Advanced Microeconomic Theory

Chapter 9: Externalities and Public Goods

Outline

- Externalities
- The Coase Theorem
- Pigouvian Taxation
- Tragedy of the Commons
- Pollution Abatement
- Public Goods
- Lindahl Equilibria
- Asymmetric Information

Externalities

Externalities

- ***Externality*** emerges when the well-being of a consumer or the production possibilities of a firm is directly affected by the actions of another agent in the economy.
  - Example: the production possibilities of a fishery are affected by the pollutants that a refinery dumps into a lake.
  - The effects from one agent to another are not captured by the price system.
- The effects transmitted through the price system are referred to as "***pecuniary externalities***."

INTRODUCTION

"Surprisingly….a fully satisfying definition of an exterality has proved elusive" (MWG)

Definition 11.B.1: An externality is present whenever the well-being of a consumer or the production possibilities of a firm are directly affected by the actions of another agent in the economy.

"Directly": excludes effects mediated by prices

INTRODUCTION

- Examples: Fishery affected by emissions from a nearby oil refinery
- Note: impact of oil price is a "pecuniary externality"
- Presence of externality is a function of the set of markets in existence

Externality and public goods

- Externality and Public Goods
  - Introduction
  - A simple bilateral Externality
  - Public Goods
  - Multilateral externalities
  - Private information and second-best solutions

A SIMPLE BILATERAL EXTERNALITY

- Consider a simple two agent partial equilibrium model
- Assume actions of consumers do not affect prices of L traded goods
- Consumer i's utility function takes the form $u_i(x_{1i}, \ldots, x_{Li}, h)$ where choice of *h* by consumer 1 affects consumer 2, i.e., $\frac{\partial u_2(x_{12}, \ldots, x_{L2}, h)}{\partial h} \neq 0$, e.g., music, polluting river

A SIMPLE BILATERAL EXTERNALITY

- Convenient to define for each consumer i a derived utility function over level of *h* assuming optimal commodity purchases by consumer i of traded goods at $p \in \mathbb{R}^L$ and wealth w_i:

$$v_i\left(p, w_i, h\right) = \underset{x_i \geq 0}{Max}\, u_i(x_i, h)$$

Such that $px_i \leq w_i$

A SIMPLE BILATERAL EXTERNALITY

- Assume quasilinear form (zero wealth effects)
- We can write derived utility function $v_i(\cdot)$ as

$$v_i\left(p, w_i, h\right) = \phi_i\left(p, h\right) + w_i$$

- Since we assume prices of L traded goods are unaffected (by changes) we shall suppress price vector and just write $\phi_i(h)$
- Assume $\phi_i(h)$ is twice differentiable and $\phi_i''(\cdot) < 0$ (not innocent)

A SIMPLE BILATERAL EXTERNALITY

- Everything applies to the derived profit function so that $\pi_j(h)$ has the same role in the analysis as $\phi_i(h)$.

NONOPTIMALITY OF THE COMPETITIVE OUTCOME

- Assume the competitive equilibrium with commodity prices p, i.e., both consumers maximize their utility limited only by wealth & prices of traded goods
- It must be the case that consumer i (who controls h outside the market) will choose her level of $h \geq 0$ to maximize $\phi_1(h)$

NONOPTIMALITY OF THE COMPETITIVE OUTCOME

- Equilibrium h^* satisfies first order conditions

$\phi_1'(h^*) \leq 0$ with equality if $h > 0$

interior solution: $\phi_1'(h^*) = 0$

NONOPTIMALITY OF THE COMPETITIVE OUTCOME

- In contrast, in any Pareto optimal allocation, the optimal level of h, h^o must maximize the joint surplus of the two consumers

$$\underset{h\geq 0}{Max}\ \phi_1(h) + \phi_2(h)$$

$$FOC: \quad \phi_1'(h^o) \leq -\phi_2'(h^o) \text{ with equality if } h^o > 0$$

Equilibrium level not optimal unless $h^* = h^o = 0$

NONOPTIMALITY OF THE COMPETITIVE OUTCOME

- For Pareto Optimal allocation in which $h^o = h$ and w_i is consumer i's wealth level for i=1,2, it must be impossible to change h to make a Pareto improvement

$(h^o, 0)$ must solve

$$\underset{h,T}{Max}\ \phi_1(h) + w_1 - T$$

$$s.t.: \quad \phi_2(h) + w_2 + T \geq \bar{u}_2$$

Constraint holds with equality so substituting into objective function h^o must max $\phi_1(h) + \phi_2(h)$

NONOPTIMALITY OF THE COMPETITIVE OUTCOME

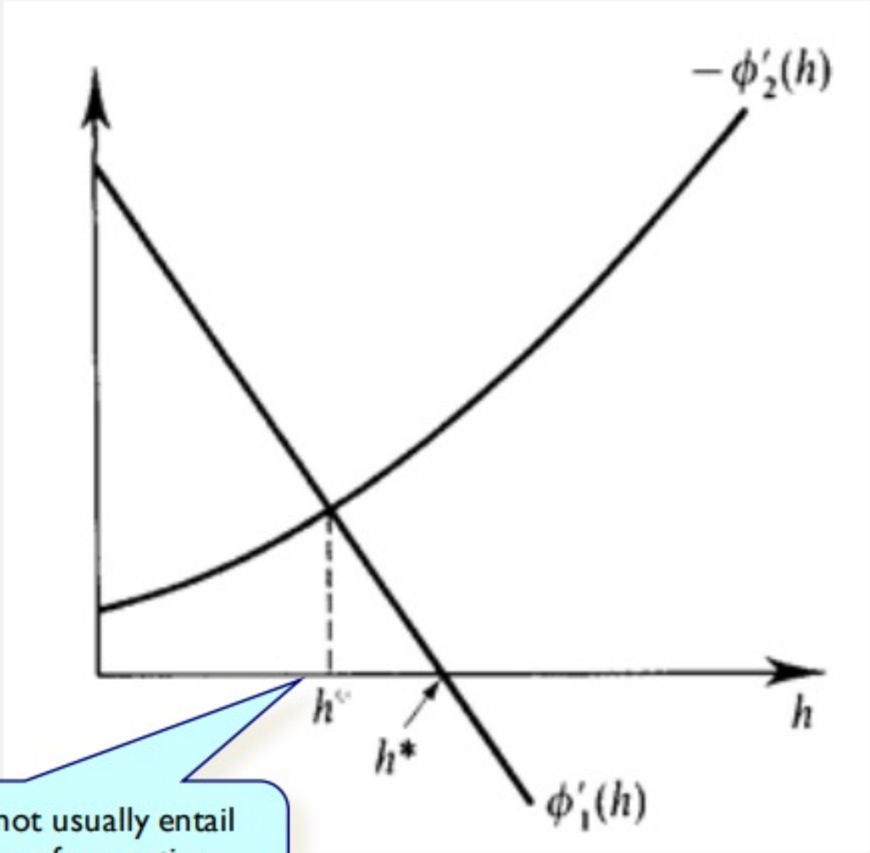
Shows the case of negative externality

$$\phi_1'(h^o) = -\phi_2'(h^o) > 0$$

Because $\phi_1'(\cdot) < 0$

and $\phi_1'(h^*) = 0$

$\Rightarrow h^* > h^o$



Note: optimality does not usually entail the complete elimination of a negative externality

Externalities

- Consider a polluting firm (agent 1) and an individual affected by such pollution (agent 2).
- The firm's profit function is

$$\pi(p, x)$$

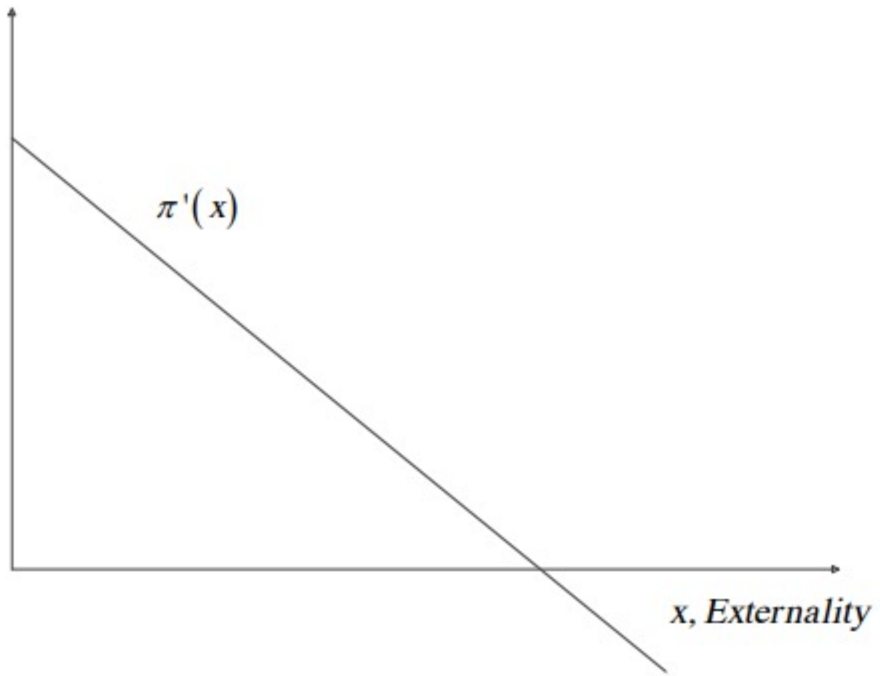
  where p is the price vector and x is the amount of externality generated.
- Assume that p is given (i.e., p is parameter). Then, the profit function becomes

$$\pi(x)$$

  where $\pi'(x) > 0$ and $\pi''(x) < 0$.

