Using Big Data to Solve Economic and Social Problems

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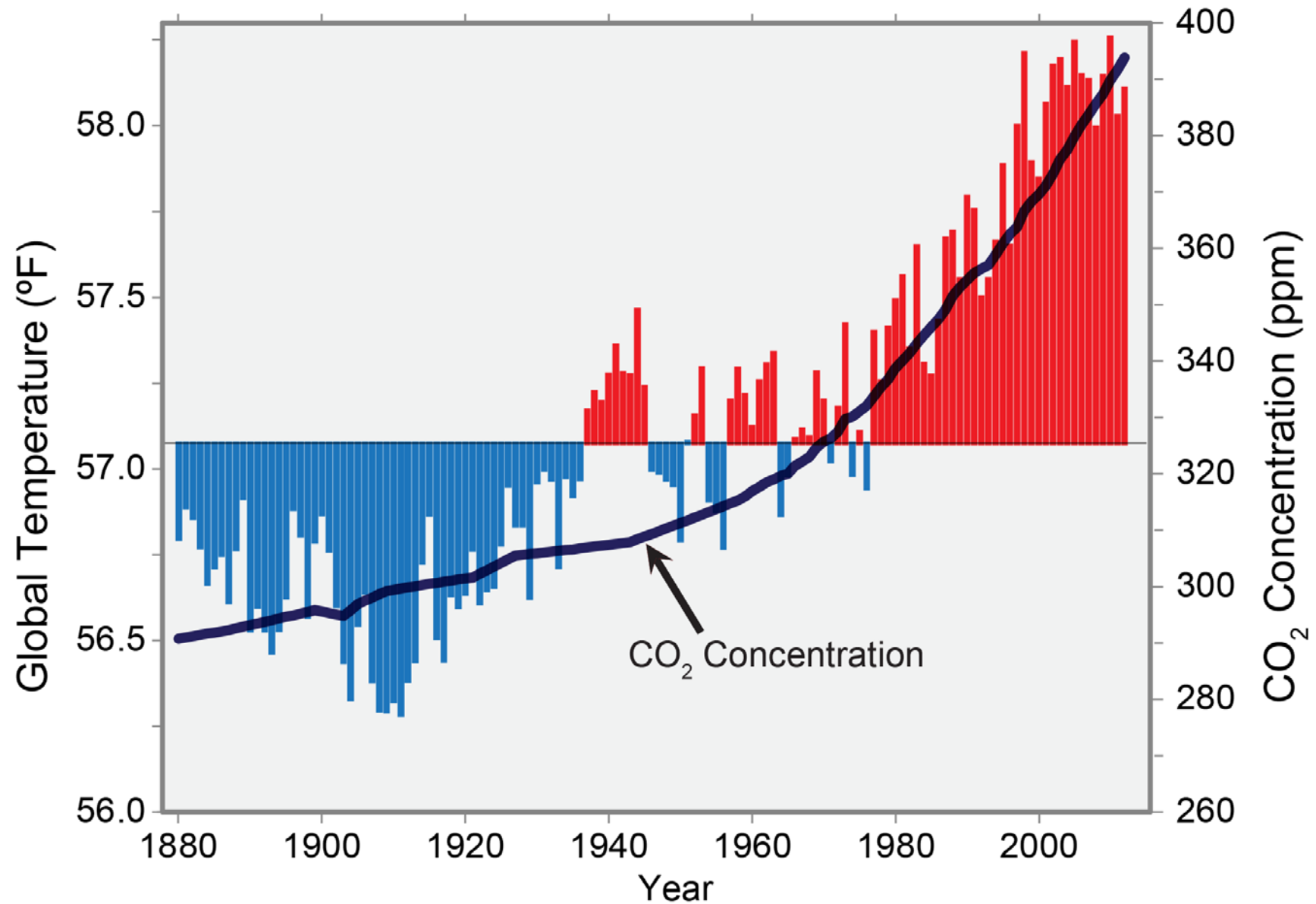
HARVARD UNIVERSITY
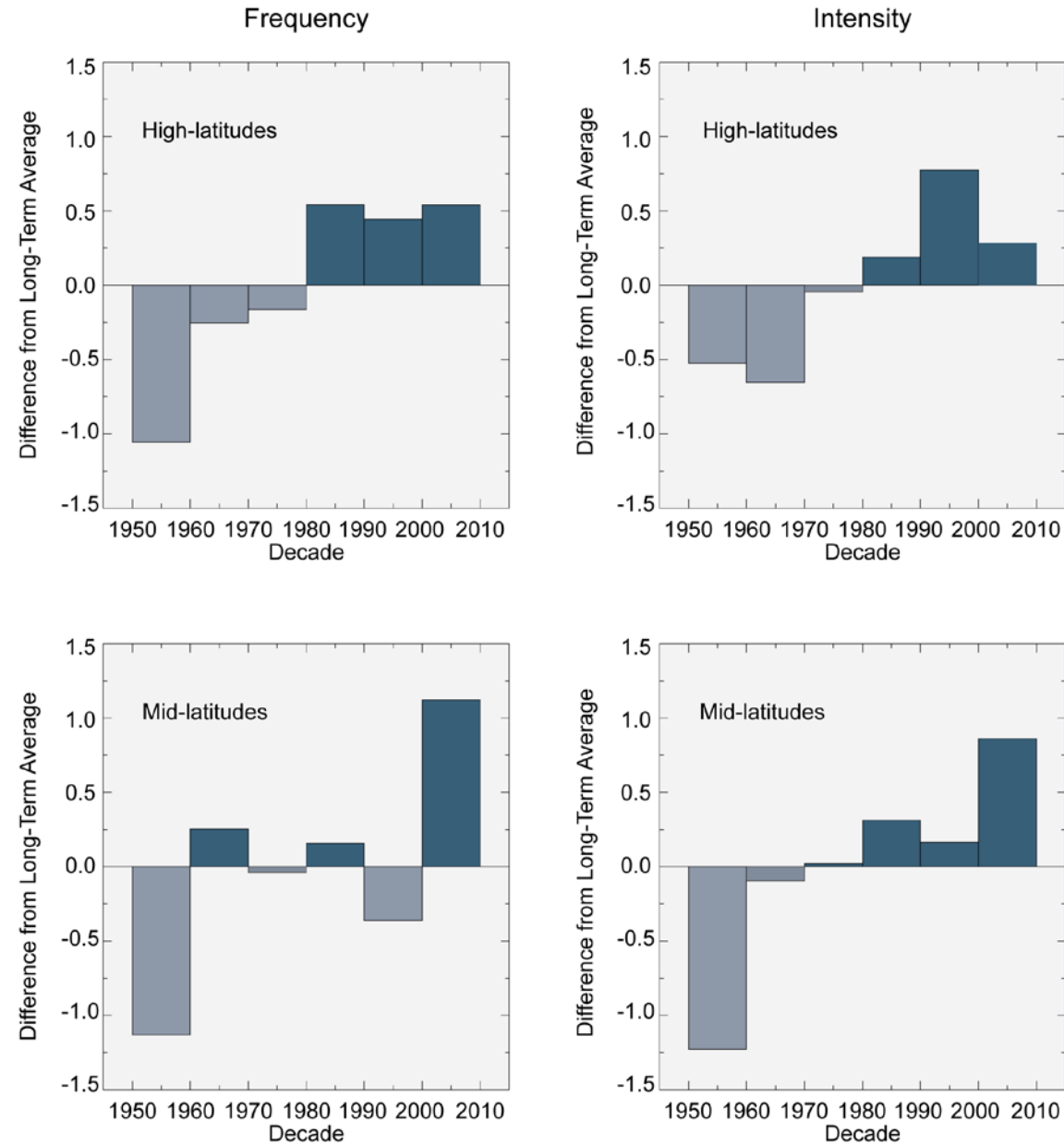
OPPORTUNITY INSIGHTS

Environmental Economics

Trends in Global Temperature and Carbon Dioxide Concentration

Source: Karl, Melillo, Peterson 2009

Trends in Frequency and Intensity of Winter Storms

Climate Change and Environmental Economics

- Idealistic response to dramatic change in climate: we should preserve environment in its original state, no matter the cost

- Environmental economists take a more practical perspective

  1. Tradeoff between economic benefits and environmental costs → need to price environmental damage created by each policy to more forward

  2. Humans have adapted in the past (e.g., using air-conditioning), mitigating costs of environmental change

Climate Change and Environmental Economics

- Example: building a new oil pipeline or permitting fracking for gas

    - These policies could have significant benefits by reducing costs of resources and effectively increasing people's incomes

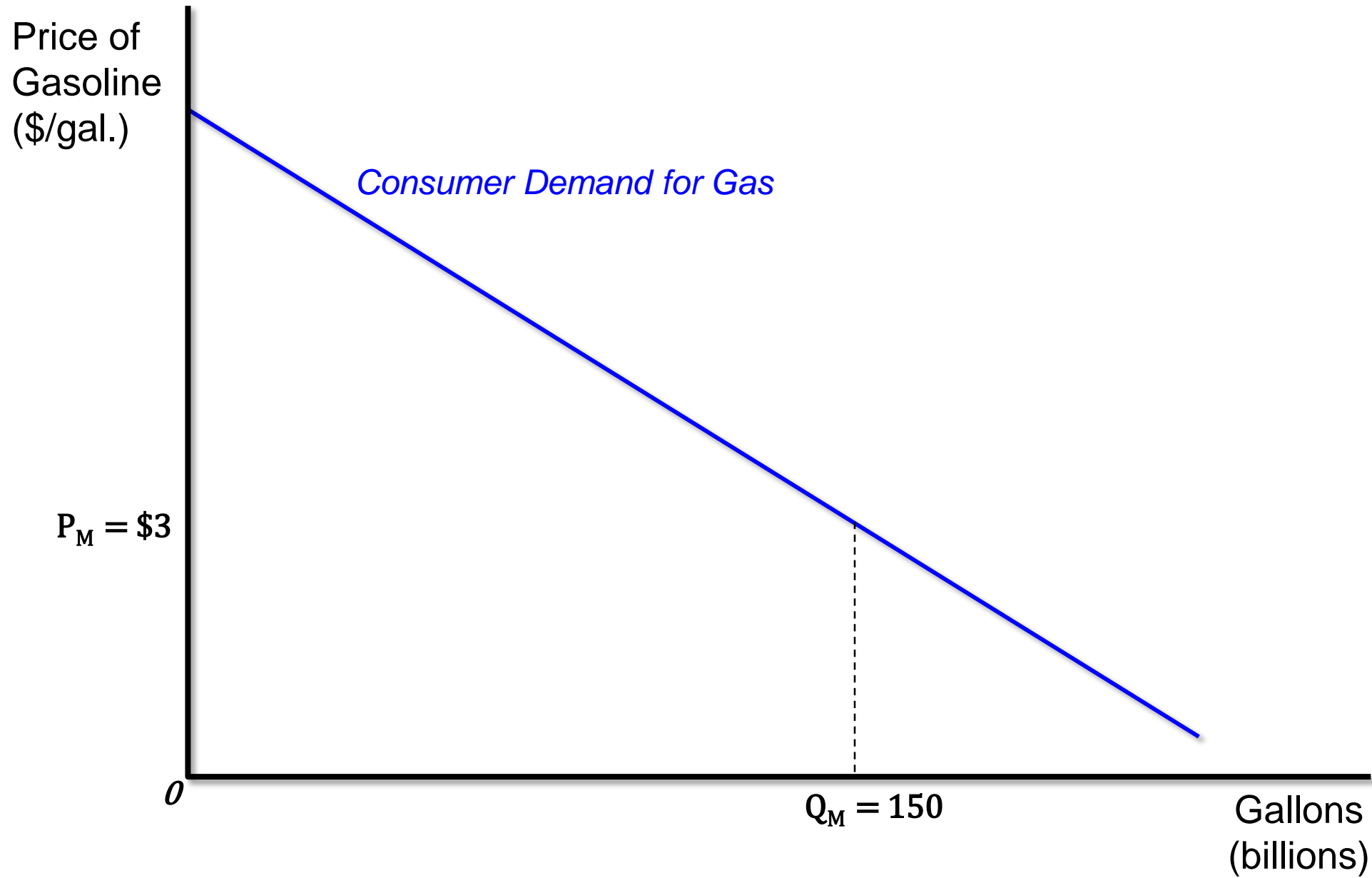   - What is the environmental damage created by these policies?

