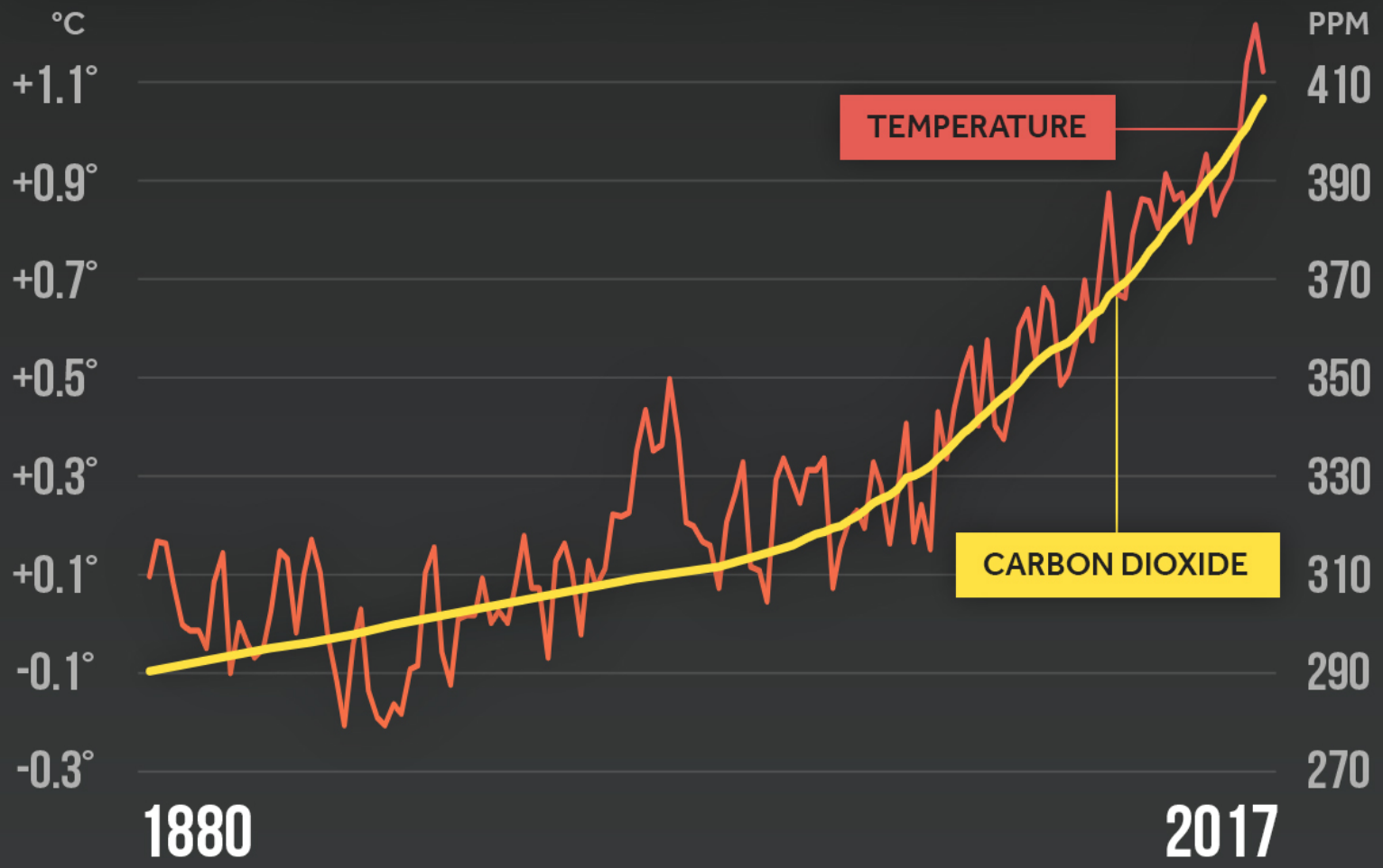
# GLOBAL TEMPERATURE & CARBON DIOXIDE

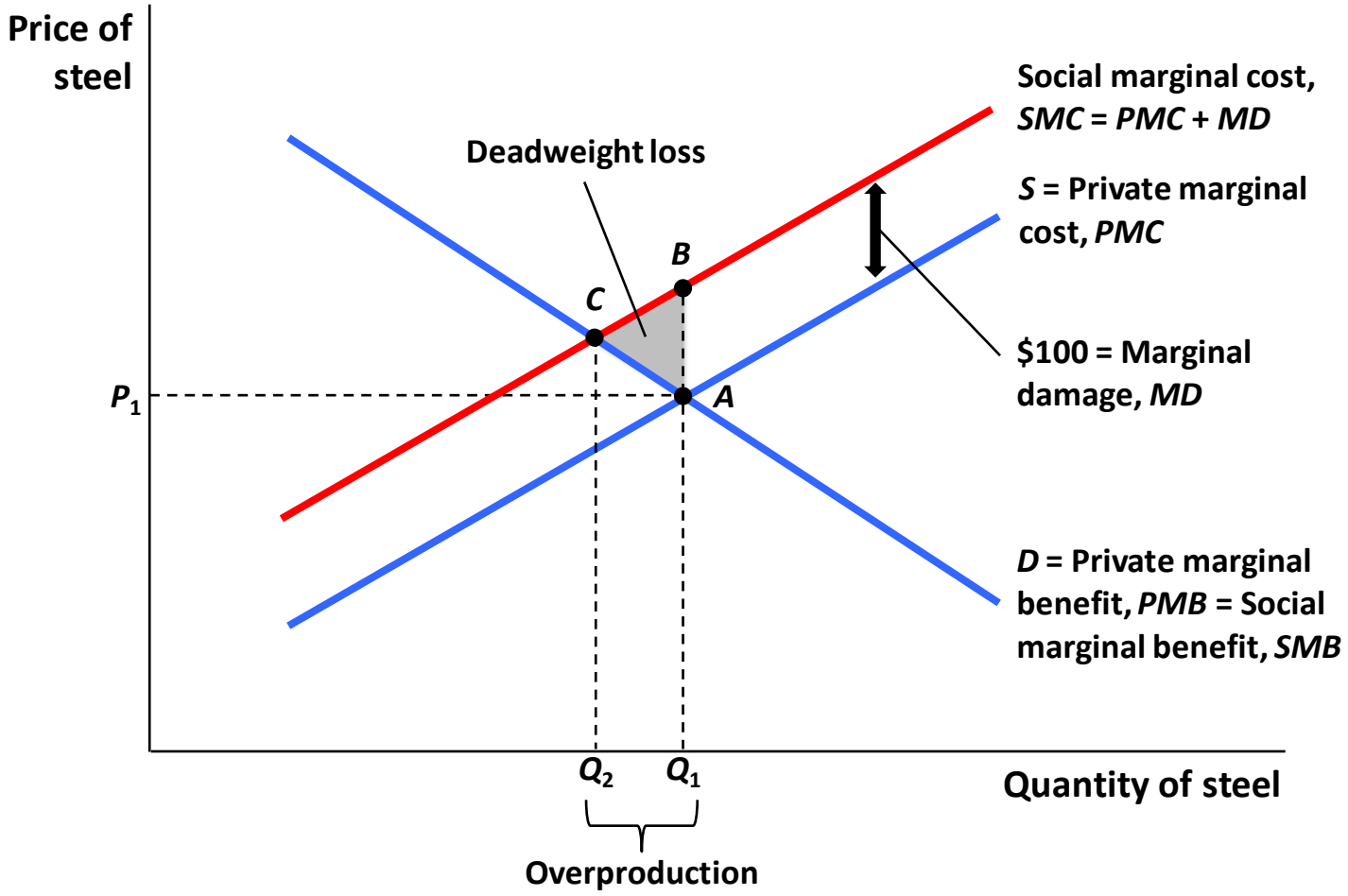



Global temperature anomalies averaged and adjusted to early industrial baseline (1881-1910)
Source: NASA GISS, NOAA NCEI, ESRL

CLIMATE CENTRAL

5.1

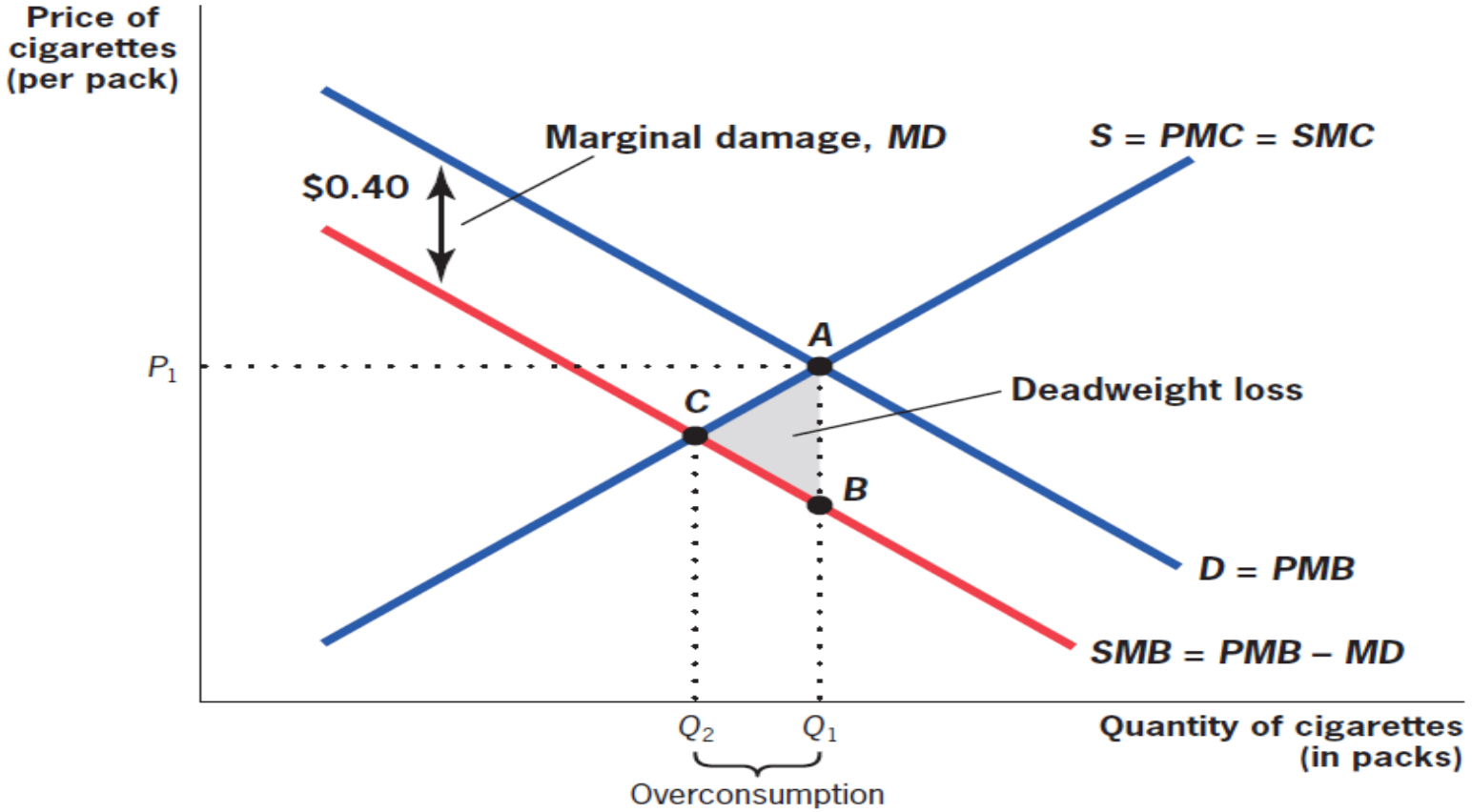
# Economics of Negative Production Externalities: Steel Production



5.1

# Economics of Positive Production Externalities: Oil Exploration



5.1

# APPLICATION: The Externality of SUVs

The consumption of large cars such as SUVs produces three types of negative externalities:

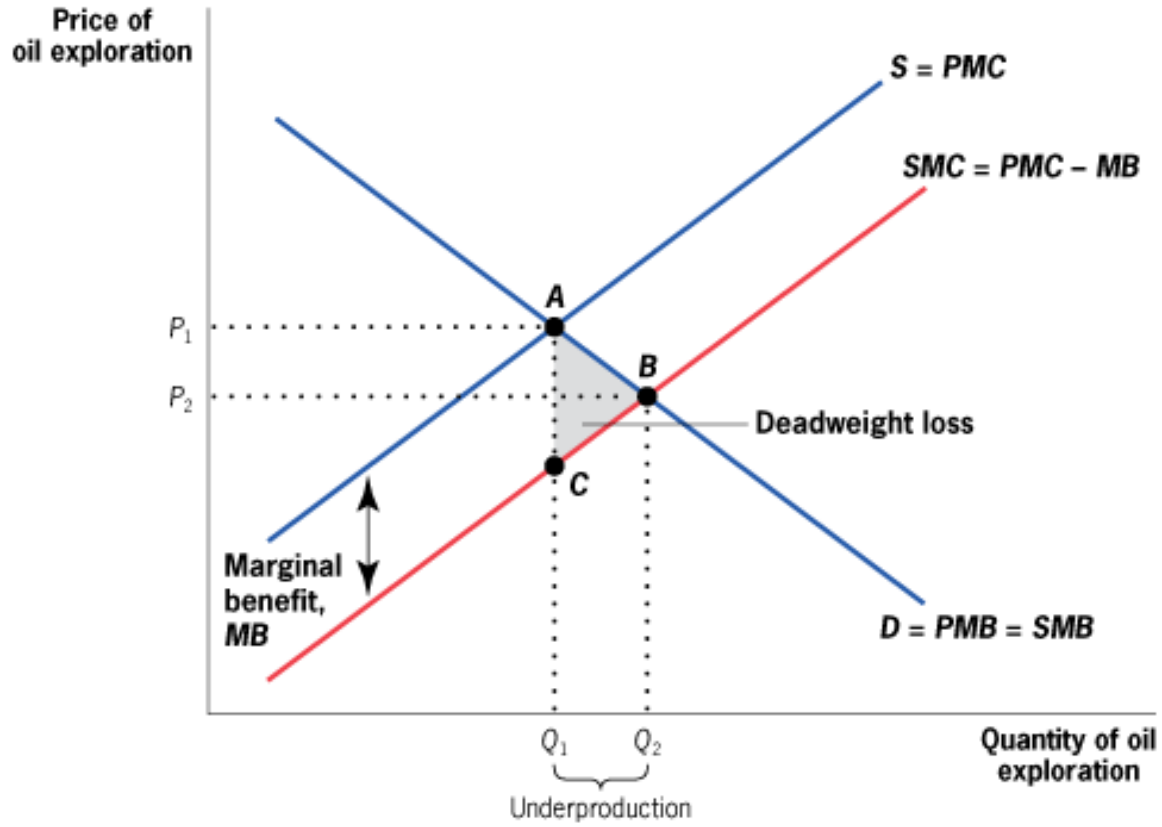
1. Environmental externalities: Compact cars get 25 miles/gallon, but SUVs get only 20.
2. Wear and tear on roads: Larger cars wear down the roads more.
3. Safety externalities: The odds of having a fatal accident quadruple if the accident is with a typical SUV and not with a car of the same size.

5.1

# Externality Theory

## Positive Externalities

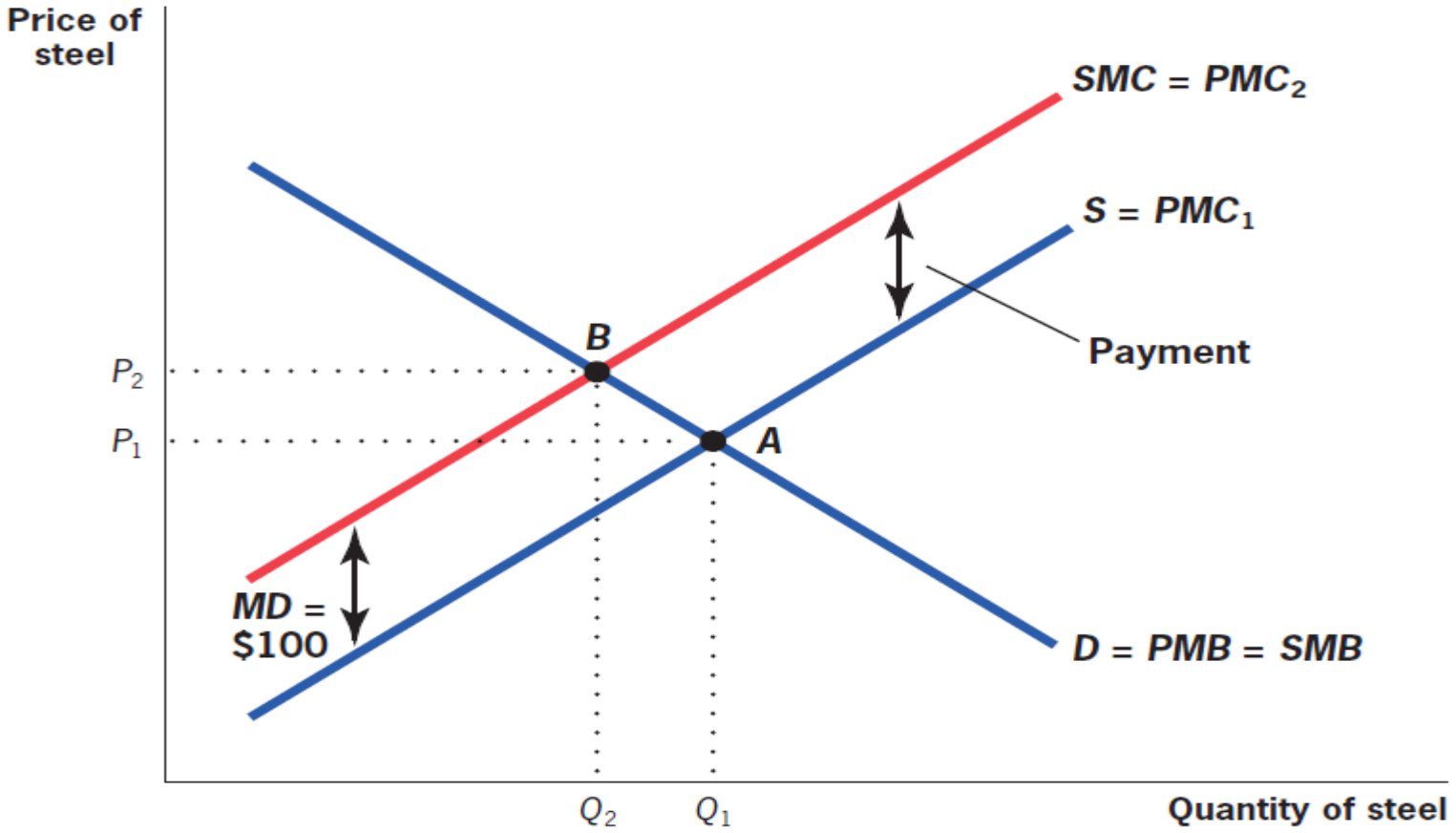
■ FIGURE 5-4




**Market Failure Due to Positive Production Externality in the Oil Exploration Market** • Expenditures on oil exploration by any company have a positive externality because they offer more profitable opportunities for other companies. This leads to a social marginal cost that is below the private marginal cost, and a social optimum quantity ($Q_2$) that is greater than the competitive market equilibrium quantity ($Q_1$). There is underproduction of $Q_2 - Q_1$, with an associated deadweight loss of area *ABC*.

