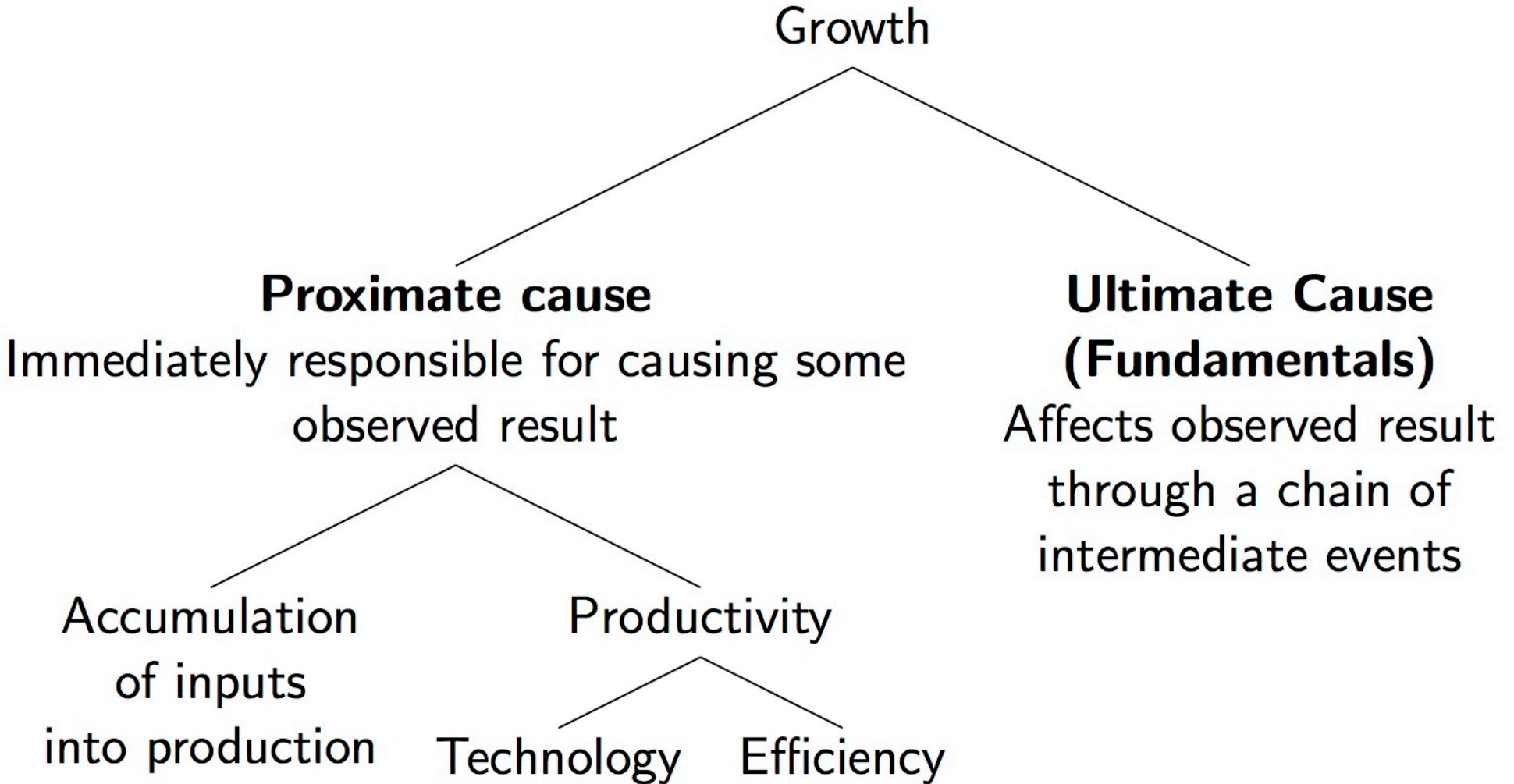


Economic Growth

Lecture 9: Climate Change

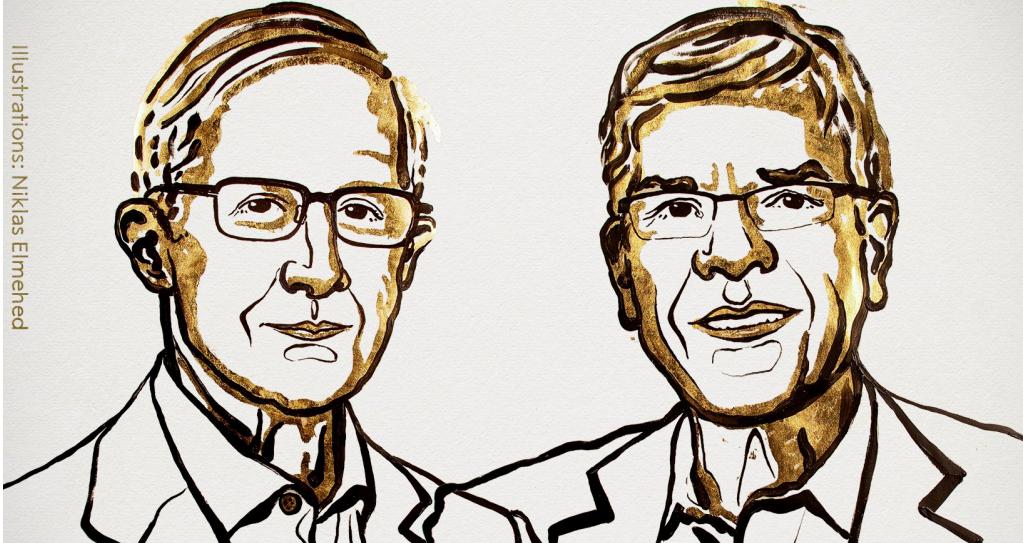
İlhan Güner

University of Kent | EC569



THE SVERIGES RIKSBANK PRIZE IN ECONOMIC SCIENCES IN MEMORY OF ALFRED NOBEL 2018

Illustrations: Niklas Elmehed



William D. Nordhaus

“for integrating climate change
into long-run macroeconomic
analysis”

