Economics and Climate Change

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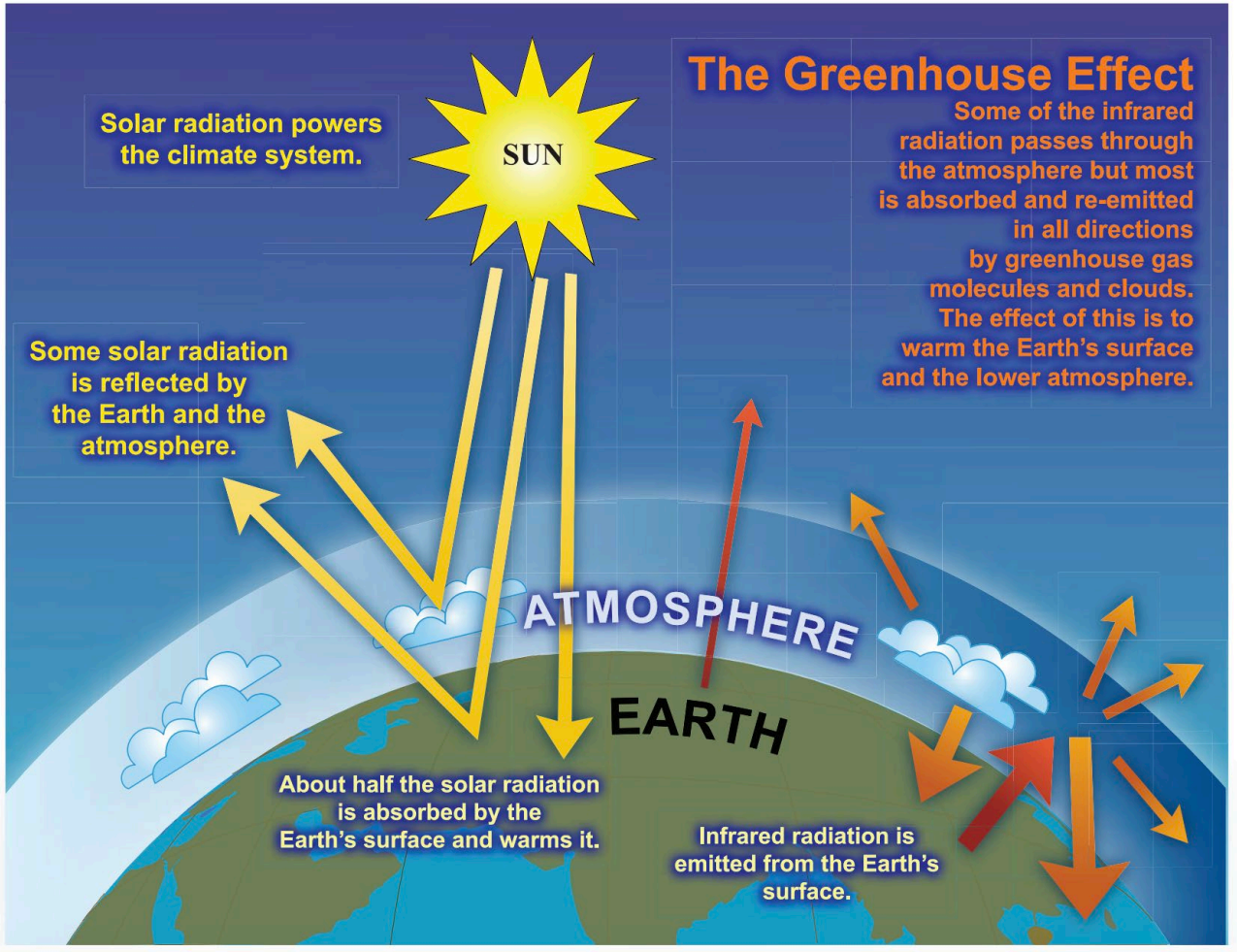
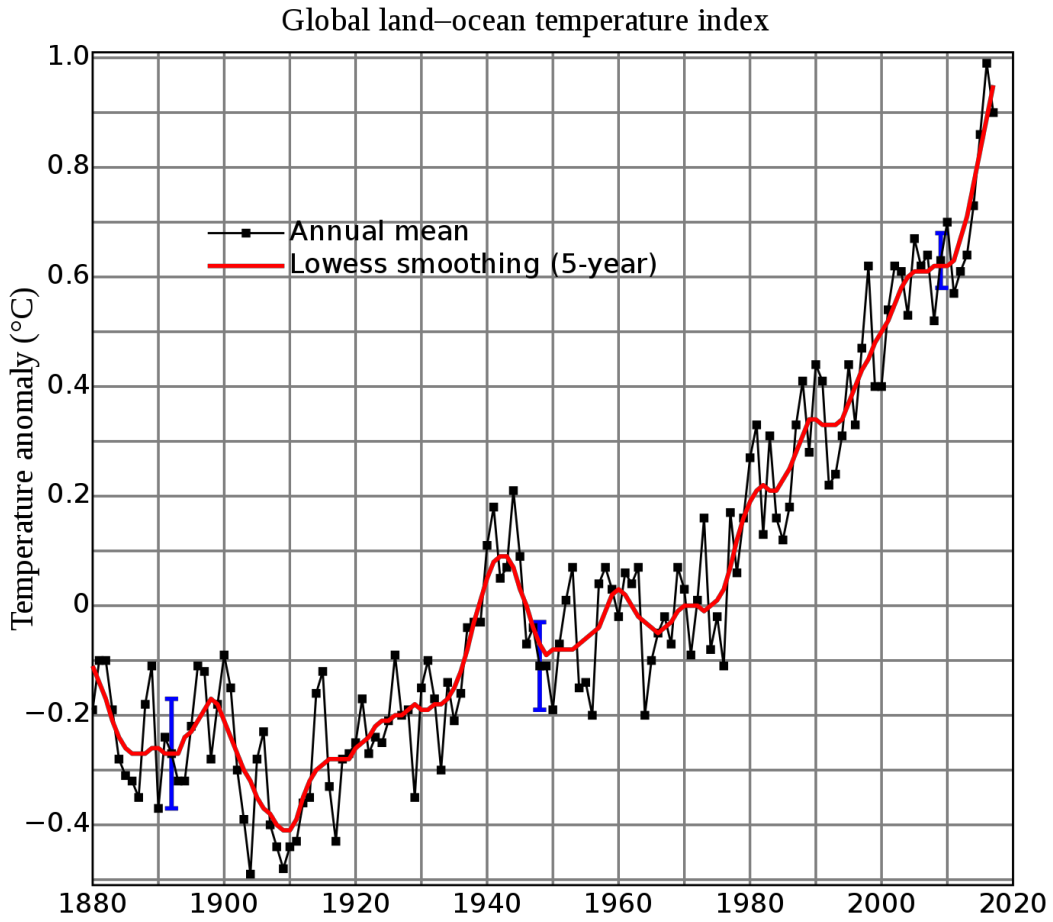
ECON 4905

