

Externalities

131 Undergraduate Public Economics
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OUTLINE

Second part of course is going to cover market failures and show how government interventions can help

- 1) Externalities and public goods
- 2) Asymmetric information (social insurance)
- 3) Individual failures (savings for retirement)

EXTERNALITIES

Market failure: A problem that violates one of the assumptions of the 1st welfare theorem and causes the market economy to deliver an outcome that does not maximize efficiency

Externality: Externalities arise whenever the actions of one economic agent **directly** affect another economic agent outside the market mechanism

Externality example: a steel plant that pollutes a river used for recreation

Not an externality example: a steel plant uses more electricity and bids up the price of electricity for other electricity customers

Externalities are one important case of market failure

EXTERNALITY THEORY: ECONOMICS OF NEGATIVE PRODUCTION EXTERNALITIES

Negative production externality: When a firm's production reduces the well-being of others who are not compensated by the firm.

Private marginal cost (PMC): The direct cost to producers of producing an additional unit of a good = Supply curve

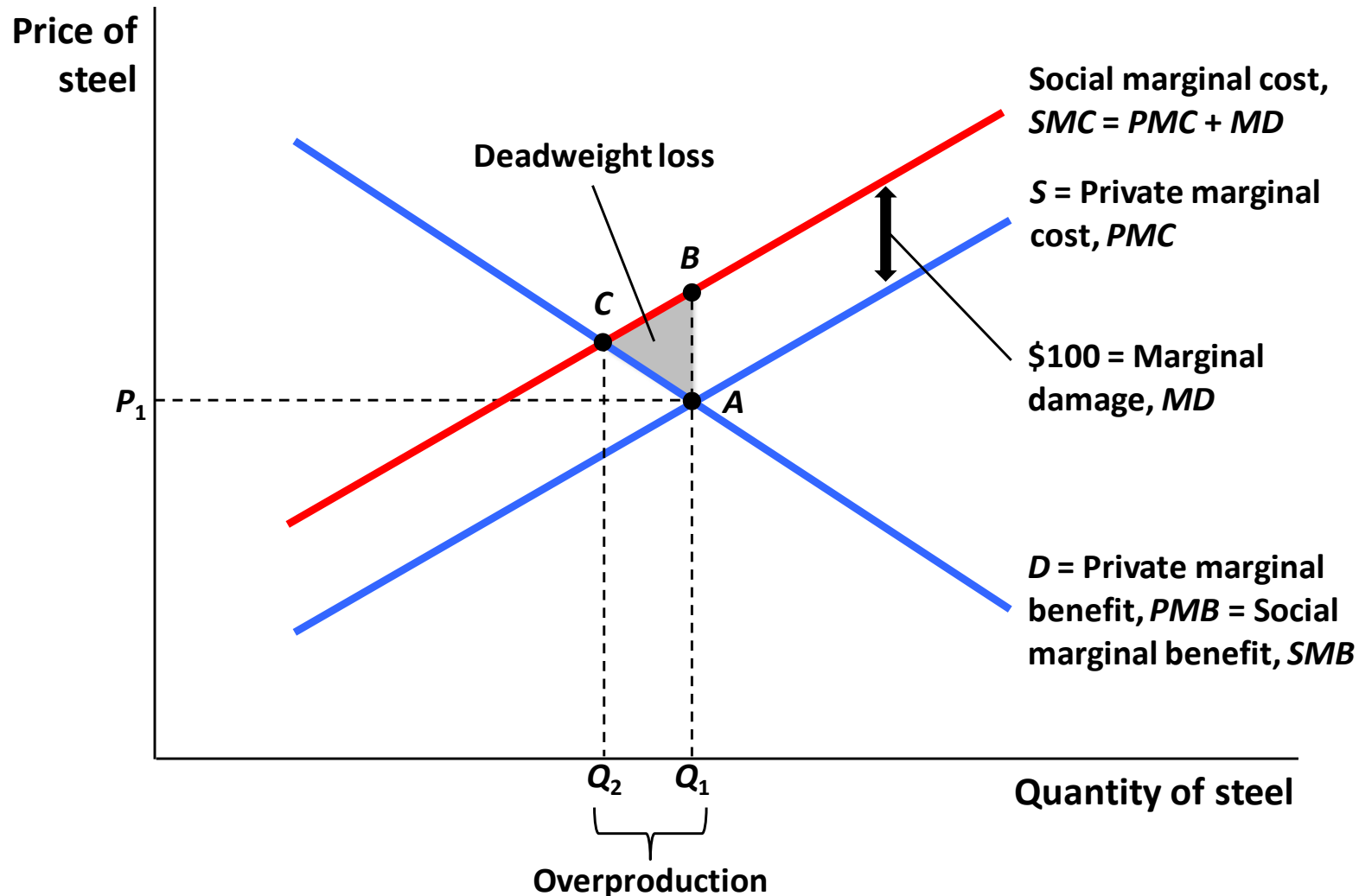
Marginal Damage (MD): Any additional costs associated with the production of the good that are imposed on others but that producers do not pay

Social marginal cost ($SMC = PMC + MD$): The private marginal cost to producers plus marginal damage

Example: steel plant pollutes a river but plant does not face any pollution regulation (and hence ignores pollution when deciding how much to produce)

5.1

Economics of Negative Production Externalities: Steel Production



EXTERNALITY THEORY: ECONOMICS OF NEGATIVE CONSUMPTION EXTERNALITIES

Negative consumption externality: When an individual's consumption reduces the well-being of others who are not compensated by the individual.

Private marginal benefit (PMB): The direct benefit to consumers of consuming an additional unit of a good by the consumer = Demand curve

Social marginal benefit (SMB): The private marginal benefit to consumers minus any costs associated with the consumption of the good that are imposed on others

Example: Using a car and emitting carbon contributing to global warming

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.

Externality Theory: Positive Externalities

Positive production externality: When a firm's production increases the well-being of others but the firm is not compensated by those others.

Example: Beehives of honey producers have a positive impact on pollination and agricultural output

Positive consumption externality: When an individual's consumption increases the well-being of others but the individual is not compensated by those others.

Example: Beautiful private garden that passers-by enjoy seeing

Externality Theory: Market Outcome is Inefficient

With a free market, quantity and price such that $PMB = PMC$

Social optimum is such that $SMB = SMC$

⇒ Private market leads to an inefficient outcome (1st welfare theorem does not work)

Negative production externalities lead to over production

Positive production externalities lead to under production

Negative consumption externalities lead to over consumption

Positive consumption externalities lead to under consumption

Private-Sector Solutions to Negative Externalities

Key question raised by Ronald Coase (famous Nobel Prize winner Chicago libertarian economist):

Are externalities really outside the market mechanism?

