Public Economics

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2 Externality

Market failure describes 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 for society. In other word, the outcome is not socially optimal, or is not first-best.

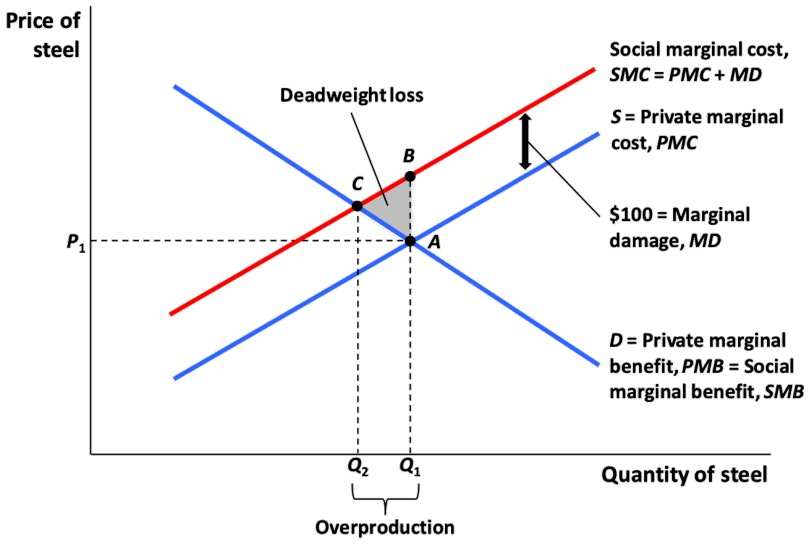
Externalities arise whenever the actions of one economic agent **directly** affect another economic agent **outside** the market mechanism. The first party neither bears the costs nor receives the benefits of doing so. Externalities are one important case of market failure.

According to the definition of externality, the effect of certain action spills over to another party, and this process is finished outside the market mechanism. A steel plant that pollutes the river nearby is a vivid example. However, a Bitcoin plant that uses more electricity and bids up the price of electricity for other electricity customers shouldn't be attributed to externality. The electricity price's bidding up is realized through market mechanism, and the Bitcoin plant also pays for the higher price.

Under the setting of externalities, we discuss externalities from either the production side or the consumption side.

2.1 Negative Production Externality

- Negative production externality: generated 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, which corresponds to the Supply Curve on plot.
- Marginal damage (MD): any additional costs associated with the production of the good that are imposed on others outside the market for the produced good, but the producers do **not** bear or internalize such cost.
- Social marginal cost (SMC): sum of private marginal cost and marginal damage, i.e., $SMC = PMC + MD$.
  - Considering producers and consumers in the market and the "affected others", holding "unaffected others" constant.

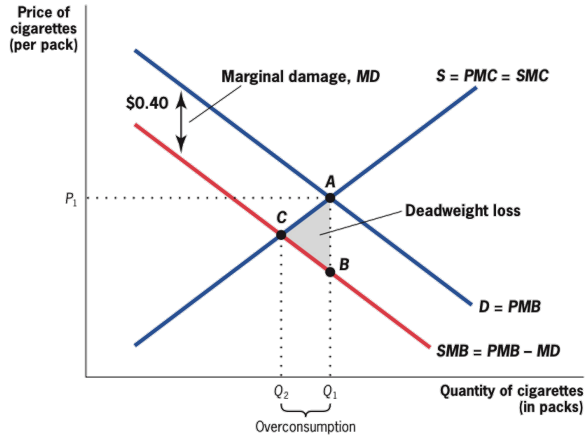


The grey-filled triangle corresponds to the deadweight loss for the society. This means if the outcome is determined simply by private marginal cost (PMC) and demand curve, from the perspective of society, private markets do not produce Pareto efficient outcome, since the firms did not take into account the social cost of pollution when making quantity decision, or say the externality was not fairly traded.