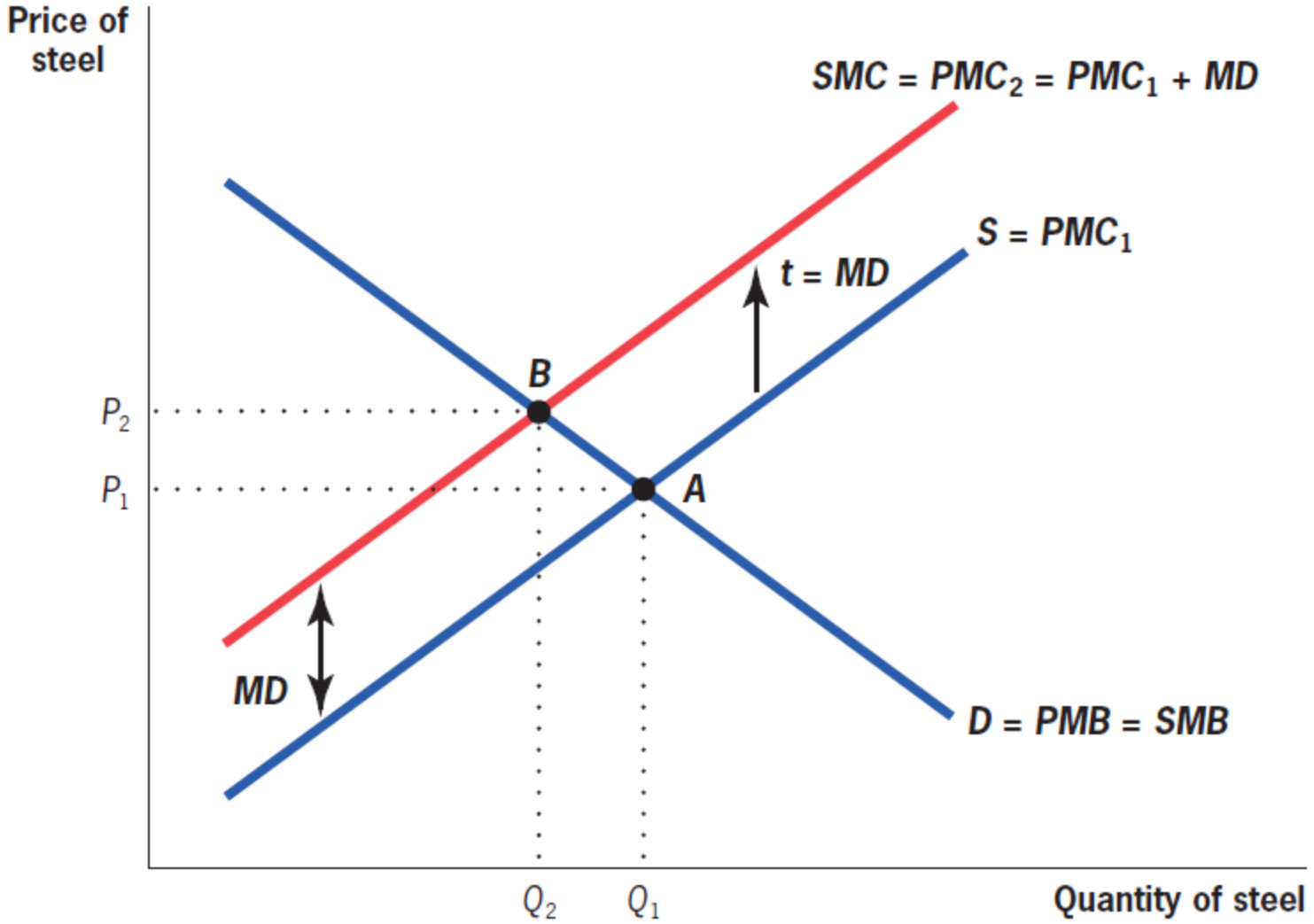
5.2

# The Solution: Coasian Payments



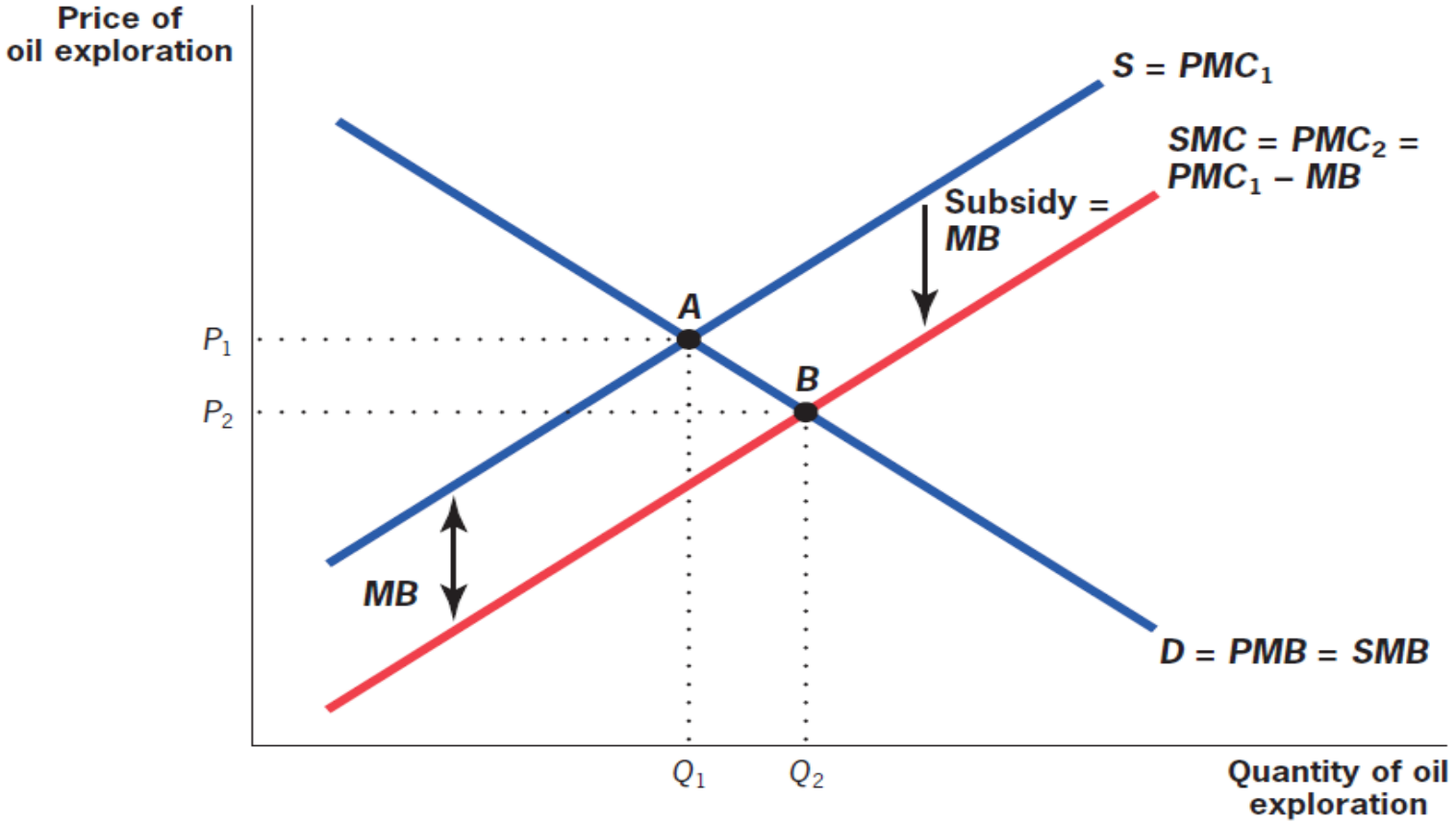
5.3

# Corrective Taxation



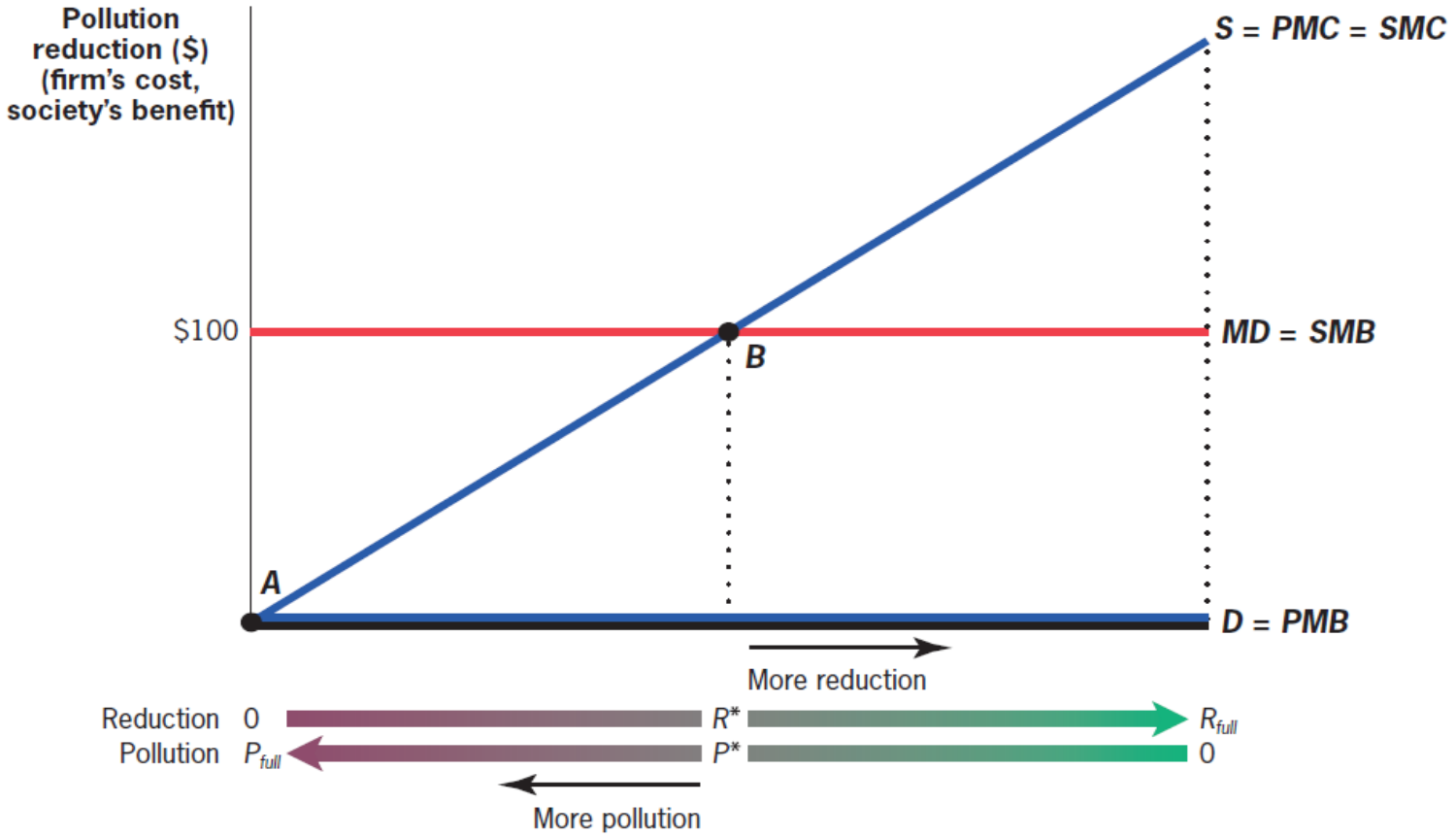
5.3

# Corrective Subsidies



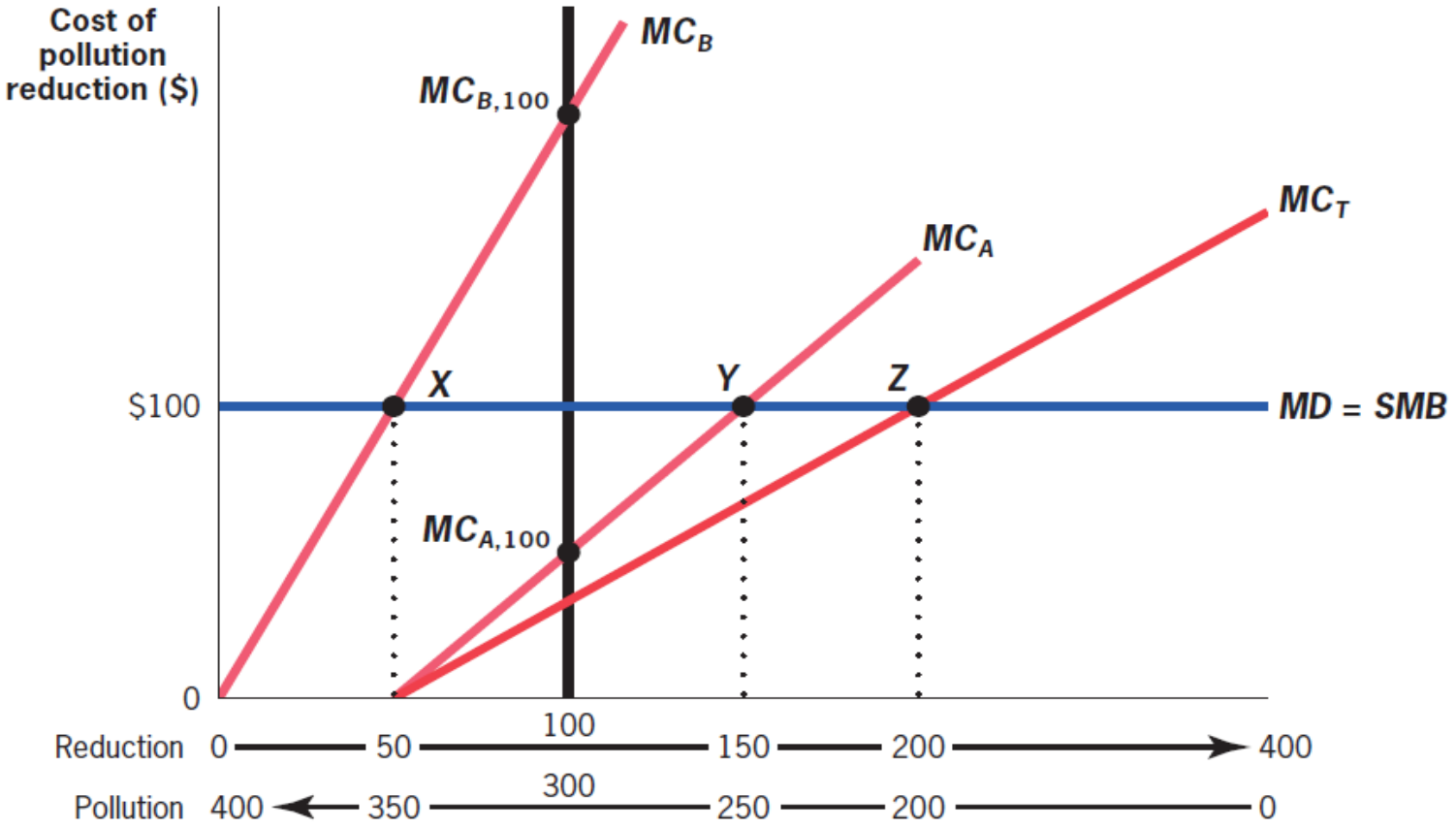
5.4

# Distinctions Between Price and Quantity Approaches to Addressing Externalities: Basic Model



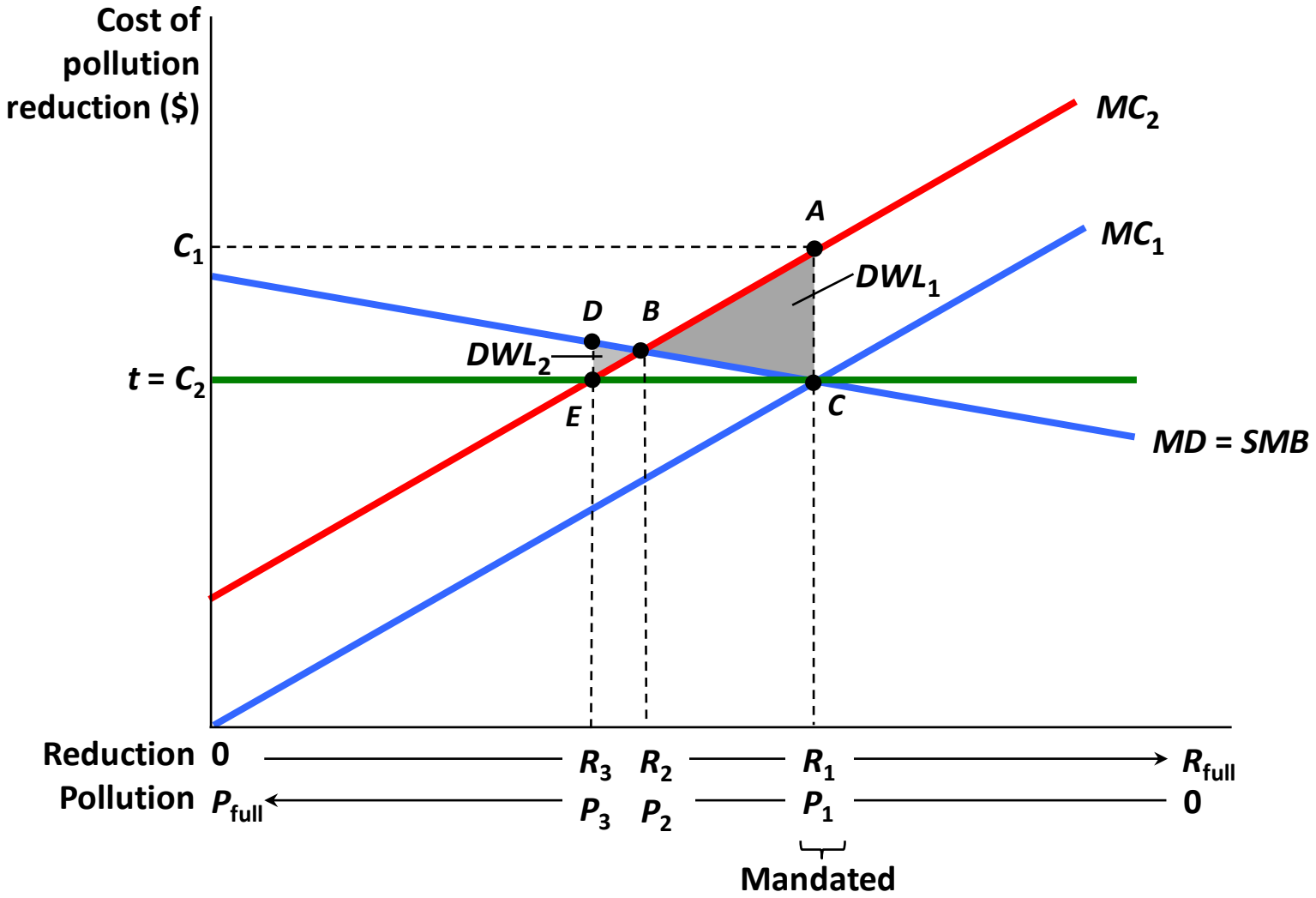
5.4

# Multiple Plants with Different Reduction Costs



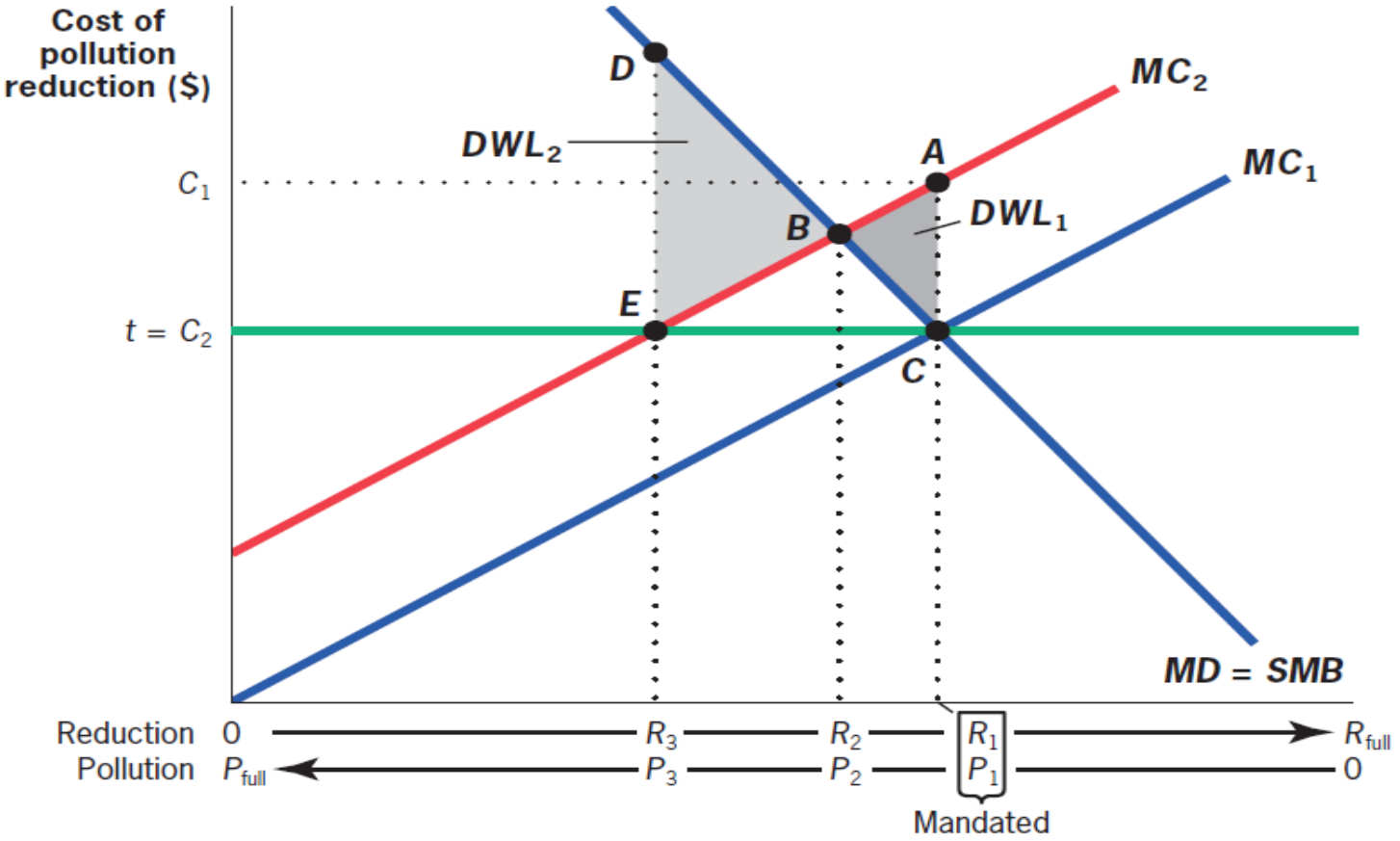
5.4

# Uncertainty About Costs of Reduction: Case 1: Flat *MD* Curve (Global Warming)



5.4

# Uncertainty About Costs of Reduction: Case 2: Steep *MD* Curve (Nuclear leakage)



6.1

# Estimating the Adverse Health Effects of Particulates

How does acid rain (or $SO_2$) affect health?

- The typical approach taken in this literature is to relate adult mortality in a geographical area to the level of particulates (such as $SO_2$) in the air.
- The results are suspect: Areas with more particulates may differ from areas with fewer particulates in many other ways, not just in the amount of particulates in the air.

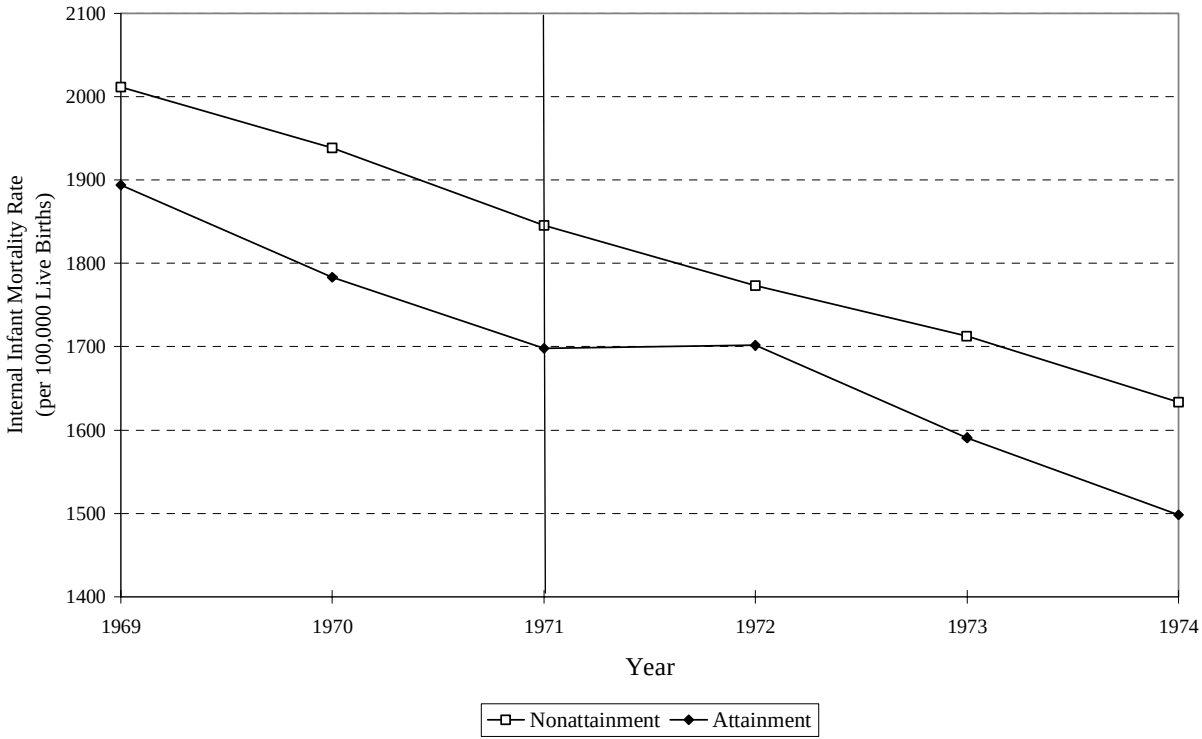
