Applied Economic Issues

Climate and the Economy: Introduction

Ewen Gallic

Master 2 DADEE – 2025

amU Aix Marseille Université

amse
école d'économie d'aix-marseille
aix-marseille school of economics

Key reference

- Before talking in a bit more details about some specific examples, we will first consider a broad overview of the challenges brought by climate change for economics.
- This introduction is built using an article by William Nordhaus:
  - Nordhaus, W. (2019). Climate change: The ultimate challenge for economics. *American Economic Review* 109:1991–2014, doi: 10.1257/aer.109.6.1991

Outline

1. Global Warming

2. Climate Change as a Good
    1. Reminders

    2. National vs. Global Public Goods

3. Approaches to Slowing Climate Change

Source of Global Warming

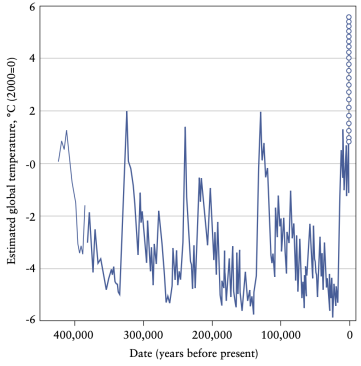
- From the work of earth scientists, we know that the main source of global warming comes from the **burning of fossil fuels** (coal, oil, natural gas).
- This releases **carbon dioxide** (CO_2) and other greenhouse gases (GHG).
- GHGs accumulate in the atmosphere, which generates trap heat and leads to:
  - surface warming of land and oceans,
  - feedback effects in atmosphere, oceans, and ice sheets,
  - impacts on ecosystems and human activities sensitive to climate.
- See the AR6 synthesis report from the IPCC (Calvin et al., 2023)

Weather and Climate

- **Weather** refers to **short-term atmospheric conditions**.
  - the time scale is usually in minutes, days, or weeks.
  - for example: today's temperature, a storm this weekend.
- **Climate** refers to the **long-term statistical average of weather**.
  - the time scale is longer: usually, 30 years.
  - for example: average temperature and rainfall patterns over 30 years.

Variation of Global Temperature (1/4)

- Average global temperature has increased since the industrial revolution.
- Warming trend accelerates in the late 20th and early 21st centuries.
- Current levels are unprecedented in the historical record.



Estimated global temperature variations for the last 400,000 years along with model projections for the next two centuries. *Source*: Nordhaus (2013, p. 201)

Variation of Global Temperatures (2/4): variance-preserving

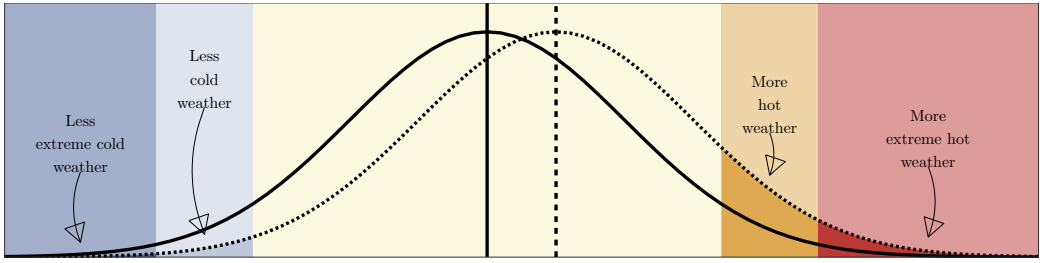


Figure 1: Effects of Climate Change on the Distribution of Temperatures: **increase in the mean**. The solid and dotted lines represent the previous climate distribution and the new climate distribution, respectively. Source: reproduction of Figure 1.8 from Cubasch et al. (2013).

Variation of Global Temperatures (3/4): mean-preserving

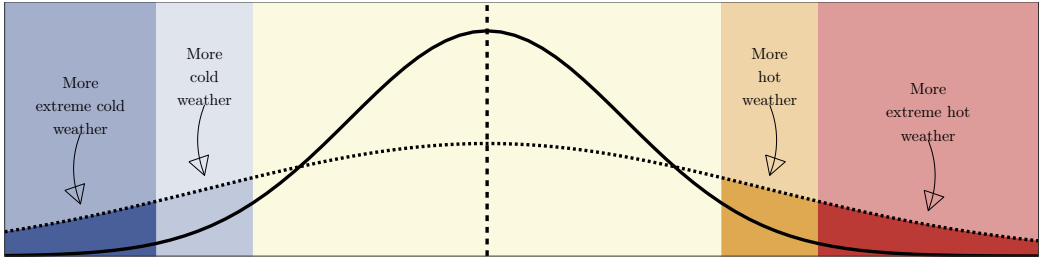


Figure 2: Effects of Climate Change on the Distribution of Temperatures: **increase in the variance**. The solid and dotted lines represent the previous climate distribution and the new climate distribution, respectively. Source: reproduction of Figure 1.8 from Cubasch et al. (2013).