Climate Change Overview

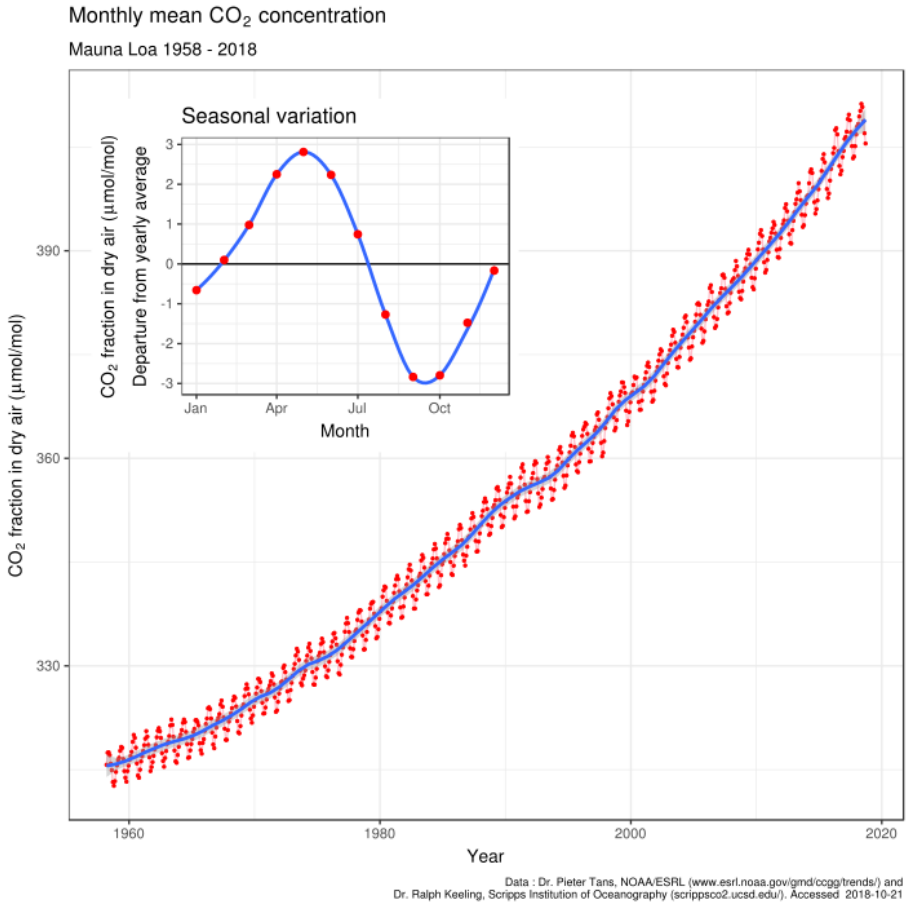


Source: Intergovernmental Panel on Climate Change

Climate Change Overview



Source: NASA (Goddard institute for Space Studies)