Figure 2: Trends in TSPs Pollution and Infant Mortality, by 1972 Nonattainment Status

A. Trends in Mean TSPs Concentrations, by 1972 Nonattainment Status


Source: Authors' tabulations from EPA's "Quick Look Reports" data file.

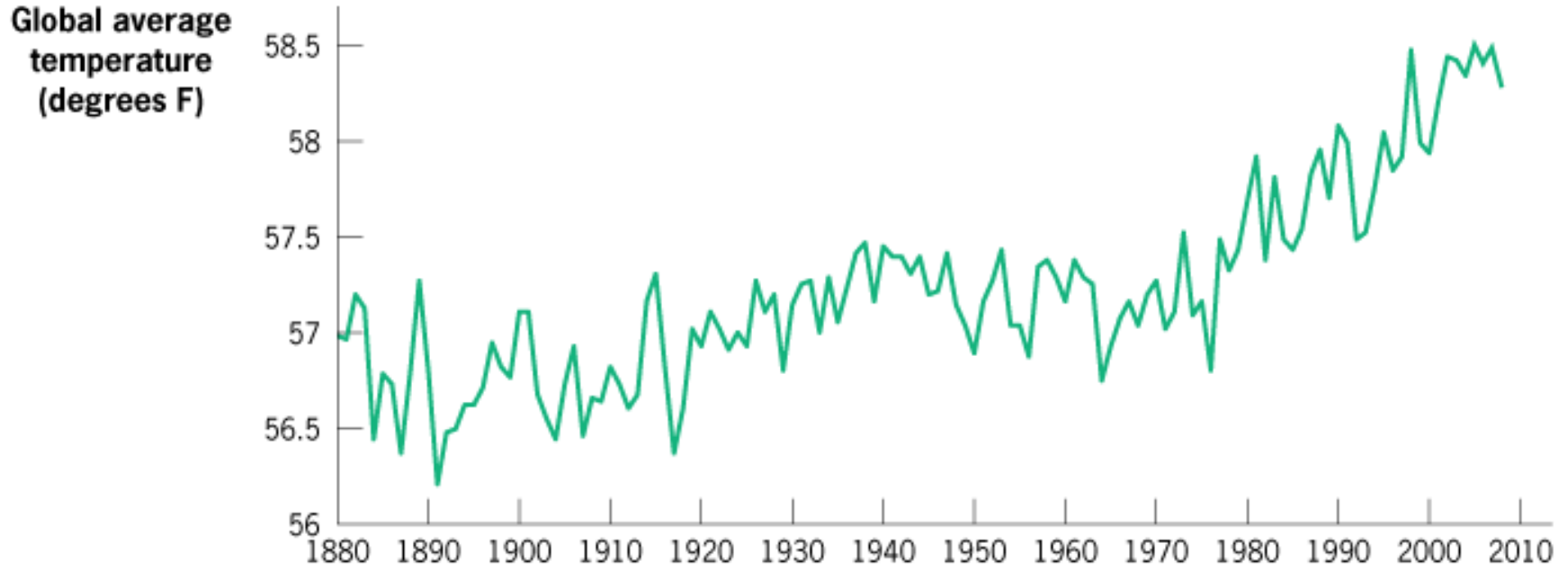
Source: Chay and Greenstone (2003)

B. Trends in Internal Infant Mortality Rate, by 1972 Nonattainment Status




Source: Chay and Greenstone (2003)

■ FIGURE 5-1




**Average Global Temperature, 1880 to 2008** • There was a steady upward trend in global temperatures throughout the twentieth century.

6.2

# Global Warming

Global warming is a serious environmental externality.

- Gas emissions lead to increased global temperature because of the greenhouse effect.
  - **Greenhouse effect:** The process by which gases in the Earth's atmosphere reflect heat from the sun back to the Earth.
- Global temperatures are increasingly more rapidly than any time in the last 1000 years.
- Temperatures are projected to rise even more rapidly over the next century.

6.2

# $CO_2$ Output: 25 Largest Contributors

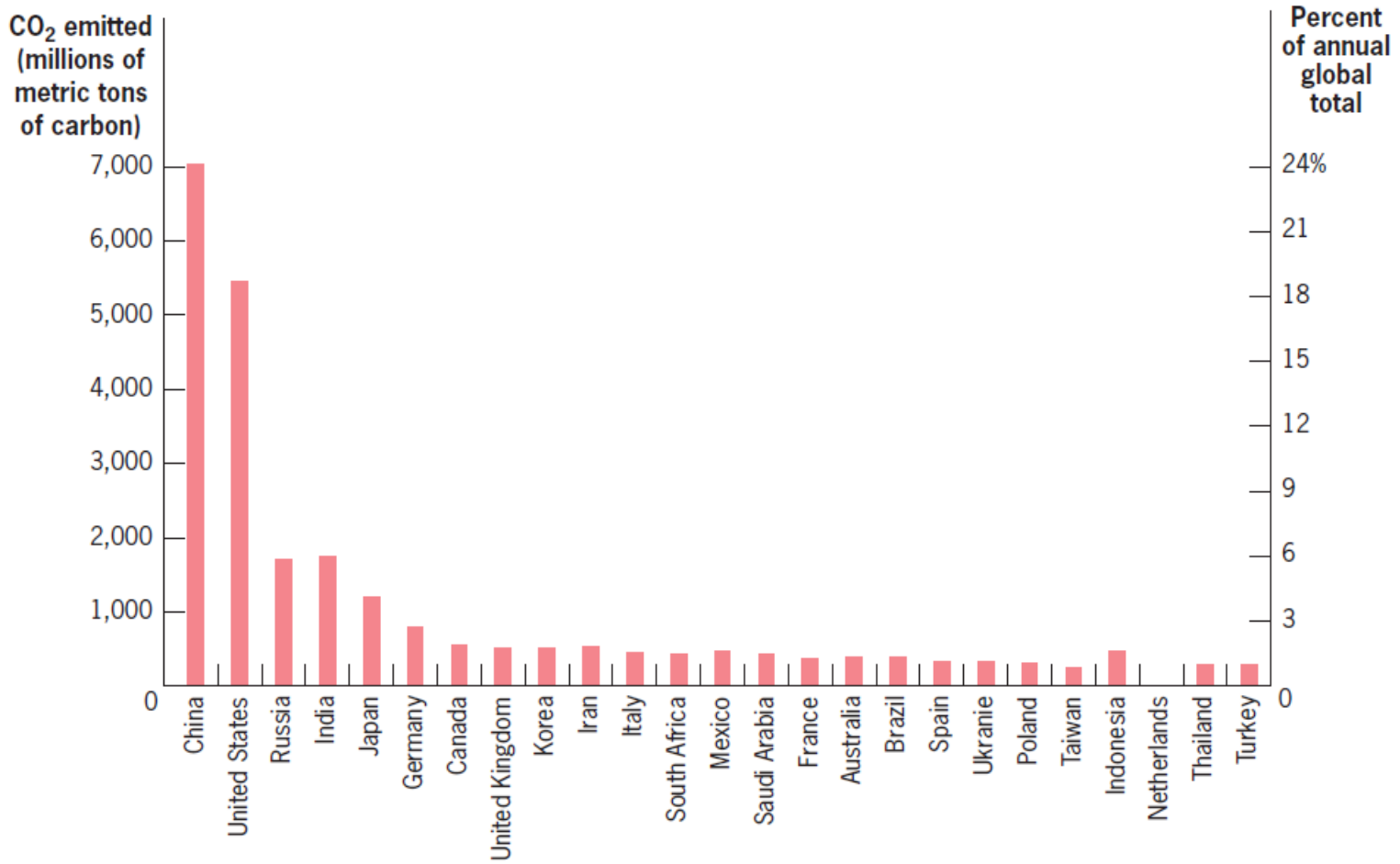
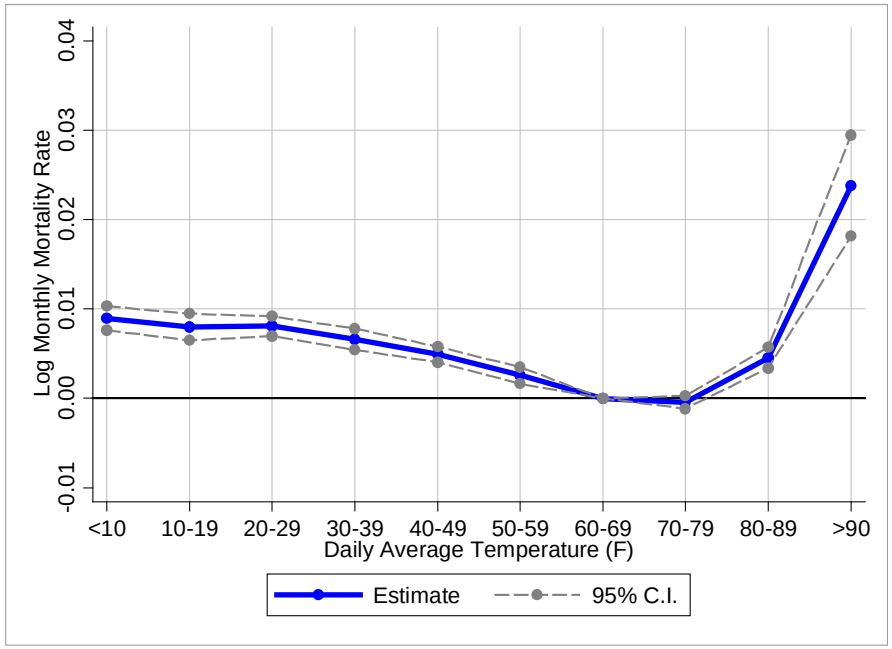
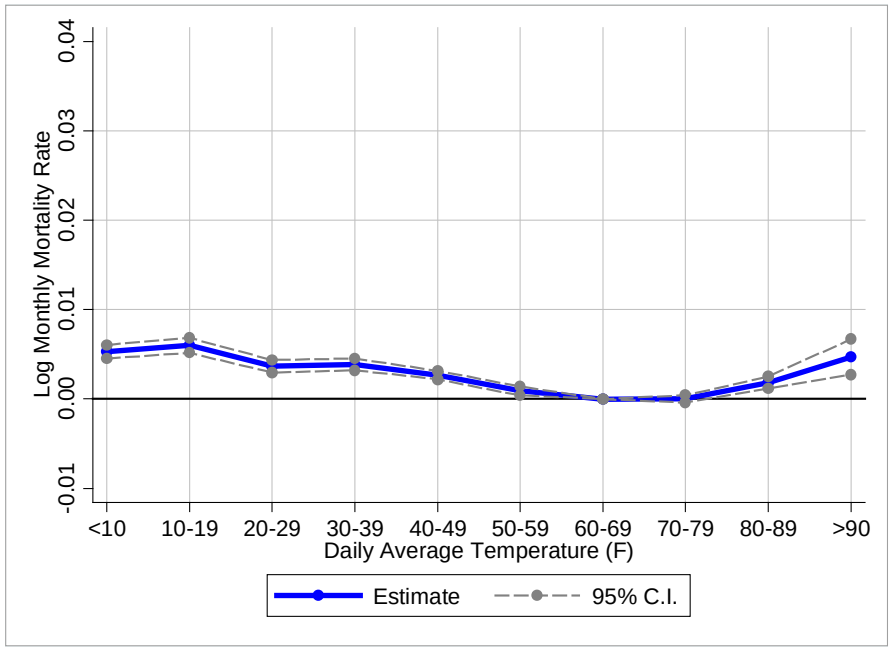


