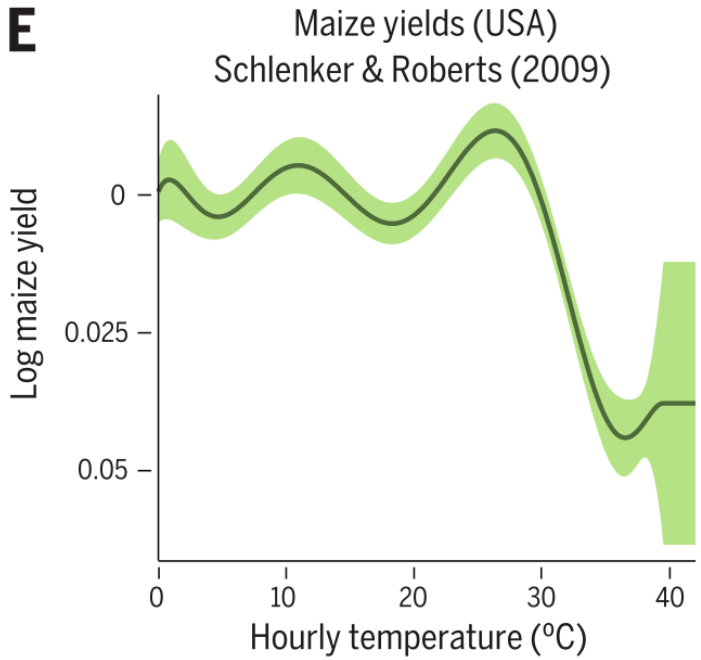
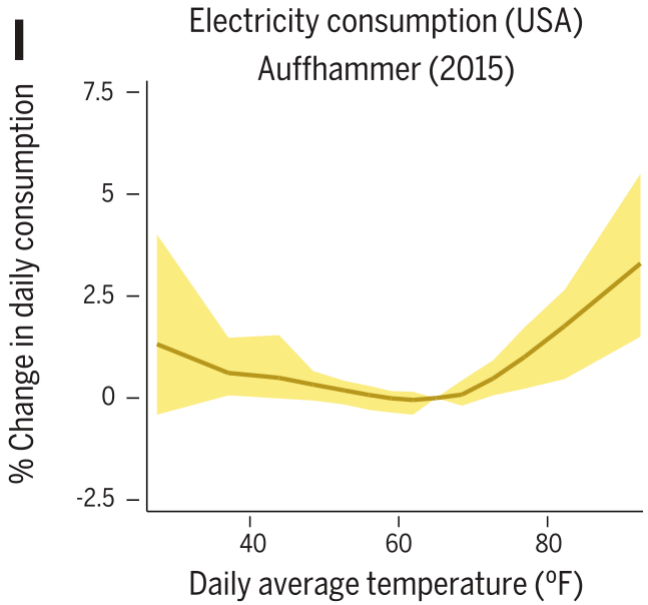


Figure from Carleton et al. (2016)

2. Main findings

Non-linear climate impacts found across sectors





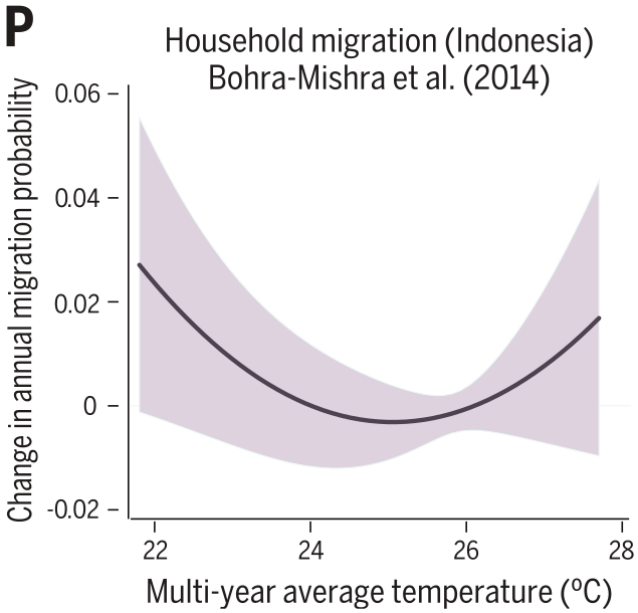


Figure from Carleton et al. (2016)

2. Main findings: Aggregate estimates

Aggregate estimates much larger than bottom-up studies suggest:

What explains the difference?

