Public Finance (First part)

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Lecture 5:

Market failures I

Limitations of Welfare Economics

- There are situations in which the competitive market equilibrium could be Pareto sub-optimal
- This means that the **First Welfare Theorem does not necessarily hold**
- These situations are called **Market Failures**
  1. **Externalities**
  2. **Public goods**
  3. **Natural monopoly**
  4. **Asymmetric information**

1. Externalities

Externalities

Definition

An activity of one entity that affects the welfare of other entities **outside market**

- Since they take place outside the market they do not affect the market price/quantity.
- Information about welfare effect of the activity not accounted for in price/quantity
- Externality: A steel plant produces carcinogen dioxin and increases society's public health costs. $\rightarrow$ Costs to society are not included in the steel price.
- Not an externality: A steel plant uses more electricity and bids up the price of electricity for other electricity customers
  $\rightarrow$ Costs to society are included in the steel price

Types of externalities

- **Positive vs Negative**
  - Positive: The activity increases welfare outside the market –¿ **underproduction/underconsumption with respect to the social optimum**
  - Negative: The activity decreases welfare outside the market –¿ **overproduction/overconsumption with respect to the social optimum**
- **Consumption vs Production**
  - Consumption: Buy a bycyle (positive), Cigarette smoke (negative)
  - Production: R&D (positive), pollution (negative)

Negative externalities in production

Definition

Marginal Private Cost (MPC): The direct cost for the producer of supplying an additional unit of a good

Definition

Marginal Damage (MD): Any additional cost associated with the production of the good that is imposed on others (society) but that the supplier does not pay

Definition

Marginal Social Cost (MSC = MPC + MD): Total cost equal to marginal private cost to producers plus marginal damage

Example

Steel plant pollutes a river but does not face any pollution regulation, hence ignores pollution when deciding how much to produce

Positive externalities in production

Definition

Marginal Social Benefit (MSC = MPC + MD): Total benefit equal to marginal private benefit to producers plus marginal benefit

Definition

Marginal Private Benefit (MPB): The direct benefit for the producer of supplying an additional unit of a good

Definition

Marginal Benefit (MB): Any additional benefit associated with the production of the good that is imposed on others (society) but that the supplier does not enjoy

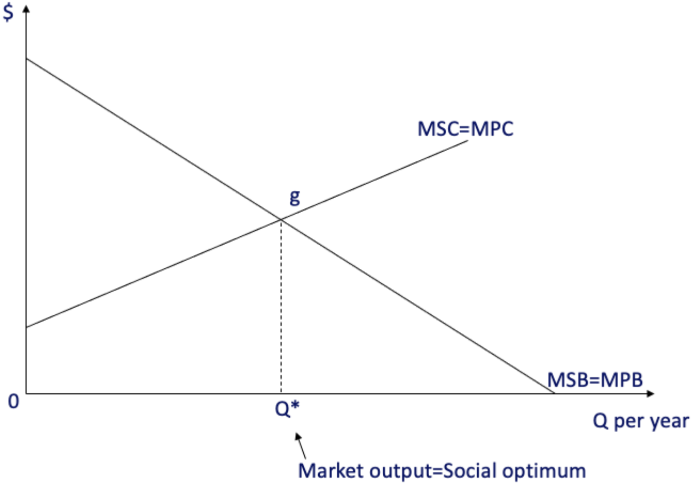
Example

Investments in Research and Development (R&D) by NASA for space exploration have an impact on techonologies employed in other important human activities (e.g., medical devices)

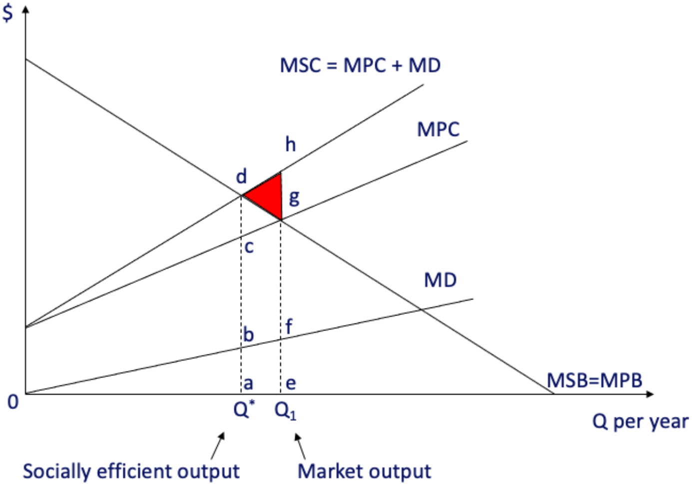
Inefficiency in presence of externalities