**Figure 2: Estimated Temperature-Mortality Relationship (Continued)**

**(c) 1929-1959**




**(d) 1960-2004**

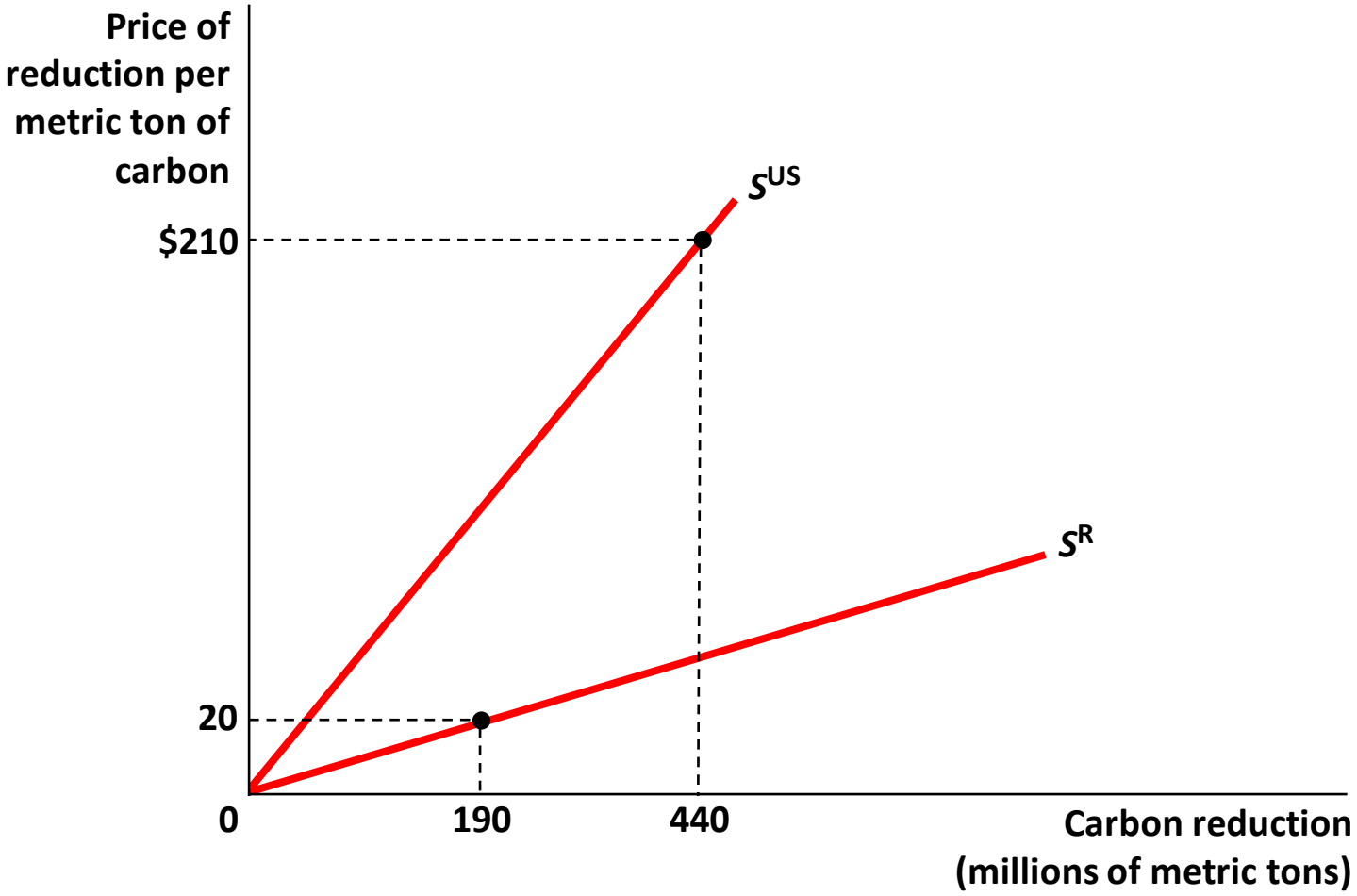



**Notes:** Figure 2 plots the response function between log monthly mortality rate and average daily temperatures, obtained by fitting Equation (1). The response function is normalized with the 60°F – 69°F category set equal to zero so each estimate corresponds to the estimated impact of an additional day in bin j on the log monthly

**Source:Barreca, Alan, et al (2013)**

6.2

# Can Trading Make Kyoto More Cost-Effective?



6.2

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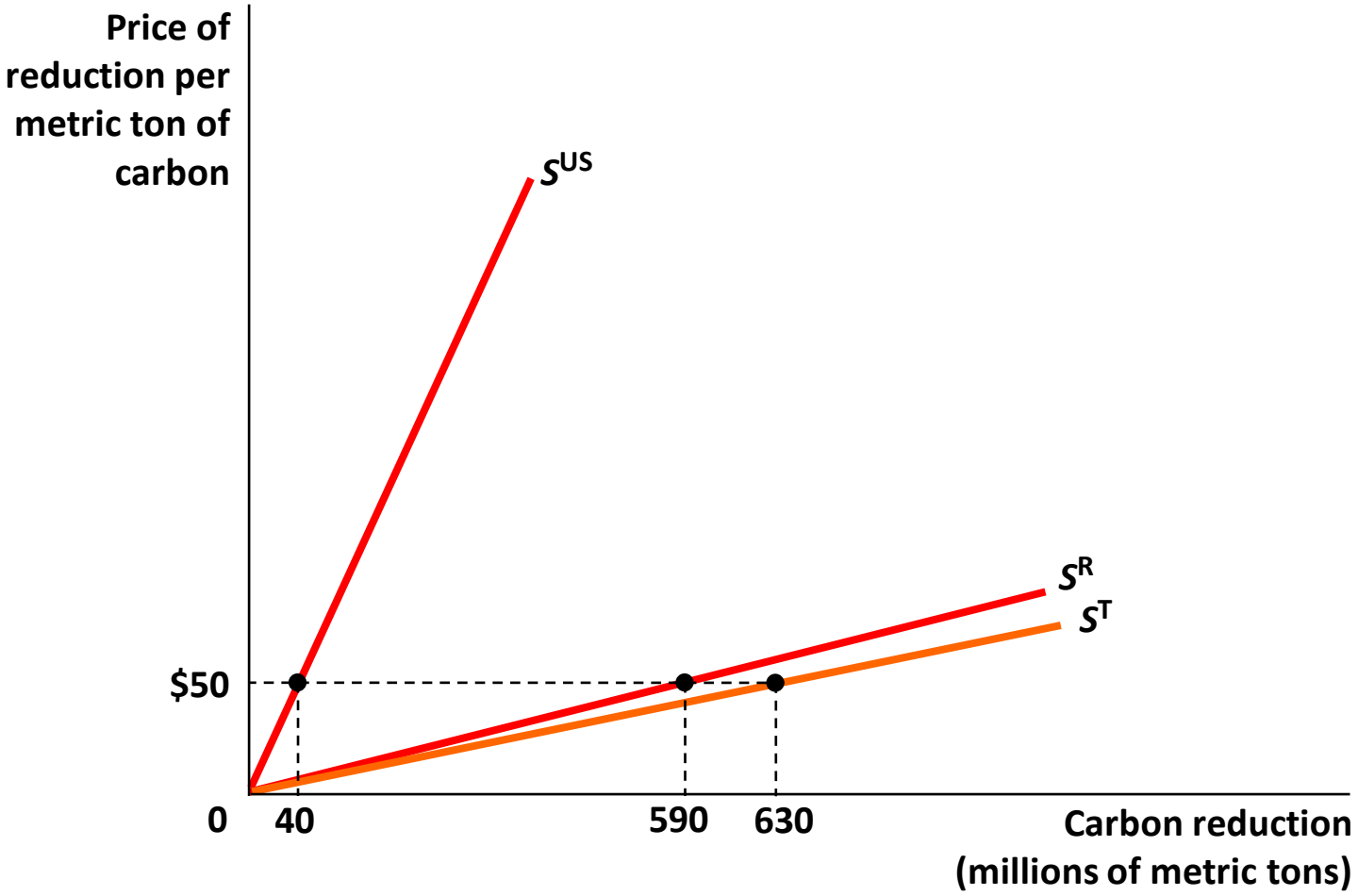


APPLICATION

## The Montreal Protocol and Ozone layer hole

- An excellent example of international cooperation is the Montreal Protocol of 1987, which banned the use of chlorofluorocarbons (CFCs).
- As with global warming, this was a potentially enormous long-run problem.
- Unlike global warming, the CFC problem was showing itself immediately and urgently: by the 1980s, a 25 million square kilometer hole had opened in the ozone layer over Antarctica!
- This hole spurred the international community to action, and in September 1987, the Montreal Protocol was adopted, aiming for complete phaseout of specified chemicals (mostly CFCs and halons) according to specified schedules.
- The result is that scientists predict the hole in the ozone layer will begin to recover and return to normal around 2050.

It may take some type of exciting, newsworthy event to spur action on global warming, but global warming will not be solved for centuries after emissions are greatly reduced. If the world waits for a crisis to take action, it may be too late.

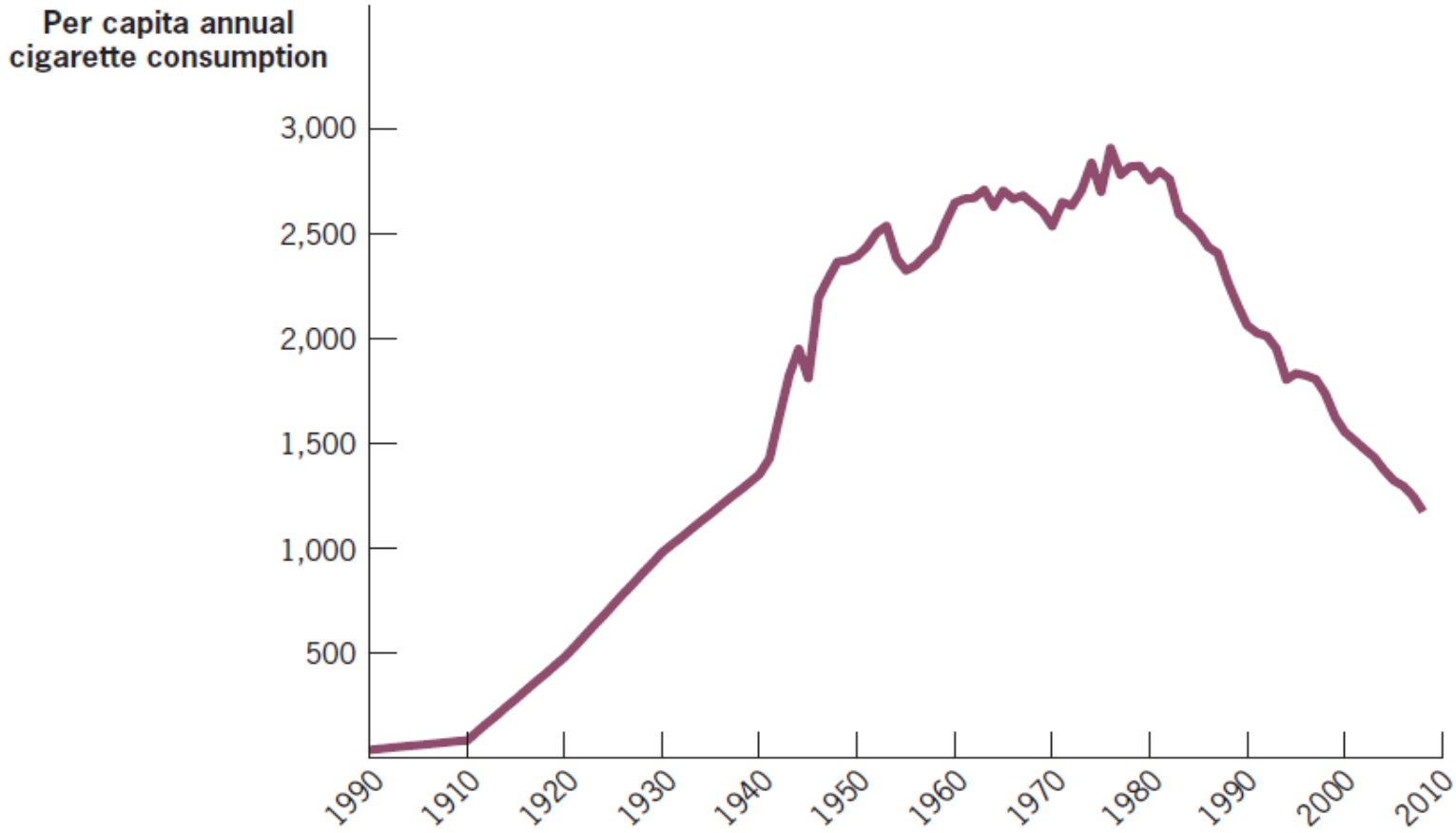
6.3

# The Economics of Smoking

- Not all externalities are large-scale environmental problems.
- Some of the most important externalities are local and individualized.
- Many of these arise in the arena of personal health, and one of the most interesting is smoking.

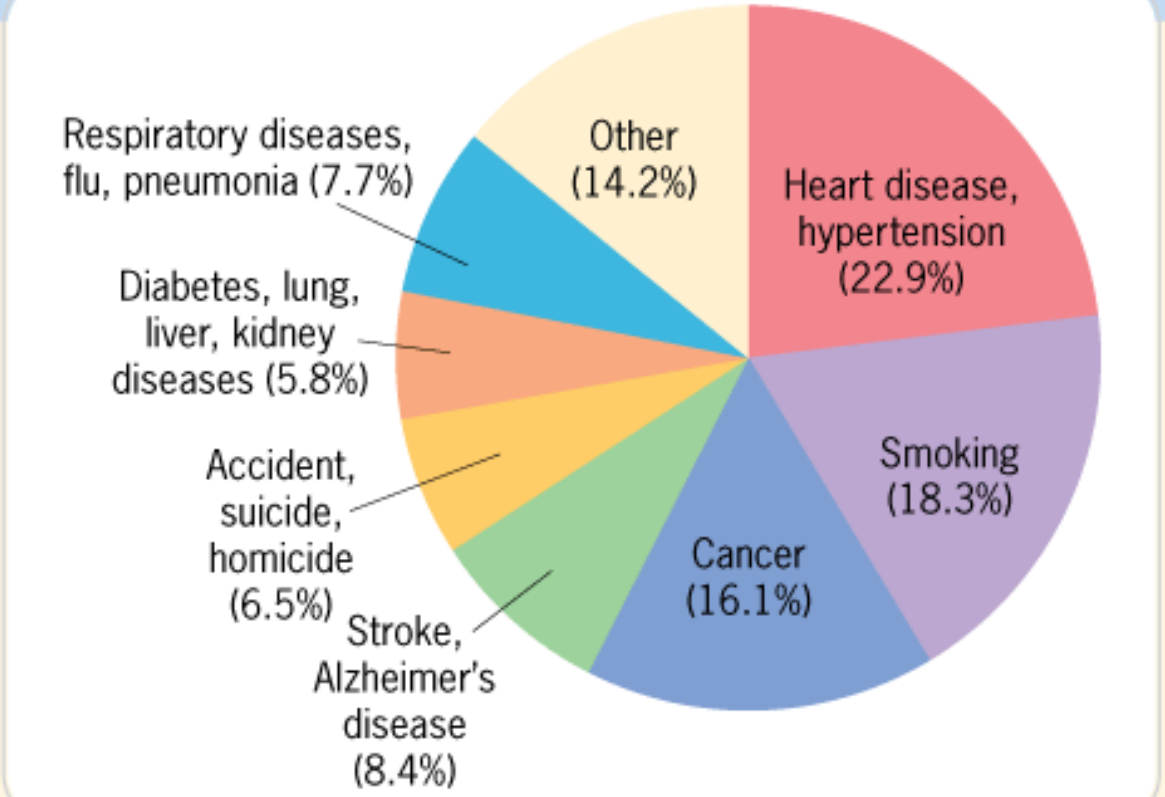
# Per Capita Annual Cigarette Consumption, 1990–2010



6.3

# The Economics of Smoking

■ FIGURE 6-5




**Leading Causes of Death, 2008** • Smoking-related deaths represent 18.3% of all deaths, more than other cancers combined and almost as much as other heart diseases.

6.3

# The Economics of Smoking

## The Externalities of Smoking

■ **TABLE 6-1**

**The Effects of Smoking: Externalities or Not?**

| Effect | Not an externality if... | An externality if... |
|---|---|---|
| Increased health care costs | Insurance companies actuarially raise premiums for smokers. | Many individuals are insured by entities that spread the health costs of smokers among all of the insured; also, the health costs of the uninsured are passed on to others. |
| Less-productive workers | Employers adjust individuals' wages according to productivity. | Employers do not adjust wages according to individual productivity, so that they must lower wages for all workers to offset productivity loss. |
| Increased number of fires | Smokers set fire only to their own property, requiring no help from the fire department, and insurance companies adjust premiums according to smoking status. | The fires damage nonsmokers' property, raise the cost of the local fire department, or raise fire insurance premiums for all. |
| Earlier deaths | Smokers do not pay Social Security taxes or would not incur medical costs later in life. | Nonsmokers save money because smokers die too early to collect full Social Security benefits and because their deaths reduce the high health costs near the end of life (a positive externality). |
| Secondhand smoke effects | The effects are minimal or smokers account for their families' utility when deciding to smoke. | The effects are serious and smokers do not account for their families' utility when deciding to smoke. |

Cigarette smoking has a number of physical and financial effects, but in many cases they may not be externalities. The first column of this table lists examples of the effects of smoking. The second column discusses the situations under which these are not externalities, and the third column discusses the situations under which they are externalities.

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

Our World in Data

**Price per megawatt hour of electricity**
This is the global weighted-average of the levelized costs of energy (LCOE), without subsidies
logarithmic axis and adjusted for inflation

$300
$250
$200
$180
$150
$120
$100
$90
$80
$70
$60
$50

**$378/MWh**
2010

## Solar Photovoltaic (PV)
At each doubling of installed solar capacity the price of solar electricity declined by 36%.
36% is the *learning rate* of solar PV.

