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

Biggest externality: carbon intensive economic growth since 19th century generates climate change

SUV Externalities Example

Example: negative externalities of driving a gas powered large Sport Utility Vehicle:

1. Environmental externality: carbon emissions and global warming

2. Infrastructure externality: Larger cars wear down the roads more

3. Safety externality on other drivers: The odds of having a fatal accident increase if hit by a bigger car

4. Congestion externality: driving a car adds to traffic which increases travel time for others

QUIZ ON EXTERNALITIES

Question: Which of these is NOT a negative externality?

A. Cigarette smoking that damages your future health.

B. Texting while driving which increases accident risk.

C. Pesticide runoff from farms that pollutes land/water.

D. Noise related to a construction project.

E. All are negative externalities

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

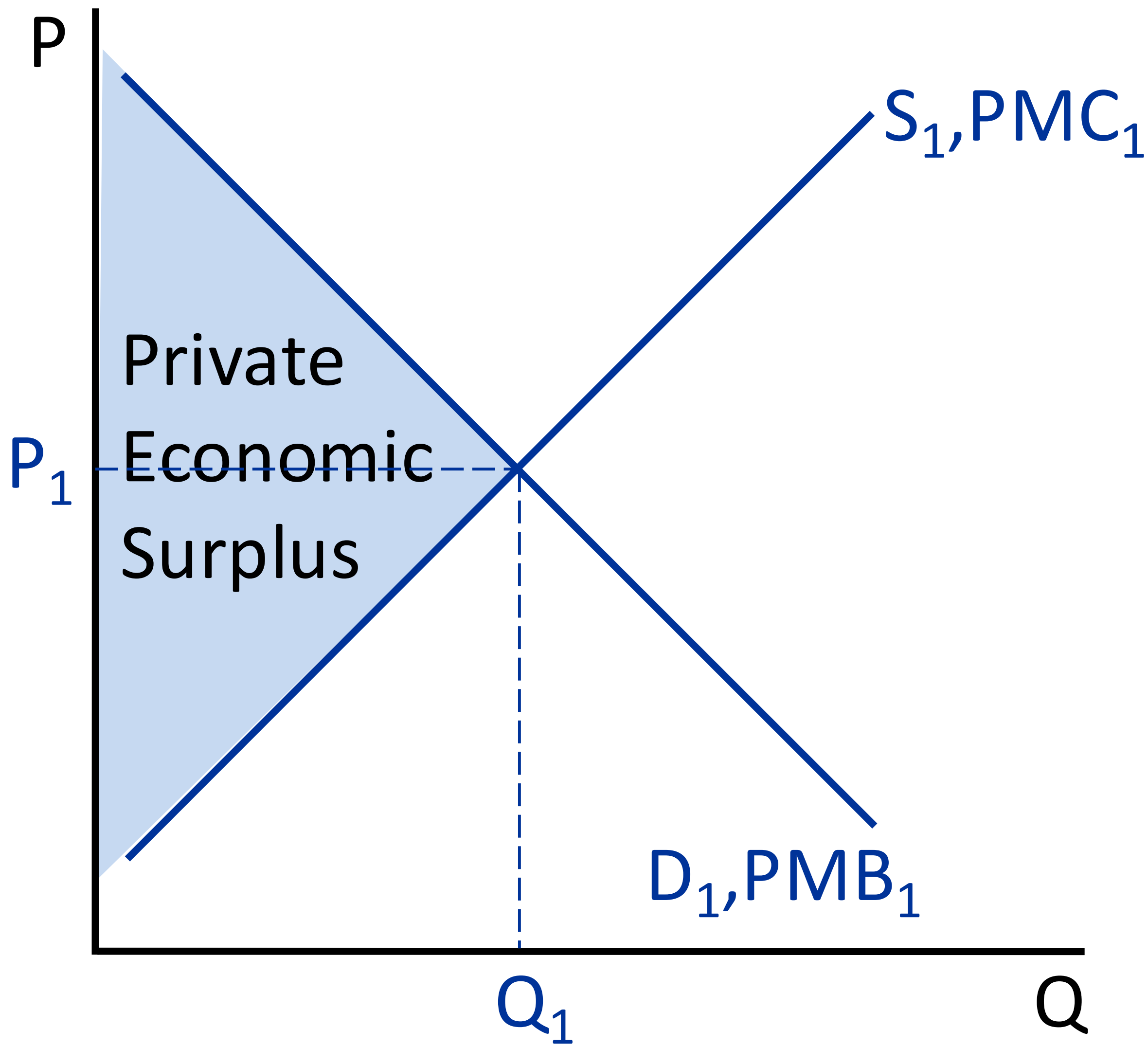
Marginal Damage (MD): Any additional costs associated with the production of the good that are imposed on others but that producers do not pay

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

Example: coal power plant produces electricity and emits carbon contributing to global warming

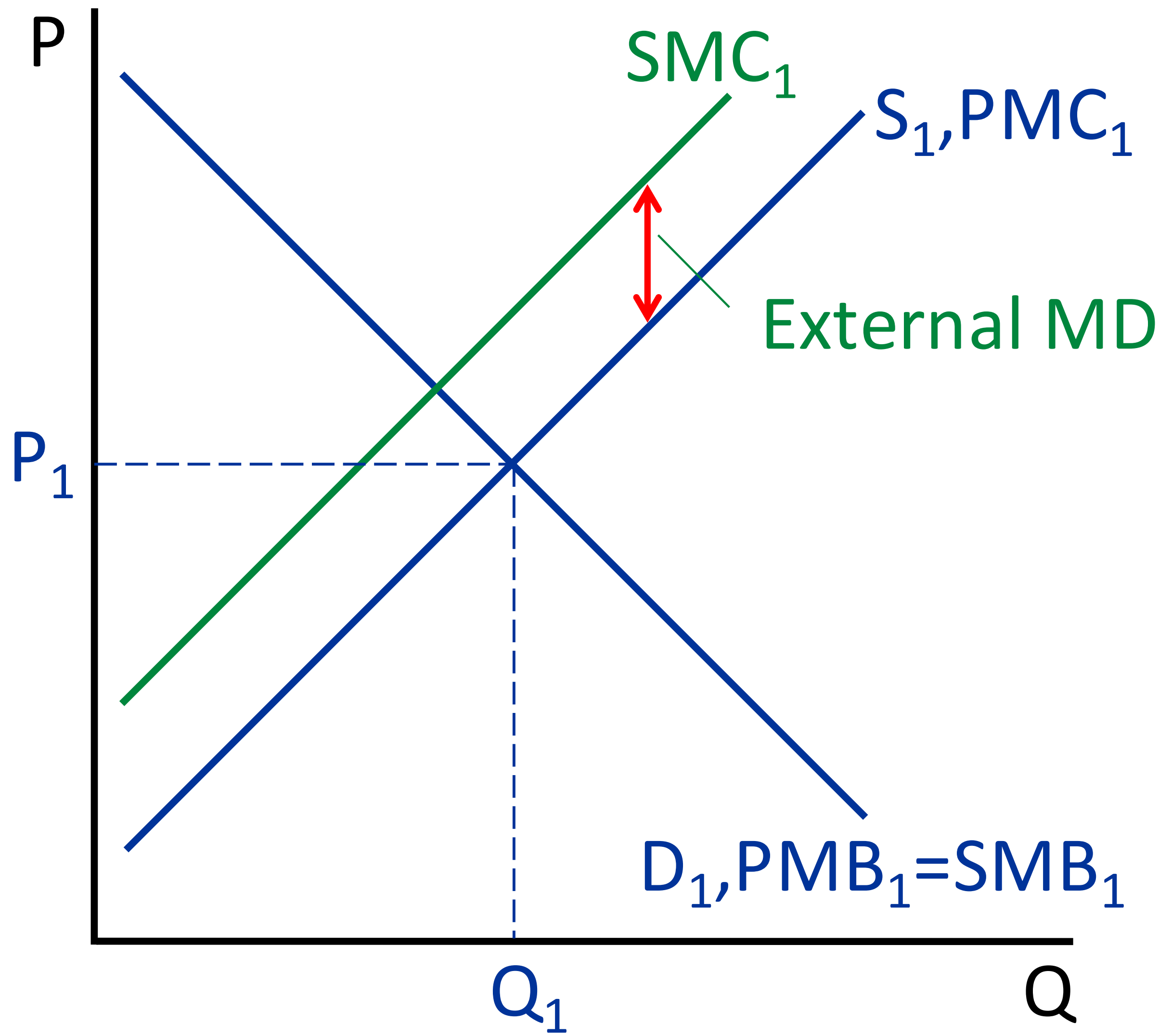
Negative Production Externality

(Market for Coal Powered Electricity)



Negative Production Externality

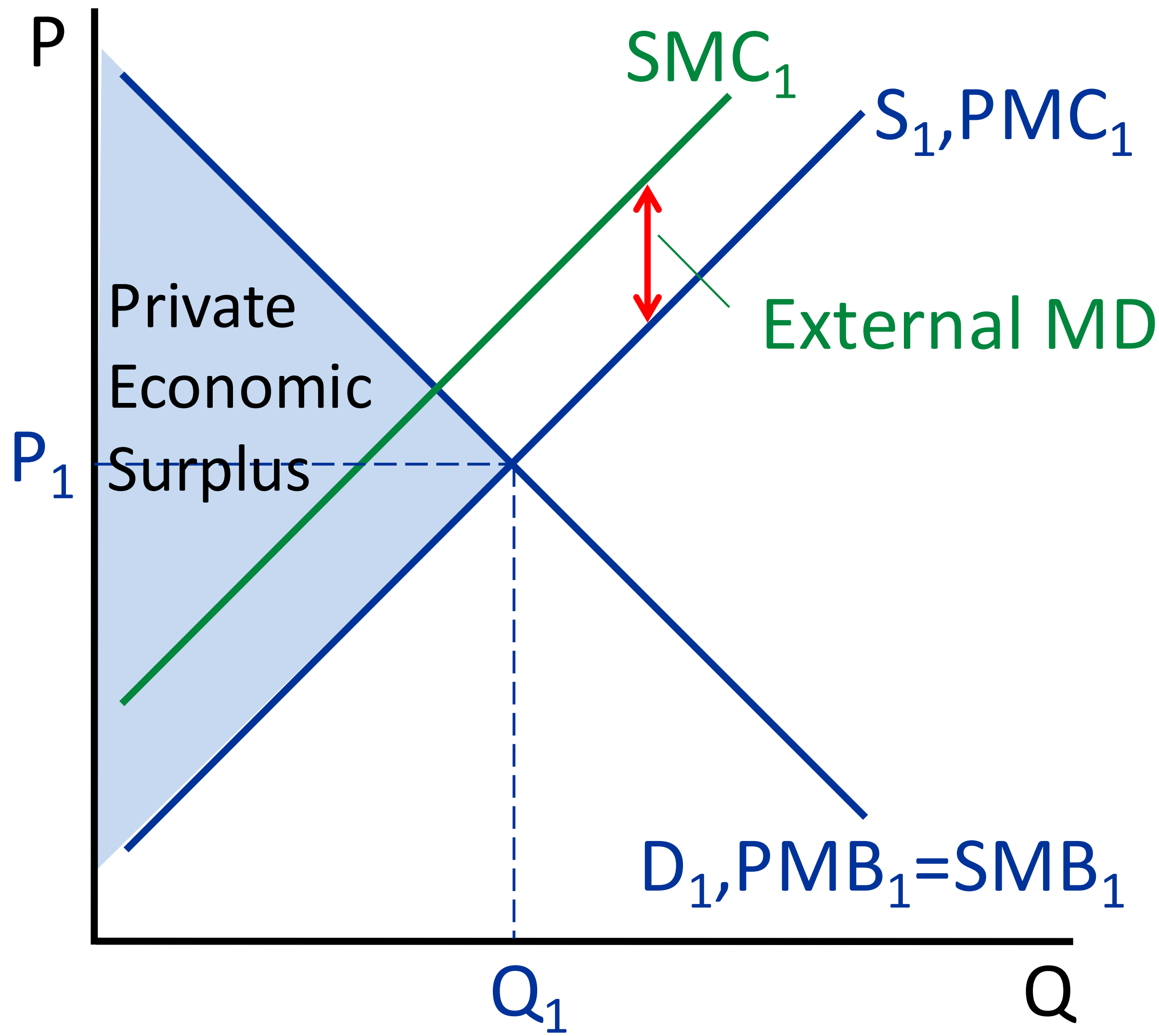
(Market for Coal Powered Electricity)