Externalities

- Environmental economics involves **externalities**

- Externality: one person's behavior directly affects another person's well-being

  - Ex: You drive a car that emits pollution → everyone pays a price

- Different from the outcomes we have considered thus far

  - Income, education, health: benefits accrue primarily to a given individual, not to others around them
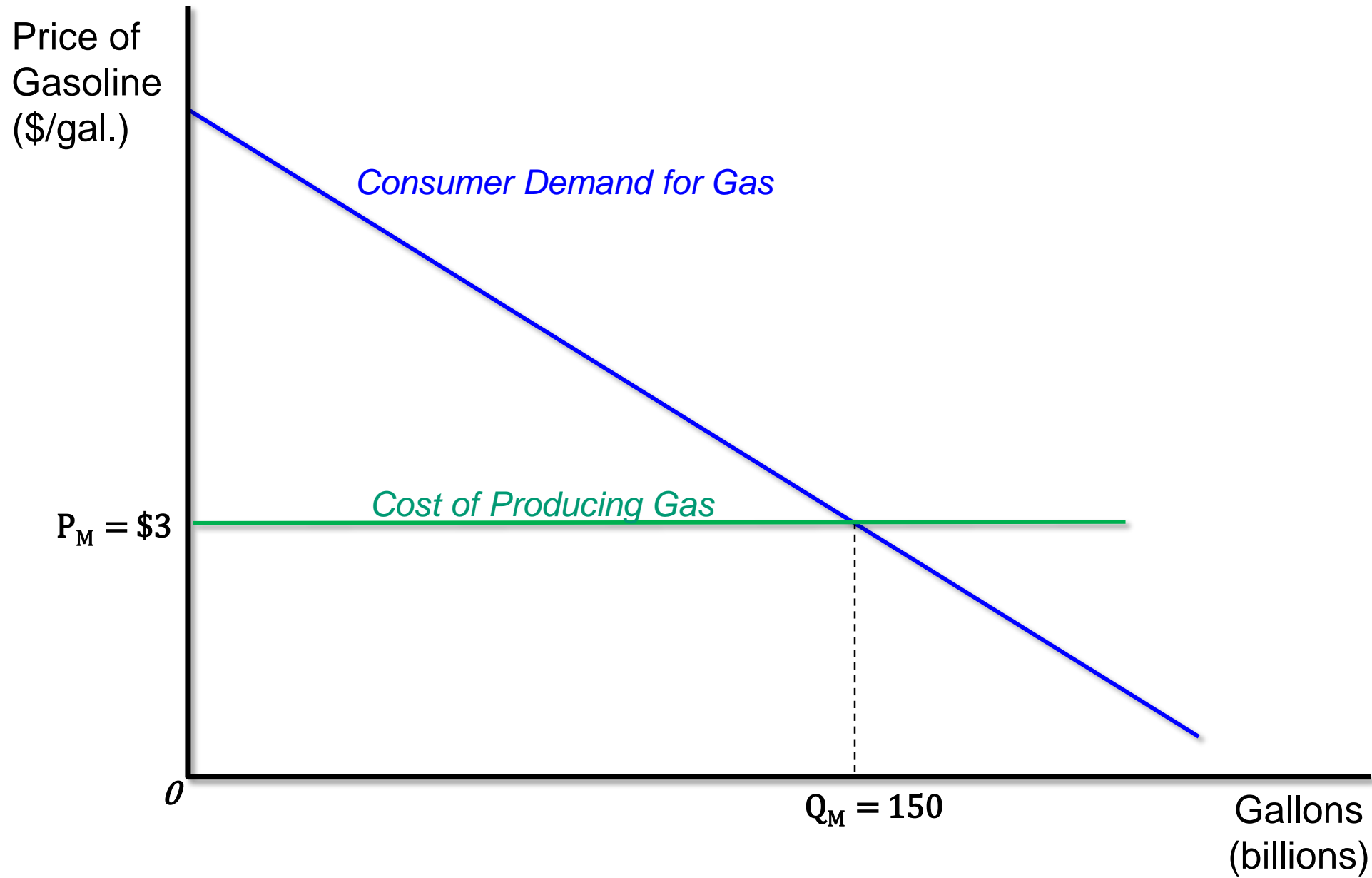
Externalities

- Tackling externalities requires different types of data and methods

- Need to measure impacts on **everyone**, not just on a given person's income or health

    - Contrast with analysis of impacts of class size on students' test scores

- Goal is to change people's behavior to move **away** from what is best for them personally

    - Contrast with college outreach programs

    - Focus on changing behavior to achieve **social** aims rather than individual benefits
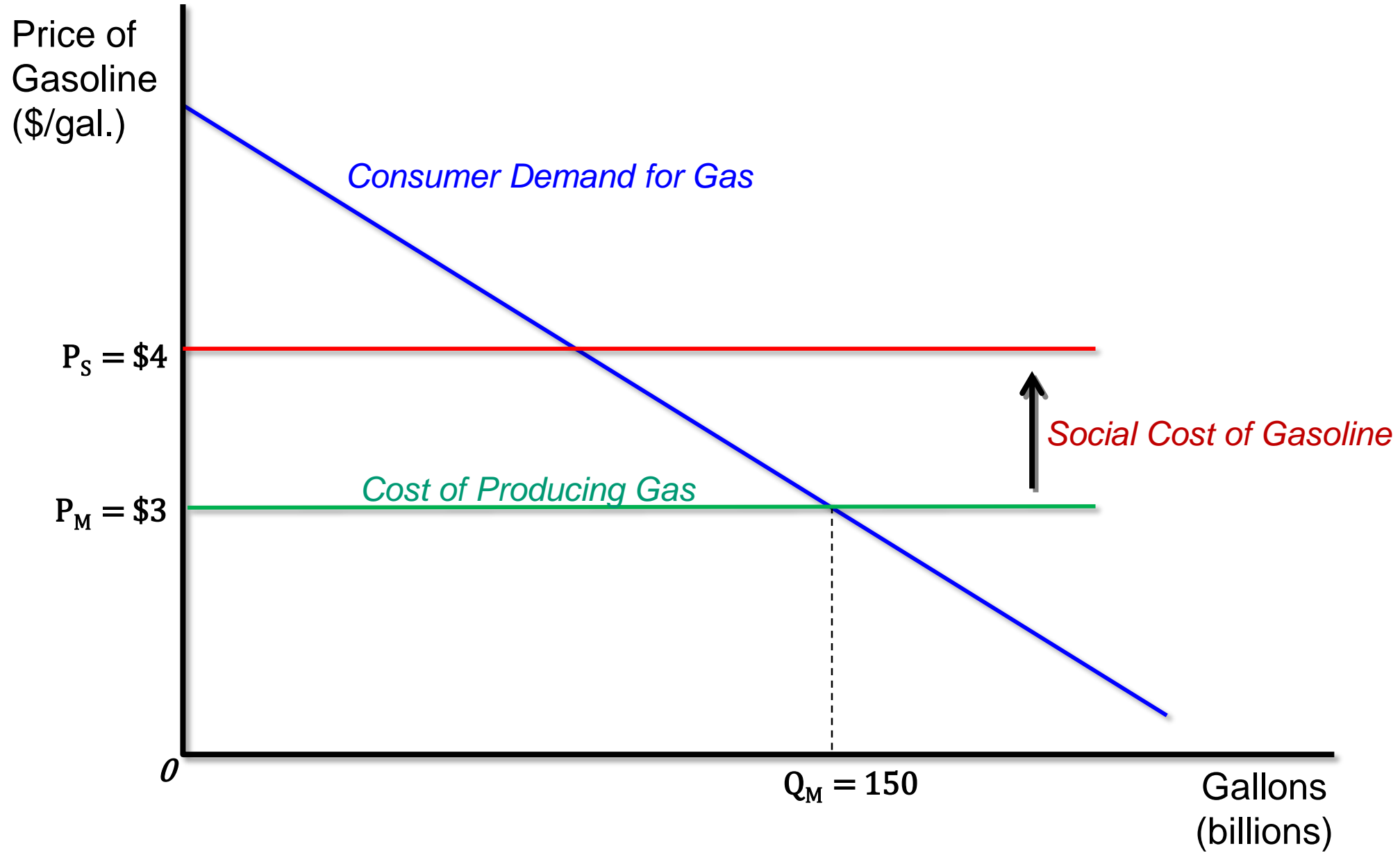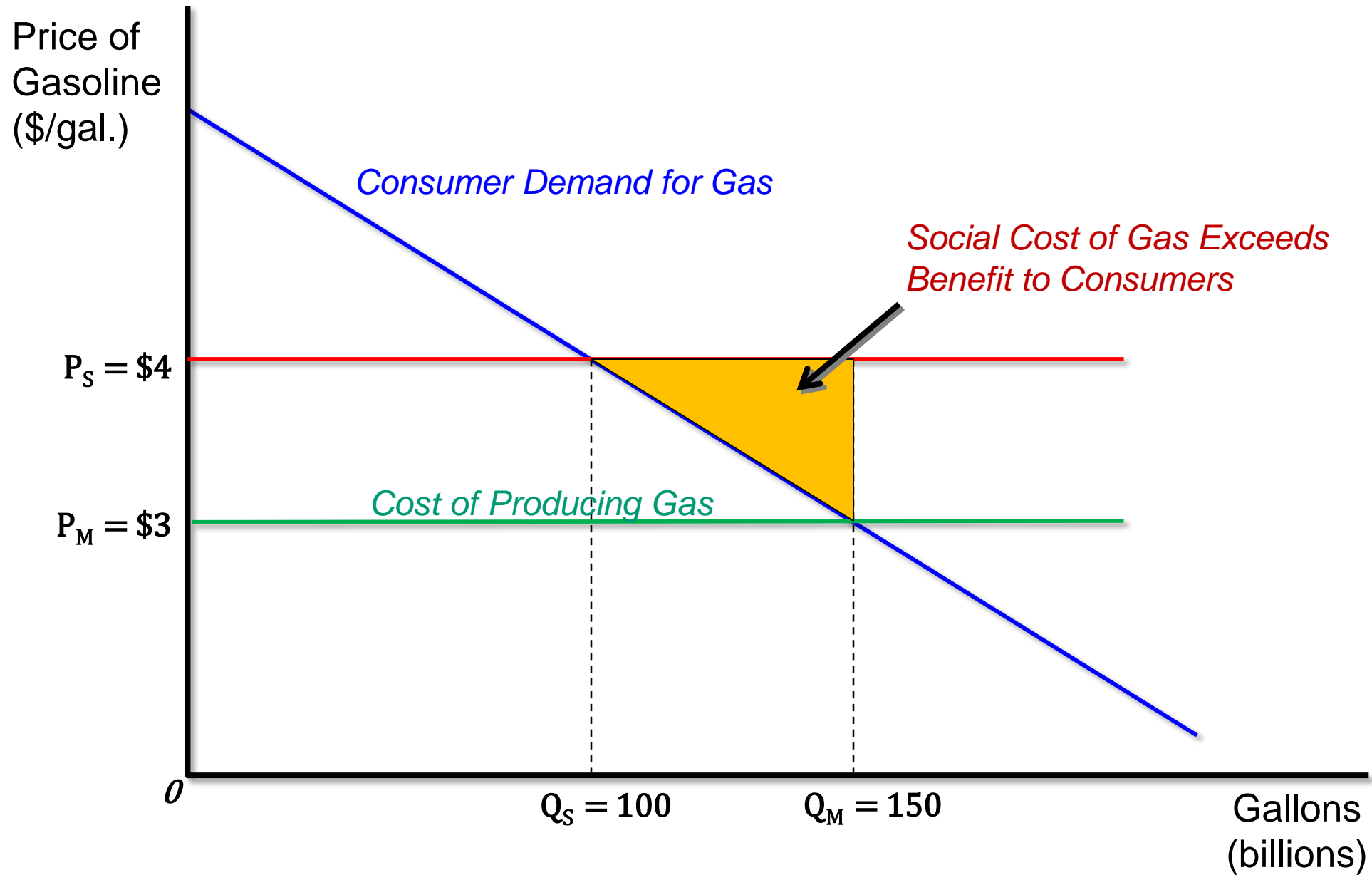
Economics of Externalities

