Externalities and Pigouvian Taxes

EC313 - Public Economics: Taxation

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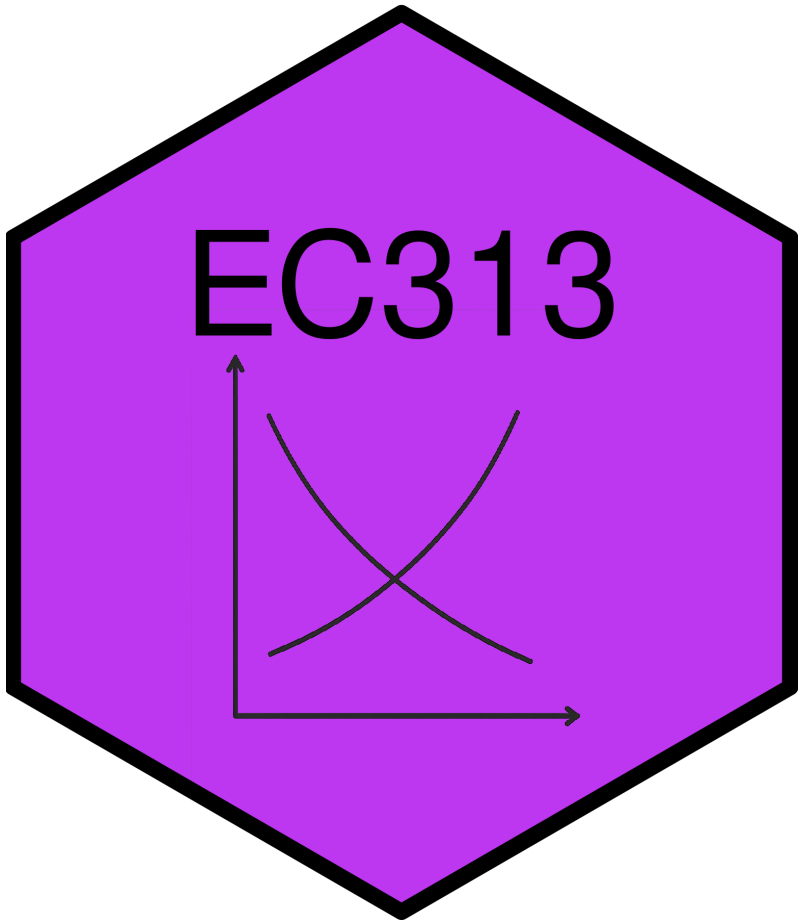

Goals of This Section

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- Define and discuss externalities
- Differentiate between negative and positive externalities
- Discuss private responses to externalities
- Discuss public responses to externalities, including Pigouvian taxes and subsidies

Externalities

Defining Externalities

- Absent any market failures, economic theory says private markets lead to efficient outcomes
- Resources are allocated to their best possible uses
- This is the first fundamental theorem of welfare economics
- However, in some cases, private markets fail to achieve efficiency
- One important source of market failure is externalities
  - An **externality** is a cost or benefit imposed on a third party not involved in a market transaction

Defining Externalities

- Some examples of negative externalities
  - Carbon emissions: pollution from burning fossil fuels harms the environment and public health
  - Crypto mining: high energy consumption leads to increased greenhouse gas emissions
  - Noise pollution: loud nightclubs disturb nearby residents
  - Fertilizer runoff: agricultural chemicals contaminate water supplies
- Some examples of positive externalities
  - Vaccinations: immunized individuals reduce disease spread, benefiting others
  - Education: educated individuals contribute to a more informed and productive society
  - Public parks: green spaces enhance community well-being and property values
  - Research and development: innovations can lead to widespread technological advancements

David Suzuki on Externalities

OPINION

David Suzuki needs an economics refresher course

MIKE MOFFATT >
SPECIAL TO THE GLOBE AND MAIL
PUBLISHED OCTOBER 10, 2012

"But if you ask the economists, in that equation where do you put the ozone layer? Where do you put the deep underground aquifers of fossil water? Where do you put topsoil or biodiversity? Their answer is 'oh, those are externalities'. Well then you might as well be on Mars, that economy is not based in anything like the real world," Dr. Suzuki goes on to say.

Dr. Suzuki's remarks on externalities were clarified in an interview given to the magazine Common Ground: "I won't go into a long critique, but currently nature and nature's services – cleansing, filtering water, creating the atmosphere, taking carbon out of the air, putting oxygen back in, preventing erosion, pollinating flowering plants – perform dozens of services to keep the planet happening. But economists call this an 'externality.' What that means is "We don't give a shit." It's not economic. Because they're so impressed with humans, human productivity and human creativity is at the heart of this economic system. Well, you can't have an economy if you don't have nature and nature's services, but economics ignores that. And that's an unbelievably egregious error."

Defining Externalities

- Economic problem with externalities
  - When externalities are present, private markets may not allocate resources efficiently
  - Negative externalities can lead to overproduction of harmful goods
  - Positive externalities can lead to underproduction of beneficial goods
- In these instances, there are possible solutions to the inefficiency
  - Private solutions: negotiation between affected parties (Coase theorem)
  - Public solutions: government intervention through taxes, subsidies, or regulations

Characteristics of Externalities

- Can be produced by individuals, firms, or governments
  - Usually think of firms polluting
  - Individuals can also create externalities (e.g., loud parties, smoking in public)
- They are reciprocal
  - One party's actions can create externalities for another party, and vice versa
  - Example: a factory polluting a river affects downstream residents, but protesting and restricting them affects the factory's operations
- Can be positive or negative
  - Negative externalities impose costs on others (e.g., pollution)
  - Positive externalities provide benefits to others (e.g., education)

Characteristics of Externalities

- Sometimes hard to distintuish from public goods
  - Public goods are goods that are non-excludable and non-rivalrous
  - Externalities can sometimes have similar characteristics (e.g., clean air)
  - Key difference is intention
    - Externalities are unintended side effects of economic activities
    - Public goods are intentionally provided for the benefit of all
  - Example: public fireworks may are both a public good and create externalities
    - Created intentially for everyone to enjoy
    - But people living nearby may experience noise pollution (negative externality)

Inefficiency of Externalities

Negative Externalities

- Inefficiency of externalities comes from the divergence between private and social costs/benefits
  - Individuals involved in a market transaction only consider their private costs and benefits
  - Typically ignore the social costs
- With negative externalities this leads to overproduction
- In this section we outline how that happens

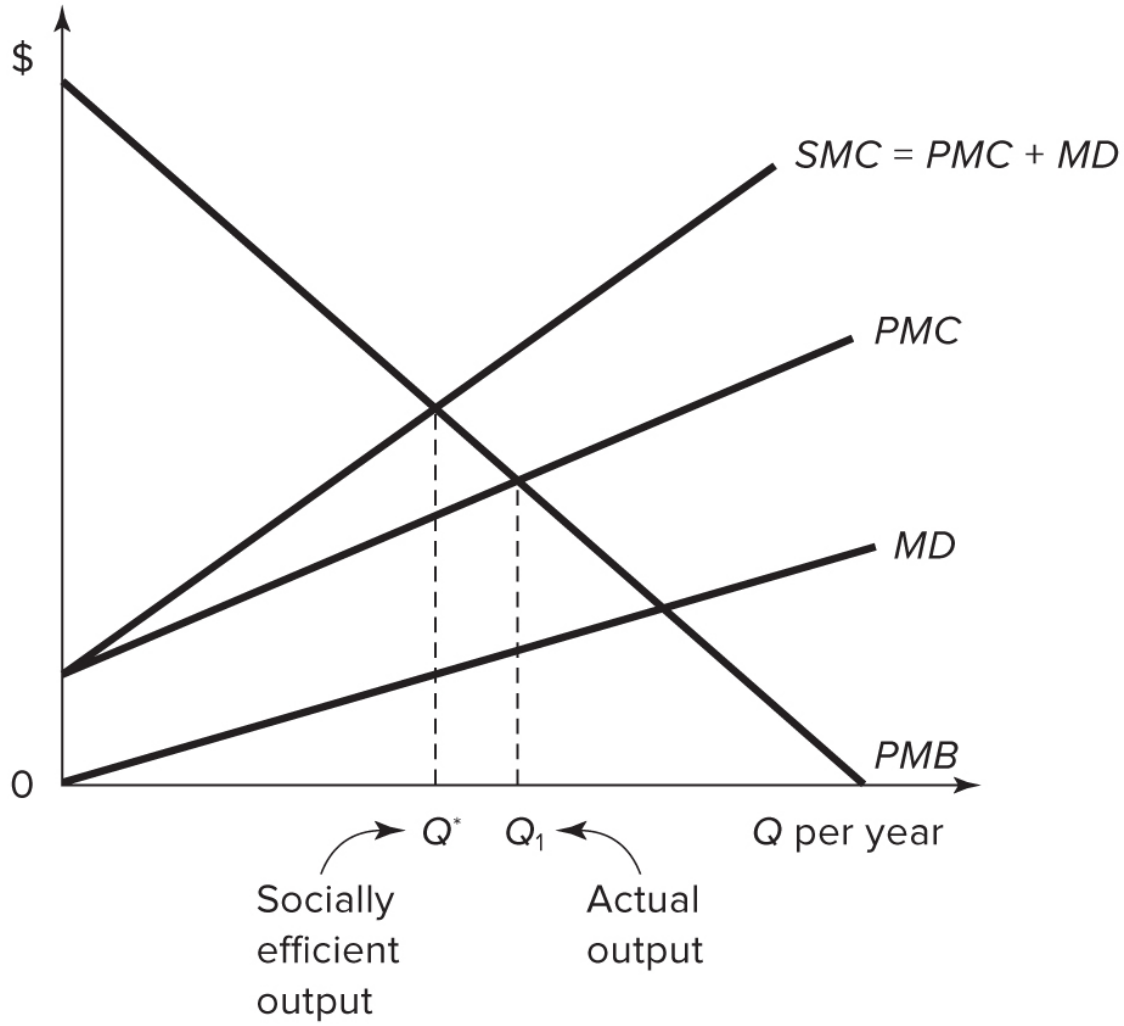
Negative Externalities

- Consider two individuals
  - Azul: operates factory that dumps waste into a river
  - Jules: fisherman downstream from Azul's factory
- Water pollution affects Jules' ability to fish
- Nobody owns the river that is polluted
  - This is key to the externality
  - If someone owned the river, a price mechanism could be established to account for pollution
  - But without ownership, it is used at a zero price
- The water is a scarce resource that can be used up
  - Polluting it reduces the amount of clean water available for others