Externalities

- The firm obtains a positive and significant benefit from the first unit of the externality-generating activity.
- But the additional benefit from further units is decreasing.



Externalities

- The individual's (i.e., agent 2's) utility is given by
$$u(q, x)$$
where $q \in \mathbb{R}^N$ is a vector of N-tradable goods and $x \in \mathbb{R}_+$ is the negative externality, with $\frac{\partial u}{\partial x} < 0$ and $\frac{\partial u}{\partial q_k} \geq 0$ in every good k.
- Let $q^*(p, w, x)$ denote the individual's Walrasian demand. Then,
$$v(x) = u(q^*(p, w, x), x)$$
is the indirect utility function with $v'(x) < 0$ for all $x > 0$.

Externalities

- ***Example***:
  - Consider the firm's profit function is given by $\pi = py - cy^2$, where $y \in \boldsymbol{R}_+^L$ is output and $p > c > 0$.
  - If every unit of output generates a unit of pollution, i.e., $x = y$, the profit function becomes $\pi(x) = px - cx^2$.
  - FOC wrt x yields $\pi'(x^*) = p - 2cx^* = 0$, producing $p = 2cx^*$ or $x^* = \frac{p}{2c}$.

Externalities

- ***Example*** (continued):
  - If every unit of output y generates $\frac{1}{\alpha}$ units of pollution, i.e., $y = \frac{1}{\alpha}x$, where $\alpha > 0$, the profit function becomes

$$\pi(x) = p\frac{x}{\alpha} - c\left(\frac{x}{\alpha}\right)^2.$$

  - Taking FOC with respect to x yields

$$\pi'(x^*) = \frac{p}{\alpha} - 2c\frac{x^*}{\alpha}\frac{1}{\alpha} = 0,$$

with a competitive equilibrium level of pollution of

$$x^* = \alpha\frac{p}{2c}.$$

Externalities

- ***Competitive equilibrium***: All agents independently and simultaneously solve their PMP (for firms) or UMP (for consumers).
  - The firm independently chooses the level of the externality-generating activity, x, that solves its PMP

$$\max_{x} \ \pi(x)$$

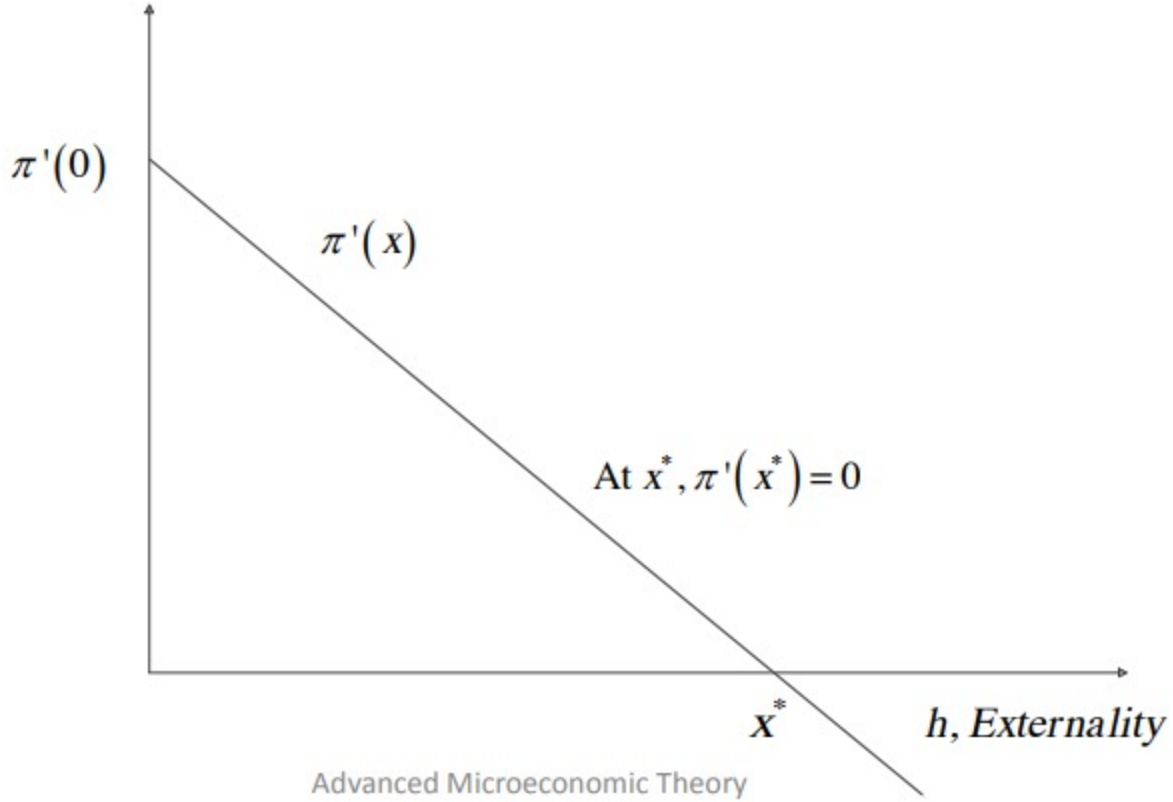
  - Taking FOC with respect to x yields

$$\pi'(x^*) \leq 0$$

    with equality if $x > 0$ (interior solution).

Externalities

– Firm increases the externality-generating activity until the point where the marginal benefit from an additional unit is exactly zero, i.e., $\pi'(x^*) = 0$.



Externalities

– The UMP of the individual affected by pollution is

$$\max_{q} \; u(q, x) \quad \text{s.t.} \quad pq \leq w$$

where $p \in \mathbb{R}_{+}^{N}$ is the given price vector.

– Notice that $q \in \mathbb{R}^{N}$ does not include pollution as one of the N-tradable goods.

– Hence the individual cannot affect the level of the externality generating activity x.