Internalizing the externality: When either private negotiations or government action lead the price to the party to fully reflect the external costs or benefits of that party's actions.

PRIVATE-SECTOR SOLUTIONS TO NEGATIVE EXTERNALITIES: COASE THEOREM

Coase Theorem (Part I): When there are well-defined property rights and costless bargaining, then negotiations between the party creating the externality and the party affected by the externality can bring about the socially optimal market quantity.

Coase Theorem (Part II): The efficient quantity for a good producing an externality does not depend on which party is assigned the property rights, as long as someone is assigned those rights.

COASE THEOREM EXAMPLE

Firms pollute a river enjoyed by swimmers. If firms ignore swimmers, there is too much pollution

1) Swimmers own river: If river is owned by swimmers then swimmers can charge firms for polluting the river. They will charge firms the marginal damage (MD) per unit of pollution.

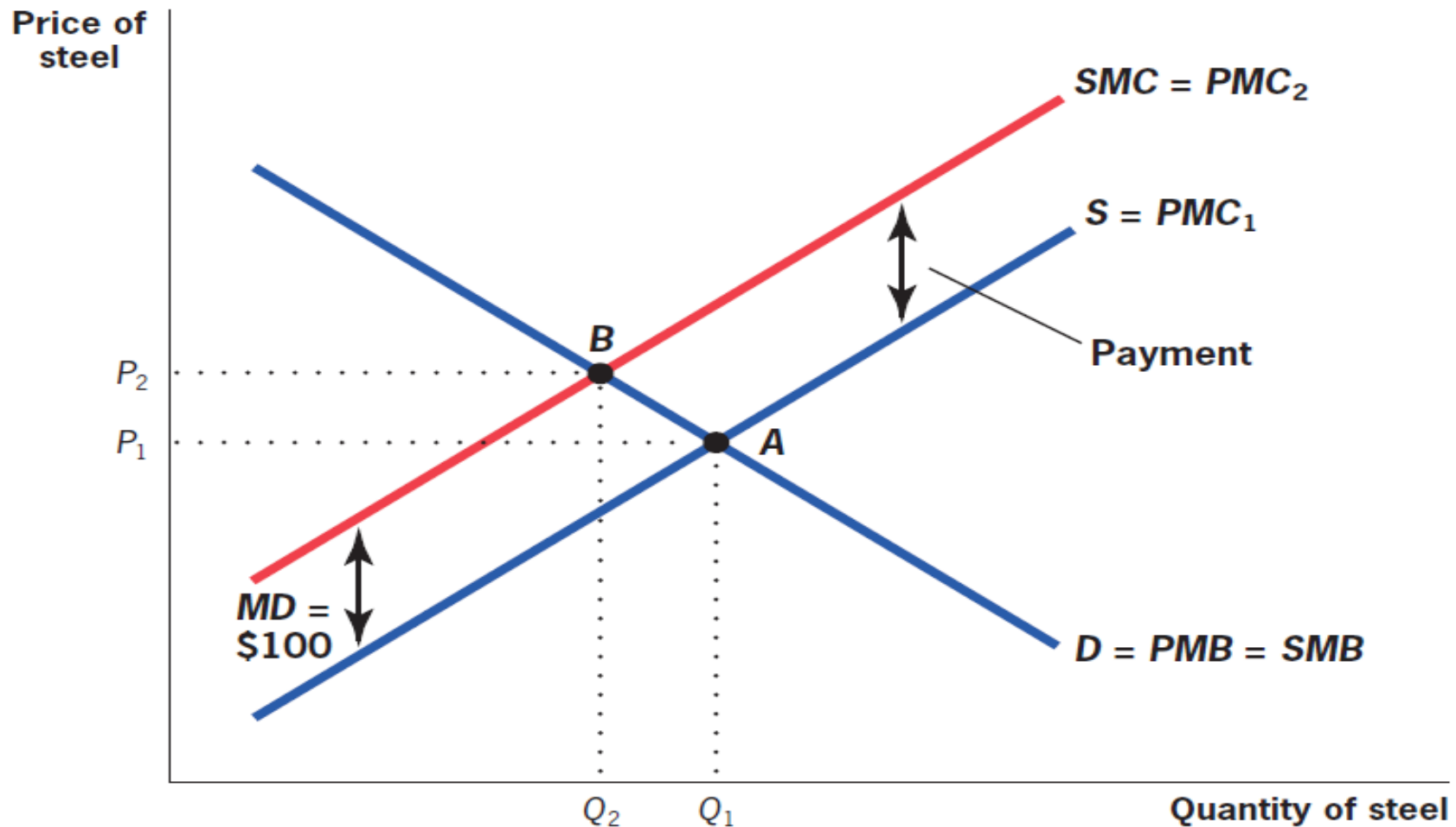
Why price pollution at MD? If price is above MD, swimmers would want to sell an extra unit of pollution and get hit by pollution damage MD, so price must fall. MD is the equilibrium efficient price in the newly created pollution market.

2) Firms own river: If river is owned by firms then firms can charge swimmers in exchange of polluting less. They will also charge swimmers the MD per unit of pollution reduction.

Final level of pollution will be the same in 1) and 2)

5.2

The Solution: Coasian Payments



PROBLEMS WITH COASIAN SOLUTION

In practice, the Coase theorem is unlikely to solve many of the types of externalities that cause market failures.

1) The assignment problem: In cases where externalities affect many agents (e.g. global warming), assigning property rights is difficult

⇒ Coasian solutions are likely to be more effective for small, localized externalities (water wells in Southern California, Ostrom 1990) than for larger, more global externalities involving large number of people and firms

2) Transaction Costs and Negotiating Problems: The Coasian approach ignores the fundamental problem that it is hard to negotiate (especially when there are large numbers of individuals on one or both sides of the negotiation)

This problem is amplified for an externality such as global warming, where the potentially divergent interests of billions of parties on one side must be somehow aggregated for a negotiation.

PROBLEMS WITH COASIAN SOLUTION: BOTTOM LINE

Ronald Coase's insight that externalities can sometimes be internalized was useful.

It provides the competitive market model with a defense against the onslaught of market failures.

