Environmental Economics for Environmental Sciences (ENR-21306)

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Pollution control: targets (Perman et al., chapter 5)

About me

- From California (PhD, UC Davis, ARE 2008)
- Travel/development economics
- Political economy of water and environment
- aguanomics.com blog
- *End of Abundance* book
- EPI-Water FP7 project
- Volunteering here! (Goal: teaching)
- www.kysq.org/EEP100 lectures
- Office hours?
- Class schedule

Now, a game...

Summary of lecture 3b (?)

- Definition of positive and negative externalities
- Categorization of relevant and irrelevant externalities
- Show (graph, algebra) externality effect on others' utility
- Reducing externalities:
  - Coase theorem: Bargaining on the basis of defined property rights (but... transaction costs)
  - Pigouvian taxation: Represents the damage from the negative externality (but... setting level and elasticity-based **incidence!**)
  - Ostrom's communal coordination: Institutions can reconcile externalities (but... evolution)

Two questions on pollution and damages

- How much pollution should society accept?
  - What pollution *targets* to set?
  - Who experiences the costs and benefits of pollution?
- What is the best method of achieving pollution targets?
  - What policy instruments to use? (next week)
- Example: air or water pollution in the local commons

Chapter 5 learning objectives

- Pollution and damages
- (Economic) criteria for choosing pollution targets
- Zero emissions are not optimal (economic)
- Identification of optimal pollution levels
  - marginal private benefits vs. marginal social costs
  - optimal abatement levels mirror this decision
  - ignores distribution of costs and benefits!
- Difference between flow and stock pollutant

Pollution targets in economics

Zero pollution is probably not a sensible target.

An efficient level of pollution that maximizes the net social benefits from the polluting activity depends on:

- Benefits to polluter
- Today’s costs to others: Risk or health impacts
- Tomorrow’s costs (does sustainability matter?)
- Technical possibilities (reduction versus mitigation)
- Political mechanism (weights for costs and benefits)
- Equity (winners and losers)
- Other?

Pollution (emissions and damages)

- Flow-damage pollution depends on the flow of pollution into the environment (e.g. noise or light) for one period
- Stock-damage pollution depend on the stock of pollution that lasts more than one period
  - cumulative, e.g., GHGs
  - threshold dependent, e.g., salt in soil or heavy metals in aquifers

Net benefit of flow pollution

- Benefit of pollution:
  - a firm emits pollutants while producing goods
  - private benefit function (concave): $B=B(M)$
- Damages from pollution
  - private damages (convex): $PD(M)$
  - externality (convex): $ED(M)$
- Concave and convex clarifies marginal changes
- Private net benefit: $PNB=B(M)-PD(M)$
- Social net benefit: $SNB=B(M)-PD(M)-ED(M)$ **[M lower]**