Paul M. Romer

“for integrating technological
innovations into long-run
macroeconomic analysis”

THE ROYAL SWEDISH ACADEMY OF SCIENCES



Justin Wolfers @JustinWolfers · Oct 8, 2018



Replying to @JustinWolfers

At one level, this prize doesn't seem like an obvious combination -- both are somewhat related to modern growth theory, but not in any particularly coordinated or similar fashion.



Justin Wolfers @JustinWolfers

But the Nordhaus-Romer pairing makes sense, because they each point to contradictions at the heart of capitalism. It's all about market failure. Left alone, markets will generate too much pollution (Nordhaus) and too few ideas (Romer).

10:57 AM · Oct 8, 2018



674



380



Copy link to Tweet

Nordhaus' Nobel Lecture

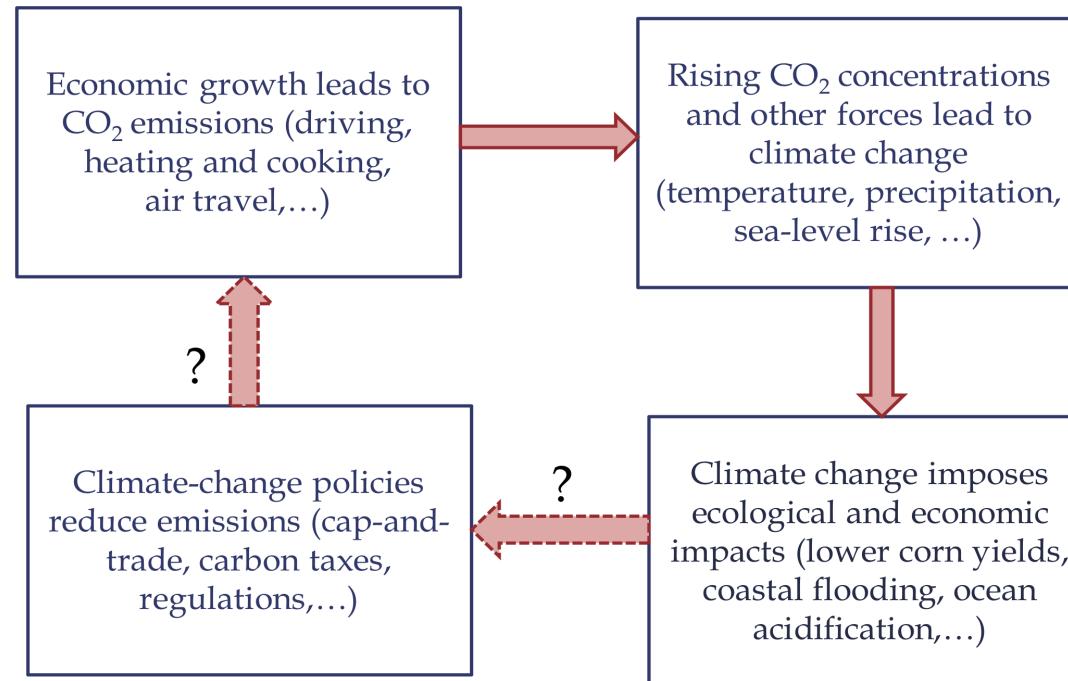
Watch Prize lecture: William D. Nordhaus

Slides here

DICE (Dynamic Integrated model of Climate and the Economy)

RICE (Regional dynamic Integrated model of Climate and the Economy)

