ECON4910, Spring 2008
Environmental Economics

- *Systematic* analysis of environmental issues using *microeconomic theory*
- Emphasis:
  - Markets and policy (rather than ecology)
  - Positive vs normative
  - Uncertainty and/or asymmetric information
  - International issues and climate change

Why study environmental economics?

- Issues/problems:
  - Climate change, biodiversity, toxic waste, noise, local air pollution (soil, waters, air), acid rain, wilderness preservation….
- An economic approach to environmental management
  - E.g.: Tradable carbon emission permits
- Impacts on economic variables:
  - Health (e.g. respiratory problems), productivity (reduced input quality: dirty water & other natural inputs, reduced health, capital depreciation), well-being (noise, recreation)
- Useful for
  - Policy making
  - Policy analysis: Pre- and post-evaluations (bureacracy, consulting)
  - Research (empirical and theoretical)
  - Public information/education (teaching, journalism)

Plan of the course

- **Lecture 1 - 6 (Nyborg):**
- Flow pollutants (static model): Efficiency, welfare, markets, bargaining
- Policy instruments: Emission taxes, subsidies, licences, tradable permits
- Instrument choice under uncertainty: Prices vs quantities
- Enforcement
- Project assessment and environmental valuation
- Voluntary contributions to public goods

Plan of the course, cont.

- **Lecture 7-13 (Hoel):**
- Environmental policy and pollution-reducing technological development
- Environmental policy in the presence of distorting taxes elsewhere in the economy
- Stock pollution problems
- International environmental problems and international environmental agreements
- Climate change and climate policy

Remarks before we start

- Assume knowledge of
  - Basic economics
  - Basic mathematics
  - For brush-up: See Perman et al. book (esp. Ch.5)
- Many ways to analyze issues at hand (models, terminology)
  - E.g.: aggregation level, partial/general equilibrium, public goods/contributions, public bads/pollution
  - Important: Understand the economic interpretation
- Original research papers vs textbooks
- 3-hour written exam, June 2nd
- Compulsory term paper
  - Required for taking the exam

An ”optimal” allocation?

- Market solutions
  - The outcome resulting from many individual consumers’ and producers’ utility and profit maximizing decisions
- Pareto optimality
  - sometimes just ”efficiency”: A situation in which no-one can be made better off without making somebody else worse off
- Welfare maximization
  - Requires *normative* criteria to resolve conflicts of interest
  - Much used social welfare function: $W=\sum U_i$ (unweighted utilitarianism); there are many others
  - Welfarism: Only individuals’ utility counts
- Sustainability; non-welfaristic / non-anthropocentric moral philosophies (e.g. right-based, religious)
  - Perman Ch. 3-4

