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Energy & Environmental Economics

Lecture 3: Externalities

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Agenda

Last week

- Of markets, economics, and efficiency
- Electricity markets

This week

- Things that markets do not consider: externalities

Progress

- Electricity market game
- Reading assignment
- Case study selection

Introduction: what is an externality?

Figures: Kemijoki Oy, Lapin Kansa, WWF.

Efficient institutions

Everything belongs to someone, and there is free trade. Then, the market outcome is efficient. This is the first fundamental welfare theorem in economics. If these pre-conditions are met, we can trust on the market outcome. In efficient markets:

1. All transactions are voluntary.
2. Individual's self-interested decisions are good for the group as a whole.
3. The group and individual benefits are aligned since market prices transmit all the costs and benefits of voluntary actions.

Introduction: what is an externality?

Not all trade is voluntary

1. My actions result in a cost or benefit borne by others.
2. Externality can be negative (e.g. pollution, noise, congestion) or positive (social and communication networks, R&D, knowledge).
3. Market prices do not reflect this externality.

Reminder: Perfect competition in a market for a single good

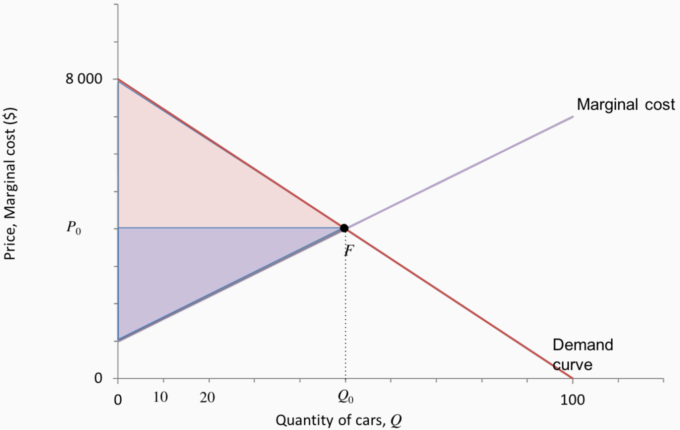

Figure 1: Demand and supply bids.

Source: CORE.

Pigou vs. Coase

Example: No externalitiy

Reminder

In perfect competition, the market equilibrium (P^*, Q^*) can be obtained by maximizing the sum of consumer and producer surplus

$$\max_{d_i, s_j} \sum_i (p_i - P^*) d_i + \sum_j (P^* - p_j) s_j$$
$$\Leftrightarrow \max_{d_i, s_j} \sum_i p_i d_i - \sum_j p_j s_j$$

with a constraint on supply meeting demand.

Example: Social cost

Solving the market equilibrium

As before, but assume now that each transaction causes a social cost $t > 0$, borne by third-parties.

Adding a social cost t to the supply side (or equivalently to the demand side) results in:

$$\max_{d_i, s_j} \sum_i p_i d_i - \sum_j p_j s_j - t \sum_j s_j$$
$$\Leftrightarrow \max_{d_i, s_j} \sum_i p_i d_i - \sum_j (p_j + t) s_j$$

All supply has become more expensive $\rightarrow$ in a new equilibrium (P', Q') we have $P' \geq P^*$ and $Q' \leq Q^*$.

One solution to the externality problem

Pigouvian solution (after A.C. Pigou)

- The cost imposed to others by your action should be transferred back to you.
- Polluters pay for the external social cost of their production, airliners pay for the cost of noise, motorist is sued for the damage done in accident, etc.
- This is the idea of the Pigouvian tax (see Figure)

Pigouvian solution

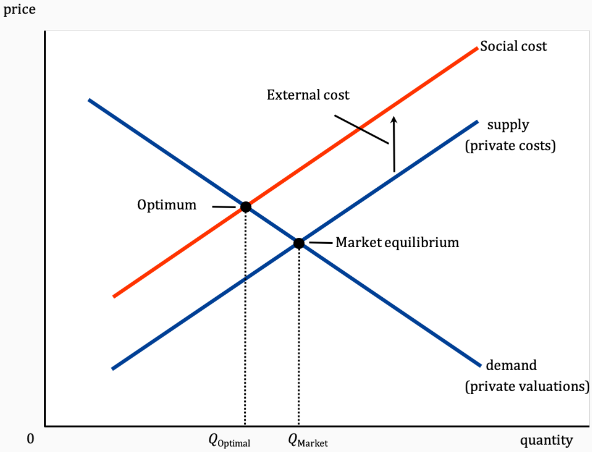

Figure 2: Negative externality: distortion in quantities.