Negative Externalities

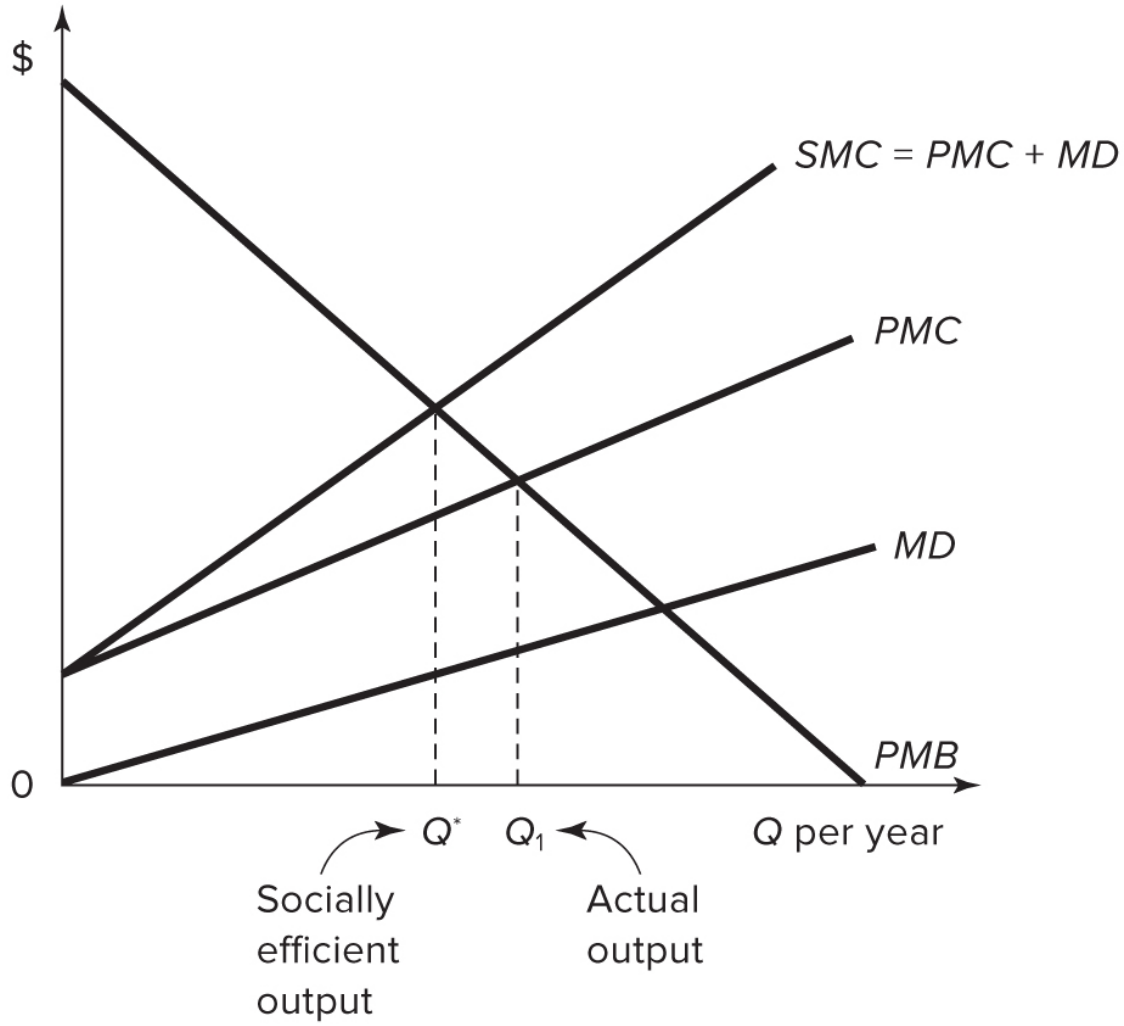
- Consider how much output Azul chooses to produce
- He faces private marginal cost (PMC) and private marginal benefit (PMB)
  - The costs and benefits that apply only to him
  - Ignores the costs imposed on others
- Azul produces where PMB = PMC

Negative Externalities



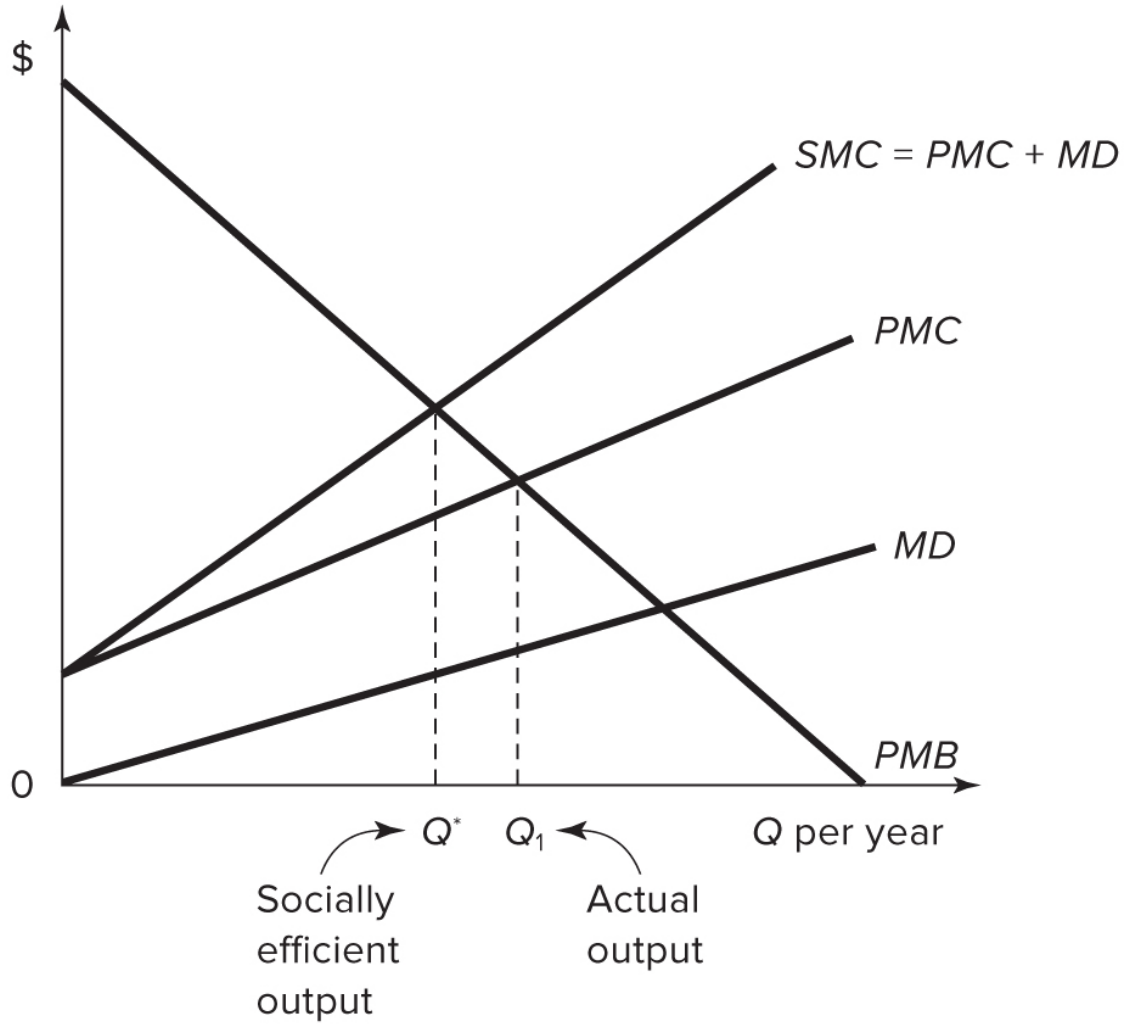
- Azul's private benefit (PMB) and cost (PMC) depicted to the left
- The PMC is upward sloping
  - Costs increase as output increases
- PMB is downward sloping
  - Benefits decrease as output increases
- Produce where PMB = PMC
- Output Q_1

Negative Externalities



- Azul's production also creates damage to the river
  - This damage imposes costs on Jules
- Assume that the marginal damage (MD) increases with output
  - Each additional unit of output causes more damage than the last
- Depicted on graph as the upward sloping MD curve