- Individuals in the free market take decision based on their private benefits and costs
  - Free market equilibrium equates Marginal Private Benefits and Costs
    $\rightarrow$ **MPB = MPC**
  - Social optimum is obtained equating Marginal Social Benefits and Costs
    $\rightarrow$ **MSB = MSC**
- Free market eq. $\neq$ Social optimum
- **Market outcome is inefficient**

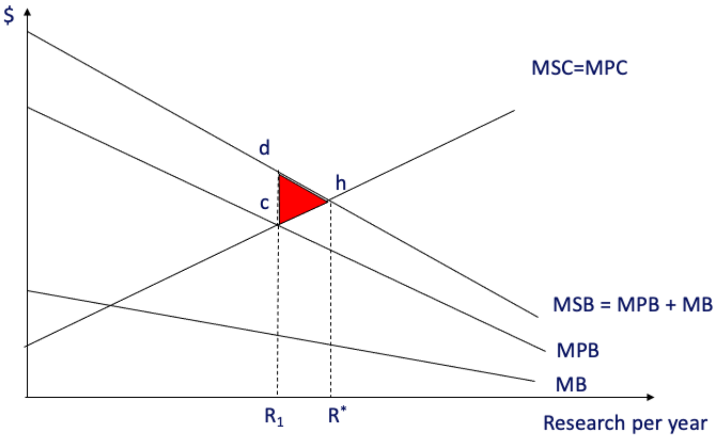
Efficient market equilibrium (no externality)



Market inefficiency (negative externality in production)



Market inefficiency (positive externality in production)



Example: Tragedy of the Commons

- Consider a lake village of 2 people who can go fishing by renting boats at a cost c.
- If boats are hired, the fish caught by each boat is $F(B)$ (decreasing and concave in B). For simplicity, assume fish price $= 1$.
- **Market Equilibrium** number of boats $B^* = B_1^* + B_2^*$ will be identified by condition:
  - **Marginal profits from an additional boat** equal to zero.
  - If marginal profits were to be greater than 0 more boats would be hired and vice-versa
- Each fisherman is concerned only with his own profit.
  $\rightarrow$ Does not take into account the negative externality they impose on the others: **each additional boat used for fishing reduces the amount of fish caught by the others**
- In equilibrium too many boats will be hired with respect to the social optimum.

Tragedy of the Commons: Analytics

- **Optimal Private number of boats for individual** i B_i^*

$$B_i^* = \underset{B_i}{\mathrm{argmax}} \Pi_i(B) = B_i F(B) - B_i c = B_i[F(B_i + B_{-i}) - c]$$

- **Optimal Private** FOC

$$F(B_i^* + B_{-i}^*) - c + B_i^* F^{'}(B_i^* + B_{-i}^*) = 0$$

- From which we get

$$B_i^* = \frac{c - F(B_i^* + B_{-i}^*)}{F'(B_i^* + B_{-i}^*)}$$

- Individuals are homogeneous, hence

$$B_{-i}^* = \frac{c - F(B_i^* + B_{-i}^*)}{F'(B_i^* + B_{-i}^*)}$$

- From which we get $B^* = 2\frac{c - F(B^*)}{F'(B^*)}$

Tragedy of the Commons: Analytics

- **Optimal Social number of boats** $B^O = B_1^O + B_2^O$

$$B^O = \underset{B}{\operatorname{argmax}} W(B) = BF(B) - Bc = B[F(B) - c]$$

- **Optimal Social** FOC

$$F(B^O) - c + B^O F^{'}(B^O) = 0 \Rightarrow F(B^O) = c - B^O F^{'}(B^O)$$

$$B^O = \frac{c - F(B^O)}{F'(B^O)}$$

Tragedy of the Commons: Analytics

- Let us now compare B^* and B^O
- $B^* = B^O$ (i.e., private agents yield efficient outcome) if

$$2\frac{c - F(B^*)}{F'(B^*)} = \frac{c - F(B^O)}{F'(B^O)}$$

- Which is clearly a contradiction
  $\rightarrow$ Optimal private choice by i does not incorporate the externality imposed on $-i$ by ignoring $F^{'}(B_i^*)$ enters individual $-i$'s profit function, which is a negative externality since $F^{'}(.) < 0$. $\Rightarrow B^O < B^*$