Hypothesis:
Direct impacts on human physiology & economic growth

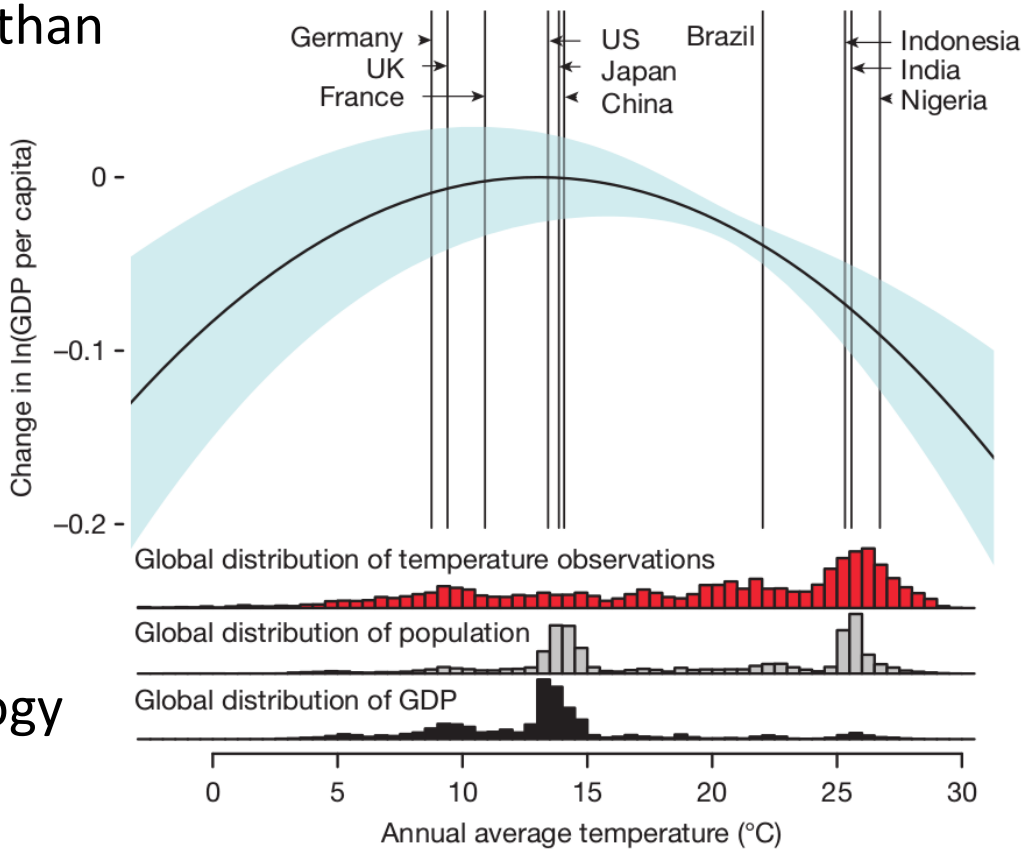


Figure from Burke et al. (2015)

2. Main findings: Direct impacts

Direct impacts on human physiology:

