Microeconomics IV

Part IV. Other Market Failures: Externalities and Public Goods

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Outline Part IV. Ohter Market Failures

TOPIC 10. EXTERNALITIES

- An ***externality*** is a cost or a benefit imposed upon someone by actions taken by others. The cost or benefit is thus generated externally to that somebody.
- An externally imposed benefit is a ***positive externality***.
  - Examples: A well-maintained property next door that raises the market value of your property, a pleasant cologne or scent worn by the person seated next to you, improved driving habits that reduce accident risks.
- An externally imposed cost is a ***negative externality***.
  - Examples: Air pollution, water pollution, loud parties next door, traffic congestion, second-hand cigarette smoke.

Inefficiency and property rights

- Externalities cause ***Pareto inefficiency***:
  - too much scarce resource is allocated to an activity which causes a negative externality:
  - too little resource is allocated to an activity which causes a positive externality.
- Causing a producer of an externality to bear the full external cost or to enjoy the full external benefit is called ***internalizing the externality***.
- Most externality problems are due to an ***inadequate specification of property rights*** and, consequently, an ***absence of markets*** in which trade can be used to internalize external costs or benefits.

Theorem

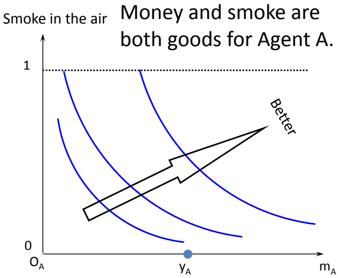
Coase's Theorem: *If there are property rights over the commodity generating the externality, then the efficient level of externality is produced no matter which agent is assigned the property right.*

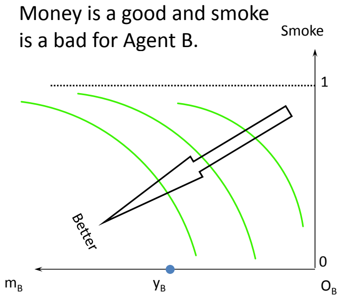
Negative consumption externalities

- Negative consumption externality example:
  - Two agents, A and B,
  - Two commodities, money and smoke.
- Both smoke and money are goods for Agent A. Money is a good and smoke is a bad for Agent B.
- Agent A is endowed with $\$y_A$, agent B is endowed with $\$y_B$.
- Smoke is a purely public commodity.
- Smoke intensity is measured on a scale from 0 (no smoke) to 1 (maximum concentration).

Consumption externality example

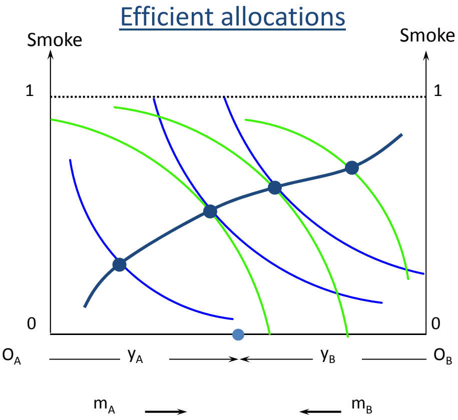
- Indifference curves:





Efficient externality levels

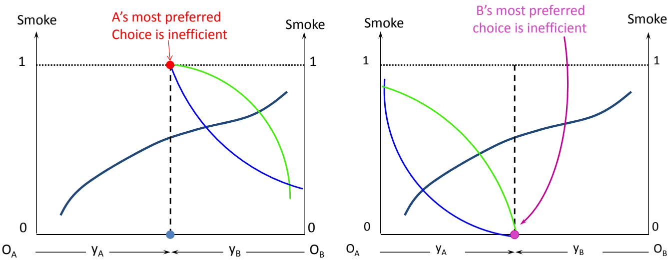
- What are the efficient allocations of smoke and money?



- Note: implicitly assumed that money can be exchanged for changes in smoke level.