Variation of Global Temperatures (4/4)

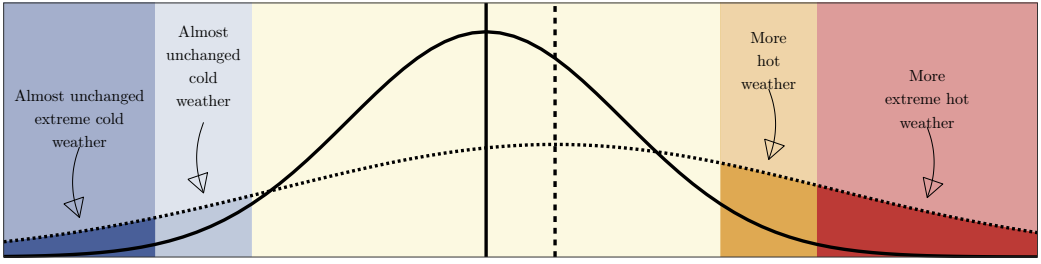


Figure 3: Effects of Climate Change on the Distribution of Temperatures: **increase in both the mean and the variance**. The solid and dotted lines represent the previous climate distribution and the new climate distribution, respectively. Source: reproduction of Figure 1.8 from Cubasch et al. (2013).

- These are examples. CC can translate to higher-order changes to the distribution.

Impacts of Climate Change

More generally, the impacts of climate change are broad (Calvin et al., 2023):

- **Physical impacts**
  - Rising temperatures, melting ice sheets, sea-level rise, extreme weather.
- **Ecological impacts**
  - Biodiversity loss, ocean acidification, forest fires, shifting ecosystems.
- **Socio-economic impacts:**
  - Agriculture yields, coastal communities, health and mortality, migration, conflict.

Applied Economics and Climate Change

- We know **why** the planet is warming: GHG emissions from human activity.
- The question is now: **how should societies respond?**
- This is particularity challenging. The impacts are global, unevenly distributed, and they increase with temperature.
- Economics provide frameworks to investigate central questions:
  - **understanding externalities** (emissions are a global negative externality, markets alone will not fix the issue),
  - **designing policies** (carbon taxes? cap-and-trade? subsidies for clean tech?) with cost–benefit analysis for example (quantify damages vs. abatement costs),
  - **measuring costs** (in agriculture, housing markets, etc.)
  - **exploring equity and distribution** of the impacts (who bears the costs of abatement? Who suffers most from climate damages?)

2. Climate Change as a Good

2.1. Reminders

Rivalry and Excludability

Rivalry

*A good is **rival** if one person's consumption reduces the amount available for others.*

- *Ex: eating an apple,*
- *Non-rival example: watching a TV broadcast.*

Excludability

*A good is **excludable** if it is possible to prevent someone from using it without paying.*

- *Example: movie theater ticket,*
- *Non-excludable example: clean air.*

Types of Goods

	Excludable	Non-excludable
Rival	**Private Goods** (e.g., food, clothing, cars)	**Common Goods** (e.g., fisheries, forest, groundwater)
Non-rival	**Club Goods** (e.g., streaming services, toll roads, private parks)	**Public Goods** (e.g., air, national defense, knowledge)

Taxonomy of goods by rivalrousness and excludability

- Climate change: **how about climate change?**

Types of Goods

	Excludable	Non-excludable
Rival	**Private Goods** (e.g., food, clothing, cars)	**Common Goods** (e.g., fisheries, forest, groundwater)
Non-rival	**Club Goods** (e.g., streaming services, toll roads, private parks)	**Public Goods** (e.g., air, national defense, knowledge)

Taxonomy of goods by rivalrousness and excludability

- Climate change: non-rival, non-excludable → public good (see Samuelson 1954, REStat).

