Economic Growth

Lecture 9: Climate Change

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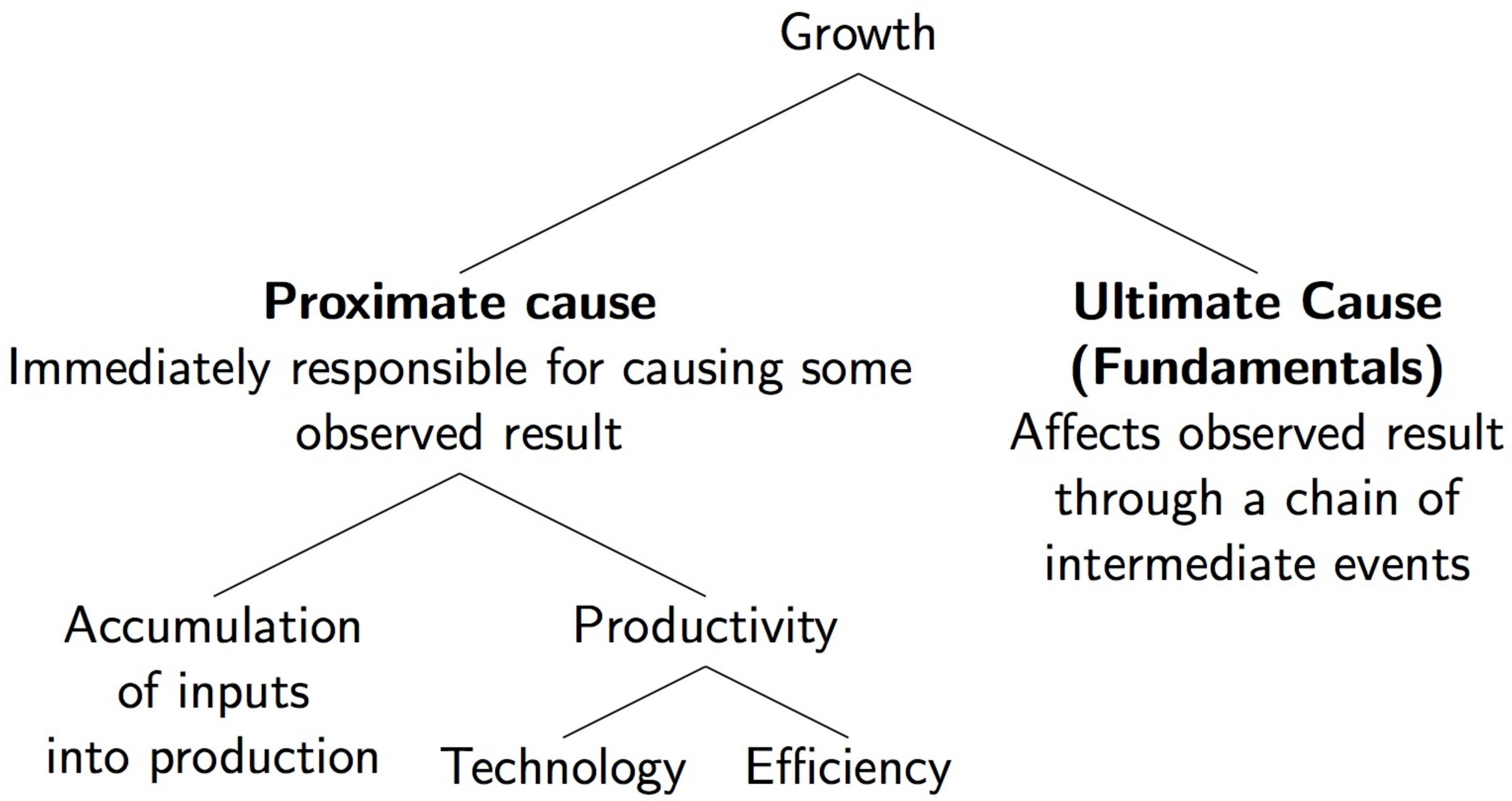
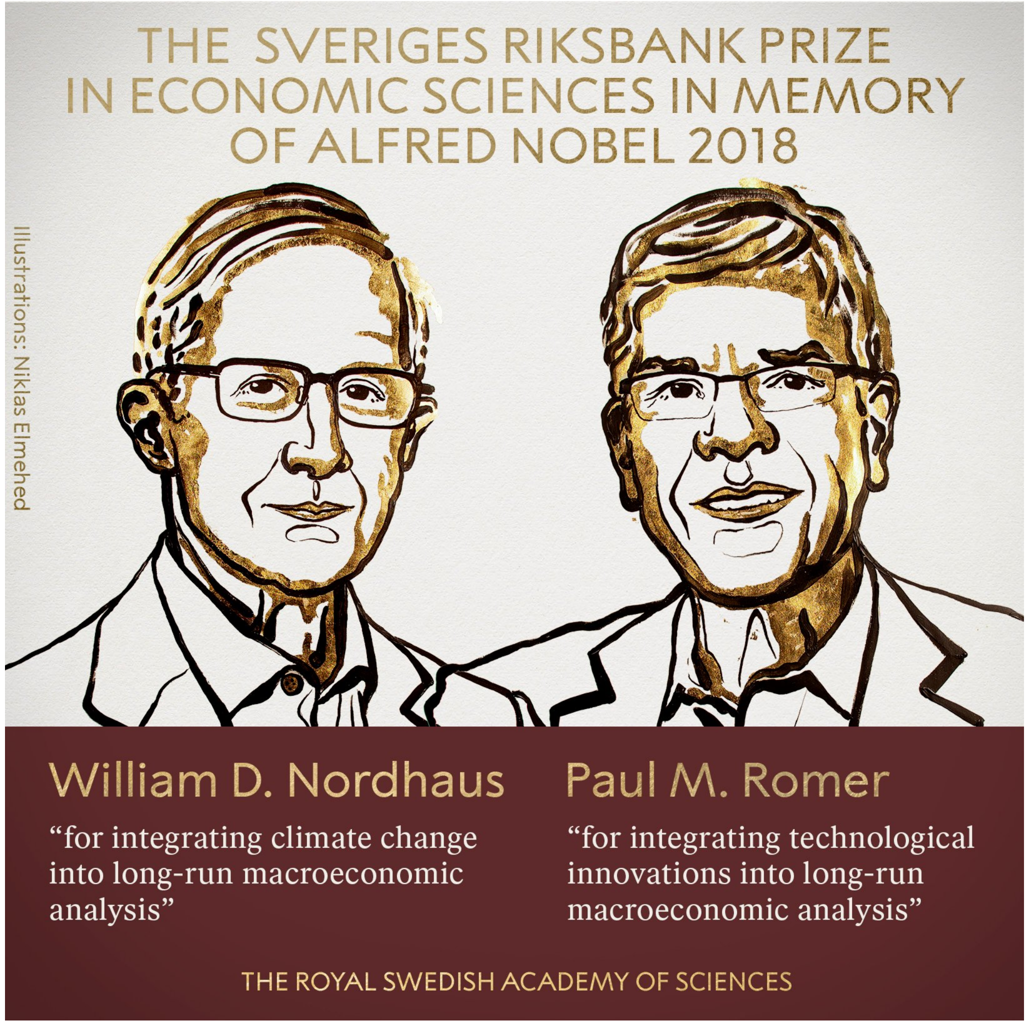
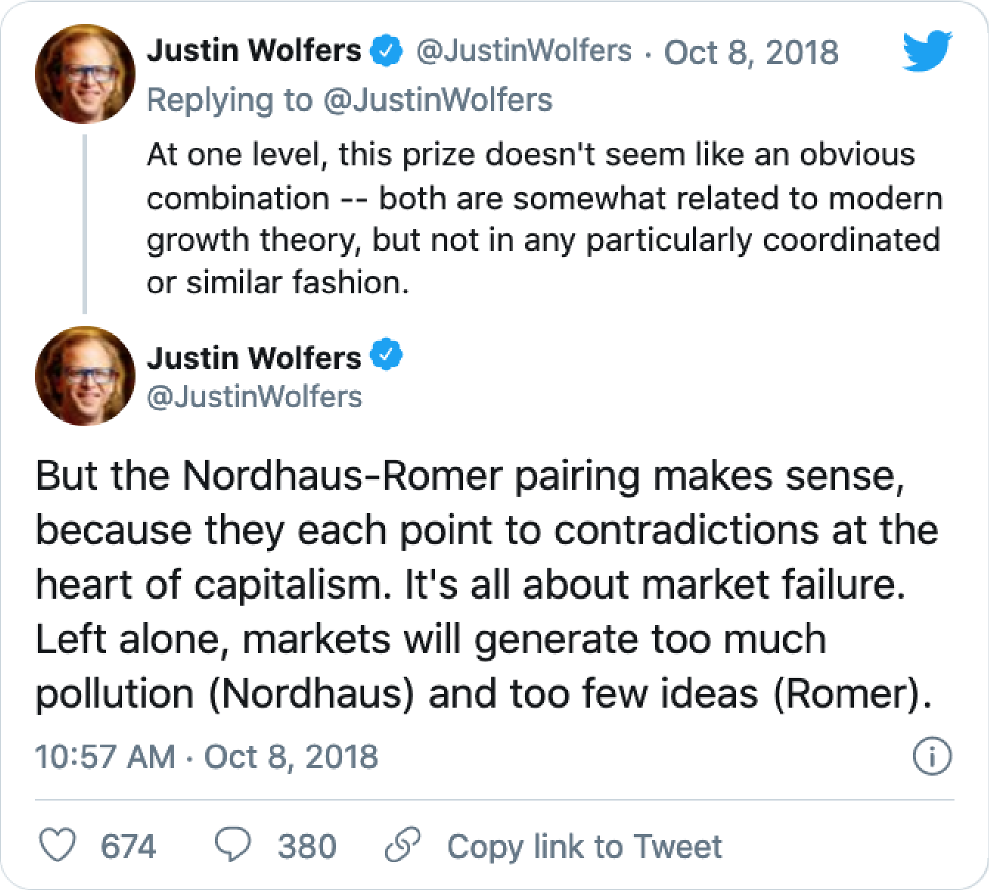