- Uninteresting case
- This assumption is later relaxed

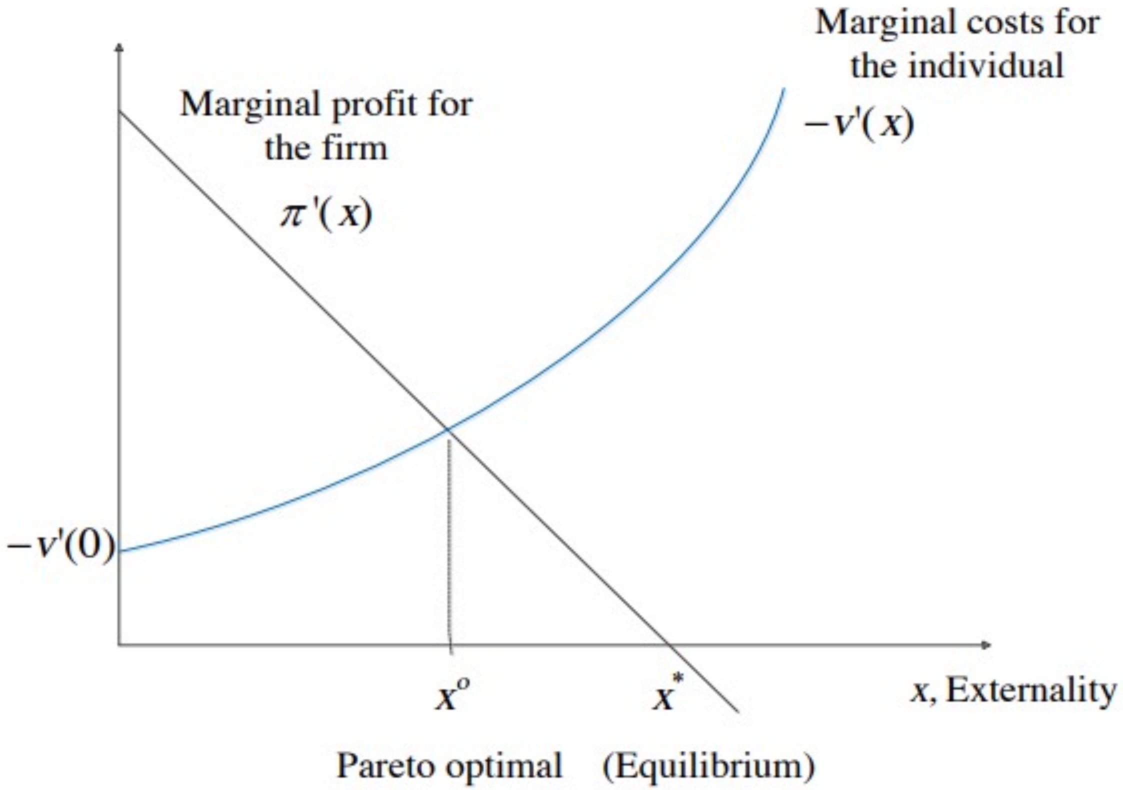
Externalities

- ***Pareto optimum***:
  - The social planner selects the level of x that maximizes social welfare
  $$\max_{x \geq 0} \ \pi(x) + v(x)$$
  - Taking FOC with respect to x yields
  $$\pi'(x^0) \leq -v'(x^0) \text{ with equality if } x^0 > 0$$
  where x^0 is the Pareto optimal amount of the externality.
  - Intuitively, at a Pareto optimal (and interior) solution, the marginal benefit of the externality-generating activity, $\pi'(x^0)$, is equal to its marginal cost, $-v'(x)$.

Externalities

- Pareto optimal and equilibrium externality level (negative externality).

- Too much externality x is produced in the competitive equilibrium relative to the Pareto optimum, i.e., $x^* > x^0$.



Externalities

- ***Example***:
  - Consider a firm with marginal profits of

    $$\pi'(x) = a - bx, \text{ where } a, b > 0$$

    which is decreasing in x.

  - Assume a consumer with marginal damage function of

    $$v'(x) = c + dx, \text{ where } c, d > 0$$

    which is increasing in x.

Externalities

- ***Example*** (continued):
  - The competitive equilibrium amount of externality x^* solves $\pi'(x^*) = 0$, i.e., $a - bx^* = 0$. Hence,
  $$x^* = \frac{a}{b}$$
  - The socially optimal level of the externality x^0 solves $\pi'(x^0) = -v'(x^0)$, i.e., $a - bx^0 = c + dx^0$. Thus,
  $$x^0 = \frac{a - c}{b + d}$$
  which is positive if $\pi'(0) > -v'(0)$, i.e., $a > c$.

Externalities

- Negative externalities are not necessarily eliminated at the Pareto optimal solution.
- This would only occur at the extreme case when $-v'(0) > \pi'(0)$.
- In this setting, curve $\pi'(x)$ and $-v'(x)$ do not cross, and the Pareto optimal solution only occurs at the corner where $x^0 = 0$.

Externalities

- If firm's production activities produce a ***positive externality*** in the individual's wellbeing, then

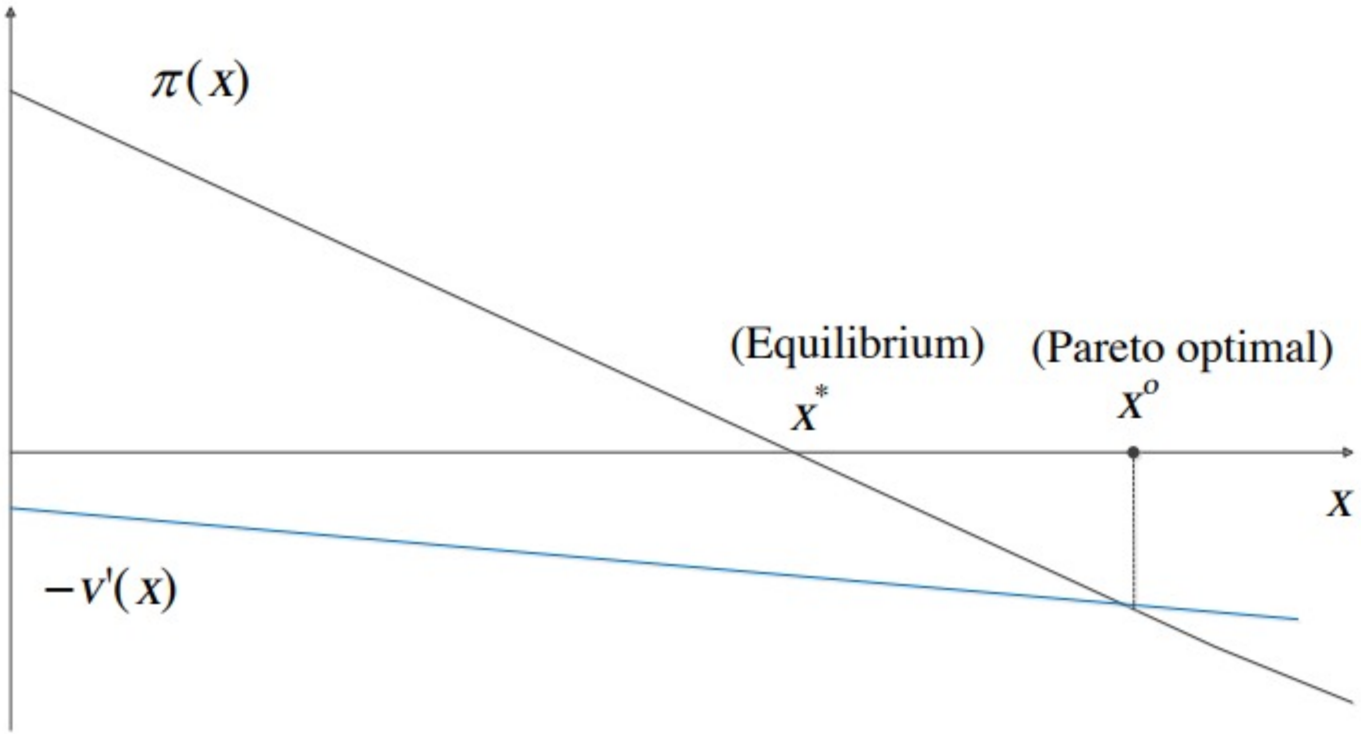
$$v'(x) > 0 \text{ and } -v'(x) < 0$$

  - That is, $-v'(x) < 0$ lies in the negative quadrant.
  - $\pi'(x)$ remains unaffected.

- In this setting, there is an underproduction of the externality-generating activity relative to the Pareto optimum, i.e., $x^* < x^0$.

Externalities

- Pareto optimal and equilibrium externality level (positive externality).



Externalities

- ***Example*** (Positive externalities):
  - Consider two neighboring countries, $i = \{1,2\}$, simultaneously choosing how many resources (in hours) to spend on recycling activities, r_i.
  - The net benefit from recycling is:

$$\pi_i(r_i, r_j) = \left(a - r_i + \frac{r_j}{2}\right) r_i - br_i$$

    where $a, b > 0$, and b denotes the marginal cost of recycling.
  - Country *i's* average benefit, $\left(a - r_i + \frac{r_j}{2}\right)$, is increasing in r_j because a clean environment produces positive external effects on other countries.

Externalities

- ***Example*** (continued):
  - Let us first find the competitive equilibrium allocation.
  - Taking FOC with respect to r_i yields country i's BRF:

$$r_i(r_j) = \frac{a-b}{2} + \frac{1}{4}r_j$$

  - Symmetrically, country *j*'s BRF is

$$r_j(r_i) = \frac{a-b}{2} + \frac{1}{4}r_i$$

    - The positive slope of the BRFs indicates that countries' recycling activities are strategic complements.

Externalities

- ***Example*** (continued):
  - Simultaneously solving the two BRFs yields

$$r_i = \frac{\frac{r_i}{4}+\frac{a-b}{2}}{4} + \frac{a-b}{2}$$

  - And rearranging, we obtain an equilibrium level of recycling

$$r_i^* = \frac{2}{3}(a-b) \text{ for } i = \{1,2\}$$

Externalities

- ***Example*** (continued):
  - A social planner simultaneously selects r_i and r_j in order to maximize social welfare

$$\max_{r_i, r_j} \left(a - r_i + \frac{r_j}{2}\right) r_i - b r_i + \left(a - r_j + \frac{r_i}{2}\right) r_j - b r_j$$

  - FOCs:

$$a - 2r_i + \frac{r_j}{2} - b + \frac{r_j}{2} = 0$$
$$a - 2r_j + \frac{r_i}{2} - b + \frac{r_i}{2} = 0$$

Externalities

- ***Example*** (continued):
  - Simultaneously solving the two FOCs yields the socially optimal levels of recycling

$$r_i^0 = a - b \text{ for every } i = \{1,2\}$$

  - Note that

$$r_i^0 = a - b > \frac{2}{3}(a - b) = r_1^*$$

Solutions to the Externality Problem:

Property Rights

Property Rights

- This is a less intrusive approach:
  - let the parties bargain over the externality
  - no government intervention
- Key assumptions:
  - The property rights over the externality-generating activity must be:
    - Easy to identify, and
    - Enforceable.
  - No bargaining costs.
- As long as property rights are clearly assigned, the two parties will negotiate in such a way that the optimal level of the externality-producing activity is implemented (***Coase Theorem***)

Property Rights

- ***Property rights assigned to consumer 2***:
  - Let us assign property rights to the individual suffering the negative externality
    - "externality-free" environment: at the initial state no externality is generated, i.e., $x = 0$
  - The firm must then pay the affected individual if it wants to increase the externality over zero.
  - In particular, let us assume that affected individual makes a take-it-or-leave-it-offer where the firm must pay $\$T$ in exchange of x units of pollution.