**$68/MWh**
2019

**$162**

## Offshore wind
Learning rate: 10%

**$115**
2019

## Nuclear energy
No learning rate – nuclear has become more expensive

**$155**
2019

**$96**
2010

## Coal
No learning rate – coal has not become significantly cheaper

**$111** 2010 → **$109** 2019

**$86**
2010

## Onshore wind
Learning rate: 23%

**$53**
2019

5,000 MW
10,000 MW
20,000 MW
50,000 MW
100,000 MW
500,000 MW
1,000,000 MW
2,000,000 MW

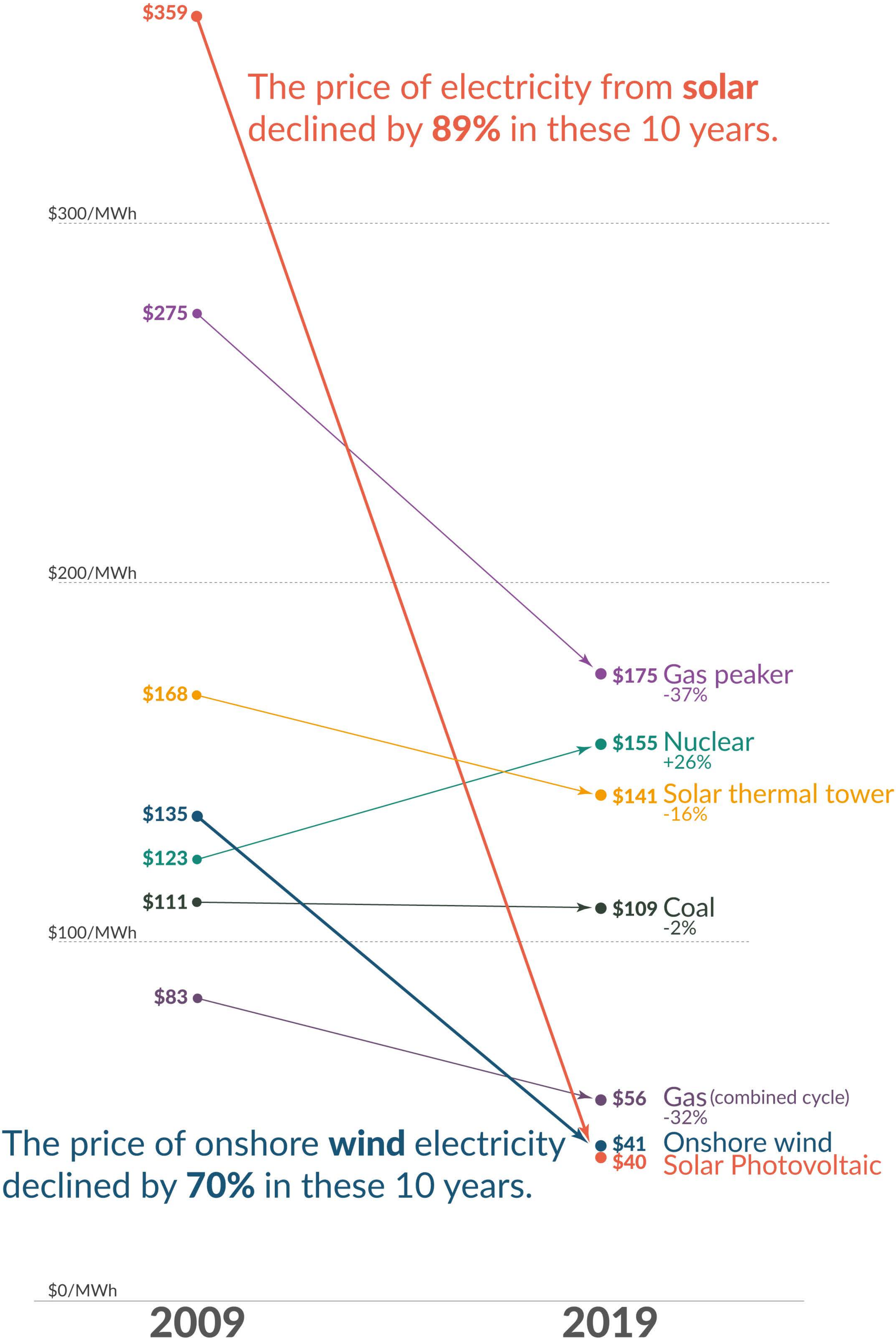
Cumulative installed capacity (in megawatts) logarithmic axis

Source: IRENA 2020 for all data on renewable sources; Lazard 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 signficantly, 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.

# The price of electricity from new power plants

Our World in Data

Electricity prices are expressed in 'levelized costs of energy' (LCOE). LCOE captures the cost of building the power plant itself as well as the ongoing costs for fuel and operating the power plant over its lifetime.



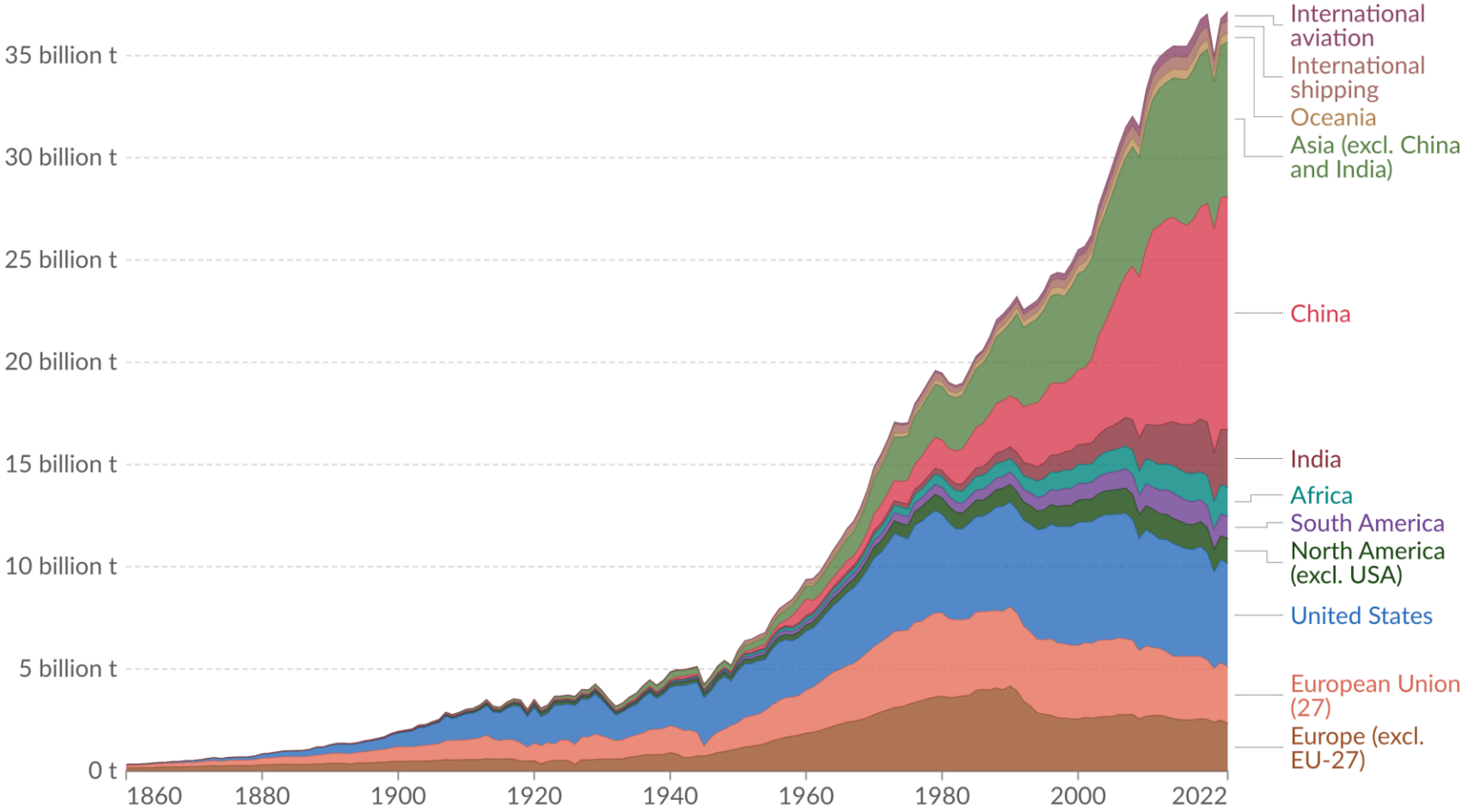

Data: Lazard Levelized Cost of Energy Analysis, Version 13.0

OurWorldinData.org – Research and data to make progress against the world's largest problems.

# Annual $CO_2$ emissions by world region

Our World in Data

Emissions from fossil fuels and industry[1] are included, but not land-use change emissions. International aviation and shipping are included as separate entities, as they are not included in any country's emissions.




**Data source:** Global Carbon Budget (2023)

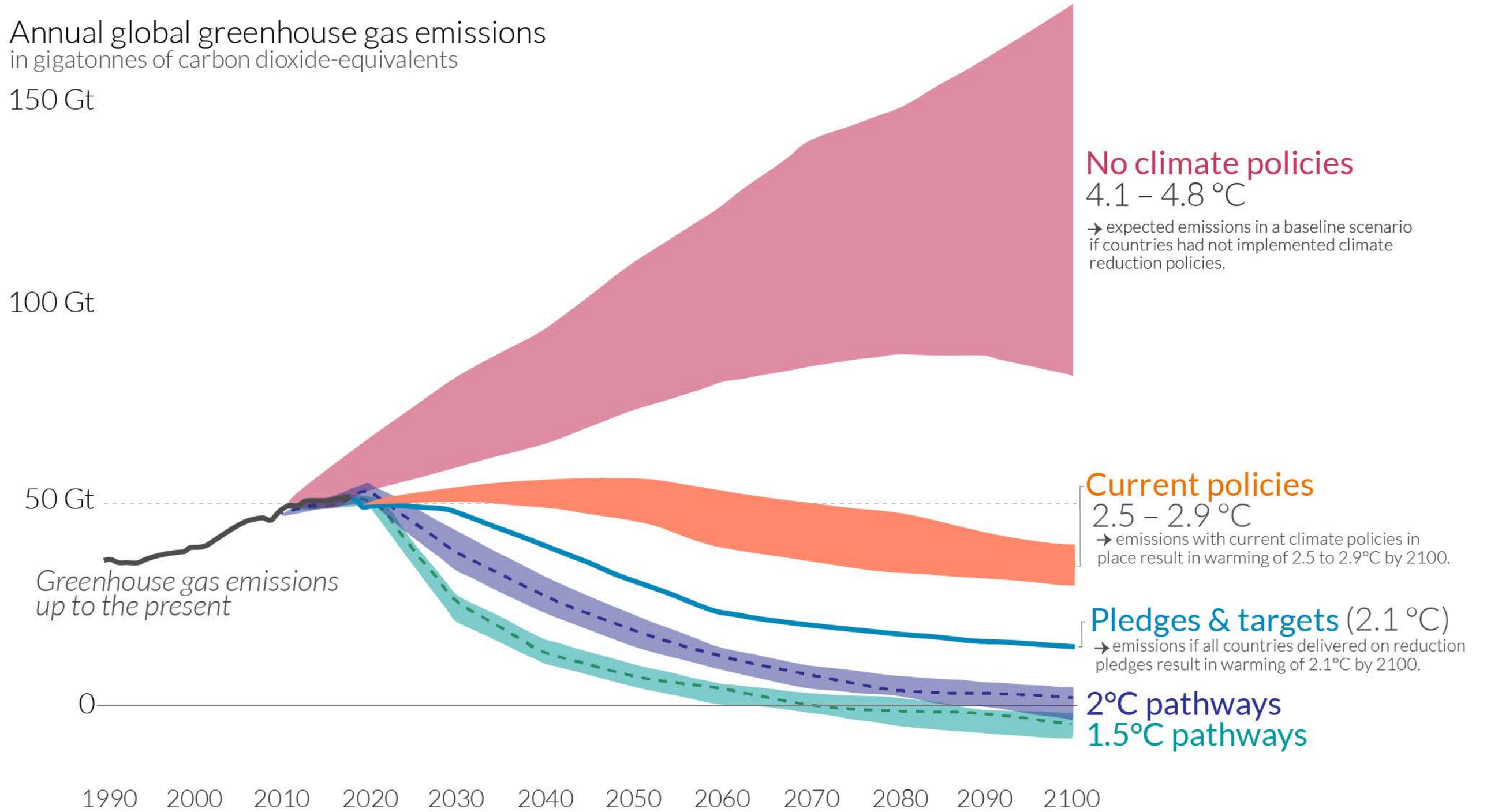
OurWorldInData.org/co2-and-greenhouse-gas-emissions | CC BY

**1. Fossil emissions**: Fossil emissions measure the quantity of carbon dioxide ($CO_2$) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil $CO_2$ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

# Global greenhouse gas emissions and warming scenarios

Our World in Data

– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

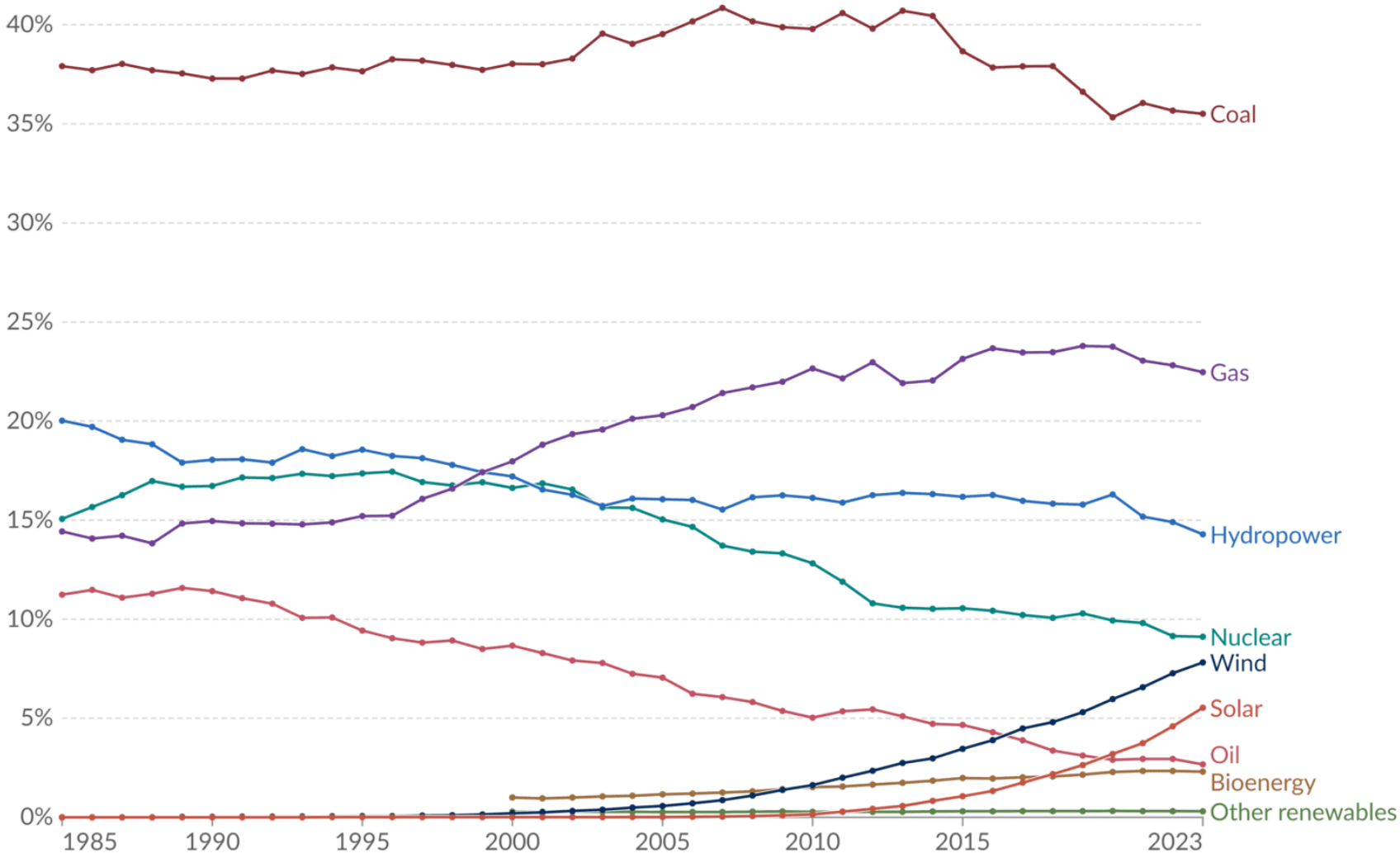



Data source: Climate Action Tracker (based on national policies and pledges as of November 2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Last updated: April 2022.

# Share of electricity production by source, World

Our World in Data




**Data source:** Ember (2024); Energy Institute - Statistical Review of World Energy (2024)

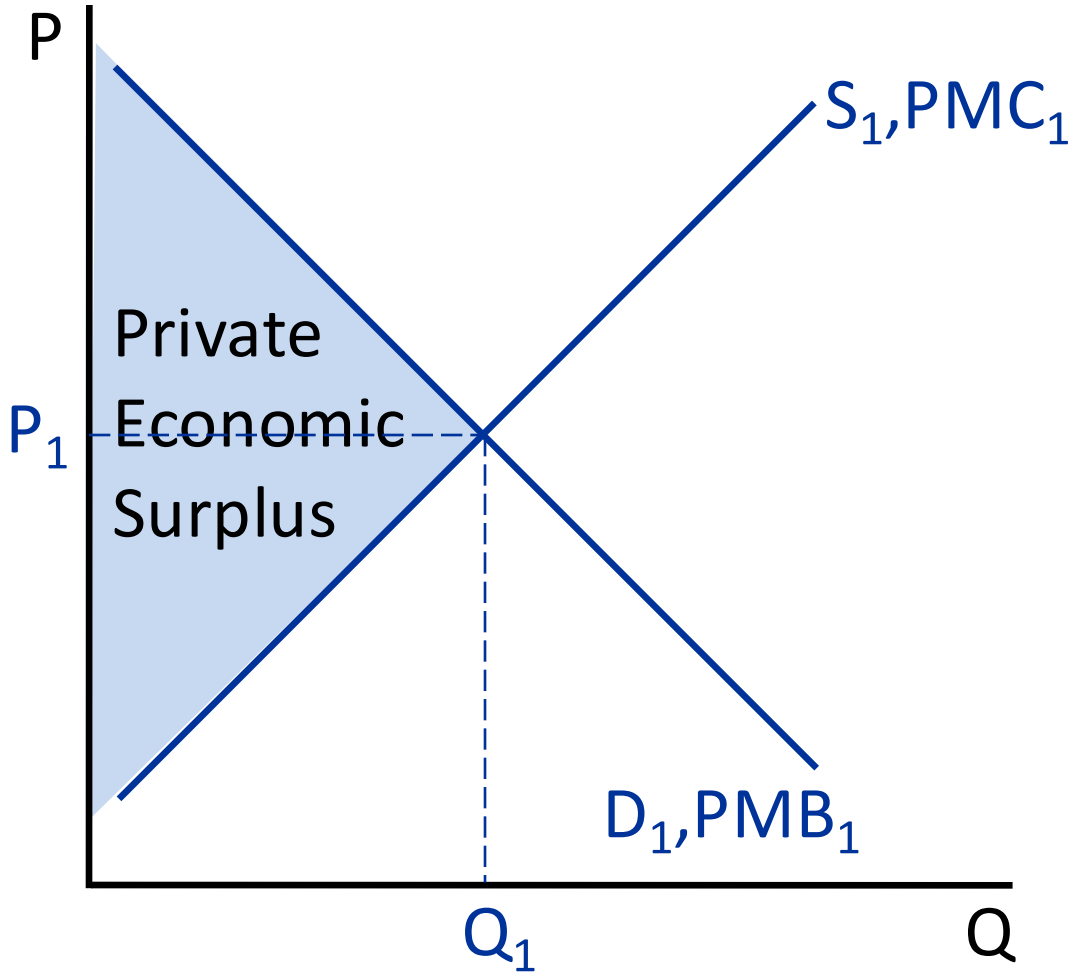
OurWorldinData.org/energy | CC BY

# Gas taxes are generally very unpopular


Gas taxes are the go-to solution for economists. In practice, many gas users are inelastic and low income and get upset. Gas taxes tend to generate “tax revolts” as in the Yellow Vest movement in France in 2022.