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

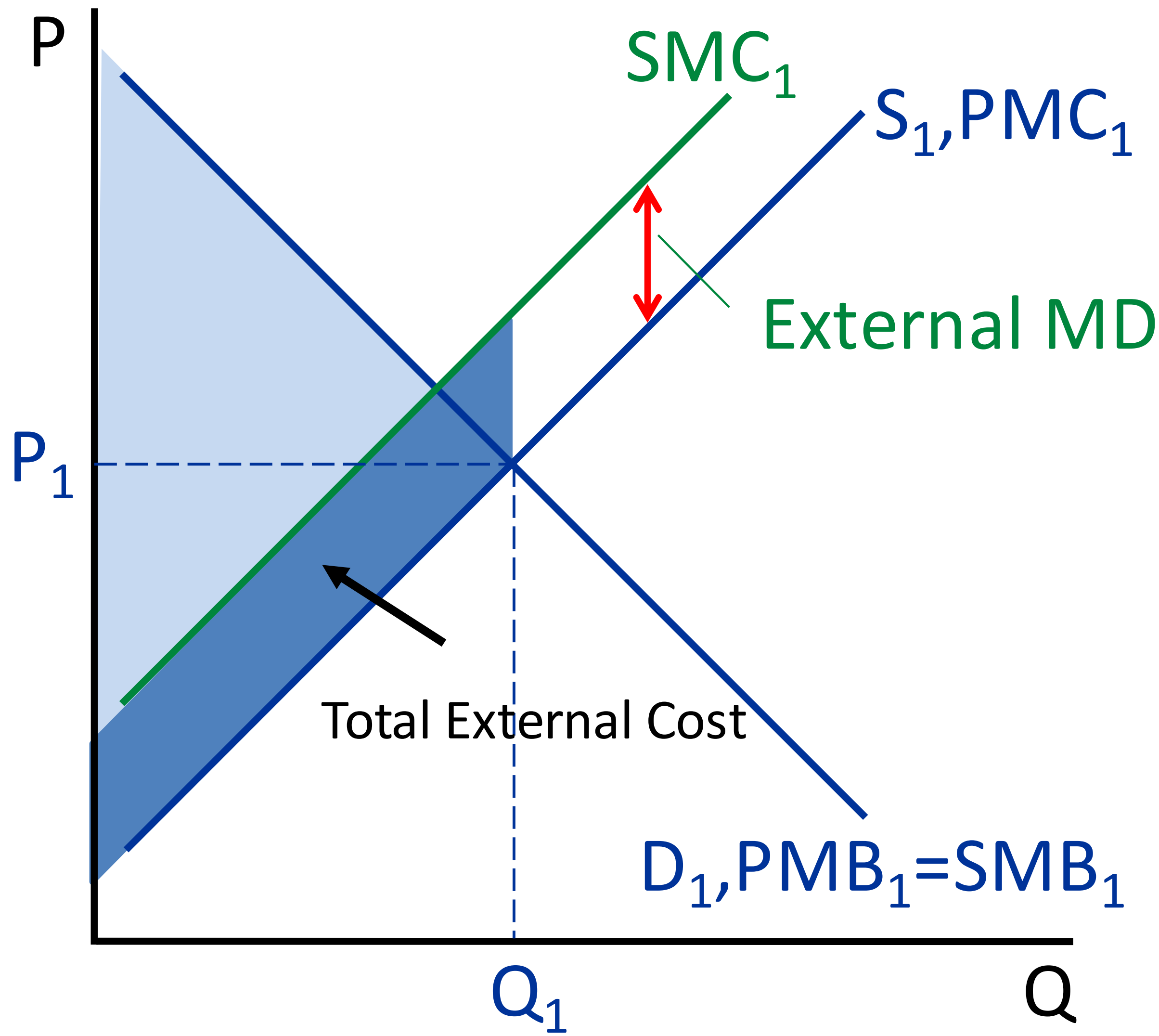
(Market for Coal Powered Electricity)



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

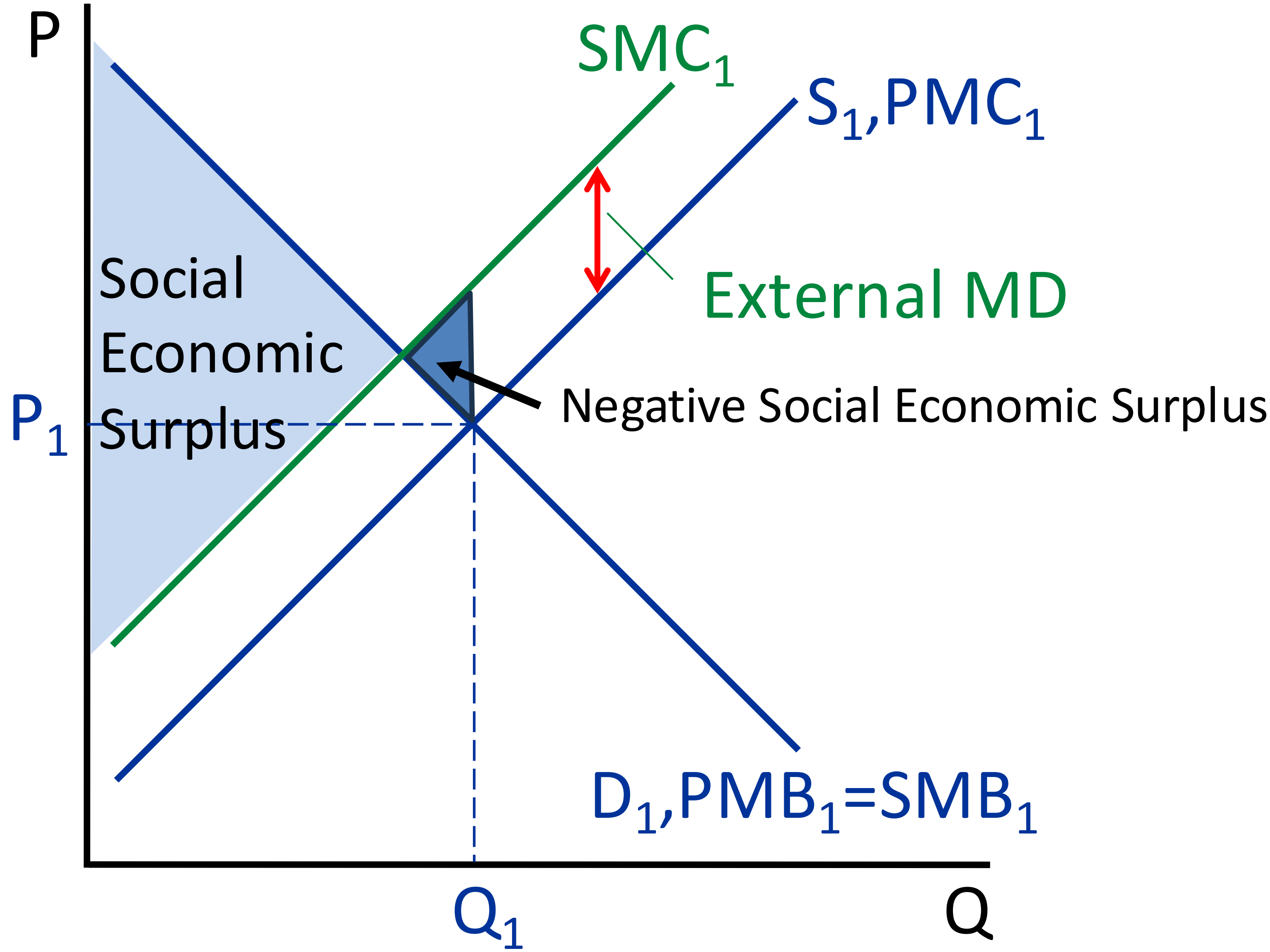
(Market for Coal Powered Electricity)



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

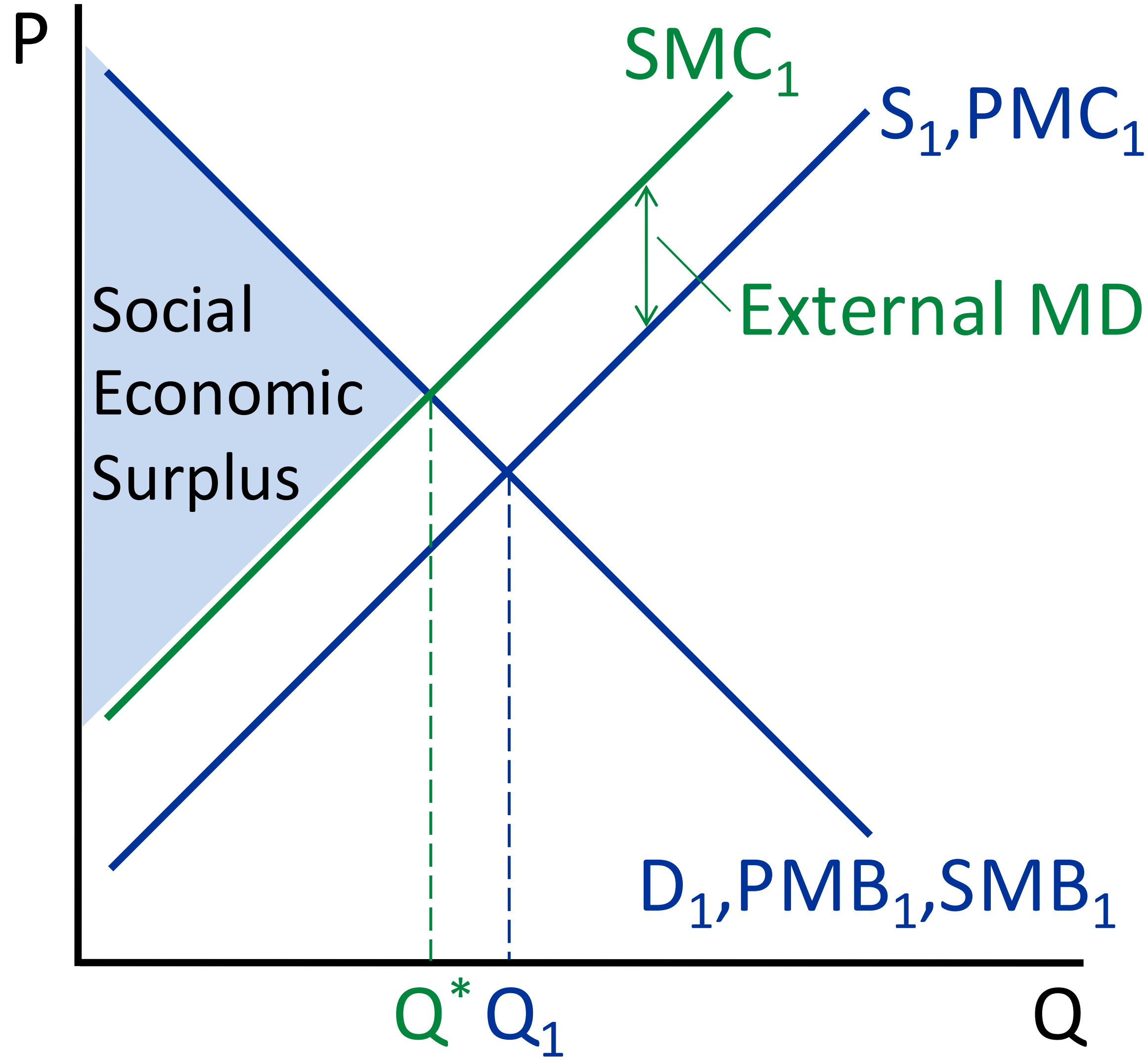
Negative Production Externality

(Market for Coal Powered Electricity)



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

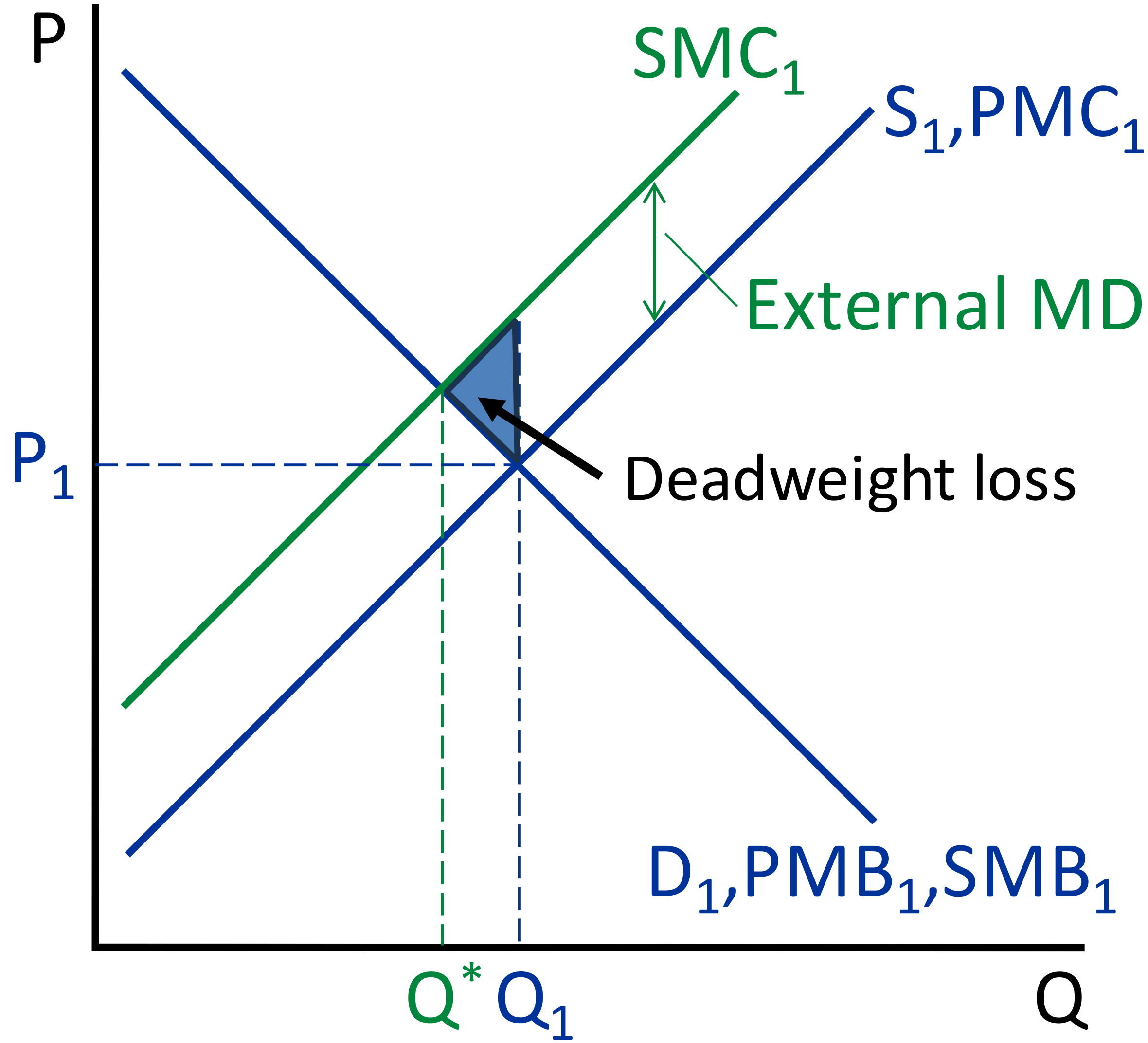
Efficient Quantity with Externality



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*

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.