There are actually TWO solutions to the externality problem

Pigouvian solution (after A.C. Pigou)

- The one we have seen.

Coasian solution: The Problem of Social Cost 1960, Journal of Law and Economics

- Coase did not agree with Pigou: (1) externalities need not lead to inefficiency; (2) Pigouvian taxes do not always lead to efficient solution; (3) the problem lies in the transaction costs, not in externalities

Coasian solution

Externalities need not lead to inefficiency, and taxes may not be efficient:

- A factory produces 200 000 € damage/year. It would take 100 000 €/year to eliminate the damage. The victim can move away from the damage area with cost 50 000 €/year. Does it make sense to impose a tax internalizing the damages?
- If there is no tax, the solution is efficient: it is better that the victim moves from the society's point of view
- If we impose the tax, the outcome is more costly
- Generally, the tax makes sense if the party paying the tax happens to be the one who solves the problem at the lowest cost. This hard to know sometimes.

Coasian solution

Coase: define property rights (one way or another), the market will take care of the rest

- Suppose the victim has the right to live without damage: the factory can pay the victim something between 50 000 € and 100 000 €, and all are better off
- If the factory has the right, it can continue polluting. If the cost of abatement is lower than 50 000 €, the victim can pay the factory not to pollute

The problem is not in the externalities but in transaction costs; the markets may have difficulties in achieving the reallocation of rights.

Coasian solution: transaction costs

Hold-up problem: suppose there are 100 victims, each suffering 2000 damage. Victims hold the rights.

- If abatement is less costly than moving away, the firm abates without transacting with individuals
- If abatement costs more than moving, the polluter should buy all the rights before being able to operate
- Abatement costs 100 000 and moving 50 000 (500 per head). Suppose the firm tendered 99 rights with overall cost 60 000. The last victim has huge bargaining power; s/he can hold up the firm, and ask up to 40 000 for the transfer of the right

Coasian solution: transaction costs

Free-rider problem: suppose there are 100 victims, each suffering 2000 € damage. Cost of moving 500 € per victim. Abatement cost is 20 000 €.

- If the factory has the right to pollute, the victims have to get together to collect 20 000 € in order to pay the polluter to stop (assume that eliminating pollution costs less than moving away from the polluted area). If all participate, the cost is 200 € per individual which is less than 500 € (cost of moving)
- If I don't show up, the rest of the group still finds it profitable to pay the firm; each must contribute just 2 more to make up my share
- However, all individuals like this free-rider idea (no costs but enjoy the gains). The contribution to reduce pollution is a public good that all victims can enjoy

Lessons from Coase

Coase helps in seeing why countries fail to solve grand externality problems such as climate change. More generally: How to design institutions to minimize the cost of externalities?

Property rules are good when the cost of allocating rights through market transactions are low.

Liability rules are good when cost of allocating rights through litigation are low.

- Protecting right to my car: liability rule would be much more expensive than property rule
- My wireless network: First, exclude the network by password, and then sell the right to use it (property rule). Second, leave it open and sue others for misusing if it happens. Courts may define a fine for misuse. Which one works?

Externalities and strategic behavior

What is the externality here?

		Player Y	
		C	D
Player X	C	$2, 2$	$-4, 4$
	D	$4, -4$	$0, 0$

- Where is the externality precisely?
- The strategic decisions that lead to the numbers in the cells?
- Can the players negotiate a solution?

Strategic decisions

Consider two agents (countries), $i = 1, 2$, choosing pollution levels z_1, z_2. Country i total benefit

$$U_i(z_1, z_2) = z_i - \frac{d}{2}\Big(\sum_{k=1,2} z_k\Big)^2$$

- private gain from pollution is z_i
- loss or damage from actions depends on total sum of choices where $d > 0$ is a constant

The setting between agents exploiting a common resource (e.g., clean air) is a "game". To analyze such games and the remedies to the externality problems, it is necessary to be more precise about the primitives of the strategic interactions.

