ECO 567A:
Energy Economics with a Geography Focus

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Jan 10, 2025

Syllabus

- Part I: Demand for Local Environmental Quality
  - Intro (Jan 10)
  - Demand I - Estimation (Jan 17)
  - Demand II - Sorting and Environmental Justice (Jan 24)
  - Amenities and Quant. Spatial Economic Models (Jan 31)
- Part II: Supply of Local Environmental Quality - Energy
  - Energy Production (Feb 7)
  - Energy Demand (Feb 14)
  - Energy Efficiency Innovation (Feb 21)
  - Trade and Pollution (March 7)
- Part III: Global Externalities
  - Climate Change (March 14)

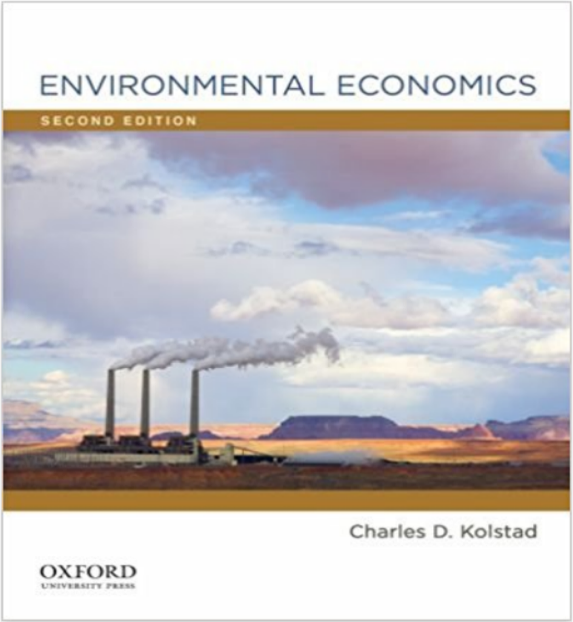
Organization and Grading

- Organization
  - Papers and Lecture Slides posted to Moodle
- Assignments & Grading
  - Projects (50%)
  - Final (50%)

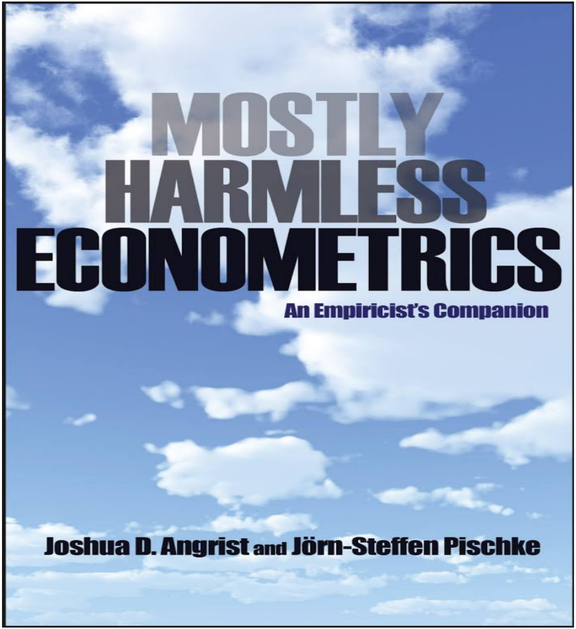
Research Project

- Pick a question that interests you in Sustainable Development/Environment/Energy/Geography
- Brief literature review on what has been done, what are outstanding questions
- Develop empirical strategy to address the question (real world)
- Identify dataset
- Obtain dataset and describe