Property Rights

- The firm agrees to pay $\$T$ to the affected individual iff

$$\pi(x) + w_1 - T \geq \underbrace{\pi(0)}_{\text{current state}} + w_1$$

or $\pi(x) - T \geq \pi(0)$

- Hence, the affected individual's UMP becomes that of choosing (x, T) that solves

$$\max_{x \geq 0, T} \; v(x) + w_2 + T$$
$$\text{s.t. } \pi(x) - T \geq \pi(0)$$

- The constraint is binding, since the affected individual will raise $\$T$ until the point where the firm is exactly indifferent between accepting and rejecting the offer.

Property Rights

- Hence, $\pi(x) - T = \pi(0)$ or $\pi(x) - \pi(0) = T$.
- Plugging this result into the affected individual's UMP, we obtain

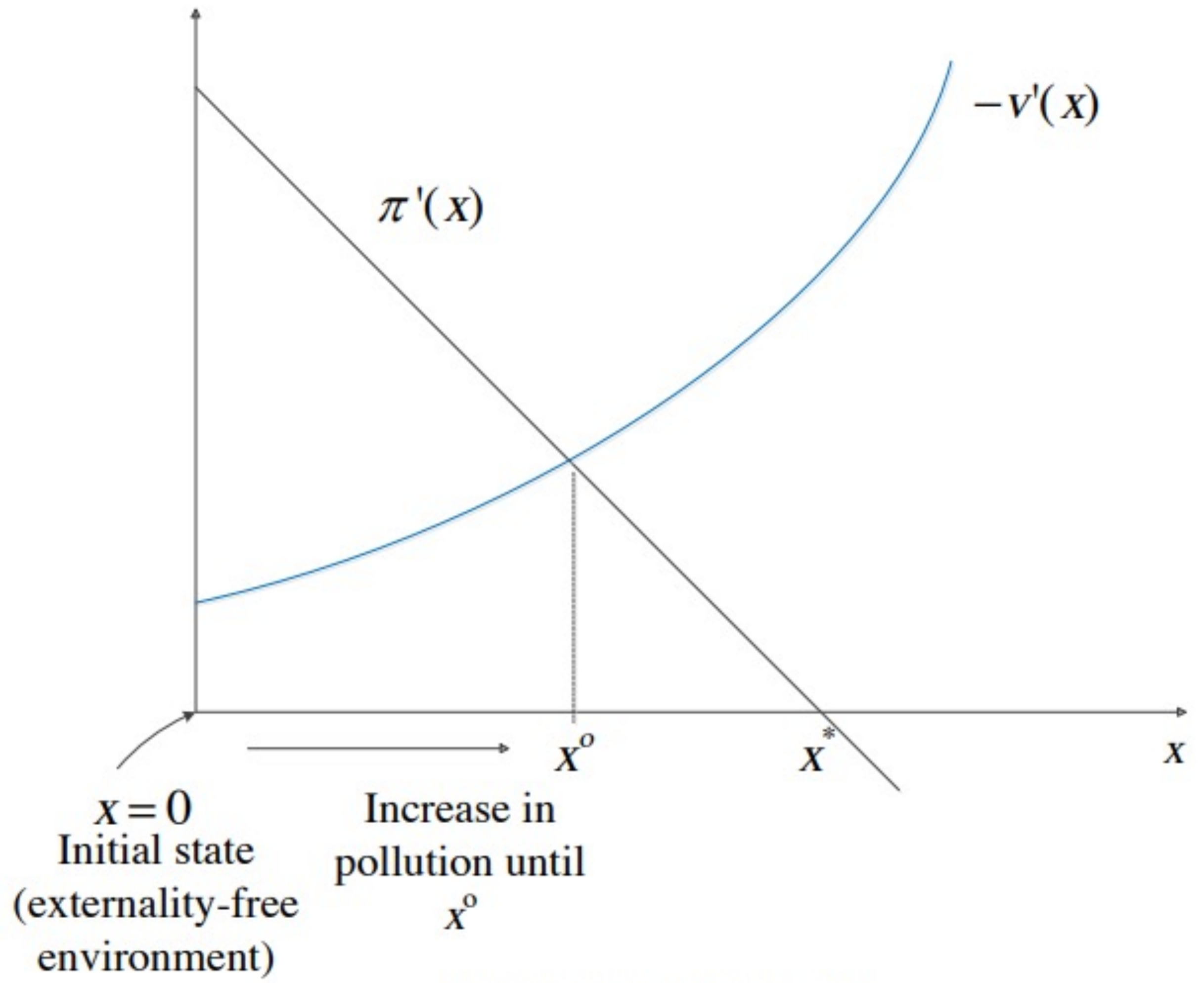
$$\max_{x \geq 0} v(x) + w_2 + \underbrace{\pi(x) - \pi(0)}_{T}$$

- FOCs with respect to x yields:

$$v'(x) + \pi'(x) \leq 0 \quad \Leftrightarrow \quad \pi'(x) \leq -v'(x)$$

- This coincides with the FOCs to the social planner's problem.
- Therefore, bargaining allows for the level of the externality x to reach the optimal level, i.e., $x = x^0$.

Property Rights



Property Rights

- ***Property rights assigned to the firm***:
  - What if the property rights were assigned to the firm (i.e., polluter)?
  - If there is no bargaining between the firm and the affected individual, the firm would pollute until $x = x^*$, where $\pi'(x^*) = 0$.
  - However, the affected individual can pay $\$T$ to the firm in exchange of a lower level of pollution, x, where $x < x^*$.

Property Rights

– The polluter is willing to accept this offer iff

$$\pi(x) + w_1 + T \geq \underbrace{\pi(x^*)}_{\text{current state}} + w_1$$

$$\text{or} \quad \pi(x) + T \geq \pi(x^*)$$

– Thus, the affected individual's UMP becomes that of choosing (x, T) that solves

$$\max_{x \geq 0, T} \; v(x) + w_2 - T$$

$$\text{s.t. } \pi(x) + T \geq \pi(x^*)$$

– Note that $\$T$ now enters negatively into the affected individual's utility, but positively into the firms'.

Property Rights

- The constraint is binding, since the affected individual reduces the $\$T$ until the point where the firm is indifferent between accepting and rejecting the offer T.
- Hence, $\pi(x) + T = \pi(x^*)$ or $T = \pi(x^*) - \pi(x)$.
- Inserting this result into the affected individual's UMP, we obtain