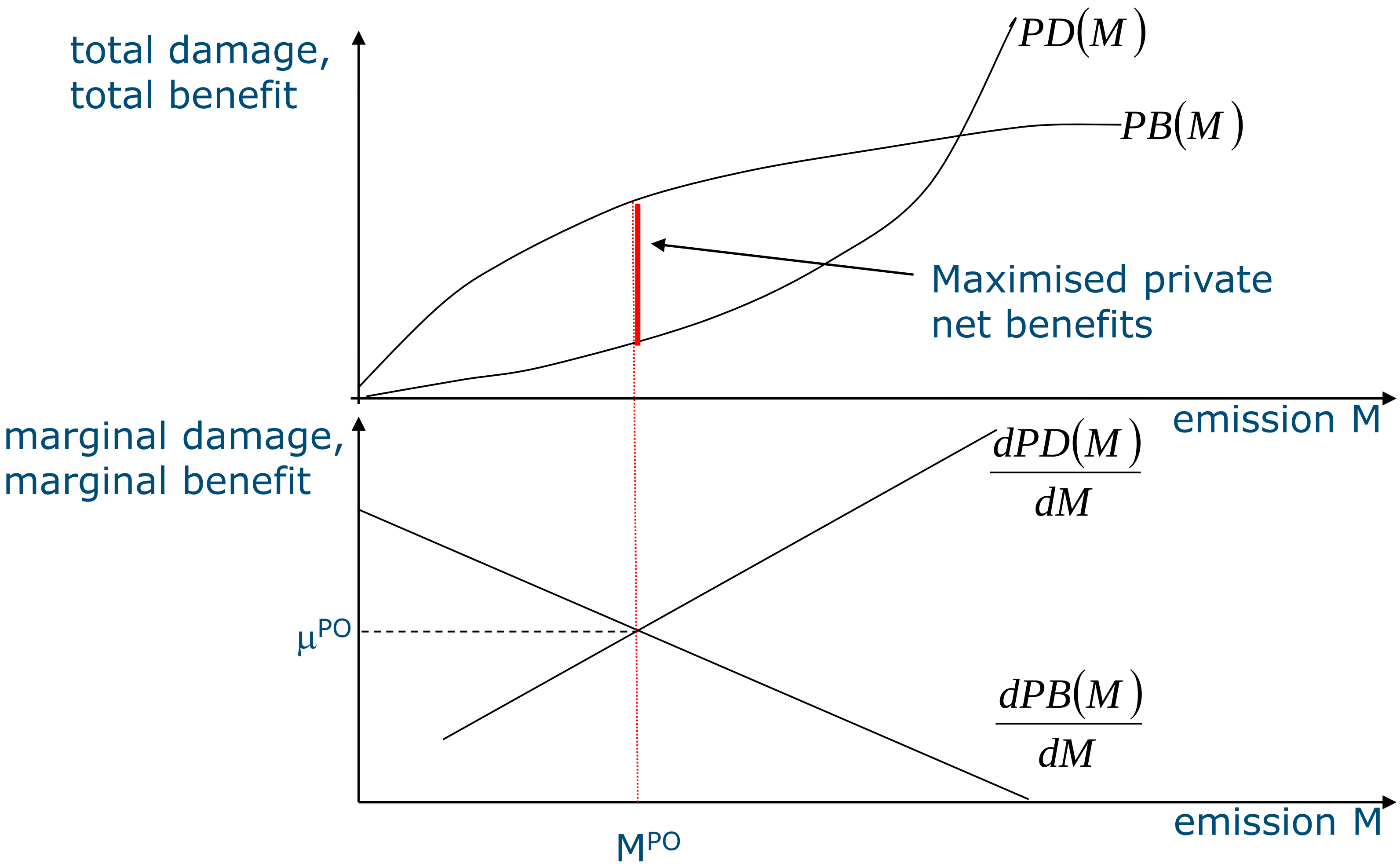
Privately efficient emission level

- Firm maximizes net benefit (profits) at a privately efficient emission level

- Optimization problem: *max PNB=PB(M)-PD(M)*
  - first order condition $$\frac{dPNB}{dM} = \frac{dPB}{dM} - \frac{dPD}{dM} = 0$$
  - marginal benefit = marginal damage: $$\frac{dPB}{dM} = \frac{dPD}{dM}$$

Picture follows...