Price of
Gasoline
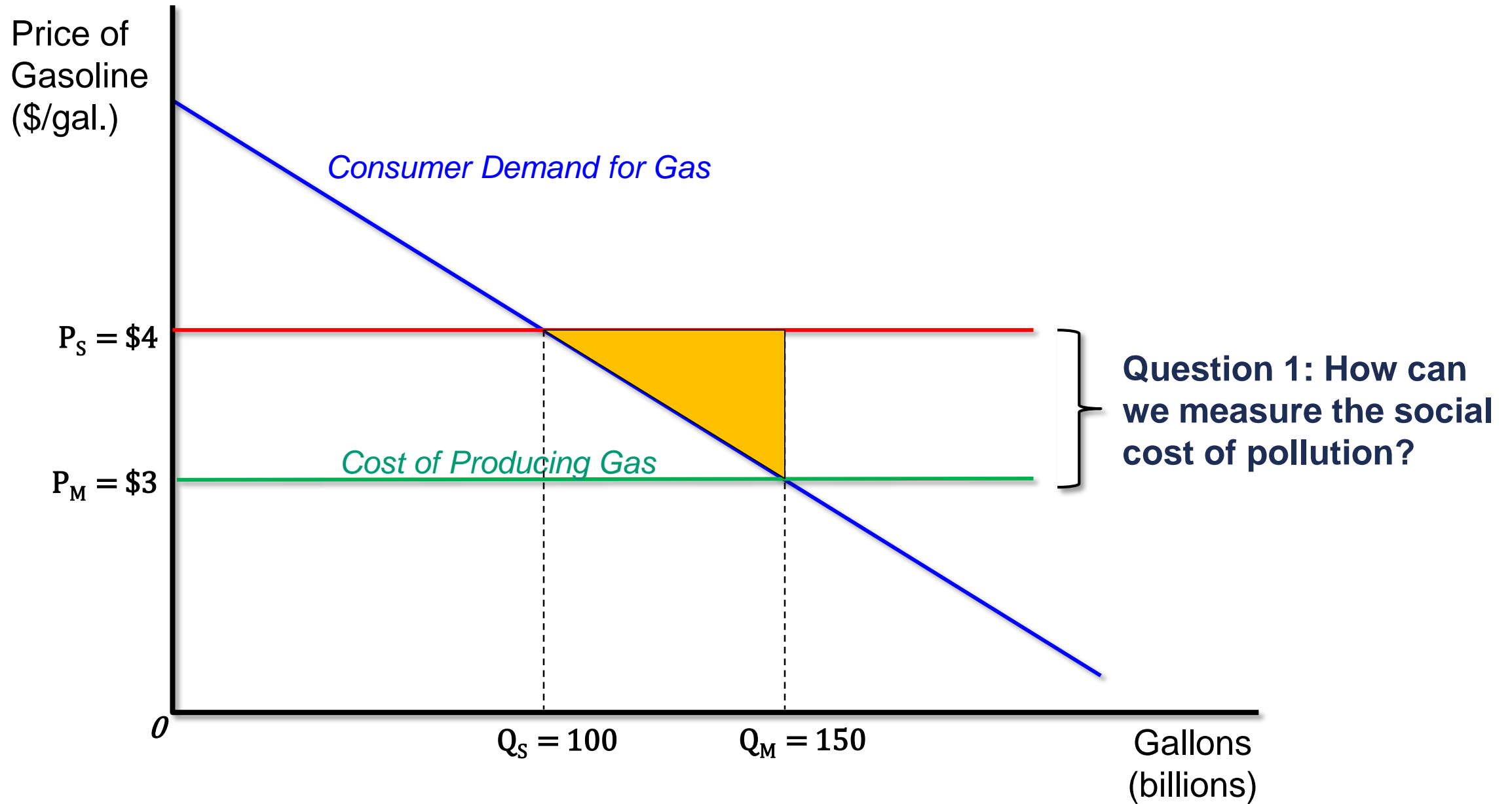($/gal.)

Consumer Demand for Gas

$P_M = \$3$

0

$Q_M = 150$

Gallons
(billions)

Economics of Externalities

Price of Gasoline ($/gal.)

Consumer Demand for Gas

$P_M = \$3$

Cost of Producing Gas

0

$Q_M = 150$

Gallons (billions)

Economics of Externalities

Price of Gasoline ($/gal.)

Consumer Demand for Gas

$P_S = \$4$

Social Cost of Gasoline

Cost of Producing Gas

$P_M = \$3$

$Q_M = 150$

Gallons (billions)

0

Economics of Externalities

Price of Gasoline ($/gal.)

Consumer Demand for Gas

Social Cost of Gas Exceeds Benefit to Consumers

$P_S = \$4$

Cost of Producing Gas

$P_M = \$3$

0

$Q_S = 100$

$Q_M = 150$

Gallons (billions)

Two Key Questions in Environmental Economics

Price of
Gasoline
($/gal.)

Consumer Demand for Gas

$P_S = \$4$

$P_M = \$3$

Cost of Producing Gas

Question 1: How can we measure the social cost of pollution?

0

$Q_S = 100$

$Q_M = 150$

Gallons
(billions)

Two Key Questions in Environmental Economics

Price of Gasoline ($/gal.)

Consumer Demand for Gas

$P_S = \$4$

Cost of Producing Gas

$P_M = \$3$

0

$Q_S = 100$ $Q_M = 150$

Gallons (billions)

Question 2: What policies can we use to reduce pollution/improve environment?

Social Costs of Climate Change and Pollution

Social Cost of Carbon

- Researchers have estimated social costs of many different types of pollution, ranging from toxic air pollution to water pollution

- Given link between CO_2 emissions and climate change, carbon emissions have received the most attention

- Governments now use estimates of "social cost of carbon" when evaluating alternative policies

- Conceptual question: how much does an additional unit of carbon emissions cost society due to environmental damage?

  - Calculating this cost is challenging and is the subject of much research

Estimating the Social Cost of Carbon

- Three general steps in estimating the social cost of carbon:

  1. Predict impact of 1 extra ton of CO_2 on climate using a climate forecasting model

  2. Measure impacts of changes in climate on economic productivity, health, property damage, etc.

  3. Calculate current social cost by converting future costs to current dollars (discounting)

- First question is the subject of research in environmental science

- Focus here on how big data is enabling social scientists to obtain better answers in steps 2 and 3

Estimating the Impacts of Climate Change

- Recent studies estimate causal impacts of climate change on many outcomes

  - Combine data on outcomes from various sources with detailed measurements of temperature from local monitors

- General approach: estimate models that relate outcomes to temperature fluctuations across days or years

  - Comparisons across time *within* areas, not comparisons across areas

  - Temperature variation random within areas → identify causal effects

  - Note that this picks up short-run effects, ignoring potential for adaptation

- Carleton and Hsiang (2016) compile results of several of these studies

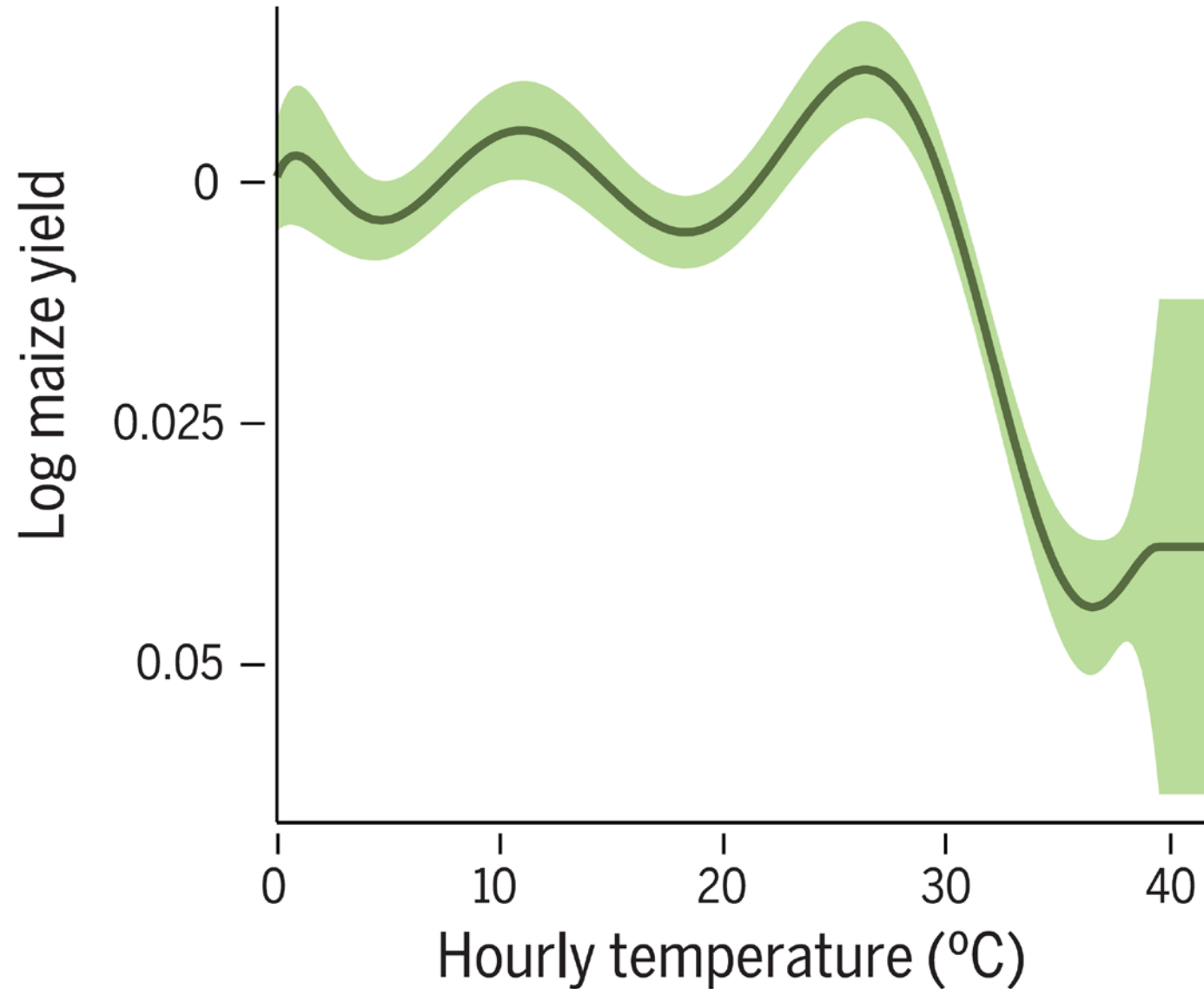Gross domestic product per capita (global)
Burke et al. (2015)