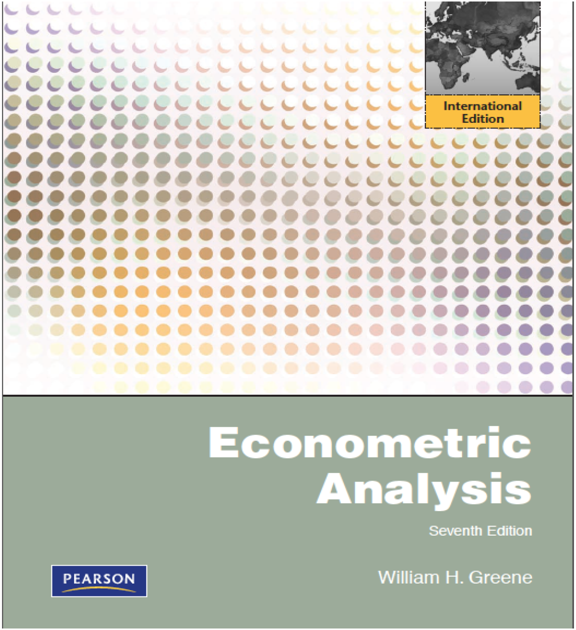
Text Books


ENVIRONMENTAL ECONOMICS
SECOND EDITION
Charles D. Kolstad
OXFORD
UNIVERSITY PRESS

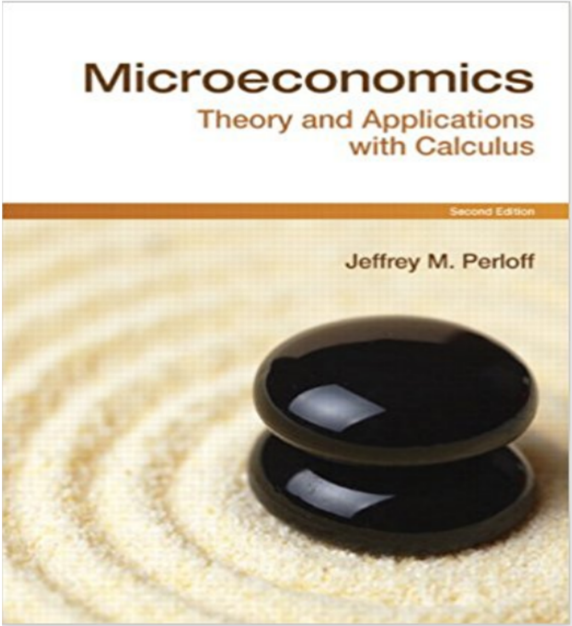
Text Books


MOSTLY
HARMLESS
ECONOMETRICS
An Empiricist's Companion
Joshua D. Angrist and Jörn-Steffen Pischke

Text Books


International Edition
Econometric Analysis
Seventh Edition
PEARSON
William H. Greene

Text Books


Microeconomics
Theory and Applications with Calculus
Second Edition
Jeffrey M. Perloff

Lecture 1: Introduction to Environment and Economics ECO 567A

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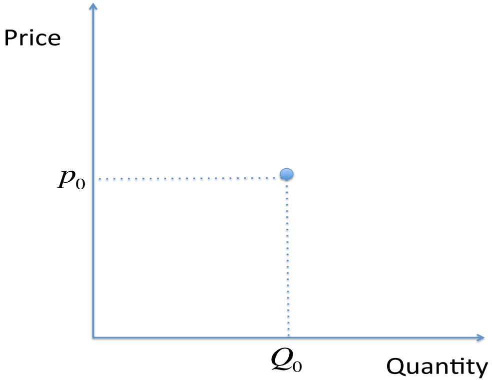
Introduction

- Demand
- Supply
- Equilibrium
- Social Welfare
- Externalities
- Policy Response

Introduction



Preferences

- Let there be two commodities in the world labeled commodity 1 and commodity 2
- A consumer considers possible combinations of q_1 and q_2, and can make comparisons

$$(q_1^a, q_2^a) \succ (q_1^b, q_2^b)$$
$$(q_1^a, q_2^a) \prec (q_1^b, q_2^b)$$
$$(q_1^a, q_2^a) \sim (q_1^b, q_2^b)$$

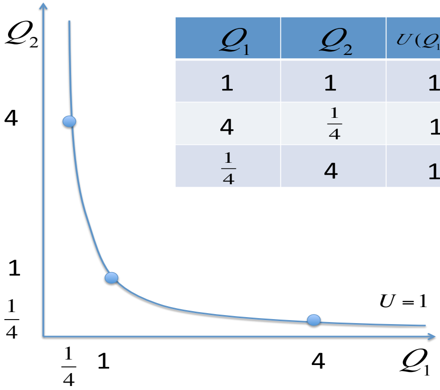
- "Preferences on a set X" is a binary relation "$\succsim$" on X satisfying
  - completeness: for any $a, b \in X$, $a \succsim b$ or $b \succsim a$
  - transitivity: for any $a, b \in X$, $a \succsim b$ and $b \succsim c$ implies $a \succsim c$

Utility Function

- Debreu Thm (1954): If "$\succsim$" is complete, transitive, and continuous, then "$\succsim$" can be represented by a continuous utility function
- $U(q_1^a, q_2^a) \geq U(q_1^b, q_2^b) \iff (q_1^a, q_2^a) \succsim (q_1^b, q_2^b)$
- $U()$ is not unique