General results from welfare economics

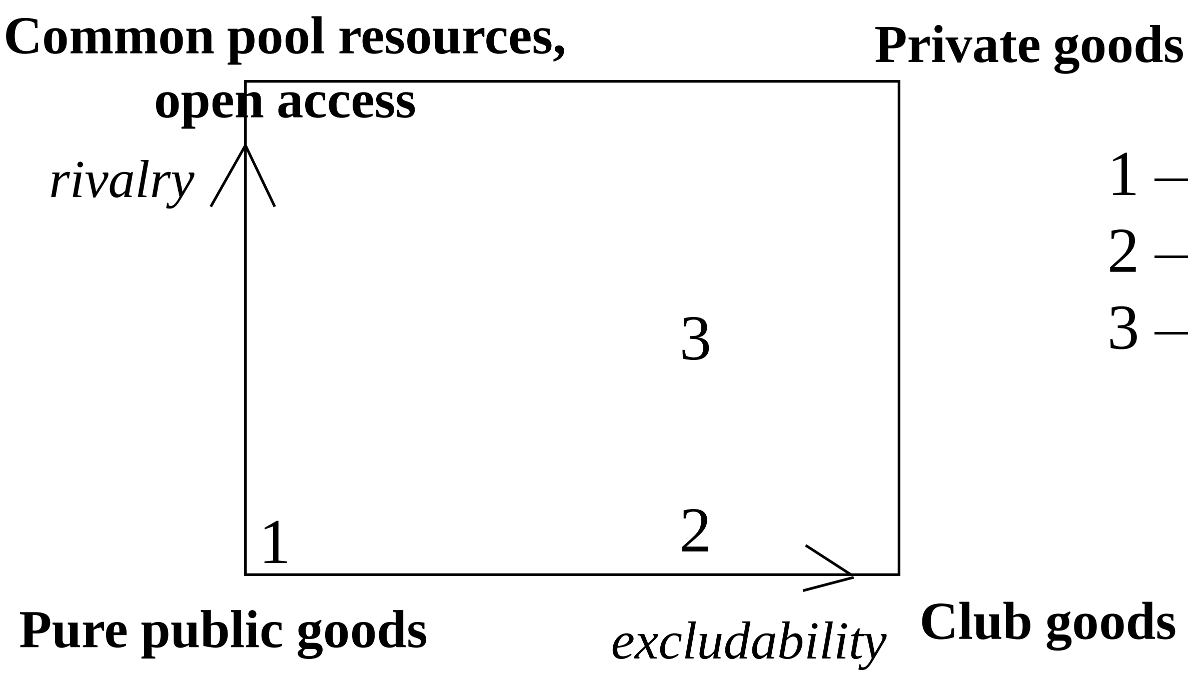
- Efficient allocations will arise from non-regulated markets (utility maximizing consumers, profit maximizing producers) if the following hold:
  - No missing markets
  - Perfect competition
  - Perfect information
  - Perfectly assigned property rights
  - No externalities
  - No public goods
  - ”Well-behaved” utility and production functions
- If lump-sum transfers are feasible, efficiency and distributional concerns can be separated under these conditions
  - Distributional concerns can be disregarded in the analysis

Public goods

- Environmental goods are often 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: If I enjoy the good air quality in Oslo, that does not reduce the air quality available to others in Oslo
  - Non-excludability: If the air in Oslo is clean for me, it is also clean for everyone else in Oslo
- Public goods (environmental quality) and public bads (pollution)

Pure and impure public goods

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



1 – stable global climate
2 – road without congestion
3 – road with congestion

Efficiency & distribution with public goods

- Efficiency concerns:
  - Imperfect property rights
  - Missing markets
  - Market prices missing/not reflecting alternative use
  - Limited & asymmetric information; strategic incentives to misrepresent values