2.2 Negative Consumption Externality

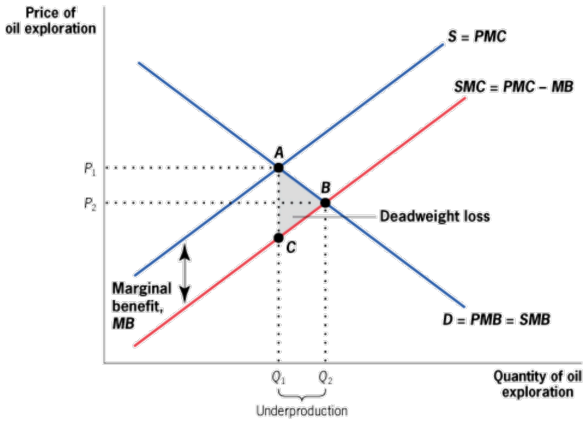
Similarly, introduce some basic terms.

- 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.
- Social marginal benefit (SMB): The private marginal benefit to consumers plus any costs associated with the consumption of the good that are imposed on others (outside the market for consuming the good).
- Marginal damage (MD): any additional costs associated with the consumption of the good that are imposed on others outside the market for the produced good, but the consumers do **not** bear or internalize such cost.



2.3 Positive Externality

- 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.



In sum, with a free market, the equilibrium is set such that

$$PMB = PMC$$

However, social optimum is realized only when

$$SMB = SMC$$

Therefore, private market leads to an inefficient outcome. The first welfare theorem hence does not work when externalities exist and are not fairly "traded" in the market.

- 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.

2.4 Private-Sector Solution

Coase proposed, externalities emerge because property rights are not well defined. If the property rights are clearly defined, the competitive market mechanism will help internalize the externalities, positive or negative.

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.

Implication: a particular and limited role for government – define, assign and protect the property rights.

2.4.1 Problems with Coasian Solution

- The assignment problem
  - When externalities affect many agents (e.g. global warming), assigning property rights is difficult.
  - Coasian solutions are likely to be more effective for **small, localized** than for larger, more global externalities involving large number of people and firms.
  - Only a "government" can potentially successfully aggregate the interests of all individuals suffering from externality.
- Transaction costs and negotiating problems
  - Hard to negotiate 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.
- Asymmetric information problem
  - Resource owners need to be able to identify source of damage.
  - First welfare theorem fails when information is not complete.

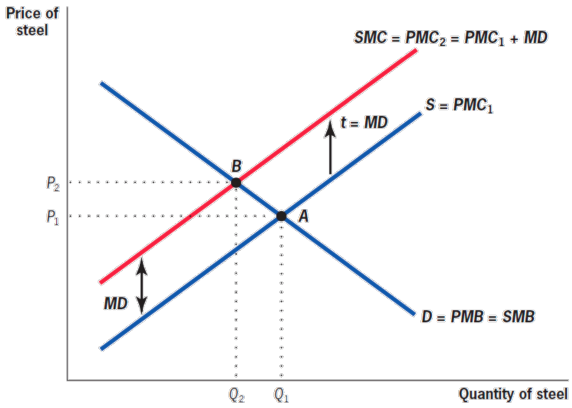
2.5 Public Sector Remedies for Externalities

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

- Corrective taxation: corrective tax or subsidy equal to marginal damage per unit (internalization)
  - Example: Carbon tax to fight global warming due to CO2 emissions
- Quantity regulation: government limits use of externality producing chemicals.
  - Example: CFCs [chlorofluorocarbons] that deplete ozone layer banned in 1990s

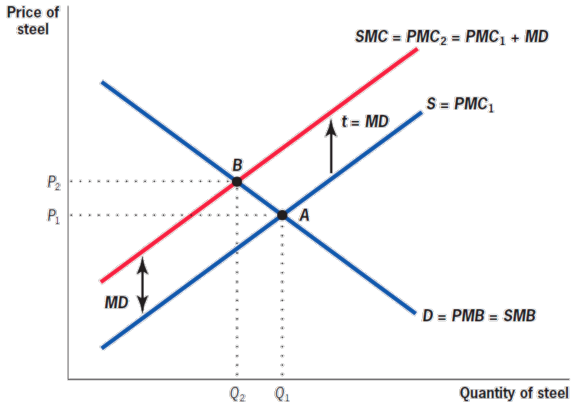
Corrective taxation and quantity regulation can be combined with tradable emissions permits to firms that can then be traded (cap-and-trade for carbon emissions).

