Economics of Climate Change

Some Recent Progress and Future Directions

Solomon Hsiang
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Once you start thinking about climate change you can’t think about anything else

2080–2099 high emission (RCP 8.5) scenario

1981–2010 (Historical)

Annual average temperature

Hsiang & Kopp (JEP, 2018)
An Optimal Transition Path for Controlling Greenhouse Gases
William D. Nordhaus

Designing efficient policies to slow global warming requires an approach that combines economic tools with insights from the natural sciences. The Dynamic Integrated Climate Economy (DICE) model builds on insights from the natural sciences to explore the economic implications of policies designed to slow global warming.

**SUMMARY**

1. **Philosophy of Optimal Policies**
   - The DICE model is designed to identify optimal policies for controlling greenhouse gases.
   - The goal is to minimize the discounted social cost of climate change.

2. **Policy Framework**
   - The model considers the trade-offs between the costs of mitigation and the benefits of adaptation.
   - Policies are evaluated based on their impact on future generations.

3. **Results**
   - Optimal policies vary significantly over time and across regions.
   - The model underscores the importance of long-term policies.

4. **Implications for Policy**
   - Policymakers should consider the long-term implications of their decisions.
   - The model supports a multi-pronged approach to climate change mitigation.

**CONCLUSION**

The DICE model provides a framework for designing effective policies to control greenhouse gases. It highlights the importance of long-term planning and cooperation among nations to achieve global climate goals.
This talk

• Recent Progress + Future Directions

• New Directions

• What might happen by 2030?
Recent progress
+
future directions
How does the climate affect economic activity and outcomes?

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What we want to know
How does the climate affect economic activity and outcomes?

Recent Progress

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What we actually know
How does the climate affect economic activity and outcomes?

**Future Directions**

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What we aren’t thinking much about
Climate change and economic growth

Recent Progress

Burke et al. (Nature, 2015)
Climate change and economic growth

Recent Progress

Figure 3.11. Effect of Temperature Increase on Real per Capita Output Estimated at the Temperature of the Median Low-Income Developing Country over Time
(Percent; years on x-axis)

The contemporaneous effect of temperature shocks on per capita output has remained relatively constant over time.

Source: IMF staff calculations.

Note: The figure depicts the effect of a 1°C increase in temperature at horizon 0 estimated at the median low-income developing country temperature (29°C), over a 20-year rolling window. Each point estimate is for a period (t, t+20).

Deryugina & Hsiang (NBER, 2016)
Climate change and economic growth
Future Directions

• What is going on?!

• Can all results be reconciled?
  • Panel vs Cross Section
  • Micro vs Macro

• How persistent are GDP effects? (80 yrs > 5 yrs)

• Can policy do anything to alter this linkage?
Social stability
Recent Progress

Type of violence

- **Institutional**
  - More organized
  - Population collapse
  - Civilization collapse

- **Intergroup**
  - More organized
  - Coups
  - Civil conflict
  - Civil war
  - Interstate conflict
  - Riots
  - Ethnic expulsion
  - Land invasions
  - Gang killings
  - Sports violence

- **Interpersonal**
  - Less organized
  - Homicide
  - Assault
  - Rape
  - Road rage

- **Intrapersonal**
  - Suicide

Examples

- Institutional: institutional change, population collapse, civilization collapse
- Intergroup: coups, civil conflict, civil war, interstate conflict, riots, ethnic expulsion, land invasions, gang killings, sports violence
- Interpersonal: homicide, assault, rape, road rage
- Intrapersonal: suicide

Selected literature

- Buckley et al (2010)
- Kuper & Kröpelin (2006)
- Harari & La Ferrara (2018)
- Kim (2016)
- Burke et al (2009)
- Bohiken & Sergenti (2010)
- Larrick et al (2011)
- Baysan (2018)
- Ranson (2014)
- Jacob et al (2007)
- Carleton (2017)
- Burke et al (2018)
- Mullins & White (2019)

Baysan et al. (JEBO, 2019)
Social stability
Recent Progress

Fig. 1. Response of asylum applications to the EU with respect to the annual average temperature over the maize growing season.

Missirian & Schlenker (Science, 2017)
Social stability
Future Directions

• What are the mechanisms?
  • Economic vs. Gov't capacity vs. Logistics vs. Psychology

• What is actually going to happen with migration?

• How have / will political systems respond?

• What stabilizer policies can be deployed sustainably?
  • Likely an important role for machine-learning
Adaptation
Recent Progress

Carleton & Hsiang (Science, 2016)
Adaptation
Recent Progress

Carleton & Hsiang (Science, 2016)
Adaptation
Recent Progress

Change in adaptation costs due to climate change

Optimal adaptation under new climate

Optimal adaptation under old climate

Adaptation costs (via revealed preference)
Adaptation
Recent Progress

Rode et al. (Nature, 2021)
Adaptation
Future Directions

• How much does the information known by agents matter?
  • Currently, the “perfect information” assumption is doing a lot of work

• Must go beyond “mechanisms” (e.g. ‘income’) to understand actual actions (technologies + policies) that are effective.