- Distributional concerns/ conflicts of interest
  - Individuals cannot decide public good consumption levels independent of others: Marginal values will differ between agents
  - Lump-sum transfers separating efficiency and distribution must be based on individual-specific values
  - This is private information
  - Strategic reasons not to reveal truthfully
  - Separating distribution and efficiency is hard (impossible?)
  - Collective choice problem; real conflicts of interest, value judgements

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
- Production of public goods/bads imply externalities
- Externalities can exist even in the absence of 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.

”Production” of environmental quality

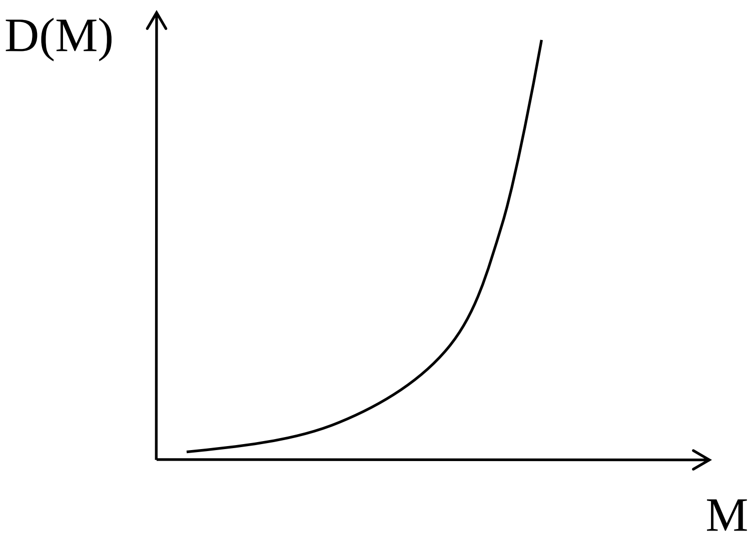
- Let environmental quality (E) be a pure public good
- E is reduced by pollution (M), increased by clean-up/repairment efforts (negative pollution)
- E is a public good; M is a public bad
- Production and/or consumption of private goods *x* creates pollution
- More E can be produced at a cost:
  - Reduce consumption/production of private goods
  - Change the consumption/production process for private goods (e.g. making efforts to avoid spills, using cleaner technology, installing heatpump technology in homes)
  - Costly end-of-pipe abatement
  - Costly clean-up/repairment of environmental damages

