ECON4910
Environmental Economics
Spring 2010

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Why study environmental economics?

Climate change

Toxic waste, radioactivity

Local pollution

Noise

Biodiversity

Acid rain

Wilderness preservation

Why study environmental economics?

- Economic activity -> environmental problems
  - emissions to air, water, soil
  - land use, noise & light pollution
- Negative impacts on ecosystems
- Environmental problems -> economic loss
  - negative impacts on human well-being
  - negative impacts on productivity: Reduced health of labor force, increased capital depreciation

About this course

Applying microeconomic theory for systematic analysis of environmental problems and policy

- Emphasis:
  - Markets, incentives and policy (rather than ecology)
  - Analytical tools (rather than factual knowledge)
  - Positive versus normative

Plan of the course

- **Lecture 1 - 7 (Nyborg):**
- Flow pollutants: Efficiency and welfare, markets, bargaining
- Policy instruments: Emission taxes, subsidies, licences, tradable permits
- Instrument choice under uncertainty
- Enforcement
- Voluntary contributions to public goods: Norms and altruism
- Monetary measures of environmental benefits
- The ethics and politics of cost-benefit analysis

Plan of the course, cont.

- **Lecture 8-13 (Hoel):**
- The double dividend debate
- Pollution-reducing technological development
- International environmental problems, international agreements
- Stock pollution problems
- Climate change and climate policy
- Discounting

Remarks before we start

- Assume knowledge of
  - Basic microeconomics & welfare economics
  - Basic mathematics ++
  - For brush-up: See Perman et al. (esp. Ch.5)
- The curriculum
  - Perman et al.; articles & reports (links)
  - Details: See lecture plan on web page
- Note: Many ways to analyze issues at hand
  - Models
  - Terminology

Teaching

- 13 lectures
- 6 seminars (two parallell): Start week 5
- No term paper
- Previous exams: http://www.oekonomi.uio.no/studier/eksamen/tidligere-eksamensoppga/tidligere-eksamensoppgave.html
  - Note: Course & exams may vary between years
- Other info: See course's web page

Remaining part of this lecture:

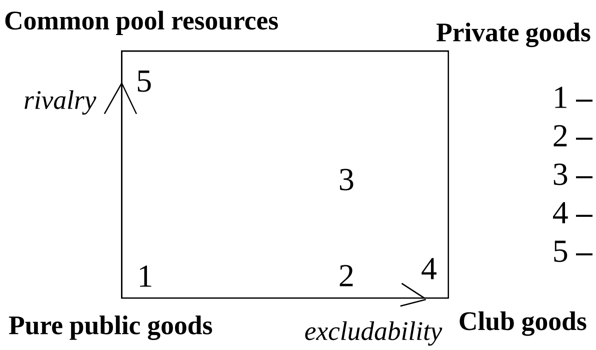
- Public goods and externalities
- A simple economic model of pollution

Public goods

- Definition: A good that satisfies
  - *non-rivalry:* Person A's consumption of a public good does not preclude person B's consumption
  - *non-excludability:* If the good is accessible to person A, it is also accessible to person B
- Example: Clean air
  - Non-rivalry: My enjoyment of good air quality does not reduce the air quality for others
  - Non-excludability: If the air is clean for me, it is not possible to keep others from enjoying clean air too
- Public goods (environmental quality) and public bads (pollution)

Pure and impure public goods

- Here: Focus on pure public goods
- Impure public goods:
  - Congestion (rivalry)
  - Costly excludability



1 – stable global climate
2 – road without congestion
3 – road with congestion
4 – private beach
5 – ocean fishery

Externalities

- Perman et al., p. 134:
  - "when production or consumption decisions of one agent have an impact on the utility or profits of another in an unintended way, and when no compensation/payment is made by the generator of the impact to the affected party."
- Effects on others (positive or negative) which are not compensated by market prices
- Changing the level of a public good/bad always produces externalities
- But: Externalities can exist even without public goods (ice cream melting and dripping on your friend's dress)

Types of externalities

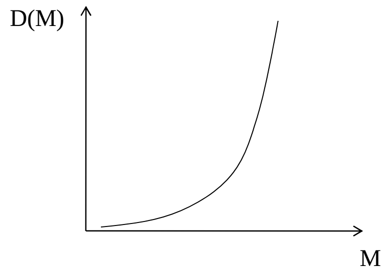
- Production to consumption
  - Industrial waste spills near a beach
- Production to production
  - Industrial waste spills near another factory's freshwater intake
  - Research and technological ”spillover”
- Consumption to consumption
  - Private cars, pedestrians with asthma
- Consumption to production
  - Noise from partying neighbors to office building
- What about **nature**?
  - In economics, usually: Consumers' valuation of nature

Types of pollution: Stock vs flow, uniformly vs. non-uniformly mixing

- Stock vs. flow
  - Does pollution accumulate? (Build-up of concentrations: CO_2 vs. ground level ozone)
  - Do damages accumulate/depend on previous emissions? (Acid rain precipitation and buffer capacities; oceans as carbon sinks.)
- Uniformly mixing vs. non-uniformly mixing
  - Does location matter?
  - CO_2 vs. acid rain: Location of CO_2 emissions unimportant. Location of sulphur/nitrate emissions crucial for local precipitation acidity; marginal environmental damages differ sharply with recipient location, due to varying buffer capacities.

