# Optimum Pollution and Externalities

Natural Resource Economics

Aditya KS

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ICAR–Indian Agricultural Research Institute
**Contact:** adityaag68@gmail.com
**Website:** `https://adityaraoks.github.io/`

# Outline

# Introduction

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- Externalities are central to environmental economics.
- Pollution is a classic example of a negative externality.
- Understanding externalities is crucial for policy design and sustainable development.

## What are Externalities?

- **Externality:** An uncompensated cost or benefit imposed on a third party by an economic activity.
- Can be positive (benefits) or negative (costs).
- Not reflected in market prices, leading to market failure.

# Types of Externalities

- **Negative:** Pollution, noise, congestion.
- **Positive:** Vaccination, education, research spillovers.
- **Production:** Arise from production (e.g., factory emissions).
- **Consumption:** Arise from consumption (e.g., second-hand smoke).

# Causes and Consequences

# Causes of Externalities

- Poorly defined property rights.
- Common pool resources (tragedy of the commons).
- Market mechanisms fail to price social costs/benefits.

# Market Failure

- Negative externalities: Overproduction (e.g., pollution-heavy industries).
- Positive externalities: Underproduction (e.g., clean energy).
- Divergence from Pareto optimality: Marginal social benefit $\neq$ marginal social cost.

## Government Failure

- Incomplete information.
- Implementation challenges.
- Policy misalignment and unintended consequences.

# Pollution as a Negative Externality

# Pollution as a Negative Externality

- Pollution imposes costs on society not borne by polluters.
- Examples: Air and water pollution, greenhouse gases, noise.
- Pollution shirking: Firms avoid abatement due to lack of penalties.

## Key Economic Concepts

- **Marginal Private Cost (MPC):** Cost to producer/consumer.
- **Marginal External Cost (MEC):** Cost to society (health, environment).
- **Marginal Social Cost (MSC):** $MSC = MPC + MEC$.
- **Marginal Abatement Cost (MAC):** Cost to reduce pollution by one unit.

# Private vs Social Optima

- **Private Optimum:** $MPC = MPB$ (ignores external costs).
- **Social Optimum:** $MSC = MSB$ (accounts for external costs).
- Negative externalities $\rightarrow$ market produces too much pollution.

# Why Not Zero Pollution?

- Thermodynamics: All production generates some waste.
- Zero pollution is not feasible or economically optimal.
- The goal: Find the **optimum** (efficient) level of pollution.

