Pollution control: Instruments I (Perman sections 6.1-6.3)
Summary of lecture 4a

- We need to know the costs and the benefits of pollution in order to find the optimal solutions.
- Efficient pollution level: maximize net benefits, implying the marginal benefit of pollution equals marginal damage of pollution.
- Stock pollution requires intertemporal optimization: e.g. climate change.

Now let’s do some economics!
Supply, demand, discount rates and BCA

- From individual utility to a demand (marginal utility) curve to an aggregate demand function.
- From a production function to a supply (marginal cost) curve to an aggregate supply curve.
- Finding market equilibrium with demand and supply.
- Two ways to show taxes (wedge or shift)
- Interest rates, discount rates, net present value and benefit cost analysis. Do 1 and 5 years, \( r = 5\% \) & 10\%
- Don’t forget... economics is fun 😊
Two questions on pollution and damages

- How much pollution (emissions) should there be in society?
  - What pollution *targets* to set? (yesterday)
  - Who bears the costs, who gets the benefits?
  - When do these costs and benefits appear?

- What is the best method of achieving pollution targets?
  - What policy instruments to use?
Overview of Chapter 6

- Criteria of choosing instruments
  - Focus on cost-effectiveness or cost-efficiency

- Pollution control instruments
  - Institutional approaches
  - Command and control instruments
  - Market-based instruments (next lecture)
Learning objectives

- Understanding concept of cost-effectiveness
- Able to assess different pollution control instruments
- Understanding institutional approaches towards pollution control
- Understanding command and control instruments
## Criteria for selection of instruments

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<tr>
<th>Criteria</th>
<th>Description</th>
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<tbody>
<tr>
<td>Dependability</td>
<td>To what extent can the instrument be relied upon to achieve the target?</td>
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<tr>
<td>Cost-effectiveness</td>
<td>Does the instrument attain the target at least cost?</td>
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<td>Enforceability</td>
<td>How much monitoring is required, and can compliance be enforced?</td>
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<td>Long-run effects</td>
<td>Does the influence of the instrument strengthen, weaken or remain constant over time?</td>
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<td>Dynamic efficiency</td>
<td>Does instrument create continual incentives to develop emission reducing technologies?</td>
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<td>Equity</td>
<td>What implications does the use of an instrument have for the distribution of income or wealth?</td>
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<td>Costs under uncertainty</td>
<td>How large are the efficiency losses when the Instrument is used with incorrect information?</td>
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Criteria for selection of instruments

- Use of any instrument will involve trade-offs among characteristics, i.e., you want cheap, accurate, and fast but you can only choose two.

- No single instrument is best for dealing with all types of pollution under all circumstances
  - Wide array of instruments used in practice
Cost-effectiveness (cost-efficiency)

- An instrument is **cost-effective (cost-efficient)** if it can attain the pollution target at lower real cost than any other instrument.

- Use of cost-effective instrument is a prerequisite for achieving an **economically efficient allocation** of resources.

- Necessary condition for abatement at least cost is that **marginal abatement costs are equal** for all abaters (polluters).
Example 1: who should reduce emissions?

Suppose policy maker wants emissions reduced by 2 units.

Suppose firm A has Marginal Abatement Cost (MAC) of €10; firm B has MAC of €20.

Then:

- If both abate 1 unit; total abatement costs are €30.
- But firm B can compensate firm A to reduce emissions by 2 units: B is willing to pay any amount up to €20, while A is willing to accept any amount from €10; transfer of money above €10 does not affect total abatement costs (income for A; expenditure for B); total abatement costs are 2x€10=€20.
Cost-effectiveness (cost-efficiency)

- **Example 2: cost-efficient abatement?**
- Suppose policy maker wants emissions reduced by 40 units
- Suppose TAC function of firm A is $C_A = 100 + 1.5Z_A^2$
- Suppose TAC function of firm B is $C_B = 100 + 2.5Z_B^2$