Market may be able to internalize some small-scale, localized externalities (e.g. beehives for pollination in agriculture has become a business rather than side-effect of honey production)

But Coasian solution unlikely with large-scale, global externalities, where only a “government” can successfully aggregate the interests of all individuals suffering from externality

Public Sector Remedies For Externalities

Public policy makers employ two types of remedies to resolve the problems associated with negative externalities:

1) quantity regulation: government limits use of externality producing chemicals. Example CFCs [chlorofluorocarbons] that deplete ozone layer banned in 1990s

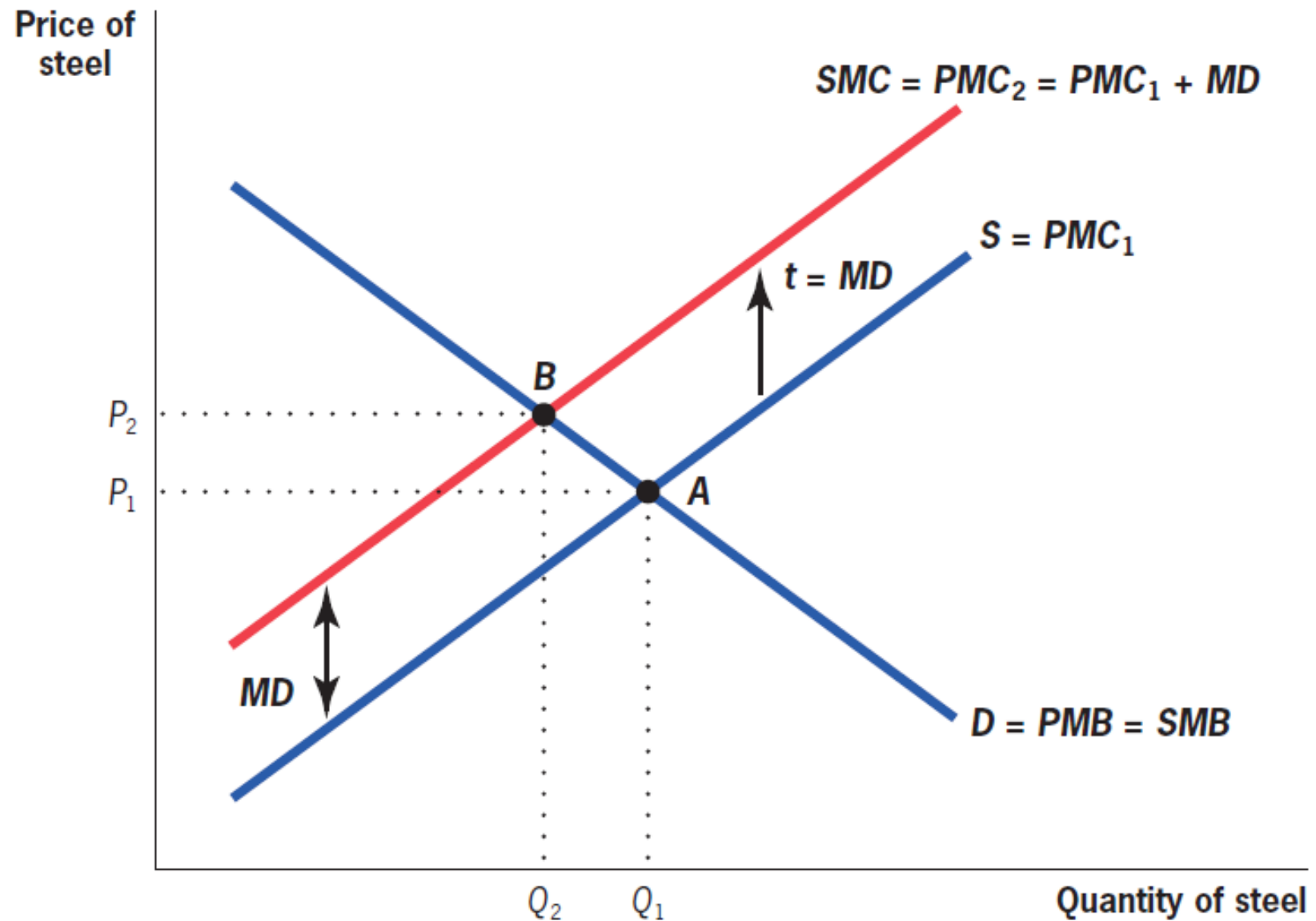
2) corrective taxation: corrective tax or subsidy equal to marginal damage per unit. Example: Carbon tax to fight global warming due to CO₂ emissions

1) and 2) can be combined with **tradable emissions permits** to firms that can then be traded (cap-and-trade for carbon emissions)

Key advantage (for economists) of price policy or tradable permits: price of emissions is the same for all which is efficient

5.3

Corrective Taxation



CORRECTIVE TAXES VS. TRADABLE PERMITS

Two differences between corrective taxes and tradable permits (carbon tax vs. cap-and-trade in the case of CO₂ emissions)

1) Initial allocation of permits: If the government sells them to firms, this is equivalent to the tax