# Optimum Pollution: Graphical Analysis

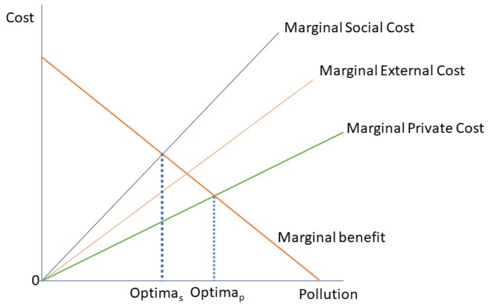



**Figure 1:** Optimum Pollution using MSC and MB

# Optimum Pollution: MAC and MDC

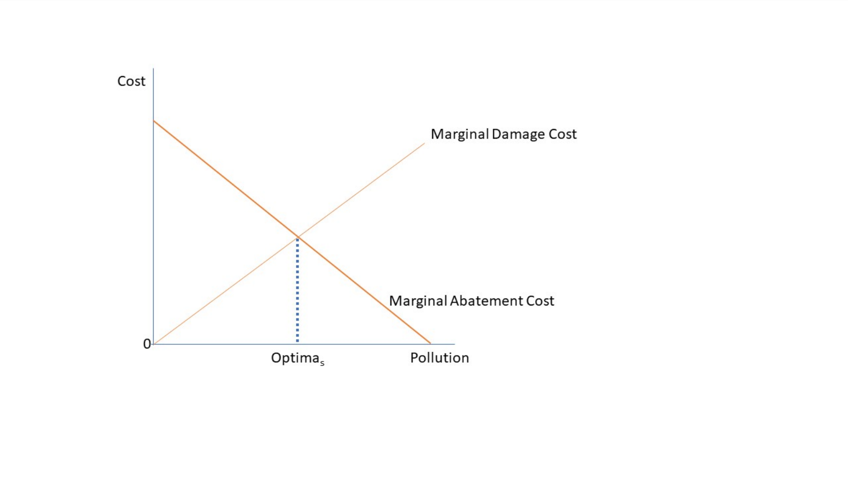



**Figure 2:** Optimum Pollution using Marginal Damage and Abatement Costs

# Empirical Evidence and Valuation

## Empirical Studies on Pollution

- Pollution affects health, property values, and ecosystems.
- Example: 1% reduction in particulates $\rightarrow$ 0.35% reduction in infant mortality (Chay & Greenstone).
- Improved air quality increases property values.

# Valuing Damage from Pollution

- Difficult to measure due to lack of markets.
- Methods: Hedonic pricing, contingent valuation, cost of illness.
- Important for setting optimal policy levels.

# Internalizing Externalities: Theory

# Internalizing Externalities

- Align private incentives with social welfare.
- Main approaches:
  - Coase Theorem (bargaining)
  - Pigouvian taxes
  - Tradable permits
  - Standards and regulations

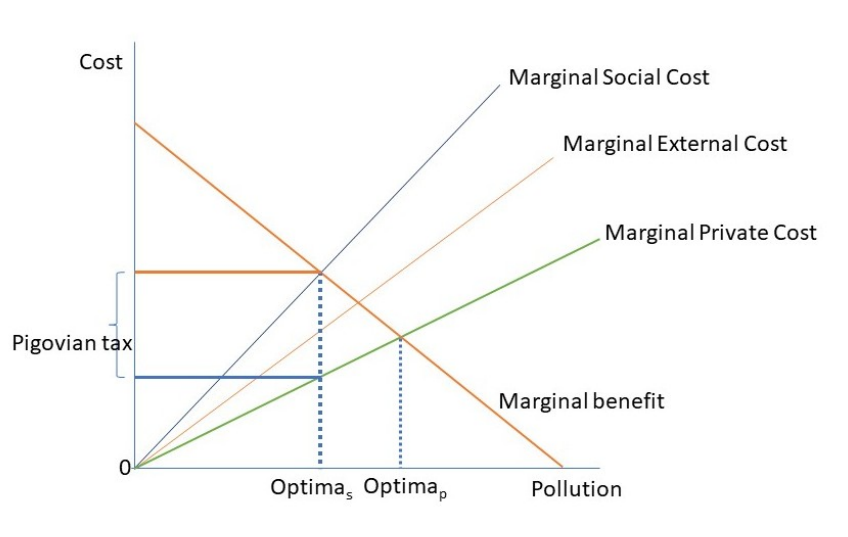
## The Coase Theorem

- If property rights are well-defined and transaction costs are low, private bargaining can achieve efficient outcomes.
- Outcome is efficient regardless of who holds rights.
- **Limitations:** High transaction costs, many parties, power imbalances.

# Pigouvian Taxes

- Tax imposed equal to marginal external cost at social optimum.
- Shifts private cost to align with social cost.
- **Challenges:** Measuring external cost, enforcement.