Source: National Oceanic and Atmospheric Administration, Global Monitoring Division

Economic Impacts

Agriculture Productivity

Water Availability

Sea Level Rise

Tourism

Energy Demand

Human Health

Labor Productivity

Economic Impacts

Agriculture Productivity

- Heat stress
- Reduced yields
- Water scarcity

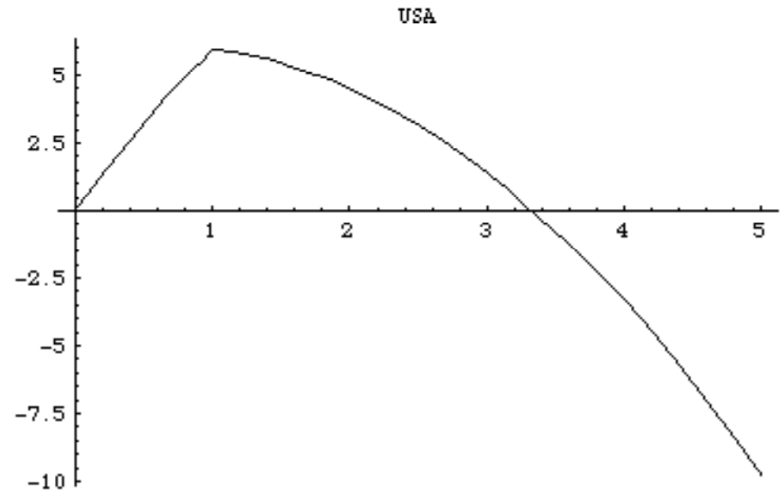


Figure 1. Agriculture productivity USA

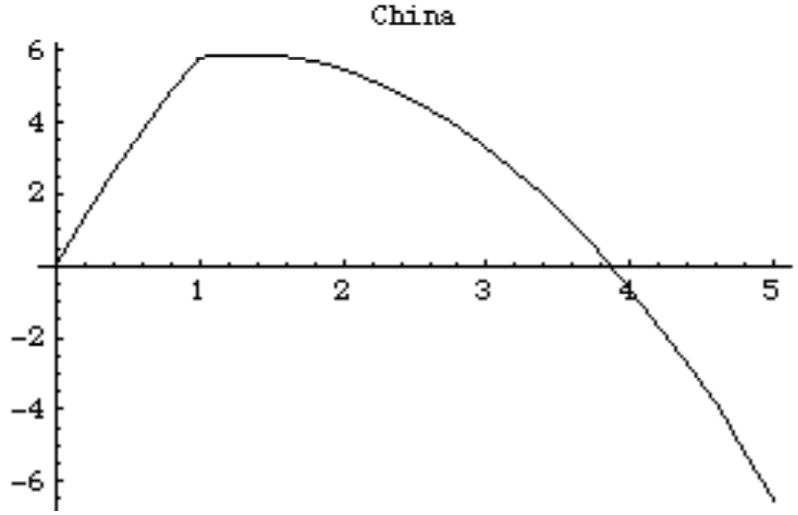


Figure 2. Agriculture productivity China

Source: University Ca' Foscari of Venice, Dept. of Economics Research Paper Series No. 07_10

Economic Impacts

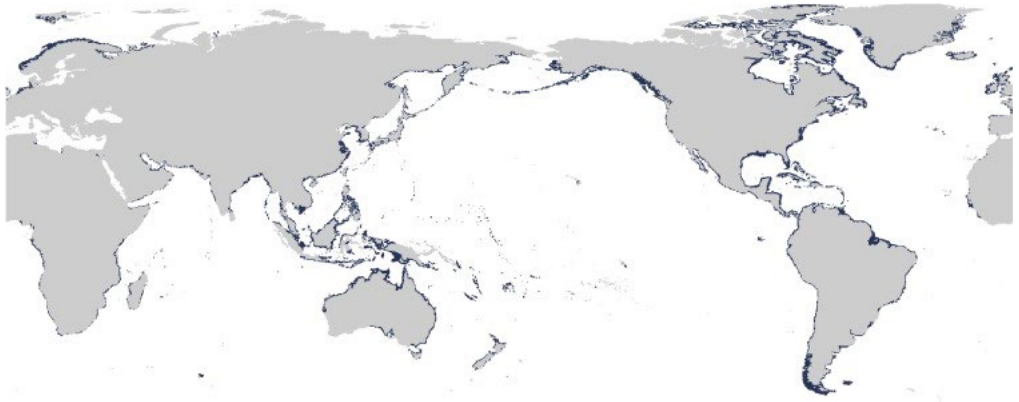
Water Availability

- Connections with agricultural yield
- Changes in precipitation patterns
- Regional changes

