Lecture 1
Welfare economics and the environment

Ingrid Hjort

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The environmental problem

Environmental problems → Economic cost

- Source: Economic activity
  - Consume/produce too much
  - Extract too much

- Consequence: Economic loss
  - Economic loss = Utility loss, welfare loss
  - Damages the environmental quality
  - Gives environmental degradation

⇒ Distinguish between different environmental problems:
Environmental problems

The environmental impact of economic activity can be looked at in terms of *insertions into* and *extractions from* the environment:

Emission externalities

- Air pollution
- Water and soil pollution
- Noise pollution and smells

Environmental degradation of

- Wildlands
- Rainforests
- Nonrenewable resources
- Wildlife and biodiversity
Extraction
How to study environmental economics?

The environmental problem is vast, complex and diverse, and therefore difficult to grasp.

→ We need a tool for systemizing the analysis

We need full understanding of the environmental problem, necessary when constructing theoretical models.

Economic models are meant to:

▶ Improve our understanding of a complex structures
▶ Provide a common ground for concepts and discussions
▶ Evoke interesting associations
▶ Derive hypothesis that can be tested empirically

(If this is not the case, then it is a bad model)
Welfare economics:

Recap welfare theory:

*Efficiency: There exist no other allocation that makes anyone better off without making someone worse off.*

1. Efficiency in consumption
2. Efficiency in production
3. Total efficiency

Gives the efficient and optimal allocation of goods.

- Note: Efficiency don’t say anything about the allocation’s implication to fairness or equality: Normative perspective
Welfare economics:

The fundamental theorems of welfare in economic theory:

First welfare theorem: The market will tend towards a competitive equilibrium that is Pareto optimal if there are no market failures

Ideal conditions:

1. Markets exist for all goods and services
2. All markets are perfect competitive
3. All agents have perfect information
4. No external effects
5. Fully assigned property rights in all resources and commodities
6. All goods and services are private goods
7. Well behaved functions
8. All agents are maximizers
The first welfare theorem breaks down in the presence of an environmental problem:

1. There exist no markets for pollution or ecosystem services
2. There is lack of information, there is uncertainty and misleading information flourish
3. Damaging pollution is an external effect
4. Many ecological resources is without property rights
5. The nature, the atmosphere and the ecosystems are public goods

→ Need to study how these market failures cause the problem

Then we can design instruments that correct the market.
Environmental economics

Study market failures following the environmental problems:

- **Externalities**
  - Missing market
    - In the comp. market there exist no price on emissions that incentives the necessary pollution reduction

- **Public goods**
  - Under provision, no one contributes enough
    - In the com. market no one are willing to pay up to sustain a public good, such as the environment

- **Incomplete information and degradation**
  - Uncertainty concerning the magnitude of future damages
    - In the com. market there is not perfect information about environmental consequences

The environmental problem is complex because there are several market failures present
Externalities

An economic side effect (costs or benefits) arising from an economic activity that are not reflected in prices

⇒ Leads to over/under-supply

▷ Negative externalities: The one imposing costs is not charged
▷ Positive externalities: The one creating benefits is not compensated

External effects can be classified according to:

▷ What activity they originate from (consumption/production)
▷ What activity they impact on (consumption/production)

Environmental externalities: The market will over-supply pollution in absence of corrections
Environmental degradation

Refers to the **over-use** of physical resources such as: Soil, fresh water, oceans, air, atmosphere, forests, fossil fuels, heavy metals 

*Imposes future costs on all users of natural resources, including the agent responsible for degrading the natural resource stock*

- Agents have no/little incentive to limit their exploitation
- The negative impact is often revealed in the future
- Consequences are not immediate, and therefore commonly unknown → cause uncertainty

Many environmental problems is a result of lack of knowledge:
- No one knew the fatal future consequences of the emissions to / extractions off natural resources
Public goods

Many environmental resources are characterized as public goods:

- Water quality, biodiversity, clean air, stable climate

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<thead>
<tr>
<th>Excludable</th>
<th>Non-excludable</th>
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<tbody>
<tr>
<td>Rivalrous</td>
<td>Pure privat good</td>
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<tr>
<td>Non-rivalrous</td>
<td>Congestible</td>
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- Non-rivalrous: one agent’s enjoyment of a good does not diminish the ability of other agents to enjoy the same good

- Non-excludable: agents cannot be prevented from enjoying the good

Market failure problem: Free-riding

*Agents have little incentive to voluntarily provide public goods when they can simply enjoy the benefits of nonrivalrous and nonexcludable public goods provided by others.*

Free-riding when protecting the environment (Barrett, 2007)
Characterize the pollution problem
Characterize the pollution problem

Important to fully understand, disentangle and clearify the pollution problem:

→ when creating economic models of the environmental problems
→ when designing mechanisms (policy instruments) to correct the market failures.

**Characteristics:**

- Local vs. global pollution
- Flow pollution vs. stock pollution
- Uniformly mixing vs. non-uniformly mixing pollution
Local vs. global pollution

Local pollution: Time-lapse from The NY Times

http://climate.nasa.gov/
Pollution flows and pollution stocks

- **Flow pollution**
  - The damage depend on the rate of the emission flow alone. That is, the instant *rate* at which they are being discharged into the environmental system.