*The circular flow of global warming science,
impacts, and policy*



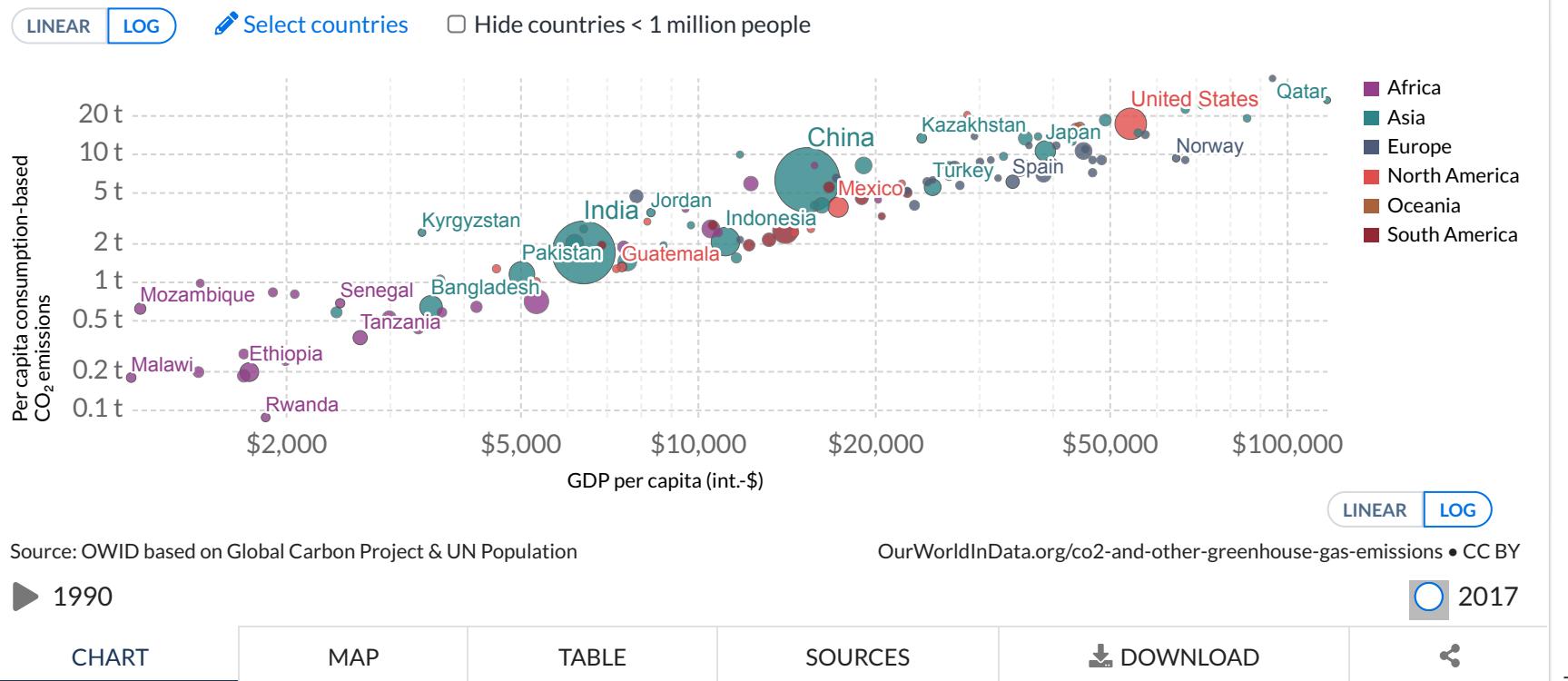
Trends in climate change

Economic growth ⇒ CO₂ Emissions

Consumption-based CO₂ emissions per capita vs GDP per capita, 2017

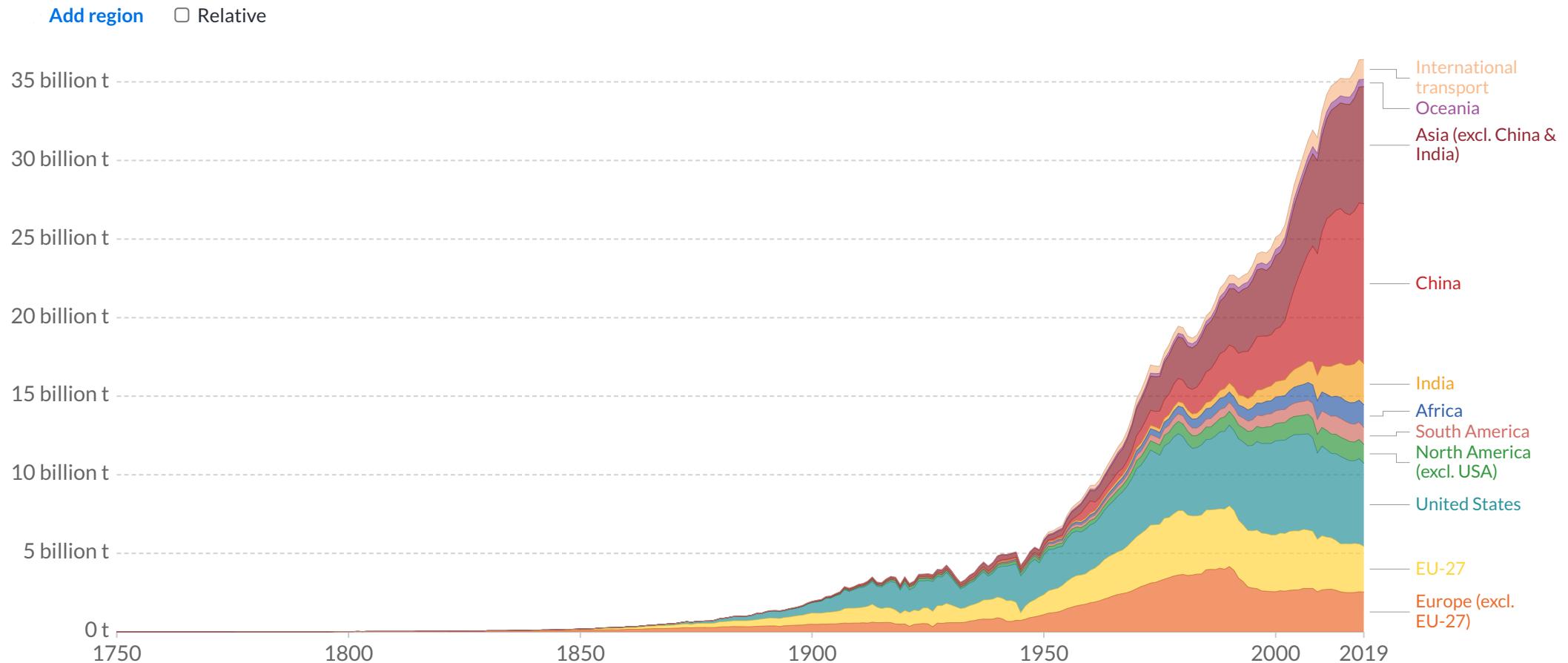
Our World
in Data

Annual consumption-based emissions are domestic emissions adjusted for trade. If a country imports goods the CO₂ emissions needed to produce such goods are added to its domestic emissions; if it exports goods then this is subtracted.
GDP per capita is adjusted for price differences between countries (PPP) and over time (inflation).