Negative Externalities

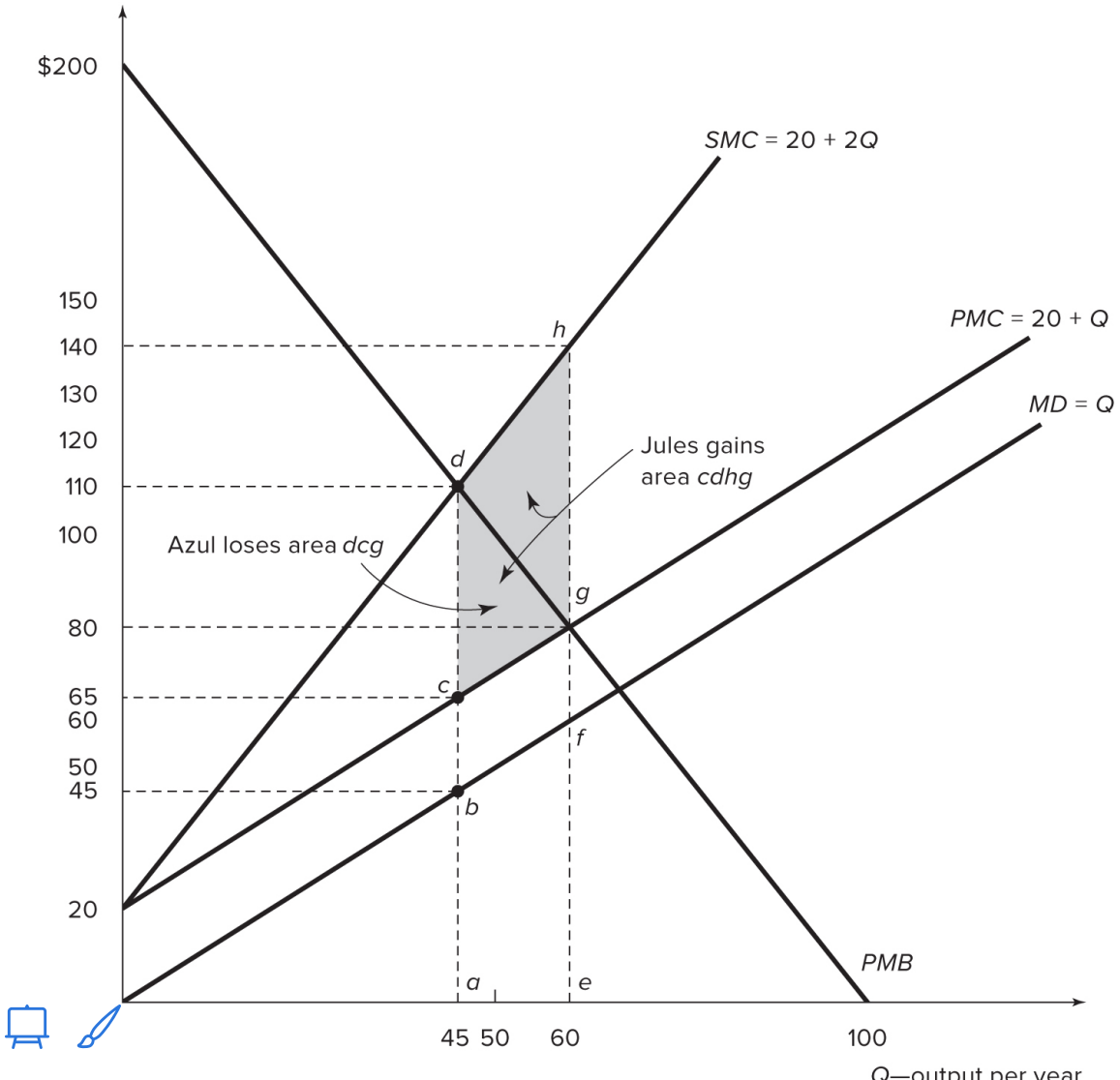


- The social cost of production includes both the private cost and the damage to others
  - Social marginal cost (SMC) = PMC + MD
- SMC curve lies above the PMC curve by the amount of MD
- SMC is what costs Azul would face if they had to pay for the damage they cause
- Assume that the private and social benefits are the same (PMB = SMB)
- From a social point of view, optimum is where PMB = SMC

Negative Externalities

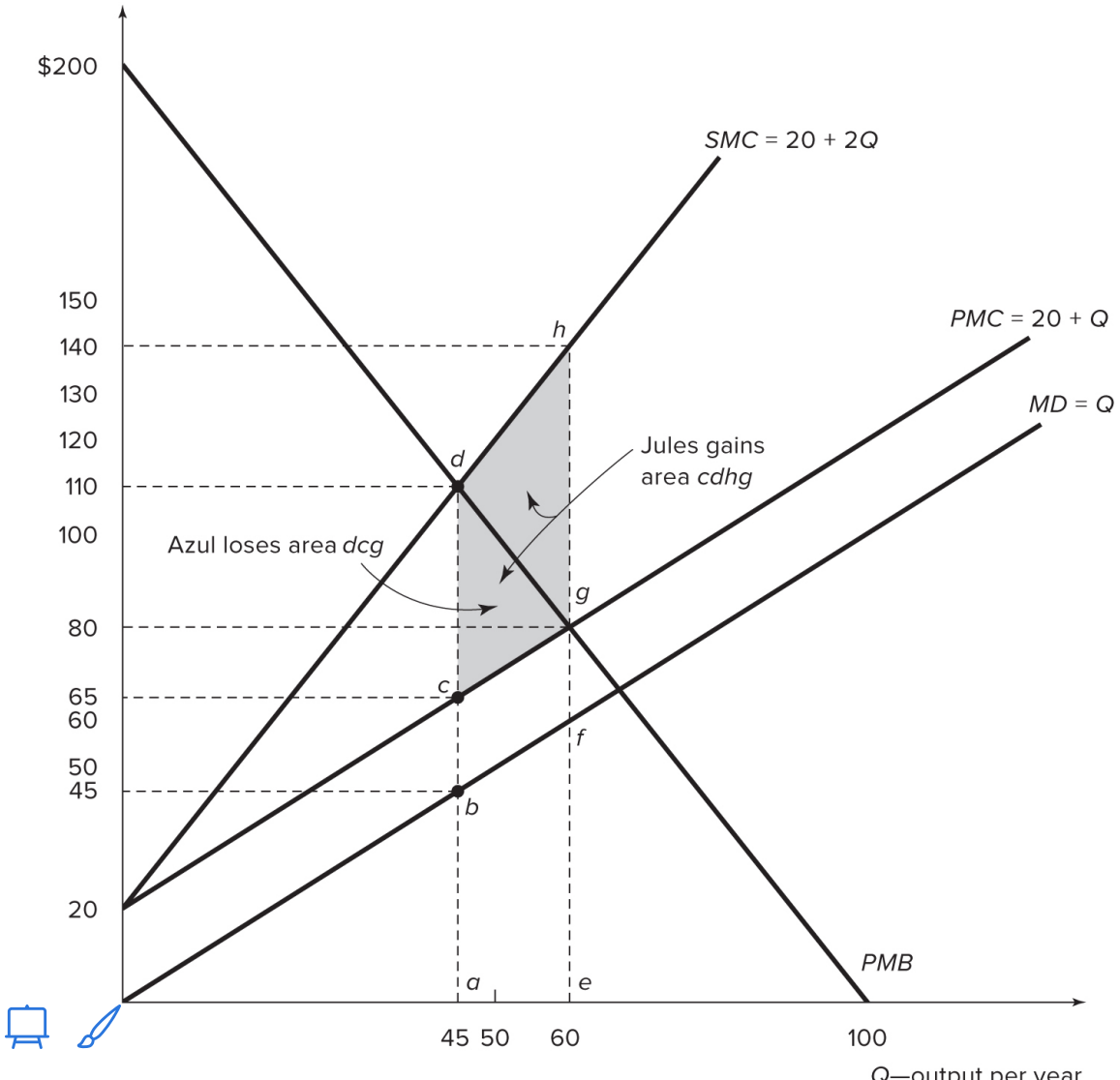
- Ignoring the negative externality leads to overproduction
  - Too much cost to society relative to the benefits
- This creates and inefficiency
- We can quantify the inefficiency using the graph
- Figure on next slide shows the inefficiency with some hypothetical numbers

Negative Externalities



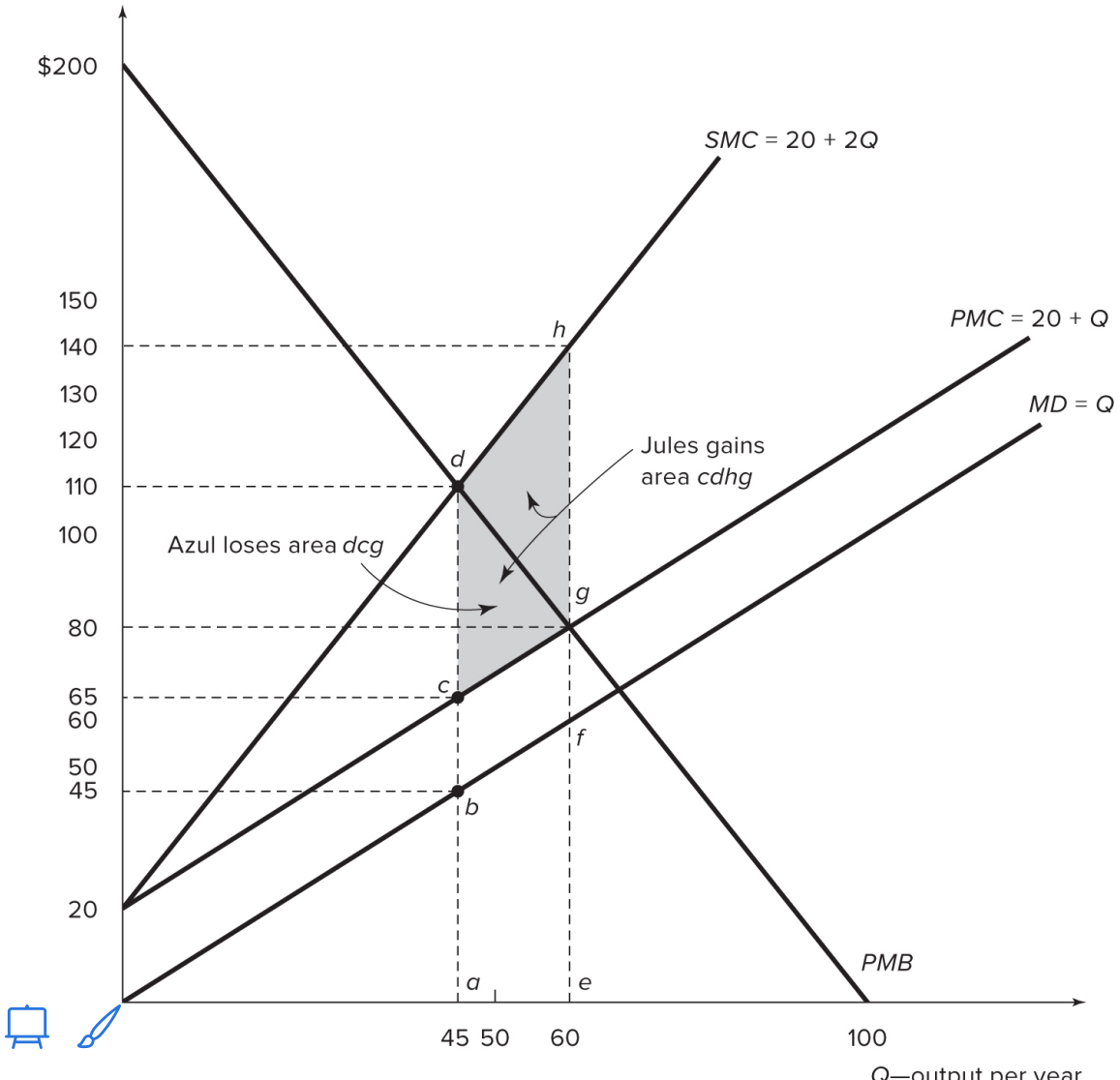
- Suppose we produce where PMB = PMC
- Total benefit to Azul from production is area under PMB curve
  - Like adding up marginal benefits for each unit produced
- Total cost to Azul is area under PMC curve
- **Net** to Azul gain is area between total benefit and total cost

Negative Externalities



- From a societal point of view, we need to account for damage to Jules
- Total damage to Jules is area beneath MD curve between private and social optimum
  - Area abfe
- It is equivalent to the area between PMC and SMC curves
  - Area cdhg
- There is a societal loss of area dhg
  - Overproduction means costs to society exceed benefits

Negative Externalities



- What happens if we reduce output to the social optimum?
- There is a gain for Jules, but a loss for Azul
- Jules gains area cdhg
  - Reduction in production means less harm to him
- Azul loses area dcg
  - Produces less and benefits less privately
- Society gains area dhg