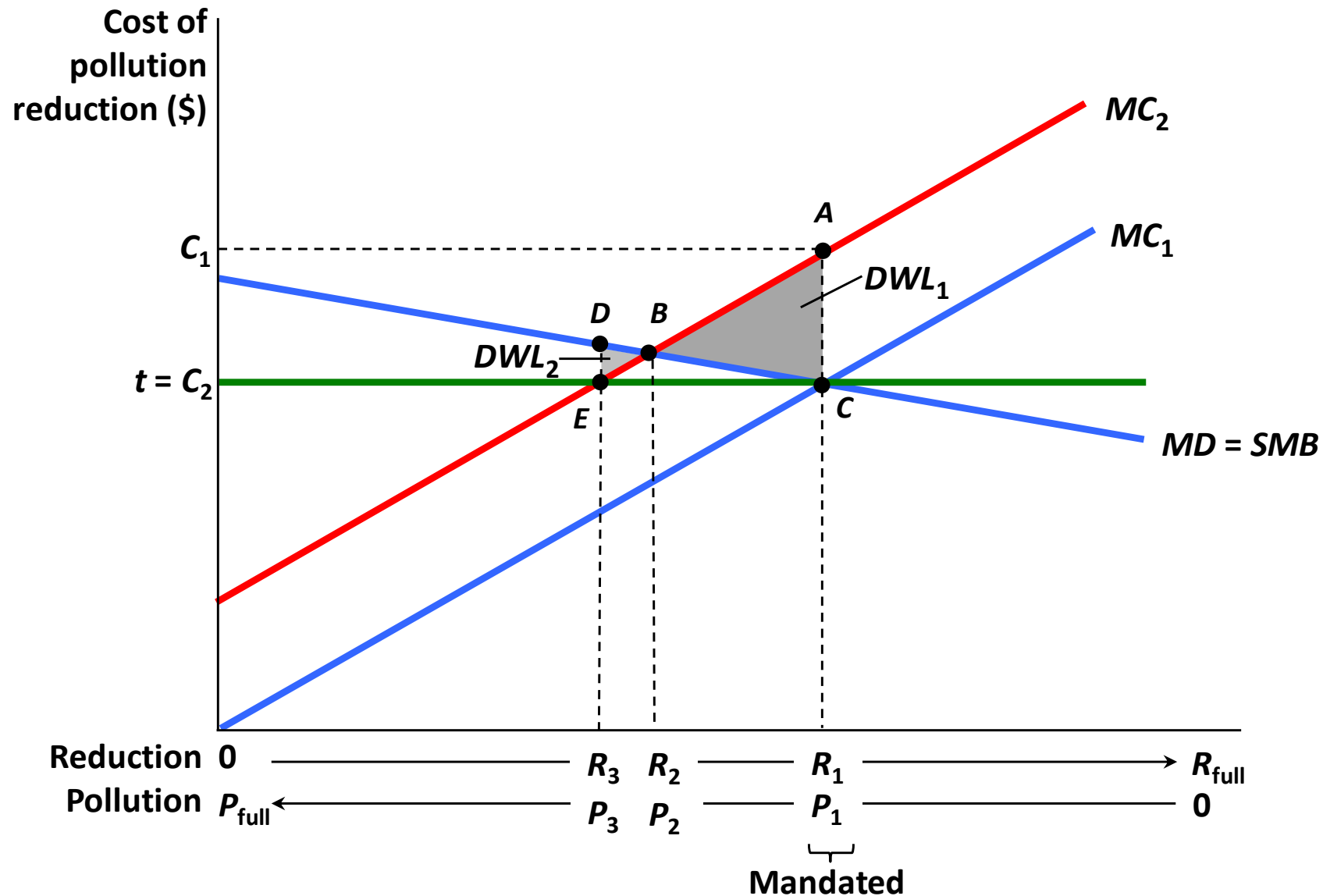
If the government gives them to current firms for free, this is like the tax + large transfer to initial polluting firms.

2) Uncertainty in marginal costs: With uncertainty in costs of reducing pollution, tax cannot target a specific quantity while tradable permits can \Rightarrow two policies no longer equivalent.

Taxes preferable when MD curve is flat. Tradable permits are preferable when MD curve is steep.

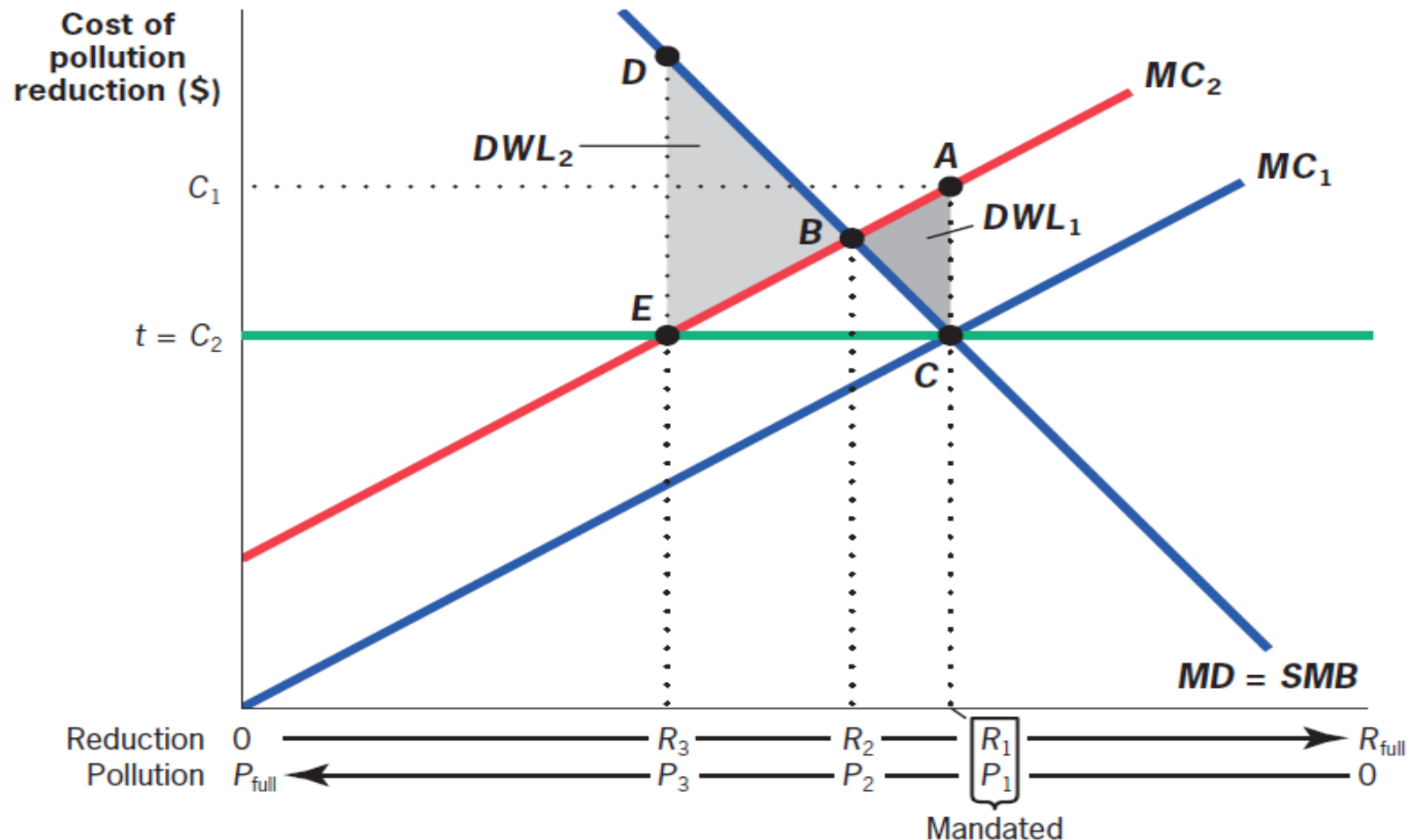
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Uncertainty About Costs of Reduction: Case 1: Flat MD Curve (Global Warming)



5.4

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



Empirical Example: Acid Rain and Health

Acid rain due to contamination by emissions of sulfur dioxide (SO_2) and nitrogen oxide (NO_x).

1970 Clean Air Act: Landmark federal legislation that first regulated acid rain-causing emissions by setting maximum standards for atmospheric concentrations of various substances, including SO_2 .

The 1990 Amendments and Emissions Trading:

SO_2 allowance system: The feature of the 1990 amendments to the Clean Air Act that granted plants permits to emit SO_2 in limited quantities and allowed them to trade those permits.