a) Discomfort, morbidity, mortality

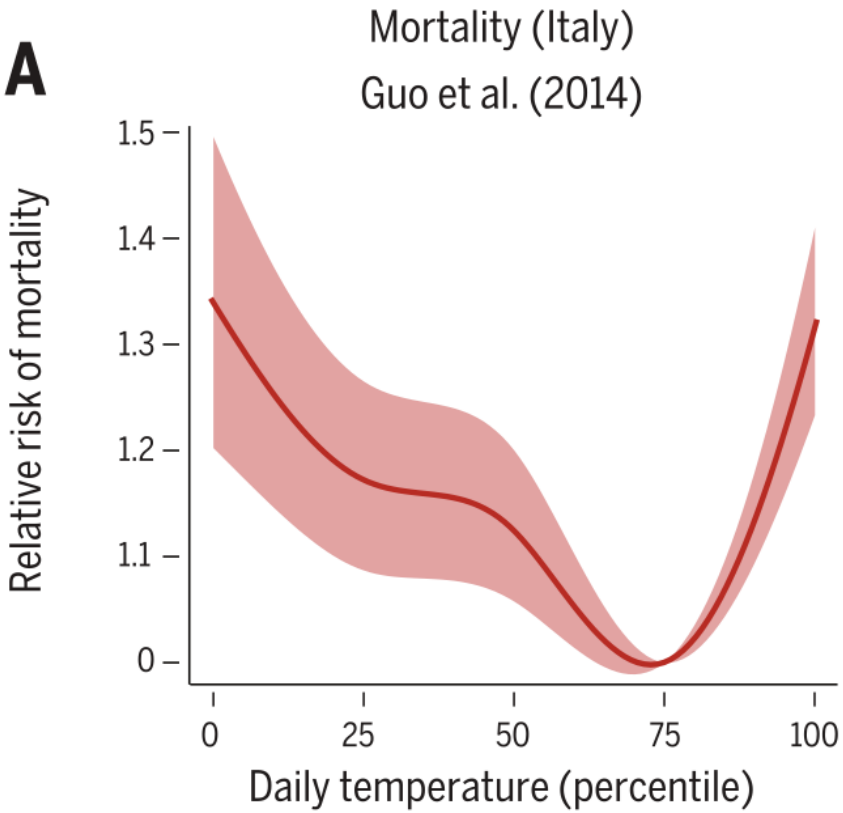


Figure from Carleton et al. (2016)

2. Main findings: Direct impacts

b) Cognitive ability, task performance

- Adaptation far from perfect:
  - Call centers (India)
  - Vehicle production (USA)

→ Impacts labor supply and productivity

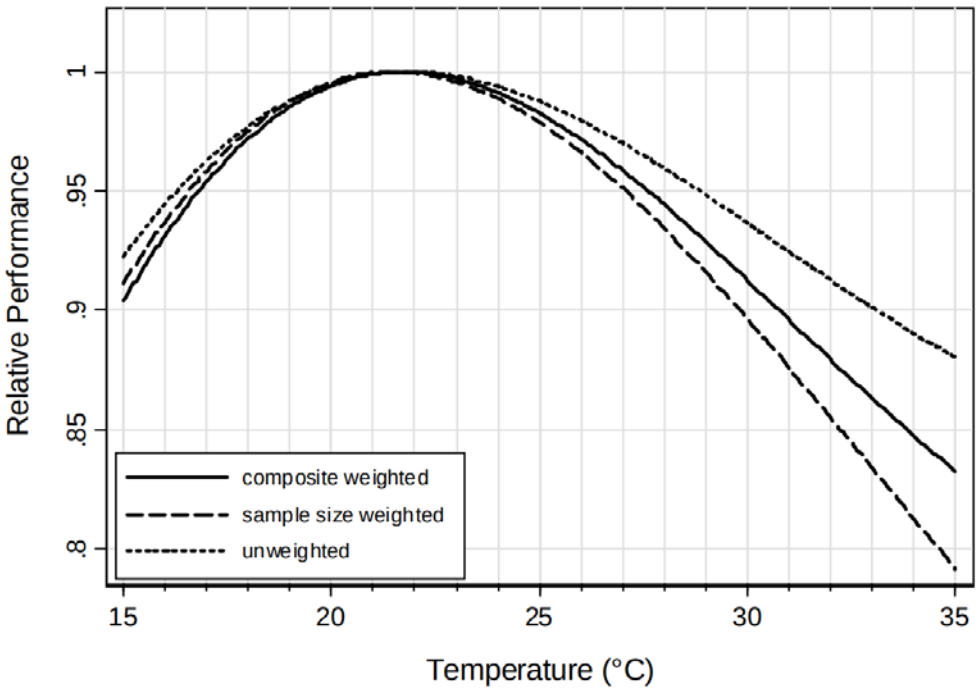
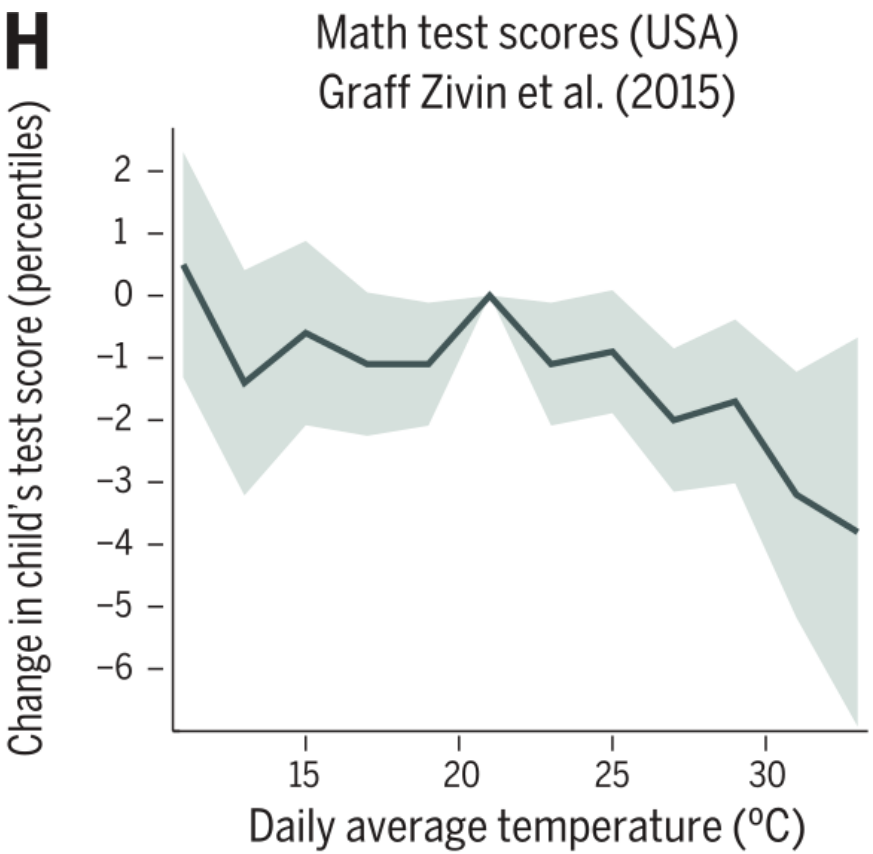