Climate Change as a Global Externality

Externality

*An **externality** arises when the costs or benefits of an action spill over to others and are not reflected in market prices.*

- **Negative externality**: GHG emissions cause damages (warming, sea-level rise, extreme weather) not paid for by the emitter.
- **Positive externality**: knowledge spillovers from clean technology innovation benefit all countries.
- When costs or benefits cross national borders and affect people and countries that are not directly involved, externalities are said to be **global**.

Examples of Global Externalities

- **Historical examples**
  - Spread of infectious diseases (e.g., plague, pandemics),
  - Religious conflicts or marauding armies.
- **Modern examples**
  - Nuclear proliferation,
  - International financial crises,
  - Cybersecurity threats.
- **Climate change**
  - Greenhouse gas emissions anywhere affect ecosystems, weather, and economies worldwide.

Key Challenges (1/4)

- **Global scope**: emissions in a country affect the entire planet.
  - No nation can solve the problem on its own. There is a need for **cooperation**.
- **Diffuse benefits vs. concentrated costs**
  - While the **benefits** of a stable climate are **shared globally**,
  - the costs of **abatement** are **borne nationally** (higher energy costs, transition for carbon-intensive industries, etc.).

Key Challenges (2/4)

Two other key challenges:

Tirole and Tribe (2017, Chap. 8)

While most of us are prepared to make small gestures for the environment, we are not willing to give up our cars, pay much more for electricity, restrict our consumption of meat, or moderate our air travel to distant places. And while local sustainable development initiatives are praiseworthy, they will absolutely not be enough by themselves. In reality, we would like everyone else to do these things for us—or rather for our grandchildren. As irresponsible as it may be, our common policy is easy to explain. It is the result of two factors: ***selfishness with regard to future generations*** *and the* ***free rider problem****. In other words, the benefits of reducing climate change remain global and distant in time, while the costs of that eduction are local and immediate.*

Key Challenges (3/4)

- **Free-riding incentive**
  - "*unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest,* rational, self-interested individuals will not act to achieve their common or group interests." (Olson, 1965)
  - Each country prefers others to cut emissions while maintaining its own growth.
  - This weakens international cooperation.
- **Long-term horizon and uncertainty**
  - Damages unfold slowly, across generations,
  - Scientific and economic uncertainties complicate policy design.

Key Challenges (4/4)

- **Limited effectiveness of agreements**
  - International treaties (e.g., Kyoto, Paris) rely on voluntary commitments.
  - Enforcement mechanisms are weak or absent.
  - Tirole and Tribe (2017, Chap. 8) mentions three flaws to the voluntary commitment nature of the Paris COP21:
    1. gives incentive for **greenwashing** (to appear much "greener" than one actually is), since the countries can choose their reference point as they wish,
    2. does not address the **free-riding issue**,
    3. the **(non)credibility of promises**.

2.2. National vs. Global Public Goods

National Public Goods

National Public Goods

Non-rival and non-excludable goods, whose benefits are confined within a country.

- Examples: clean air standards, national flood defenses, public health system.
- Actors: citizens, national government, domestic industries.
- Issue: mostly political, not technical (regulations are feasible but may be resisted by powerful interest groups).
- **Costs**: concentrated on a few groups (e.g., polluting industries).
- **Benefits**: diffuse across many citizens.

Global Public Goods

Global Public Goods

Non-rival and non-excludable goods, whose benefits extend across countries and generations.

- Examples: climate stability, ozone layer protection, biodiversity conservation.
- Actors: sovereign states, international organizations, global industries.
- Issue: coordination and incentive problems (no global authority to enforce cooperation).
- **Costs**: borne nationally (e.g., emission reductions).
- **Benefits**: spill over globally, creating strong incentives to free-ride.

National vs. Global Public Goods (recap)

	National Public Goods	**Global Public Goods**
Definition	Non-rival, non-excludable within a country	Non-rival, non-excludable across all countries
Examples	Clean air standards	Climate stability
Actors	Citizens, government, domestic industries	Sovereign nations, international organizations, global industries
Issue	Political: institutions may favour concentrated interests over diffuse public welfare	Coordination: no global authority, incentives to free-ride
Costs	Concentrated on a few groups	Borne nationally
Benefits	Diffuse across many citizens	Spill over to all countries

3. Approaches to Slowing Climate Change

Three Main Approaches to Slowing Climate Change

- Nordhaus (2019, AER) lists three main approaches to slowing climate change:
  1. **Mitigation**: reduce GHG emissions at the source.
  2. **Carbon Removal**: extract CO_2 from the atmosphere.
  3. **Geoengineering**: alter Earth's radiation balance to offset warming.
- Only mitigation is currently feasible at scale, but removal and geoengineering are part of the policy debate.