Tragedy of the commons – $F(B) = \sqrt{B}$

- Individual i solves

$$\max_{B_i} B_i[\sqrt{B_i + B_{-i}} - c]$$

- With FOC $(B_i + B_{-i})^{\frac{1}{2}} - c + \frac{1}{2}(B_i + B_{-i})^{-\frac{1}{2}} B_i = 0$
- Individuals are homogeneous hence $B_i^* = B_{-1}^* \rightarrow (2B_i)^{\frac{1}{2}} - c + \frac{1}{2}(2B_i)^{-\frac{1}{2}} B_i = 0$
- $(2B_i)^{-\frac{1}{2}} \frac{5}{2} B_i = c \rightarrow B_i^{\frac{1}{2}} = \frac{2}{5} 2^{\frac{1}{2}} c$
- Total number of boats is equal to $B_1^* + B_2^* = (\frac{4}{5}c)^2 = 0.64c^2$

Tragedy of the commons – $F(B) = \sqrt{B}$

- Society optimal achieved when

$$\max_B B[\sqrt{B} - c]$$

- With FOC $B^{\frac{1}{2}} - c + \frac{1}{2}B^{-\frac{1}{2}}B = 0 \rightarrow$ total number of boats is $B^O = (\frac{2}{3}c)^2 \approx 0.444c^2$
- $B^O = B_1^O + B_2^O$ hence $B_1^O = B_2^O = \frac{(\frac{2}{3}c)^2}{2}$

Market equilibrium leads agents to rent many more boats than the socially optimum amount

Intertemporal externalities

- We can also think of externalities of current generation vs. future generations
  - For many resources, over-exploitation leads to reduced ability to regeneration (fisheries, pastures,...) $\rightarrow$ **In the long term, the over-exploitation realized by the market equilibrium leads to low production**
- Example: pension system
  - Pensions financed by contributions paid by current workers
  - Pensions received by current retired individuals
- Social choice problem
  1. Current retired demand higher pensions
  2. Soon-to-retire workers demand to retire as soon as possible
  3. Young workers demand lower contributions
- **Who pays?** $\rightarrow$ Public debt (future generations)

Private and public remedies to externalities

How to internalize the externality?
→ Private negotiations or government action (to different degree) so that the private price fully reflects the social costs or benefits

- **Definition of property rights (regulation)**: Let the market solve the issue of externalities through private transaction of rights
- **Public intervention on price (tax/fees/subsidies) / Quantity:**
  → Tax on boat to make each fisherman internalize the external effect of sending a boat to the lake
  → Max number of boats allowed
  → Imposing complusory standards aimed at avoiding exploitation
- **Mergers** *(not treated in this course)*
- **Public production** *(not treated in this course)*

Property rights: the Coase Theorem

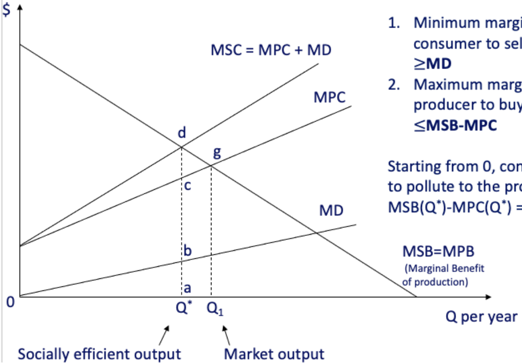
Main contribution of Ronald Coase, Nobel Prize winner

Theorem

Part I: *When there are **well-defined property rights and costless bargaining**, negotiations between the party creating the externality and the party affected by the externality can lead to the socially optimal market quantity*

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: graphical analysis



Case 1:
Production rights assigned to the agent bearing the cost of the externality **(consumer)**

1. Minimum marginal price for consumer to sell the rights to pollute **≥MD**
2. Maximum marginal price for producer to buy rights to pollute **≤MSB-MPC**

Starting from 0, consumer will sell right to pollute to the producer until Q^*
$MSB(Q^*)-MPC(Q^*) = MD(Q^*)$