Empirical Example: Effects of Clean Air Act of 1970

How does acid rain (or SO_2) affect health?

Observational approach: relate mortality in a geographical area to the level of particulates (such as SO_2) in the air

Problem: 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

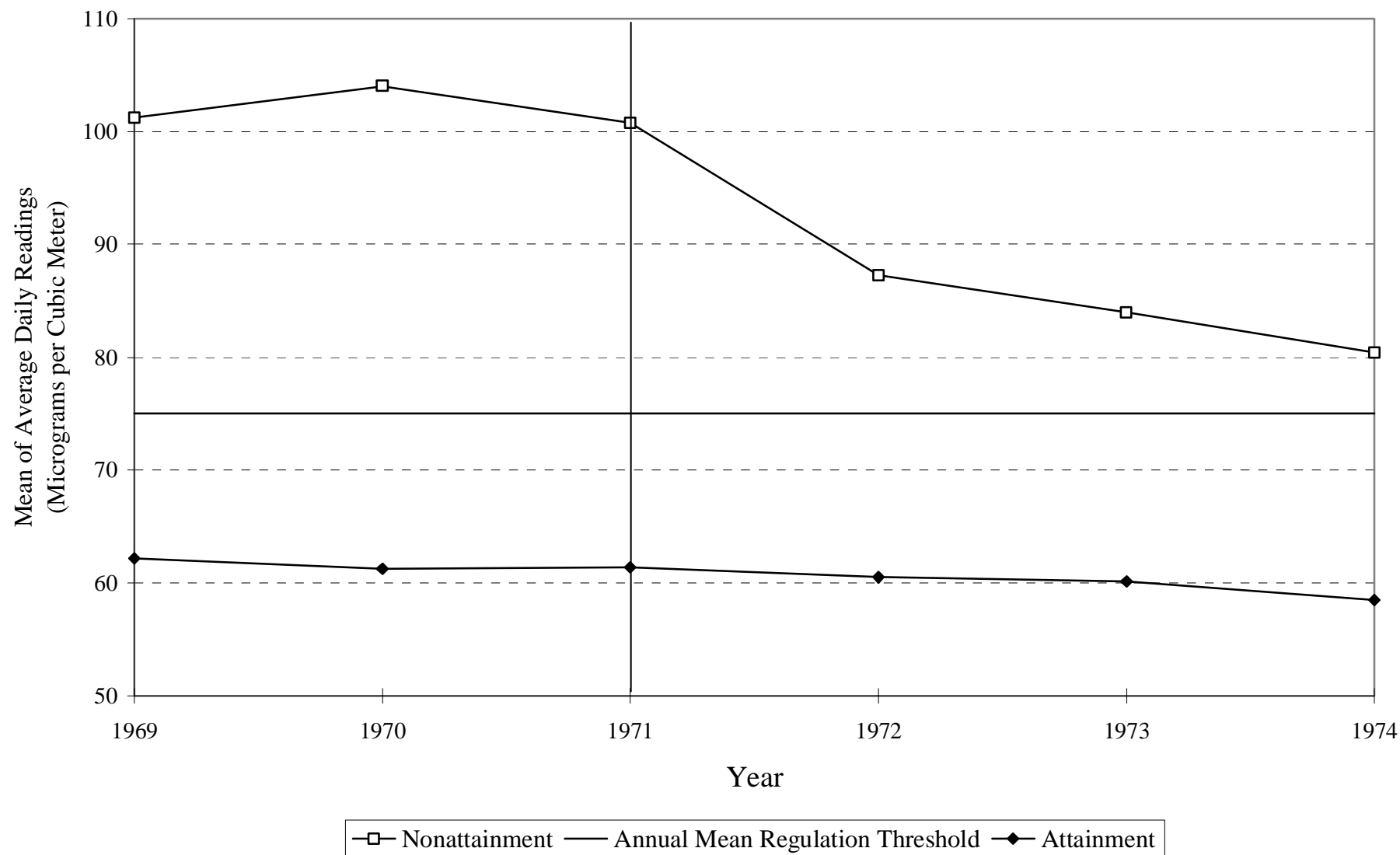
Chay and Greenstone (2003) use clean air act of 1970 to resolve the causality problem:

Areas with more particulates than threshold required to clean up air [treatment group]. Areas with less particulates than threshold are control group.

Compares infant mortality across 2 types of places before and after (DD approach)

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

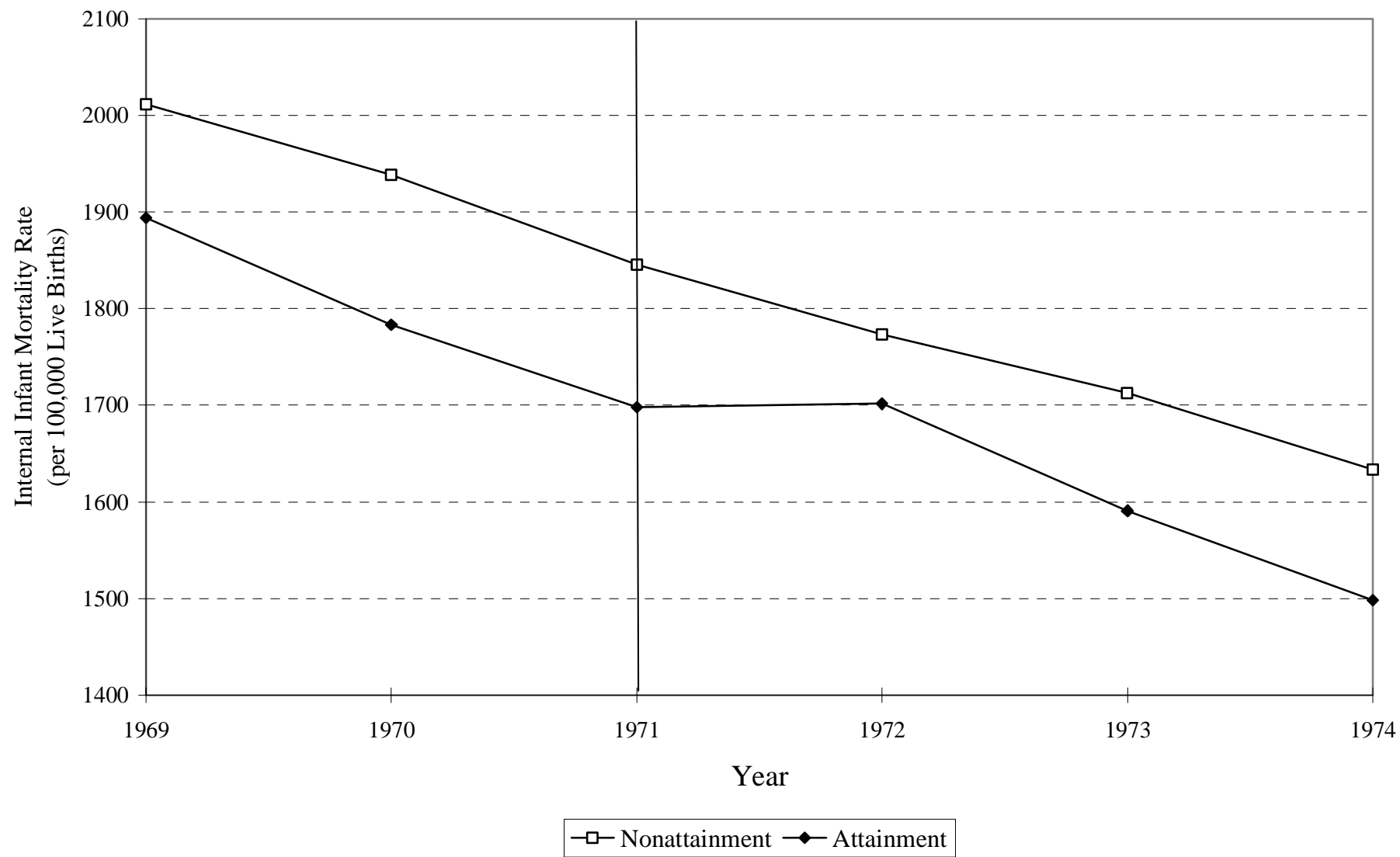
A. Trends in Mean TSPs Concentrations, by 1972 Nonattainment Status