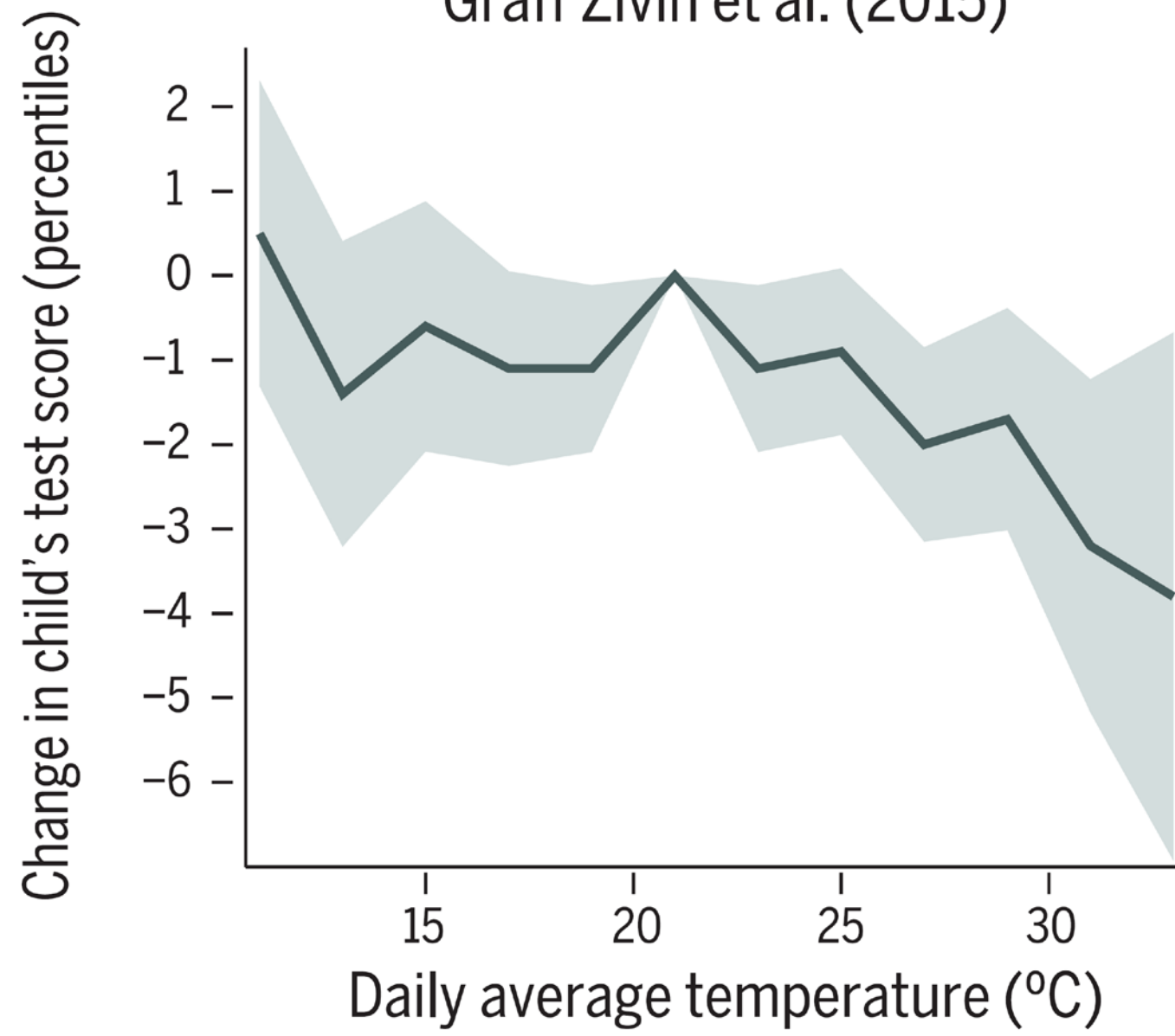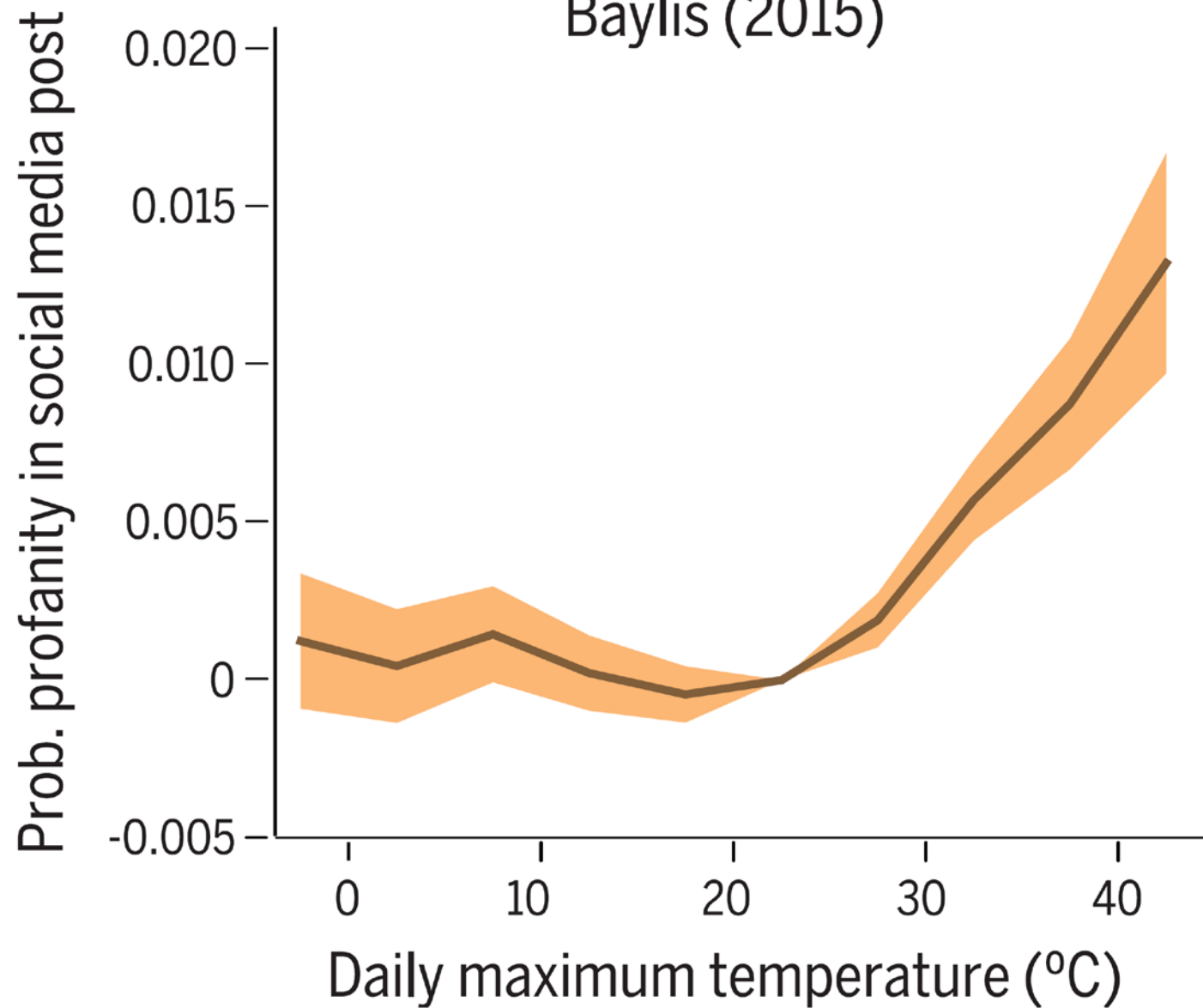Total income per capita (USA)
Deryugina & Hsiang (2014)