Utility Function and Indifference Curves

E.g. $U(q_1, q_2) = q_1^{1/2} q_2^{1/2}$



Q_1	Q_2	$U(Q_1, Q_2)$
1	1	1
4	$\frac{1}{4}$	1
$\frac{1}{4}$	4	1

Consumer's Problem

- Assume conditions of Debreu are met
- Assume consumer chooses q_1 and q_2 to maximize utility function
- Then the consumer's problem is well specified as

$$\begin{array}{ll} \underset{q_1, q_2}{\text{Max}} & U(q_1, q_2) \\ \text{subject to} & p_1 q_1 + p_2 q_2 \leq y \end{array}$$

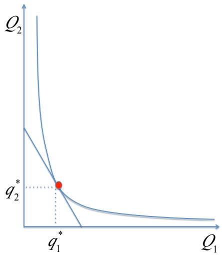
Solving the Consumer's Problem: Graphically

Budget Constraint:

$$\begin{aligned} y &= p_1 q_1 + p_2 q_2 \\ q_2 &= \frac{y}{p_2} - \frac{p_1}{p_2} q_1 \end{aligned}$$

Indifference Curve:

$$\begin{aligned} U &= U(q_1, q_2) \\ dU &= \frac{\partial U}{\partial q_1} dq_1 + \frac{\partial U}{\partial q_2} dq_2 \equiv 0 \\ \Longrightarrow & \quad \frac{dq_2}{dq_1} = -\frac{\partial U}{\partial q_1} \Big/ \frac{\partial U}{\partial q_2} \end{aligned}$$



All together:

$$\frac{\partial U}{\partial q_1} \Big/ \frac{\partial U}{\partial q_2} = \frac{p_1}{p_2}$$

Solving the Consumer's Problem: Algebraically

Assume the budget constraint binds and substitute in:

$$
\begin{aligned}
&\underset{q_1}{\text{Max}} \quad U(q_1, \frac{y}{p_2} - \frac{p_1}{p_2} q_1) \\
&\implies \frac{\partial U}{\partial q_1} + \frac{\partial U}{\partial q_2}\left(-\frac{p_1}{p_2}\right) = 0 \\
&\implies \frac{\partial U}{\partial q_1} \Big/ \frac{\partial U}{\partial q_2} = \frac{p_1}{p_2}
\end{aligned}
$$

Example

Let

$$U(q_1, q_2) = q_1^{\alpha} q_2^{1-\alpha}$$

Then we have

$$\underset{q_1}{\text{Max}} \quad q_1^{\alpha} \left(\frac{y}{p_2} - \frac{p_1}{p_2} q_1 \right)^{1-\alpha}$$

$$\Longrightarrow \left[\frac{y}{p_2} - \frac{p_1}{p_2} q_1 \right]^{1-\alpha} \alpha q_1^{\alpha-1} + q_1^{\alpha} (1-\alpha) \left[\frac{y}{p_2} - \frac{p_1}{p_2} q_1 \right]^{-\alpha} \left(-\frac{p_1}{p_2} \right) = 0$$

$$\Longrightarrow \boxed{q_1^* = \frac{\alpha y}{p_1}}$$

$$\Longrightarrow \boxed{q_2^* = \frac{(1-\alpha) y}{p_2}}$$

Marshallian Demand

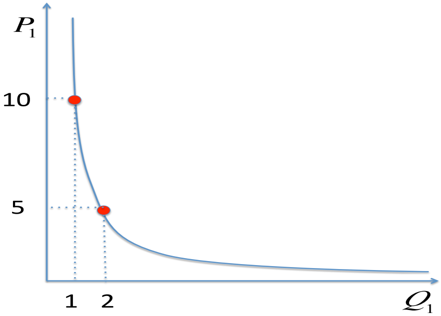
Market Demand:

$$Q_1 = \sum_n q_1^* = \sum_n \frac{\alpha y}{p_1} = n\frac{\alpha y}{p_1}$$

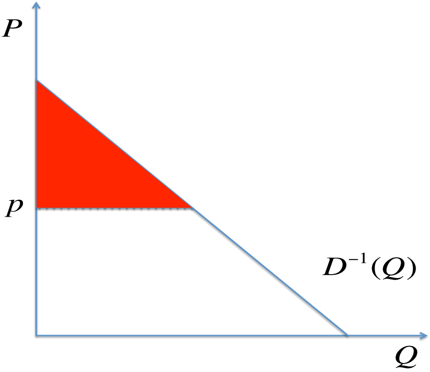
Inverse Market Demand Curve:

$$p_1 = n\frac{\alpha y}{Q_1}$$

Inverse Demand = Marginal Willingness to Pay = Marginal Benefit



Consumer Surplus



$$CS = \int_0^{Q^*} (D^{-1}(Q) - P^*)dQ$$

Supply: Firm's Problem

- Firms choose inputs (k and l) to maximize profits subject to technology

$$\begin{aligned} \underset{k,l}{\text{Max}} \quad & \Pi = pQ - wl - rk \\ \text{subject to} \quad & Q = f(k,l) \end{aligned}$$

- We break this up into 2 steps
  - First Step: Compute Cost Function $c(Q)$

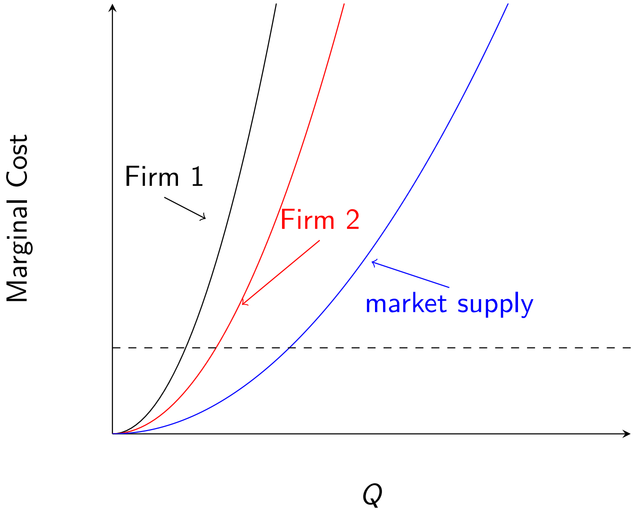
$$\begin{aligned} \underset{k,l}{\text{Min}} \quad & c = wl + rk \\ \text{subject to} \quad & Q = f(k,l) \end{aligned}$$

  - Second Step: Choose Q

$$\underset{Q}{\text{Max}} \quad \Pi = pQ - c(Q)$$

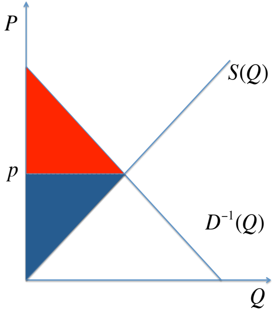
- First Order Condition: $p = c'(Q)$

Market Supply



Equilibrium and Welfare

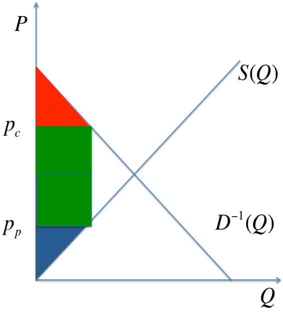
- Equilibrium : $D^{-1}(Q^*) = S(Q^*)$
- $CS = \int_0^{Q^*} (D^{-1}(Q) - P^*) dq$
- $PS = \int_0^{Q^*} (P^* - S(Q)) dq$



- Total Social Welfare : TSW= CS + PS

The First Welfare Theorem

- Adam Smith/Arrow-Debreu: In a perfectly competitive market, the competitive equilibrium maximizes total social welfare



Externalities

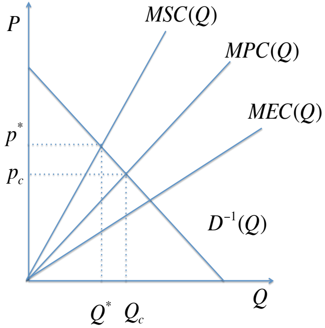
- Externality (external cost) is a cost that is borne by someone external to the market transaction that generates the cost

Market Failure

- Suppose there is an environmental cost associated with the production of Q, $EC(Q)$
- Then Total Social Welfare is

$$TSW = CS + PS - EC$$

- $MSC(Q) = MPC(Q) + MEC(Q)$
- $Q^* < Q_c$
- Competitive market fails to reach the social optimum