- What are total costs when $Z_A = Z_B = 20$?
  - $TC = C_A + C_B = (100+1.5*20^2) + (100+2.5*20^2)$
  - $= 1800$
Cost-effectiveness (cost-efficiency)

- What are total costs from cost-effective fulfillment?
- Objective function:
  
  \[ \text{Minimize } TC = C_A + C_B \text{ subject to } Z_A + Z_B = 40 \]

- This gives the following Lagrangian function:

  \[
  L = C_A + C_B - \lambda(Z_A + Z_B - 40)
  \]

  \[
  L = 100 + 1.5Z_A^2 + 100 + 2.5Z_B^2 - \lambda(Z_A + Z_B - 40)
  \]

  \[
  L = 100 + 1.5Z_A^2 + 100 + 2.5Z_B^2 + \lambda(40 - Z_A - Z_B)
  \]
Cost-effectiveness (cost-efficiency)

\[ L = C_A + C_B - \lambda (Z_A + Z_B - 40) \]

\[ L = 100 + 1.5Z_A^2 + 100 + 2.5Z_B^2 - \lambda (Z_A + Z_B - 40) \]

First-order conditions:

\[ \frac{\partial L}{\partial Z_A} = \frac{\partial C_A}{\partial Z_A} - \lambda = MC_A - \lambda = 0 \]

\[ \frac{\partial L}{\partial Z_B} = \frac{\partial C_B}{\partial Z_B} - \lambda = MC_B - \lambda = 0 \]

\[ \frac{\partial L}{\partial \lambda} = Z_A + Z_B - 40 = 0 \]

\[ MC_A = MC_B \]
\[ MC_A = 3Z_A = MC_B = 5Z_B \]

\[ Z_A = \frac{5}{3} Z_B; Z_B = \frac{3}{5} Z_A \]
Cost-effectiveness (cost-efficiency)

\[ MC_A = MC_B; \ 3Z_A = 5Z_B; \ Z_A = \frac{5}{3}Z_B; \ Z_B = \frac{3}{5}Z_A \]

\[ Z_A + Z_B = 40 \]
\[ Z_A + \frac{3}{5}Z_A = 40 \]
\[ Z_A = \frac{40 \cdot 5}{8} = 25 \]
\[ Z_B = \frac{40 \cdot 3}{8} = 15 \]

Results: \[ MC_A = MC_B = 75; \ Z_A = 25, Z_B = 15 \]

Cost-efficiency: equalization of marginal abatement costs; but typically different abatement levels
Cost-effectiveness (cost-efficiency)

- The total costs at cost-effective abatement are:
  \[ TC = (100 + 1.5 \times 25^2) + (100 + 2.5 \times 15^2) = 1700 \]

- Recall, when each firm had to reduce emissions by 20, total abatement costs were 1800: higher!

\[ \text{MC}_A = 3Z_A \]
\[ \text{MC}_B = 5Z_B \]
Cost-effectiveness (cost-efficiency)

- Cost-effective regime requires that the marginal abatement costs are equal over all firms:
  \[ MC_A = MC_B \]

- In general, a cost-effective solution does not involve equal abatement efforts among firms. Polluters who can decrease their pollution in a cheap way, shall do more on abatement.

- NB: Do NOT need to know MACs for Cap and Trade! Firms know their MACs and will make profitable trades.
Institutional approaches

- Institutions means humanly devised constraints that structure policy, economic and social interactions. They contain formal rules (e.g. laws) and informal constraints (e.g. code of conduct).

- For achieving the pollution or abatement target, we may consider using “institutions” that can reduce or internalize externalities.

- Examples of institutions are...
Institutional approaches

- Bargaining (Coase Theorem)
  - When there is an externality, bargaining may lead to an efficient outcome
  - Assumes clearly defined property rights, zero transaction costs, the possibility of bargaining with future generations, etc.
  - Still, clearly defined property rights can facilitate an efficient outcome (cap and trade systems are based on property rights!)

*We stopped here*