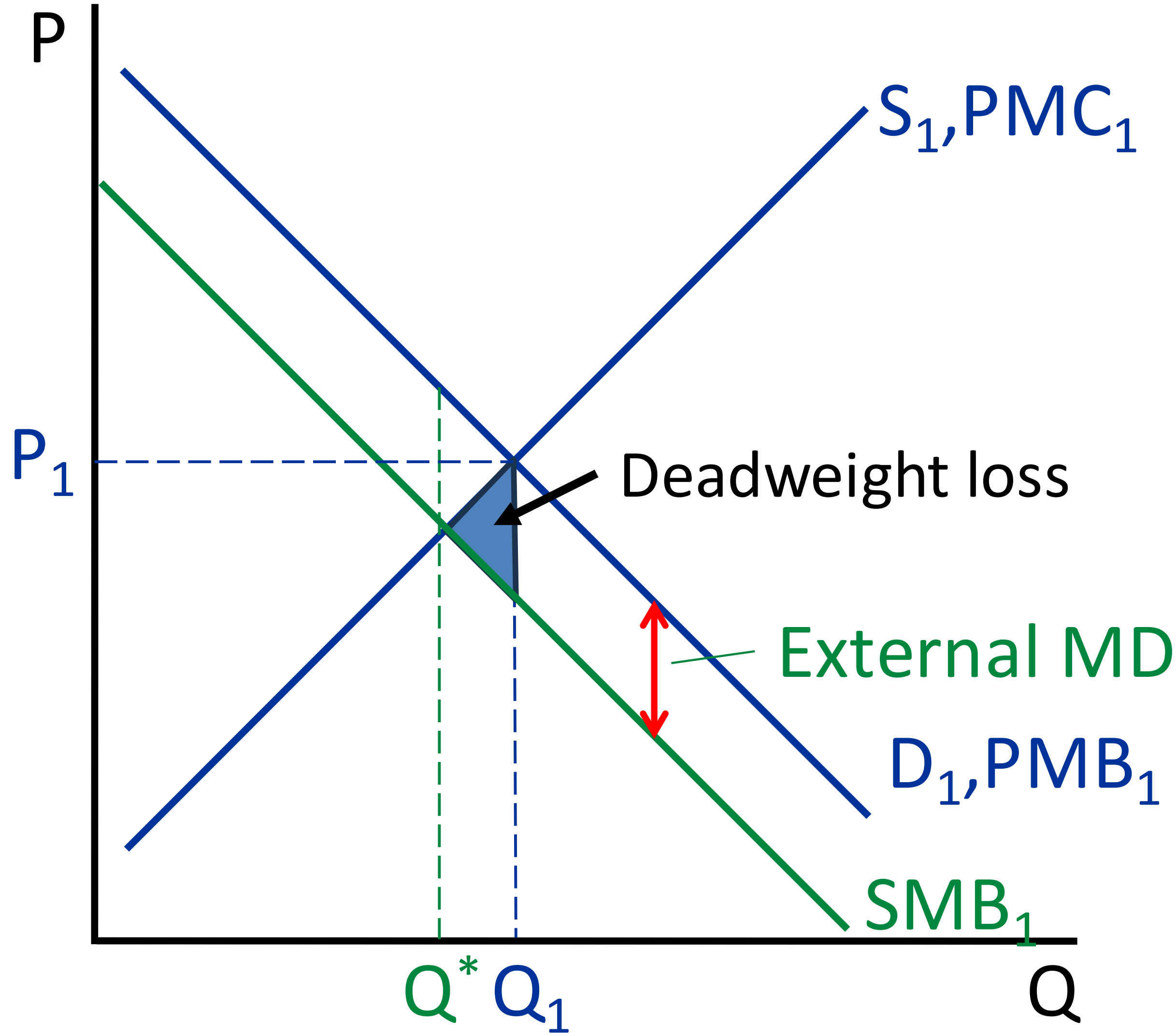
Private marginal benefit (PMB): The direct benefit to consumers of consuming an additional unit of a good by the consumer = Demand curve

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

Example: gasoline that powers cars contributes to global warming

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*

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: Beehive honey production that helps pollinate crops for agriculture

Each unit of production creates a positive external marginal benefit (MB) so that SMC=PMC-MB

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

Each unit of consumption creates a positive external marginal benefit (MB) so that SMB=PMB+MB

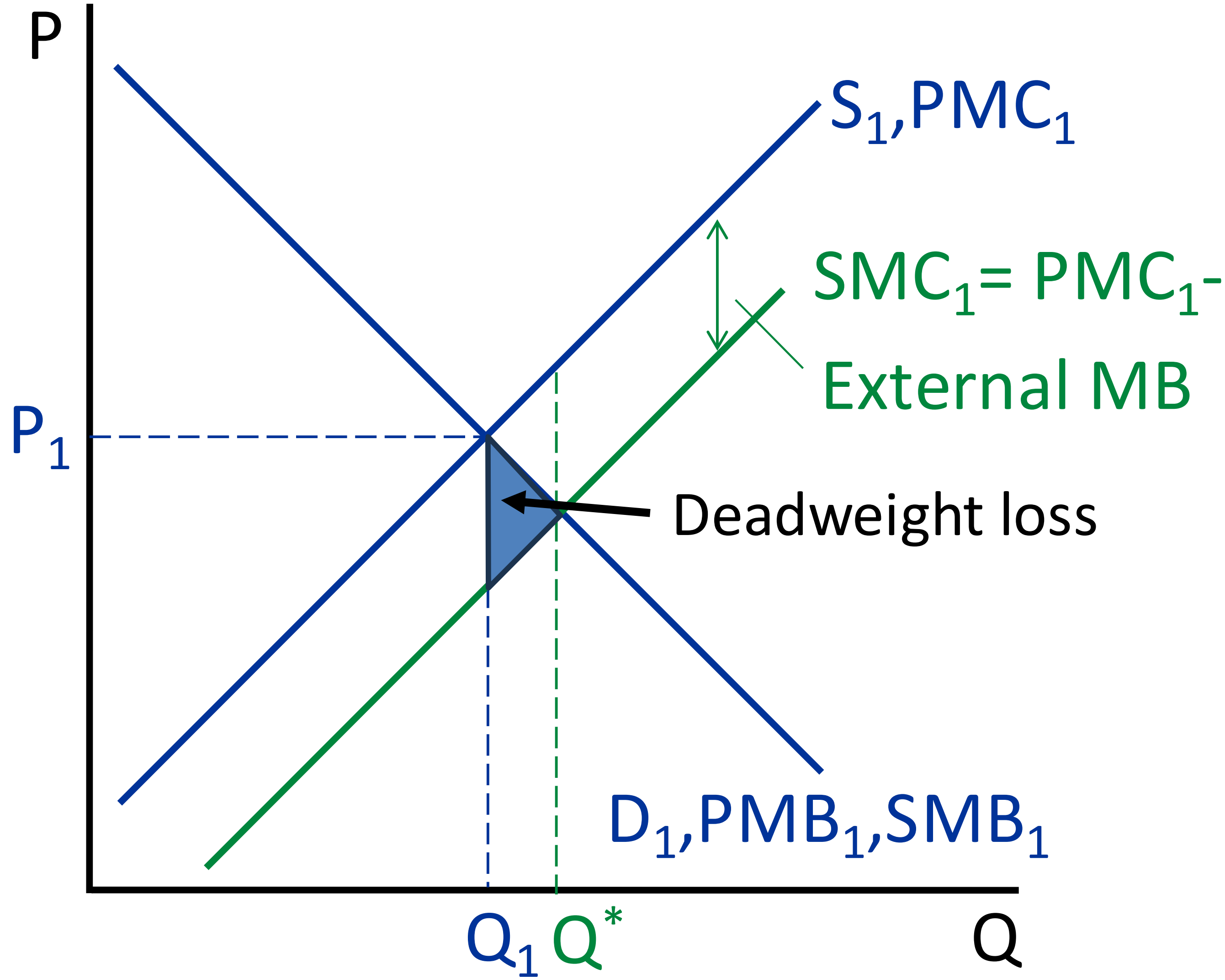
Main Positive Externalities

Technology spillovers: Firms constantly invent better production processes that can then be copied and drive long-run economic growth

Education and research: Fundamental knowledge taught and created also has spillovers on production:

- Federal agencies NIH for health research, NSF for Science
- Stanford/Berkeley and Silicon Valley

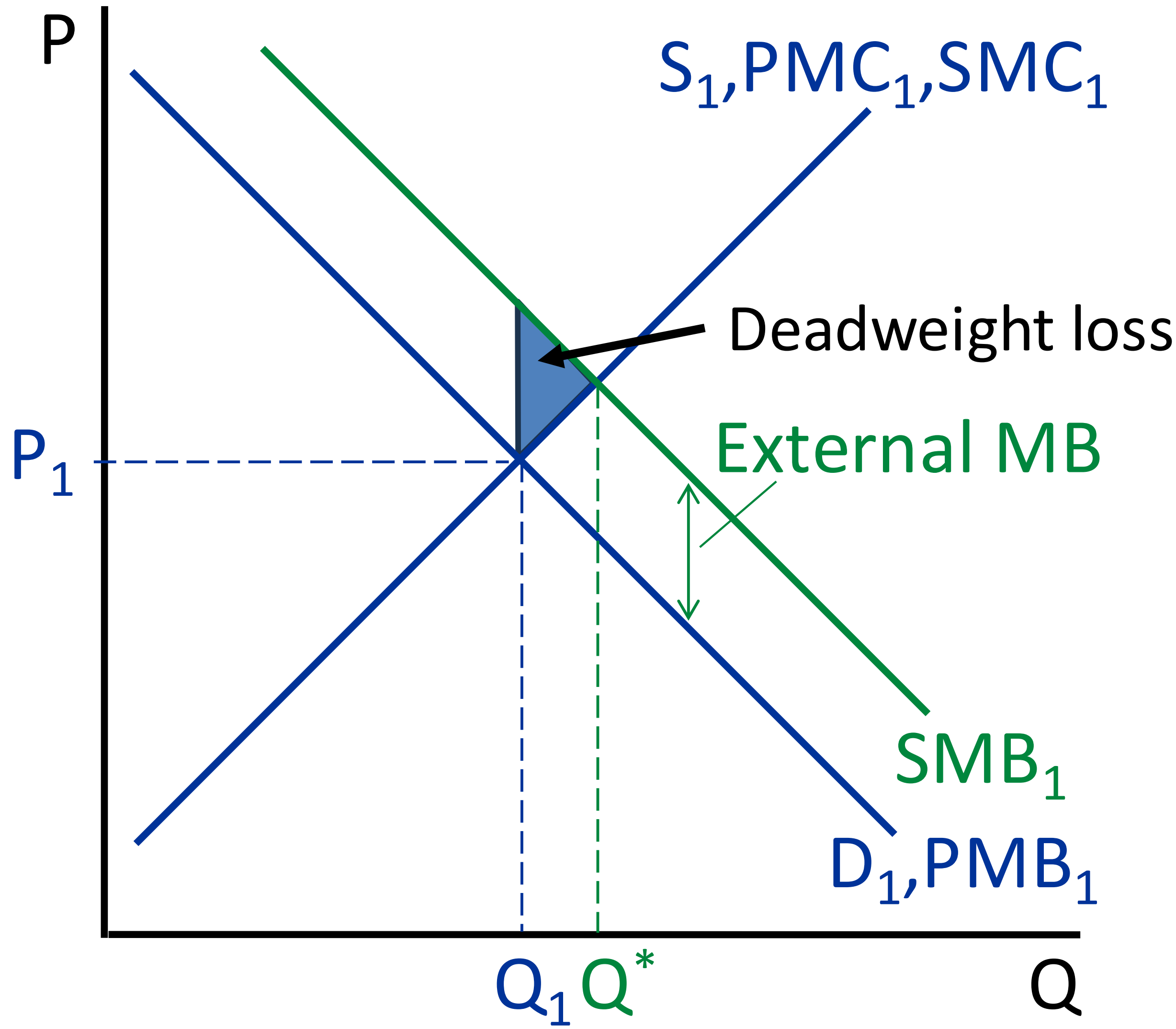
Positive Production Externality
(Beehive honey production that helps crops)



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*

Externality Theory: Market Outcome is Inefficient

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

Social optimum is such that $SMB = SMC$

$\Rightarrow$ 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 producing steel 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)