Economic Impacts

Sea Level Rise

- Flooding of low-lying coastal areas
- Displacement of populations
- Salt water intrusion



Source: Proceedings of the Japan Academy, Series B

Economic Impacts

Human Health

- Cardiovascular and respiratory disorders
- Cold-related diseases
- Health care costs
- Labor productivity

Economic Impacts

Labor Productivity

- Occupations requiring open air activity
- Agriculture incidence

The DICE Model

The Dynamic Integrated Model of Climate and the Economy

Developed by William Nordhaus starting in 1992

Widely adapted

Pizer (1999), Popp (2005), Baker *et. al.* (2006), Hoel and Sterner (2007), Yang (2008)

Won the Nobel Prize in Economics in 2018

The DICE Model

Social Welfare

$$W = \sum_{t=1}^{T\,max} U[c(t)]\, L(t)\, R(t)$$

W = Social welfare
U = Utility
c(t) = Per capita consumption
L(t) = Population
R(t) = Discount factor

The DICE Model

Net Output

$$Q(t) = \Omega(t)[1 - \Lambda(t)]Y(t)$$

Y(t) = Gross output
Ω(t) = Damage function
Λ(t) = Abatement cost

The DICE Model

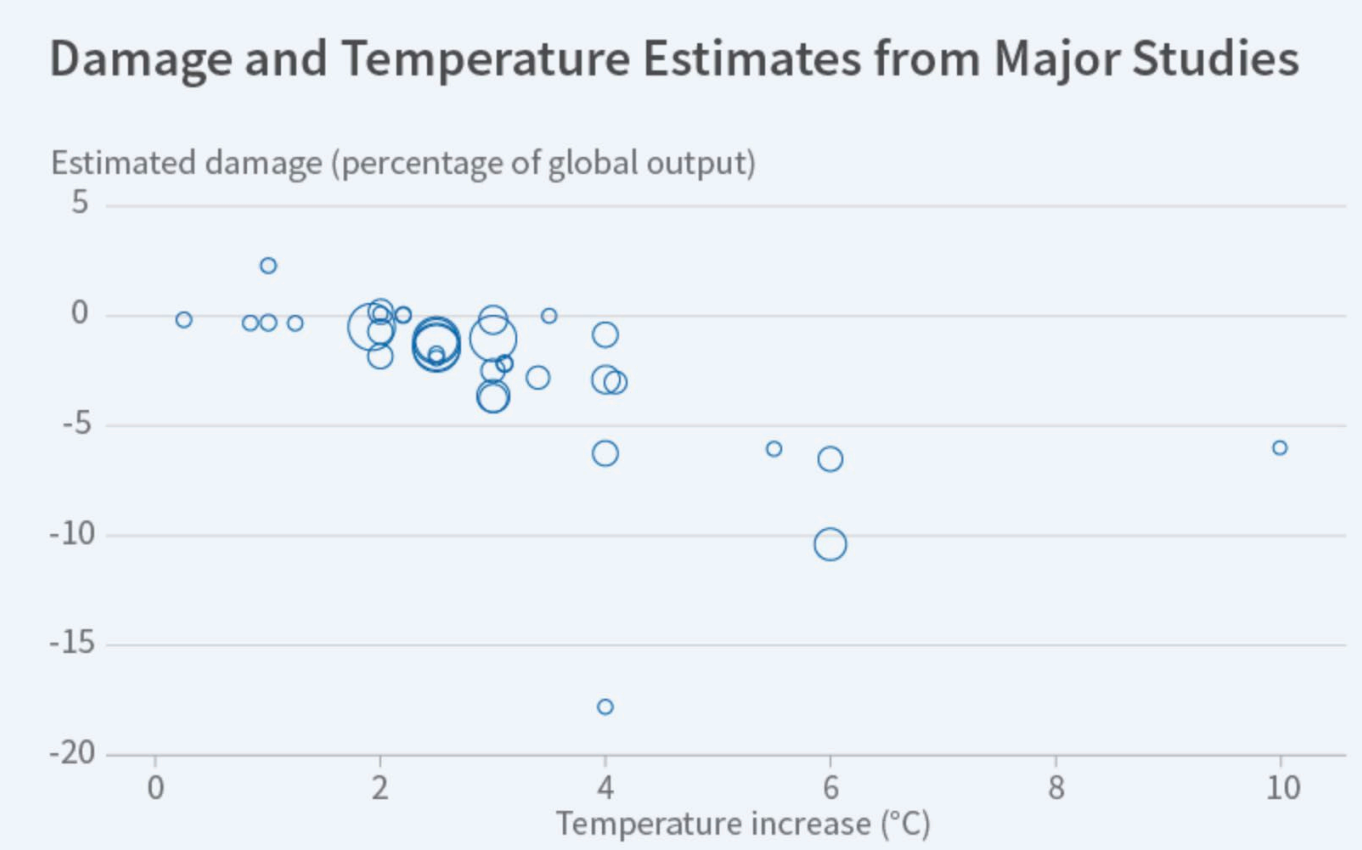
Damages

$$D(t) = \psi_1 T_{AT}(t) + \psi_2 [T_{AT}(t)]^2$$

T_{AT} = Globally averaged temperature change
ψ_1 and ψ_2 = Damage coefficients

The DICE Model

Damages



Source: William Nordhaus and Andrew Moffat, NBER Working Paper No. 23646

The DICE Model

Total Emissions

$$E(t) = \sigma(t)[1 - \mu(t)]Y(t) + E_{Land}(t)$$

E(t) = Total CO_2 emissions
σ(t) = CO_2-output ratio
μ(t) = Emissions reduction rate
E_{Land}(t) = Land-use emissions

The DICE Model

Geophysical Equations

$$M_j(t) = \phi_{0j} E(t) + \sum_{i=1}^{3} \phi_{ij} M_i(t-1)$$

The carbon cycle

$$F(t) = \eta\{log_2[M_{AT}(t) / M_{AT}(1750)]\} + F_{EX}(t)$$

Radiative forcing

$$T_{AT}(t) = T_{AT}(t-1) + \xi_1\{F(t) - \xi_2 T_{AT}(t-1) - \xi_3[T_{AT}(t-1) - T_{LO}(t-1)]\}$$

$$T_{LO}(t) = T_{LO}(t-1) + \xi_4[T_{AT}(t-1) - T_{LO}(t-1)]$$

Surface and ocean temperatures

The DICE Model

Social Cost of Carbon

Economic cost of an additional ton of CO_2 emissions

Currently estimated around \$31/ton CO_2

Expected to increase over time

The DICE Model

Uncertainty

Equilibrium Temperature Sensitivity (ETS)