If no trade, inefficient allocation

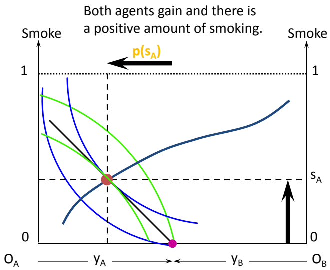
- Suppose there is no means by which money can be exchanged for changes in smoke level.

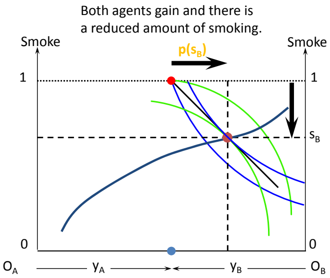


- So if A and B cannot trade money for changes in smoke intensity, then the outcome is inefficient:
  - there is too much smoke (A's most preferred choice)
  - or there is too little smoke (B's choice).

Property rights assignment

- What happens if property right is created and is assigned to one of them?
  - If B is assigned ownership of the air in the room, B can now sell "rights to smoke".
  - If A is assigned the ownership of the air in the room, B can now pay Agent A to reduce the smoke intensity.



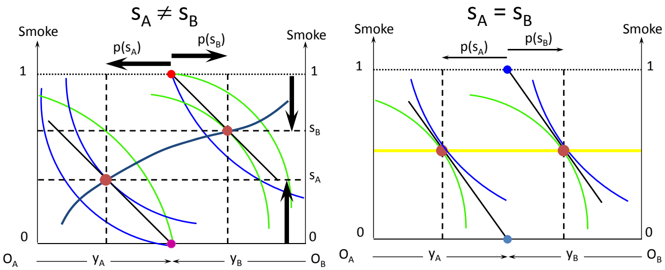


- Establishing a market for trading rights to smoke causes an efficient allocation to be achieved.

Externality amount and property rights

- Notice that
  - Agent given property right is better off than at her own most preferred allocation in the absence of the property right;
  - In general, amount of smoking occuring in equilibrium depends upon which agent is assigned the property right.
- If the preferences are quasilinear in money, however, the same amount of smoking occurs in equilibrium no matter which agent is assigned ownership of the air in the room:

$$U(m,s) = m + f(s)$$



Production externalities

- Consider a steel mill producing jointly steel and ***pollution*** of the lake water.
- Pollution adversely affects the profits of a nearby fishery, but the steel firm does ***not internalize*** its externality because it does not pay for the pollution costs.
- If both ***firms merge***, economic efficiency is achieved and less pollution is produced by the merged firm.
- If ***tradable property rights*** over the lake are created and assigned to one of the firms, the efficient outcome is achieved.
  - In terms of pollution level, it doest not matter who is assigned the property right (profits are linear and therefore quasi-linear in money).
  - The asset owner obviously gets richer.

Production externalities example

- Let p_S be the market price of steel and p_F the market price of fish. Both firms are price-takers.
- Let $c_S(s,x)$ be the steel firm's cost of producing s units of steel jointly with x units of pollution, where

$$\frac{\partial c_s(s,x)}{\partial s} > 0, \ \frac{\partial c_s(s,x)}{\partial x} < 0.$$

- Steel firm optimization problem (if not facing external costs of its pollution production):

$$\max_{s,x} \Pi_s = p_s s - c_s(s,x) \ \Rightarrow \ \frac{\partial c_s(s,x)}{\partial s} = p_s, \ -\frac{\partial c_s(s,x)}{\partial x} = 0$$

  - The firm chooses the output level of steel for which price = marginal production cost.
  - The firm chooses a pollution level such that the marginal cost of pollution reduction is zero.

Externality on fishery

- Steel firm inflicts a negative externality on the fishery, since its cost of catching f units of fish increases with x:
  - Fishery cost of catching f units of fish when the steel mill emits x units of pollution is $c_F(f, x)$:

$$\frac{\partial c_F(f,x)}{\partial f} > 0, \ \frac{\partial c_F(f,x)}{\partial x} > 0, \ \frac{\partial^2 c_F(f,x)}{\partial f \partial x} > 0.$$

- The fishery's optimization problem is

$$\max_f \Pi_F = p_F f - c_F(f,x) \ \Rightarrow \frac{\partial c_F(f,x)}{\partial f} = p_F$$

  - Therefore, higher pollution raises the fishery's marginal production cost and lowers its output and its profit.
  - This is the external cost of the pollution.