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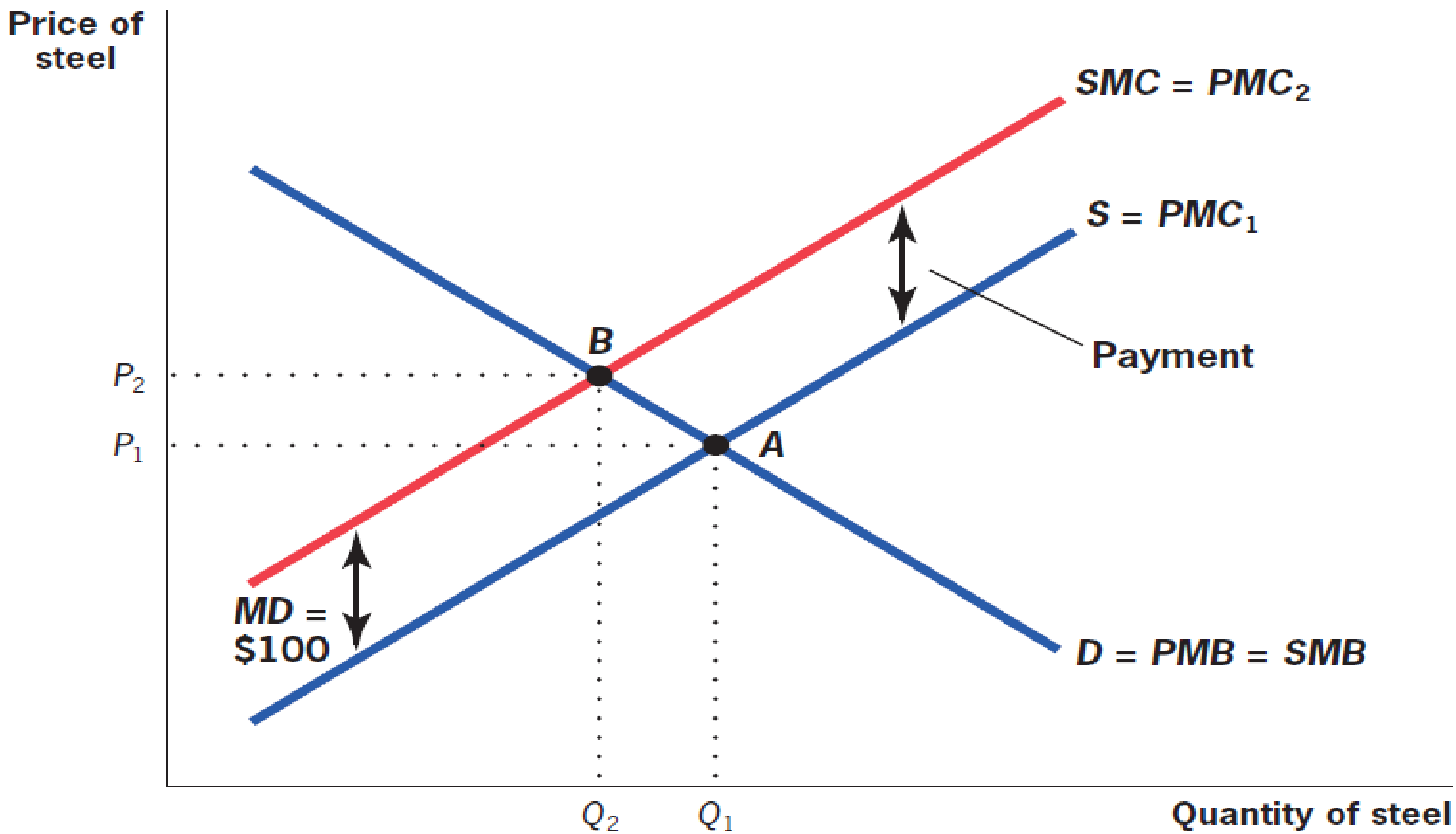
The Solution: Coasian Payments



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: Assigning property rights is difficult particularly when externalities affect many agents (e.g. global warming)

$\Rightarrow$ Coasian solutions are likely to be more effective for small, localized externalities (beehives for pollination in agriculture has become a business rather than external side-effect of honey production) than for larger, more global externalities involving large number of people and firms

2) Transaction Costs and Negotiating Problems: Negotiating is costly (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

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:

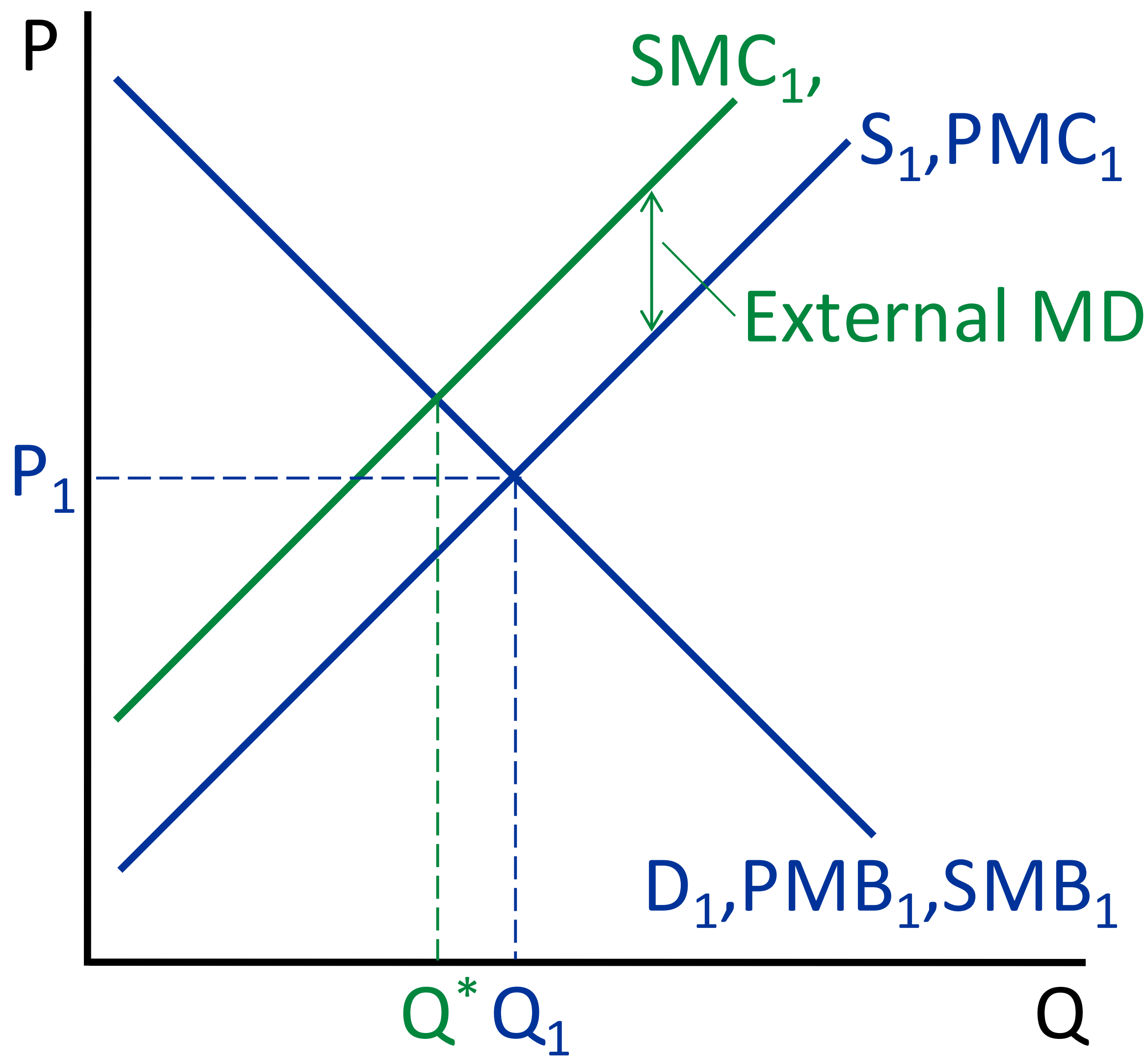
1) quantity regulation: government limits use of externality producing chemicals. Example CFCs [chlorofluorocarbons] that deplete ozone layer banned in 1990s

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

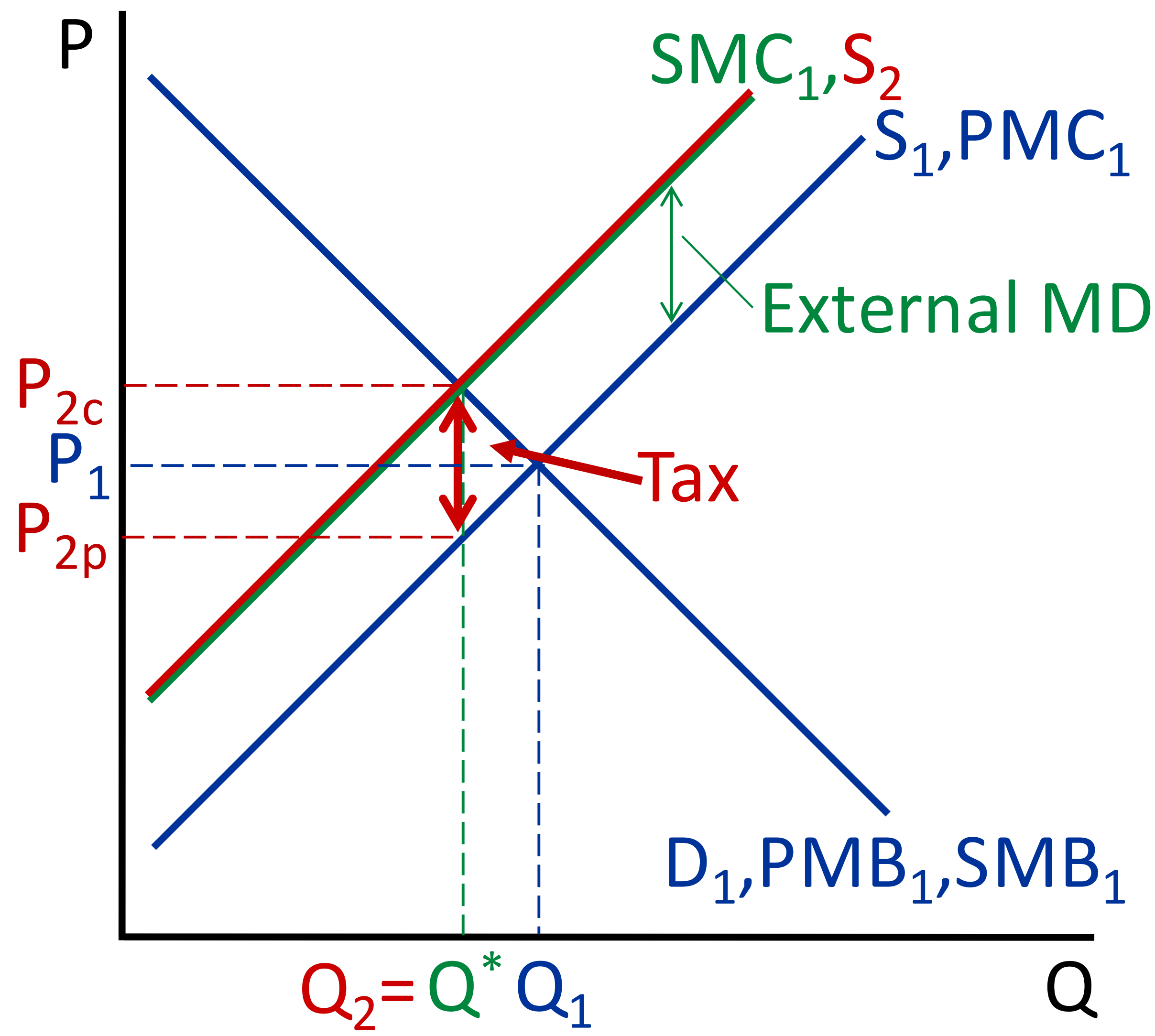
1) and 2) can be combined with **tradable emissions permits** to firms that can then be traded (cap-and-trade for carbon emissions)