Growth
Proximate cause
Immediately responsible for causing some observed result
Ultimate Cause (Fundamentals)
Affects observed result through a chain of intermediate events
Accumulation of inputs into production
Productivity
Technology
Efficiency


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

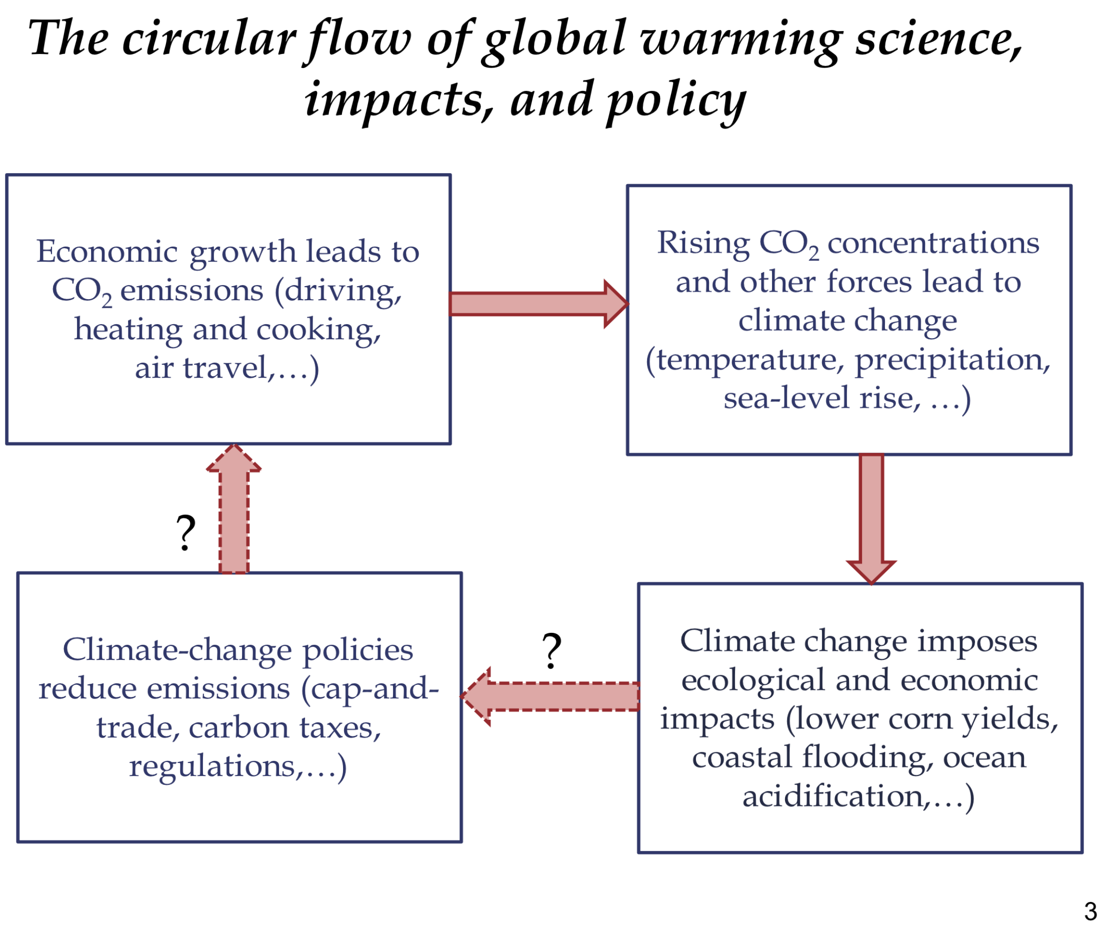
Nordhaus' Nobel Lecture

Watch Prize lecture: William D. Nordhaus

Slides here

DICE (Dynamic Integrated model of Climate and the Economy)

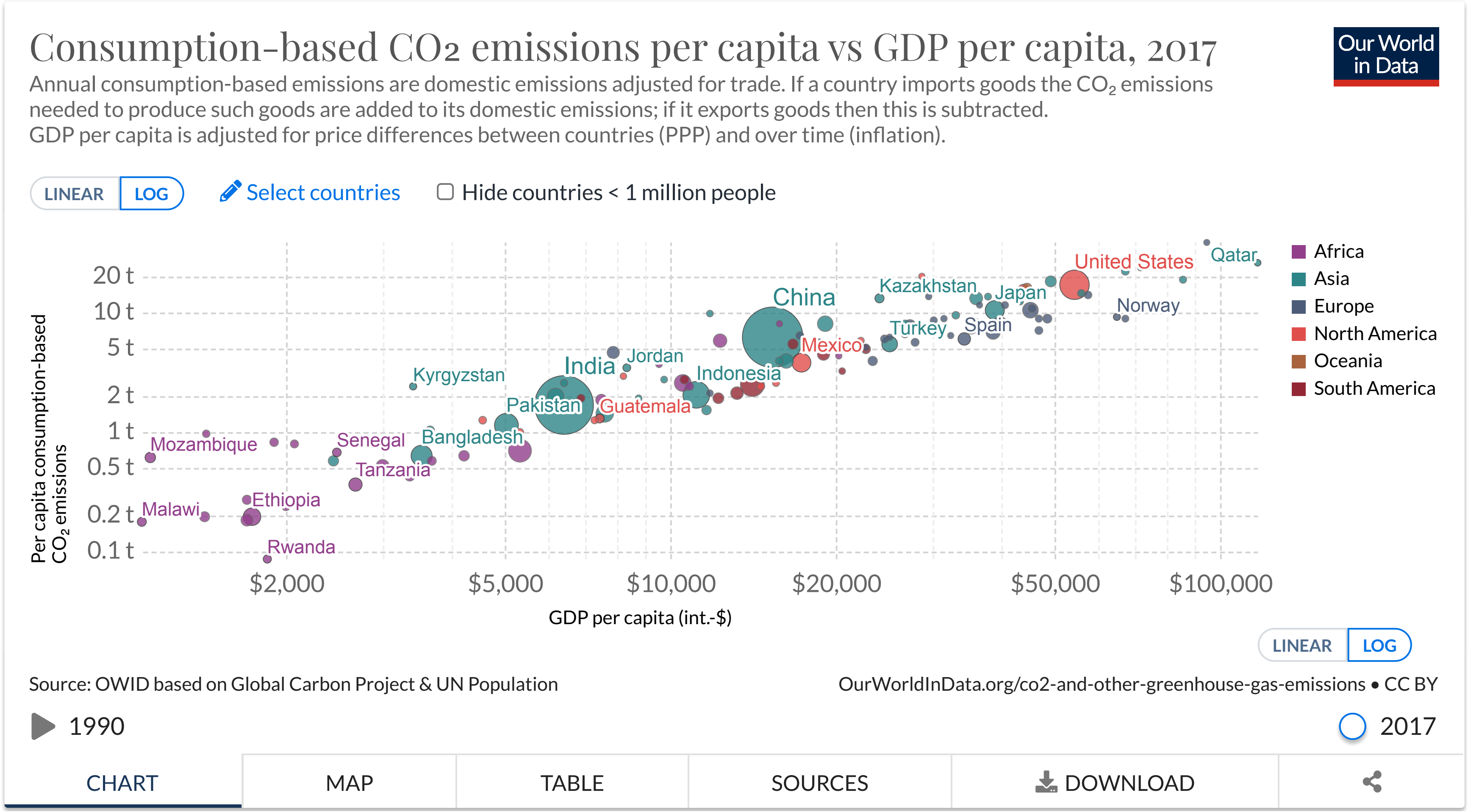
RICE (Regional dynamic Integrated model of Climate and the Economy)