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)

Climate Change and CO2 Emissions

Industrialization has dramatically increased CO2 emissions and atmospheric CO2 generates global warming

Four factors make this challenging (Wagner-Weitzman 2015):

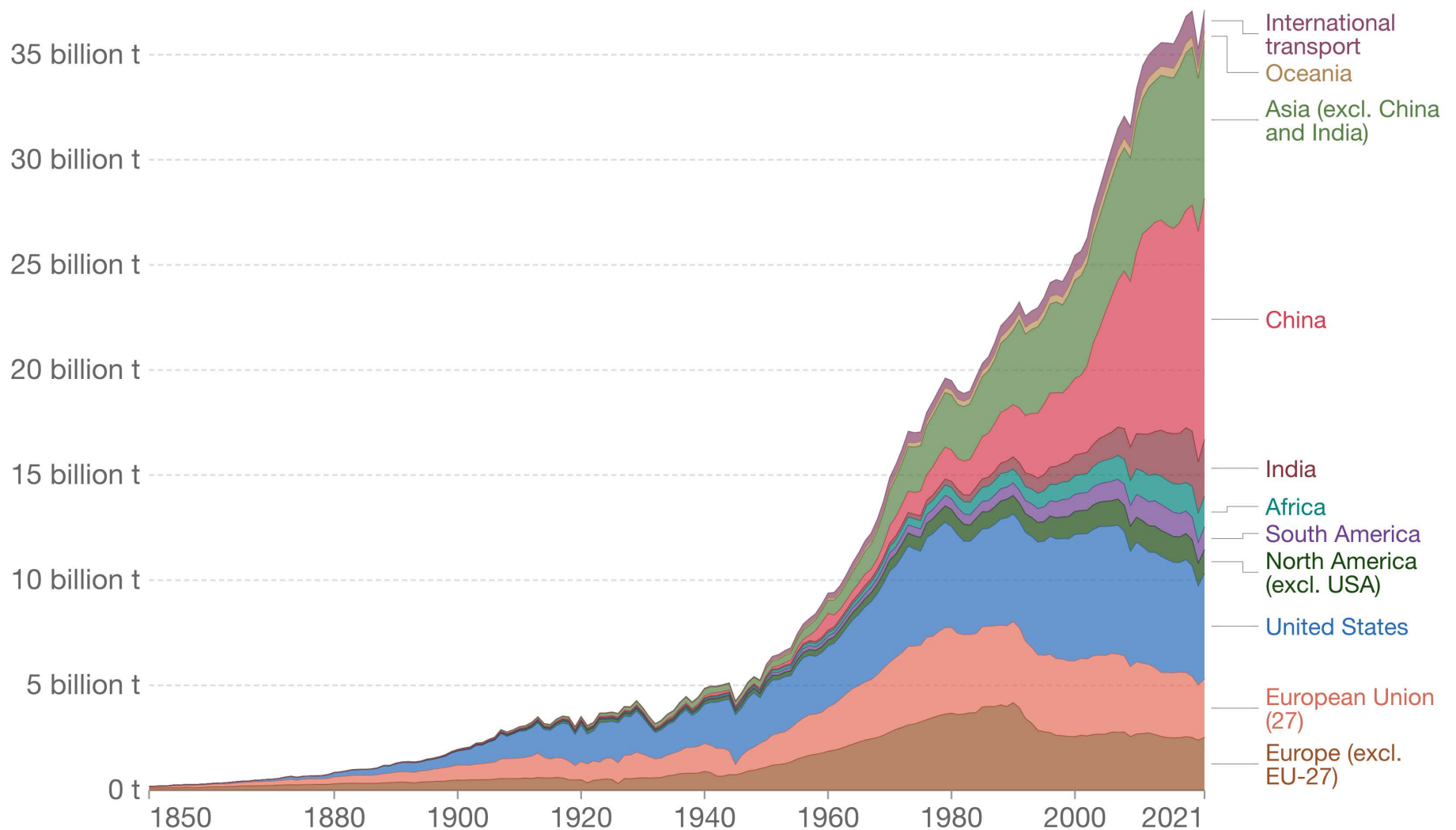
- 1) Global:** Emissions in one country affect the full world
- 2) Irreversible:** Atmospheric CO2 has long life (centuries) [absent carbon capture tech breakthrough]
- 3) Long-term:** Costs of global warming are decades/centuries away [how should this be discounted?]
- 4) Uncertain:** Great uncertainty in costs of global warming [mitigation vs. amplifying feedback loops]

How fast should we start reducing emissions? [Stern-Weitzman want a fast reduction, Nordhaus advocates a slower path]

Annual CO₂ emissions by world region

This measures fossil fuel and industry emissions¹. Land use change is not included.

Our World
in Data



Source: Our World in Data based on the Global Carbon Project (2022)

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

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ 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.