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

Tax Remedy for a Negative Producer Externality

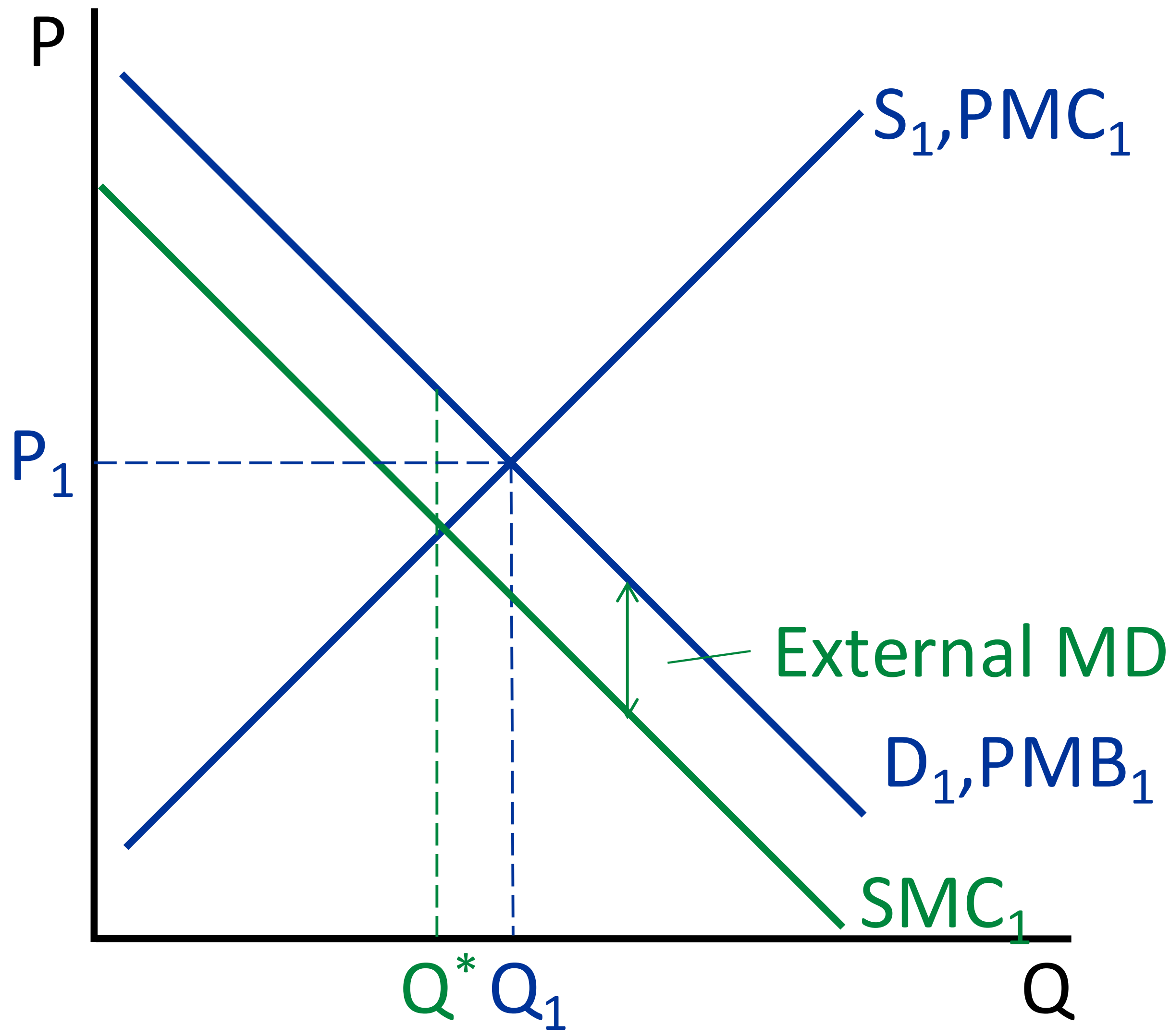


Tax Remedy for a Negative Producer Externality

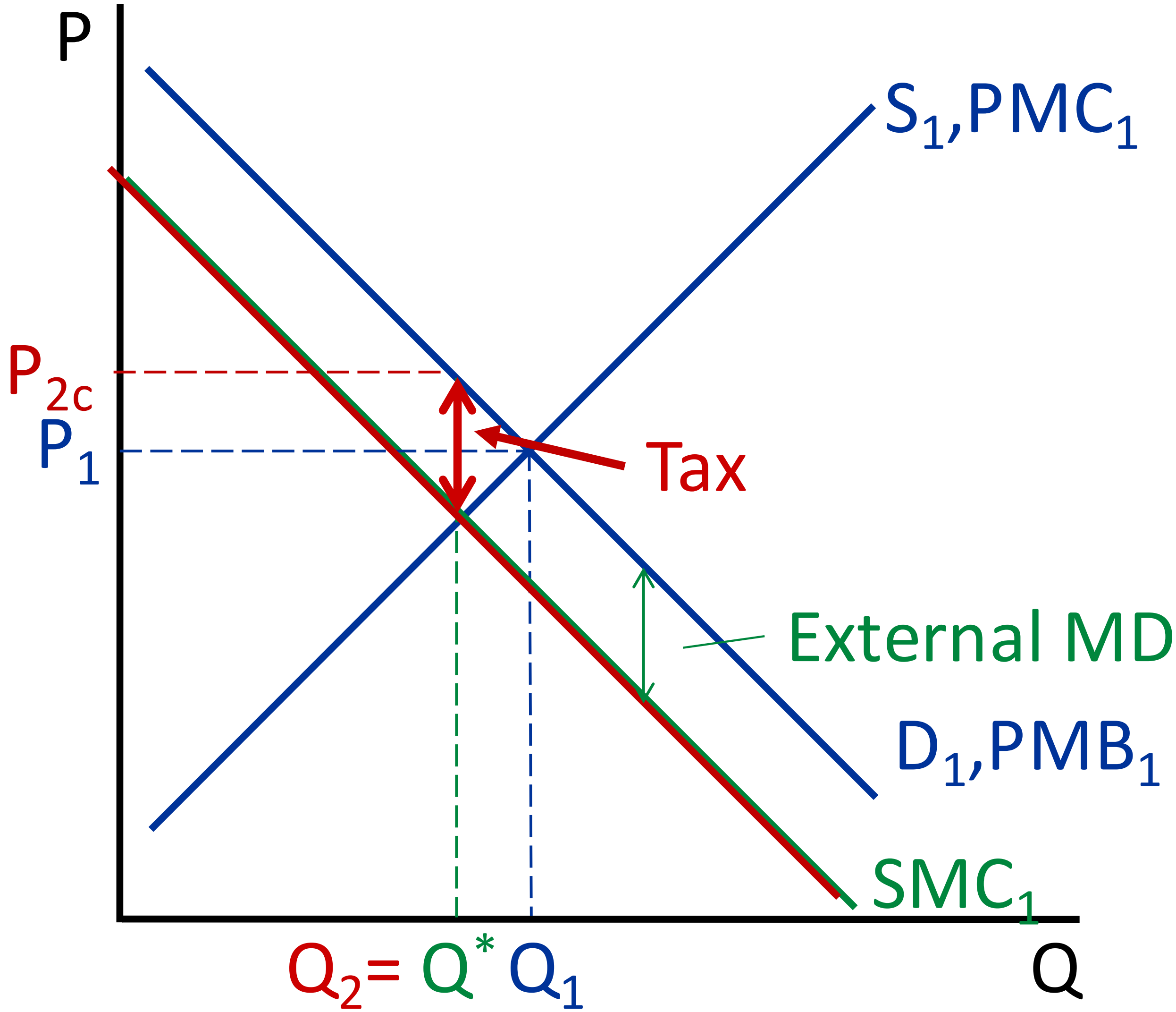


A tax on producers equal to the external MC shifts PMC up to SMC and moves equil. from Q_1 to Q_2=Q*. P_{2c} is consumer price, P_{2p} producer price

Tax Remedy for a Negative Consumption Externality

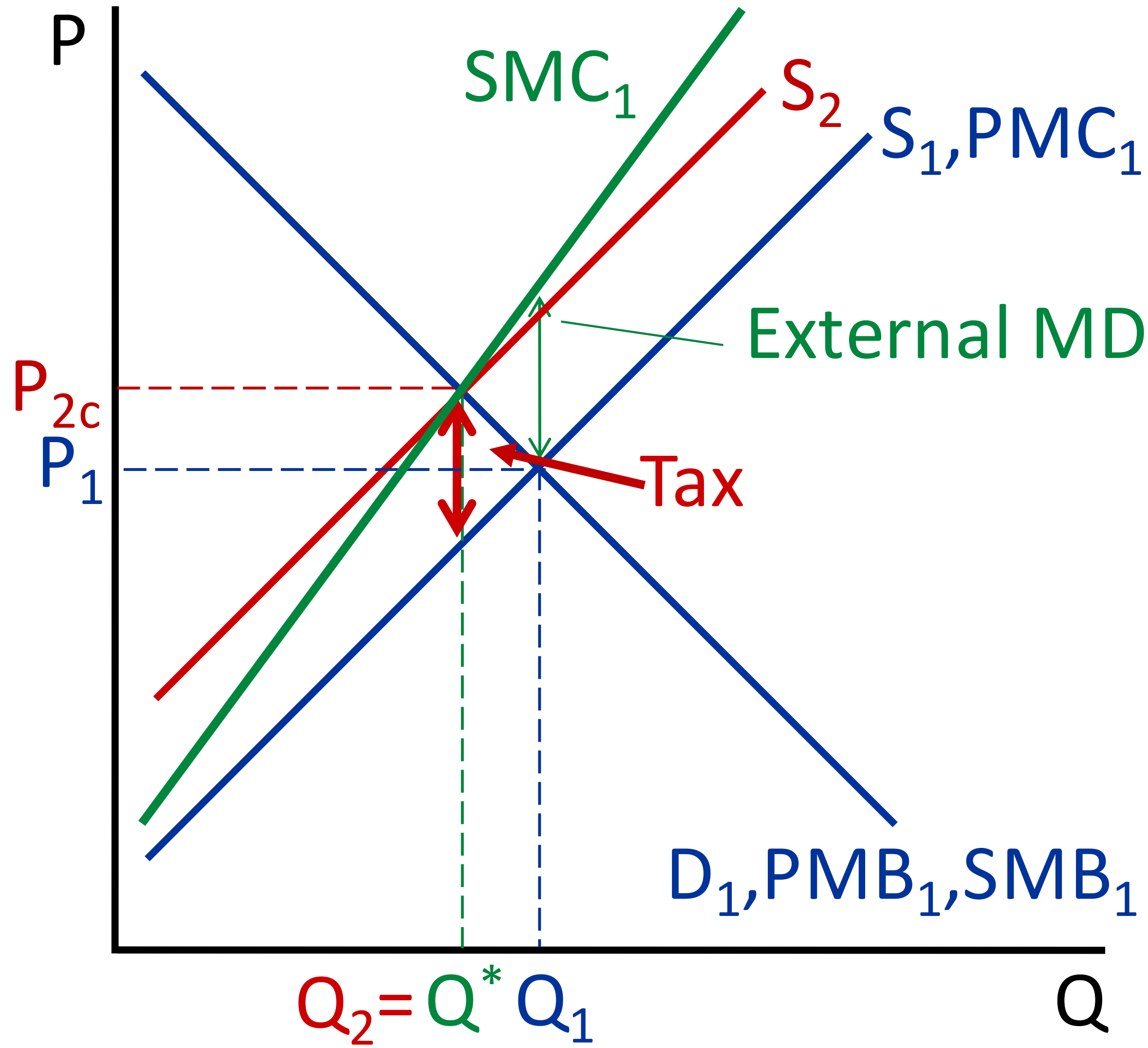


Tax Remedy for a Negative Consumption Externality



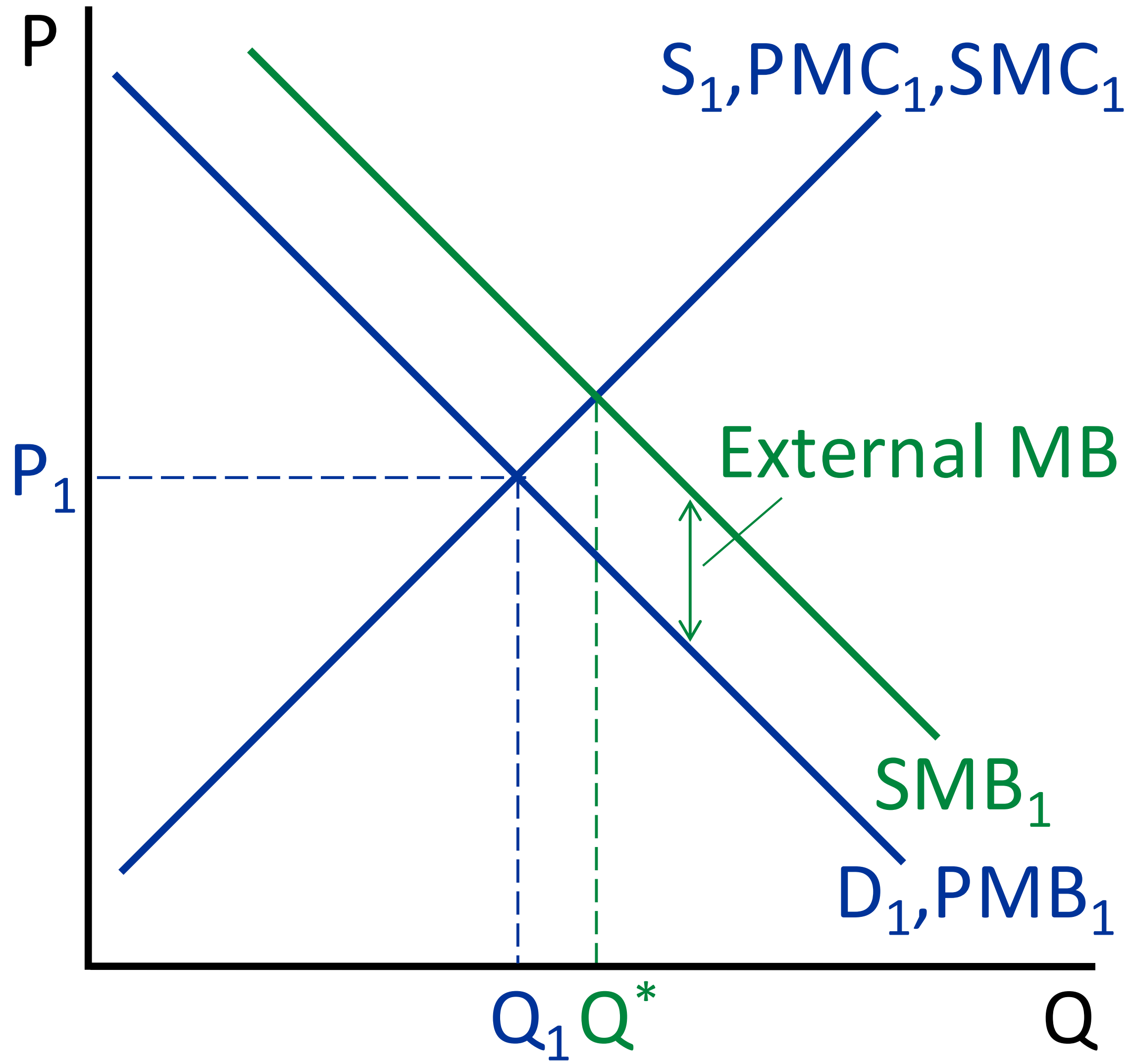
A tax on consumers equal to the external MC shifts PMB down to SMB and moves equilibrium from Q_1 to $Q_2=Q^*$.