Source: William Nordhaus

Trends in climate change

Economic growth ⇒ CO_2 Emissions



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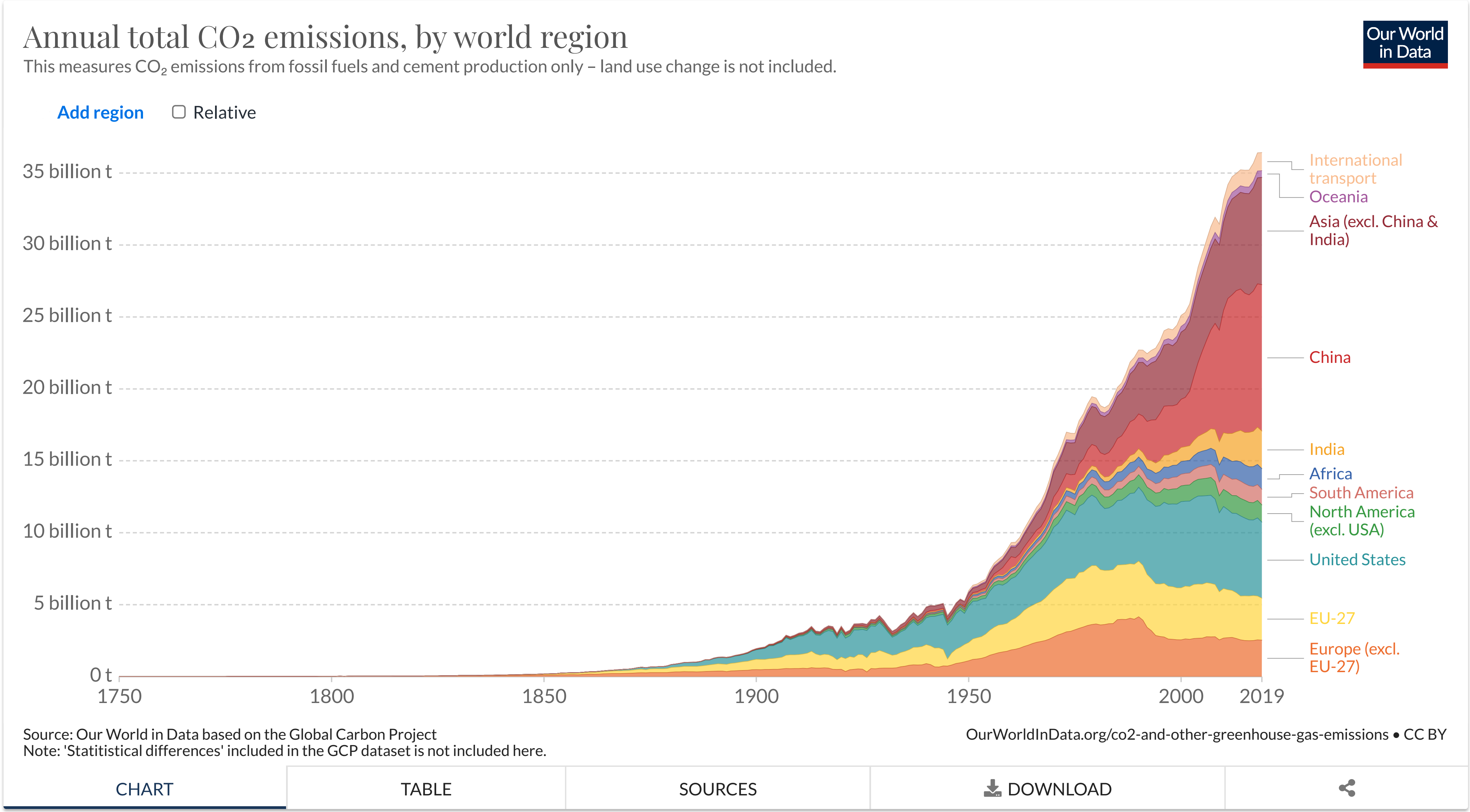
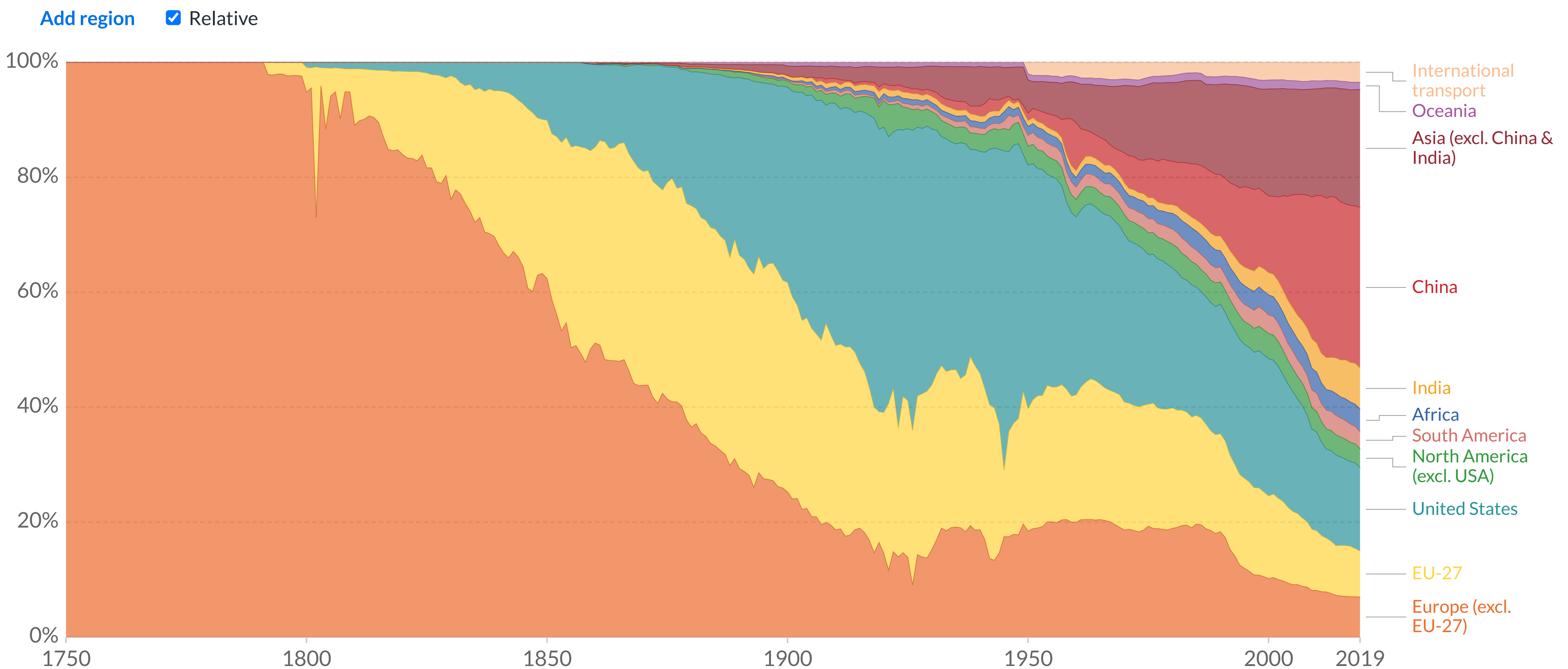