A very simple model of uniformly mixing flow pollution

- Perman et al., Ch. 6
- No specification of what ”benefits” and ”damages” of pollution consist of
- No specification of markets, institutions, individuals’ and firms’ behavior and incentives
- No explicit consideration of losers versus gainers
- Could describe any type of externality (consumption to consumption, prod. to cons., etc.)
- Consistent with different normative criteria (for example, distributional weights could be integrated in the ”benefits”, or concern for animals’ rights in the ”damages”)
- Useful for showing some general points; for policy analysis and policy evaluation, we need to be more specific

Damages of pollution

- Let M be total emissions of a polluting substance
- Let environmental damages, D, be a *convex* and *increasing* function of M, D(M)

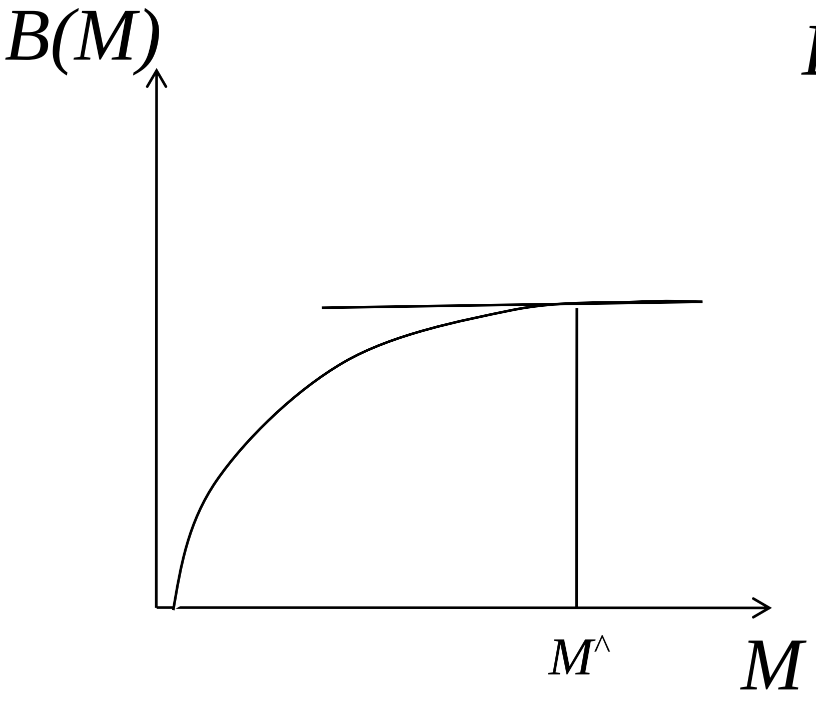


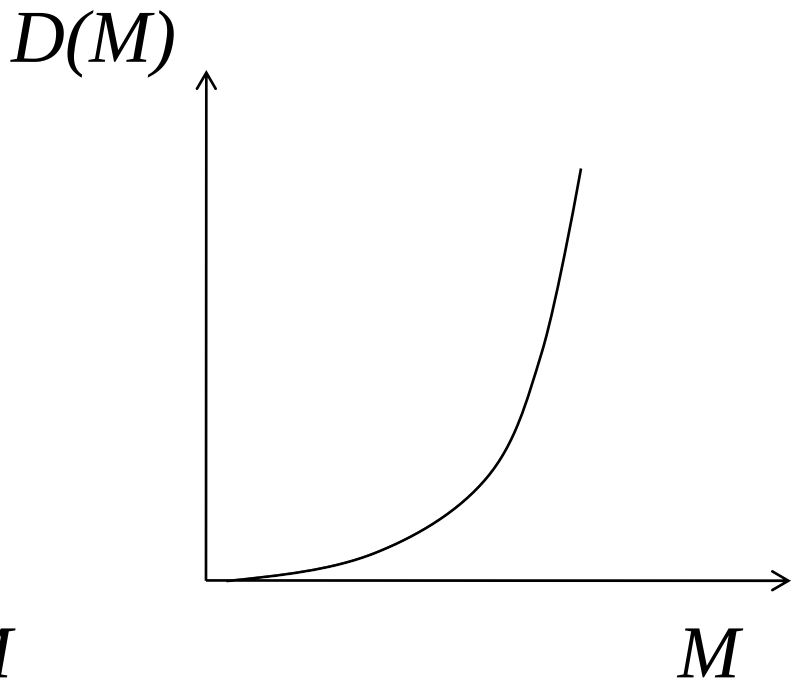
  - Gradually reduced natural abatement /restitution capacity
  - Increasing marginal valuation of E

Benefits of pollution

- ”The benefits of pollution” is an increasing function of total emissions, B(M)
  - Polluting allows (low-cost) production and/or consumption, and/or saves abatement expenditures
- B(M) is concave:
  - Reducing M a little is relatively cheap; reducing it a lot is expensive (on the margin)
- Limited benefits:
  - Assume: There is a level of pollution $M^{\wedge}$ for which further pollution yields no social benefits.
  - Reducing pollution below $M^{\wedge}$ is costly in terms of forgone benefits