Annual total CO₂ emissions, by world region

This measures CO₂ emissions from fossil fuels and cement production only – land use change is not included.



Source: Our World in Data based on the Global Carbon Project

Note: 'Statistical differences' included in the GCP dataset is not included here.

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

CHART

TABLE

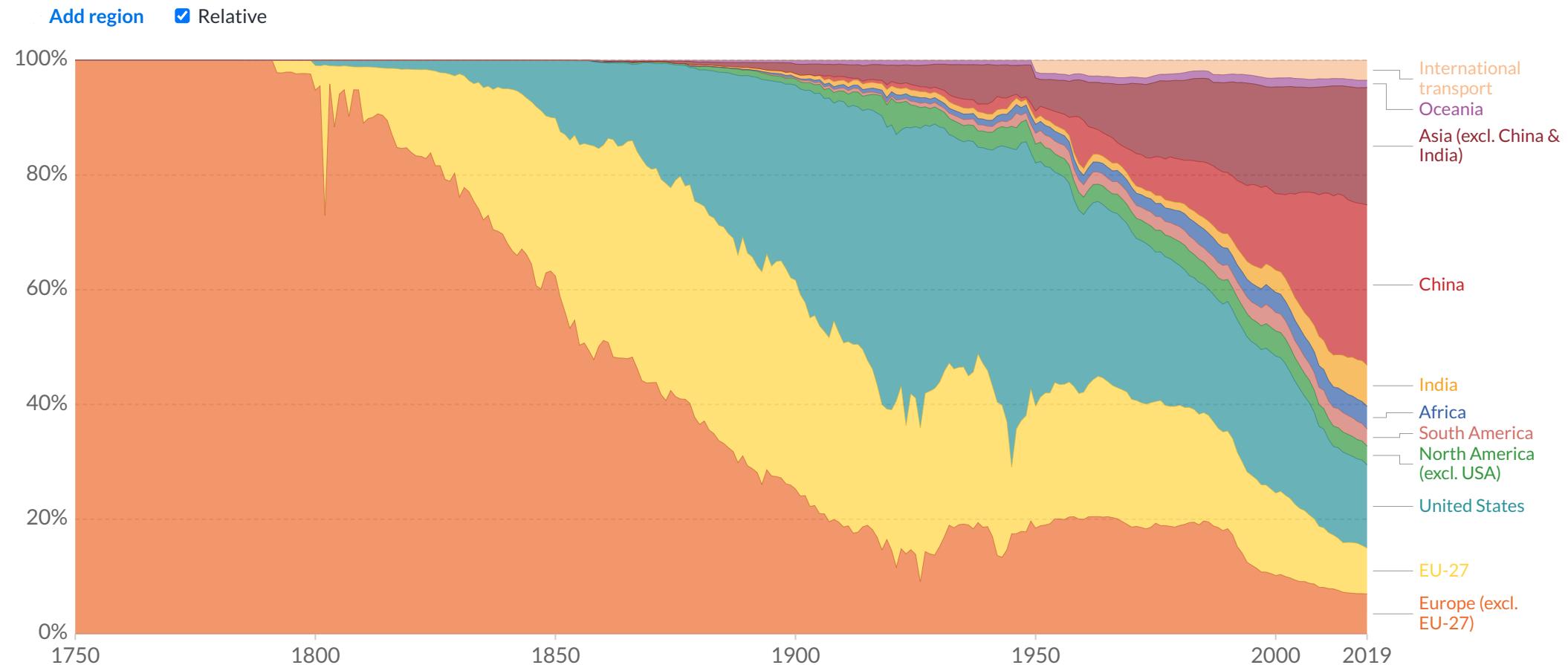
SOURCES

DOWNLOAD



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CHART

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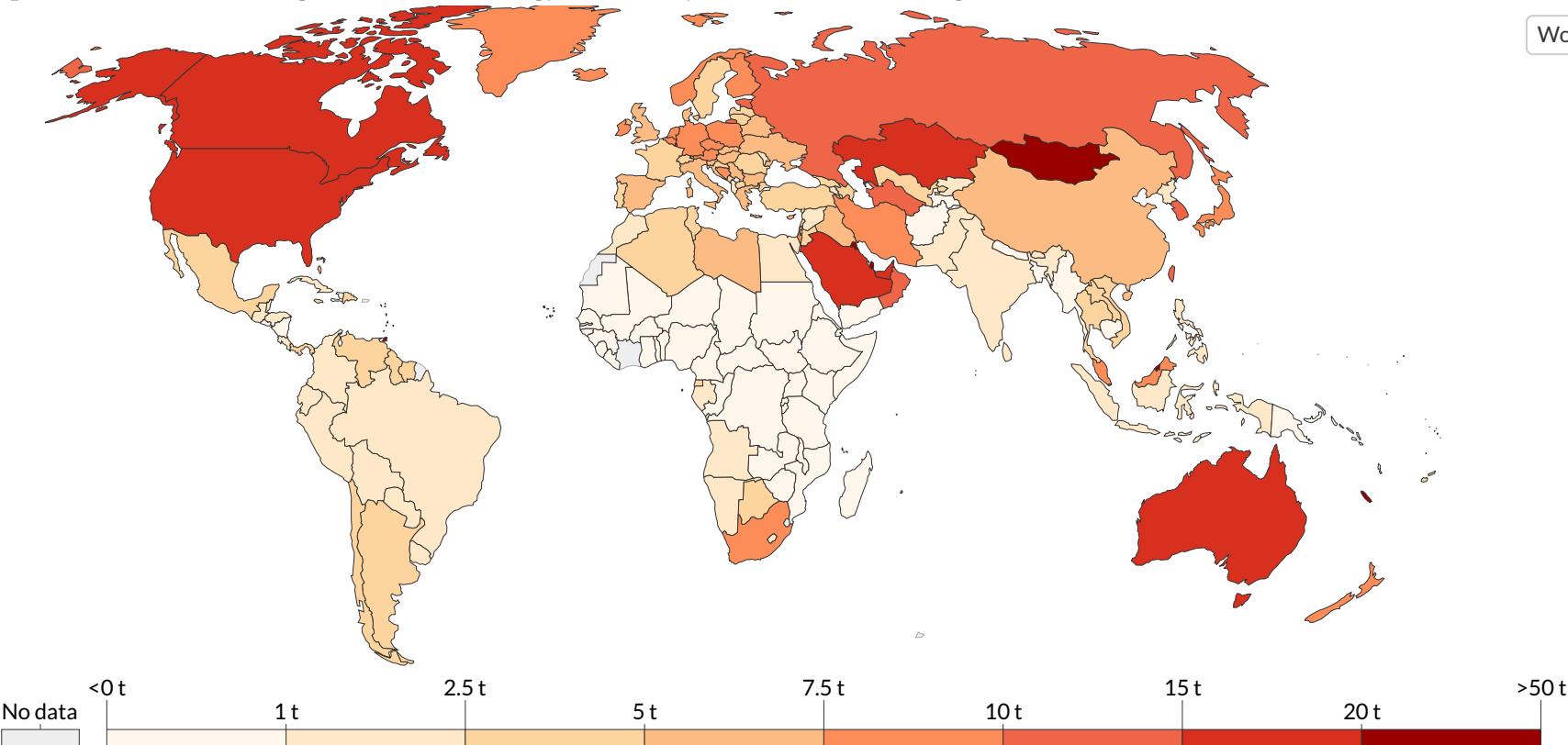
DOWNLOAD