2.5.1 Pigouvian Corrective Taxation



The tax collected is used to compensate the externality-induced loss. However, an apparent limitation is that, you have to know the MD function before setting up the optimal tax. Moreover, if MD is not constant, the tax may fail.

2.5.2 Quantity Regulation



In the simple model, Pigouvian tax and regulation produce exactly the same outcome.

- Advantages of regulation
  - Easy to enforce and administer
  - Useful to quickly reduce pollution if you want to meet a certain salient target.
- Disadvantages of regulation
  - Dynamics: discourage innovation; no monetary incentives to discover new technologies to reduce pollution further.If with a tax, the firm will have a strong incentive to cut such burden.
  - Heterogeneity: inefficient allocation when there is heterogeneity in costs of pollution abatement across firms.

2.5.3 Permits (Cap-and-Trade)

The governemnt can cap total amount of socially desirable pollution level and allow firms to sort out between themselves who pollutes more and less using tradable permits. In equilibrium, firms with the highest MC of reducing pollution will end up buying the most permits; firms that can easily reduce pollution will sell. If total number of permits is set to achieve the social optimum, both productive and allocative efficiency will be achieved, Additionallu, cap-and-trade will induce dynamic incentives to innovate , because firms are bearing the MC of pollution

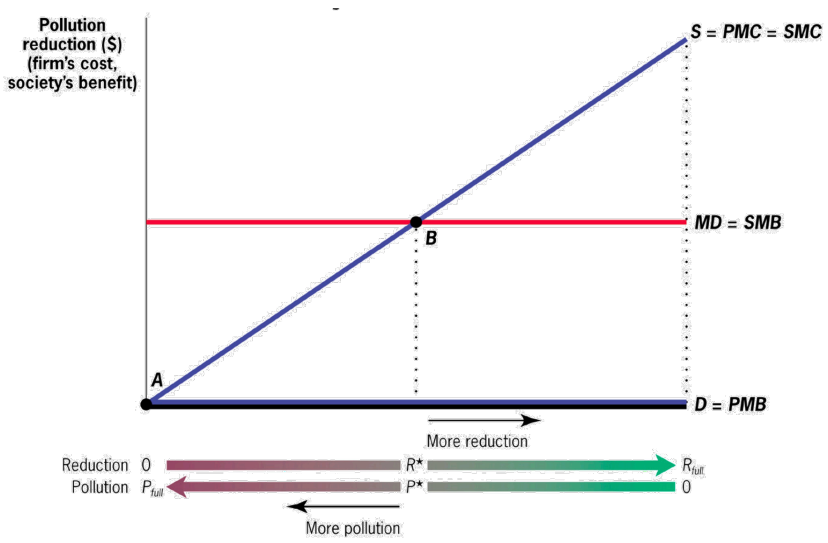
Initial allocation of permits matters. If the government sells them to firms, this is equivalent ot the tax; if the government gives them to current firms for free, this is like the tax with large lump-sum transfer to initial polluting firms. The trade system for permits will expose each firm's wililngness to pay and marginal cost to reduce pollution, and this property outbeats the tax mechanism greatly, where uncertainty in costs of cutting off pollution will make such system fail.

2.6 Price v.s. Quantity

2.6.1 Basic Model

Let R denote the amount of pollution reduction starting from private market equilibrium ($R = 0$); let $SMB(R)$ denote social MB of pollution reduction and $SMC(R)$ denote social MC. You can map any externality model into a model of costs and benefits of externality reduction, where

- $PMB(R)$ of abatement (private demand for abatement) is 0;
- $SMB(R) = MD$, where MD is assume to be flat here, but can be downward sloping due to diminishing returens;
- MC of abatement is increasing and $PMC = SMC$.



where $PMB = PMC \Longrightarrow R = 0; SMB = SMC \Longrightarrow R = R^*$.