Annual total CO2 emissions, by world region
This measures CO_2 emissions from fossil fuels and cement production only – land use change is not included.
Our World in Data
Add region
Relative
35 billion t
30 billion t
25 billion t
20 billion t
15 billion t
10 billion t
5 billion t
0 t
1750
1800
1850
1900
1950
2000
2019
International transport
Oceania
Asia (excl. China & India)
China
India
Africa
South America
North America (excl. USA)
United States
EU-27
Europe (excl. EU-27)
Source: Our World in Data based on the Global Carbon Project
Note: 'Statitistical differences' included in the GCP dataset is not included here.
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY
CHART
TABLE
SOURCES
DOWNLOAD

Annual total CO_2 emissions, by world region

This measures CO_2 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: 'Statitistical differences' included in the GCP dataset is not included here.

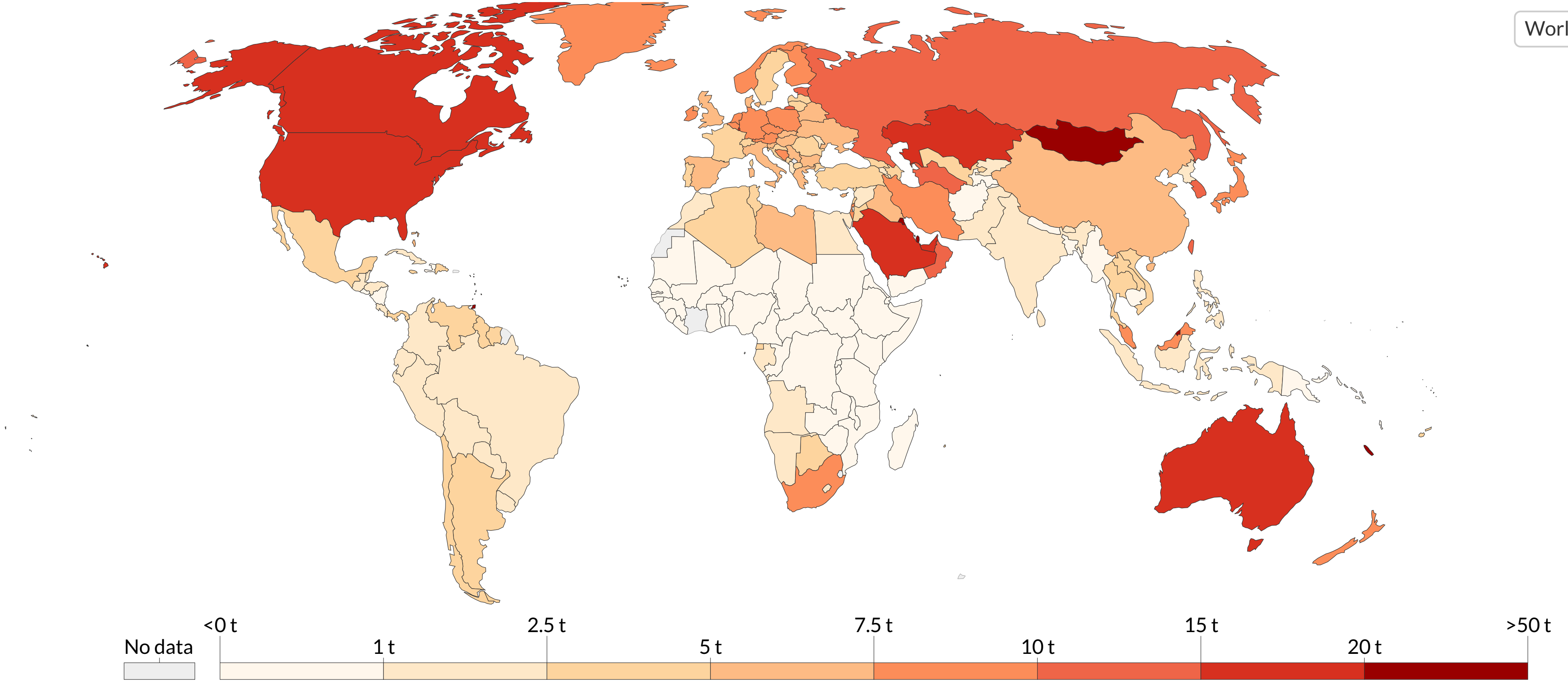
CHART | TABLE | SOURCES | DOWNLOAD

Per capita CO2 emissions, 2019

Carbon dioxide (CO_2) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.

Our World in Data

World



Source: Our World in Data based on the Global Carbon Project; Gapminder & UN
Note: CO_2 emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.

1800 2019

CHART | MAP | TABLE | SOURCES | DOWNLOAD

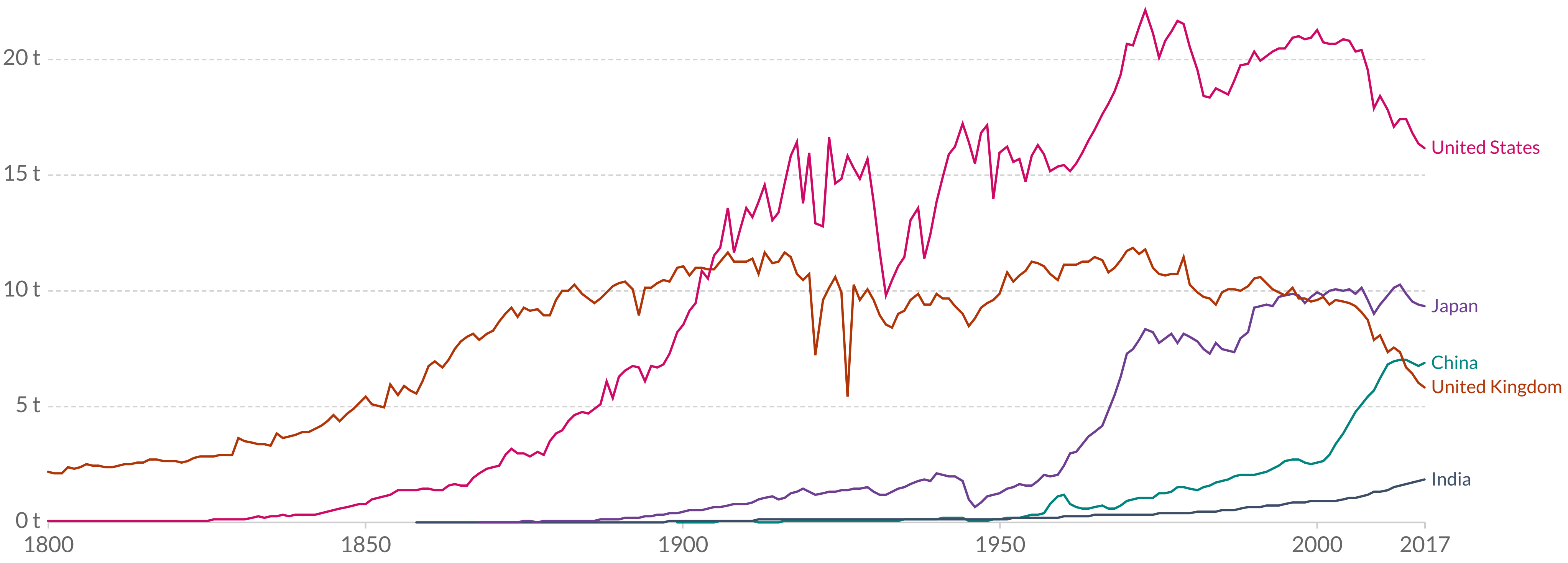
Related: Where in the world do people emit the most CO_2?

Per capita CO_2 emissions

Carbon dioxide (CO_2) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.