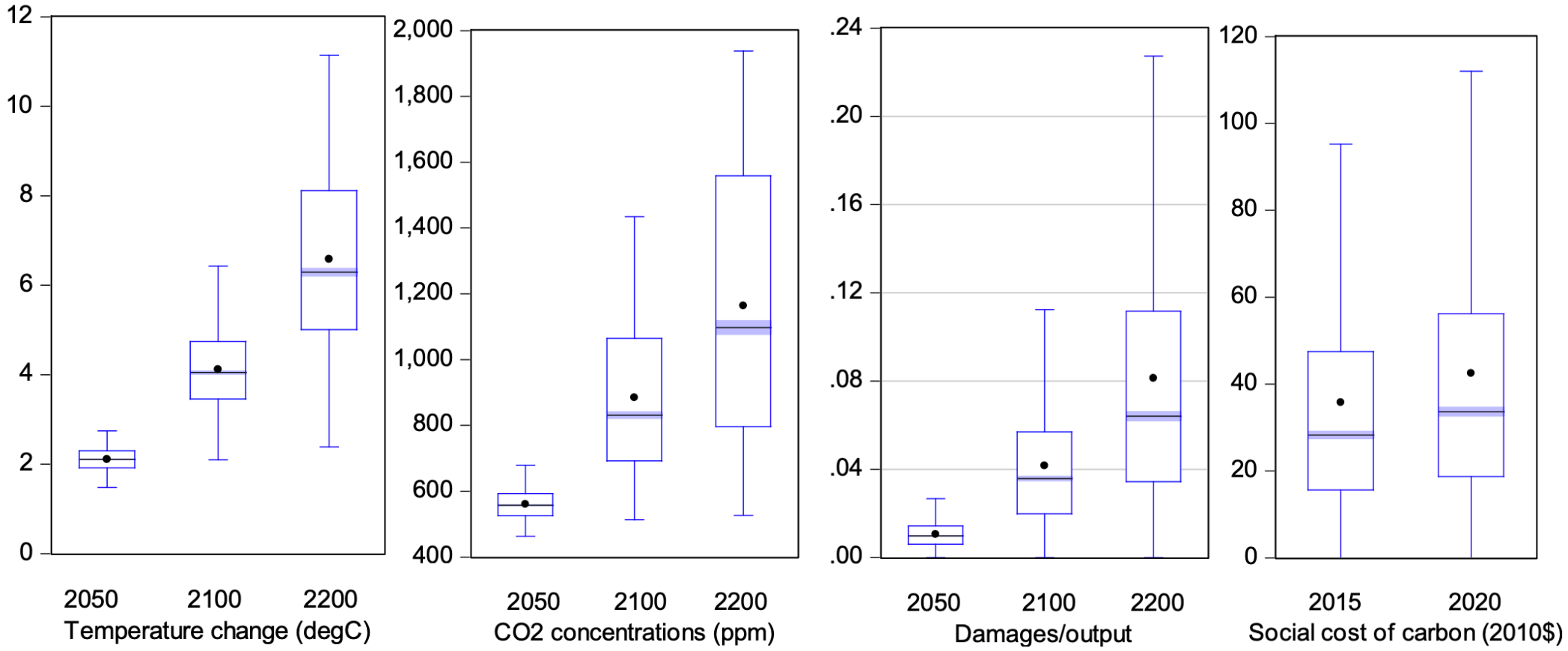
Productivity Growth

Decarbonization

Damage Coefficients

The DICE Model

Uncertainty