If there is no uncertainty, we can obtain optimum with either a quantity policy (impose P^* perimits) or a price policy (set $t = MB = PMB$). Two approaches are equivalent.

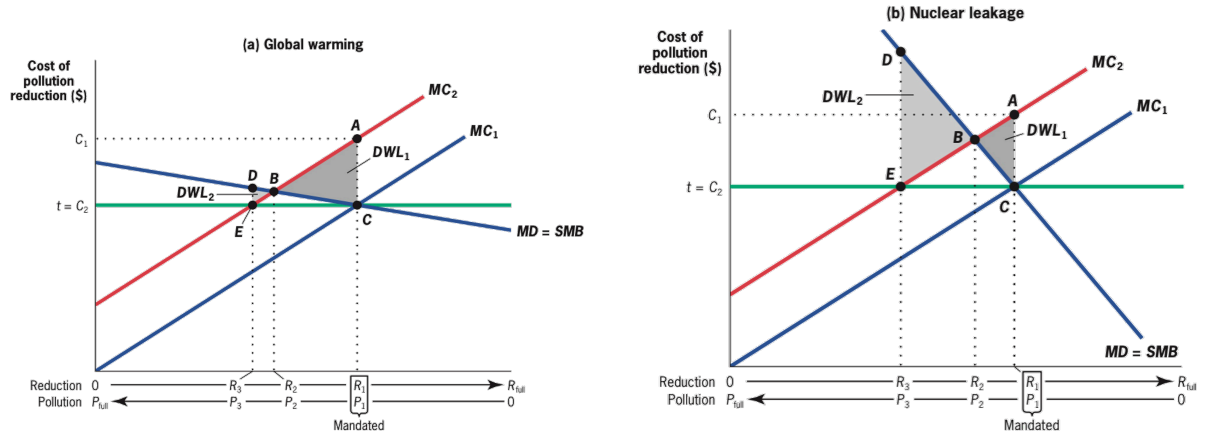
2.6.2 Heterogeneous Abatement Costs

If firms differ in marginal cost of abatement, the optimal condition for each firm is its MC of abatement equals to SMB. One equivalent way to think about this issue is, horizontally summing up MC curves and getting the total marginal cost of abatement curve of society MC_T, the intersection of MC_T and SMB determines the optimal abatement level for society.

In order to achieve such goal, you can either exert quantity regulation for each firm (cannot treat them equally), or take price regulation through a corrective tax set at $t = MD = SMB$. Another comprehensive design is exert quantity regulation with tradable permits.

2.6.3 Uncertainty of Costs

Now suppose that we are uncertain about MC of reducing pollution (also assume homogeneous firms). Specifically, regulators use MC_1 to set the tax at $t = C_2$; however, the actual marginal cost is given by MC_2, higher than MC_1, then the firms should have been taxed higher at $t = C_1$. With uncertainty of costs, quantity-policy and price-policy are not equivalent and will land at different effects.



With a flat MD curve, the tax is likely to play its role with less DWL. The intuition is that, since pollution cost is modest or gradual, reducing distortion using price mechanism rather than administrative intervention to the economy may be more important. With steeep MD curve, then quantity regulation is likely to work well, because steep MD implies the case of a very risky outcome.

2.7 Measuring Externality

Measuring externalities is hard, because there is by definition no direct market that can be used to recover willingness-to-pay. If there were a market, there would be no externality. Two prevalent approaches are applied in practice: indirect market-based methods and contingent valuation.

- Indirect Market-Based Method
  - Use quasi-experiment and DiD to estimate price change related to the level change of such externality.
    - e.g. *Clean Air Act 1970*
- Contingent Valuation
  - Put respondents in a hypothetical scenario through statement, and ask how much people would be willing to pay for it.
  - Sometimes impossible to have a market value for some outcomes.
  - Problems with this method
    - No resource cost to respondents, thus noisy answers and upward biased.
      - Warm glow: people feel having the idea that they are supporters of good causes.
    - People do not have well-defined preferences over these type of hypothetical choices.
      - Farming effect: people think you may want to receive this answer.
      - Timing of question matters: not same answers each time.