Tax Remedy for Negative Externality with non constant MC

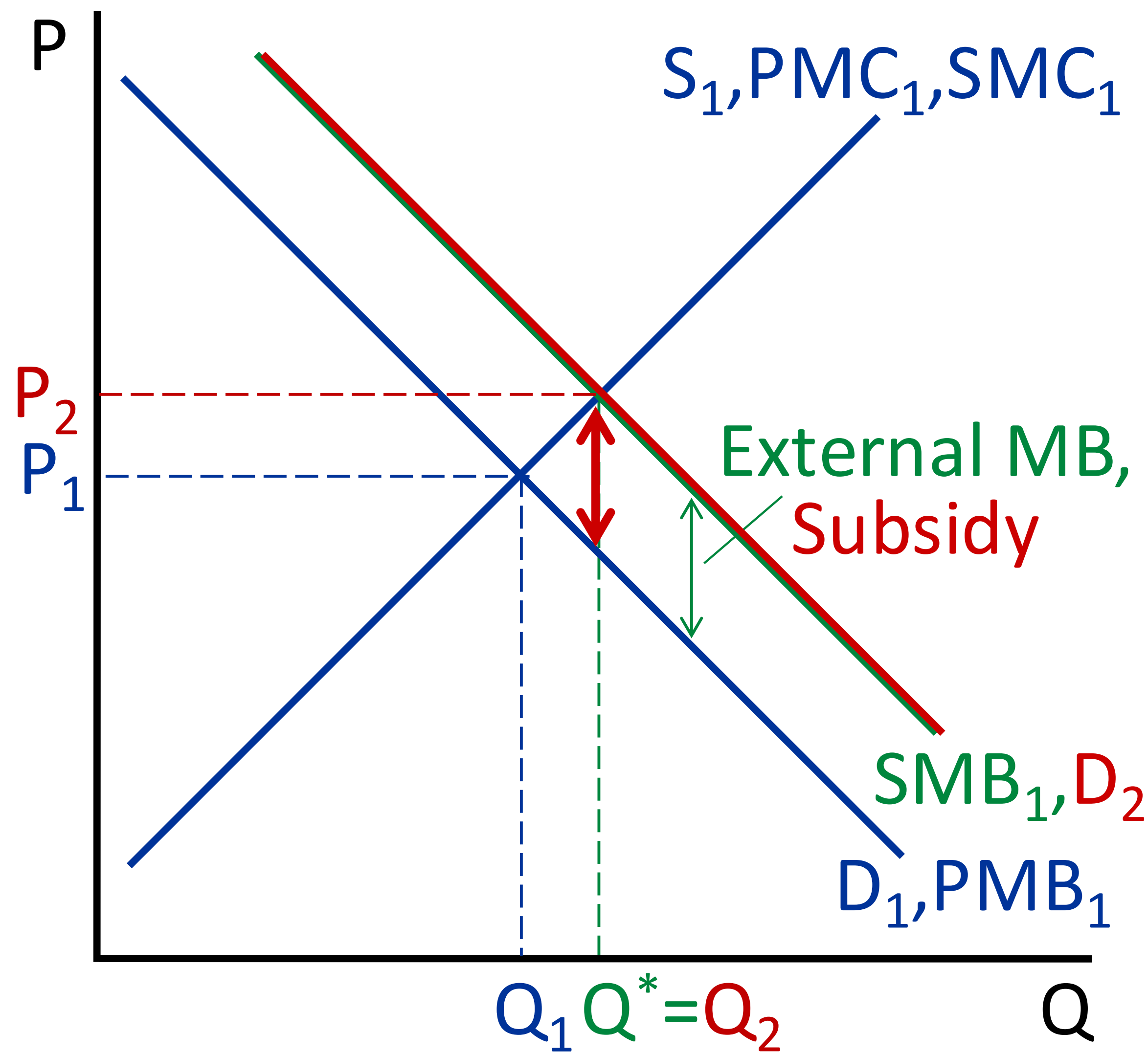


A tax per unit equal to the external MC at Q* shifts PMC up and moves equilibrium from Q_1 to Q_2=Q*

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*

QUIZ ON EXTERNALITIES

Question: Suppose agriculture industry invents a powerful new pesticide that helps grow coffee in poor countries more cheaply but is toxic. Marginal damage is \$10/unit as locals are poor (would be \$100/unit in the US). What is the correct remedy?

A. A \$10 tax per unit

B. A \$100 tax per unit

C. Nothing

D. The pesticide should be entirely prohibited

QUIZ ON EXTERNALITIES

Question: Gasoline consumption generates a climate change marginal external cost of $2 per gallon. But suppose gasoline consumption is completely inelastic to price. What is the correct remedy for efficiency?

A. A $2 tax per gallon

B. Nothing

C. Either A. or B.

D. Phase-out gas cars

Do taxes/subsidies work in practice?

Examples where the idea is currently used:

1) Gas tax: in the US, gas taxes are earmarked for road maintenance (deals with the wear and tear externality only, not global warming)

2) Congestion pricing: some cities have imposed taxes on cars coming in crowded cities (London £15 daily) to fight congestion externalities

3) Research and Development (R&D) tax credits for firms: subsidy to encourage innovation (but not tied explicitly to size of positive externality)

4) Income tax deduction for charitable contributions (giving to charities benefits others, tax subsidy not tied explicitly to size of positive externality)

How do we deal with externalities in practice?

Most common response is regulation:

Products/actions that generate negative externalities are forbidden by law (Harmful pollutants, dangerous consumer goods, littering, speeding, criminal behavior)

The penalty starts with a fine: economically equivalent to a tax but psychologically/socially very different [goal is to prohibit not price externality]

Limit (=allowance) on pollutant emissions. Example: smog check for gas cars in California

Issue with regulation (for economists):

Issue: cheap to reduce pollutant in some cases but not others. Example: electric cars exist but not electric planes $\Rightarrow$ CO2 allowance could kill high value aviation industry

Taxes and regulation combination: Cap&Trade

Emission permits and trading (=cap&trade):

Pollutant emitters are given emission permits

Pollutant emitters can trade their emission allowances

Price of emissions is the same for all. If total allowances set such that price=MD then efficient

Cap&trade has been used in transitions:

SO2 emissions creating acid rain, CFCs depleting ozone layer: costly to prohibit immediately as time is needed to develop substitutes

Phased-out over years through cap&trade system with shrinking allowances

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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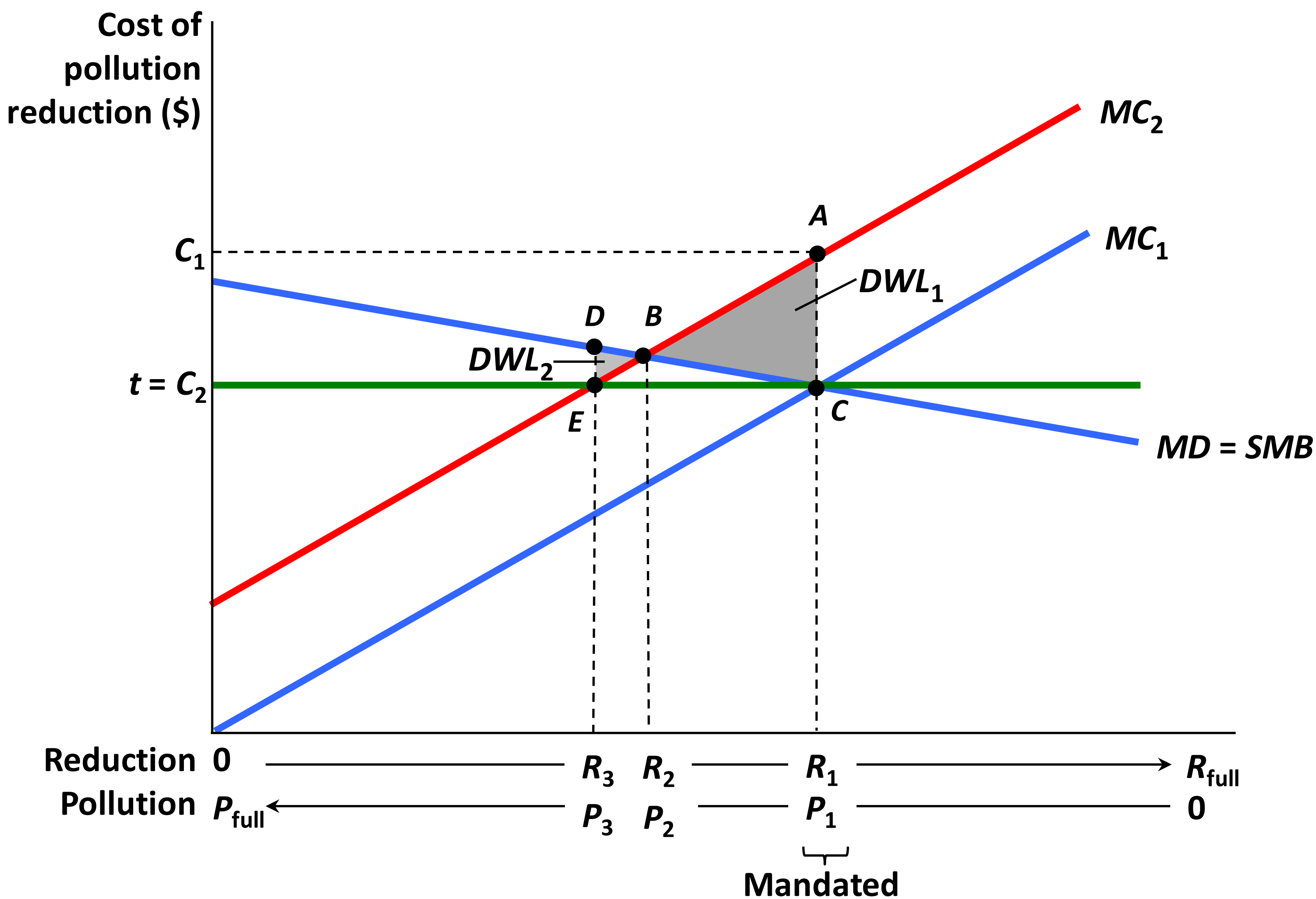
Uncertainty About Costs of Reduction:

Case 1: Flat *MD* Curve (Global Warming)



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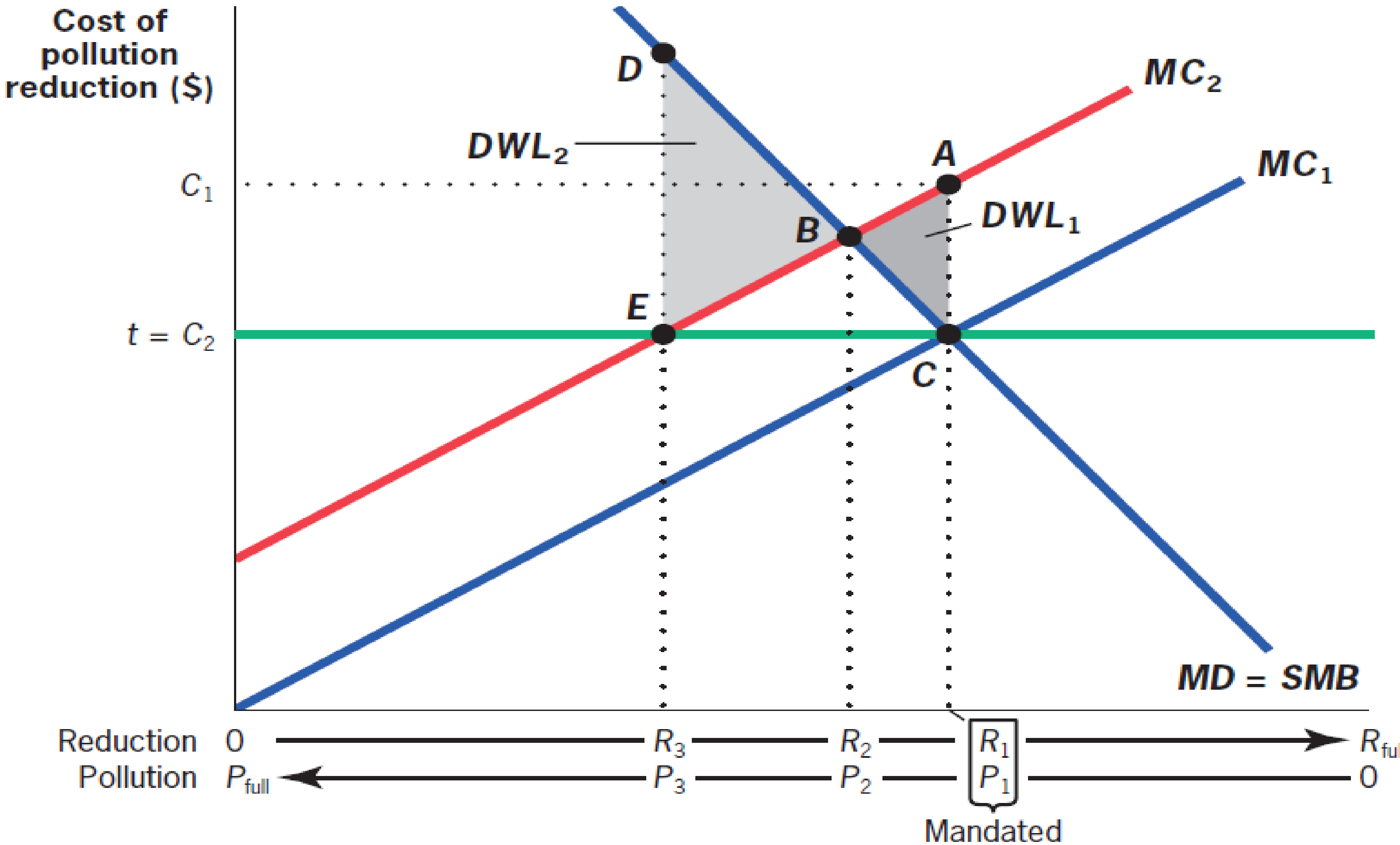
Uncertainty About Costs of Reduction:
Case 2: Steep *MD* Curve (Nuclear leakage)