$cd=ab=MD(Q^*)$

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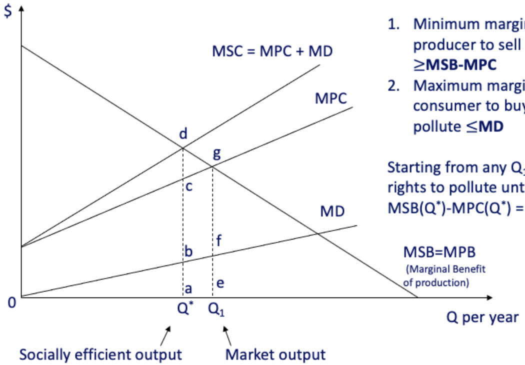
Coase Theorem: graphical analysis



Case 2:
Production rights assigned to the agent creating the cost of the externality **(producer)**

1. Minimum marginal price for producer to sell rights to pollute **≥MSB-MPC**
2. Maximum marginal price for consumer to buy the rights to pollute ≤**MD**

Starting from any Q_1 producer will sell rights to pollute until Q^* since:
$MSB(Q^*)-MPC(Q^*) = MD(Q^*)$

$cd=ab=MD(Q^*)$

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Limitations of the Coase Theorem

- 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 complex when agents involved in by the externality are many/disperse (e.g. global warming)
  2. **Transaction Costs and Negotiating Problems** → Coasian approach ignores the fundamental problem that negotiation is complex
  3. **Veto power**
     → Transactions are complex when property is shared because joint owners have all to agree to the Coasian solution → Worsened by variety/conflict of interests among the parties
- **Coasian solutions are more effective for small, localized externalities than for larger and more global externalities**

Summary of Coasian solution

- Coase's Theorem shows that externalities can sometimes be internalized
- It provides the competitive market model with a defence against the onslaught of market failures
- It is also an excellent reason to suspect that the market may be able to internalize some small-scale, localized externalities $\rightarrow$ Market creation of incentives towards the efficient outcome
- Coasian solution does not help with large-scale, global externalities, where only a "government" can successfully aggregate the interests of all individuals suffering from externality
- Crucial role of government in setting up well defined property rights and possibly regulating the market

Public sector remedies to externalities

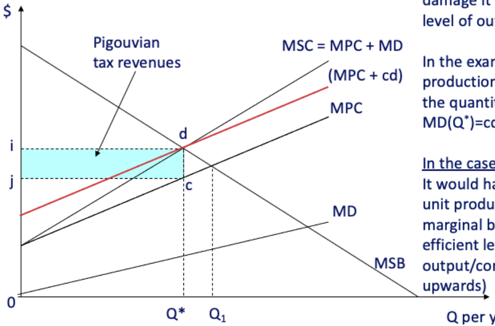
- Policymakers employ two types of remedies to resolve the problems associated with externalities
  1. **Price policy**: corrective tax or subsidy on quantity produced or on measure of external effect (e.g., emissions)
  2. **Quantitaty regulation**: government forces firms to produce the socially efficient quantity

Government intervention: Pigovian (or Pigouvian) tax and subsidies

Notice: Pigovian tax is named after the economist Arthur Cecil Pigou

- **Negative externality**:
  - A pigovian tax would be levied on each unit **produced/consumed** and equal to the marginal damage of the activity at the efficient level of output/consumption
  - A pigovian subsidy would be given on each unit **not produced/consumed** and equal to the marginal damage of the activity at the efficient level of output/consumption
- **Positive externality**:
  - A pigovian tax would be levied on each unit **not produced/consumed** and equal to the marginal damage of the activity at the efficient level of output/consumption
  - A pigovian subsidy is a subsidy levied on each unit **produced/consumed** and equal to the marginal damage of the activity at the efficient level of output/consumption

Pigovian tax



Pigouvian tax

Negative externality: levied on each unit of a polluter's output in an amount equal to the marginal damage it entails at the efficient level of output

In the example of a negative production externality it is a tax on the quantity produced equal to MD(Q^*)=cd

In the case of a positive externality:
It would have been a subsidy on each unit produced and equal to the marginal benefit of the activity at the efficient level of output/consumption (MB shifts upwards)