# Negative Production Externality

## (Market for Coal Powered Electricity)



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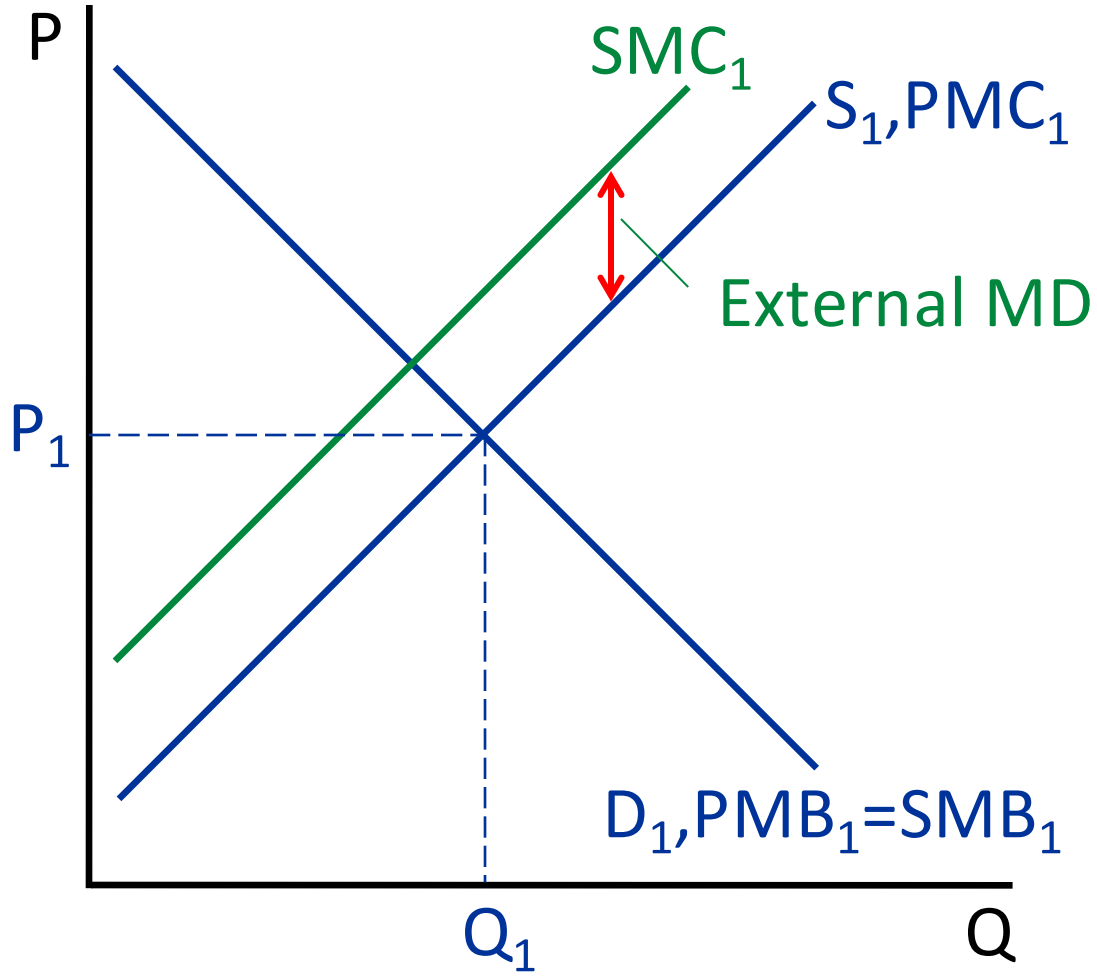
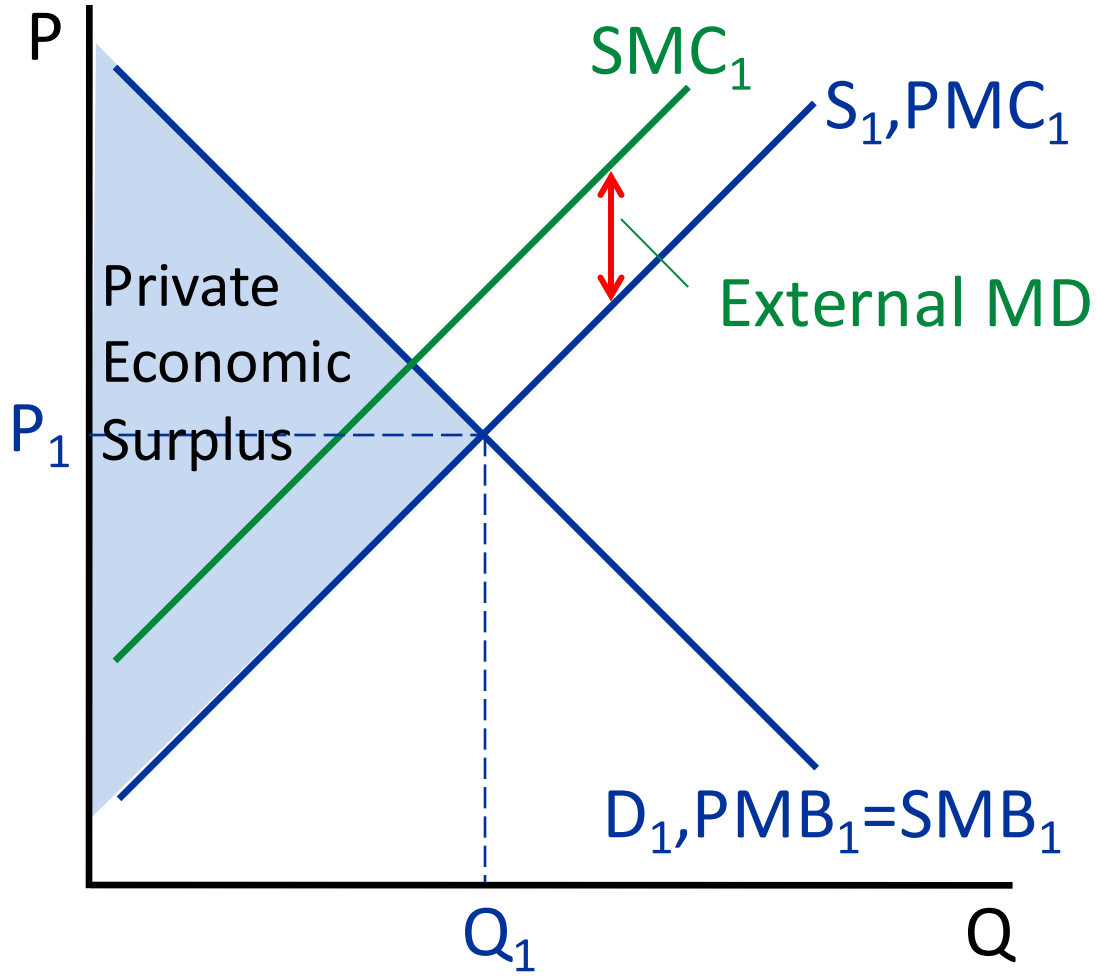



External MD is the $ measure of the external marginal damage of producing 1 extra unit of coal powered electricity (e.g. global warming)

# Negative Production Externality

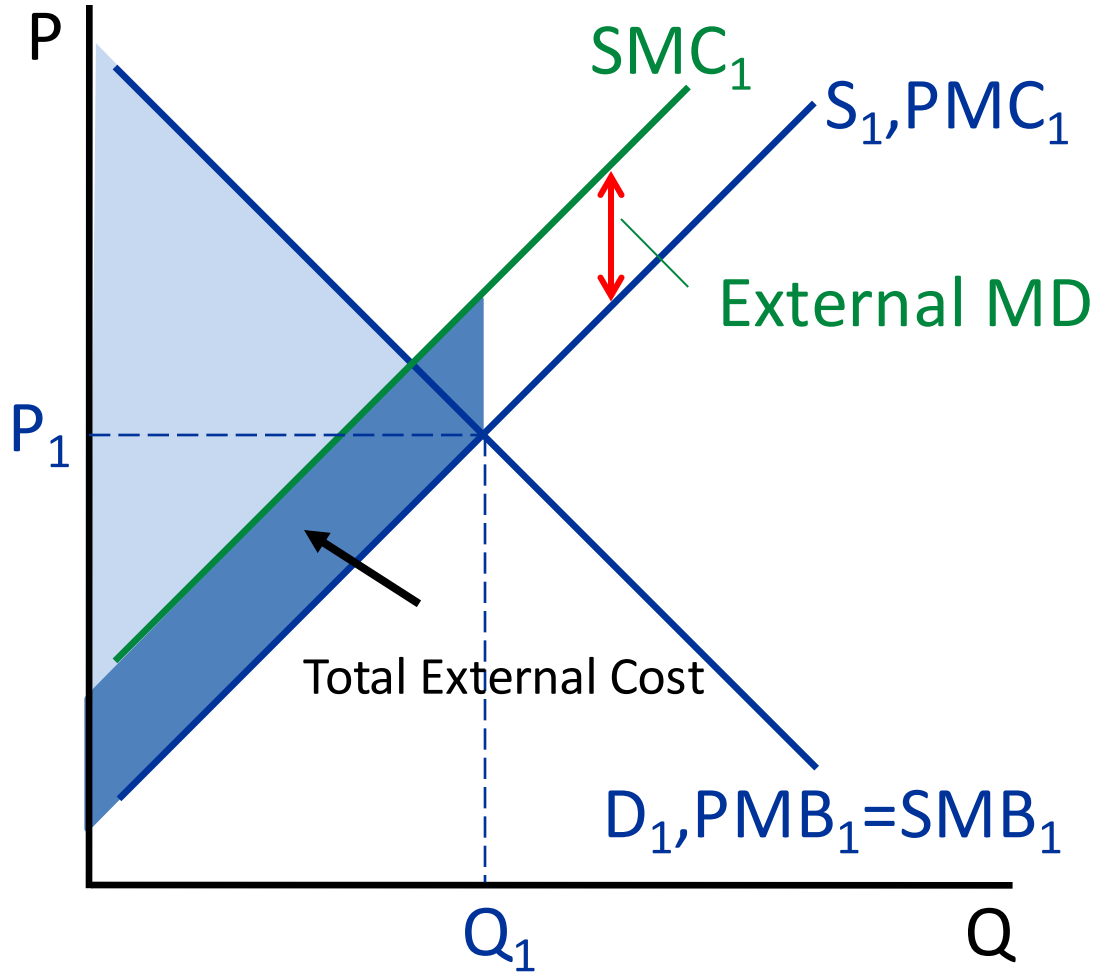
## (Market for Coal Powered Electricity)




External MD is the $ measure of the external cost of producing 1 extra unit of coal powered electricity (due to climate change)

# Negative Production Externality

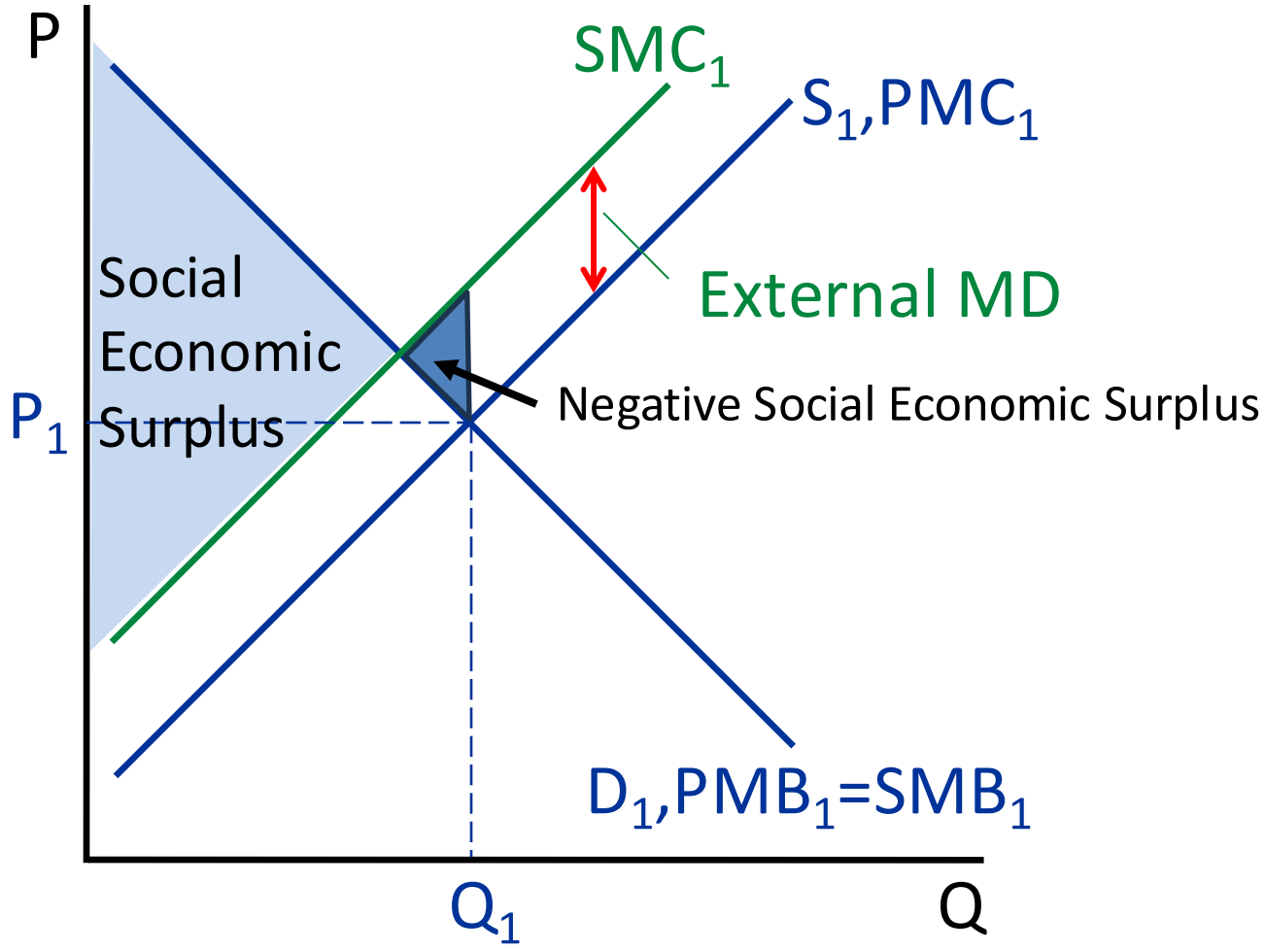
## (Market for Coal Powered Electricity)




Dark blue area is the total external cost of producing $Q_1$: sum of external MC from 0 to $Q_1$

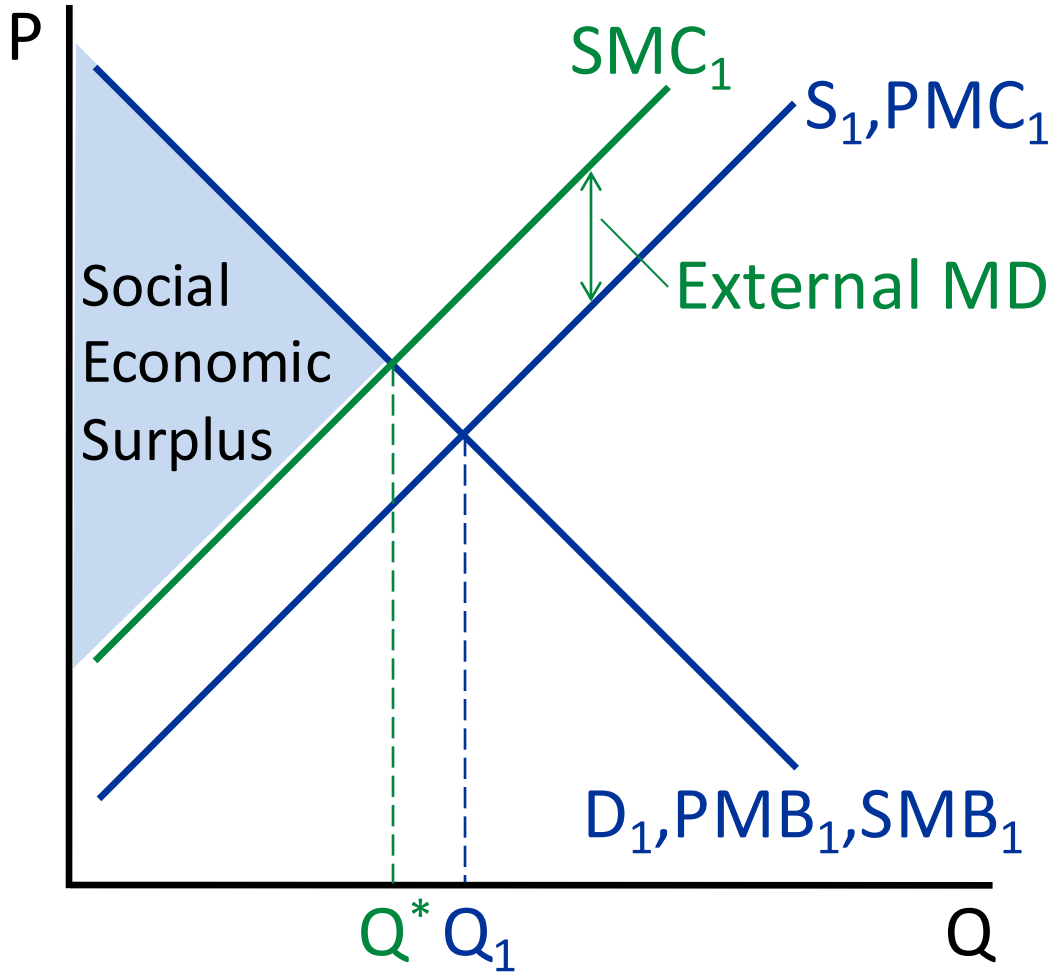
# Negative Production Externality

## (Market for Coal Powered Electricity)




Social Economic Surplus at $Q_1$ is the light blue area minus the dark blue area

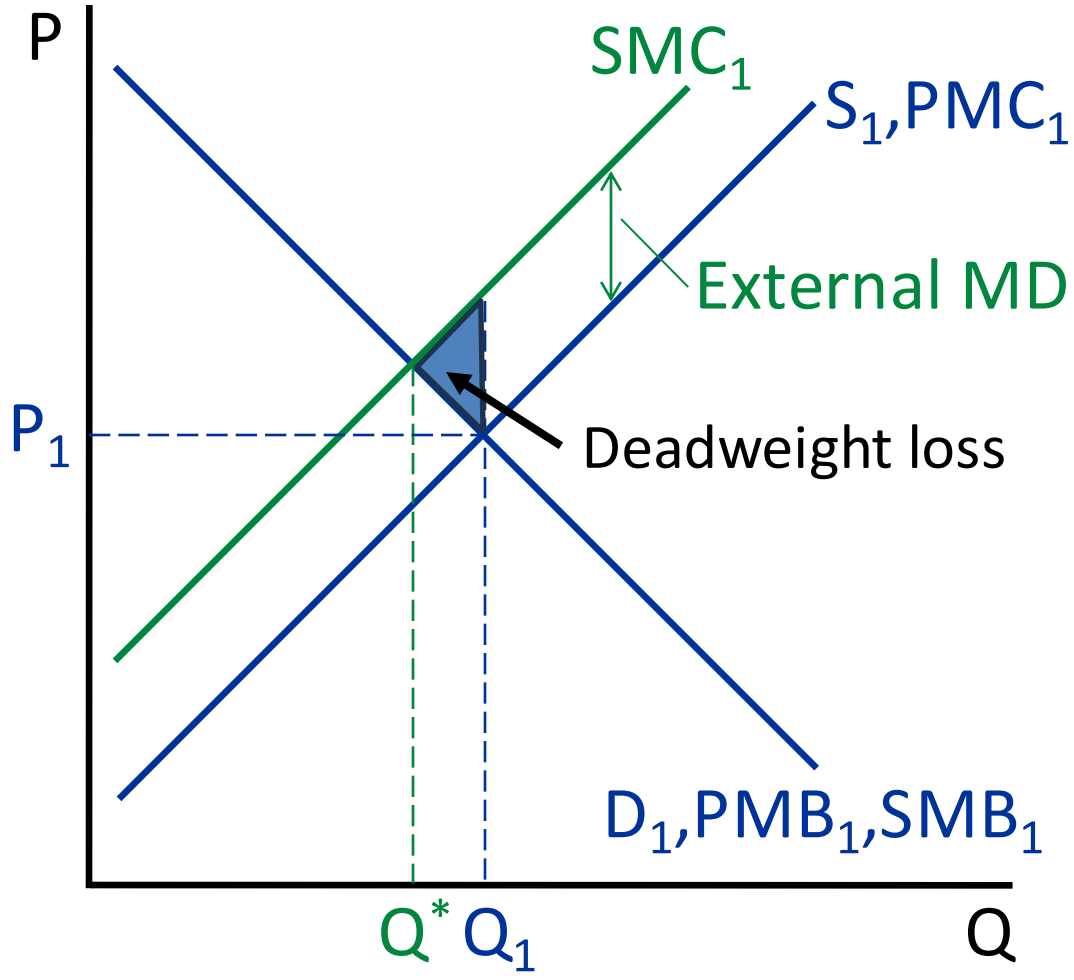
# Efficient Quantity with Externality




Efficient quantity that maximizes social economic surplus is Q*
(where SMC and SMB intersect)