Negative Externalities

- What activities tend to pollute and cause negative externalities?
  - Manufacturing and industrial processes
  - Transportation (cars, trucks, airplanes)
  - Energy production (coal, oil, natural gas)
  - Agriculture (fertilizers, pesticides, livestock)
  - Waste disposal (landfills, incineration)
  - Many of these produce smog, which pollutes the air and travels long distances
- Which pollutants do harm?
  - Particulate matter (PM2.5 and PM10): tiny particles that can penetrate lungs and cause respiratory issues
  - Nitrogen oxides (NOx) and sulfur dioxide (SO2): contribute to acid rain and respiratory problems

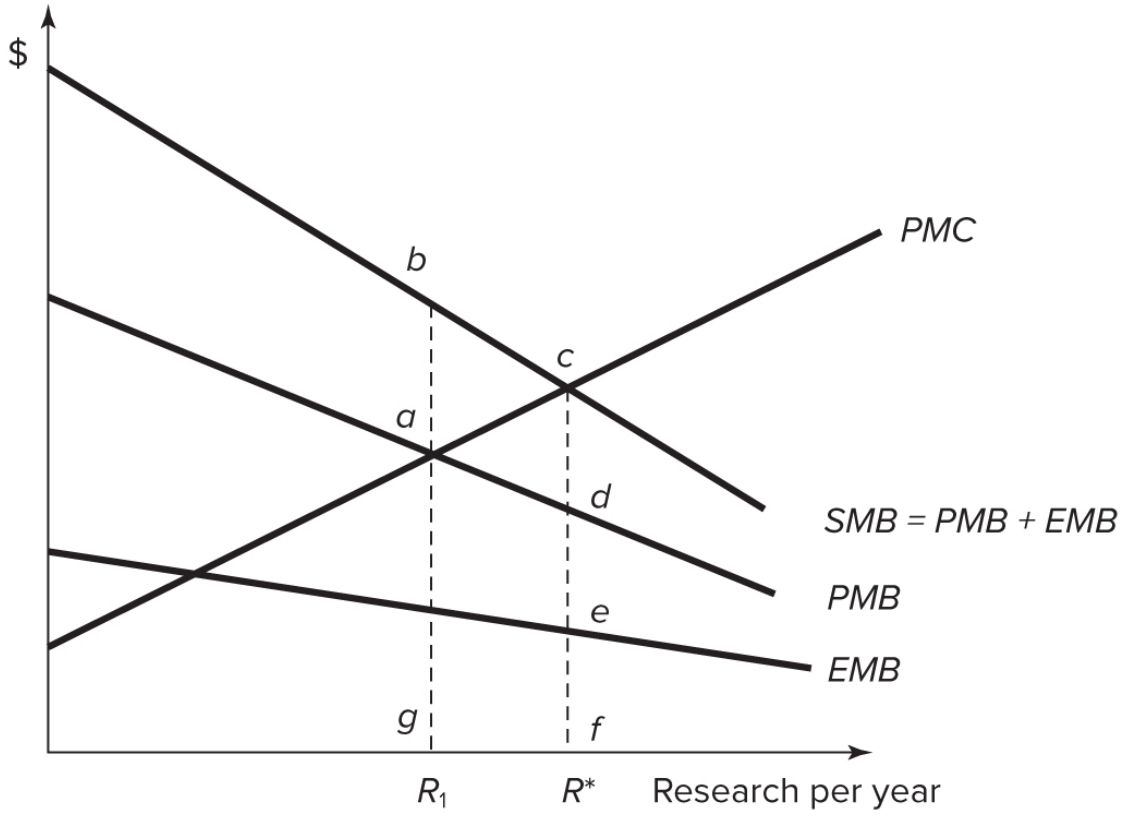
Negative Externalities

- What is the value of the damage?
  - Difficult to measure precisely
  - Economists have used differences in house prices in areas with different levels of pollution
  - Illustrates how much people are willing to pay to avoid pollution
  - But can be complicated by other factors affecting house prices

Positive Externalities

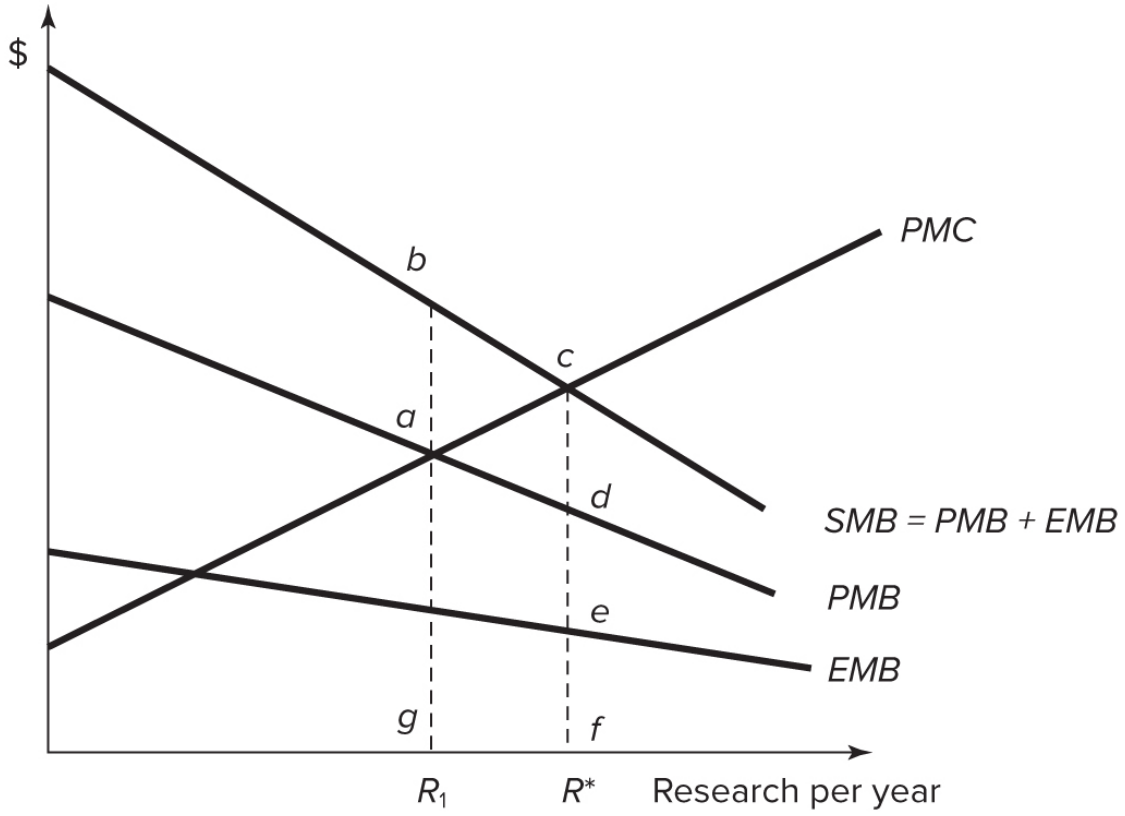
- Less salient, but some production leads to positive externalities
  - Vaccinations: reduce disease spread, benefiting others
  - Education: educated individuals contribute to a more informed and productive society
  - Public parks: green spaces enhance community well-being and property values
  - Research and development: innovations can lead to widespread technological advancements
- Can lead to similar inefficiencies
  - This time due to underproduction

Positive Externalities



- Private and social costs are assumed equal
- Private and social benefits differ by an external marginal benefit
  - SMB = PMB + EMB
- Optimum ignoring externalities is where PMB = PMC
- Social optimum is where SMB = PMC
  - At higher level of output

Positive Externalities



- Can illustrate inefficiency using areas on the graph
- The unrealized benefit to society from underproduction is area under EMB
  - Equivalently, area between PMB and SMB curves bcda
- If we move to the social optimum
  - Society gains area bcda
  - Individual loses acd through extra production
- Total gain is area abc

Private Solutions to Externalities

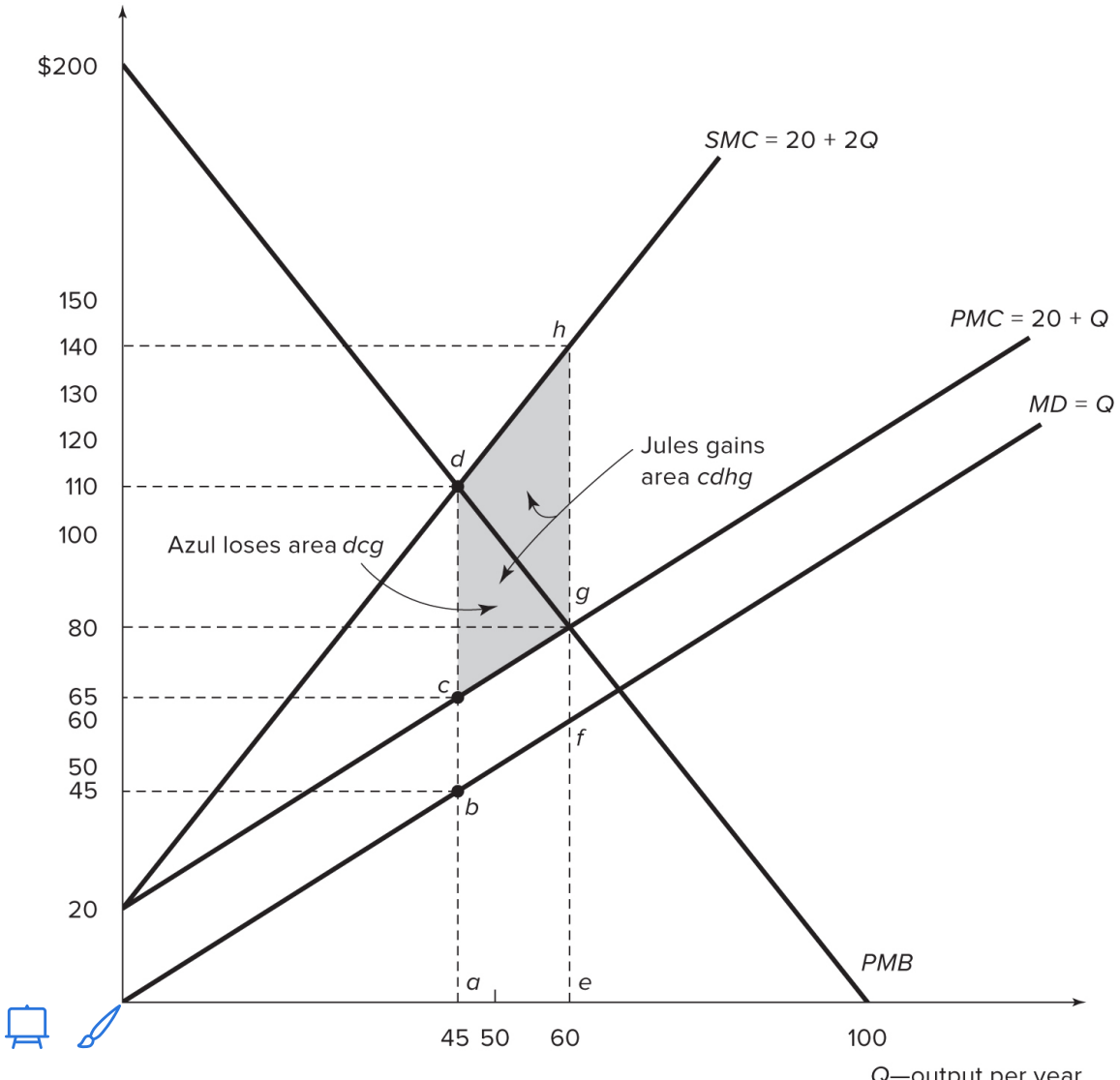
Introduction

- With market failures, government can intervene to get to efficient outcome
- But they do not have to
- In the case of externalities, private solutions are sometimes possible
- Issue with externalities is that property rights are not well defined
  - Example: nobody owns the river that Azul pollutes
- Can be solved by allocating property rights