Per capita CO₂ emissions, 2019

Carbon dioxide (CO₂) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.

World



Source: Our World in Data based on the Global Carbon Project; Gapminder & UN

Note: CO₂ emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.

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► 1800

○ 2019

CHART

MAP

TABLE

SOURCES

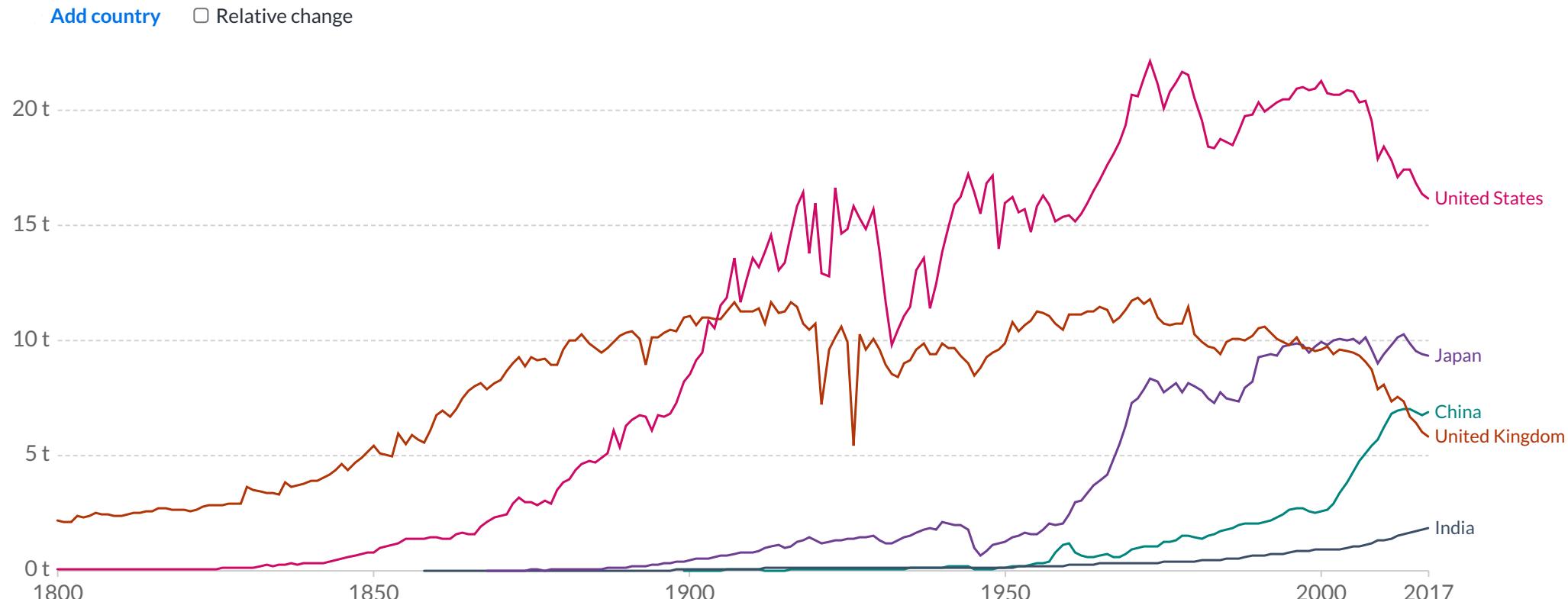
DOWNLOAD



Related: [Where in the world do people emit the most CO₂? ↗](#)

Per capita CO₂ emissions

Carbon dioxide (CO₂) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.



Source: Our World in Data based on the Global Carbon Project; Gapminder & UN

Note: CO₂ emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.