# Negative Production Externality

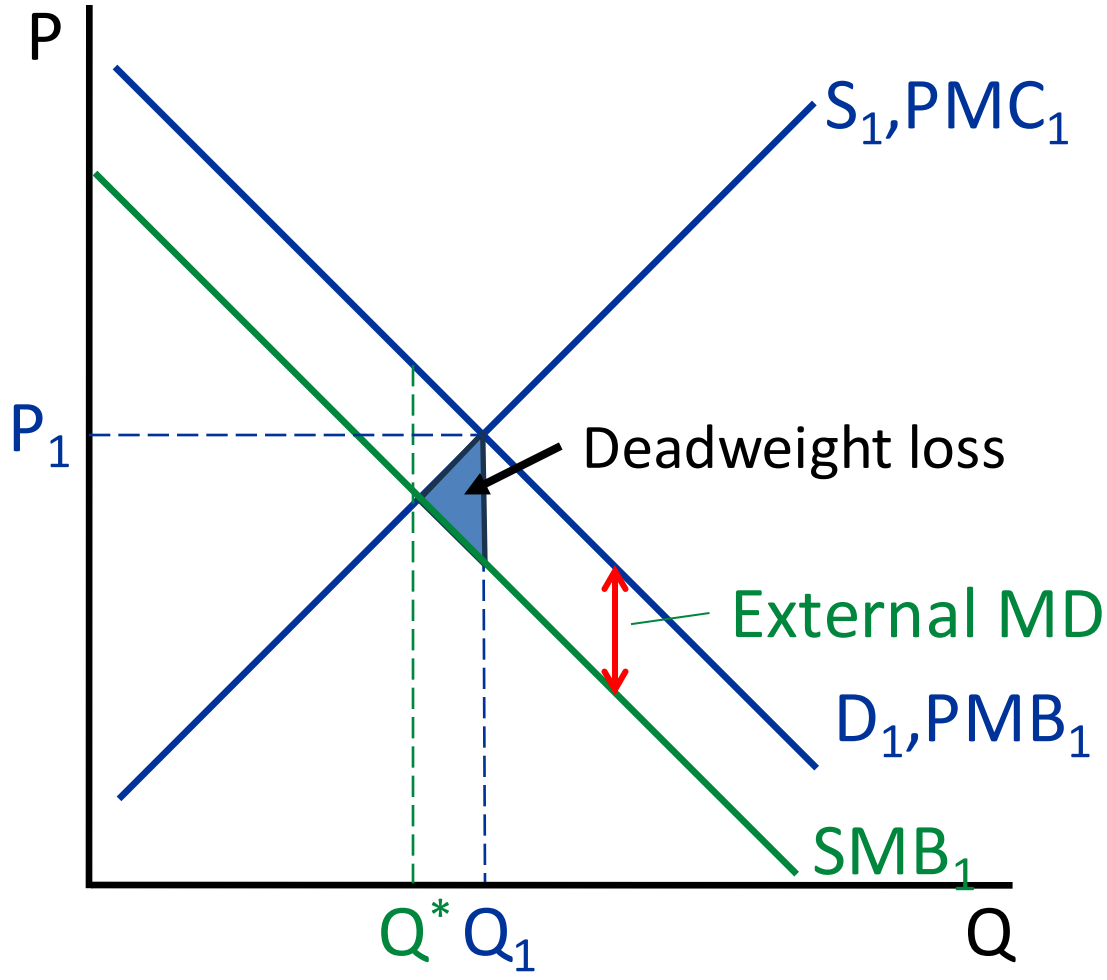
## (Market for Coal Powered Electricity)




Efficient quantity is Q* but market equilibrium quantity is $Q_1$:
Deadweight loss: triangle starting at $Q_1$ and pointing to Q*

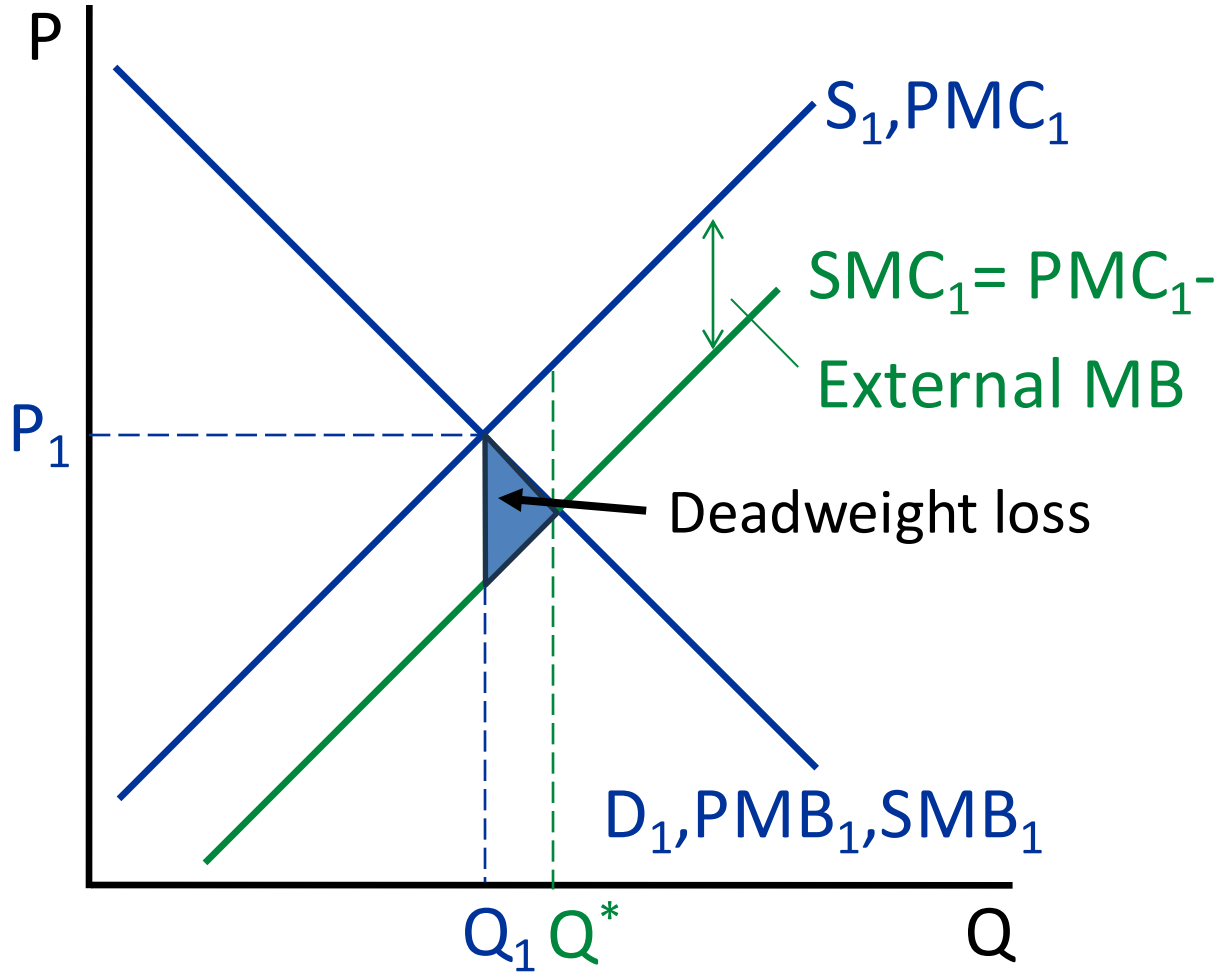
# Negative Consumption Externality

(Market for Gasoline)



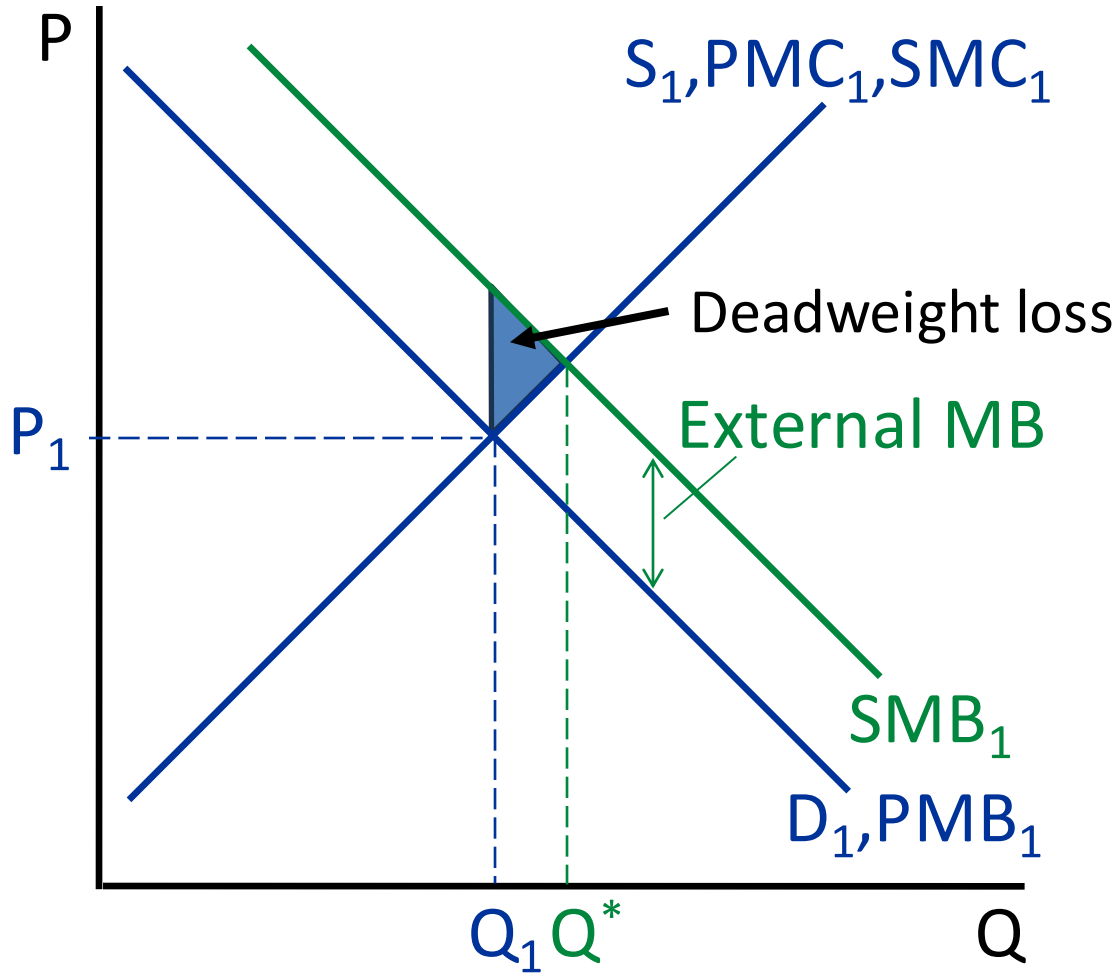

Efficient quantity is Q* but market equilibrium quantity is $Q_1$:
Deadweight loss: triangle starting at $Q_1$ and pointing to Q*

# Positive Production Externality
# (Beehive honey production that helps crops)



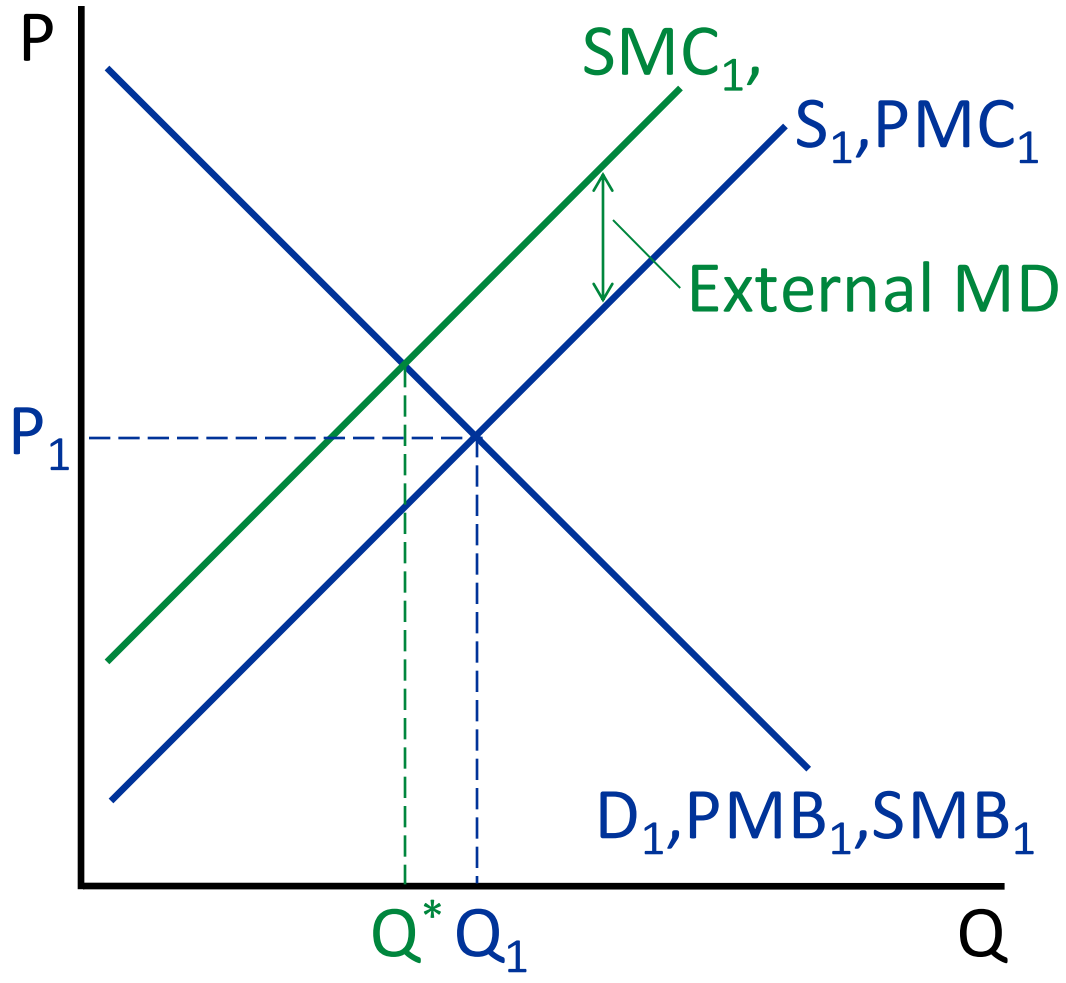

Efficient quantity is Q* but market equilibrium quantity is $Q_1$:
Deadweight loss: triangle starting at $Q_1$ and pointing to Q*

# Positive Consumption Externality
## (Market for Vaccines)




Efficient quantity is Q* but market equilibrium quantity is $Q_1$:
Deadweight loss: triangle starting at $Q_1$ and pointing to Q*