Coase Theorem

- **Coase Theorem**: if property rights are well defined and transaction costs are low, private parties can negotiate to resolve externalities efficiently
  - It does not matter who owns the property rights
- Suppose Azul owns the river
  - Azul has the right to pollute
  - Would be willing to not produce an extra unit if he is paid PMB-PMC or more
  - Jules would pay Azul to not produce if the payment is less than MD
  - Payments could happen if PMB-PMC > MD

Coase Theorem

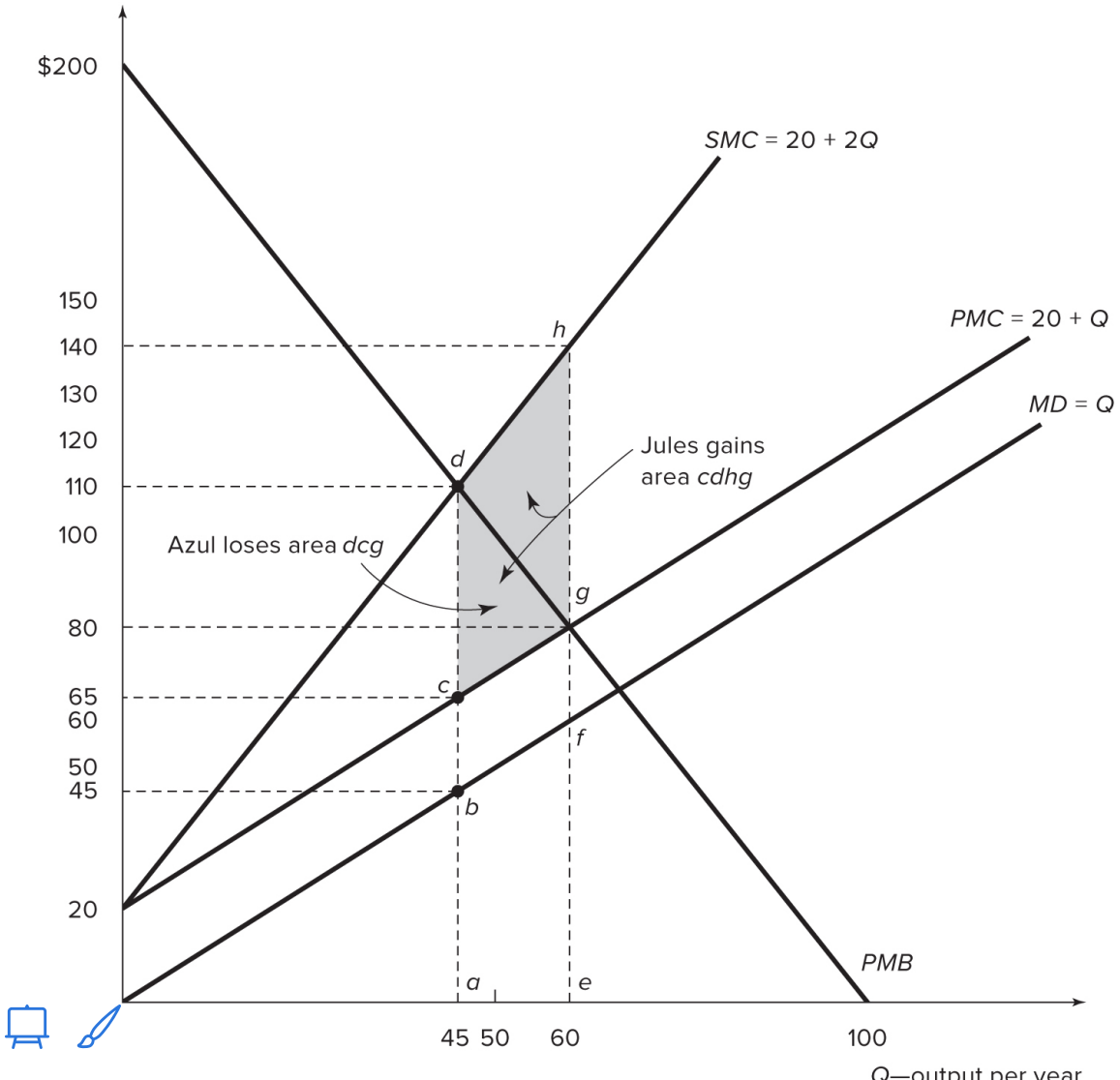


- Suppose Azul owns the river and is currently producing the private optimum
  - Marginal damage at that point is ef
  - PMB-PMC for Azul is zero
  - Jules could pay to not produce that unit
- At every output above the social optimum MD > PMB-PMC
  - Jules could pay Azul to reduce output
- At social optimum MD = PMB-PMC
  - No further mutually beneficial trades possible

Coase Theorem

- Bargaining also works if Jules owns the river
  - Azul would pay Jules to allow pollution
- Azul would pay up to PMB-PMC to pollute
- Jules takes that payment if it is more than MD
- Bargaining stops where PMB-PMC = MD

Coase Theorem



- Consider starting at zero and moving up
- Will Azul produce the next unit?
- At low levels of output, PMB-PMC is large, and MD is small
  - Worth it for Azul to produce and pay for damage
- As more units are produced, PMB-PMC falls and MD rises
- They are equal when production reaches social optimum

Coase Theorem

- Coase won a Nobel prize for this insight into externalities
- However, there are limitations
  - Transaction costs may be high
  - Many parties may be involved
  - Property rights may be hard to define or enforce
- Air pollution is good example of these problems
  - Many polluters and many affected parties
  - Hard to assign property rights to air

Mergers

- The Coase Theorem is an example of internalizing an externality
  - Making it part of the costs or benefits of the decision maker
- Another way to internalize an externality is through mergers
  - If Azul and Jules merge into one firm, the externality disappears
  - The new firm considers both private costs and damages

Social Conventions

- Sometimes social conventions can help solve externalities
  - People may voluntarily reduce negative externalities to avoid social disapproval
  - Example: littering, smoking in public
- However, social conventions may not be sufficient for large-scale externalities
  - Example: climate change requires coordinated action beyond social norms

Public Solutions to Externalities

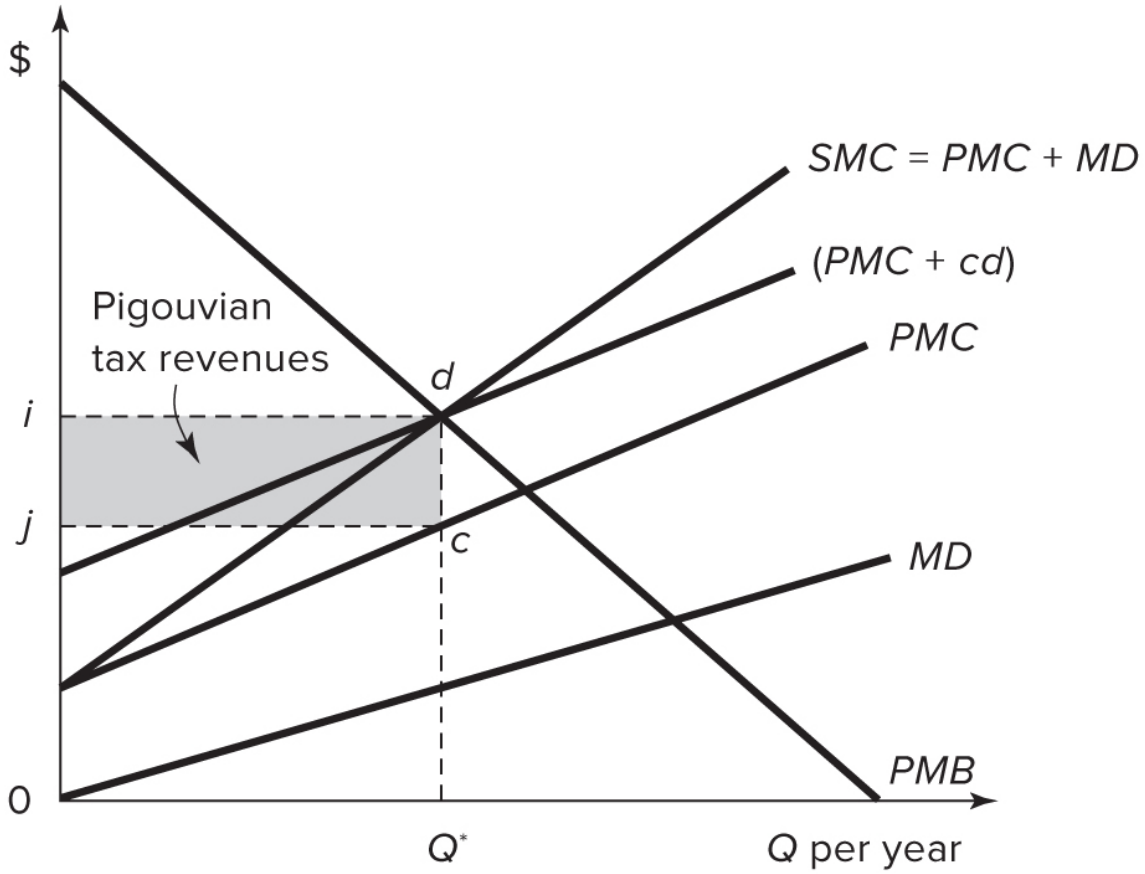
Introduction

- This is a class in public economics, so it is natural to consider government intervention
- Government can use taxes, subsidies, or regulations to address externalities
- This is a feasible approach when private solutions are not possible or insufficient
  - There are many situations where private solutions fail
- Government approaches are or have been used in practice to address carbon emissions
  - Carbon tax
  - Cap and trade
  - Regulations