- **Stock pollution**
  - Damages depend only on the stock of pollution in the relevant environmental system at any point in time. Stock pollutants accumulate in the environment over time. Stock pollutants are persistent over *time*, and may be transported over *space* → two dimensions
Pollution flows and pollution stocks

- The static flow pollution model:
  - noise, light, smell, smoke, exhaust
  - These problems have no time dimension: the pollution stops when the emissions stops.
  - Flow-damage pollution: \( D = D(M) \)

- The stock pollution problem:
  - Stock pollutants accumulate in the environment over time.
  - Emissions \( M_t \) builds up over time \( t \in (0, T) \) and create a stock \( S \) of a harmful substance.
  - Stock-damage pollution: \( D_t = D_t(S) \)
  - Damage today depend on previous emitted emissions
  - Stock pollutants can create a burden for future generations by passing on damage that persists well after the benefits received from incurring that damage have been forgotten. Example?
Pollution flows and pollution stocks

The distinction between flows and stocks becomes crucial for two reasons:

1. Important when create economic models

   → This distinction enables us to understand the science lying behind the pollution problem and translate this into economic models.

2. Important for policy design

   → While the damage is associated with the pollution stock, that stock is outside the direct control of policy makers. Environmental protection agencies may, however, be able to control the rate of emission flows. Even where they cannot control such flows directly, the regulator may find it more convenient to target emissions rather than stocks. Given that what we seek to achieve depends on stocks but what is controlled or regulated are typically flows, it is necessary to understand the linkage between the two.
Non uniform vs. uniformly mixing

- **UM**: The pollutant disperse s.t. its spatial distribution is uniform, concentration does not vary from place to place
  - Emission location do not matter
  - Greenhouse gases (GHG)

- **Non-UM**:
  - Emission location matters
  - Ozone accumulation in the lower atmosphere
  - Some local water and ground pollutants do not uniformly mix
  - Local air pollution:
    - particulate pollutants from diesel engines and trace metal emissions
    - Oxides of Nitrogen and Sulphur in urban airsheds

- Complicates the policy problem: Total emissions is no longer the sole source of concern, must also consider the emissions site and its impact on concentration levels at other sites.
Climate change

What characterize the climate change problem?
The target
Pollution

What determines the environmental impact of pollution?

- Population size
- Consumption per capita - determines produced quantity
  - Demand and supply
- Technology - determines emission intensity
  - Efficiency in consumption or production
Emissions involves both benefits and costs:

- **Benefit**
  - Enables production
  - Produces energy
  - Increase consumption

- **Costs**
  - Reduces the environmental quality
  - Reduces welfare
  - Reduces utility

- We call the costs of emissions ‘damages’.

Gives an interesting trade-off
What is the efficient level of pollution?

The Damage function:

\[ D = D(M), \quad D'(M) > 0, \quad D''(M) > 0 \quad (1) \]

The Benefit function

\[ B = B(M), \quad B'(M) > 0, \quad B''(M) < 0 \quad (2) \]

where \( M \) is aggregate emission flow of all emission sources:

\[ M = \sum_{n}^{i=1} m_i \quad (3) \]

where \( n \) is total firms, where each firm emits \( m_i \);

- Total damage is thought to rise at an increasing rate, with the size of the emission flow. The more emissions thus more harm on nature. *Convex*

- Total benefits will rise at a decreasing rate as more emissions are used in production, assuming decreasing marginal productivity. *Concave*
What is the efficient level of pollution?

Evaluate the trade-off between benefits from producing more private goods to the increased damage on public goods. Stricter pollution targets will generate benefits but will also generate costs.

Max social net benefit:

\[
\max_M NB = \{ B(M) - D(M) \} 
\]  

- **Marginal damage of pollution:** The harm/reduction of the public environment from one extra unit of pollution.

- **Marginal benefit of pollution:** The benefits from using one extra unit of pollution to produce private consumption goods.
Maximize net benefits

The efficient level of emissions
Comment to the figure

- The area $A$: The reduction in output value
- The area $(A + B)$: The reduction in environmental damage
  $(A + B) - A = B$
- The area $B$: The net efficiency gain when internalizing the externality

The intercept of MB and MD, $\mu^*$ is the shadow price of emission (or the price of the pollution externality), since there are no price revealed in market transactions.

- $\mu^*$ would be the efficient market price
- $\mu^*$ Gives the optimal level of emissions $M^*$
- Emissions has been reduced from the BaU level $\hat{M}$
The efficient level of pollution

Efficient level of pollution:

\[ D'(M^*) = B'(M^*) \]  

*The net benefit of emissions is optimized at the point where the marginal benefits of pollution equal the marginal damage from pollution.*

Limitations: This was a first best world, with a single externality, assuming that the rest of the market is perfectly competitive.
Instruments

How do we introduce \( \mu^* \) in the most efficient way?

Next lecture:
Environmental policy → economic instruments → economic incentives → market-based instruments