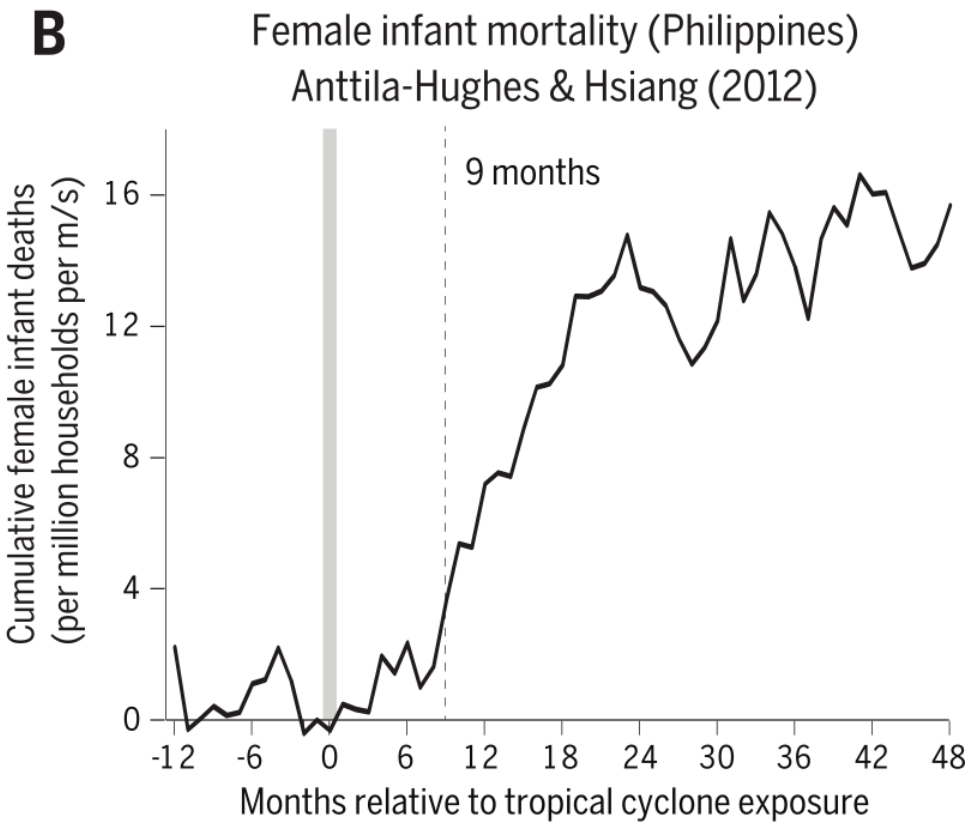
Figure: Seppanen et al. (2006)

3. Growth effects: Human capital formation

Impacts on education and health

→ Human capital formation affected?