$$\max_{x \geq 0} v(x) + w_2 \underbrace{-\pi(x^*) + \pi(x)}_{-T}$$

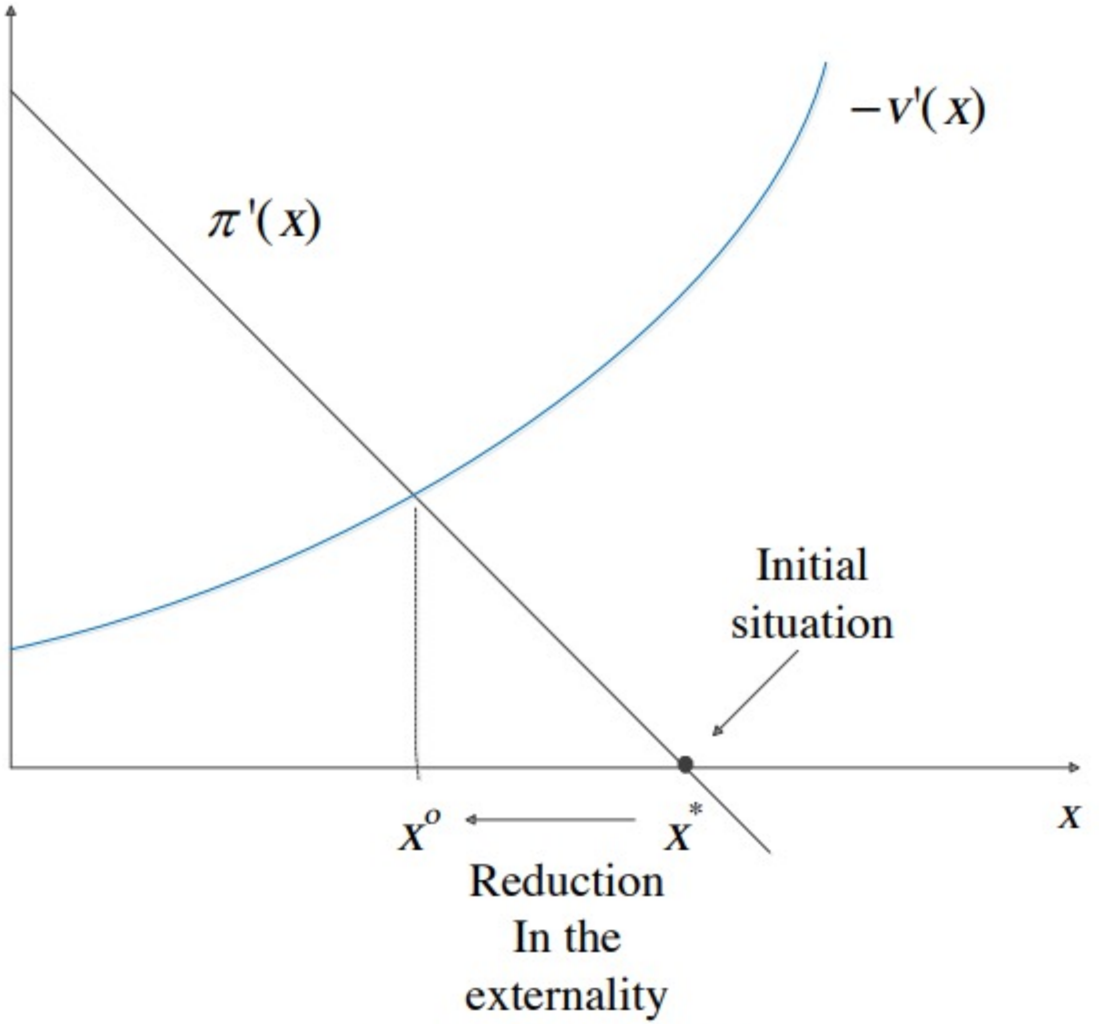
- FOCs with respect to x yields:

$$v'(x) + \pi'(x) \leq 0 \iff \pi'(x) \leq -v'(x)$$

Property Rights

- Again, the above coincides with the FOCs at the optimal level of the externality (i.e., social planner's problem), where $x = x^0$.

Property Rights



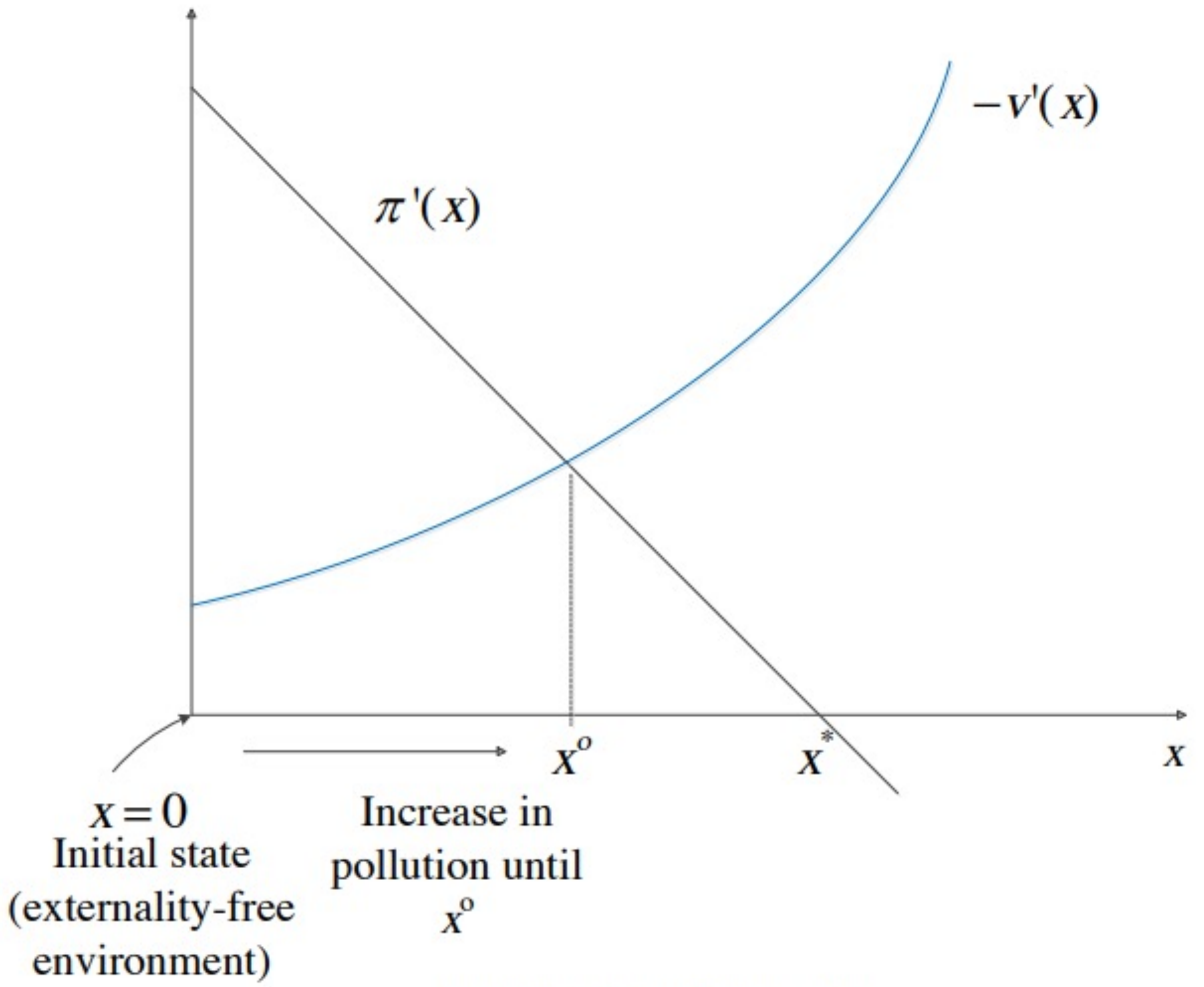
Property Rights

- In summary, regardless of the initial assignment of property rights over the externality-generating activity…
  - agents can negotiate to increase or decrease the externality, x, until reaching the Pareto optimal level x^0.