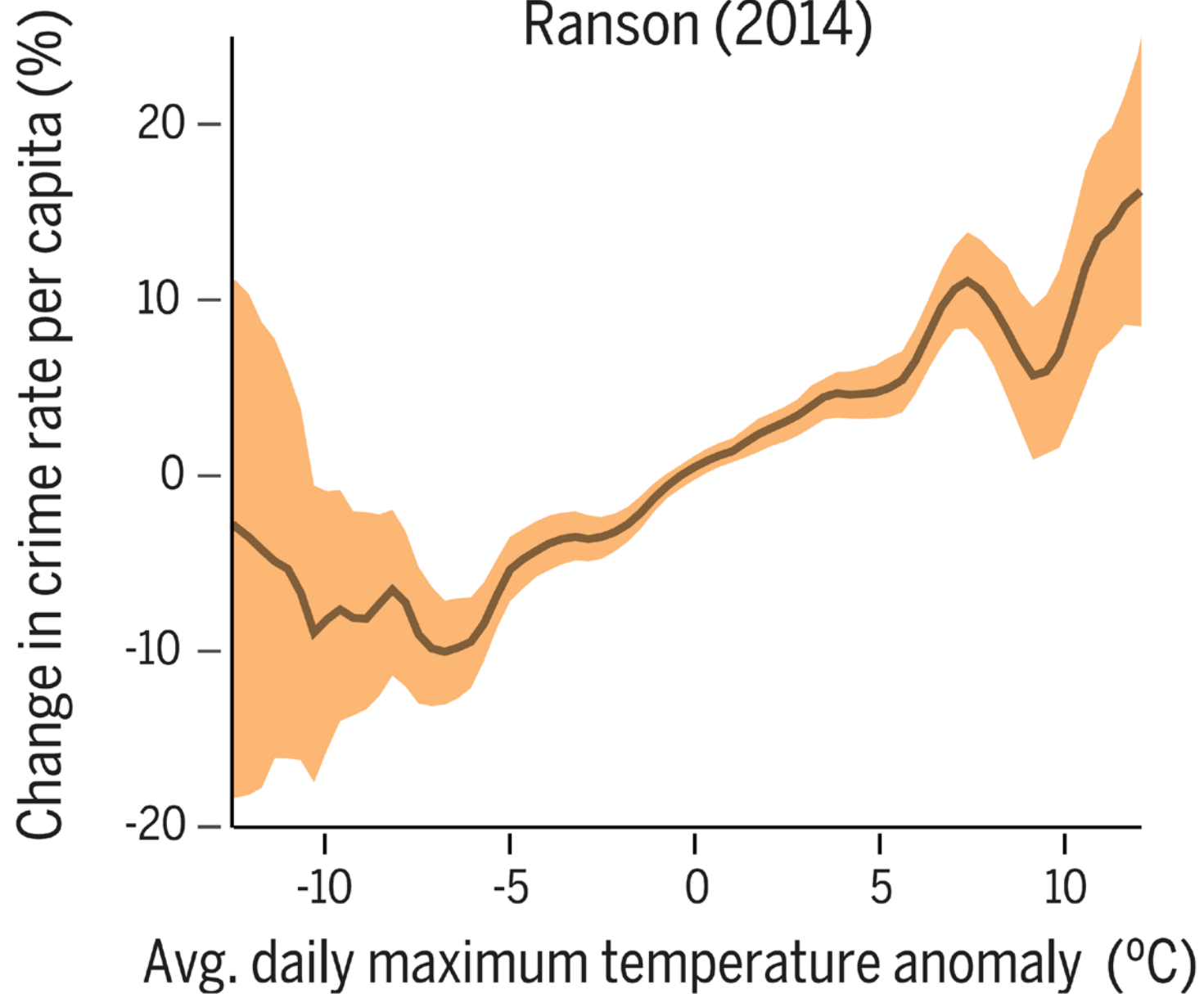Maize yields (USA)
Schlenker & Roberts (2009)

Math test scores (USA)
Graff Zivin et al. (2015)

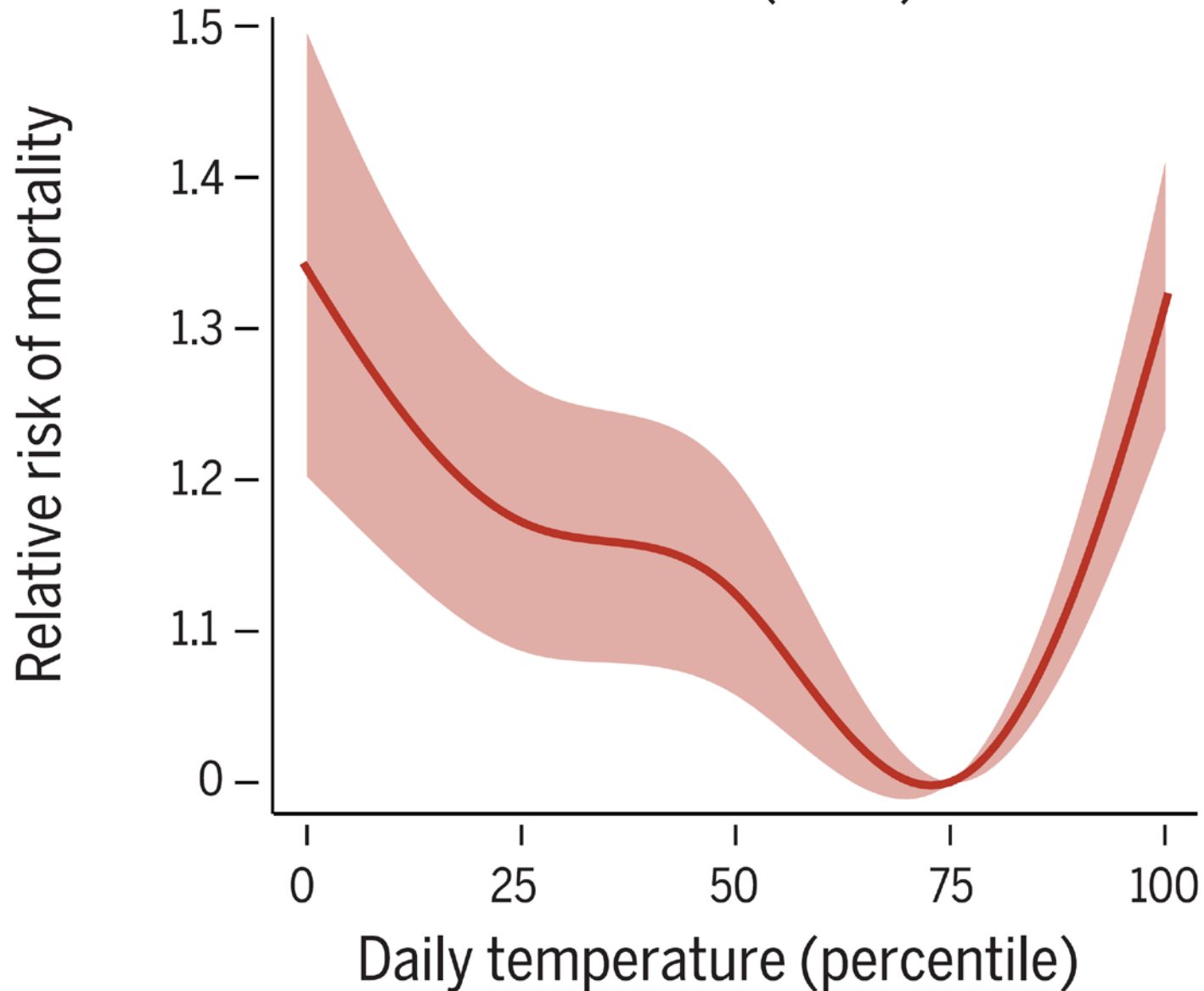Profanity in social media (USA)
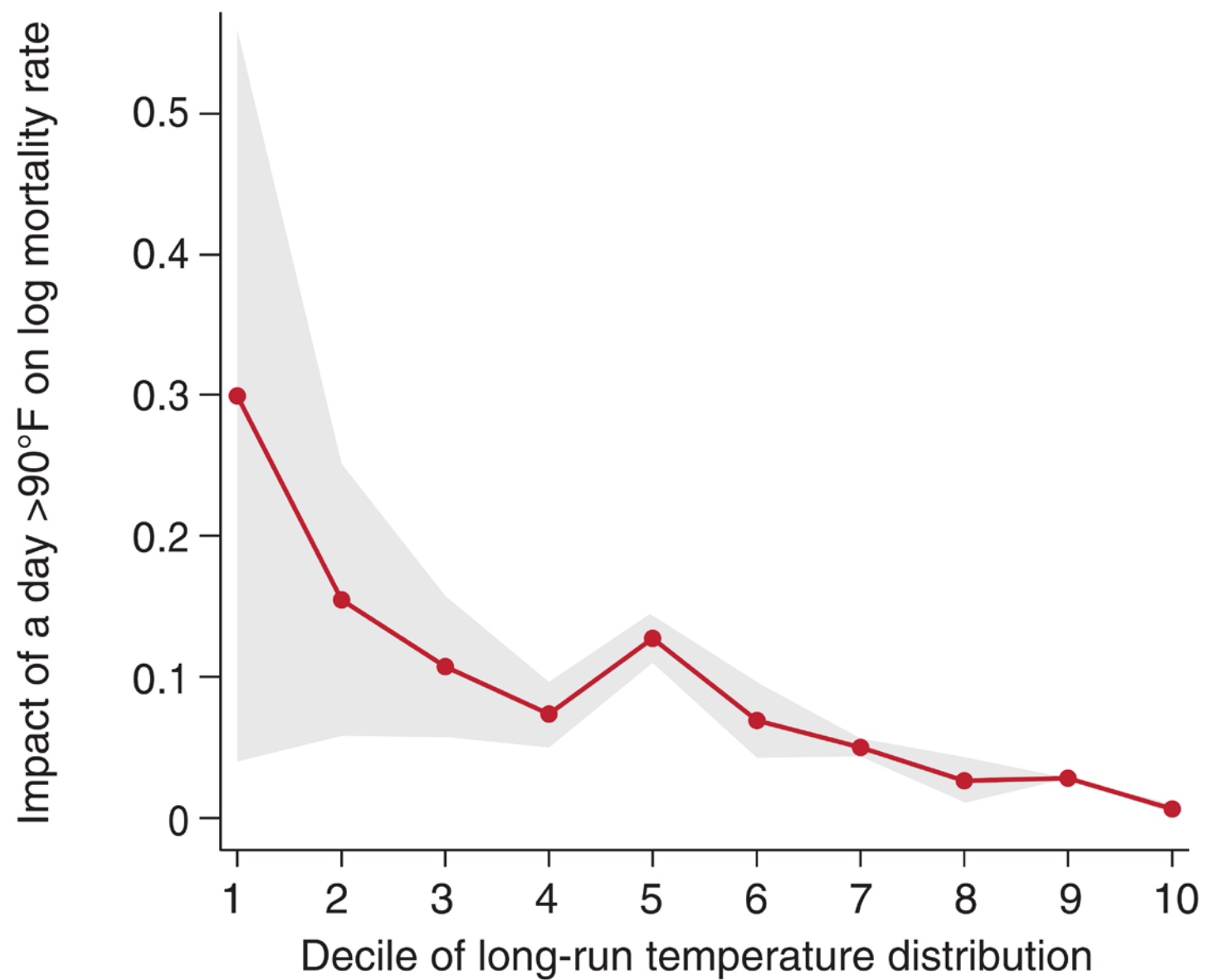Baylis (2015)