Pigouvian Taxes for Negative Externalities

- With negative externalities, too much is produced
  - People/firms do not consider the full social cost of their actions
- One way to internalize the externality is through a **Pigouvian tax**
  - A tax equal to the marginal damage at the socially optimal level of output
- As with other taxes, this imposes a cost on the producer
  - Changes their incentives to account for the externality

Pigouvian Taxes for Negative Externalities



- The socially optimal output is where PMB = SMC
- But private producers only consider PMC
- Pigouvian tax shifts PMC up to intersect PMB at the social optimum
  - Private producers now face the full social cost of production
- The tax equals the vertical distance between PMC and SMC at the social optimum
- Revenues equal height of the tax times quantity produced

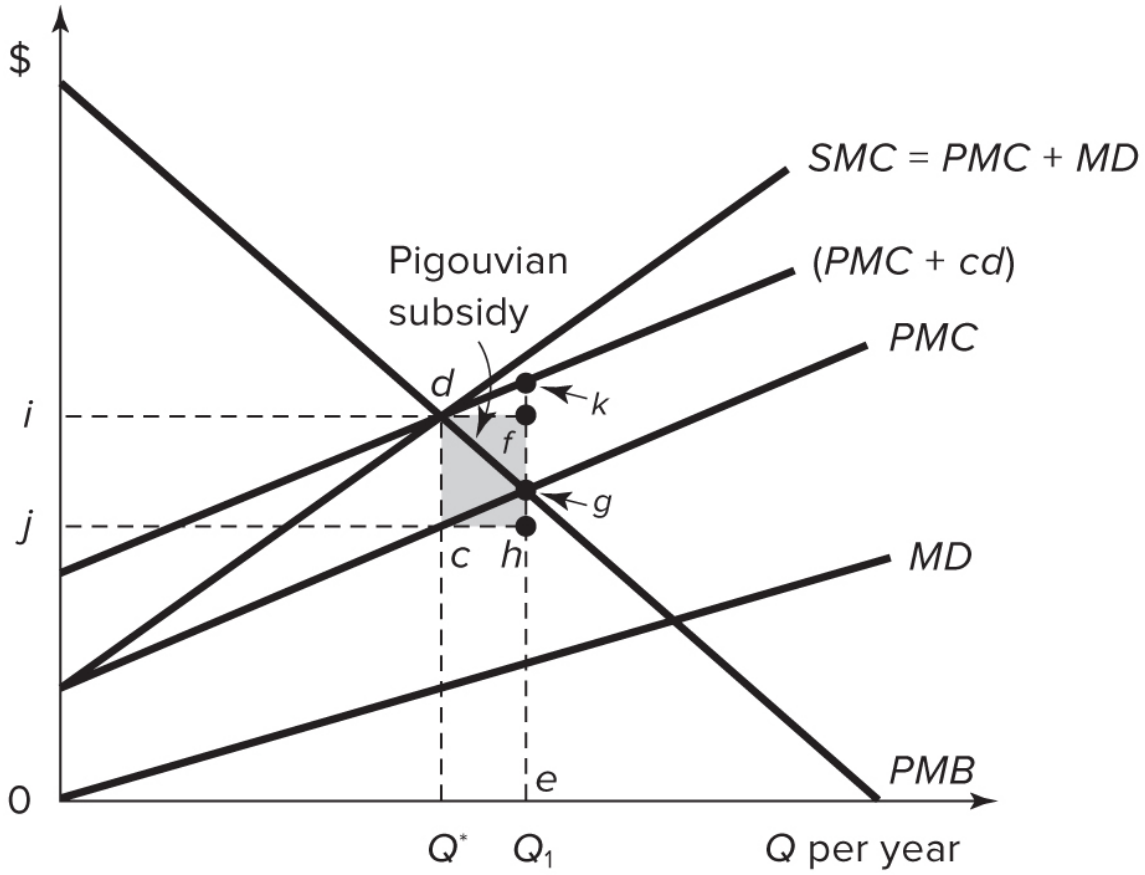
Pigouvian Taxes for Negative Externalities

- Graph makes pigouvian tax seem straightforward
- But depends on knowing the marginal damage function
  - Difficult to measure in practice
- In practice, governments may not get the tax at the perfect level
  - But even an approximate tax can improve efficiency

Pigouvian Subsidies for Negative Externalities

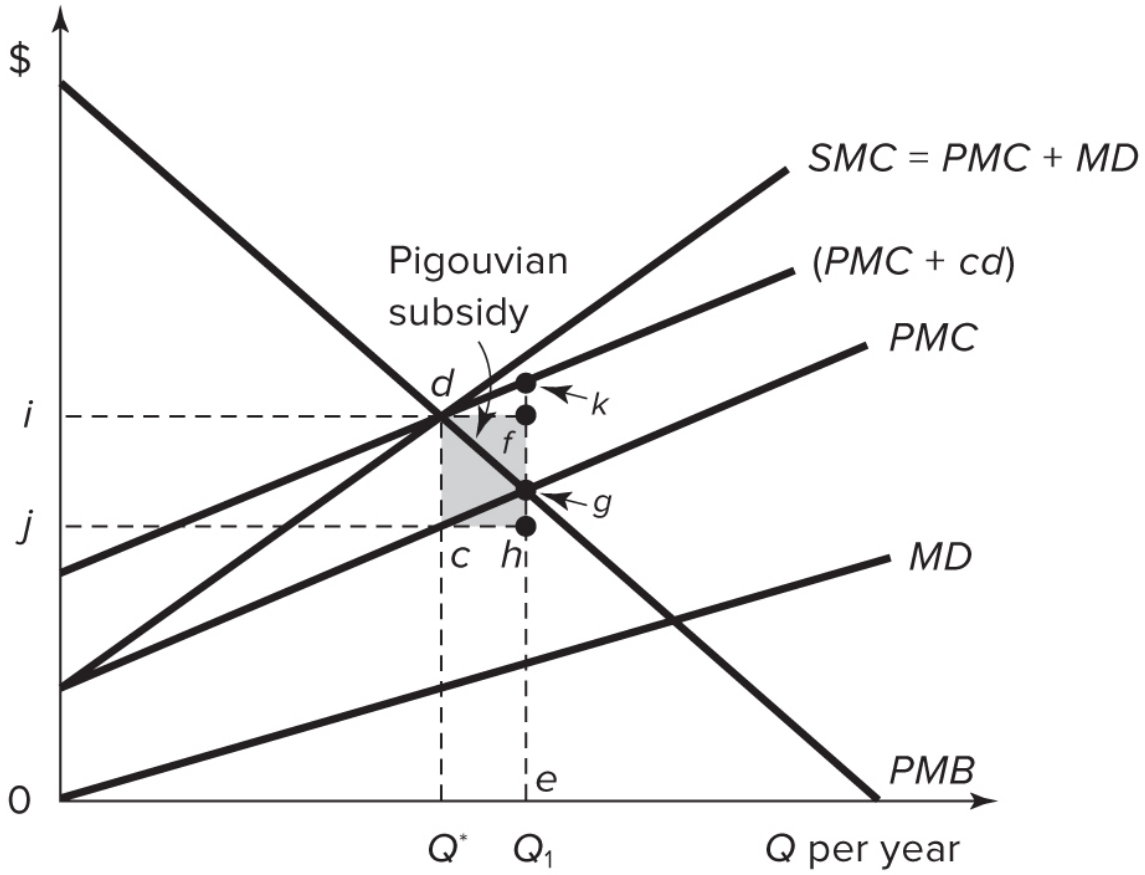
- Pigouvian taxes are a natural way to address negative externalities
  - Acts like a punnishment for harmful behavior
- But the optimal output can also be achieved by *subsidizing* polluters
  - Paying the polluter to reduce output
- The subsidy would equal the marginal damage at the social optimum
- Any production above the social optimum would be discouraged by the subsidy

Pigouvian Subsidies for Negative Externalities



- Consider producing Q_1 initially
- Where $PMB = PMC$
- Government offers subsidy equal to MD at social optimum for each unit not produced
  - This **increases** the private marginal cost
  - Cost = PMC + foregone subsidy
  - Shifts the cost curve up
- Acts the same way as the tax

Pigouvian Subsidies for Negative Externalities



- It is now optimal to produce at the social optimum
- The government must pay money for each unit not produced
  - Equals the height of the subsidy times the reduction in quantity from Q_1 to Q^*

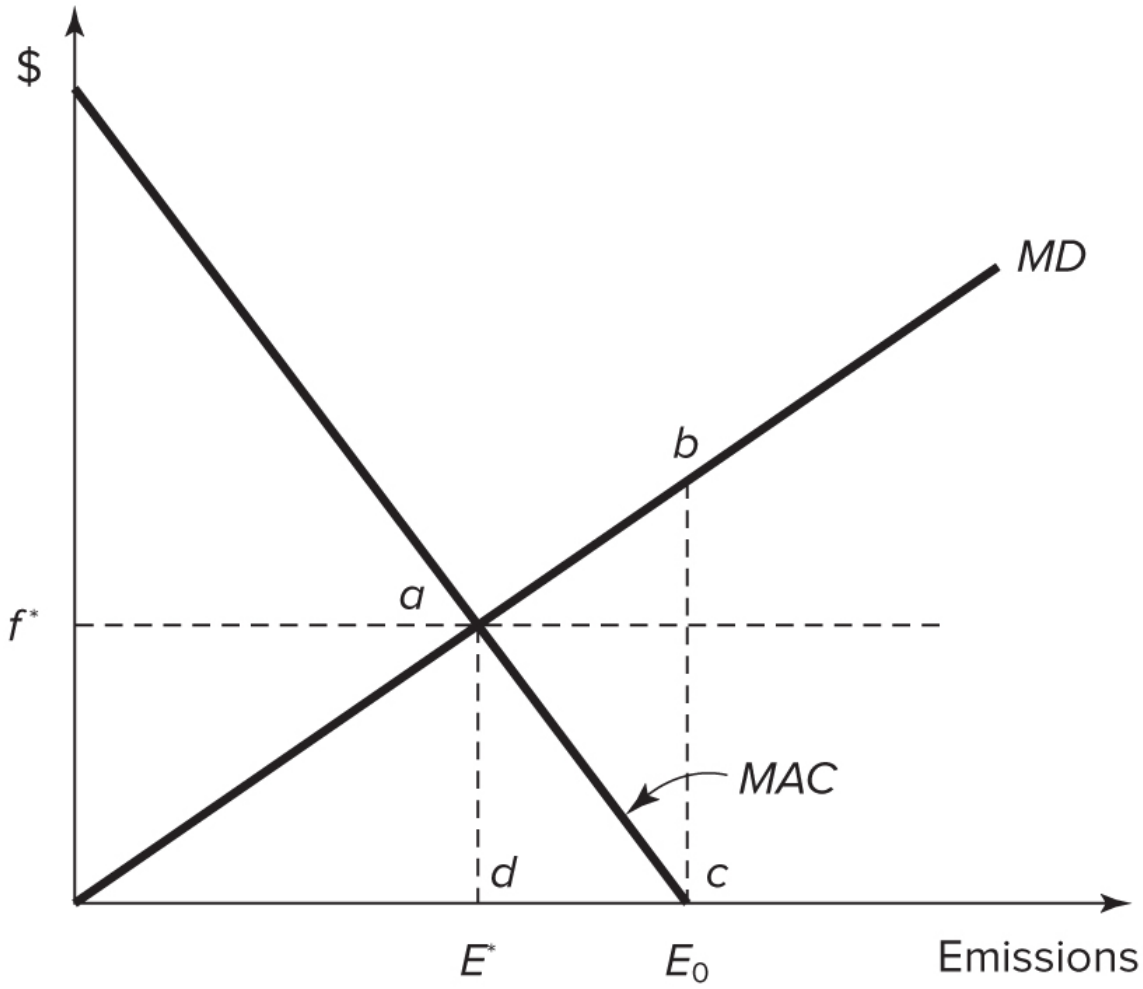
Pigouvian Subsidies for Negative Externalities