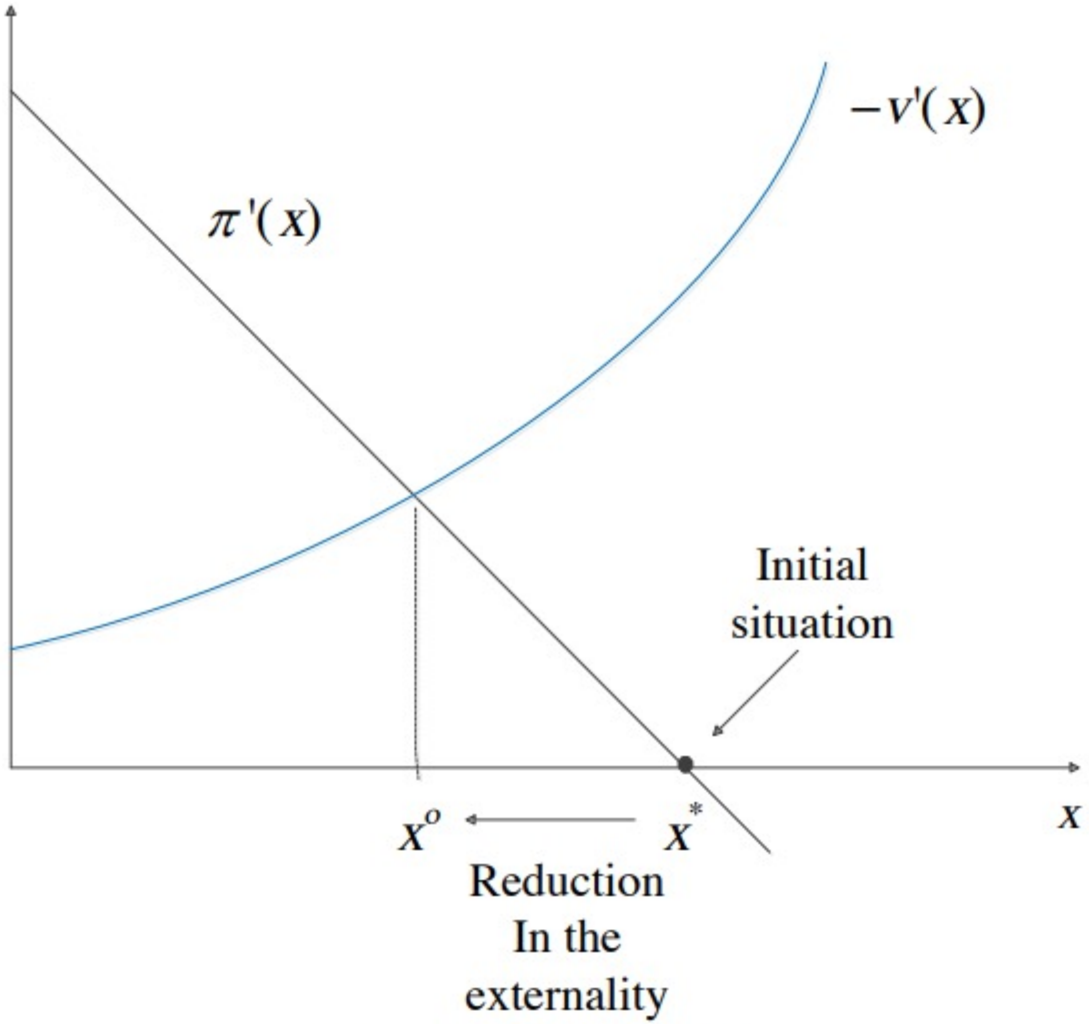
Property Rights

- ***Coase Theorem***: If bargaining between the agents generating and affected by the externality is possible and costless, then
  - the initial allocation of property rights does not affect the level of the externality.
  - That is, bargaining helps set the level of the externality at the optimal level $x = x^0$.
- The allocation of property rights, however, affects the final wealth of the two agents!

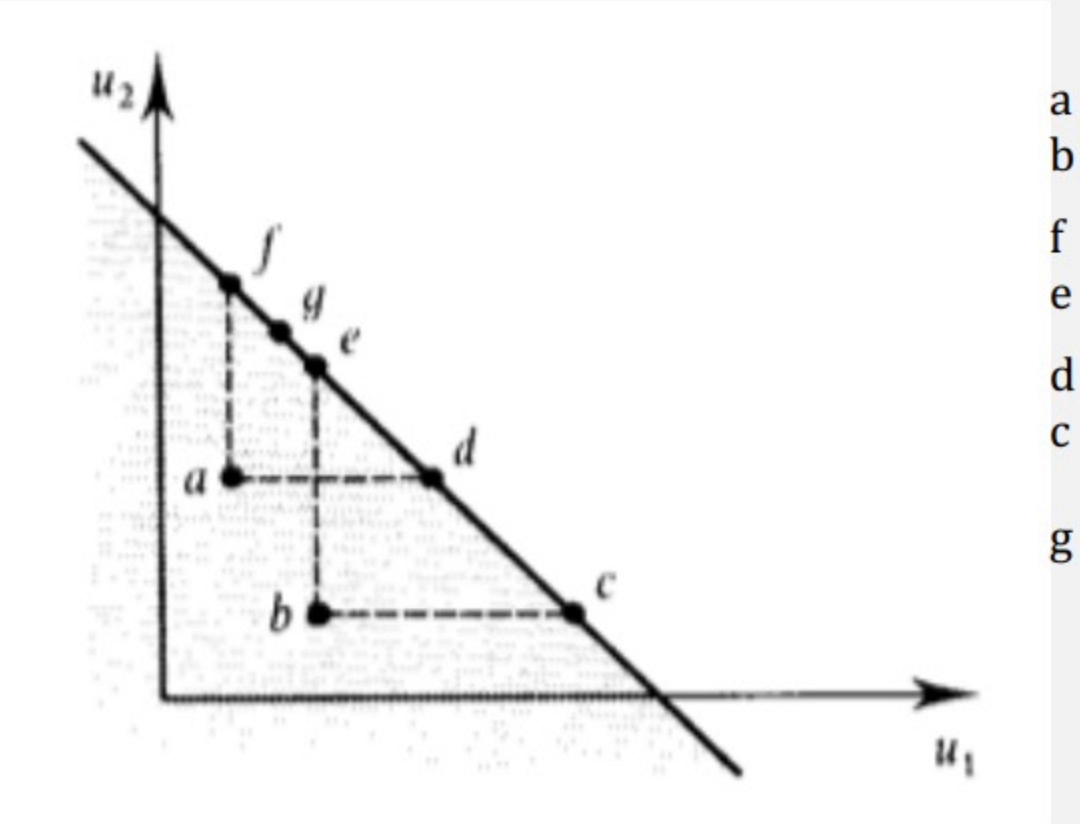
Property Rights



Property Rights



BARGAINING OUTCOMES



a zero externality		without
b h^* externality		transfers
f	After bargaining under	
e	t.i.o.l.i. by consumer 2	
d	t.i.o.l.i. by consumer bargaining	
c	power with 1 by consumer 1	

g Other possible outcomes of alternative bargaining mechanism, e.g., comp market

Property Rights

- ***Disadvantages of the Coase Theorem***:
  - Property rights must be perfectly defined
    - Who should I bargain with?
  - Bargaining must be costless.
    - Not true if many agents are involved.
  - Property rights must be perfectly enforced:
    - The level of x must be perfectly observable and measurable by both parties
    - If a party does not comply with the agreement, it can be brought to court at no cost.
  - These assumptions are not satisfied in many cases, which limits the possibility of using negotiations.

Property Rights

- ***Advantages of the Coase Theorem***:
  - Only the parties involved must know the marginal benefits and costs associated with externality
  - The regulator does not need to know anything!

Property Rights

- ***Remark***:
  - If the two parties are firms (e.g., fishery and refinery) a form of bargaining could be the sale of one firm to the other, i.e., a merger.
  - This is efficient as the now merged firm would internalize the effects that pollution imposes on the production process of the fishery.

Solutions to the Externality Problem:
More Intrusive Approaches

Quota

- Setting a quota (emission standard) that bans production levels higher than the Pareto optimal level x^0.

- The social planner must be perfectly informed about the benefits and damages of the externality for all consumers.

Pigouvian Taxation

- This policy sets a tax t_x per unit of the externality-generating activity x.
- What is the level of tax t_x that restores efficiency?
- Let us start by re-writing the firm's PMP

$$\max_{x \geq 0} \; \pi(x) - t_x \cdot x$$

- FOC with respect to x:

$$\pi'(x) - t_x \leq 0 \;\; \Longrightarrow \;\; \pi'(x) \leq t_x$$

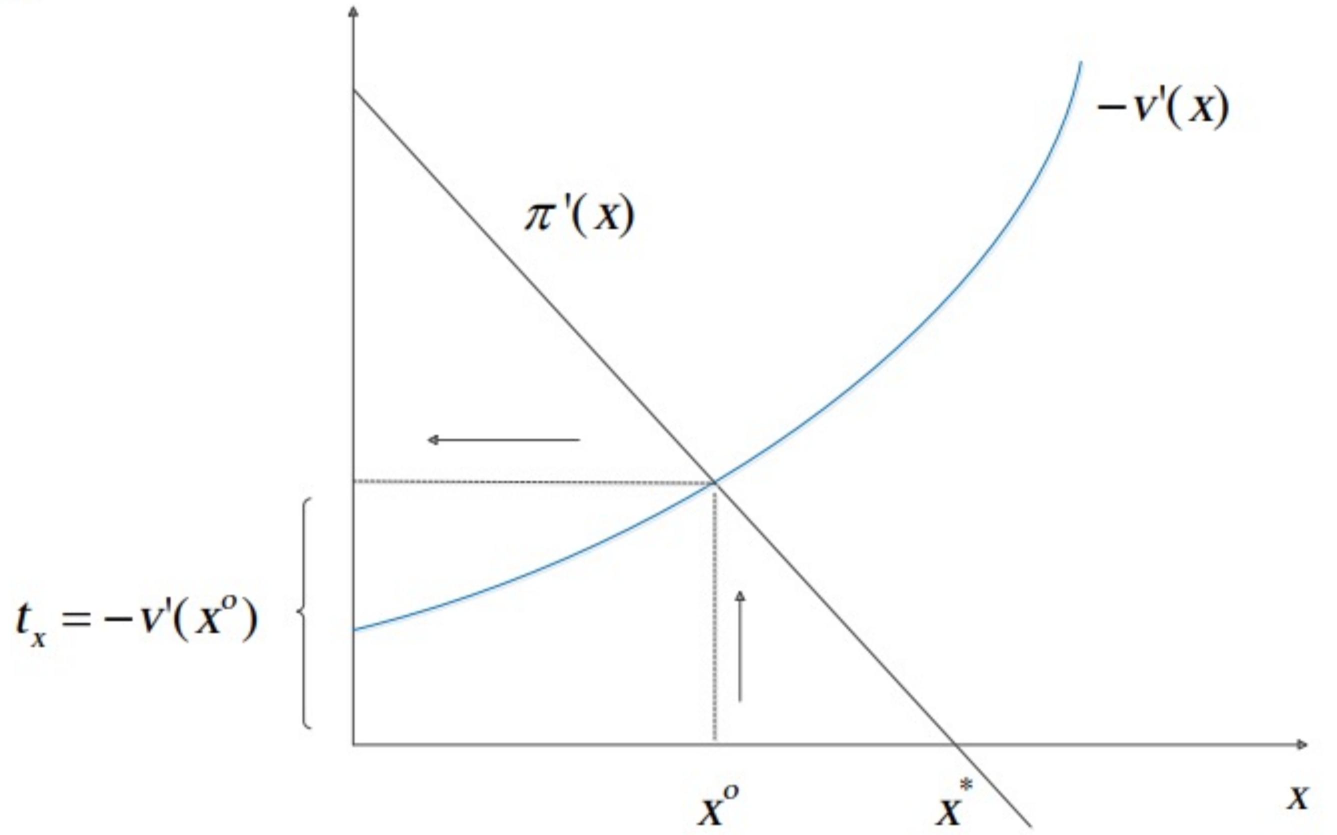
  or $\pi'(x) = t_x$ for interior solutions.
- *Intuition*: the firm increases x until the point where the marginal benefit from an additional unit of x coincides with the per-unit tax t_x.