Damages of pollution

- M = total emissions of a uniformly mixing flow pollutant
- Assume: D(M) = Environmental damages = a *convex* and *increasing* function of M

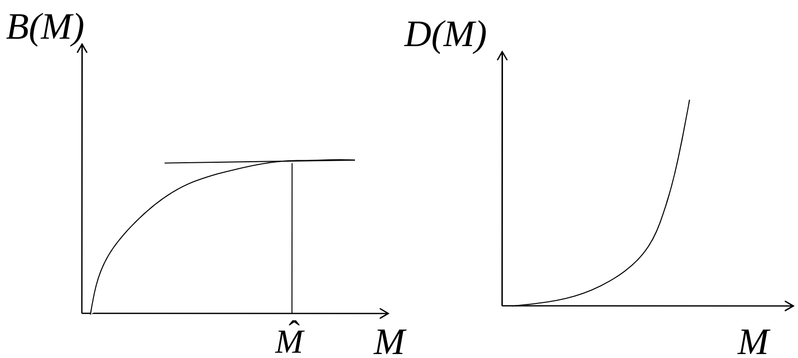


  - Gradually reduced natural restitution capacity
  - Increasing marginal valuation of environmental quality

Benefits of pollution

- Allowing pollution allows
  - low-cost/high quality production (no/low abatement costs)
  - low-cost/high quality consumption
  - These are the ”benefits of pollution”
- Assume: B(M) = The social benefits of pollution (gross, i.e. not corrected for environmental damages) = an increasing and concave function of emissions
  - Higher pollution levels -> lower gain of further increase in M
- Limited benefits:
  - Assume: There is a level of pollution $\hat{M}$ for which further pollution yields no benefits.
  - Reducing pollution below $\hat{M}$ is costly in terms of forgone benefits

Benefits and damages, uniformly mixing flow pollutant



How much pollution is optimal?

- **Net** social benefits: NB(M) = B(M) – D(M)
- Maximize net social benefits:
  - Differentiate NB(M) with respect to M
  - First order condition for interior maximum:

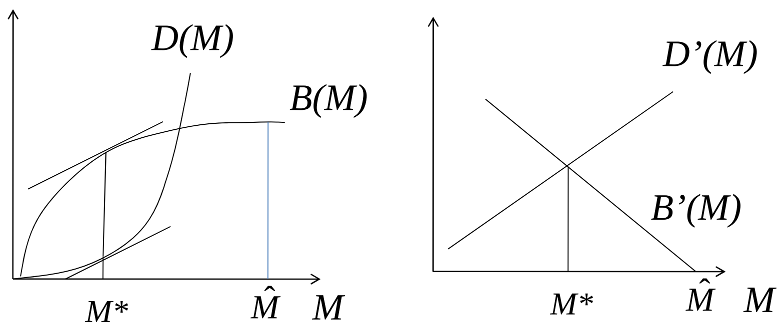
  $B'(M^*) - D'(M^*) = 0$ or $B'(M^*) = D'(M^*)$

  M^* = the M maximizing net social benefits.

> Net social benefits are maximized when marginal benefits equal marginal damages

- Second order conditions satisfied because B is increasing and concave and D increasing and convex.

Benefits and damages, uniformly mixing flow pollutant



A very simple, but rather vague, model

- What are ”benefits” and ”damages”? (Consumption, justice, animal rights?)
- How are they measured? (Dollars? Utility? Birds?)
- How do they arise (markets, institutions, behavior) ?
- Who gets them? (Losers versus gainers)
- Why are some effects called ”benefits” (i.e. implicitly *good*) while others are called ”costs” (*bad*)?

- Specific conclusions (on incentives, policy etc.) require more specific assumptions.

A more specific model

- Consumers: Preferences for private good *x*, pure public good *E* (environmental quality)
- Production to consumption externality: Profit maximizing producers of *x* pollute the environment
- Competitive market: Producers take input and product prices as given
- Emissions create
  - Utility from produced private product: **Benefits**
  - Disutility from reduced environmental quality: **Damage**

Ways to reduce emissions

- ”End of pipe” cleaning
- Cleaner inputs
- Changed technology
- Reduced production level

The production function

- Production of *x* a function of emissions
  - As if: emission is a production input
  - For a fixed production level: emissions can only be reduced at the cost of increasing other inputs
  - If other inputs are kept fixed: Higher production can only be achieved through higher emissions
- Producer *j*'s production of *x*, y_j, is given by

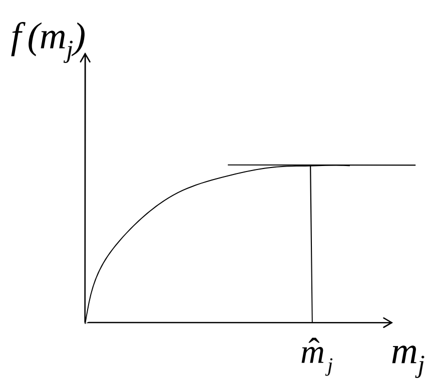
(1) $y_j = f(m_j)$

m_j = polluting emissions from firm *j*'s production.

