Environmental Economics for Environmental Sciences (ENR-21306)

David Zetland
Environmental Economics and Natural Resources Group

Pollution control: Instruments I (Perman sections 6.1-6.3)

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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

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

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)

Cost-effectiveness (cost-efficiency)

- **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 $Z_A = Z_B = 20$?
  - $TC = C_A + C_B = (100+1.5*20^2) + (100+2.5*20^2) = 1800$

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Cost-effectiveness (cost-efficiency)

- What are total costs from *cost-effective* fulfillment?
- Objective function:
  Minimize $TC = C_A + C_B$ *subject to* $Z_A + Z_B = 40$
- This gives the following Lagrangian function:

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

$$L = 100 + 1.5{Z_A}^2 + 100 + 2.5{Z_B}^2 - \lambda(Z_A + Z_B - 40)$$

$$L = 100 + 1.5{Z_A}^2 + 100 + 2.5{Z_B}^2 + \lambda(40 - Z_A - Z_B)$$

Cost-effectiveness (cost-efficiency)

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

$$L = 100 + 1.5 Z_A{}^2 + 100 + 2.5 Z_B{}^2 - \lambda(Z_A + Z_B - 40)$$

First-order conditions:

$$\left.\begin{aligned} \frac{\partial L}{\partial Z_A} &= \frac{\partial C_A}{\partial Z_A} - \lambda = MC_A - \lambda = 0 \\ \frac{\partial L}{\partial Z_B} &= \frac{\partial C_B}{\partial Z_b} - \lambda = MC_B - \lambda = 0 \\ \frac{\partial L}{\partial \lambda} &= Z_A + Z_B - 40 = 0 \end{aligned}\right\}$$

$$MC_A = MC_B$$

$$MC_A = 3Z_A = MC_B = 5Z_B$$

$$Z_A = \frac{5}{3} Z_B ; Z_B = \frac{3}{5} Z_A$$

Cost-effectiveness (cost-efficiency)

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

$$Z_A + Z_B = 40$$

$$Z_A + \frac{3}{5}Z_A = 40$$

$$Z_A = \frac{40 \cdot 5}{8} = 25$$

$$Z_A + Z_B = 40$$

$$\frac{5}{3}Z_B + Z_B = 40$$

$$Z_B = \frac{40 \cdot 3}{8} = 15$$

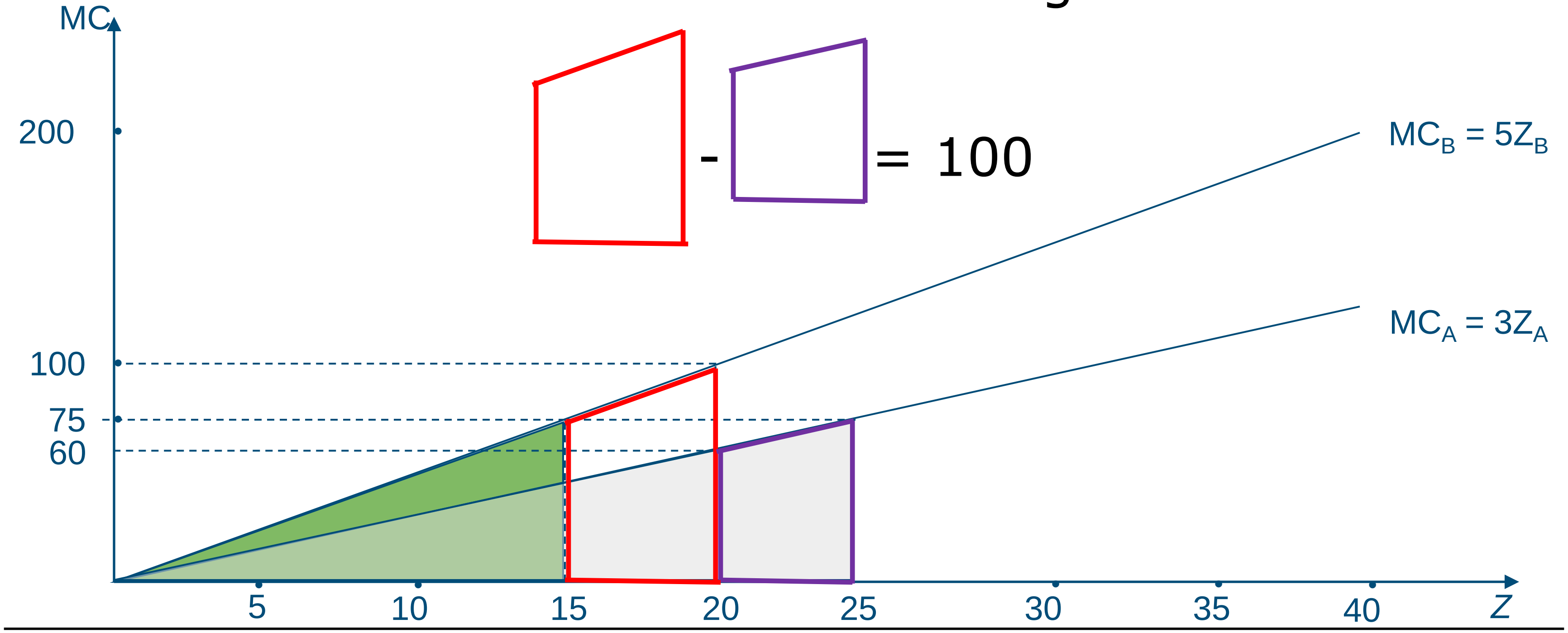
- Results: $MC_A = MC_B = 75$; $Z_A = 25$, $Z_B = 15$
- Cost-efficiency: equalization of marginal abatement costs; but typically different abatement levels

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!



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