• Can deployment of tech + policies be replicated and cost effective?
  • Think: field experiments
Risk

Recent Progress

Hsiang et al. (Science, 2017)
Risk
Recent Progress

Panel A. Climate feedback tipping point

V. The Dismal Theorem

Let $E[M|\lambda]$ represent the expected value of a stochastic discount factor $M(C)$ given by formula (3) when $C \geq D(\lambda)$ (or, equivalently, $Y \geq \ln D(\lambda)$) and given by $M(C) = (D(\lambda))^{-n}$ when $C < D(\lambda)$ (or, equivalently, $Y < \ln D(\lambda)$), where $D(\lambda)$ is defined by equation (16). The following “dismal theorem” (hereafter sometimes abbreviated “DT”) shows under quite general circumstances what happens to the price of future consumption $E[M|\lambda]$ when $\lambda$ might be very big.

Theorem 1. For any given $n$ and $k$,

$$\lim_{\lambda \to \infty} E[M|\lambda] = +\infty.$$  (17)
Risk

Future Directions

• Should different “flavors of uncertainty” be managed / valued using the same tools?
  • Parameter uncertainty
  • Scientific uncertainty
  • Uncertain state of the world

• How do we manage globally aggregate risk?

Full mortality risk of climate change, accounting for statistical and climate model uncertainty:
- 33 climate models
- 25,000 impact regions
- 365 days
- 100 years
- Resampling from full distribution of estimated response surface parameters

Carleton et al. (NBER, 2020)
Inequality
Recent Progress

Impact of climate change in 2100
(deaths per 100,000)

Burke et al. (Nature, 2015)
Carleton et al. (NBER, 2020)
Inequality
Future Directions

• Systematically identify causes of unequal effects

• Gradual extinction of representative agents

• Elimination of “Negeshi weights” from models (explicit down weighting of poor populations)

• Explicit discussion of how inequality is valued (recall discounting debate)

Hsiang et al. (REEP, 2019)
Integrated Assessment + Social Cost of Carbon

Recent Progress

Diaz & Moore (Nature Climate Change, 2017)

DICE (1992)
1 region

FUND (1996)
16 region

DICE sector
- Sea-level rise
- Aggregate non-SLR

Global damages (% loss of GDP)

Temperature change (°C)

FUND sector
- Sea-level rise
- Agriculture
- Forests
- Heating
- Cooling
- Water resources
- Tropical storms
- Extratropical storms
- Biodiversity
- Cardiovascular respiratory
- Vector-borne diseases
- Morbidity
- Diarrhoea
- Migration

Diaz & Moore (Nature Climate Change, 2017)
Integrated Assessment + Social Cost of Carbon

Recent Progress

- All Cause Mortality
- Agriculture (e.g. Maize)
- Labor
- Sea Level Rise
- Electricity
- Other Fuels

Climate Impact Lab (2021)
Integrated Assessment + Social Cost of Carbon

Recent Progress

Damages scaled to change in GMST (°C above 2001-2010 average), change in GMSL (cm relative to 2005)

Climate Impact Lab (2021)
Integrated Assessment + Social Cost of Carbon
Future Directions

• Simultaneously valuing inequality and uncertainty

• Systematic updating

• Practical international harmonization

• Integration with concepts of “Loss & Damage”
New Directions for Research
Long-term Economic Projections (New Directions)

• “Shared Socioeconomic Pathways” are standardized inputs to climate models.

• They were not designed to be realistic or for use in economic analyses.

• We need projections that are.
Financialization of Carbon
(New Directions)

• Global CO2 emissions = 40 billion tons
• Suppose SCC = $60 / ton (Obama, 2.5% discount rate)
• Annual emissions valued at $2.4 trillion (Global GDP = $94T)
• Explicit or implicit carbon pricing will create a new major asset class “out of thin air”.
• What are the implications for non-carbon markets (e.g. inflation)?
• How should control of the price be structured?
Innovation forecasting (New Directions)

- Technological innovation is the weakest link in many analyses.
- How can we project it better?
- What do current markets indicate about the future?
- What policies accelerate changes in relative prices via innovation?
Geoengineering
(New Directions)

- Incentives to geoengineer are enormous
- What is the scale/scope of externalities?
- Local, national, and global regulatory regimes almost non-existent
- Geoengineering changes the SCC. How to design a consistent management system?
- What is a reasonable and tractable liability regime?
Practical energy strategies for developing economies (New Directions)

- Energy access must scale.
- Emissions probably shouldn’t.
- What is a practical plan?
- Integrated global welfare analysis of proposals?
- How is intragenerational and intergenerational equity achieved?
Treaty design in the presence of “adversaries”  
(New Directions)

• The global treaty system is experimental

• Kyoto and Paris did not “work”

• Treaty design literature focuses on incentive-compatible & self-enforcing systems among sovereigns that are regulators.

• Actual treaties are pulled apart by strategic agents that are not sovereigns and not bound by the same game.

• We need treaties that are robust to adversarial strategies, not just self-interest of participants.

Fig. 1 | Waxman–Markey lobbying spending and change in firm value.

Meng & Rode (Nature Climate Change, 2019)
Institutions for adaptation
(New Directions)

• There are / will be massive efforts to minimize economic damages from climate change.

• There are no institutions to ensure policies / technologies are “safe and effective”

• We must design institutions for third-party verification (think: RCTs) to protect consumers (e.g. cities).

• What is the structure / design of these institutions?

We do not have comparable institutions for climate-related policies or technologies
One view of the research outlook
What might happen by 2030?
One view of the research outlook
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• Policy will be driven by testable models with verifiable data
  • Financial stakes are real and too big to trust researcher intuition
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- Geoengineering will be a major research area
- We will design a global treaty that works