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
- Environmental problems -> economic loss
  - Negative impacts on productivity: reduced health of labor force, increased capital depreciation
  - Direct negative impacts on human well-being: reduced visibility, reduced health
- Negative impacts on ecosystems

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)

ECON 4910 Environmental Economics, Spring 2011
Lecture plan and reading list

Readings listed in **bold types** constitute the curriculum. Other listed readings are recommended.

Week	Date	Lecture	Topics	Readings (Listings in **bold** are the curriculum)
3	17.01	**1**	Flow pollution in a simple, static model (Nyborg)	**Perman et al. Ch 6** (6.8 – 6.10 can be skipped.) General background: Perman Ch. 5, part III.
4	24.01	**2**	Market outcomes (Nyborg)	**Perman et al. Ch 6, cont.**
5	31.01	**3**	Bargaining Policy instruments: Taxes, subsidies, licences (Nyborg)	**Perman et al. Ch 7**
6	07.02	**4**	Policy instruments: Tradeable permits Instrument choice under uncertainty (Nyborg)	**Perman et al. Ch 7** **Perman et al. Ch. 8**
7	14.02	**5**	Instrument choice under uncertainty Enforcement (Nyborg)	**Perman et al. Ch. 8** **Heyes (1998)**
8		*No lecture*	*Work with voluntary term paper*	
9	28.02	**6**	Optimal environmental taxation in the presence of other taxes (Hoel)	**Bovenberg (1999)** **Hoel (2008)**
10	07.03	**7**	Environmental policy and pollution reducing technological development (Hoel)	**Hoel (2010),** Greaker, Golombek and Hoel (2010)
11	14.03	**8**	International environmental problems and international environmental agreements (Hoel)	**Perman et al: sec. 10.1-10.3** **Hoel (2005)** Barrett (2006)
12	21.03	**9**	Stock Pollution Problems (Hoel)	**Perman et al: sec. 6.9 and ch. 16**
13	28.03	**10**	Climate change and climate policy (Hoel)	**The Stern Review** **Hoel et al. (2009)** Weitzman (2007)
14	04.04	**11**	Discounting (Hoel)	**Perman et al., ch. 3.1-3.4.** **Dasgupta (2008)**
15	11.04	**12**	Voluntary contributions	**Nyborg and Rege (2003)** Lyon and Maxwell (2008)
16	02.05	**13**	Monetary valuation of the environment The ethics and politics of environmental cost-benefit analysis (Nyborg)	**Perman et al. Ch 12** Perman et al., Ch. 3.1-3.4.

Teaching

- Curriculum: Reading list & lectures
  - Lectures: Motivation, explanation
  - Seminars: Problem solving, discussion
  - Own reading: Details; repetition; material not covered in lectures
- Previous exams: http://www.sv.uio.no/econ/studier/admin/eksamen/tidligere-eksamensoppgaver/eksamensoppgaver%20master/econ4910/
  - Note: Course & exams may vary between years

Voluntary term paper

- Sign up **TODAY or 24.01**, get partner (list to be posted on web)
- Assignment: to be posted on web **14.02.**
- No teaching week 8 – work with assignment
- Lecture **28.02** (Hoel): Bring your paper to class, exchange papers with partner
- Solution to be posted on web page **28.02**
- After class: Correct and comment your partner’s paper
  - Is the main argument understood? Is it well explained? Precise?
  - Are formal models applied in useful & meaningful ways? Why/why not?
  - Important points missing? Superfluous material included?
  - Mistakes/errors? Notation well defined?
- Lecture **07.03**: Bring your partner’s paper, with your comments/corrections, exchange papers. (Recommended: After class coffee & discussion!)

Remarks before we start

- Assume knowledge of
  - Basic micro, welfare economics, game theory
  - Basic mathematics ++
  - Brush-up: See Perman et al. 2003 (esp. Ch.5)
- Learning outcomes:
  - Intuitive understanding of results and mechanisms
  - Ability to use economic methodology to analyze environmental issues

  Note: Many ways to analyze issues at hand (models, terminology, more/less formal). Use the one you prefer. Goal: demonstrate ability to use economic concepts & methods to gain systematic understanding of issues at hand.