Figures from Carleton et al. (2016)

3. Growth effects: Long term

If human capital formation (labor productivity growth) affected

→ high long-term economic damages

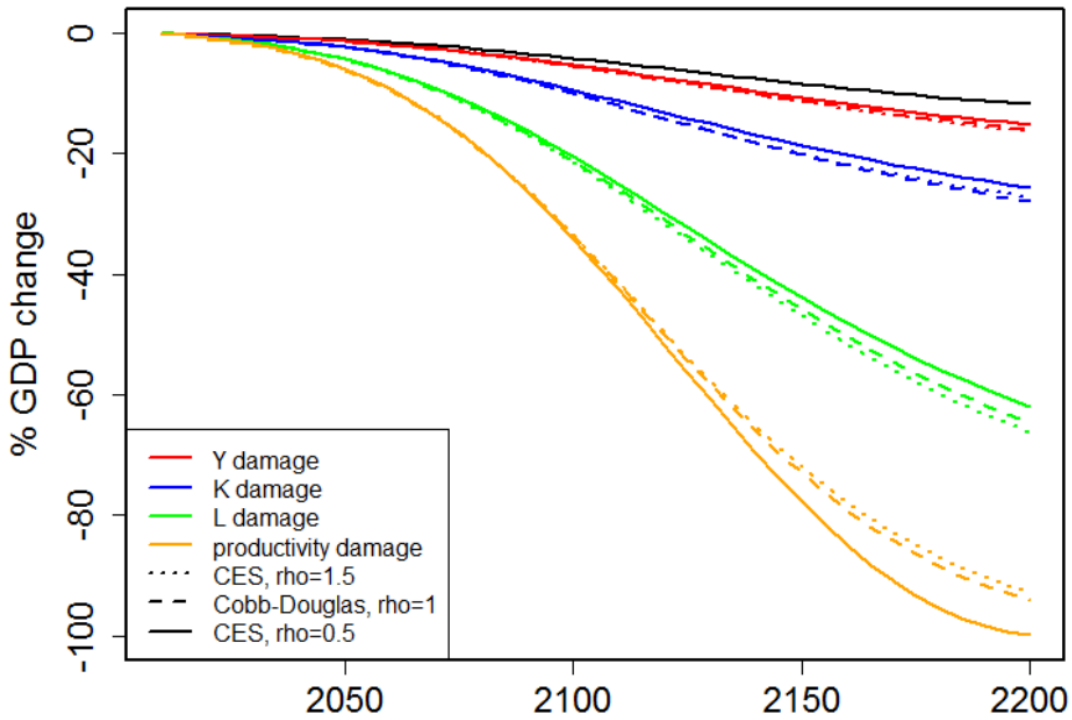


Figure from Piontek et al. (2017)

3. Growth effects: Adaptation

Long-term economic growth and welfare effects crucially depend on adaptation:

- Societal change (preferences)
- Migration
- Structural change, potential for maladaptation (Kalkuhl et al., 2016)
- Trade
- Technical adaptation measures and their limits

→ Successful adaptation requires right incentives, rational planning, financing, strong institutions and risk sharing.