Pigouvian Taxation

- We know that at the social optimum (i.e., x^0)
$$\pi'(x^0) = -v'(x^0)$$
- Hence, the tax t_x needs to be set at
$$t_x = -v'(x^0)$$
- This forces the firm to internalize the negative externality that its production generates on consumer's wellbeing at x^0.

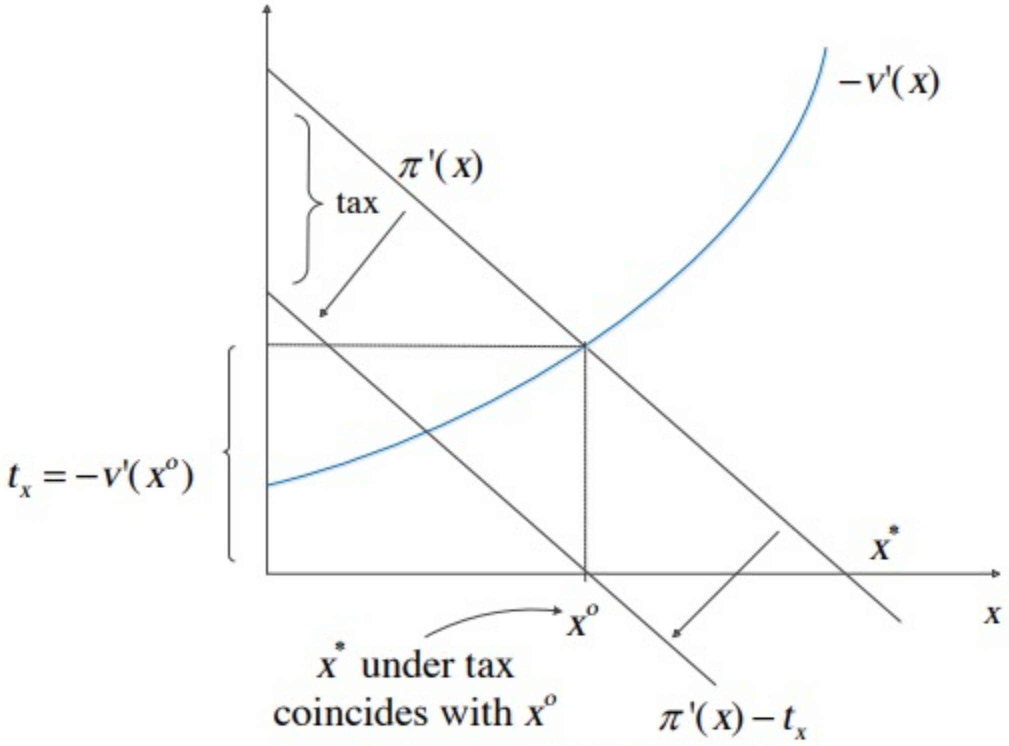
Pigouvian Taxation

- The tax t_x leads the firm to choose a level of x equal to x^0



Pigouvian Taxation

- The tax produces a downward shift in $\pi'(x)$.
- The new marginal benefit curve $\pi'(x) - t_x$ crosses the horizontal axis exactly at x^0.

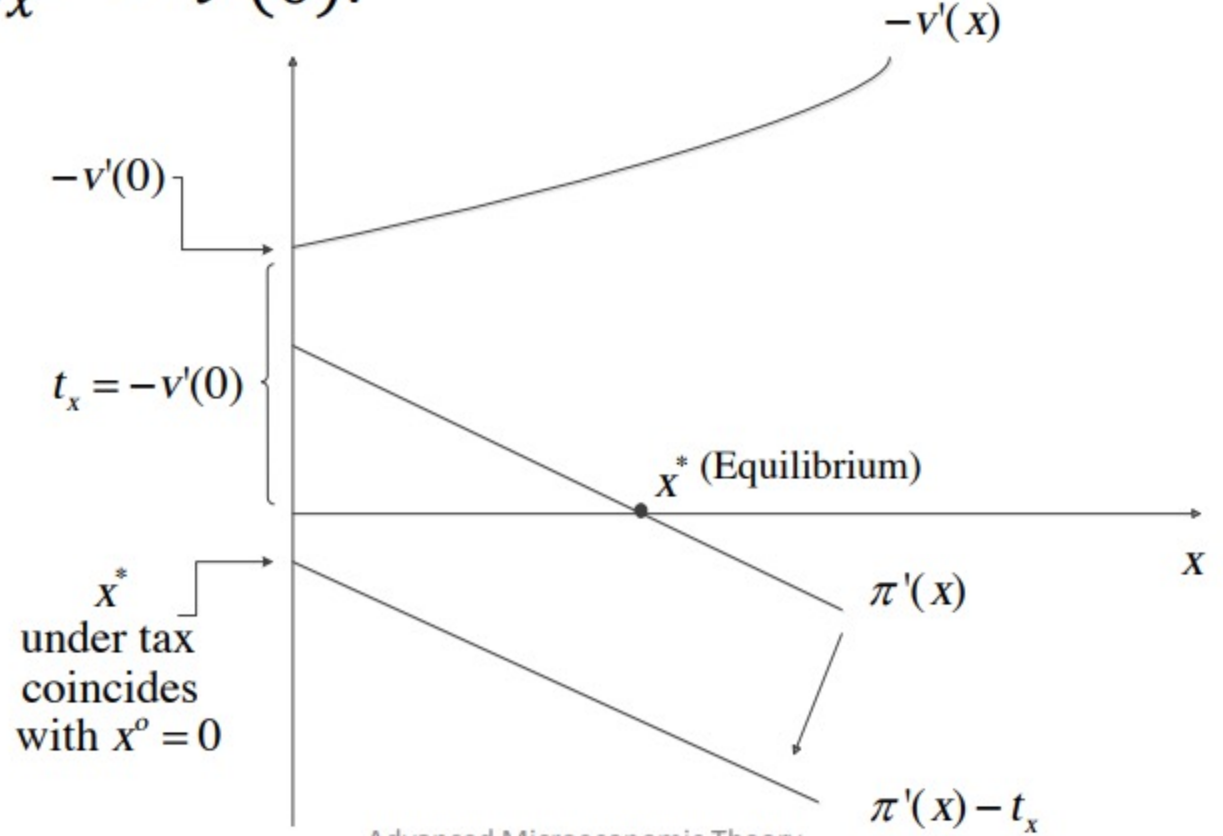


Pigouvian Taxation

- The optimality-restoring tax t_x is equal to the marginal externality at the optimal level x^0.
  - That is, it is equal to the amount of money that the affected individual would be willing to pay in order to reduce x slightly from its optimal level x^0.
- The tax t_x induces the firm to internalize the externality that it causes on the individual.

Pigouvian Taxation

- If the negative externality is very substantial (and the socially optimum is at $x^0 = 0$), the optimal Pigouvian tax is $t_x = -v'(0)$.