Benefits and damages, uniformly mixing flow pollutant





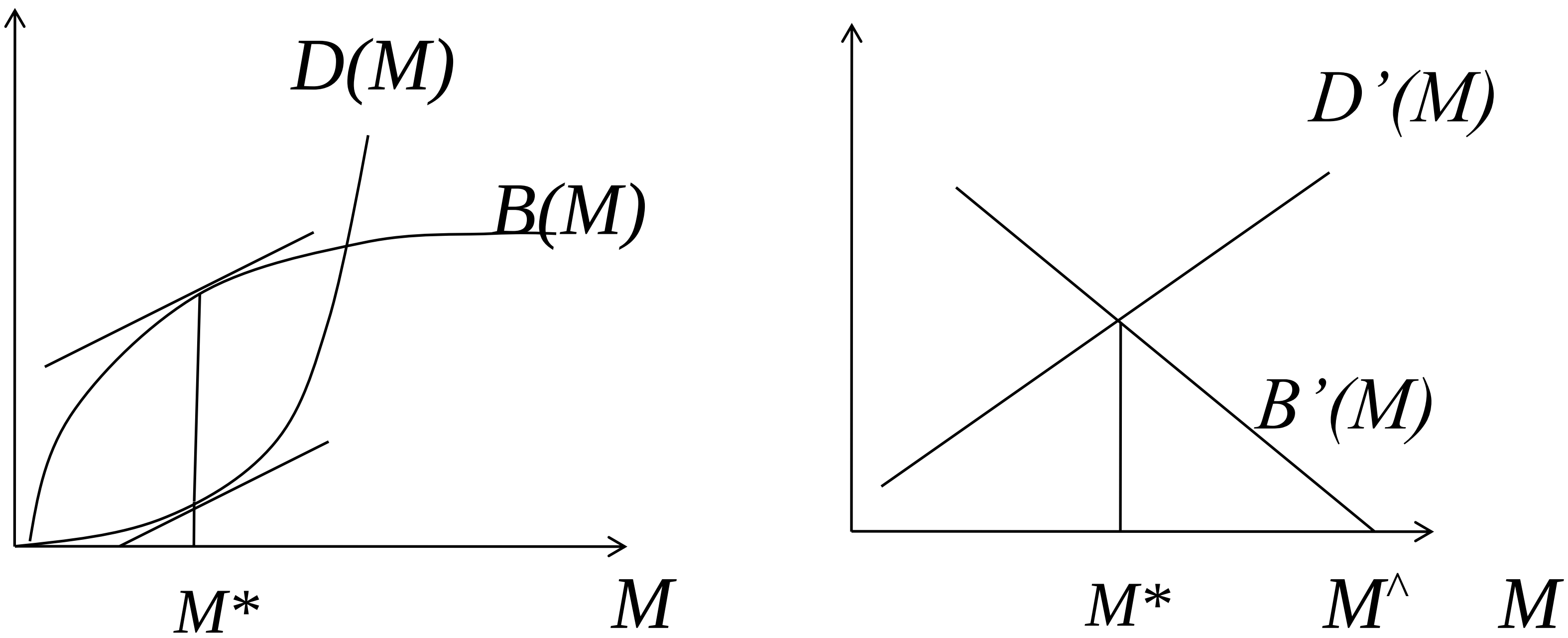
Max net social benefits of pollution

- Net social benefits: NB(M) = B(M) – D(M)
- Perman et al:
  - ”An allocation is said to be efficient if it is not possible to make one or more persons better off without making at least one other person worse off” (p.107) (PARETO EFFICIENCY)
  - ”An efficient level of emissions is one that maximizes the net benefits from pollution” (IS THIS PARETO EFFICIENCY? NOT NECESSARILY!)
- First order condition for interior maximum:
  - Differentiating NB(M) with respect to M, setting equal to 0

$$B'(M) - D'(M) = 0 \longrightarrow B'(M) = D'(M)$$

- 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 more specific model

- Two goods: Private good *x*, pure public good *E* (environmental quality)
- Utility-maximizing consumers prefer high E and high *x*
- Profit maximizing producers of *x* pollute the environment
  - For a given production level, pollution can only be reduced at a cost
  - Production a concave and increasing function of emissions (consider pollution an input)
  - Disregard other inputs.
  - Production to consumption externality
- Production to consumption externality.