→ Long term growth effects are a research challenge

4. Social cost of carbon

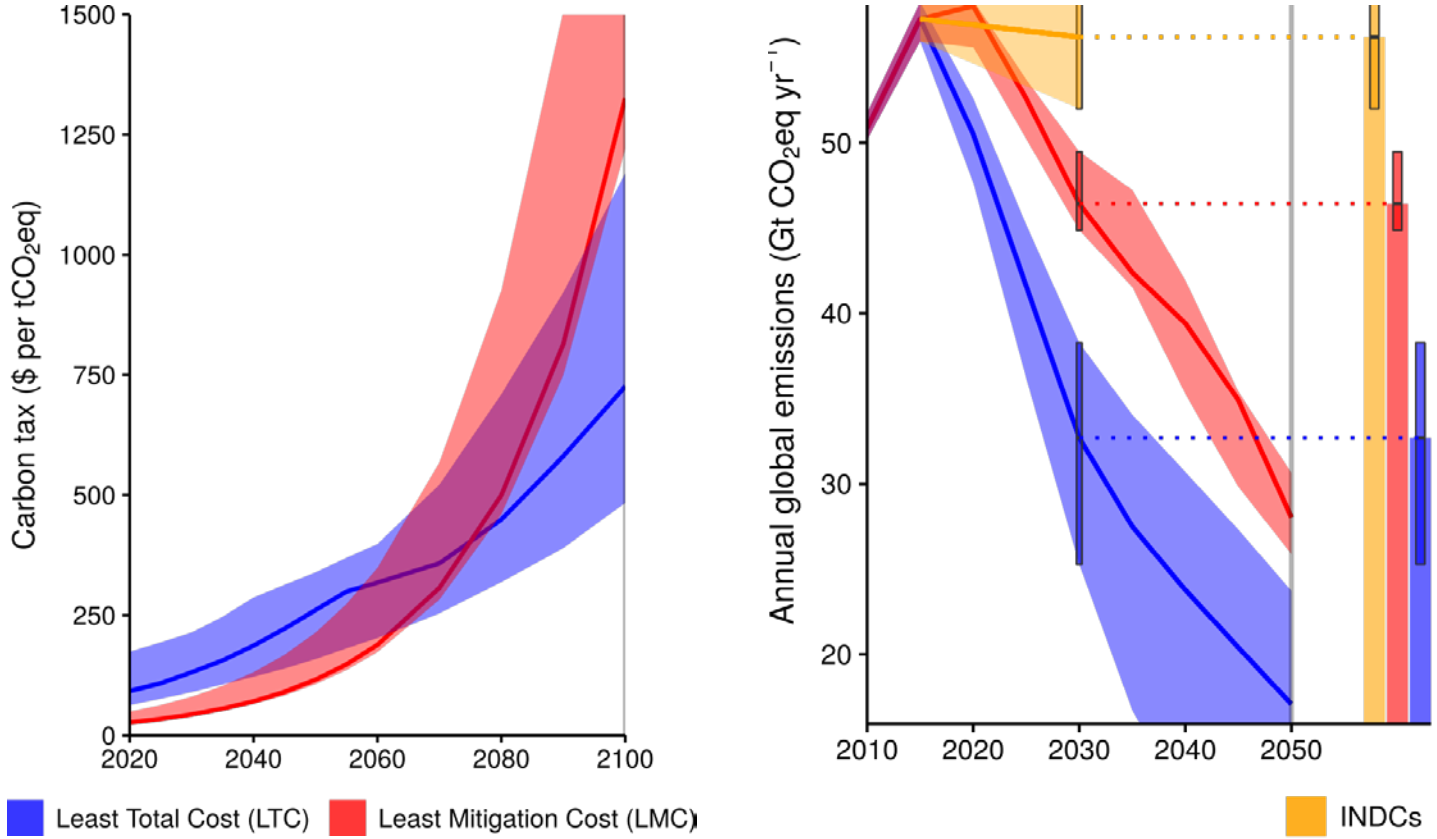
Social cost of carbon (SCC) = damages due to an additional emission in monetary terms

- Relevant in regulatory contexts (United States especially)
- Determined by
  - Climate impact estimates (descriptive)
  - Societal preferences, e.g. for equity across nations, generations, and income classes (normative)

$$\mathrm{SCC}_B = \frac{\sum_{t=1}^{T}\sum_{r=1}^{R} \Delta C_{tr} \frac{\partial W}{\partial C_{tr}}}{\frac{\partial W}{\partial C_{1B}}}$$

4. Social cost of carbon: Impact estimates

Growth damages increase optimal near-term mitigation



→ Need for modeling based on micro findings

Figure from Schultes et al., forthcoming

4. Social cost of carbon: Inequalities

Three sources of inequality matter:

- Existing national and international income inequalities
- Climate impacts often regressive, as
  - poor countries warmer
  - adaptation harder when poor
  - the poor work in more exposed sectors
  - poor areas exposed to higher pollution
- Climate policy itself can be regressive or progressive

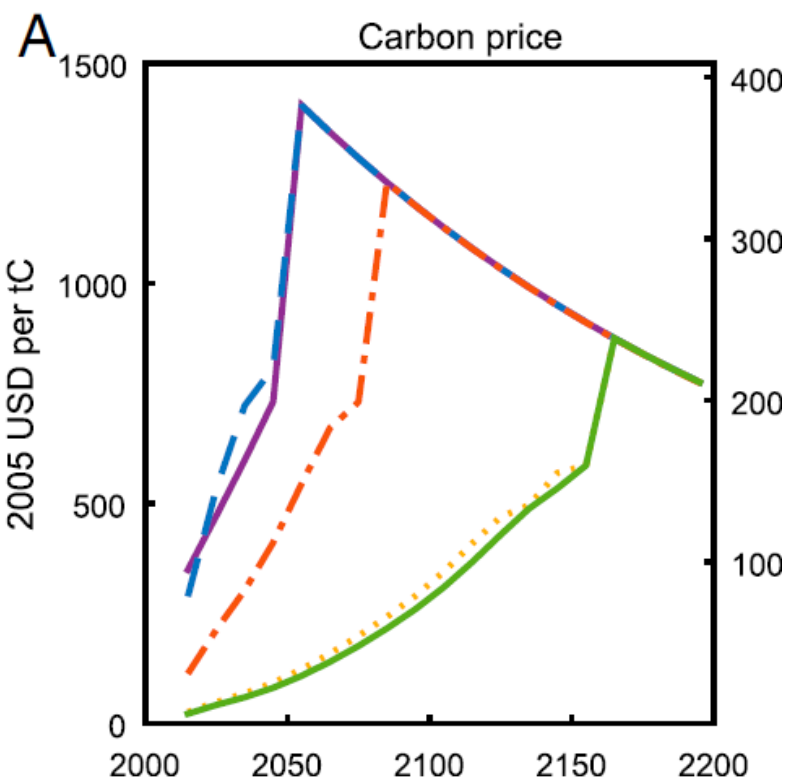
→ If inequalities are not addressed by redistribution, they strongly influence optimal climate policy