Efficient pollution level

- Suppose the two firms merge to become one; optimization problem becomes

$$\max_{s,f,x} \Pi_s + \Pi_F = p_s s + p_F f - c_s(s,x) - c_F(f,x)$$

$\Rightarrow$

$$\frac{\partial c_s(s^*,x^*)}{\partial s} = p_s, \quad \frac{\partial c_F(f^*,x^*)}{\partial f} = p_F$$

$$-\frac{\partial c_s(s^*,x^*)}{\partial x} = \frac{\partial c_F(f^*,x^*)}{\partial x}$$

- Note that merger achieves efficiency: the marginal external pollution cost (the external cost inflicted on the fishery) is equal to the steel firm's cost of reducing pollution.
- Less pollution is produced by the merged firm because the merged firm faces the full cost of its own pollution through increased costs of production in the fishery.

Tradeable property rights on pollution

- How else might internalization be caused so that efficiency can be achieved?
  - Coase argues that externality exists because nobody owns the water being polluted.
- Suppose the property right to the water is created and assigned to the fishery:
  - Fishery decides units of pollution to sell:

$$\max_{f,x} \Pi_F = p_F f + p_x x - c_F(f,x) \Rightarrow \frac{\partial c_F(f,x)}{\partial f} = p_F, \; \frac{\partial c_F(f,x)}{\partial x} = p_x$$

  - Steel mill decides units of pollution to buy:

$$\max_{s,x} \Pi_s = p_s s - c_s(s,x) - p_x x \Rightarrow \frac{\partial c_s(s,x)}{\partial s} = p_s, \; -\frac{\partial c_s(s,x)}{\partial x} = p$$

$\Rightarrow$

$$-\frac{\partial c_s(s,x)}{\partial x} = \frac{\partial c_F(f,x)}{\partial x}$$

  - Efficiency is achieved!

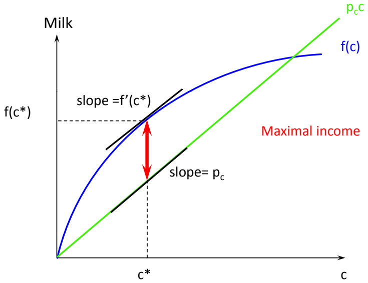
Property rights owner

- Would it matter if the property right to the water was instead been assigned to the steel firm?
- No, because
  - profit is linear (and therefore quasi-linear) in money.
  - and Coase's Theorem states that the same efficient allocation is achieved whichever of the firms gets the property right.

The tragedy of the commons

- Consider a grazing area owned "in common" by all members of a village, who graze cows on it:
  - When c cows are grazed, the total milk production is $f(c)$, where $f' > 0$ and $f'' < 0$.
- Let the price of milk be 1 and the relative cost of grazing a cow p_c. Profit optimization problem:

$$\max_c f(c) - p_c c \Rightarrow f'(c^*) = p_c$$



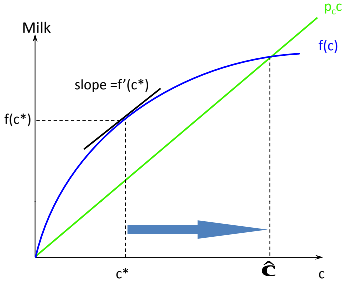
Over-grazed common

- Note: when $c = c*$, the average gain is positive:

$$\frac{\pi(c^*)}{c^*} = \frac{f(c^*) - p_c c^*}{c^*} = \frac{f(c^*)}{c^*} - p_c > 0$$

  - Hence, positive profits when introducing one more.