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)

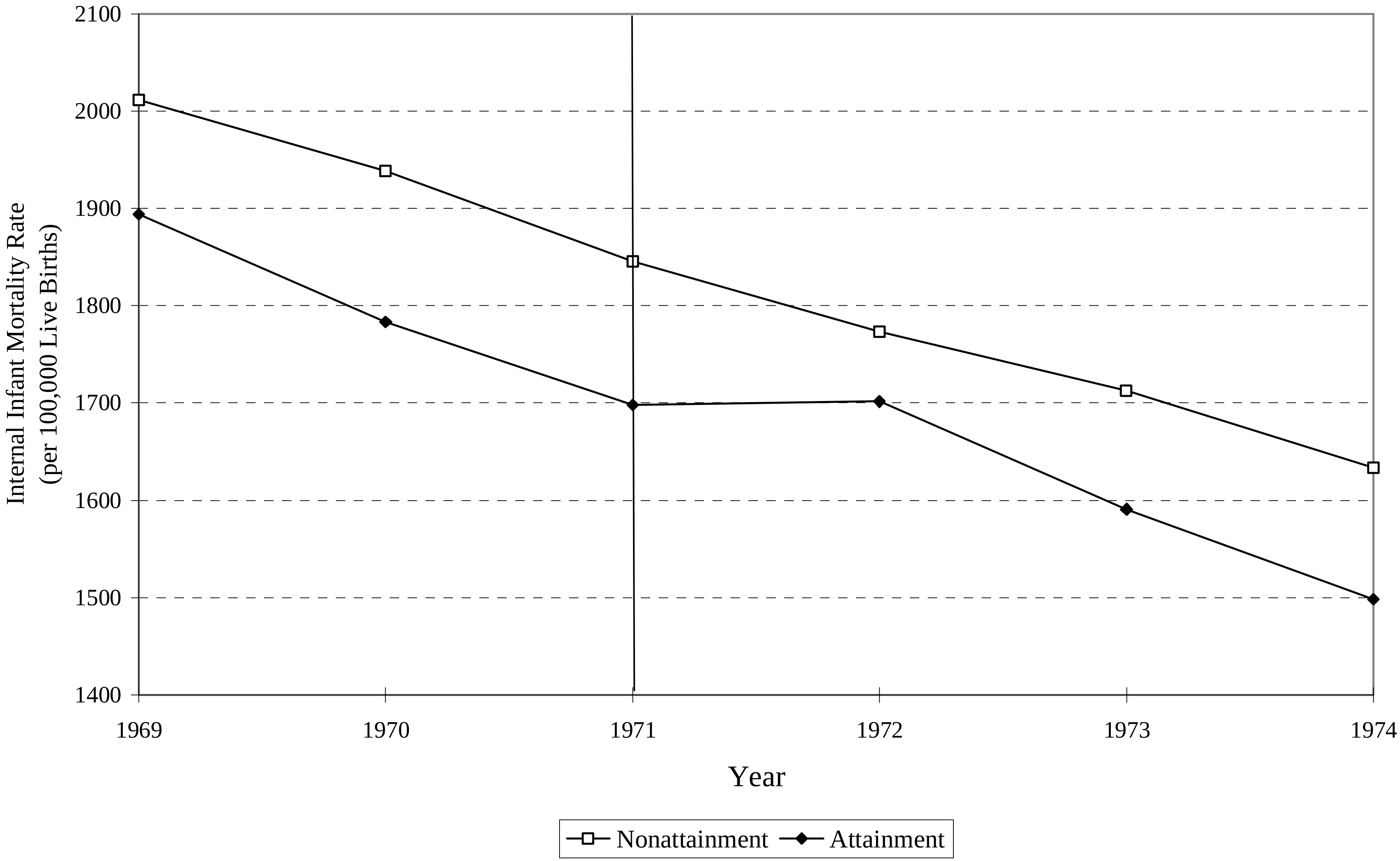
Figure 2: Trends in TSPs Pollution and Infant Mortality, by 1972 Nonattainment Status

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 CO_2 Emissions

Industrialization has dramatically increased CO_2 emissions and atmospheric CO_2 generates global warming

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

1) Global: Emissions in one country affect the full world

2) Irreversible: Atmospheric CO_2 has long life (centuries) [absent carbon capture tech breakthrough]

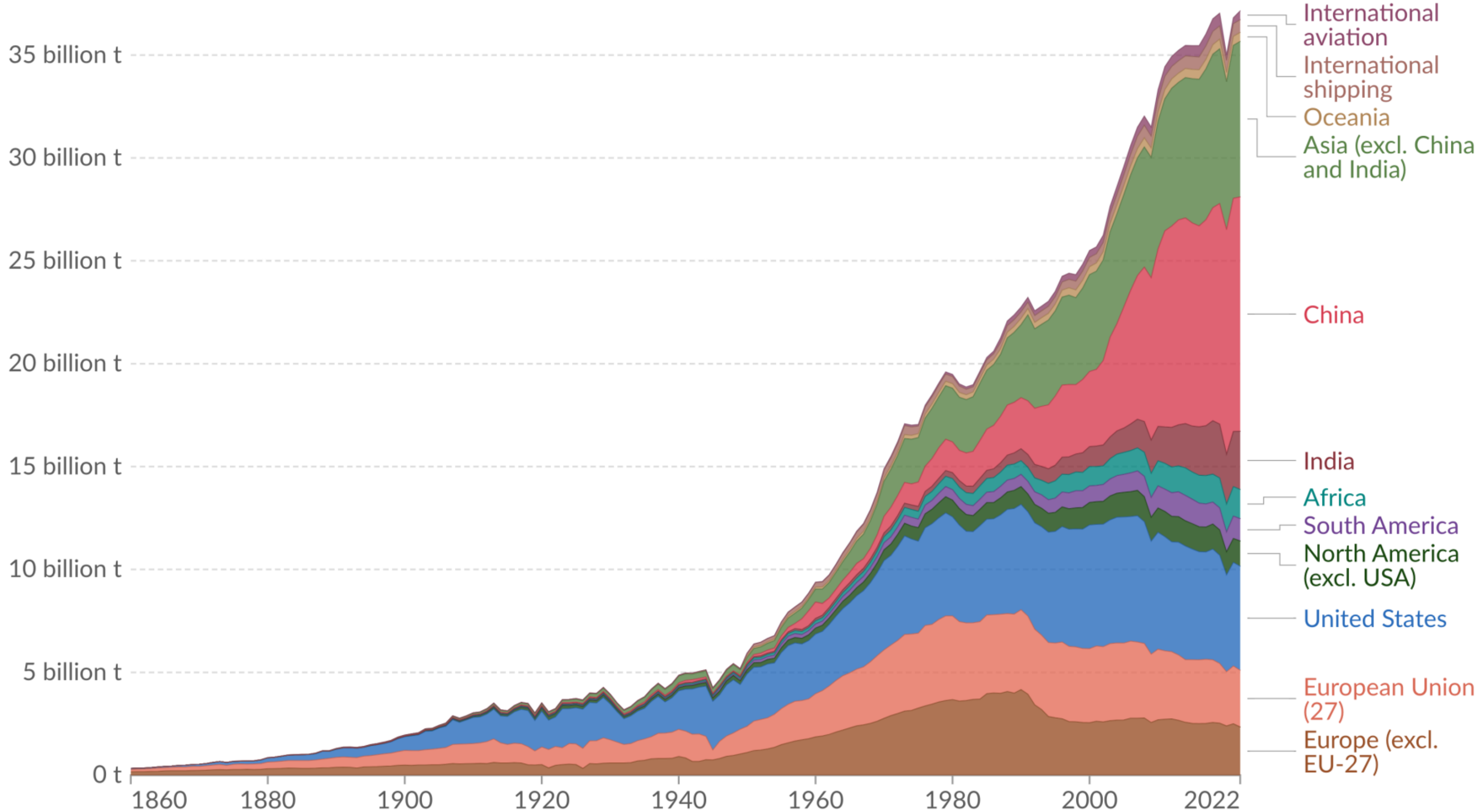
3) Long-term: Costs of global warming are decades/centuries away [how should this be discounted?]

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 CO_2 emissions by world region

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)

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.

Main costs of global warming

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

1) Extreme weather makes many populated places less livable (sea rise, heatwaves, droughts, smoke from fires)

Could lead to mass migration movements that are disruptive in our world of independent nations

2) 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

3) Impact on bio-diversity (mass extinctions)

Quiz

Question: Suppose extreme weather shock reduces vegetables production globally by 20% which makes prices go up 200%. Which mitigating policy is most efficient?

A. Nothing: Let poor people in poor countries starve and let others pay more for food

B. Regulation: Prohibit meat so that everybody can survive with vegetarian diet.

C. Tax: Impose a high tax on meat to discourage wasteful use of cereals to grow meat.

D. Universal basic income so that everybody can afford food funded by tax on rich people/countries

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)

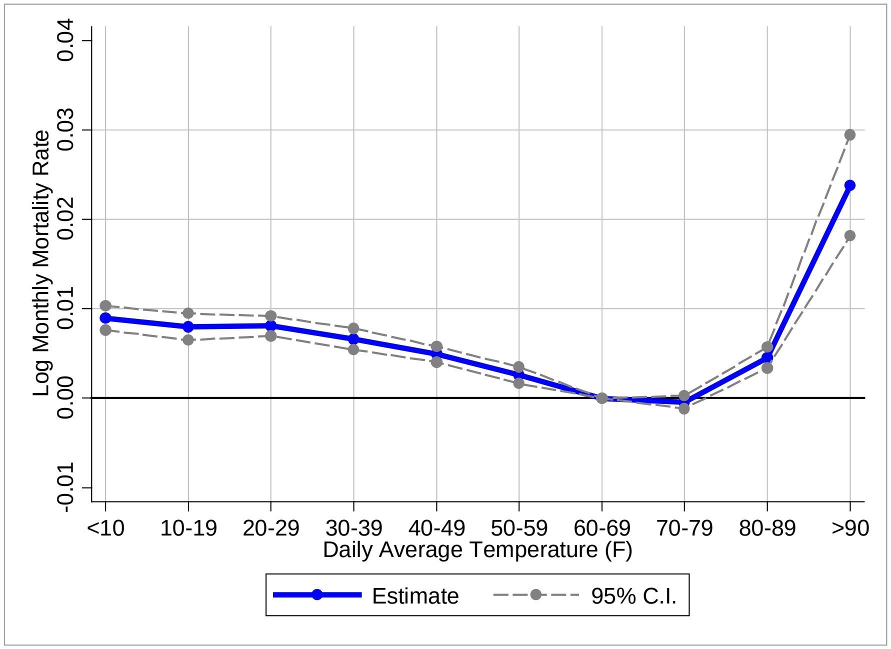
1) The mortality effect of an extremely hot day (80^oF+) declined by about 75% between 1900-1959 and 1960-2004.