Source: William Nordhaus, Projections and Uncertainties About Climate Change (2016)

The DICE Model

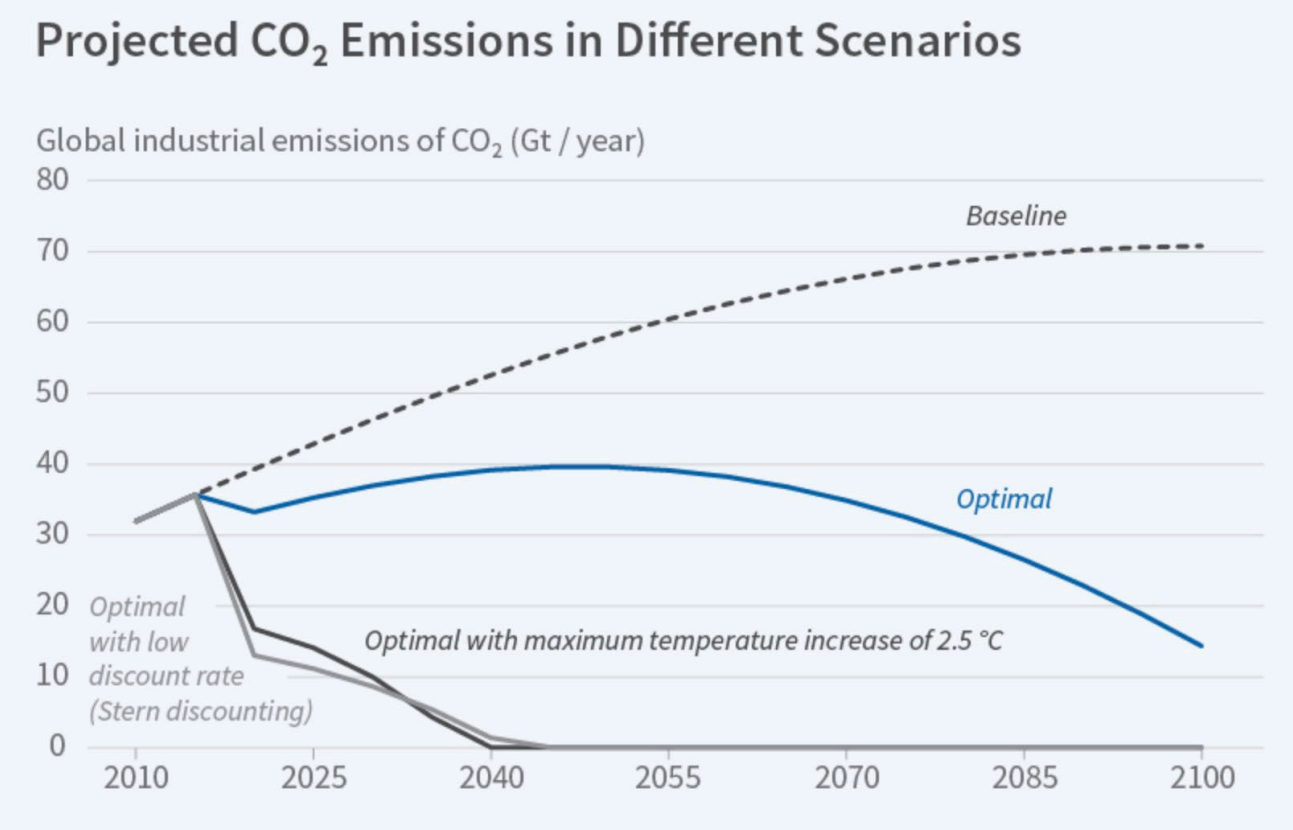
RESULTS

Four Scenarios:

- Business As Usual (Base)
- Economic Optimum (Opt)
- Temperature Limited (T<2.5)
- Stern Review (Stern)

The DICE Model

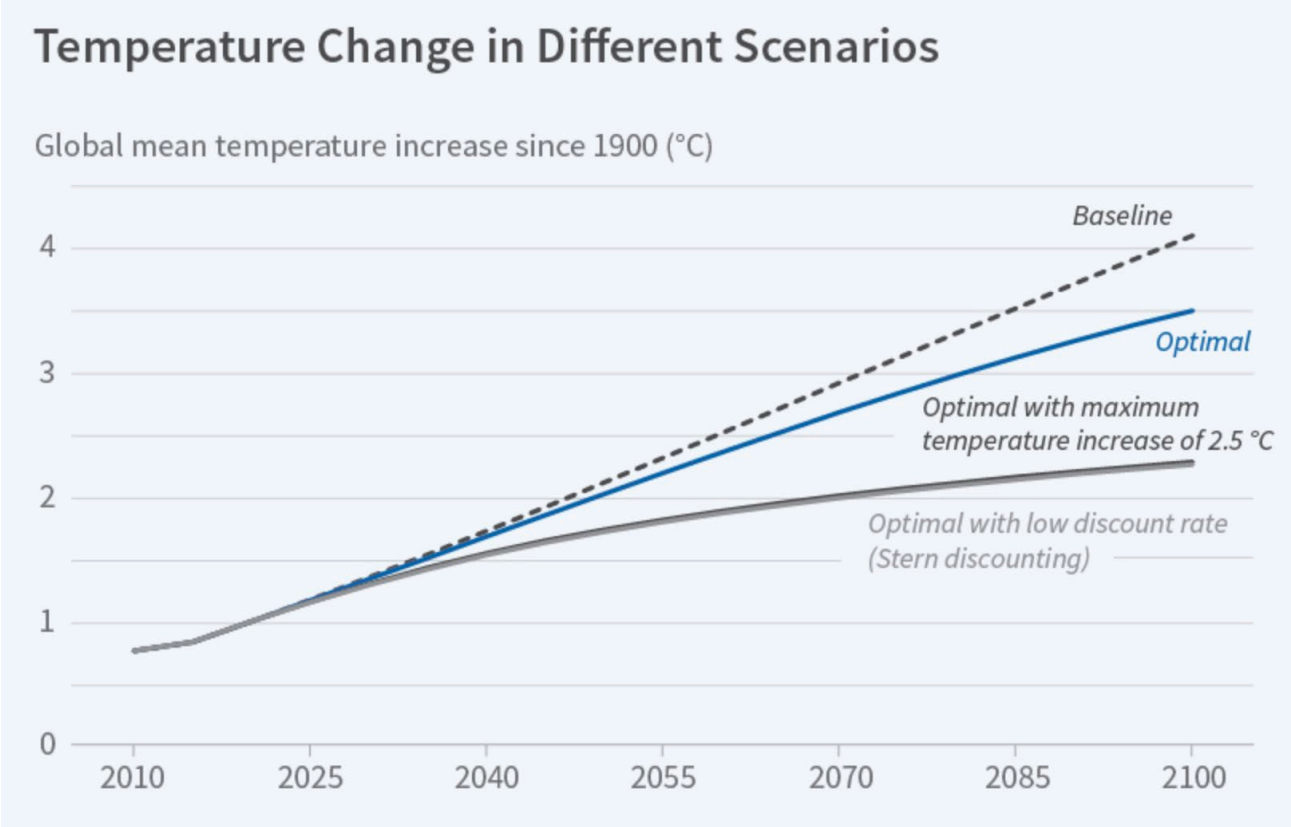
RESULTS



Source: William Nordhaus and Andrew Moffat, NBER Working Paper No. 23646

The DICE Model

RESULTS



Source: William Nordhaus and Andrew Moffat, NBER Working Paper No. 23646

Other Models

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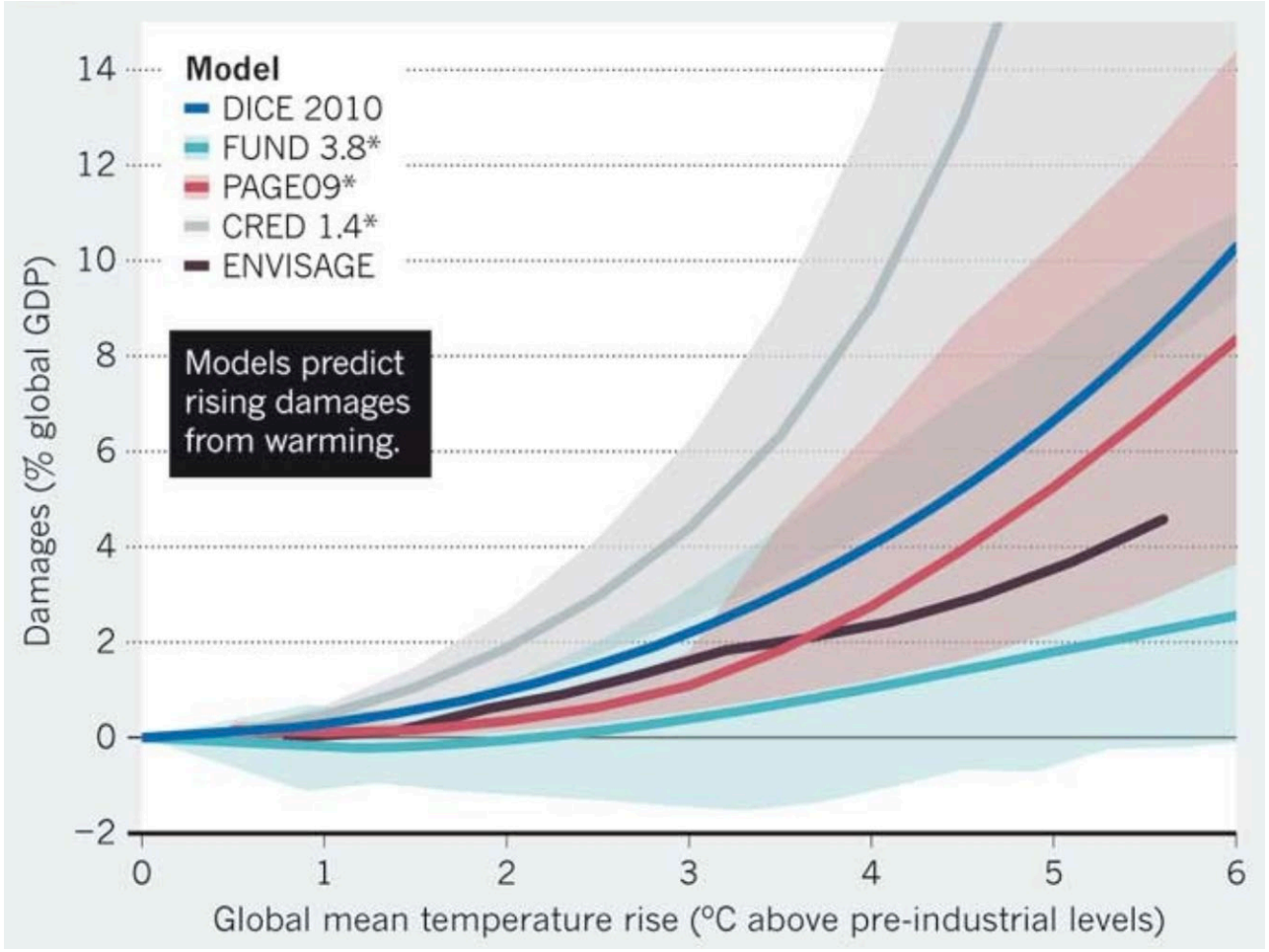
Other Models



Source: Richard Revesz et. al., Improve Economic Models of Climate Change (2014)

Criticism

- Arbitrary Inputs (discount rate, climate sensitivity)
- Damage Function
- Catastrophic Climate Outcomes
- Scientific Dishonesty
- Alternatives

Sources

Greenhouse Effect Diagram: https://oceanservice.noaa.gov/education/pd/climate/factsheets/whatgreenhouse.pdf

Global Mean Temperature Graph: https://data.giss.nasa.gov/gistemp/graphs/

CO2 Concentration Graph: https://www.esrl.noaa.gov/gmd/ccgg/trends/

Economic Impacts and Interactions: https://www.gtap.agecon.purdue.edu/resources/download/4928.pdf

Economic Impact Assessment: https://www.feem.it/m/publications_pages/201223111664NDL2012-002.pdf

Sea Level Changes: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3758961/

History of the DICE Model: https://yosemite.epa.gov/ee/epa/eerm.nsf/vwan/ee-0564-114.pdf/$file/ee-0564-114.pdf

DICE Model Structure: http://cowles.yale.edu/sites/default/files/files/pub/d20/d2057.pdf

DICE Model Results: https://www.nber.org/reporter/2017number3/nordhaus.html

Other Models: https://www.nature.com/news/global-warming-improve-economic-models-of-climate-change-1.14991

Criticism: https://www.nber.org/papers/w21097.pdf