Production

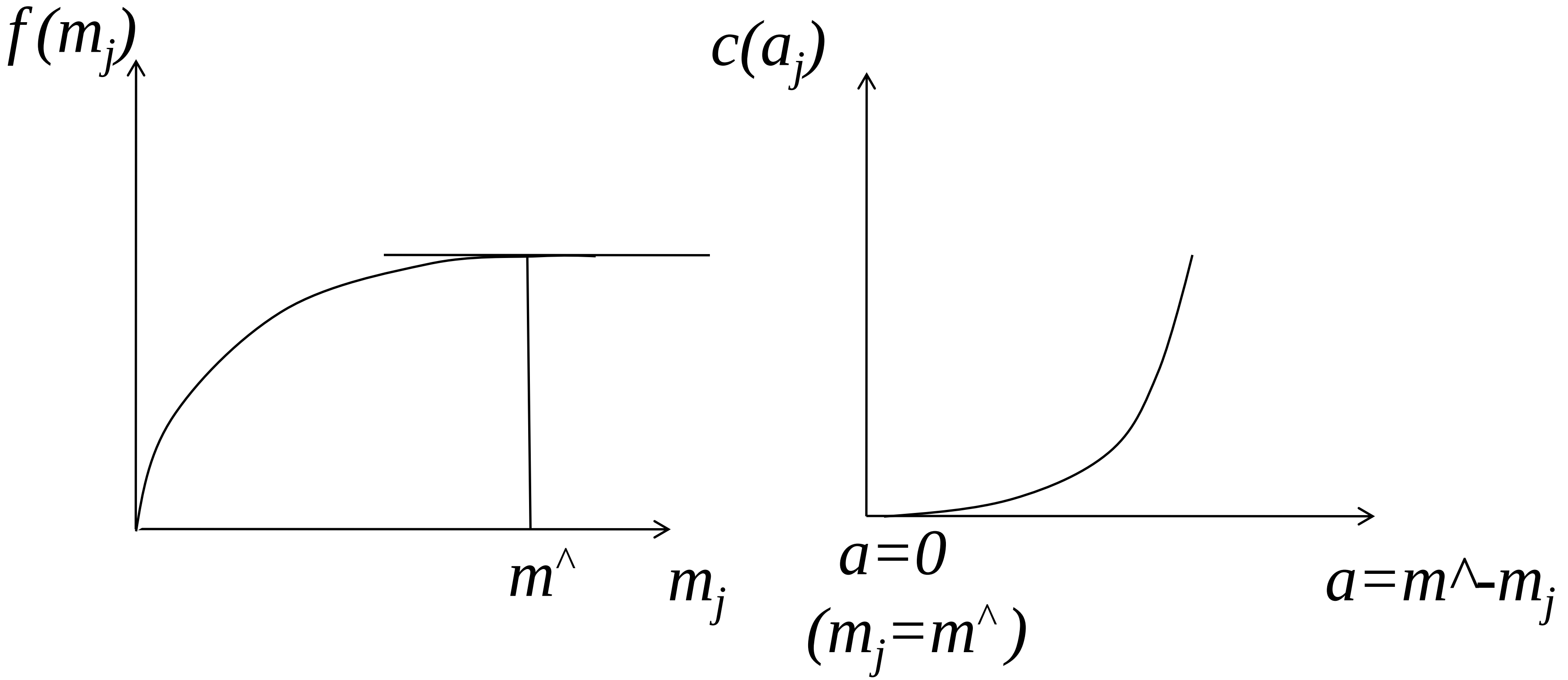
- Perfectly competitive market for *x*
- Producer *j*'s production of *x*, y_j, is given by

(1) $y_j = f(m_j)$

where m_j = polluting emissions from firm *j*'s production. Assume that there is a $m^\wedge < \infty$ such that if $m_j \geq m^\wedge$, $f' = 0$. If $m_j < m^\wedge$, $f' > 0$ and $f'' < 0$.

- Another way to state this:
  - firm *j*'s abatement costs c_j are given by an increasing and convex function $c_j(a_j)$, where $a_j = m^\wedge - m_j$ is the firm's abatement, and $c_j(0) = 0$.

Production and abatement cost



Profit maximization

- Let τ be the unit price of emissions (tax or permit price)
  - With no regulation, $\tau = 0$.
- Profits: Production (*x* is numeraire) minus fixed costs *b*, minus tax/permit costs:

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

- Why don't we subtract abatement costs?
  - they're integrated in the production function!

Profit maximization, cont.

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

  $f' = \tau$
- If $\tau = 0$, $m_j = m^\wedge$: Profit maximization gives no abatement when emissions are costless (when $m_j = m^\wedge$, $f' = 0$).
- If $\tau > 0$, $m_j < m^\wedge$: Profit maximization does give abatement if emissions are costly (when $m_j < m^\wedge$, $f' > 0$).
- Assume: Fixed costs *b* low enough to allow profitable production

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,…,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.

Different production functions

- If $f_j\,(m_j)$ is different for different firms:
- Each profit maximizing firm adjusts emissions until $f_j' = \tau$
- If τ=0, each firm emits $m_j^{\wedge}$, where $f_j\,(m_j^{\wedge})$=0 and $m_j^{\wedge}$ may differ between firms
- If τ>0, each firm emits less than $m_j^{\wedge}$
- Actual emissions m_j will then differ between firms, but f_j' (marginal productivity of emissions) will be equal
- That is: The marginal cost of abatement is equal for all firms
- $B(M)=\sum_j f_j\,(m_j)$

Next lecture

- The damage function:
  - Damages of pollution
  - Benefits of a clean environment
- Pareto efficiency versus market solutions
- Bargaining: Can the market solve the efficiency problem?
- Policy instruments in the simple model:
  - Taxes
  - Subsidies
  - Licences
  - Tradable permits