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○ 2019

CHART

MAP

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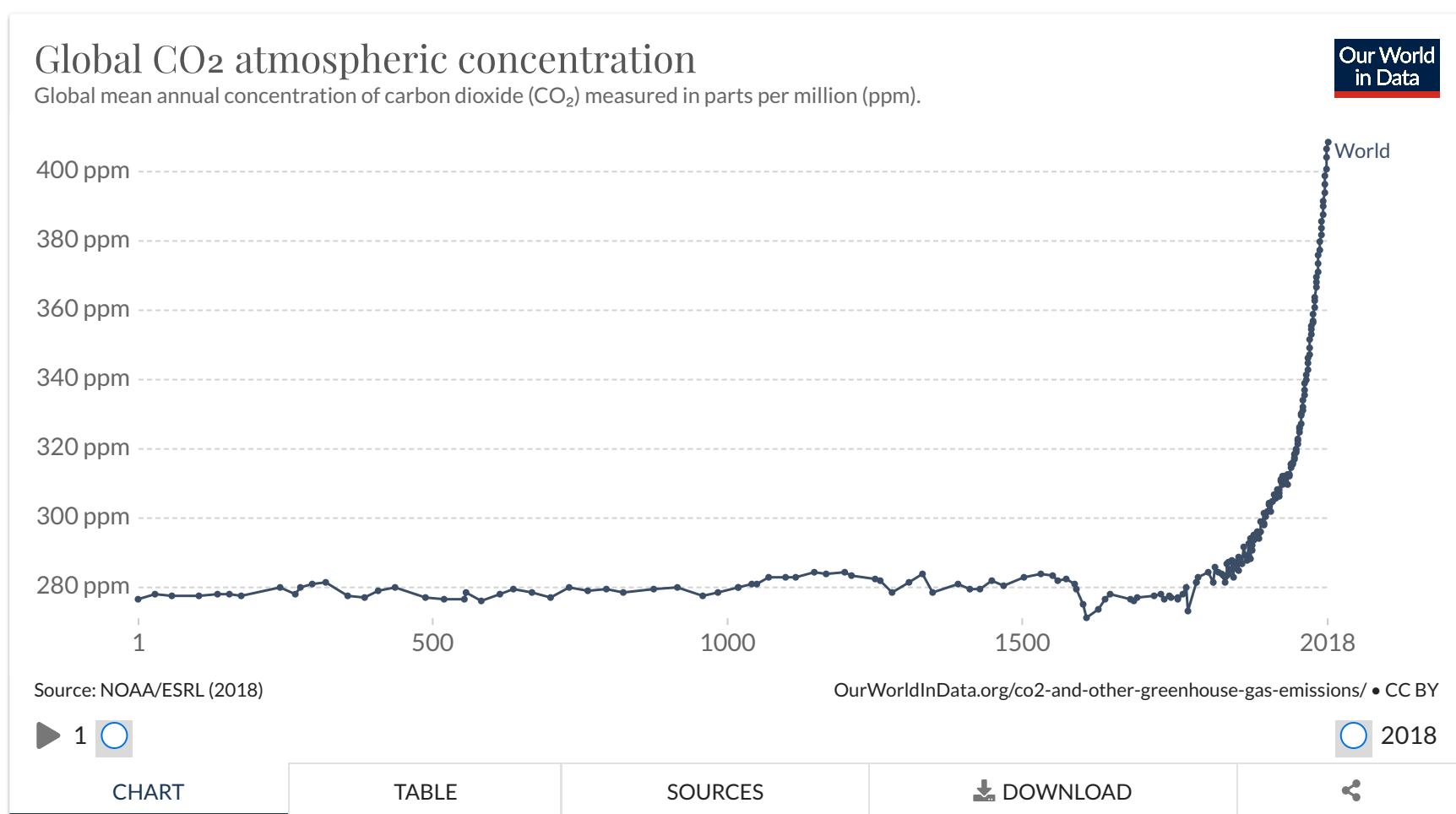
SOURCES

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Related: [Where in the world do people emit the most CO₂? ↗](#)

CO₂ Emissions ⇒ CO₂ Concentrations



Climate Change ⇒ Economic and Ecological Impacts

- Lower corn yields
- Coastal flooding
- Extreme weather events
- Ocean acidification

Economic policy

Climate Change ⇒ ?? Climate-change policies ??

Why do we need climate-change policies?

Because of market failures

- Climate change is a public bad
 - Non-rival (everyone will lose from it)
 - Non-excludable (one cannot exclude themselves from the negative effects)
 - Free-rider problem: if a country keeps producing CO₂ emissions, but the rest of world reduces the emissions, that country will be better off without paying any costs
- Negative externality
 - negative impact of CO₂ emissions on others
 - global: emissions by people in one country have negative impacts on residents of far away countries
 - long-run: emissions today have negative impact on future generations

Other factors

- Potential tipping point problem:
 - if the increase in global temperatures exceeds a point, it might be impossible to reverse the climate change
 - low probability but catastrophic event
 - necessitates prudential policies