Mitigation

Mitigation

- Reduce emissions from fossil fuels, industry, and agriculture.
- The tools to do so: carbon taxes, emissions trading, renewable energy, energy efficiency.
- The solutions are scalable and offer long-term effectiveness.
- However, they are **costly** and **require global cooperation**.

Carbon Removal

Carbon Removal

- Extract CO_2 from the atmosphere (hence, negative emissions).
- How ? Afforestation (panting trees), BECCS (bioenergy with carbon capture and storage), direct air capture.
- This offers a permanent removal and can complement mitigation.
- However, carbon removal techniques are not yet scalable and they have high energy, land, and cost requirements.

Geoengineering (Solar Radiation Management)

Geoengineering

- Reduce warming by reflecting sunlight back into space.
- How? Stratospheric aerosols, cloud brightening, space reflectors.
- This offers low direct costs and rapid cooling potential.
- But, geoengineering techniques are associated with large uncertainties, uneven regional effects, and they do not allow us to solve ocean acidification.

Approaches to Slowing Climate Change: Wrap-up

Strategy	**Benefits**	**Costs / Risks**
Mitigation	Proven feasible; reduces emissions at source; long-term effectiveness	Expensive transition; politically difficult; needs global cooperation
Carbon Removal	Permanent CO_2 removal; complements mitigation	Not scalable yet; high costs; energy and land requirements
Geoengineering	Low direct cost; rapid cooling; possible emergency backup	Uncertain effects; uneven global impacts; does not fix acidification; moral hazard

4. Appendix

References I

Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barret, K., Blanco, G., Cheung, W. W., Connors, S. L., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., Jotzo, F., Krug, T., Lasco, R., Lee, Y.-Y., Masson-Delmotte, V., Meinshausen, M., Mintenbeck, K., Mokssit, A., Otto, F. E., Pathak, M., Pirani, A., Poloczanska, E., Pörtner, H.-O., Revi, A., Roberts, D. C., Roy, J., Ruane, A. C., Skea, J., Shukla, P. R., Slade, R., Slangen, A., Sokona, Y., Sörensson, A. A., Tignor, M., Vuuren, D. van, Wei, Y.-M., Winkler, H., Zhai, P., Zommers, Z., Hourcade, J.-C., Johnson, F. X., Pachauri, S., Simpson, N. P., Singh, C., Thomas, A., Totin, E., Alegría, A., Armour, K., Bednar-Friedl, B., Blok, K., Cissé, G., Dentener, F., Eriksen, S., Fischer, E., Garner, G., Guivarch, C., Haasnoot, M., Hansen, G., Hauser, M., Hawkins, E., Hermans, T., Kopp, R., Leprince-Ringuet, N., Lewis, J., Ley, D., Ludden, C., Niamir, L., Nicholls, Z., Some, S., Szopa, S., Trewin, B., Wijst, K.-I. van der, Winter, G., Witting, M., Birt, A. and Ha, M. (2023). *IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.*. doi: 10.59327/ipcc/ar6-9789291691647.001.

Cubasch, U., Wuebbles, D., Chen, D., Facchini, M., Frame, D., Mahowald, N. and Winther, J. (2013). Climate change 2013: the physical science basis. *Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge, United Kingdom and New York, NY, USA* : 119–158.

Nordhaus, W. (2019). Climate change: The ultimate challenge for economics. *American Economic Review* 109: 1991–2014, doi: 10.1257/aer.109.6.1991.

References II

Nordhaus, W. D. (2013). *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*. Yale University Press.

Olson, M. (1965). *The Logic of Collective Action: Public Goods and the Theory of Groups*. Harvard University Press.

Samuelson, P. A. (1954). The pure theory of public expenditure. *The Review of Economics and Statistics* 36: 387, doi: 10.2307/1925895.

Tirole, J. and Tribe, K. (2017). *Economics for the Common Good*. Princeton University Press, hardcover ed.