Main costs of global warming

Enormous variation across geographical areas and economic development. Pace of change makes adaptation daunting

1) Sea rise will flood low lying coasts and major population centers in many countries (e.g., Miami, Florida; value of real estate subject to regular flooding has dropped)

2) Impact on bio-diversity (mass extinctions)

3) Agricultural production could be disrupted by climate change creating food security risks:

demand for food is very inelastic in the short-run \Rightarrow Spikes in prices if agricultural output falls \Rightarrow disruption/famines possible in low income countries

4) Droughts and heat waves will make many places less livable

Some societies may collapse and generate mass migration movements

Empirical Example: Adjusting to Global Warming

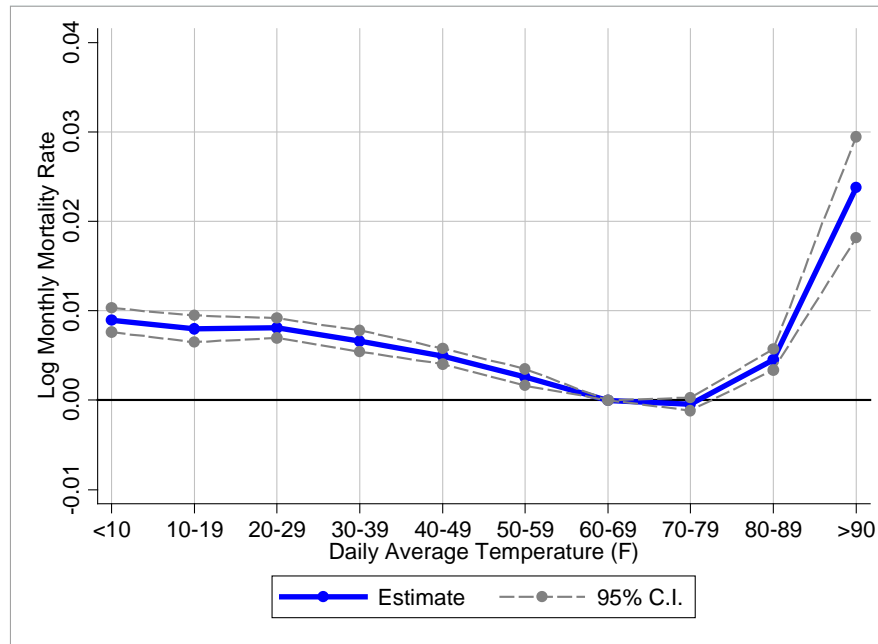
Estimating costs of Global warming is difficult because society will adapt and reduce costs (relative to a scenario with no adaptation)

Example: heat waves and mortality analysis of Barreca et al. (2016)

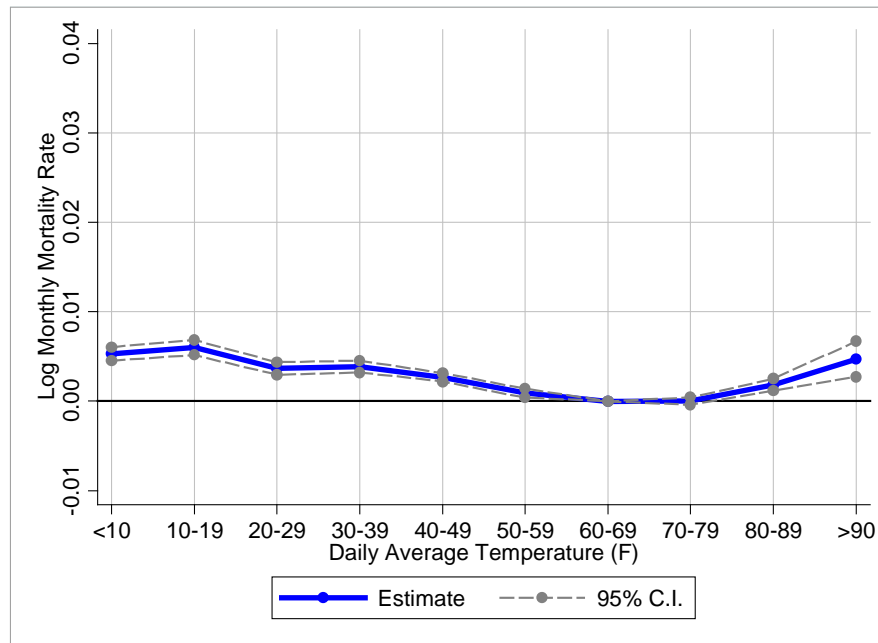
- 1) The mortality effect of an extremely hot day (80°F+) declined by about 75% between 1900-1959 and 1960-2004.
- 2) Adoption of residential air conditioning (AC) explains the entire decline
- 3) Worldwide adoption of AC will speed up the rate of climate change (if fossil fuel powered)

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,

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

Global Warming: Economists' Narrow View

Economists view global warming as a classical externality

CO₂ emissions impose a global warming externality \Rightarrow Solution is to impose a carbon tax equal to the marginal damage of CO₂ emissions and let market forces work their magic

E.g. see recent economists' statement in favor of carbon tax (rebated with a fixed carbon dividend)

But what is the marginal damage of CO₂? Costs hard to evaluate and depend greatly on how you discount the future

Economists use interest rate r to discount future: \$1 today is worth $\$(1 + r)^T$ in T years (long-distance future heavily discounted: e.g., $r = 4\%$ and $T = 1000 \Rightarrow (1 + r)^T = 10^{17}$)

If interest rate is high (=individual humans are impatient), it is desirable to let global warming happen and societies collapse!

Global Warming: Broader View

Massive CO₂ emissions pose existential civilizational risk (like CFC destroying vital ozone layer)

Only solution is to decarbonize as a social choice and we need to do it fast (within decades not centuries)

Decarbonization is within sight: renewable electricity (solar/wind) + grid + big batteries could power most energy needs and replace most fossil fuels, renewable cost dropping fast

⇒ could be done without killing economic growth and without huge short-term disruptions (less costly than COVID)