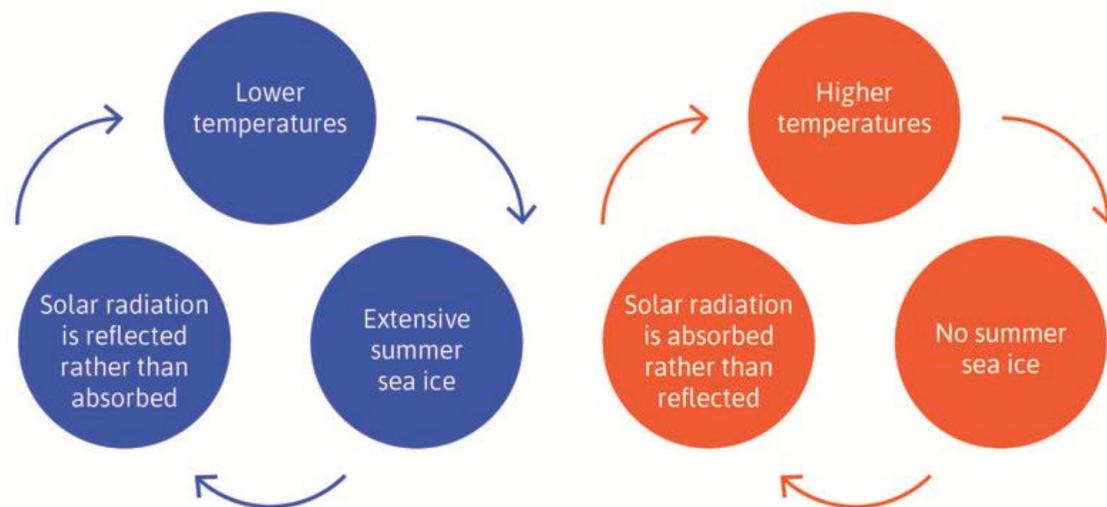


Figure from Core The Economy

Design of optimal policies

- People get utility from consumption
- They maximize discounted sum of utility from future consumption
 - subject to resource constraints: reductions CO₂ emissions require sacrifices from consumption
 - if CO₂ emissions is not reduced, the future consumption will be negatively affected.
- Question: **how do you reduce the CO₂ emissions most efficiently (with limited cost)?**
 - Models help us answer this question.

The mathematics of the DICE model

$$(1) \max_{c(t)} W = \max_{c(t)} \left[\int_0^{\infty} U[c(t)] e^{-\rho t} dt \right]$$

subject to

$$(2) \quad c(t) = M[y(t); z(t); \alpha; \varepsilon(t)]$$

Source: William Nordhaus

Modeling decisions

- Discount factor: weight on the welfare of future generations
 - Positive
 - Normative
- Households do not derive utility from the welfare of other households
 - How much weight should be put on the welfare of different regions?

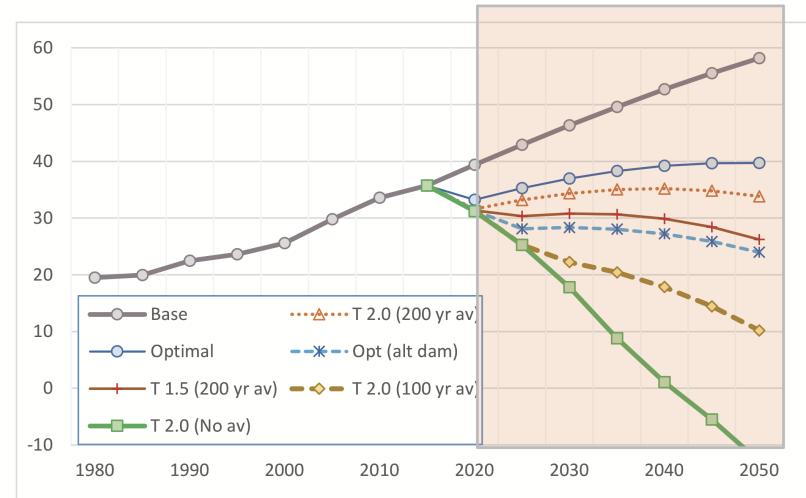
Modeling decisions

- Discount factor: weight on the welfare of future generations
 - Positive
 - Normative
 - Households do not derive utility from the welfare of other households
 - How much weight should be put on the welfare of different regions?
 - Policy implementation
 - carbon tax
 - tradable carbon emission permit
 - regulation
 - innovation policy/subsidies
 - industrial policy (subsidizing industries)
- Efficient certainties in policies
certainty to taxation*

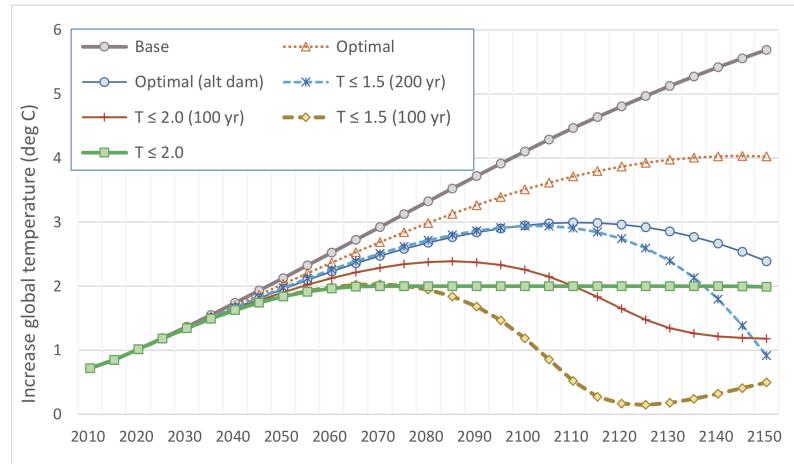


Alternative policies

- Business as usual (minimal policies)
- Cost-benefit optimum (two damage functions)
- Limit temperature increase (to 1.5 , 2, 2.5 °C) with hard cap
- Limit temperature increase (to 1.5 , 2, 2.5 °C) over 100-year or 200-year averaging period



Temperature trajectories in different policies



Source: William Nordhaus

Social cost

Social cost: "the present value of the damage stream resulting from a marginal unit of fossil-fuel emissions"

Table 1 Carbon taxes 2010 US Dollars	2015	2020	2025	2030	2050
Optimal (Nordhaus's best parameter guess)	29.5	35.3	49.1	64.0	153.5
Optimal (Temperature Limit <2.5°C)	184.1	229.0	284.0	351.0	1008.4
Optimal (Stern discounting at 0.1%)	256.5	299.6	340.7	381.7	615.6