Strategic decisions: non-cooperative outcome

Nash-equilibrium: given z_j by the other player, the best-response by i:

$$\frac{\partial U_1}{\partial z_1} = 1 - d\left(z_1 + z_2\right) = 0 \Rightarrow z_1 = 1/d - z_2$$
$$\frac{\partial U_2}{\partial z_2} = 1 - d\left(z_1 + z_2\right) = 0 \Rightarrow z_2 = 1/d - z_1$$

- actions are strategic substitutes: if j uses less, i will use more
- two equations, two unknowns: in Nash equilibrium, $(z_1, z_2) = (\frac{1}{2d}, \frac{1}{2d}) \Rightarrow (U_1, U_2) = (0, 0)$. Corner (D, D) in the payoff matrix above!

Strategic decisions: cooperative outcome

What would be the group-optimal outcome? This would arise if parties could negotiate efficiently:

$$max_{z_1,z_2}(U_1 + U_2)$$
$$\frac{\partial(U_1 + U_2)}{\partial z_1} = 1 - 2d(z_1 + z_2) = 0$$
$$\frac{\partial(U_1 + U_2)}{\partial z_2} = 1 - 2d(z_1 + z_2) = 0$$

- two equations, two unknowns: in cooperative outcome, $(z_1, z_2) = (\frac{1}{4d}, \frac{1}{4d}) \Rightarrow (U_1, U_2) = (\frac{1}{8d}, \frac{1}{8d})$. Corner (C, C) in the payoff matrix above!

Strategic decisions: the incentive to deviate

Suppose parties agreed on $(z_1, z_2) = (\frac{1}{4d}, \frac{1}{4d})$ in a "Paris meeting", and then go home. What would party 1 do?

$$max_{z_1} U_1(z_1, \frac{1}{4d}) \Rightarrow$$
$$\frac{\partial U_1}{\partial z_1} = 1 - d\big(z_1 + \frac{1}{4d}\big) = 0 \Rightarrow z_1 = \frac{3}{4d}$$

- Deviation: $(z_1, z_2) = (\frac{3}{4d}, \frac{1}{4d}) \Rightarrow (U_1, U_2) = (\frac{1}{4d}, -\frac{1}{4d})$. Corner (D, C) in the payoff matrix above!
- We have now identified the payoff externality precisely: $\frac{1}{8d} - \frac{1}{4d} = -\frac{1}{8d}$. Each agent has an incentive to free-ride at the expense of others!

Strategic decisions: full picture

		Player Y	
		C	D
Player X	C	$\frac{1}{8d}, \frac{1}{8d}$	$-\frac{1}{8d}, \frac{1}{4d}$
	D	$\frac{1}{4d}, -\frac{1}{8d}$	$0, 0$

- Now, suppose the players are at liberty to propose and accept contracts. A contract specifies four transfers (positive if X pays, negative if Y pays), one transfer for each of the four cells in the matrix. Can you think of a contract that solves the externality problem? Contract should be such that both players are better off by signing it. Explain how the contract changes the payoffs in the matrix.
- This case is left as a voluntary exercise (see lecture notes).

Why is it so difficult to bargain over externalities?

Consider three parties, A, B, C. Let AB denote the group consisting of A and B, AC of A and C, and so on.

- Can the parties come with a contract that they all produce together? That is, will ABC emerge?
- Let the parties enter the negotiation room in the following order: A first, B second, C third.
- How much A will offer B? Depends on what B can expect from collaboration with C.

This case is covered in the lecture notes.

Summary: Strategic decisions and externalities

- Common pool problem
  - Scare resource that is extracted by many
- Non-cooperative outcomes
  - Participants maximize their own payoffs
  - Everyone can be worse off
- Cooperative outcomes
  - Everyone agrees to maximize the common good
  - Hard to maintain: incentives to free-ride
- Multiple parties make bargaining challenging
  - Negotiation protocols matter!