Our World in Data

Add country ☐ Relative change



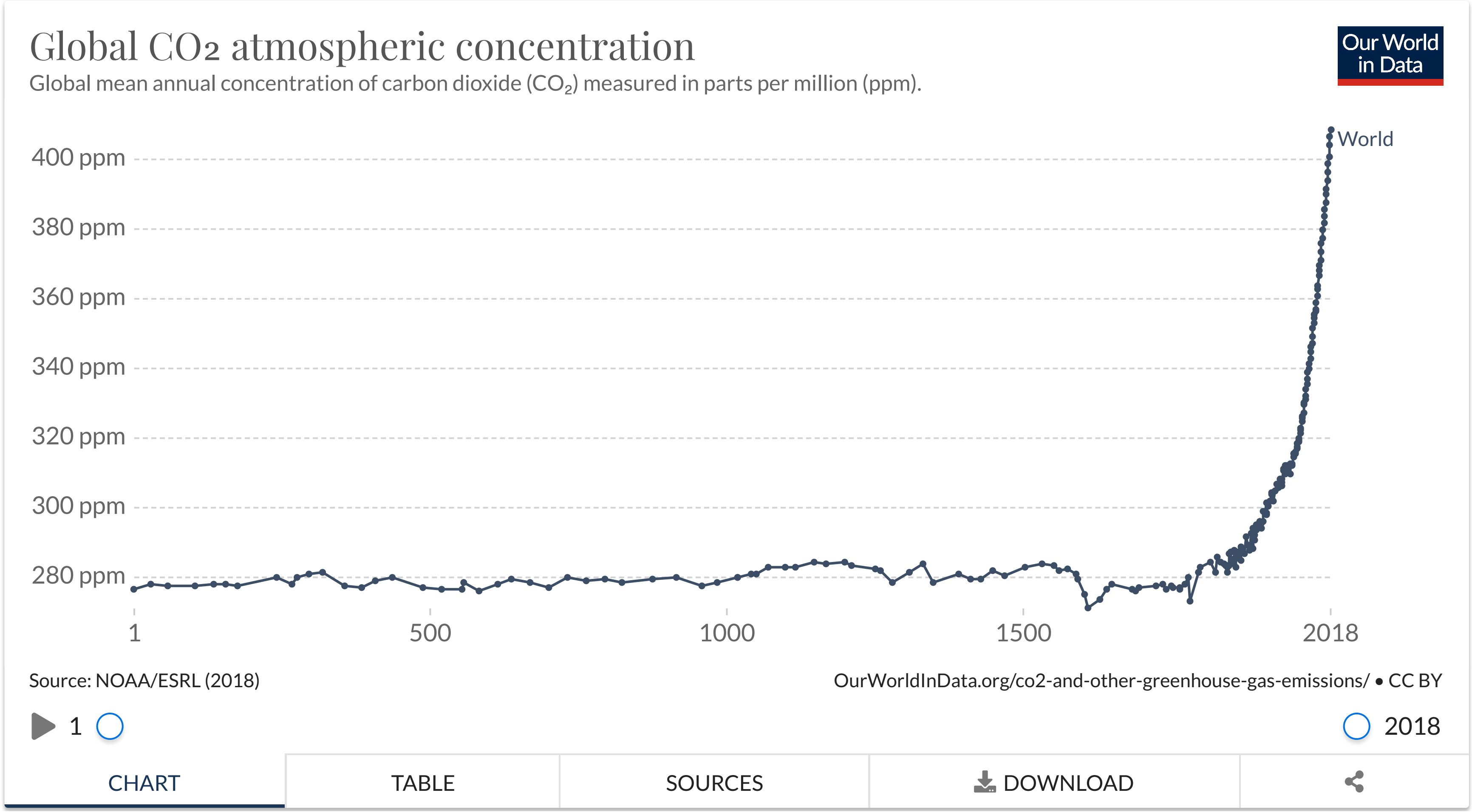
Source: Our World in Data based on the Global Carbon Project; Gapminder & UN
Note: CO_2 emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.

1800 2019

CHART | MAP | TABLE | SOURCES | DOWNLOAD

Related: Where in the world do people emit the most CO_2?

CO_2 Emissions ⇒ CO_2 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 CO_2 emissions, but the rest of world reduces the emissions, that country will be better off without paying any costs
- Negative externality
    - negative impact of CO_2 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

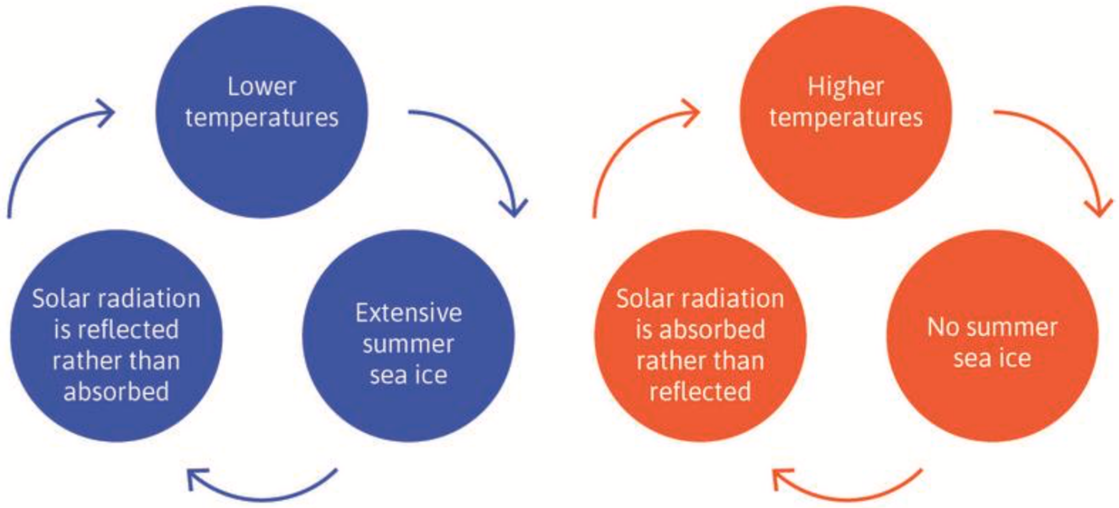


Figure from Core The Economy

Design of optimal policies

- People get utility from consumption
- They maximize discounted sum of utility from future consumption
  - subject to resource constraints: reductions CO_2 emissions require sacrifices from consumption
  - if CO_2 emissions is not reduced, the future consumption will be negatively affected.
- Question: how do you reduce the CO_2 emissions most efficiently (with limited cost)?
  - Models help us answer this question.