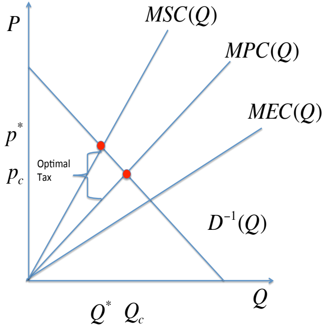


Solution 1: Tax the bad

- Induce the supply side to "internalize" the externality, i.e. act as if the $MSC(Q^*) = MPC(Q^*)$

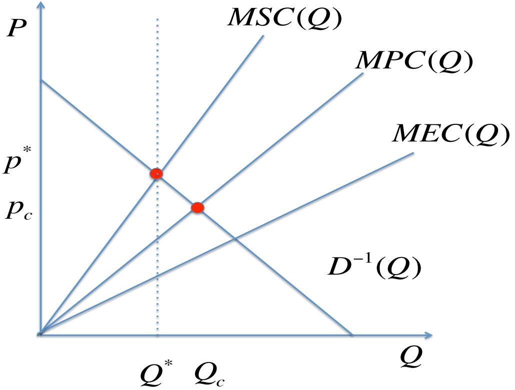
- Choose τ such that

$$D^{-1}(Q^*) = MPC(Q^*) + \tau$$

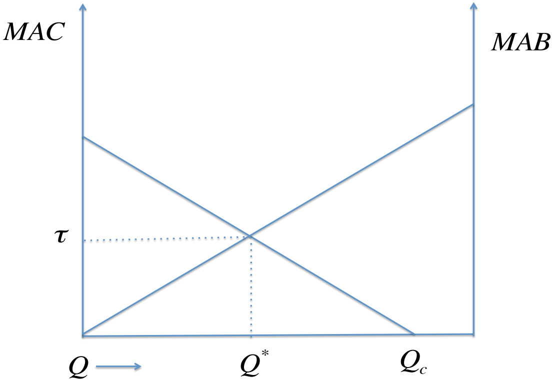


Solution 2: Cap and Trade

- Just cap Q at Q^*, perhaps allowing firms to trade permits



Solution 3: Coase Thm



- Coase Thm (1960): If bargaining is possible and transaction costs are not too high, then agents will bargain to the efficient outcome regardless of initial allocation of property rights

Example

Let $P(Q) = 305 - Q$ be the inverse demand for an industry, where P is the price in dollars and Q is the quantity. The marginal private cost is given by $MPC(Q) = 5 + 3Q$. Production generates a negative externality in the form of air pollution, the marginal external costs are given by $MEC(Q) = 2Q$.

1. Find the unregulated equilibrium (price and quantity) under perfect competition.
2. Now assume there is only one firm (i.e. a monopolist). Find the monopolist's unregulated equilibrium.
3. Find the socially optimal quantity and price.
4. Find the deadweight loss under an unregulated monopoly and under perfect competition.
5. Which market structure is closer to the social optimum: perfect competition or monopoly?
6. Find the optimal tax or subsidy that the government needs to impose to make the monopolist produce on the social optimum.
7. Find the optimal tax or subsidy that the government needs to impose to make the perfectly competitive market reach the social optimum.

Example

Let $P(Q) = 305 - Q$ be the inverse demand for an industry, where P is the price in dollars and Q is the quantity. The marginal private cost is given by $MPC(Q) = 5 + 3Q$. Production generates a negative externality in the form of air pollution, the marginal external costs are given by $MEC(Q) = 2Q$.

1. Find the unregulated equilibrium (price and quantity) under perfect competition. $Q^c = 75,\ P^c = 230$
2. Now assume there is only one firm (i.e. a monopolist). Find the monopolist's unregulated equilibrium. $Q^m = 60,\ P^m = 245$
3. Find the socially optimal quantity and price. $Q^* = 50,\ P^* = 255$
4. Find the deadweight loss under an unregulated monopoly and under perfect competition. $DWL^c = 1875,\ DWL^m = 300$
5. Which market structure is closer to the social optimum: perfect competition or monopoly? Monopoly
6. Find the optimal tax or subsidy that the government needs to impose to make the monopolist produce on the social optimum. $\tau^m = 50$
7. Find the optimal tax or subsidy that the government needs to impose to make the perfectly competitive market reach the social optimum. $\tau^c = 100$

References

- Rubinstein, Ariel. Lecture notes in microeconomic theory: the economic agent. Princeton University Press, 2012.

- Perloff, Jeffrey M. Microeconomics: theory and applications with calculus. Pearson Higher Ed, 2017.