Assume: there exists a $\hat{m}_j < \infty$ such that if $m_j \geq \hat{m}_j$, $f'=0$.

If $m_j < \hat{m}_j$, $f'>0$ and $f''<0$.

The production function



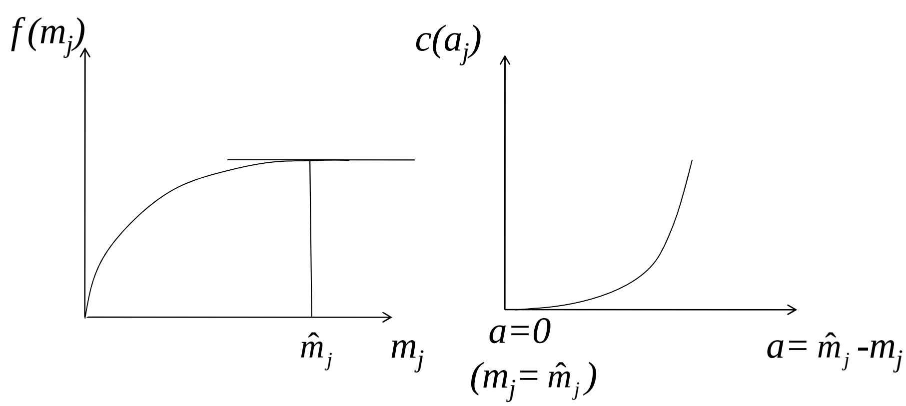
Abatement cost

- *Abatement* (cleaning) is the firm's emission reduction compared to "baseline" emissions:

  $a_j = \hat{m}_j - m_j$
- *Abatement cost*: Lost production value due to cleaning

  $c(a_j) = f(\hat{m}_j) - f(m_j)$
- Since f is increasing and concave in emissions, the abatement cost function is increasing and convex in *abatement* (and $c_j(0) = 0$).

Production and abatement cost



On production and abatement

- Background for our production function:
  - $F(L^p_j, K^p_j)$ = firm j's output as a function of labor and capital **used directly in production,** L^p_j and K^p_j
  - $a_j = (\hat{m}_j - m_j) = A(L^a_j, K^a_j)$ = abatement: An increasing function of labor and capital used for **cleaning,** L^a_j and K^a_j
  - Total labor and capital use for j: $L_j = L^p_j + L^a_j$, $K_j = K^p_j + K^a_j$
  - Output of x as a function of **total** labor/capital inputs is lower the more of the inputs are used for **abatement**:

    $y_j = F^T(L_j, K_j, m_j)$

Output: increasing in total labor use, capital use, emissions allowed

If L_j and K_j are kept fixed, we can write

$y_j = f(m_j)$ where $f' > 0$.

Profits

- Producer j's profits: Production (x is numeraire, price = 1) less fixed costs b_j (other inputs, fixed) less costs paid for emissions (e.g. emission tax, permit price), if any

(2) $\pi_j = f(m_j) - b_j - \tau m_j$

where τ = unit price of emissions

- With no regulation, $\tau = 0$.

Profit maximization

- Max $\pi_j = f(m_j) - b - \tau m_j$ with respect to m_j
- Differentiate, get first order condition for interior max:

  $f'(m_j) - \tau = 0$ or $f'(m_j) = \tau$
- If $\tau = 0$: F.o.c. requires $m_j = m^\wedge$ (because $f'(\hat{m}_j) = 0$).
- If $\tau > 0$, $m_j < \hat{m}_j$: If emissions are costly, they will be reduced (profit maximizers will choose $f' > 0$).
- Profit maximization gives no abatement when emissions are costless
- Assume: Fixed costs *b* low enough to allow $\pi_j > 0$.

Benefits of pollution

- B(M): Total production of *x* as a function of the sum of emissions from all (profit maximizing) firms, that is
- $B(M) = \sum_j f(m_j)$

  where $j = 1,\ldots,K$, and K = # of firms.
  - Some distributions of emissions might be wasteful
  - B(M) gives the *maximum* production of *x* for any level of pollution M.
- Since $f(m_j)$ is concave, B(M) is concave too.
- Note: With this definition, benefits are measured in units of the private (numeraire) good.

Next time

- Continued: the benefits of pollution
- On the damage function
- Market solution: Pareto inefficiency
- Can bargaining (unregulated market) solve the efficiency problem?