Rape (USA)
Ranson (2014)
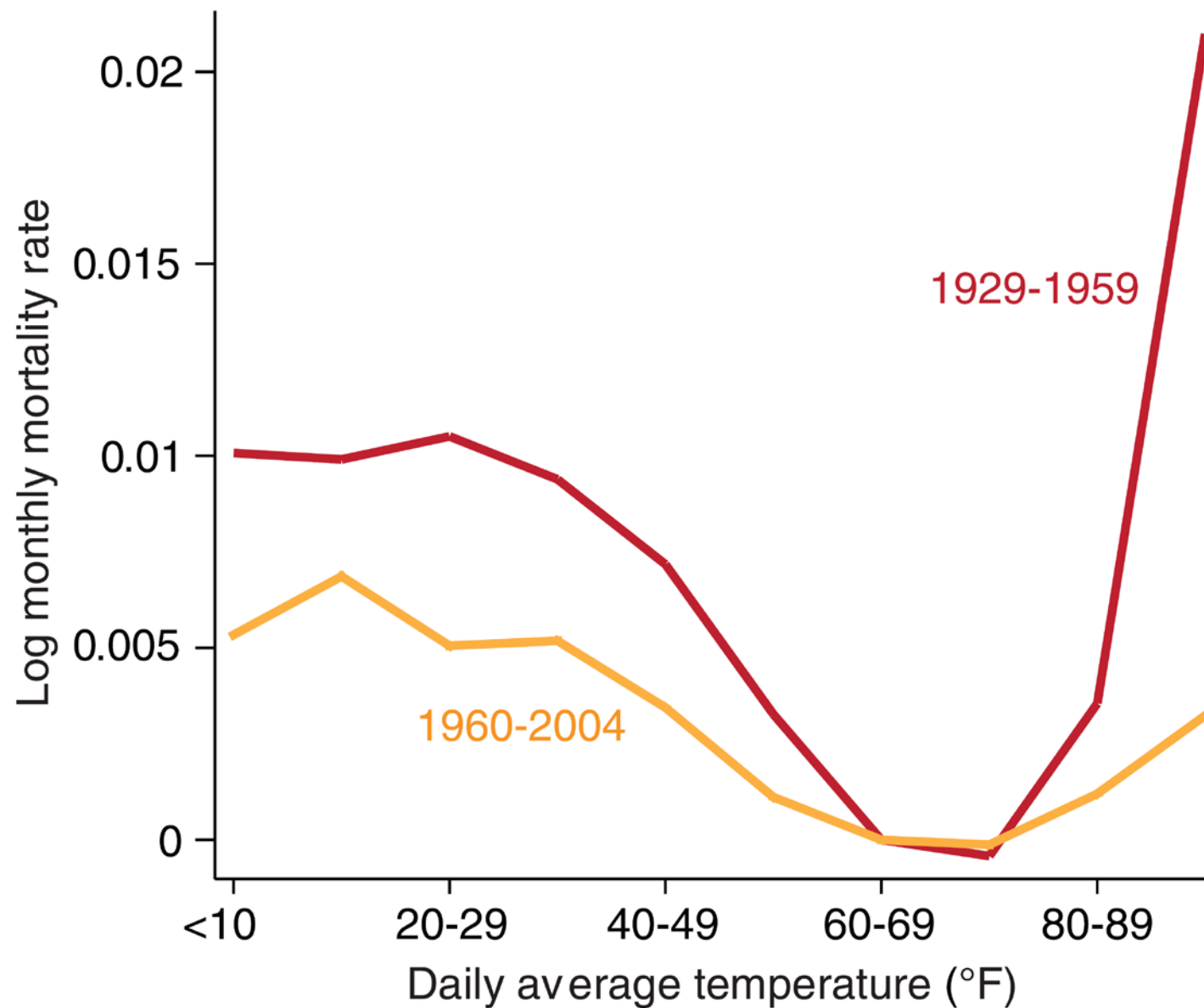
Mortality (Italy)
Guo et al. (2014)

Effects of Adaptation

- How do these short-run impacts change if society has time to adapt?

- Challenge: difficult to directly identify causal impacts of long-term trends in climate

    - Lots of other things are changing as climate changes

- Instead, compare effects of short-run changes in places that have had time to adapt vs. places that have not

    - Ex: does a heat wave have smaller effects in areas that experience heat waves regularly?

    - Do temperature fluctuations have smaller costs in advanced economies?
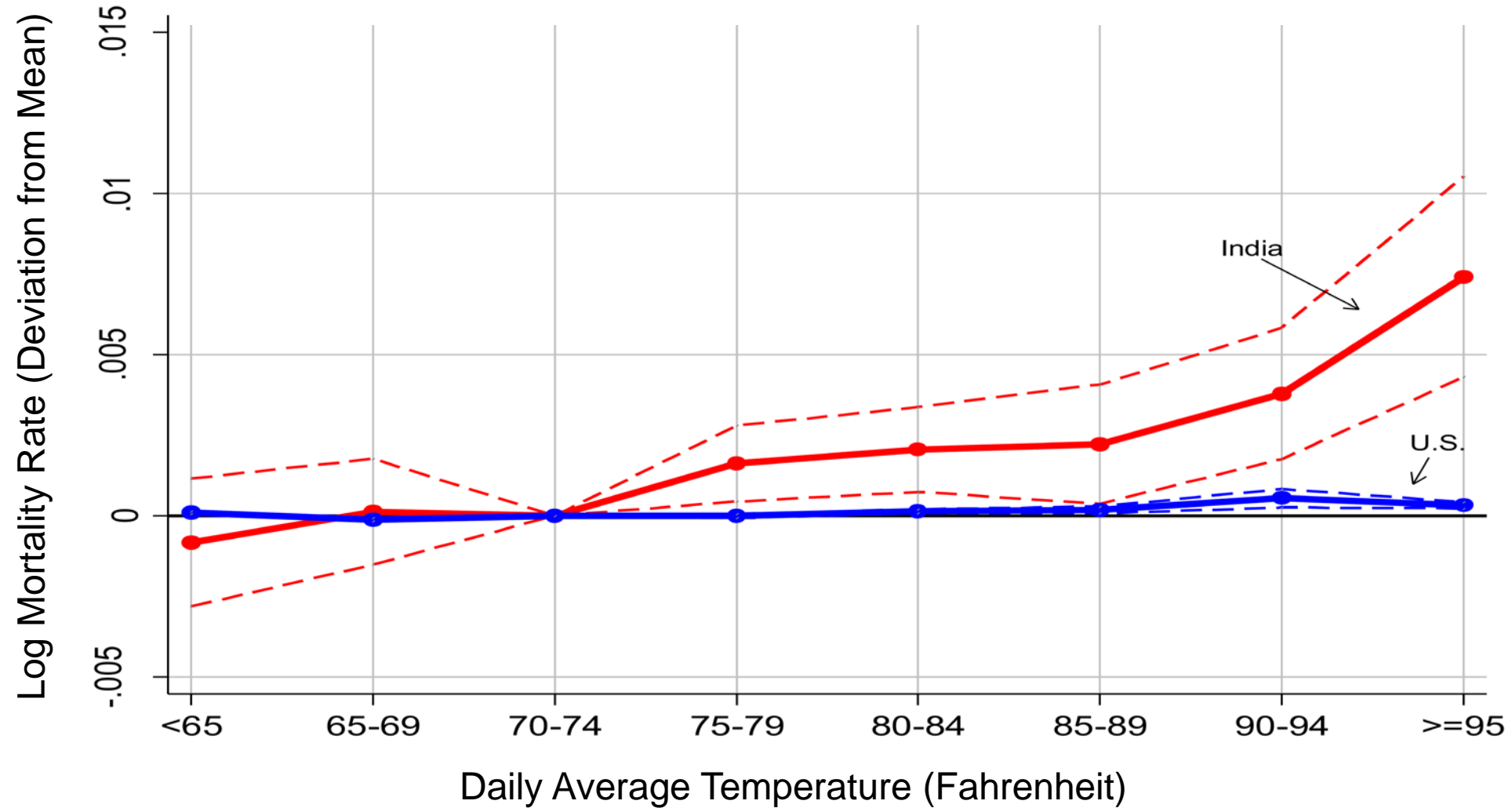
Temperature & mortality over space (USA)
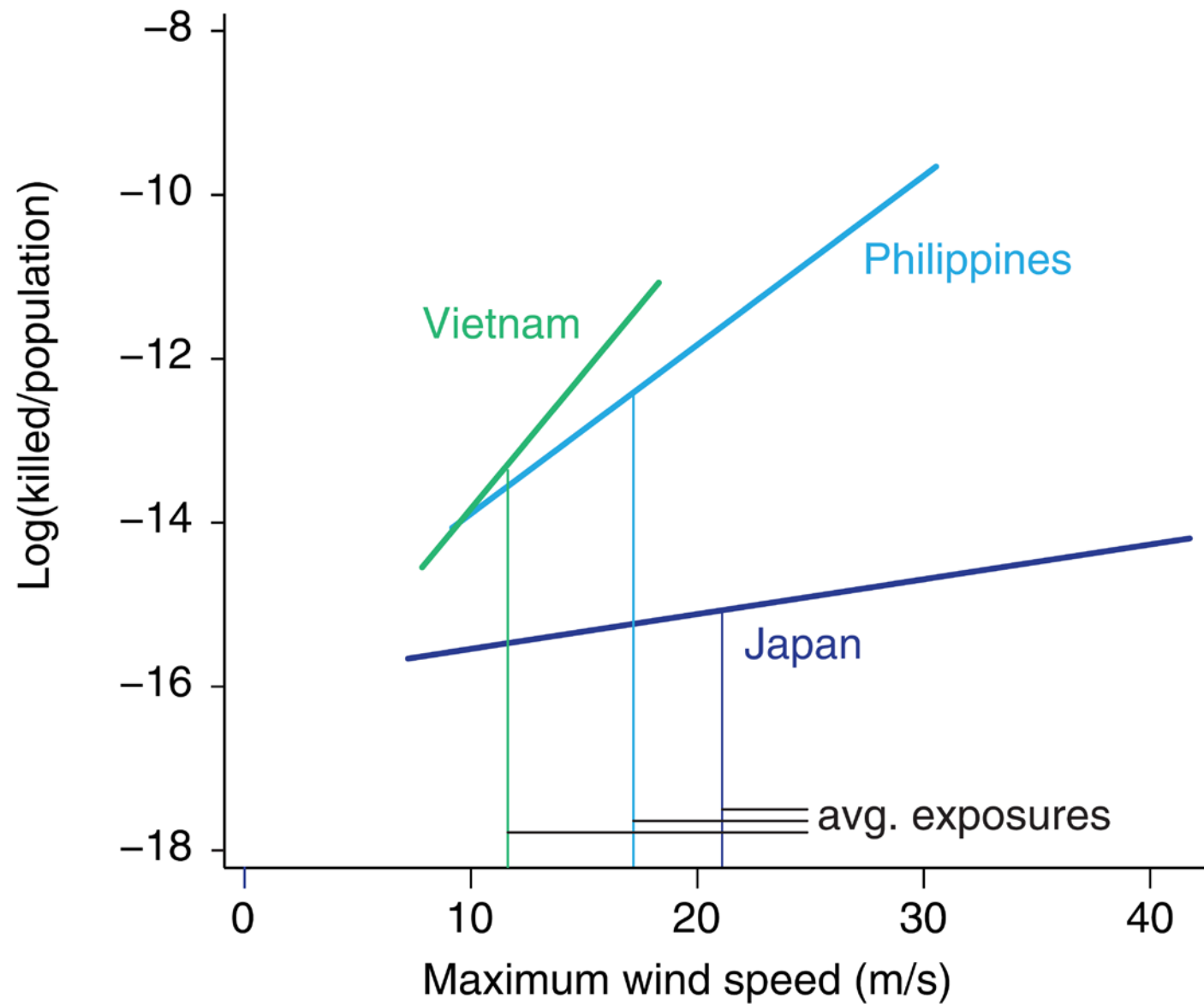Barreca et al. (2015)

Temperature & mortality through time (USA)
Barreca et al. (2016)