- Since nobody owns the common, entry is not restricted. Thus, entry continues until the economic profit of grazing another cow is zero:



Common's tragedy

- The reason for the tragedy:
  - When a villager adds one more cow his income rises by $\frac{f(c)}{c} - p_c$ but every other villager's income falls.
  - The villager who adds the extra cow takes no account of the cost inflicted upon the rest of the village.
  - Entry continues until economic profit of grazing one more cow is zero:

$$\frac{\pi(\hat{c})}{\hat{c}} = \frac{f(\hat{c})}{\hat{c}} - p_c = 0$$

- Modern-day "tragedies of the commons":
  - over-fishing the high seas
  - over-logging forests on public lands
  - over-intensive use of public parks
  - urban traffic congestion.

Outline Part IV. Other Market Failures

TOPIC 11. PUBLIC GOODS

- A good is purely public if it is both nonexcludable and nonrival in consumption.
  - Nonexcludable: all consumers can consume the good.
  - Nonrival: each consumer can consume all of the good.
- Hence, a public commodity is consumed by everyone (nonexcludability), and everybody consumes the entire amount of the commodity (nonrivalry in consumption).
- Examples:
  - Broadcast radio and TV programs.
  - National defense.
  - Public highways.
  - Reductions in air pollution.
  - National parks.

Free riding problem

- Suppose we have a situation where it is efficient to supply a public good.
- If one of the agents is willing to pay for it by herself,
  - then she would supply the good even if nobody else made no contribution,
  - and the other agents enjoy the good for free: ***free-riding***.
- If nobody is willing to pay for it,
  - then, nobody will supply the good alone: they all try to free-ride on each other, causing no good to be supplied.
  - Allowing contributions may make possible the supply of a public good when no individual will supply the good alone.
  - However, free-riding can persist even with contributions and there may not be ***private provision*** of the public good.
- ***Public provision*** may then be the only way to have to good supplied.

Reservation prices

Definition

A consumer's reservation price for a unit of a good is his maximum willingness-to-pay for it.

- Consumer's wealth is w.
- Utility of not having the good is $U(w,0)$.
- Utility of having the good when paying p for it $U(w-p,1)$
- Reservation price is defined as the amound r such that

$$U(w-r,1) = U(w,0)$$

Theorem

It is efficient to provide a public good if the sum of everybody's reservation price is higher than the cost of the public good.

Discrete public good provision

- When should a public good be provided?
  - Consider a public good which costs c.
  - There are two consumers, A and B; individual payments for providing the public good are g_A and g_B.
  - Payments must be individually rational: $g_A \leq r_A$ and $g_B \leq r_B$.
  - The good is provided if $g_A + g_B \geq c$.
  - Then, if $r_A + r_B \geq c$, it is Pareto-improving to supply the good.
- Suppose $r_A > c$ and $r_B < c$.
  - Then A would supply the good even if B made no contribution.
  - B then enjoys the good for free; free-riding.
- Suppose now that $r_A < c$ and $r_B < c$ (but $r_A + r_B > c$).
  - Then neither A nor B will supply the good alone.
  - Yet, it is Pareto-improving for the good to be supplied.
  - A and B may try to free-ride on each other, causing no good to be supplied.

Discrete private good example

- Example:
  - Suppose A and B each have just two actions: individually supply a public good, or not.
  - Cost of supply c = \$100.
  - Payoff to A from the good = \$80. Payoff to B from the good = \$65.
  - \$80 + \$65 > \$100, so supplying the good is Pareto-improving.
  - However, it does not occur in the unique Nash Equilibrium.

Player B

Player A		Buy	Don't Buy
	Buy	-\$20 -\$35	-\$20 \$65
	Don't Buy	\$100 -\$35	\$0 \$0

(Don't' Buy, Don't Buy) is the unique NE.
But (Don't' Buy, Don't Buy) is inefficient.