Remaining part of this lecture:

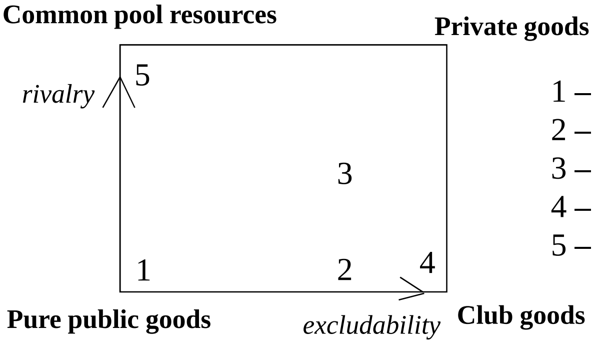
- Public goods and externalities
- A simple economic model of pollution

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 left to others
  - Non-excludability: If I can enjoy clean air, I cannot stop others from enjoying it 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 park
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
- Does the existence of a public good imply the existence of an externality?
  - Yes: if someone changes the public good level, this must produce an externality
- Does the existence of an externality imply that there must be a public good?
  - No: ice cream melting and dripping on your friend’s dress

Types of externalities

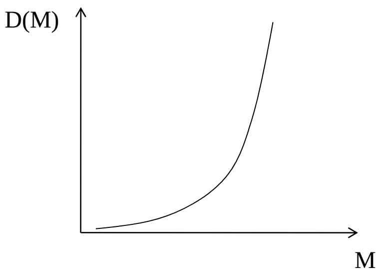
- Production to consumption
  - Industrial waste spills near a beach
- Production to production
  - Industrial waste spills near another factory's freshwater intake
  - Research and technological ”spillover”
- Consumption to consumption
  - Private cars, pedestrians with asthma
- Consumption to production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

Pollution

- 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

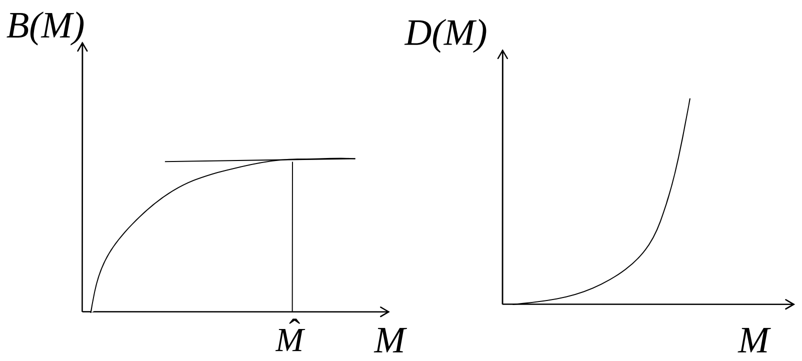


  - Gradually reduced natural restitution capacity
  - Increasing marginal valuation of environmental quality

Benefits of pollution

- Pollution allows for
  - low-cost production (no/low abatement costs)
  - low-cost consumption
  - ”Benefits of allowing 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.

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 NB(M):
  - Differentiate NB(M) with respect to M
  - First order condition for interior maximum M*:

  B'(M*) – D'(M*) = 0

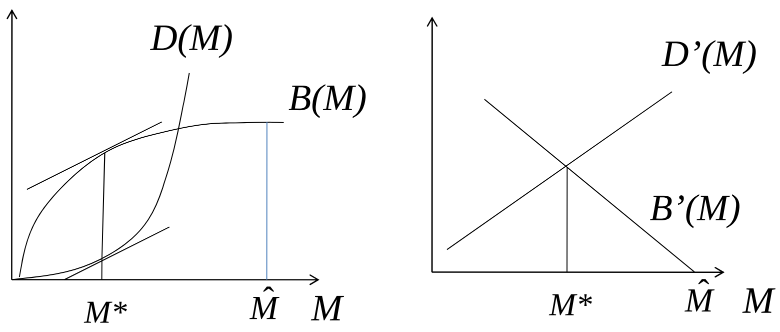
  or B'(M*) = D'(M*)

  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* the ”benefits” and ”damages”? (Consumption? Justice? Animal rights?)
- What are the *normative reasons* for calling some effects ”benefits” (i.e. *good*) and others ”costs” (*bad*)?
- How are they measured? (Utility? Dollars? Birds?)
- How/why do they arise? (Markets? Planning?)
- Who gets them? (Losers versus gainers)

- B’(M*) = D’(M*) is true regardless…
- But to use this for anything practical at all (better understanding of policy, incentives etc.) we need to specify.