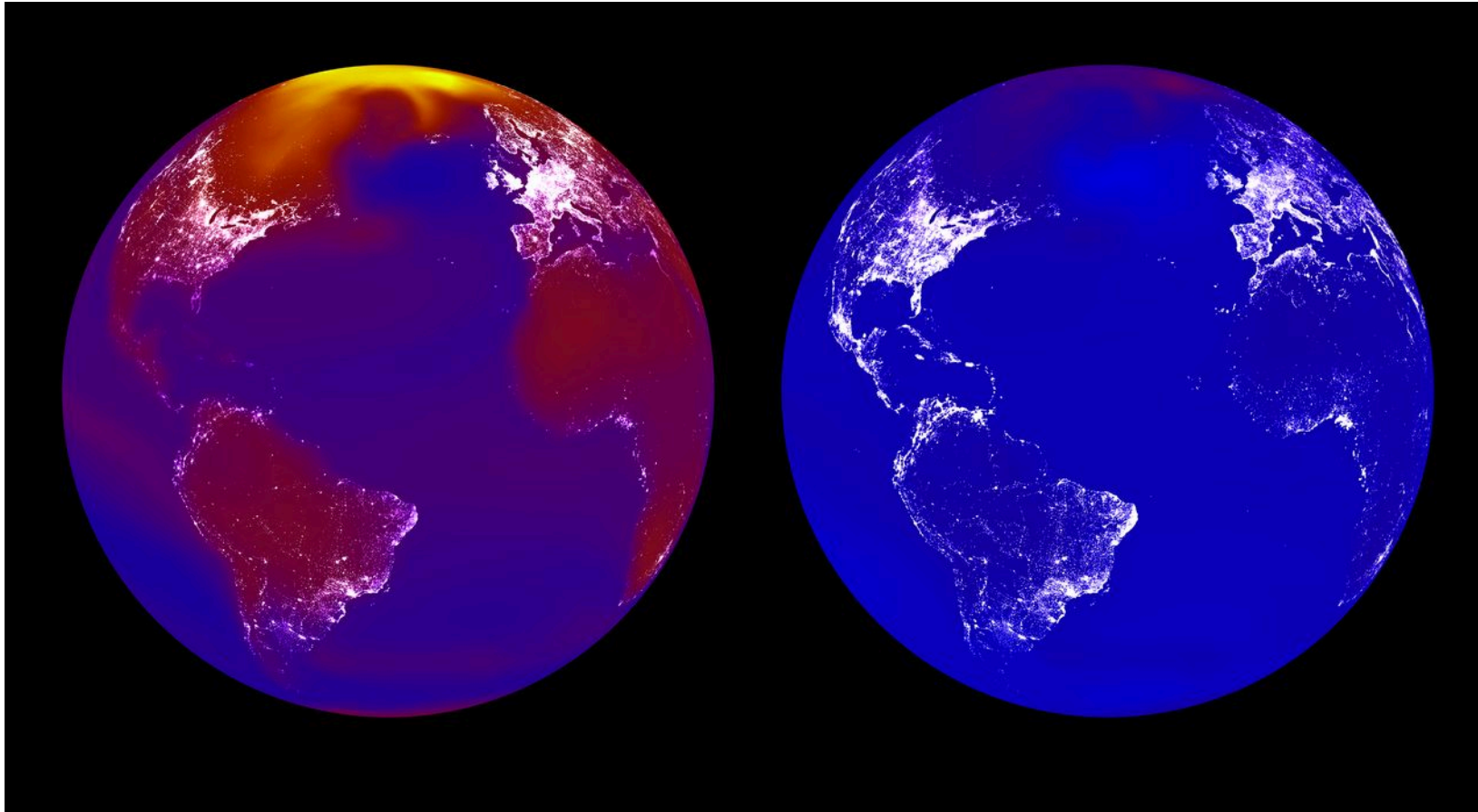Impact of Daily Temperature Fluctuations on Mortality Rates in India vs. the U.S.

Source: Burgess, Deschenes, Donaldson, Greenstone 2017

Cyclones & damage over space (Asia)
Hsiang & Narita (2012)

Estimating the Impacts of Climate Change

- Burke et al. (2015) predict that climate change by 2100 will lower global GDP by 23%

- This estimate is based on short-run fluctuations in temperature, though Burke et al. argue that long-term impacts are likely to be similar

  - No evidence that relationship between temperature and GDP has changed in recent years

- Further limitation of these measures: difficult to measure economic output systematically, especially in rural areas in developing countries

- Alternative approach: night-time light intensity, based on satellite images

Visualizing the Impacts of Climate Change Using Night-Time Light Intensity

Business as Usual   Stringent Emissions Reduction

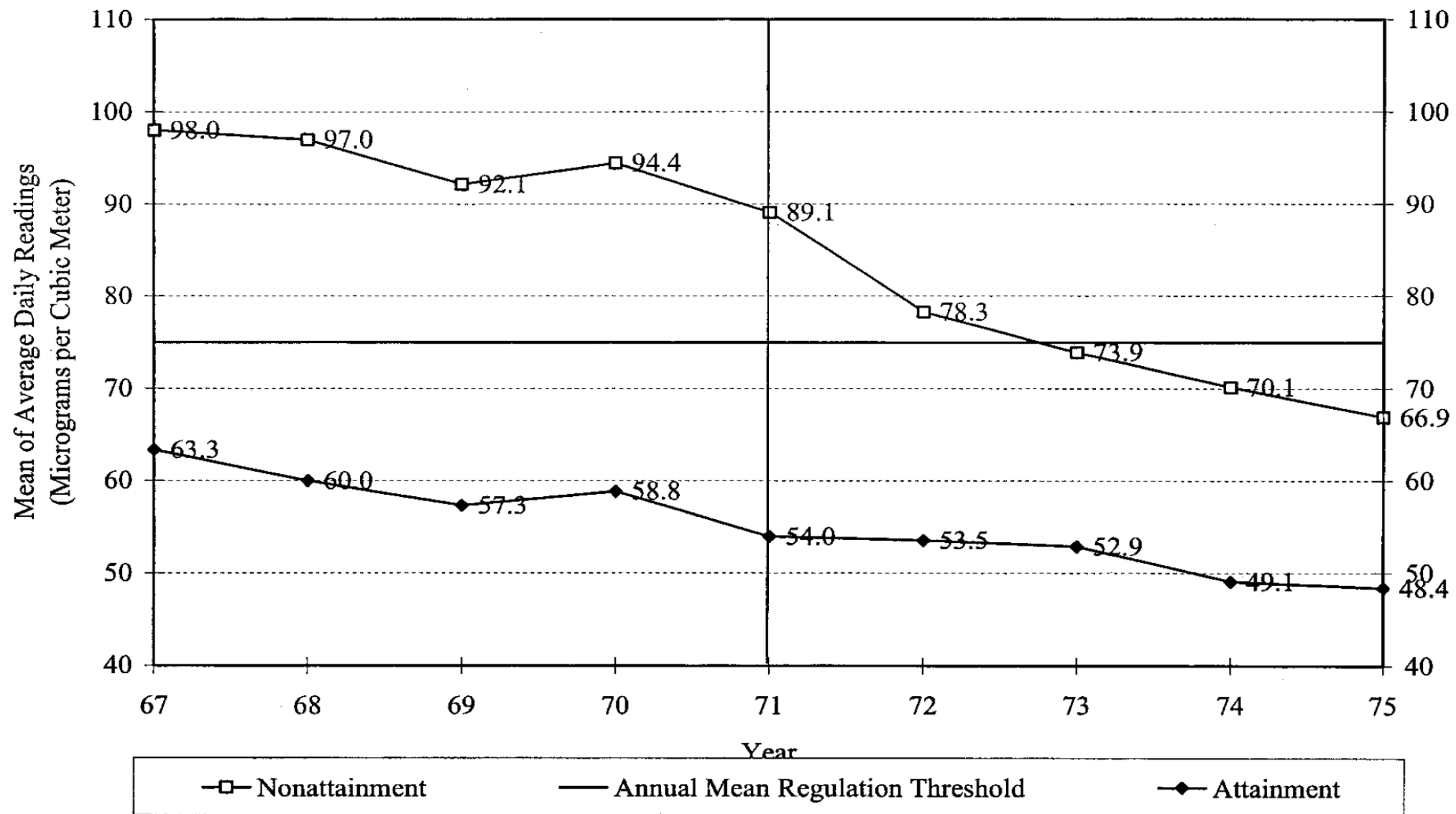Source: Carleton and Hsiang (*Science* 2016)

Impacts of Air Pollution

- Similar methods can be used to examine the impacts of other environmental damage

- Isen et al. (2014) examine impacts of air pollution on children's long-term economic outcomes

- Use administrative data from Census and tax records to examine how pollution in birthplace affects children's employment and earnings at age 30

Using the Clean Air Act to Estimate Causal Effects of Air Pollution

- Isen et al. exploit 1970 Clean Air Act to estimate causal effects of air pollution

- Clear Air Act placed a ceiling on total suspended particulates that all counties in the U.S. had to abide by

- Some counties were already below this ceiling, while others were not

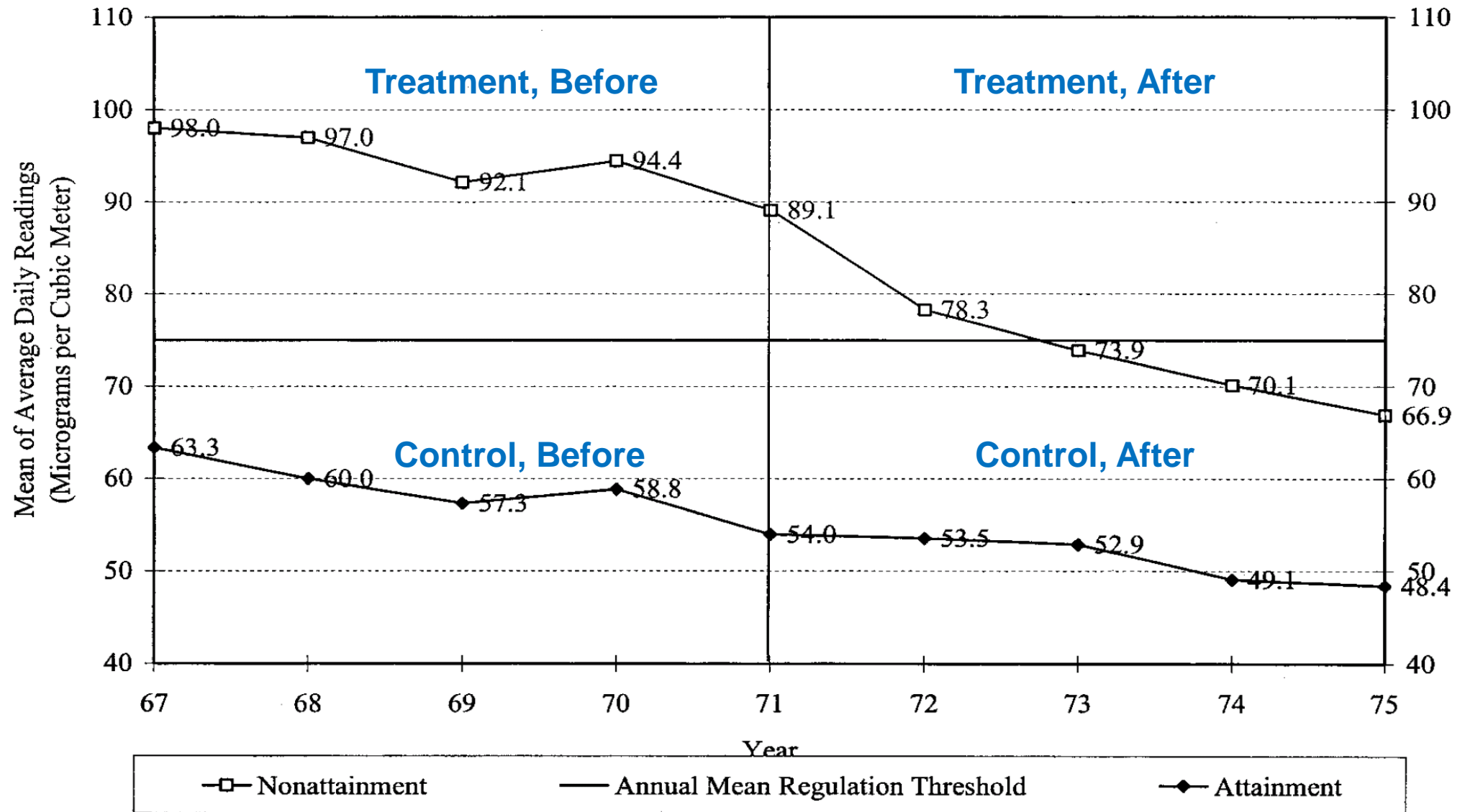- This led to differential changes in pollution across counties…