The mathematics of the DICE model

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

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
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- Households do not derive utility from the welfare of other households
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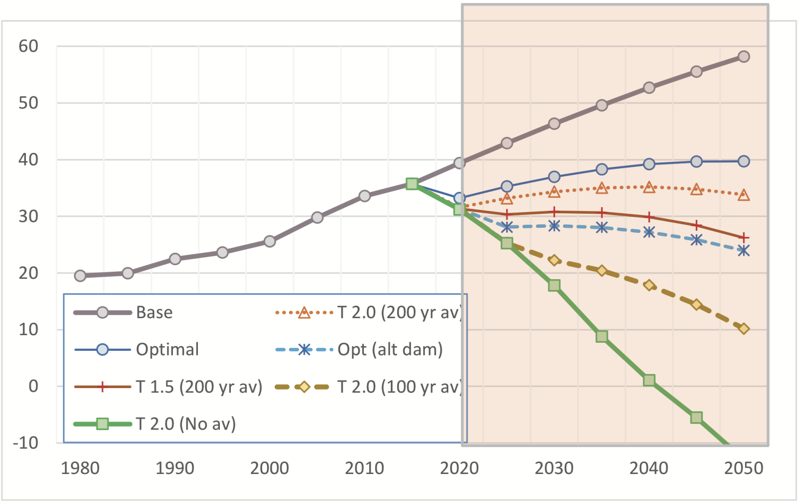
- Policy implementation
  - carbon tax
  - tradable carbon emission permit
  - regulation
  - innovation policy/subsidies
  - industrial policy (subsidizing industries)

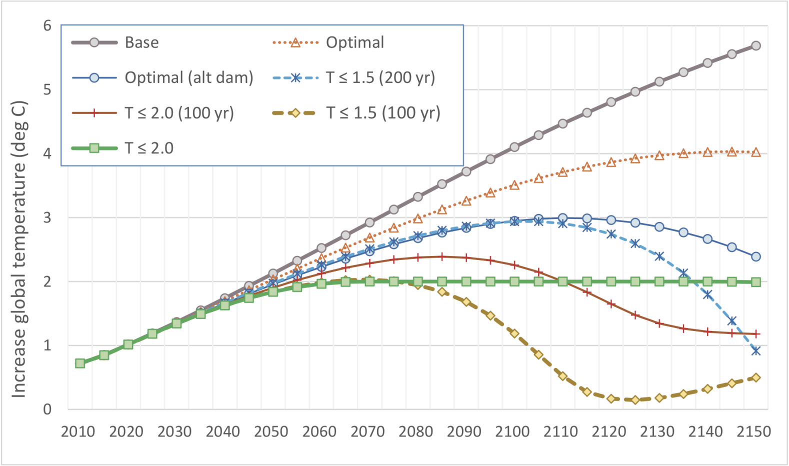
Alternative policies

- 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

Emissions trajectories in different policies



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?

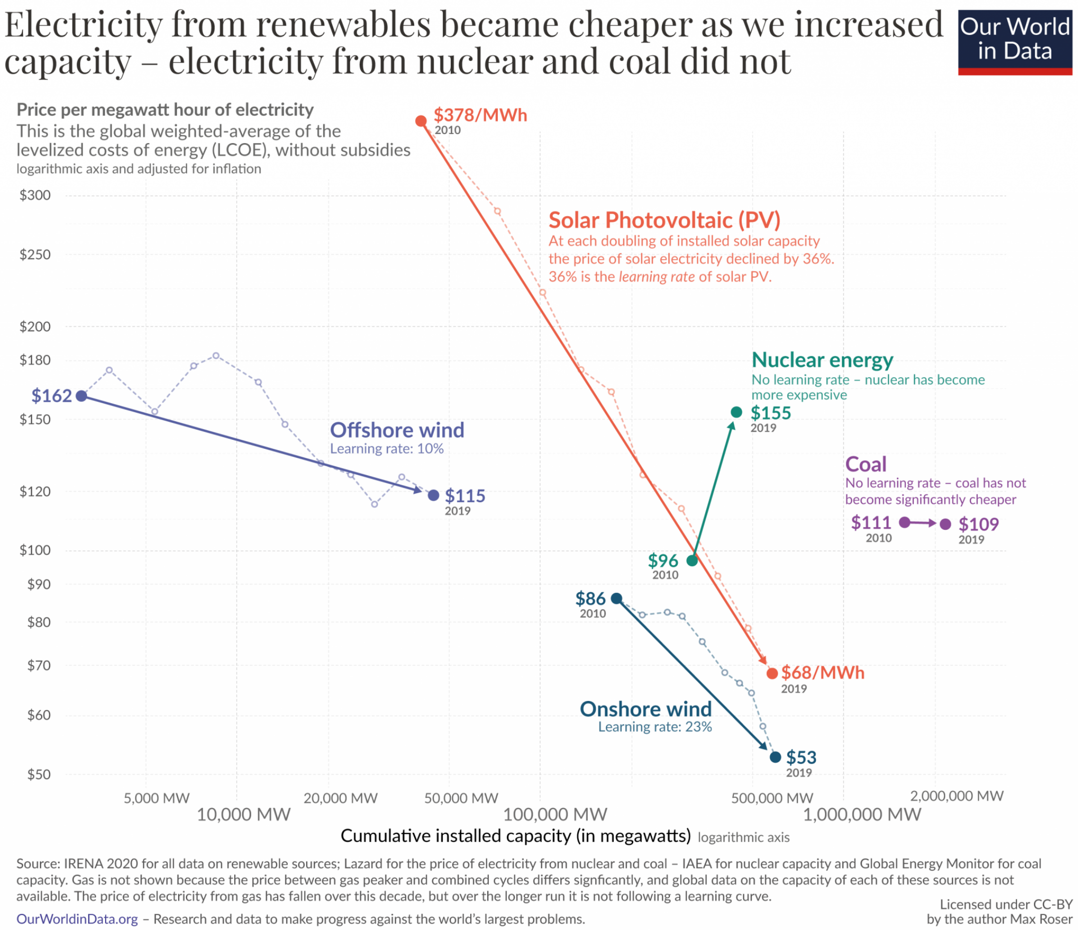
Jenkins, Stokes, and Wagner (Eds). (2020):

- 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 tax ~~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



Source : Our World in Data

Summary

We covered

- Surge in CO_2 emissions and atmospheric CO_2 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 (CO_2) concentration
> 2. a climate model that describes the evolution of the climate over time depending on the path of CO_2 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.