# Pigouvian Tax: Diagram



# Pigouvian Tax: Magnitude

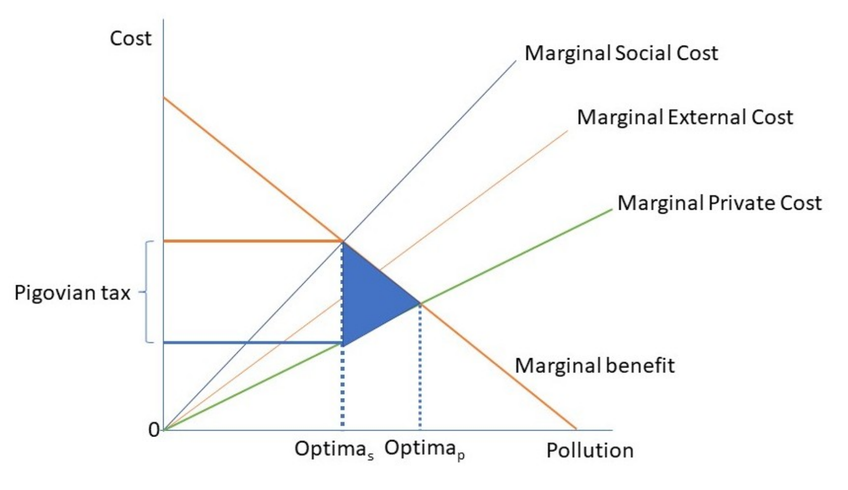



**Figure 4:** Pigovian taxation - magnitude

## Tradable Permits

- Cap is set on total emissions; permits are allocated or auctioned.
- Firms trade permits, achieving pollution reduction at lowest cost.
- **Challenges:** Initial allocation, market manipulation, local hotspots.

# Standards and Regulations

- Government sets emission limits or technology mandates.
- Ensures compliance through monitoring and penalties.
- **Challenges:** Inflexibility, high administrative costs, stifled innovation.

# Comparison of Mechanisms

**Table 1:** Comparison of Internalization Mechanisms

| **Mechanism** | **Type** | **Key Features / Limitations** |
|---|---|---|
| Coase Theorem | Market-based | Needs low transaction costs, property rights |
| Pigouvian Tax | Fiscal policy | Accurate measurement, enforcement needed |
| Tradable Permits | Market-based | Cost-efficient, allocation issues |
| Standards/Regulation | Direct control | High admin cost, inflexible |

# Policy in Practice

# Case Study: Carbon Pricing

- Carbon taxes: Sweden, British Columbia.
- Cap-and-trade: EU Emissions Trading System.
- Results: Emissions reductions, revenue for public investment.

# Case Study: Water Pollution

- Effluent charges in Germany.
- Tradable permits in the US (Clean Water Act).
- Challenges: Monitoring, enforcement, equity.

## Distributional Impacts

- Pollution control can affect income distribution.
- Taxes may be regressive; permit allocation may favor incumbents.
- Policy design can mitigate negative impacts (e.g., recycling tax revenue).

## Political Economy of Pollution Policy

- Lobbying by affected industries.
- Public awareness and demand for clean environment.
- International coordination for global pollutants (e.g., $CO_2$).

# Advanced Topics

## Dynamic Considerations

- Technological change can lower abatement costs.
- Policies can incentivize innovation (e.g., R&D subsidies, flexible standards).
- Long-term vs. short-term tradeoffs.

# Uncertainty and Risk

- Damage costs and abatement costs are uncertain.
- Price vs. quantity instruments: Weitzman rule.
- Precautionary principle for irreversible damages.

## Global Externalities

- Climate change: Global public good problem.
- International agreements (Kyoto, Paris).
- Free-rider problem and enforcement challenges.

# Tragedy of the Commons

- Common pool resources (air, water) are overused.
- Solutions: Privatization, regulation, community management.
- Examples: Fisheries, groundwater, atmosphere.

# Summary and Discussion

## Summary

- Externalities cause market failure; pollution is a key example.
- Internalization mechanisms: taxes, permits, bargaining, regulation.
- Policy choice depends on context, costs, and institutional capacity.

## Discussion Questions

- Why is zero pollution not optimal?
- Compare Pigouvian taxes and tradable permits.
- When does the Coase theorem fail?
- How do we value environmental damages?
- What are the distributional impacts of pollution policy?

# Assignments

1. Identify a local negative externality and suggest an internalization mechanism.
2. Compare effectiveness of Pigouvian taxes vs. tradable permits for air pollution.
3. Discuss challenges of applying the Coase theorem to climate change.
4. Write a one-page summary on the tragedy of the commons and externalities.

# References

## References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- Tietenberg, T. (2019). Environmental and Natural Resource Economics.
- Chay, K.Y. & Greenstone, M. (2003). The Impact of Air Pollution on Infant Mortality.