# Tax Remedy for a Negative Producer Externality



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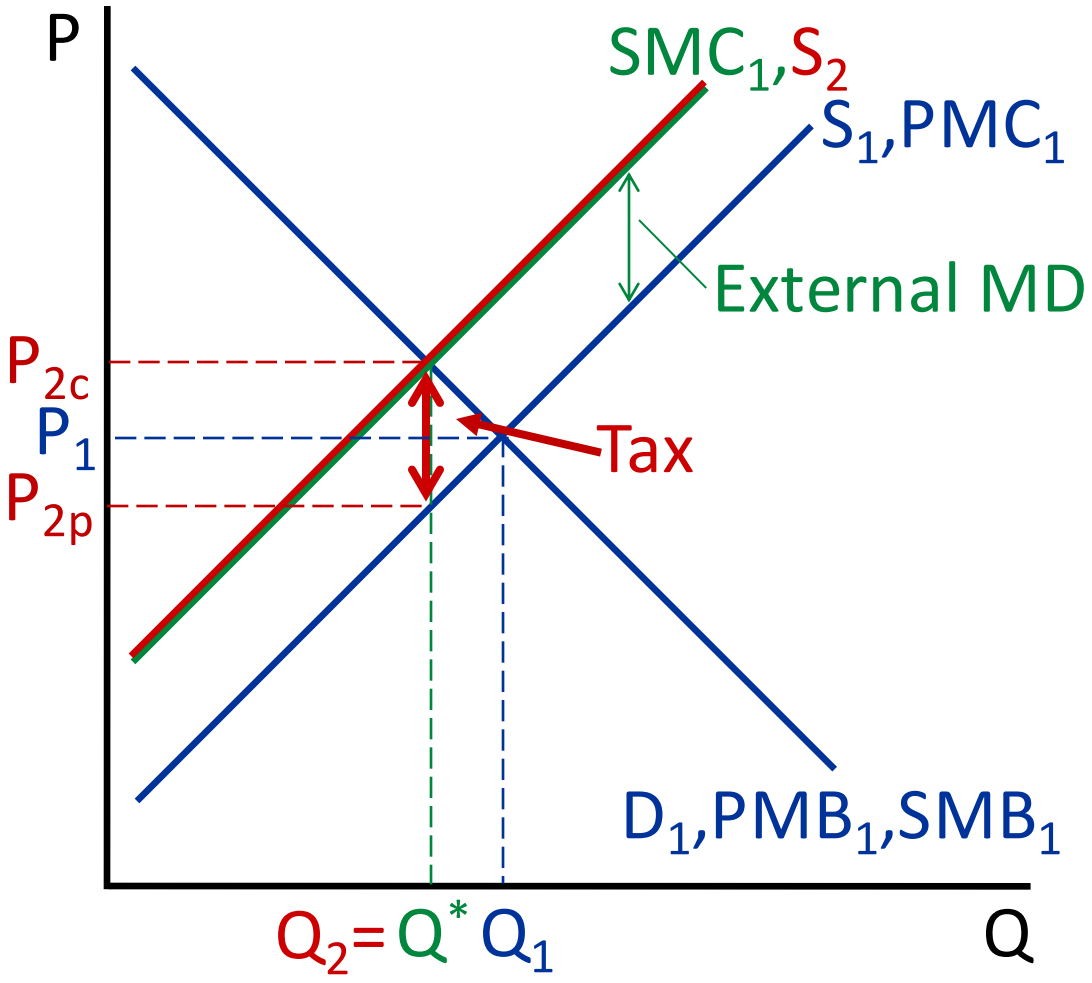
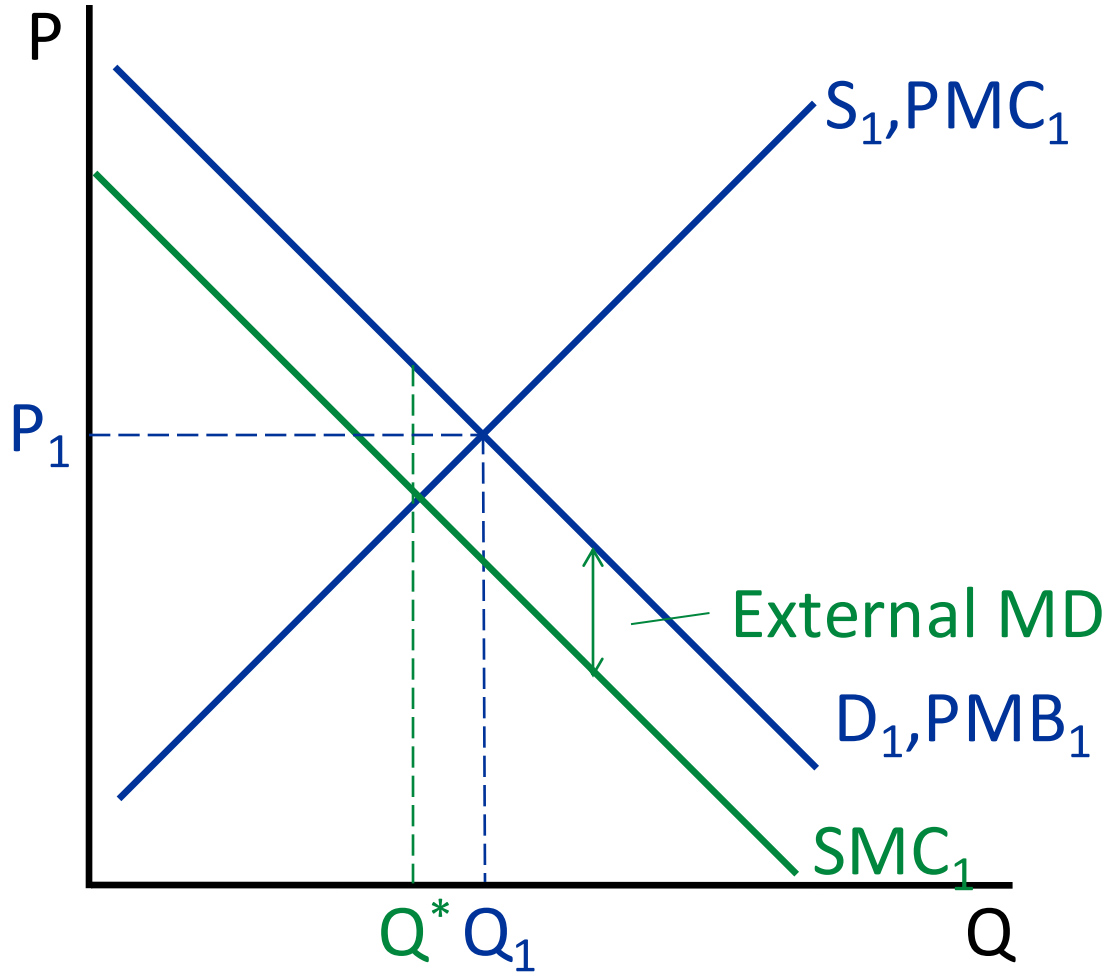
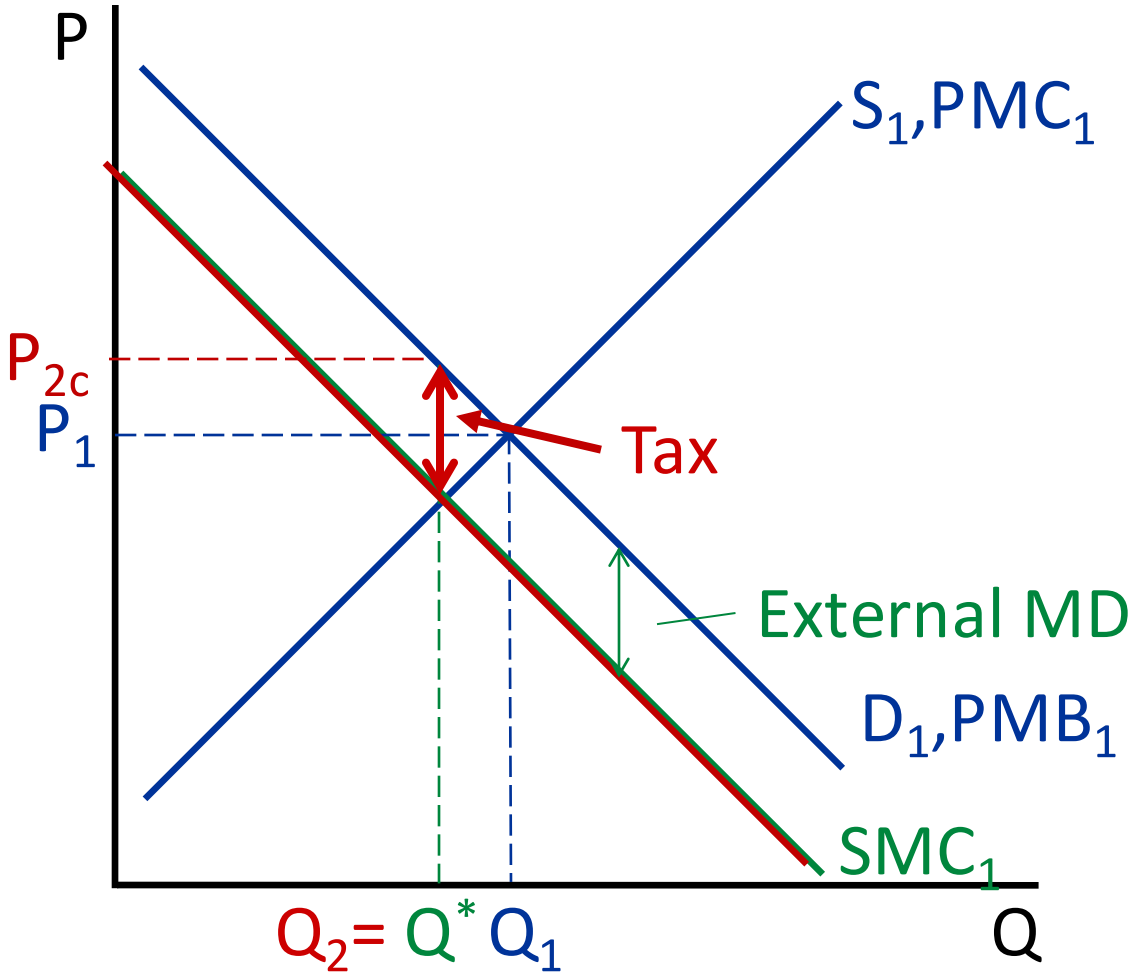



A tax on producers equal to the external MC shifts PMC up to SMC and moves equil. from $Q_1$ to $Q_2$=Q*. $P_{2c}$ is consumer price, $P_{2p}$ producer price

# Tax Remedy for a Negative Consumption Externality

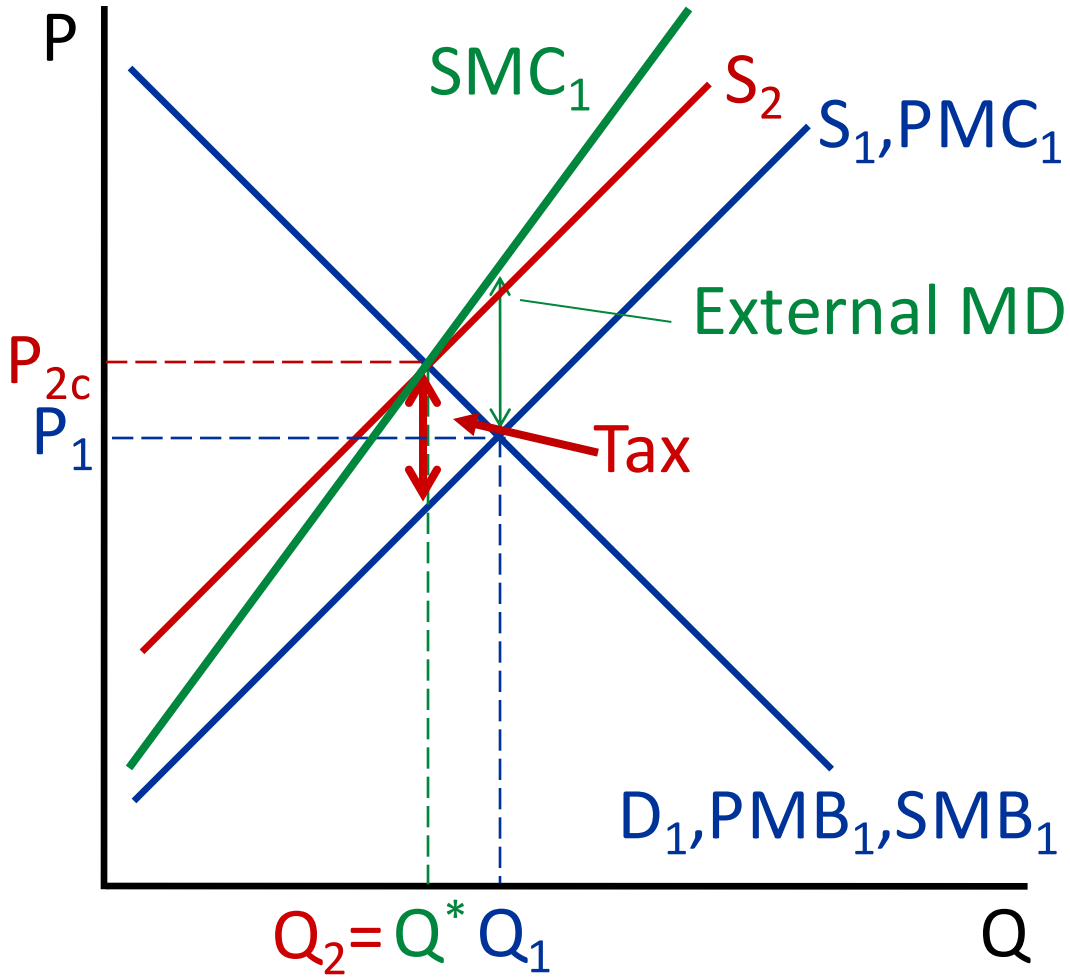


# Tax Remedy for a Negative Consumption Externality



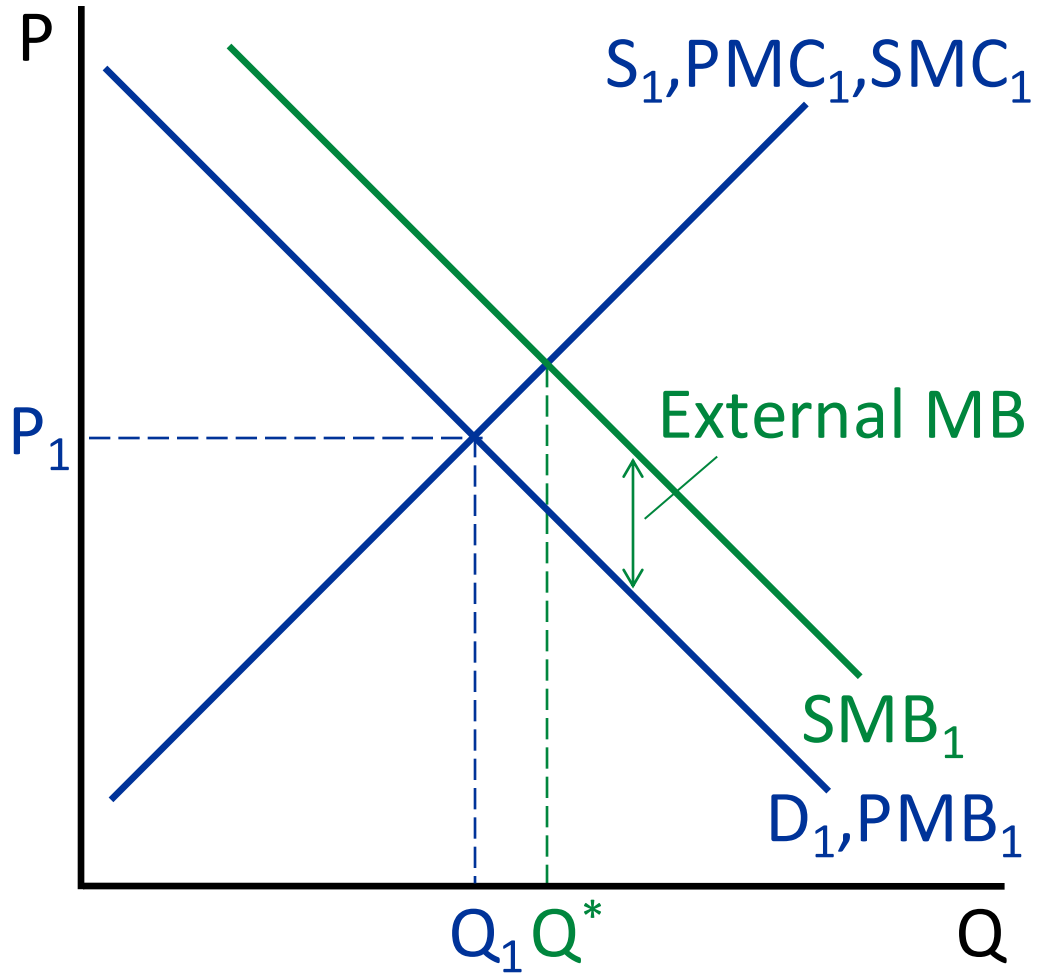

A tax on consumers equal to the external MC shifts PMB down to SMB and moves equilibrium from $Q_1$ to $Q_2$=Q*.

# Tax Remedy for Negative Externality with non constant MC

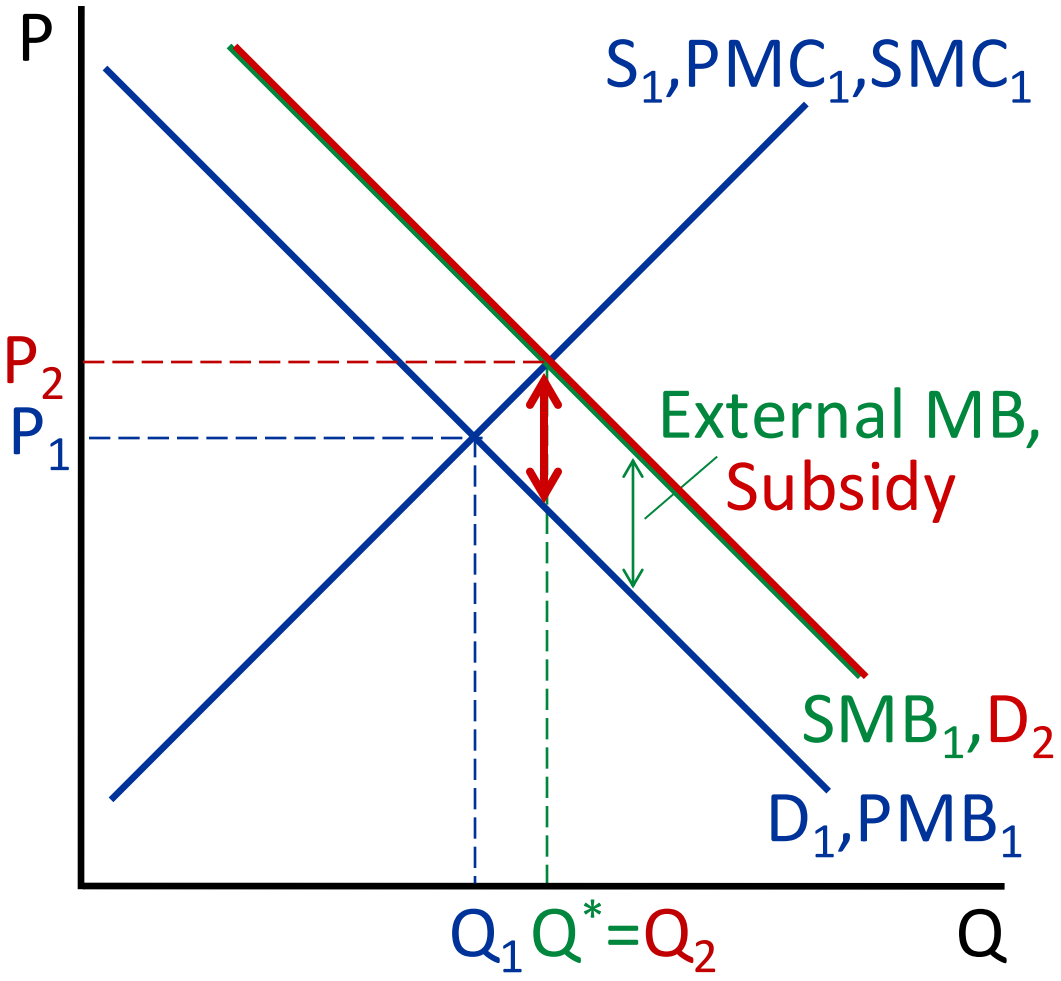



A tax per unit equal to the external MC at Q* shifts PMC up and moves equilibrium from $Q_1$ to $Q_2$=Q*

# Remedy for a Positive Externality (Subsidy)



# Remedy for a Positive Externality (Subsidy)




A producer subsidy equal to the external MB shifts PMB up to SMB and moves equilibrium from $Q_1$ to $Q_2$=Q*