Impact of Clean Air Act on Air Pollution (Total Suspended Particulates)

Source: Chay and Greenstone 2005

Difference-in-Differences Quasi-Experimental Methodology

- Exploit differential changes in pollution across counties to implement a **differences-in-differences** quasi-experimental research design

- Idea of diff-in-diff: approximate experiment by comparing an area that experienced a change ("treatment") with an area that did not ("control")

- Compare *differences* in outcomes in treatment area vs. control area, before vs. after policy change
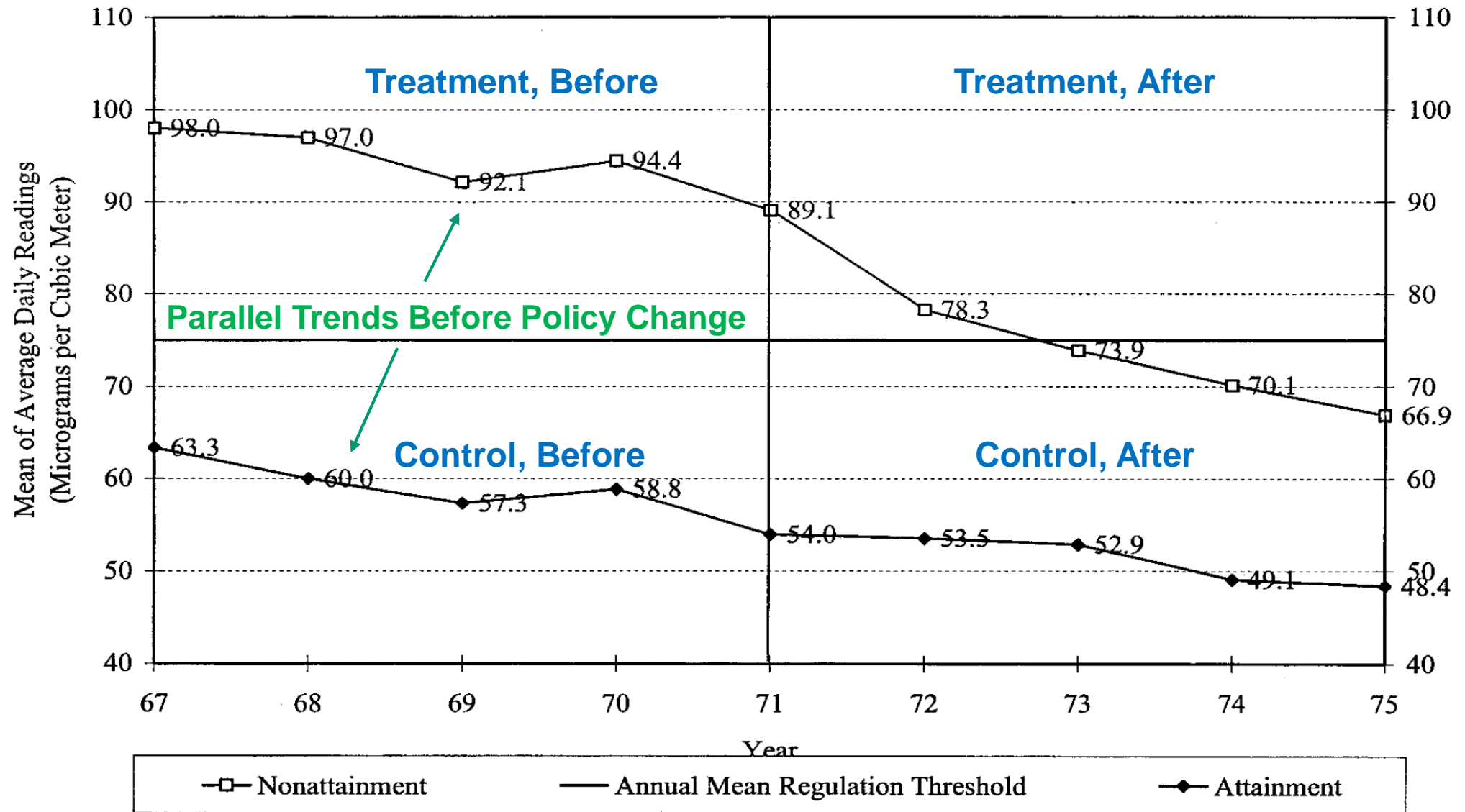
Impact of Clean Air Act on Air Pollution (Total Suspended Particulates)

Source: Chay and Greenstone 2005

Diff in Diff Estimate = (TA – TB) – (CA – CB)

Difference-in-Differences Quasi-Experimental Methodology

- Diff-in-diff avoids biases that can arise from comparing different types of places or simply examining changes over time in a single place

- Key identification assumption to make diff-in-diff as good as an experiment: **parallel trends**

    - Absent the policy reform, outcomes would have changed similarly across the two types of areas

    - Does not necessarily have to hold, but can be evaluated by examining data *before* the policy change

Impact of Clean Air Act on Air Pollution (Total Suspended Particulates)

Source: Chay and Greenstone 2005

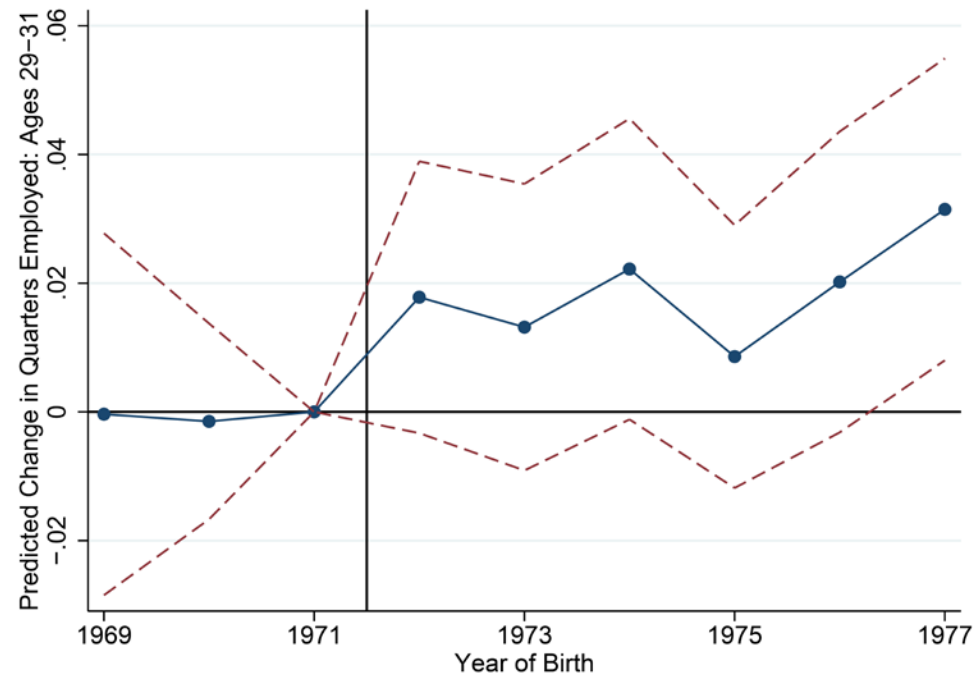**Diff in Diff Estimate = (TA − TB) − (CA − CB)**
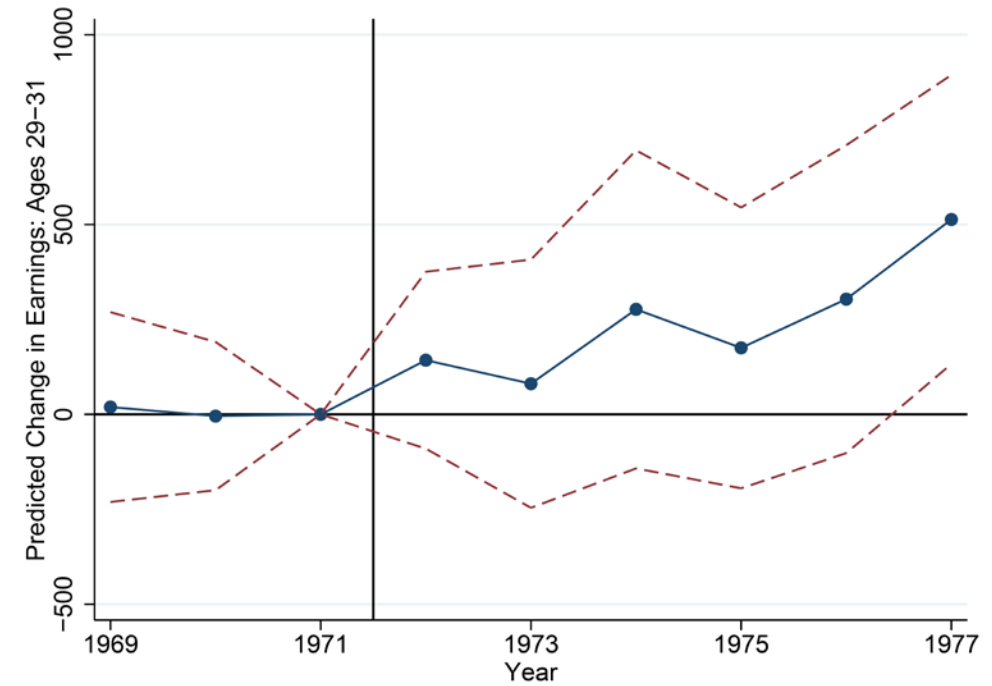
Effects of Pollution on Economic Outcomes

- Isen et al. examine economic outcomes at age 30 vs. year of birth using this approach

- Plot *difference* between outcomes in treated and control areas vs. birth cohort

Impact of Clean Air Act on Children's Economic Outcomes at Ages 29-31

(a) Quarters Worked

(b) Earnings

Impacts of Air Pollution: Summary

- Reduction in pollution in non-attainment counties increased children's earnings by about 1%

- Implies that total gain in earnings was about $6.5 billion per birth cohort

- Excludes other potential gains that may have accrued to society, but shows that benefits were quite substantial even purely in terms of earnings