- Pigouvian subsidies for negative externalities are problematic
  - Politically difficult to justify paying polluters
  - Requires government to have funds to pay subsidies
    - Could require taxes elsewhere
  - Would increase firm profits and draw firms into the industry
- There are some real world examples
  - EV rebates
  - Subsidies for renewable energy production

Emissions Fees for Negative Externalities

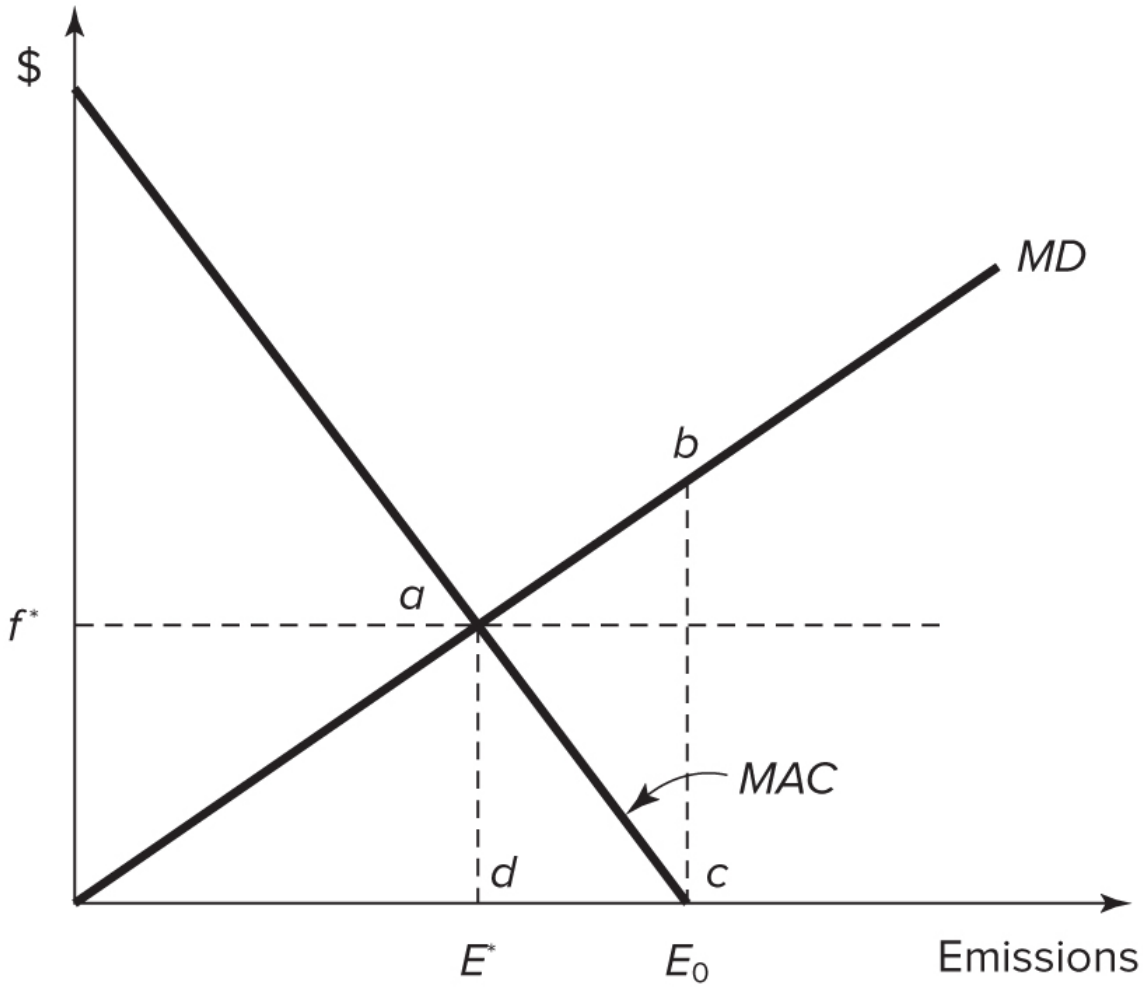
- A subtle detail about the pigouvian tax is that it is levied on *output*
  - Tax gives the incentive to reduce output
  - But does not directly target emissions
  - Could be that the firm installs a pollution control technology instead of reducing output
  - In the case of the pigouvian tax, the tax bill would be the same
- An alternative is an *emissions fee*
  - A tax on the amount of pollution emitted
  - Directly targets the externality
  - Still provides the incentive to reduce emissions through any means

Emissions Fees for Negative Externalities



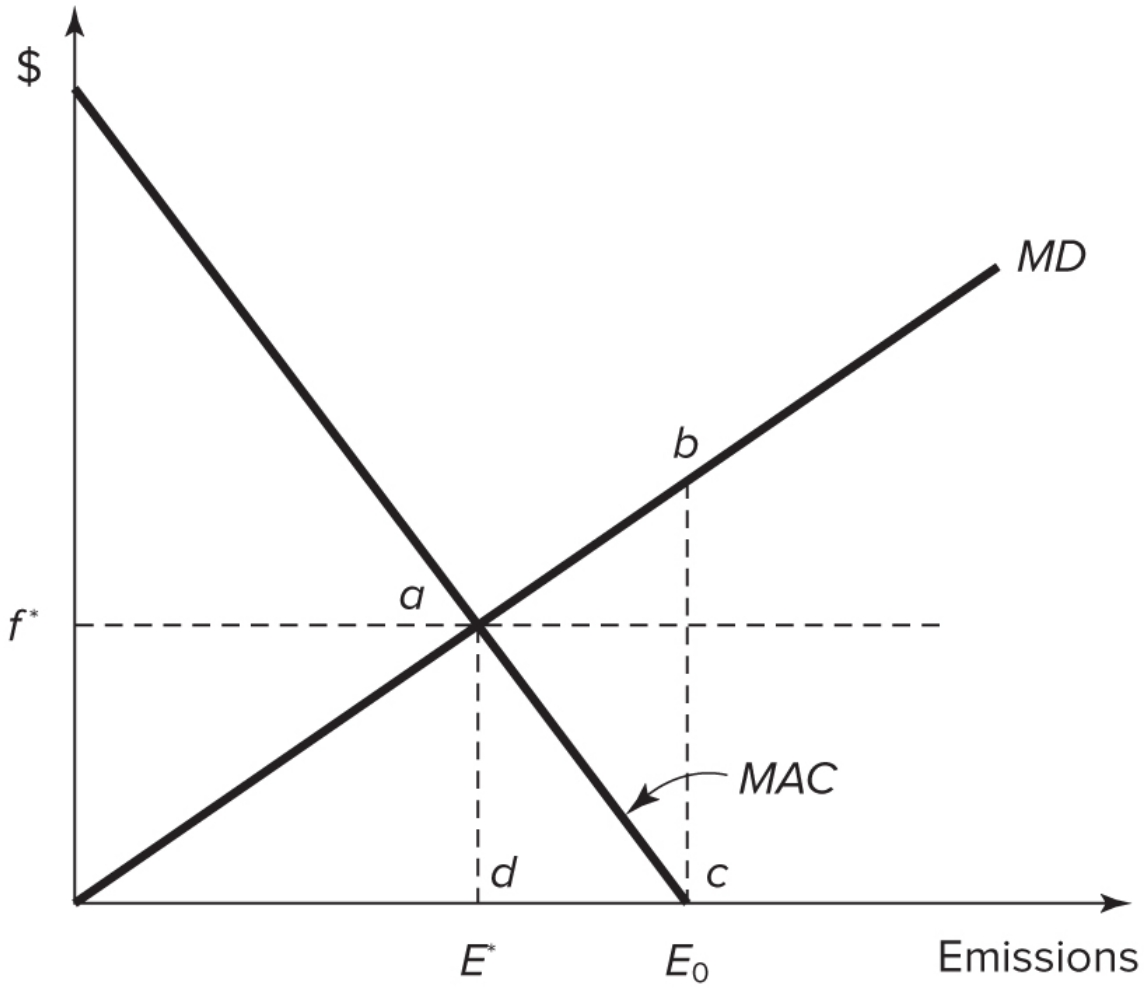
- Graph depicts costs on vertical axis, emissions on horizontal
- Marginal damage (MD) increases with emissions
  - There is a benefit to reducing emissions
- Marginal abatement cost (MAC) increases with abatement
  - Abatement reduces emissions, but is costly
  - Read this curve from right to left
  - i.e. at E_0 emissions, abatement is zero and MAC is zero
- Without emissions fee, firm emits E_0

Emissions Fees for Negative Externalities



- There are net societal benefits to reducing emissions from E_0 to E^*
  - Reducing emissions reduces damage
  - There are costs, but benefits exceed costs
- Without some intervention, firm would not incur the cost of abatement despite societal benefit
- Government can impose an emissions fee equal to MD at E^*
  - This incentivizes the firm to reduce emissions to the social optimum