4. Social cost of carbon: Influence of inequality

Dennig et al. (2015):

Models often operate on coarse scale with global/regional representative agent

- subnational inequality in income and damages: no transfers
- Equal regional consumption: unlimited, first-best transfers



4. Social cost of carbon: National institutions

1. <u>Global governance level</u>: determines optimal climate policy with national optimal carbon taxes without international transfers
2. <u>National governance level</u>: determination of distribution between households j in country

$$\max \sum_{t=0}^{T} \frac{1}{(1+\rho)^t} \sum_{i=1}^{N} \boxed{\sum_{j=1}^{h_i^t}} w_{ij}^t u_{ij}^t$$

Optimal climate policy

$$s.t. \sum_{j=1}^{h_k} L_{kj}^t = 0$$

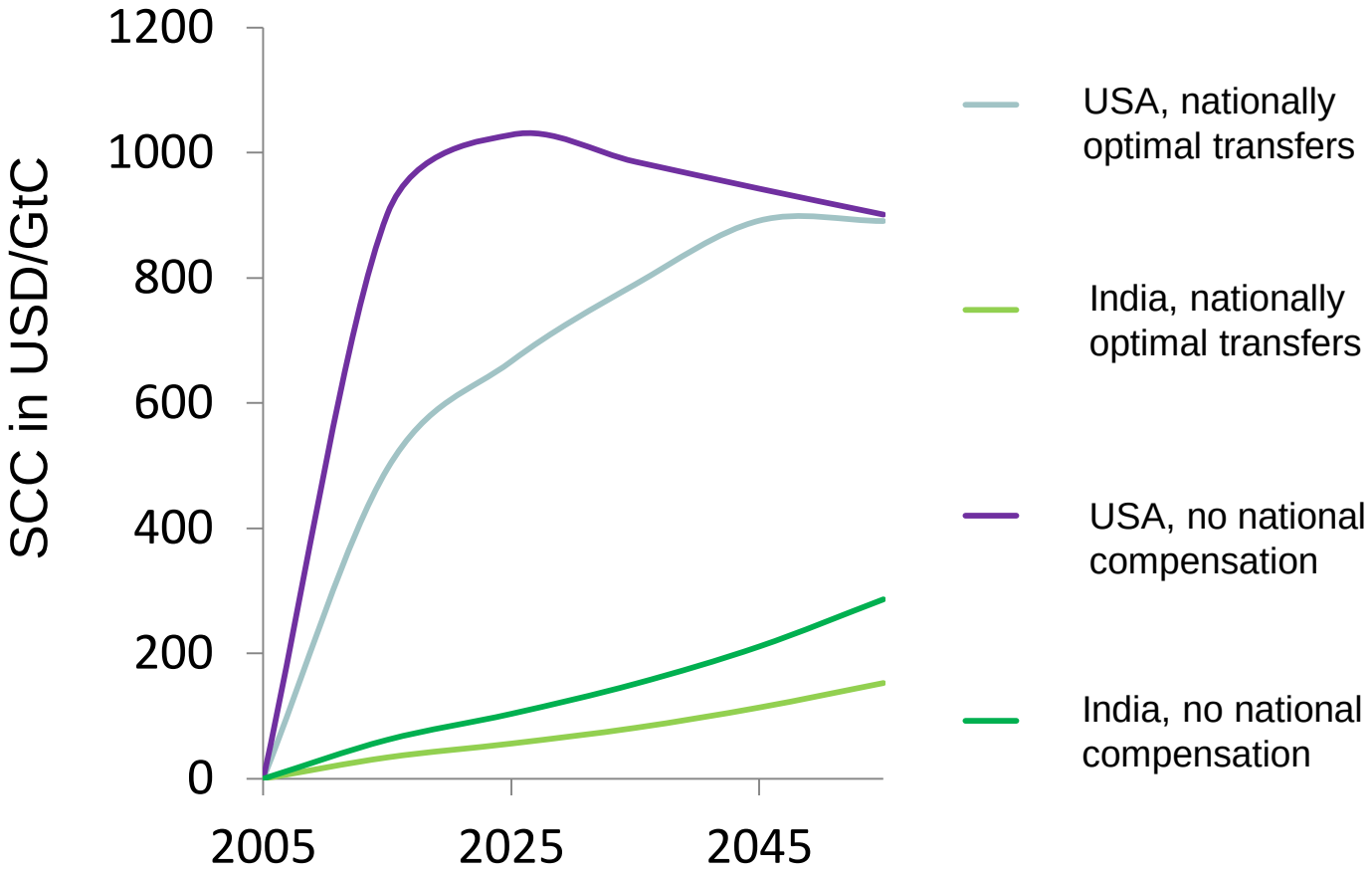
$$F_{kl}^t(\cdot) = 0$$

National distribution policy

Based on Kornek et al.(2017)

4. Social cost of carbon: Numerical example

Not addressing in-country inequalities strongly increases the SCC.



Based on Kornek et al.(2017)

4. Social cost of carbon: Inequalities

National:

- Implementation of climate policy into fiscal and tax policy decisive for efficiency and distributional impacts (Siegmeier et al. 2015)
- Revenue from climate policy can eliminate regressive effects of climate policy (Klenert et al., 2016)

International:

- International transfers influence optimal climate policy (Kornek et al., 2017)

Conclusions

- Advances in causal inference allow identifying climate impacts
- Direct impacts on human physiology
- Economic growth may be impacted, adaptation is key

  → Need for better long-term modeling
- Social cost of carbon as central measure of impacts
- Inequalities and social preferences strongly influence SCC and optimal climate policies

  → Science should not only provide numbers, but also embrace multiple perspectives on justice and fairness.

Literature

- Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. American Economic Review, 91(5), 1369–1401.