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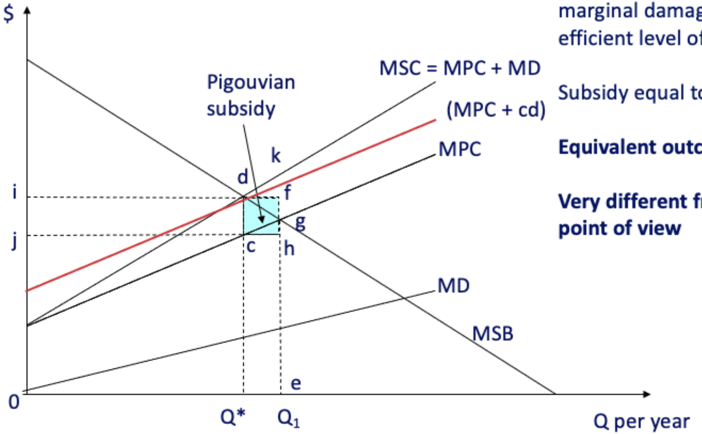
Pigovian subsidy



Pigouvian subsidy: given on each unit of a polluter's output **not produced** in an amount equal to the marginal damage it entails at the efficient level of output

Subsidy equal to MD(Q*)=cd

Equivalent outcome to the tax

Very different from distributional point of view

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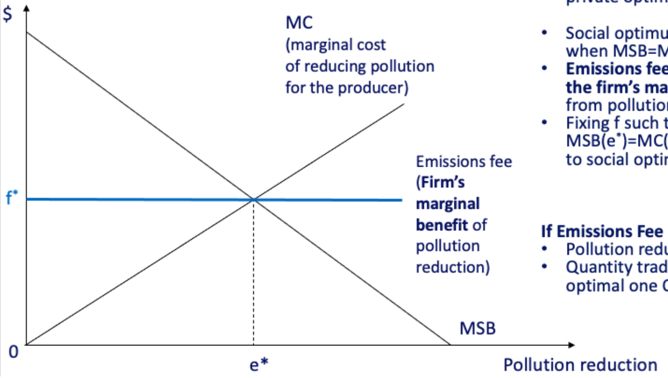
Pigovian taxation Vs. quantity regulation

- In an ideal world, Pigovian taxation and quantity regulation (imposing Q* by law) would have identical outcomes
- Quantity regulation seems more straightforward, hence, it has been the traditional choice for addressing environmental externalities
- In practice, there are complications that may make taxes amore effective means of addressing externalities
  - It requires that governement would have perfect information on many parameters
  - Setting quantities totally overrides market
  - With tax quantities prices can still vary in response to change in demand/supply
  - High transaction costs for controlling
- Pigovian Taxation and Quantity Regulation entirely remove any incentive to improve the effects of the externality
  $\rightarrow$ Why set up a pollution reduction system if that would not lower the tax bill?

Public Responses to Externalities – Emissions Fee



Tax on each pollution unit (rather than on each unit of production)

If no Emissions Fee e=0 :
- Pollution reduction
- Quantity traded is the private optimal one Q_1

- Social optimum is reached when MSB=MC.
- **Emissions fee represents the firm's marginal benefit** from pollution reduction
- Fixing f such that $MSB(e^*)=MC(e^*) \Rightarrow f^*$ leads to social optimum

If Emissions Fee = f^*
- Pollution reduction $e = e^*$
- Quantity traded is the social optimal one Q^*

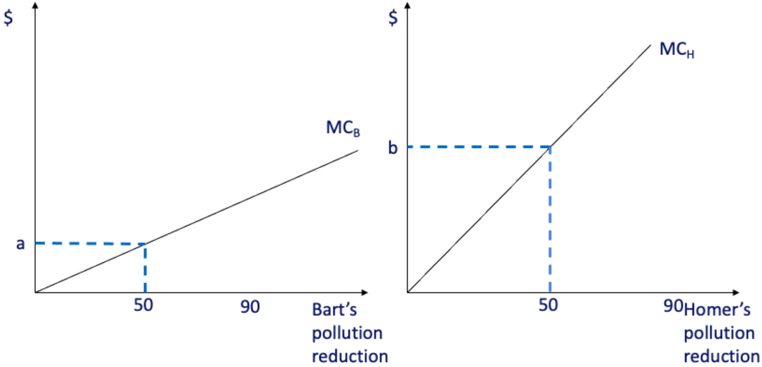
Pigovian Taxation Vs. emission fee

- Pigouvian Taxation and **emission fee** achieve the same efficient outcome
- Emission fee however has some crucial advantages
    - Provides incentives to improve the effects of the externality
    - Efficient allocation of emissions among entities with different ability to reduce emissions (heterogeneous)