Discrete private good example 2

- Example:
  - Now allow A and B to make contributions to supplying the good: e.g. A contributes \$60 and B contributes \$40.
  - Payoff to A from the good = \$20 > \$0. Payoff to B from the good = \$25 > \$0.
  - So allowing contributions makes possible supply of a public good when no individual will supply the good alone.
  - But what contribution scheme will work?
  - And free-riding can persist even with contributions.

Player A \ Player B	Contribute	Don't Contribute
Contribute	\$20 \$25	-\$60 \$0
Don't Contribute	\$0 -\$40	\$0 \$0

Two NE: (Contribute, Contribute) and (Don't Contribute, Don't Contribute).

Public good with variable quantities

- Let G be the units of a public good with variable quantities.
  - E.g. how many broadcast TV programs, or how much land to include into a national park.
- Suppose $c(G)$ is the production cost of G units of public good and that there are n consumers; $i = 1, \ldots, n$.
  - MRS_i is i's utility-preserving payment in private good units for a one-unit increase in public good.
  - $\sum_i \mid MRS_i \mid$is the total payment of private good that preserves both utilities if G is raised by 1 unit.
  - $MC(G)$ is the cost increase if G is raised by 1 unit.
  - Then efficient public good production requires:

$$\sum_i \mid MRS_i \mid = MC(G)$$

Efficient provision of a continuous public good

- Suppose there are two individuals, A and B and let x_A and x_B be the consumptions of private good.
- Budget allocations must satisfy $x_A + x_B + c(G) = w_A + w_B$.
- The Pareto efficiency condition for public good supply is

$$|MRS_A| + |MRS_B| = c'(G)$$

- Why?
  - The public good is nonrival in consumption, so 1 extra unit of public good is fully consumed by both A and B.
  - If $|MRS_A| + |MRS_B| < c'(G)$, there is a Pareto-improvement from reduced G:
    - Making 1 less public good unit releases more private good than the compensation payment requires.
  - If $|MRS_A| + |MRS_B| > c'(G)$, there is a Pareto-improvement from increased G:
    - The total payment of private good A & B are willing to make to have G raised by 1 unit is higher than the cost of providing 1 more public good unit.

Quasi-linear preferences case

- Two consumers, A and B, with preferences

$$U_i(x_i, G) = x_i + f_i(G)$$

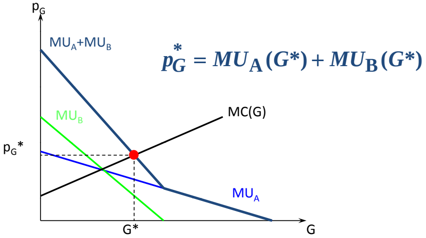
$\Rightarrow$

$$MRS_i \equiv -\frac{\partial U_i / \partial G}{\partial U / \partial x_i} = f_i'(G), \; i = A, B$$

.

- Thus, assuming $p_x = 1$, utility-maximization requires

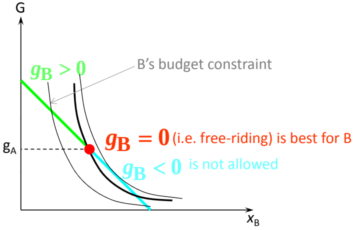
$$f_A'(G) + f_B'(G) = p_G, \; i = A, B$$



Private provision of a continuous public good

- When is free-riding individually rational?
  - Let g_A and g_B be the individual contributions to the public good ($g_i \geq 0,\ i = A, B$).
  - Given A contributes g_A units of public good, B's problem is

$$\max_{x_B, g_B} U_B\left(x_B,\ g_A + g_B\right) \text{ s.t.} x_B + g_B = w_B$$



- When individual utility-maximization requires a lower public good level, free-riding is rational.

Nash equilibrium

Definition

A Nash equilbrium of this game is a set of contributions (g_A^*, g_B^*) such that both contributions are individually optimal given the other contribution.