- Burke, M., Hsiang, S. M., & Miguel, E. (2015). Global non-linear effect of temperature on economic production. Nature, 527(7577), 235–239.
- Carleton, T. A., & Hsiang, S. M. (2016). Social and economic impacts of climate. Science, 353(6304).
- Dennig, F., Budolfson, M. B., Fleurbaey, M., Siebert, A., & Socolow, R. H. (2015). Inequality, climate impacts on the future poor, and carbon prices. PNAS, 112(52), 15827–15832.
- Heal, G., & Park, J. (2016). Reflections-temperature stress and the direct impact of climate change: A review of an emerging literature. Review of Environmental Economics and Policy, 10(2), 347–362.
- Klenert, D., & Mattauch, L. (2016). How to make a carbon tax reform progressive: The role of subsistence consumption. Economics Letters, 138, 100–103.
- Kornek, U., Klenert, D., Edenhofer, O. (2017). Who should abate carbon emissions? Optimal climate policy when national preferences determine its implementation, EAERE 2017
- Nordhaus, W. D. (2006). Geography and macroeconomics: new data and new findings. Proceedings of the National Academy of Sciences of the United States of America, 103(10), 3510–7.
- Albouy, D. Y. (2012). The Colonial Origins of Comparative Development: An Empirical Investigation: Comment. American Economic Review, 102(6), 3059–3076.
- Piontek, F., et al. (2016) SEARCHING FOR THE WEAK SPOT: A COMPARATIVE ANALYSIS OF CLIMATE CHANGE IMPACT CHANNELS IN AN ECONOMIC GROWTH MODEL. EAERE 2016. Zurich
- Schultes, A., et al. (2018). Strictness of near-term climate change mitigation underestimated as damages below 2C neglected. mimeo.
- Siegmeier, J., Mattauch, L., Franks, M., Klenert, D., Schultes, A., & Edenhofer, O. (2015). A Public Finance Perspective on Climate Policy: Six Interactions That May Enhance Welfare. FEEM Working Paper Series, 031.2015.
- Seppanen, O., William J. Fisk, and Q. H. Lei. (2006) Effect of temperature on task performance in office environment. LBNL-60946. Lawrence Berkeley National Laboratory, Berkeley, CA.

P I K