Privately efficient emission level

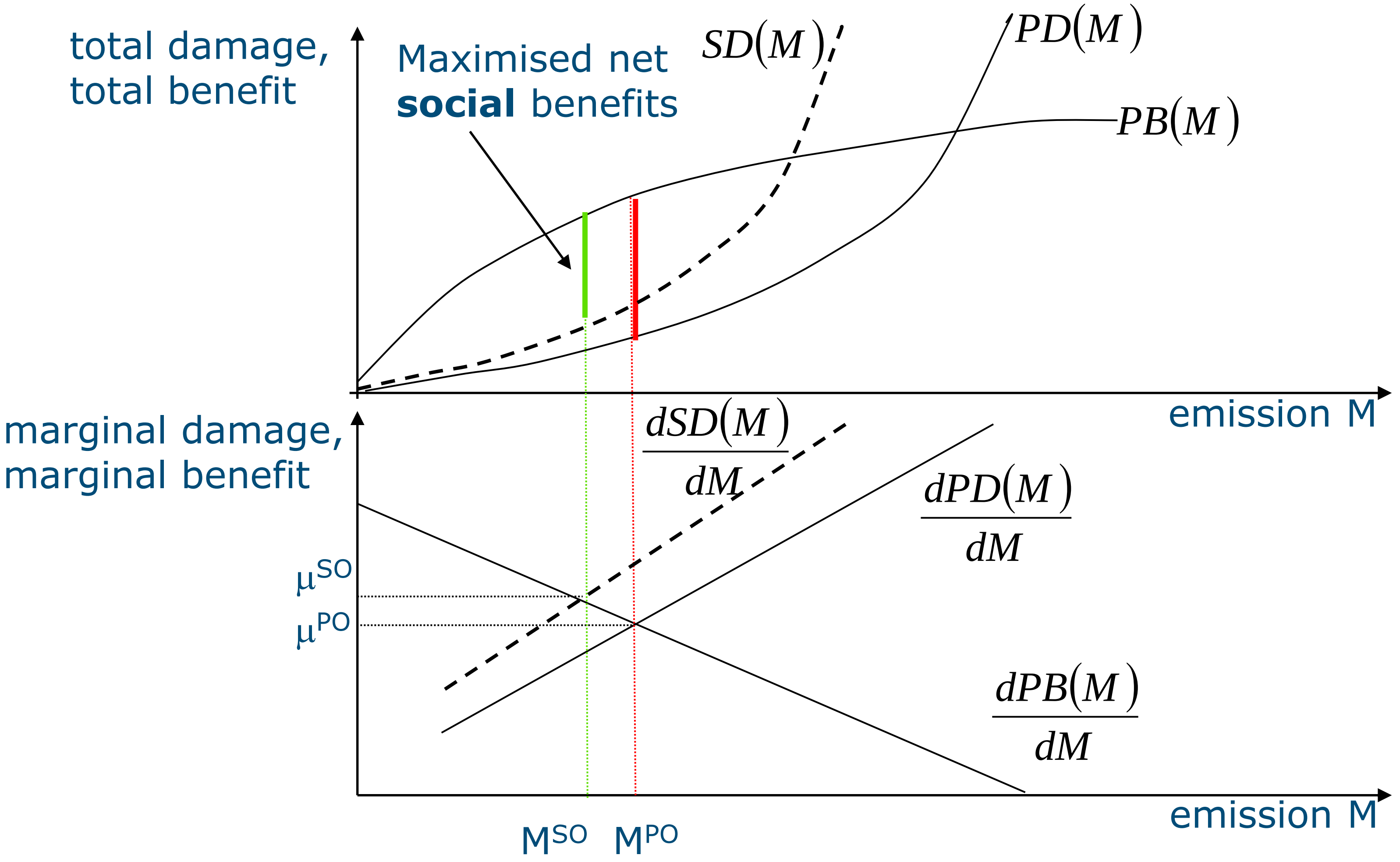


Socially efficient emissions

- Economic agents consider only private benefits/costs, but external damages matter to others
- Social optimization problem
  - max *SNB=B(M) – PD(M) - ED(M)*
  - First order condition: $\frac{dSNB}{dM} = \frac{dPB}{dM} - \frac{dPD}{dM} - \frac{dED}{dM} = 0$
  - Marginal social benefits = marginal social damage

    show this!
- Goal: Private actor considers external costs

Socially efficient emissions



Socially efficient emission level

- Reducing emissions to an efficient level implies a reduction in private benefits. This can happen by reducing activity or increasing abatement

- Maximizing **difference** between total benefit and total damage is equivalent to minimizing **sum** of
  - total damage costs, and
  - total abatement costs

Example of flow pollution (homework)

A paper factory discharges waste water in river.

Waste water in m^3/day: M

Private revenues: $PB = 400M - 2.5M^2$

Private damage: $PD = 10 + 100M + 2.5M^2$

External damage: $ED = 2.5M^2$

1. How much would the factory discharge when it does not take into account damages of pollution?
2. What is the socially efficient discharge level
3. Show the private and the social optimum in a graph
4. Don’t forget caveats (measurement and distribution)

Flow pollutants vs stock pollutants

- Thus far: Damages depend only on **flow** of emissions
- **Stock** pollutants:
  - Damages depend on new and previous emissions
  - Damages therefore often depend on time
  - We ignore location (point or vs non-point source)

For example...

Intertemporal analysis of stock pollution

- Benefits: $B_t = B(M_t)$ with M_t emissions **flow** in period t
- Damage at time t depends on the stock of pollutants at time t, i.e., $D_t = D(A_t)$
- Equation of motion for pollution stock: $\dot{A}_t = M_t - \alpha A_t$

  α = decay/cleanup parameter

  $\alpha = 0$ → no decay, perfectly persistent pollutant

  $\alpha = 1$ → flow pollutants

  $0 < \alpha < 1$ → imperfectly persistent pollutant

- $A_{t+1} = A_t + \dot{A}_t$

Intertemporal analysis of stock pollution

- Net benefits in discrete time with r = discount rate

$$\sum_{t=0}^{\infty}[B(M_t)-D(A_t)]\cdot\frac{1}{(1+r)^t}$$

- Why discounting? Opportunity costs of time!
- Present value of B in t years is $B/(1+r)^t$
- Present value with a 5% discount rate:
  - €100 now is worth $100/(1.05)^0$ = €100 today
  - €100 in a year is worth $100/(1.05)^1$ = €95.24 today
  - €100 in ten years is worth $100/(1.05)^{10}$ = €61.39 today

Conclusions

- We need to know the costs and the benefits of pollution 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
- Chapter 6: Instruments that target efficient levels.