- The Nash equilibrium can also be described as the contributions (g_A^*, g_B^*) that satisfies the reaction function of both agents:

$$g_A^* = \max\{f_A(w_A, g_B^*) - g_B^*, 0\}$$
$$g_B^* = \max\{f_B(w_B, g_A^*) - g_A^*, 0\}$$

- Quasi-linear preferences example: $U_i(x_i, G) = x_i + \bar{g_i}$

$$g_A^* = \max\{\bar{g_A} - g_B^*, 0\}$$
$$g_B^* = \max\{\bar{g_B} - g_A^*, 0\}$$

Lindahl prices

- Suppose we want to implement the efficient level of public through a system of prices/taxes.
- We offer each consumer the right to buy public good at some price p_i:

$$\max_{x_i, G} u_i(x_i,\ G) \text{ s.t.} x_i + p_i G = w_i$$

$\Rightarrow$

$$\frac{\partial u_i / \partial G}{\partial u_i / \partial x_i} = p_i$$

- How to choose the individual prices to make consumers choose the efficient level of public good:

$$p_i = \frac{\partial u_i(G^*, x_i^*) / \partial G}{\partial u_i(G^*, x_i^*) / \partial x_i}$$

where (G^*, x_A^*, x_B^*) satisfy the efficiency condition

$$\frac{\partial u_A(G^*, x_A^*) / \partial G}{\partial u_A(G^*, x_A^*) / \partial x_A} + \frac{\partial u_B(G^*, x_B^*) / \partial G}{\partial u_B(G^*, x_B^*) / \partial x_B} = 1.$$

Revelation mechanisms

Definition

A scheme that makes it rational for individuals to reveal truthfully their private valuations is a ***revelation mechanism***.

- Example: ***the Groves-Clarke taxation scheme***.
  - There are N individuals, $i = 1, \ldots, N$, and v_i is individual i's true (private) valuation of the public good.
  - Each agent is assigned a cost c_i and each agent states a public good net valuation, s_i.
  - The public good is supplied if $\sum_i s_i$; otherwise not.
  - A ***pivotal*** person j pays a tax equal to
    - $-\sum_{i \neq j} s_i$ if j changes the outcome from not supply to supply ($\sum_{i \neq j} s_i < 0$ and $\sum_{i \neq j} s_i + s_j > 0$),
    - $\sum_{i \neq j} s_i$ if j changes the outcome from supply to not supply ($\sum_{i \neq j} s_i > 0$ and $\sum_{i \neq j} s_i + s_j < 0$).
- The GC tax scheme implements the efficient supply but causes an inefficiency because of lost taxes.

Groves-Clarke taxation scheme

- An example: 3 persons; A, B and C, with valuations $v_A = 40$, $v_B = 50$, and $v_C = 110$.
- Public good cost: \$180 (efficient to supply it).
- Assign $c_A = \$60$, $c_B = \$60$, $c_C = \$60$ (so that $v_A - c_A = -20$, $v_B - c_B = -10$, $v_C - c_C = 50$)
  - If B and C are truthful, then what net valuation s_A should A state?
    - B & C's net valuations sum to \$(50 - 60) + \$(110 - 60) = \$40 > 0.
    - If $s_A \geq -40$, the public good is supplied and he has a loss of \$20.
    - If $s_A < -40$, A prevents supply by becoming pivotal; then A suffers a GC tax of -\$10 + \$50 = \$40.
    - Therefore, A can do no better than state the truth; $s_A = -20$.
  - Similarly, if A and C are truthful, B can do no better than state the truth; $s_B = -10$.

Groves-Clarke taxation scheme (continuation)

If A and B are truthful, what net valuation s_C should C state?

- Net valuation of agents A & B's: \$(40 - 60) + \$(50 - 60) = -\$30.
- If $s_C \geq 30$, the public good is supplied and C is pivotal; then, must pay a GC tax of -\$(40 - 60) - \$(50 - 60) = \$30, for a net payoff of \$(110 - 60) - \$30 = \$20 .
- If $s_C < 30$, the public good is not supplied, in which case C loses his net valuation \$110 - \$60 = \$50.
- Therefore, C can do no better than state the truth; $s_C = 50$.

THE END