Heterogenous polluters – uniform quantity reduction

Bart and Homer are polluting 90 each
Optimal pollution estimated to be 80

Uniform Quantity Reduction
Require each company to reduce pollution by 50 units
Given that a<b the same outcome can be obtained in a more efficient way



Heterogenous polluters – differentiated quantity reduction

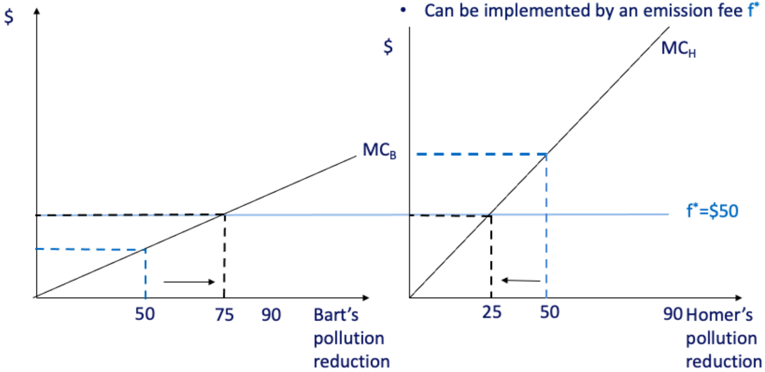
Bart and Homer are polluting 90 each
Optimal pollution estimated to be 80

Differentiated Quantity Reduction
Reduce pollution to equate Marginal Costs

- Bart (more efficient) higher reduction 75
- Homer (less efficient) lower reduction 25

Cost Effective Solution

- Can be implemented by an emission fee f*

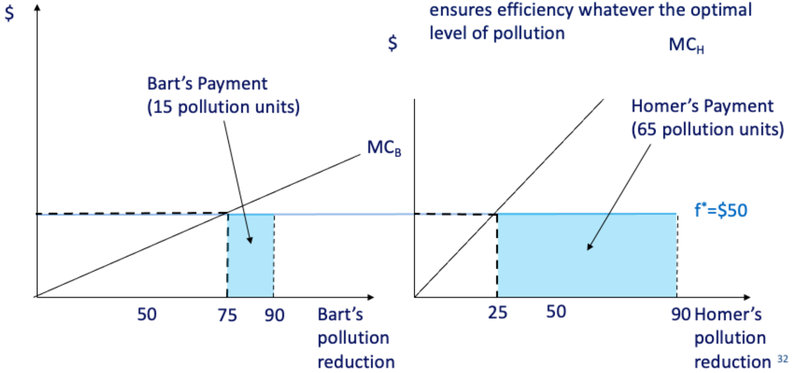


Heterogenous polluters – differentiated quantity reduction

Bart and Homer are polluting 90 each
Optimal pollution estimated to be 80

Differentiated Quantity Reduction

- **Incentives to improve efficiency of externalities reduction methods**
  - Taxes paid are bigger for less efficient agents
- By modifying the optimal emission fee ensures efficiency whatever the optimal level of pollution



Cap-and-trade

- It is possible to achieve an efficient externalities regulation by setting up emission rights
- Particular application of the Coase theorem
  - With costless bargaining/negotiation the efficient outcome is attained irrespective of the initial allocation of rights
  - Distributive implications
- Consider the same example of Homer and Bart with emissions capped to 80 units
  - Suppose that the goverment allocates these emission rights to Bart
  - Ex-ante, Bart will have to reduce emission just by 10 units, while Homer will have to reduce all emissions (by 90 units)
  - Since Homer has a higher marginal cost of reducing emission than Bart, he will be willing to pay Bart to get some of his polluting permits.

Emissions fee vs. cap-and-trade

Many differences between corrective taxes and tradable permits (e.g., carbon tax vs. cap-and-trade in the case of CO_2 emissions)

- **Initial allocation of permits**
  - If the government sells them to firms $\Rightarrow$ equivalent to the tax
- **Inflation**
  - Emissions fees are affected by change in the value of money
  - Lower (higher) reduction in pollution than optimal if inflation (deflation)
- **Change in costs of pollution reduction**
  - With emission fees, if cost of pollution reduction increase (decrease), pollution reduction will be lower (higher) than optimal
  - The cap-and-trade strictly enforces a level of pollution reduction, the cost for the firm will vary

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