Source: Nobel Committee

- Carbon taxes disincentivize carbon-intensive production and consumption
- Carbon tax should be set equal to the social cost
- An increasing carbon tax is the most efficient way to coordinate economic activity
 - Needs coordination of economic activity by billions of people
- Carbon taxes incentivizes innovation in green technologies

Political economy

- Diverse group of countries/people with different incentives
- Pareto optimal allocation requires compensation of losers
- Free rider problem
- Proposal by Nordhaus
 - Form a climate club
 - Target carbon price, say \$50 per ton CO₂
 - Penalty tariff on non-participants, say 3% uniform
- Without cooperation, equilibrium tax would much lower than the optimal tax
- Incentives for innovation

Can carbon taxes alone solve the climate problem?

Jenkins, Stokes, and Wagner (Eds). (2020):

- Politically feasible carbon taxes might not be sufficient to avert climate catastrophe
- Carbon pricing should be supplemented with other policies
 - 'clean energy standards'
 - 'low or no-carbon transportation projects'
 - 'government procurement and subsidy for market adoption of emerging technologies'
 - 'direct support for clean energy research, development, demonstration, and deployment (RDD&D)'

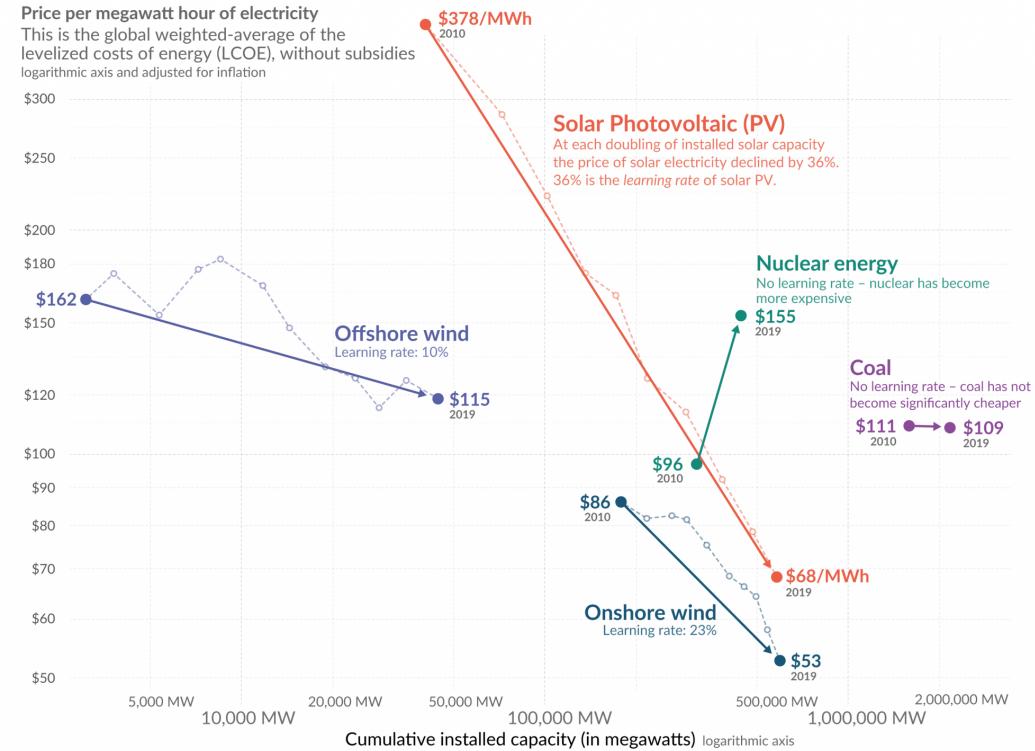
Acemoglu, Akcigit, Hanley and Kerr (2016)

- Carbon taxes reduce current emissions and direct tech. change toward clean technologies
- Even with optimally chosen carbon subsidies, there's a major role for research subsidies to clean technologies
 - 'it is not worth distorting the initial production too much by introducing very high carbon taxes'
- Research subsidies redirect technological change towards cleaner technologies

Cost of clean energy

Electricity from renewables became cheaper as we increased capacity – electricity from nuclear and coal did not

Our World
in Data



Source: IRENA 2020 for all data on renewable sources; Lazarus for the price of electricity from nuclear and coal – IAEA for nuclear capacity and Global Energy Monitor for coal capacity. Gas is not shown because the price between gas peaker and combined cycles differs significantly, and global data on the capacity of each of these sources is not available. The price of electricity from gas has fallen over this decade, but over the longer run it is not following a learning curve.

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Source : Our World in Data

Summary

We covered

- Surge in CO₂ emissions and atmospheric CO₂ concentration
- Market failures in carbon-intensive production/consumption
- Designing optimal policies

To review this lecture:

- Watch Bill Nordhaus' Nobel lecture
- Read cited papers/blogs
- Read Unit 20 of Core the Economy

Appendix

DICE model

ECONOMIC GROWTH, TECHNOLOGICAL CHANGE, AND CLIMATE CHANGE

by The Committee for the Prize in Economic Sciences in Memory of Alfred Nobel:

1. a carbon-circulation model that maps emissions of fossil carbon to a path for atmospheric carbon-dioxide (CO₂) concentration
2. a climate model that describes the evolution of the climate over time depending on the path of CO₂ concentration
3. an economic model that describes how the economy and the society is affected by climate change over time, and – closing the loop – how the path of economic activity leads to emissions of fossil carbon.