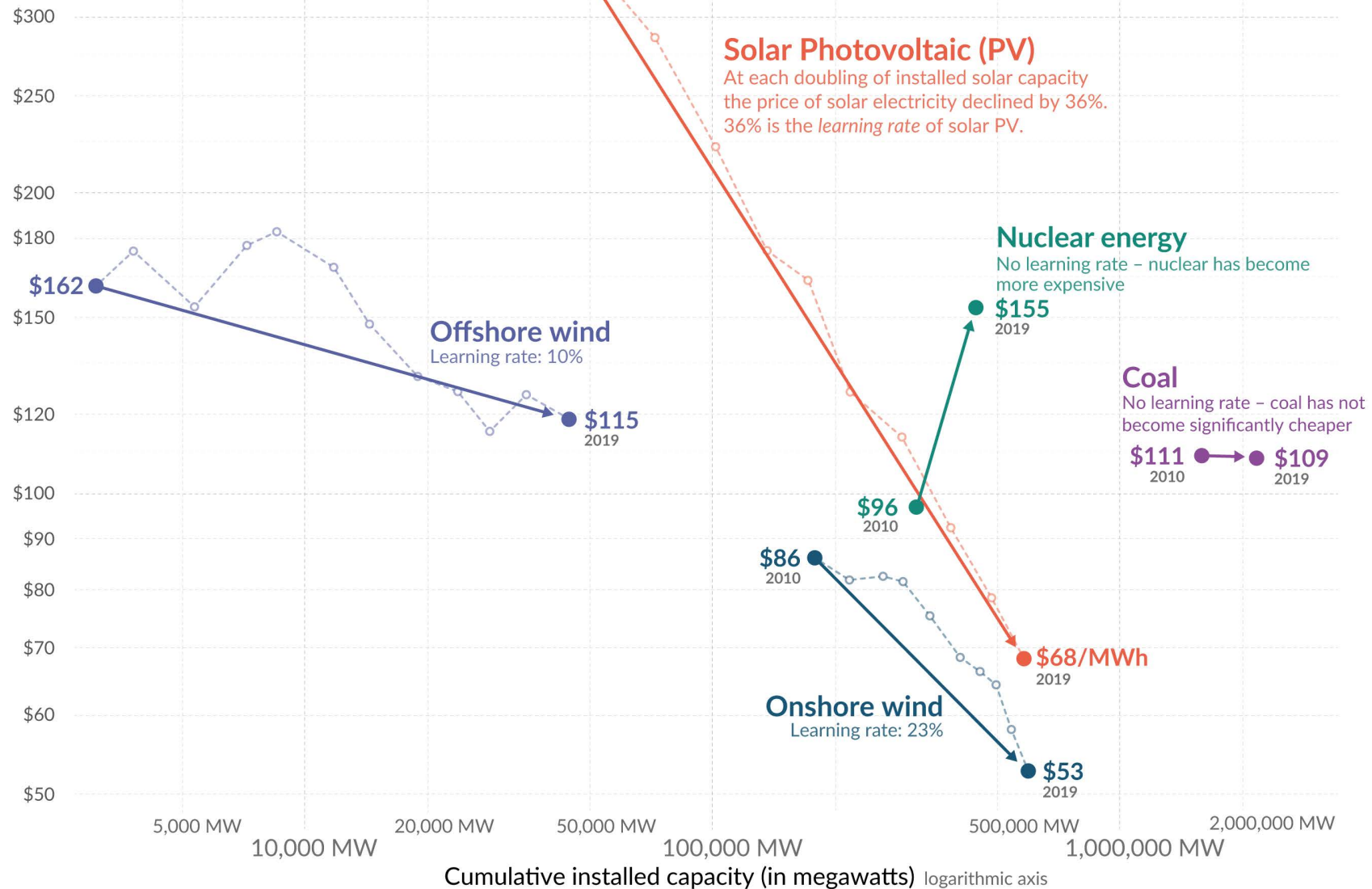
Economists' useful point: some sectors are easier to decarbonize than others (e.g. cars easier than planes)

⇒ start decarbonizing easiest sectors first (Sachs 2020)

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

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



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 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.

Global greenhouse gas emissions and warming scenarios

- 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.

Annual global greenhouse gas emissions
in gigatonnes of carbon dioxide-equivalents

150 Gt

100 Gt

50 Gt

Greenhouse gas emissions
up to the present

0

1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

No climate policies

4.1 – 4.8 °C

→ expected emissions in a baseline scenario
if countries had not implemented climate
reduction policies.

Current policies

2.5 – 2.9 °C

→ emissions with current climate policies in
place result in warming of 2.5 to 2.9°C by 2100.

Pledges & targets (2.1 °C)

→ emissions if all countries delivered on reduction
pledges result in warming of 2.1°C by 2100.

2°C pathways

1.5°C pathways

International Coordination

From one country perspective, decarbonizing is costly and benefit is modest (as global emissions is what matters)

Economists: countries need to make a coordinated binding agreement to decarbonize together

Kyoto 1997: 35 industrialized nations (but not US) agreed to reduce their emissions of greenhouse gases to 1990 levels by 2012 [with ability to trade emission rights among themselves]

Since then, series of international (but non-binding) pledges

However, a leader country can have dramatic impact:

⇒ Makes sense to provide successful local examples of decarbonization (such as California with its 100% renewable electricity mandate by 2045)

⇒ Big countries want to develop and control future renewable tech (race US vs. China is good in speeding transition)

How to Decarbonize? Richer countries

Must become a clear policy choice that mobilizes society

Encourage research on renewable technologies both public and private (King, David et al. 2015)

Plan phase out of carbon in various sectors [industrial policy] and weaken fossil fuel industry political power (Sachs 2020)

Raising carbon tax could be one tool (but we should not bet everything on it as it is regressive and unpopular)

Be flexible and compensate low income losers (to avoid yellow vests protests as in France with higher gas tax)

In the US, modest Obama moves, undone by Trump

Democrats offer **Green New Deal** (economic planning and industrial policy ideas coupled with social justice vision)

Biden administration passed Inflation-Reduction-Act in 2022

US Build back better bill (currently stalled)

Environment piece is \$555B over 10 years (= .2% of US GDP)
[COVID govt cost was \$4T over 2 years]

Does not have any carbon tax (politics of carbon tax toxic).
Instead, incentives for renewables:

- 1) \$320B in tax credits for producers and buyers of wind, solar, nuclear power (\$12.5K tax credit for electric car purchase)
- 2) Infrastructure: e.g., electric grid, high-speed rail, resilience, local renewable energy programs
- 3) Climate and clean energy research and development
- 4) Penalty on oil+gas companies for methane leaks

Fairly modest but makes US look like it's finally moving

How to Decarbonize? Developing countries

Disagreement between rich and developing countries on who should bear the cost of curbing greenhouse gas emissions

Rich countries responsible for most of historical CO₂ emissions

Poor countries want to develop using the cheapest available technologies (coal power still cheaper than renewables)

Makes sense for richer countries to encourage/help poorer countries leapfrog carbon in favor of renewable energy

Carrot: R&D on renewables in rich countries can be adopted in poorer countries, direct subsidies can help

Stick: Impose tariffs on carbon content of imported goods

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