Emissions Fees for Negative Externalities

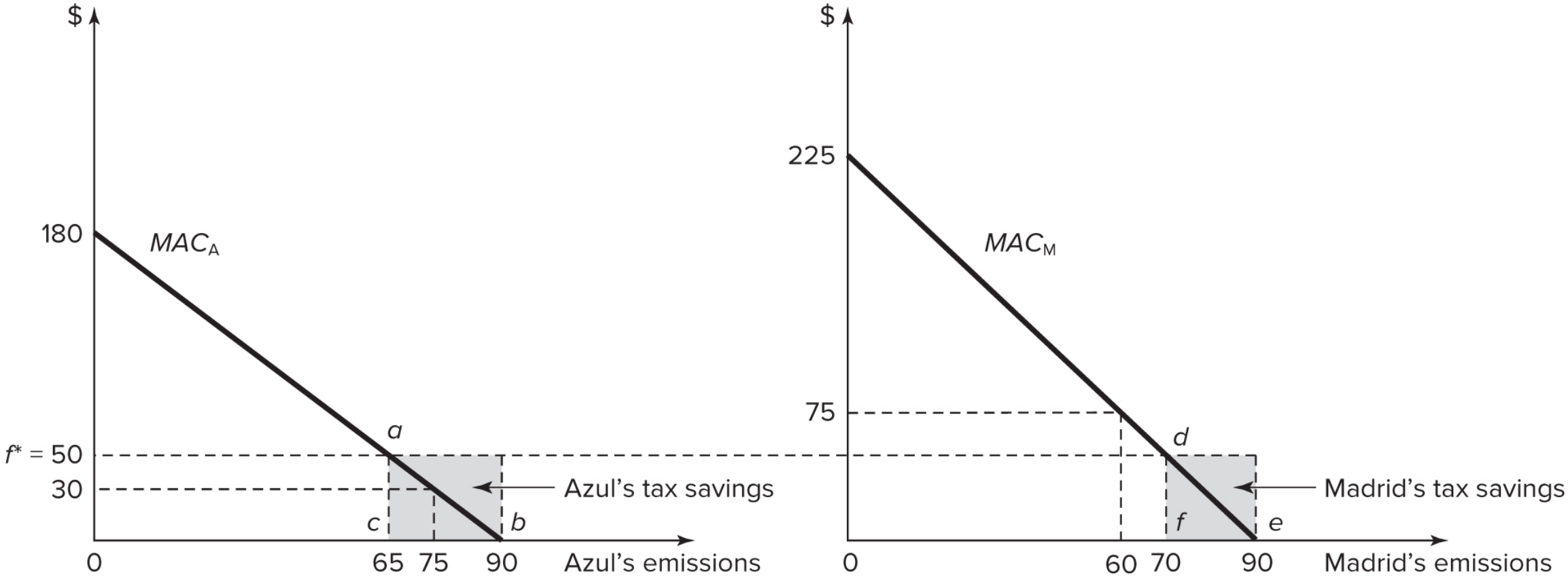


- Imagine reducing emissions by one unit below E_0
  - Firm incurs cost of MAC
  - But avoids paying the emissions fee equal to f
  - Emissions fee is higher, so worth doing
- Firm continues reducing emissions until MAC = f
  - This occurs at E^*, the social optimum
  - Beyond that point, MAC exceeds f, so not worth further abatement

Emissions Fees for Negative Externalities

- What if there are multiple polluters?
  - Each firm has different abatement costs
  - Each firm has different levels of pollution
  - But fee is the same for each polluter
- Mechanism works the same way
  - Each firm reduces emissions until MAC = f
  - Firms with low abatement costs reduce more
  - Firms with high abatement costs reduce less

Emissions Fees for Negative Externalities



Emissions Fees for Negative Externalities

- Canada’s carbon tax was an example of an emissions fee
  - Applied to fossil fuels based on their carbon content
  - Incentivized firms and individuals to reduce carbon emissions
- Additional detail is that it was revenue-neutral
  - Most revenues were distributed back to individuals as lump sum payments
- This has been paused as of 2025 in favour of other approaches
  - Likely some regulations or subsidies

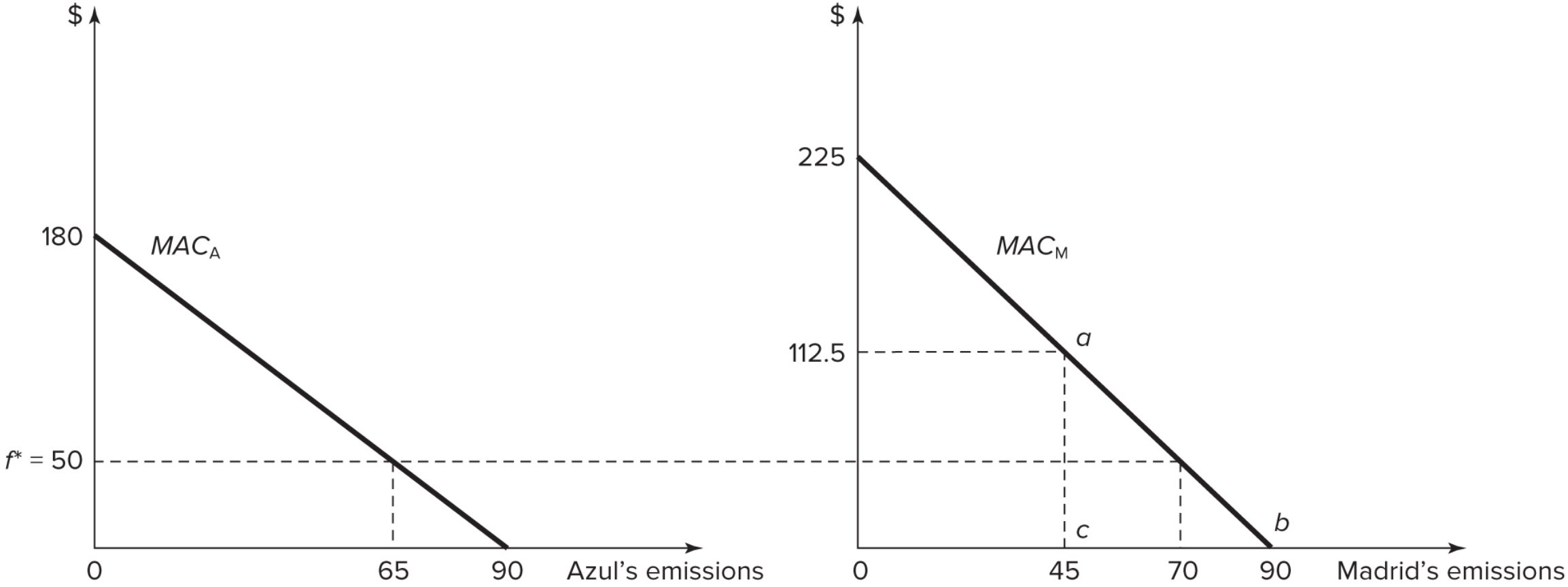
Tradeable Permits for Negative Externalities

- Another approach to addressing negative externalities is through tradeable permits (cap-and-trade)
  - Government sets a cap on total emissions allowed
  - Issues permits equal to the cap
  - Firms can buy and sell permits in a market
- Government can either give away the permits or auction them
  - In the real world, they are typically auctioned

Tradeable Permits for Negative Externalities

- Imagine government wants to cap emissions at 135 units
  - Issues 135 permits
  - Each permit allows one unit of emissions
- Azul is allocated 90 units, Madrid 45 units
- This initial allocation does not matter
- In graph on next slide, initially Azul emits 90 units, Madrid 45 units
- There is an incentive for Azul to sell some of its permits to Madrid
  - Madrid willing to pay more than Azul's cost to reduce emissions
  - Keep trading until MACs are equalized

Tradeable Permits for Negative Externalities



Tradeable Permits for Negative Externalities

- Cap and trade achieves the social optimum
  - Total emissions equal to the cap
  - Firms reduce emissions until MACs are equalized
- Note that the emissions reduction is achieved regardless of permit trading
  - The trades just ensure that reductions are made by firms with the lowest costs
- Quebec has a cap and trade system in place
  - Linked with California's system
  - Covers large industrial emitters and fuel distributors

Regulations and Negative Externalities

- Market approaches like taxes and cap-and-trade allow the firms to figure out how to reduce emissions
  - Provide flexibility and cost-effectiveness
- The government can just regulate emissions directly
  - Set limits on emissions for firms
  - Require use of specific technologies
- Generally, regulations are less efficient
  - Do not allow firms to find the cheapest way to reduce emissions
  - Can be more costly overall

Subsidies for Positive Externalities

- Negative externalities are more prominent in policy discussions
- But positive externalities also create inefficiencies
  - Too little of the good is produced
- Key areas with positive externalities
  - Education
  - Vaccinations
  - Research and development
- Governments often subsidize these activities to encourage more production

Subsidies for Positive Externalities

- Pigouvian subsidies can address positive externalities
  - Subsidy equal to the external marginal benefit at the social optimum
  - This increases private marginal benefit to equal social marginal benefit
  - Encourages more production to the socially optimal level
- Main issue with subsidies is that they need to be funded
  - Requires government revenue from taxes or other sources
  - Can create political challenges

Regulations for Positive Externalities

- We can regulate to encourage more production of goods with positive externalities
  - Mandatory schooling laws
  - Vaccination requirements for school entry
- Typically failure to comply results in penalties
  - Fines
  - Denial of services (e.g., school enrollment)
- Main issue is balancing freedom versus public good
  - Can be controversial in some cases
  - Vaccines are especially contentious in recent years

Implications for the Income Distribution

Introduction

- All of the discussion has been about efficiency
  - How to get to the socially optimal level of production
- But equity is also important
  - How are the costs and benefits of externalities distributed across society?
  - How are the costs and benefits of government interventions distributed?

Who Benefits?

- The costs and benefits of externalities are not evenly distributed
  - Low income neighbourhoods bear costs of pollution disproportionately
    - Pollution from factories often located near low-income neighborhoods
    - Health impacts from pollution can exacerbate existing inequalities
  - They also stand to benefit more from vaccination policies
    - Lower-income individuals may have less access to healthcare
    - May also live in denser areas, increasing disease spread risk
    - Vaccination reduces disease spread in vulnerable populations
- Policies to address externalities should consider these distributional impacts

Who Bears Costs?

- As with taxes, it is not always clear who bears costs
- With a Pigouvian tax, emissions fee, or regulation, it is not as simple as who pays the tax
  - Firms may pass on costs to consumers through higher prices
  - Workers may face lower wages if firms reduce profits
  - Landowners may see changes in property values due to pollution or improvements
  - Subdidies are financed by taxpayers
- Carbon taxes on their own are regressive
  - Low-income households spend a larger share of income on energy
  - But rebates can offset this effect
- It is a difficult empirical question to determine the incidence of these policies

Summary

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- Externalities are costs or benefits imposed on third parties not involved in a market transaction
- Negative externalities lead to overproduction, positive externalities lead to underproduction
- Private solutions like the Coase theorem can sometimes resolve externalities
- Public solutions include Pigouvian taxes and subsidies, emissions fees, tradeable permits, and regulations

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