2) Adoption of residential air conditioning (AC) explains the entire decline

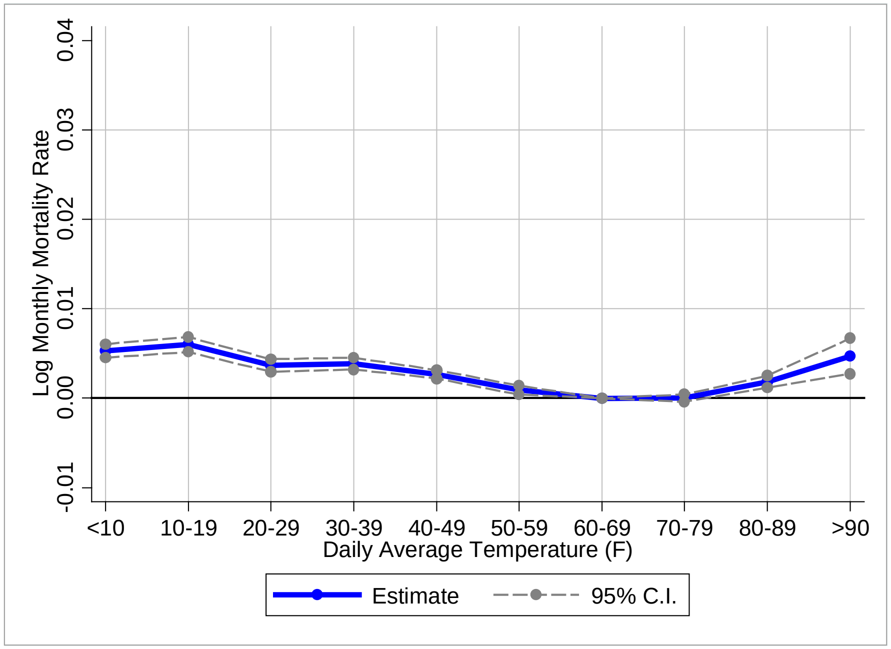
3) Worldwide adoption of AC will speed up the rate of climate change (if fossil fuel powered)

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, 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)

Global Warming: Economists' Narrow View

CO_2 emissions impose a global warming externality $\Rightarrow$ Solution is to impose a carbon tax equal to the marginal damage of CO_2 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

a) If future is discounted heavily (individual humans are impatient), CO2 damage cost is small and it is desirable to let global warming happen and civilization collapse!

b) If future not discounted heavily, then big but unpopular carbon tax is called for

Economists likely slowed down the process by underestimating global warming costs (Nordhaus comparing Florida to Minnesota)

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.

Global Warming: Broader View

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

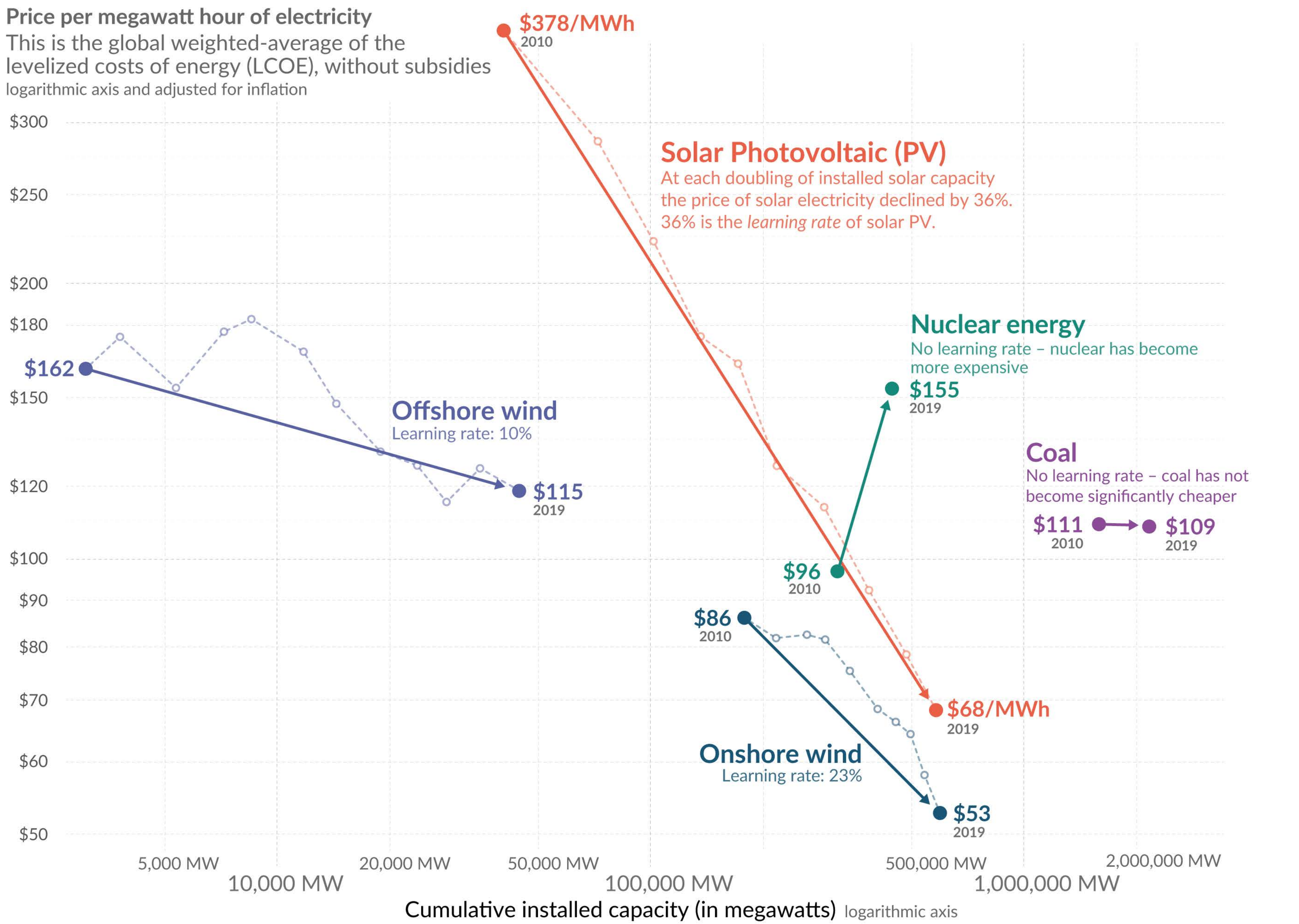
Only solution is to decarbonize as a social choice and we need to do it fast (within decades not centuries)

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

$\Rightarrow$ 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)
$\Rightarrow$ start decarbonizing easiest sectors first (Sachs 2020)

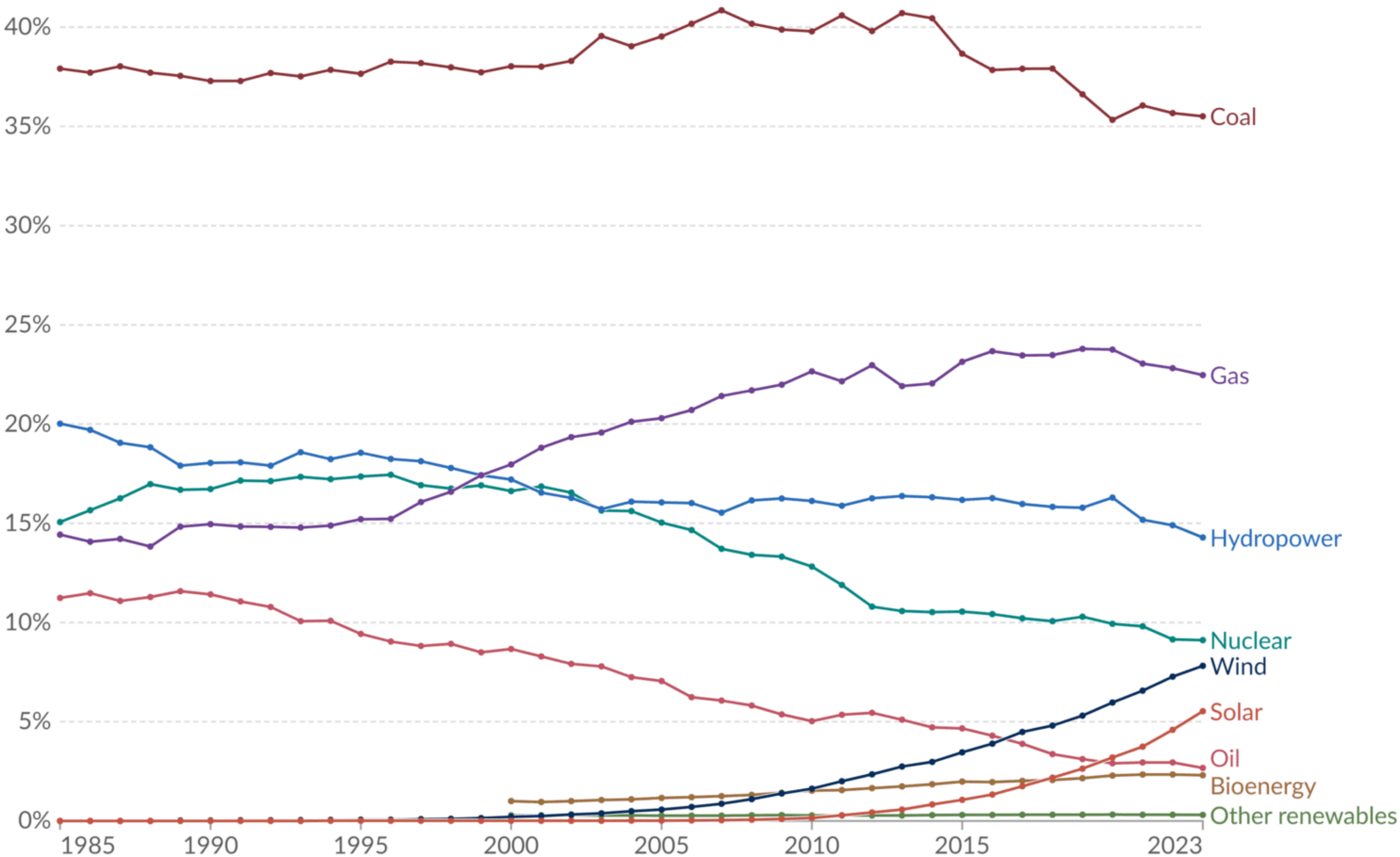
Electricity from renewables became cheaper as we increased capacity – electricity from nuclear and coal did not



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.

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

Share of electricity production by source, World

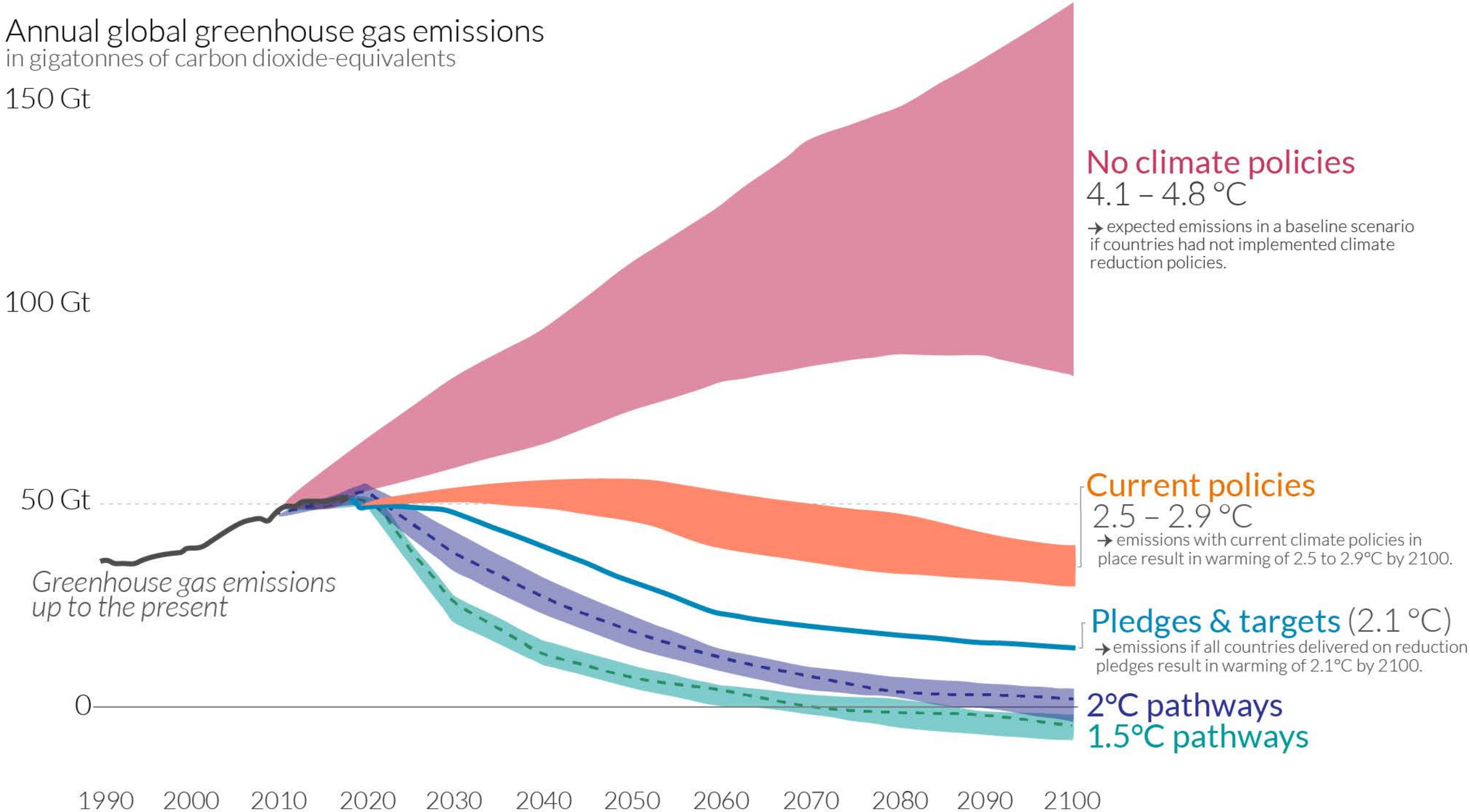


Data source: Ember (2024); Energy Institute - Statistical Review of World Energy (2024)

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.

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:

$\Rightarrow$ Makes sense to provide successful local examples of decarbonization (such as California with its 100% renewable electricity mandate by 2045, phasing out new gas cars by 2035)

$\Rightarrow$ 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, Biden 2022 Inflation Reduction Act but might get undone by Trump

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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