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
  - **Benefits**: Utility from private goods produced
  - **Damages**: Disutility from reduced environmental quality

Ways to reduce emissions

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

The production function

- Producer *j*'s production of *x*, y_j, is given by

(1) $y_j = f(m_j)$

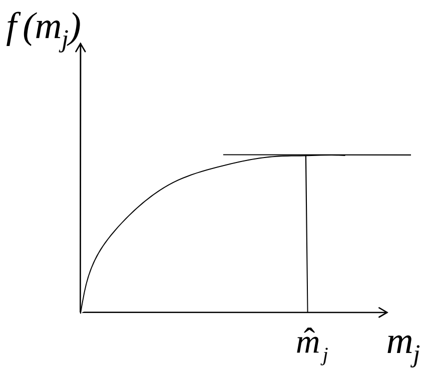
m_j = polluting emissions from firm *j*'s production.

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 $f''<0$.

- As if: emission is a production input
  - For any fixed production level y_j: emissions m_j can only be reduced at the cost of increasing other inputs (labor, capital)
  - If other inputs are kept fixed: Higher production can only be achieved through higher emissions
  - Interpretation of $f(m_j)$: The maximal production possible for firm *j*, given that emissions equal m_j and other inputs are kept at exogenously fixed levels.

The production function



Abatement cost: a mirror of the production function

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

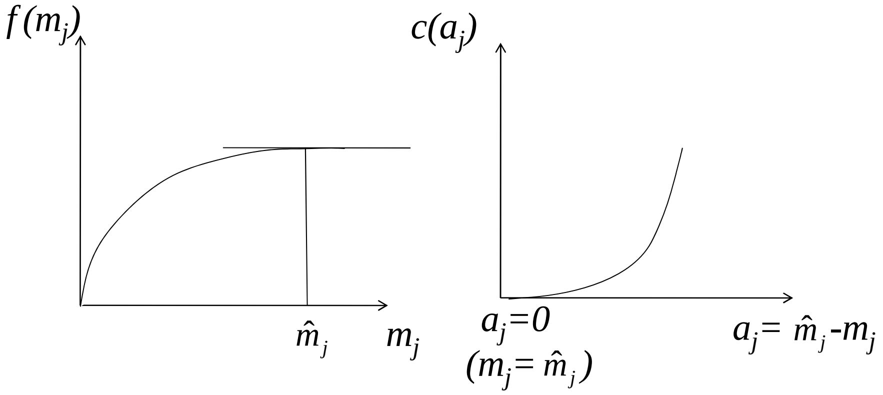
  $a_j = \hat{m}_j - m_j$
- *Abatement cost*: Lost production value due to cleaning

  $c(a_j) = f(\hat{m}_j) - f(m_j)$
- Marginal changes in abatement: $c'(a_j) = f'(m_j)$

$$\frac{\partial c(a_j)}{\partial a_j} = \frac{\partial [f(\hat{m}_j) - f(m_j)]}{\partial m_j} \frac{\partial m_j}{\partial a_j} = - f'(m_j)(-1) = f'(m_j)$$

- Since *f* is increasing and concave in emissions, the abatement cost function is increasing and convex in *abatement.* Also, $c_j(0) = 0$.

Production and abatement cost



On production and abatement

- Background for our production function:
  - $F(L^p_j, K^p_j)$ = firm j's output y_j as a function of labor and capital **used directly in production,** L^p_j and K^p_j
  - $a_j = (\hat{m}_j - m_j) = A(L^a_j, K^a_j)$: 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 $m_j = \hat{m}_j$ (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 $f' > 0$).
- If emissions are costless to the firm: Profit maximization gives no abatement
- 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 $j = 1,\dots,K$, 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?