Pigouvian Subsidy

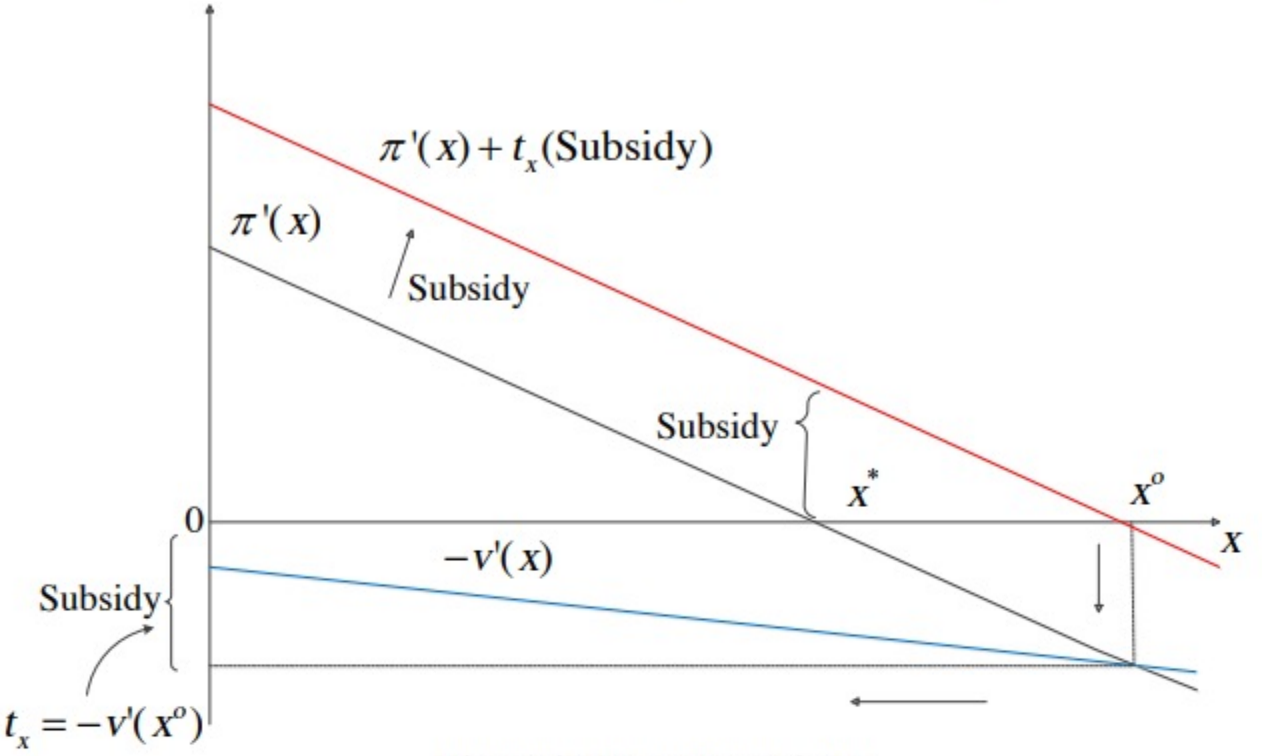
- Previous discussions can also be extended to *positive externalities*.
- Since now $v'(x^0) > 0$ (i.e., x increases individual's welfare), the optimality-correcting tax is

$$t_x = -v'(x^0) < 0$$

- We thus set "negative taxes" on the externality: a per-unit subsidy (s_x).
- The firm receives a payment of t_x for each unit of the positive externality it generates.

Pigouvian Subsidy

- The per-unit subsidy produces an upward shift in the marginal benefits of the firm.
- The firm has incentives to increase x beyond the competitive equilibrium level x^* until reaching the Pareto optimal level x^0.



Pigouvian Policy: Important Points

a) A tax on the negative externality is equivalent to a subsidy inducing agents to reduce the externality.

- Consider a subsidy $s_x = -v'(x^0) > 0$ for every unit that the firm's choice of x is below the equilibrium level of x^*.
- The firm's PMP becomes:

$$\max_{x \geq 0} \pi(x) + s_x(x^* - x) = \pi(x) + \underbrace{s_x x^*}_{\text{subsidy}} - \underbrace{s_x x}_{\text{per unit tax}}$$

- FOC with respect to x yields

$$\pi'(x^0) - s_x \leq 0 \text{ or } \pi'(x^0) \leq s_x$$

Pigouvian Policy: Important Points

b) *The Pigouvian tax levies a tax on the externality-generating activity (e.g., pollution) but not on the output that generated such pollution.*

- Taxing output might lead the firm to reduce output, but it does not necessarily guarantee a reduction in pollutant emissions.
- A tax on output can induce the firm to reduce emissions if emissions bear a constant relationship with output.

Pigouvian Policy: Important Points

c) *The quota and the Pigouvian tax are equally effective under complete information.*

   – They might not be equivalent when regulators face incomplete information about the benefits and costs of the externality for consumers and firms.

Solutions to the Externality Problem:

Tradable Externality Permits

Tradable Externality Permits

- Every permit grants the right to generate one unit of the externality.
- Suppose that $x^0 = \sum_j x_j^0$ total permits are given to the firms, with every firm receiving $\bar{x}_j$ of them.
- Let p_x^* denote the equilibrium price of these permits.
- Firm j's PMP is

$$\max_{x \geq 0} \; \pi_j(x_j) + p_x^*(\bar{x}_j - x_j)$$

where firm j must pay a price p_x^* for every permit it needs to buy in excess of its initial endowment $\bar{x}_j$.

Tradable Externality Permits

- FOC wrt x_j yields

$$\pi'_j(x_j) - p_x^* \leq 0$$

with equality if $x_j > 0$ (interior solution).

- If all J firms carry out this PMP, we need the market clearing condition

$$x^0 = \sum_j x_j$$

- The efficiency can be restored by setting

$$p_x^* = -\sum_{i=1}^{I} v_i'(x^0)$$

Tradable Externality Permits

- Thus, firm j's FOCs become

$$\pi_j'(x_j^0) + \sum_{i=1}^{I} v_i'(x^0) \leq 0$$

  with equality if $x_j^0 > 0$ (interior solution).

- This condition coincides with the FOC that solves the social planner's problem.

- Therefore, every firm j is induced to voluntarily choose $x_j = x_j^0$.

Tradable Externality Permits

- The advantage of tradable externality permits relative to quotas or taxes:
  - Government officials do not need so much information.
  - They only need data about the optimal level of pollution x^0
    - Specifically, data on aggregate industry profits and damage from the externality
    - But not on individual firms and consumers

Missing markets

- Externalities can be seen as inherently tied to absence of markets of certain comp mkts
- Missing market: point noted by Meade (1952) and extended by Arrow (1969)
- Comp mkt in this example (two consumers/producers) unrealistic (price taking)
- Most externalities involve many agents (multilateral externalities)
- Extension of missing market approach depends on public or private nature of goods

Presence of Asymmetric Information in Externality Problems

Presence of Asymmetric Information in Externality Problems

- Consider a setting in which firms generate the externality whereas consumers are affected by that externality.
- Let $v(x, \eta)$ be the derived utility of a consumer of type $\eta \in \mathbb{R}$ from x amount of externality.
- Let $\pi(x, \theta)$ be the derived profit function of a firm of type $\theta \in \mathbb{R}$ which generates x amount of externality.
- Consider that parameters η and θ are privately observed by the consumer and firm, respectively.
  - Agents do not observe each other's types, but know the ex-ante likelihoods of η and θ.
  - For simplicity, we consider that parameters η and θ are independently distributed.
- Functions $v(x, \eta)$ and $\pi(x, \theta)$ are strictly concave in the externality x for any value of η and θ.

Presence of Asymmetric Information in Externality Problems

- Let us first consider the decentralized bargaining procedure.
- Bargaining in the presence of asymmetric information does not necessarily lead to an efficient level of the externality x^0.
- Suppose that the consumer has the right to an externality-free environment, and he makes a take-it-or-leave-it offer to the firm.
- Assume that there are two levels of the negative externality: $x = 0$ and $x = \bar{x}$
  - the consumer prefers $x = 0$ to $x = \bar{x}$, whereas the firm prefers $x = \bar{x}$ to $x = 0$.

Presence of Asymmetric Information in Externality Problems

- The benefits that a firm of type θ obtains from having an externality level $x = \bar{x}$ is
$$b(\theta) = \pi(\bar{x}, \theta) - \pi(0, \theta) > 0$$
- The costs that a consumer of type η bears from having an externality level $x = \bar{x}$ is
$$c(\eta) = v(0, \eta) - v(\bar{x}, \eta) > 0$$
- What matters in the negotiation between the consumer and the firm are the precise values of $b(\theta)$ and $c(\eta)$.
  - The CDF of $b(\theta)$ and $c(\eta)$ are $G(b)$ and $F(c)$, respectively.
  - The PDF of $b(\theta)$ and $c(\eta)$ are $g(b) > 0$ for all $b > 0$ and $f(c) > 0$ for all $c > 0$, respectively.

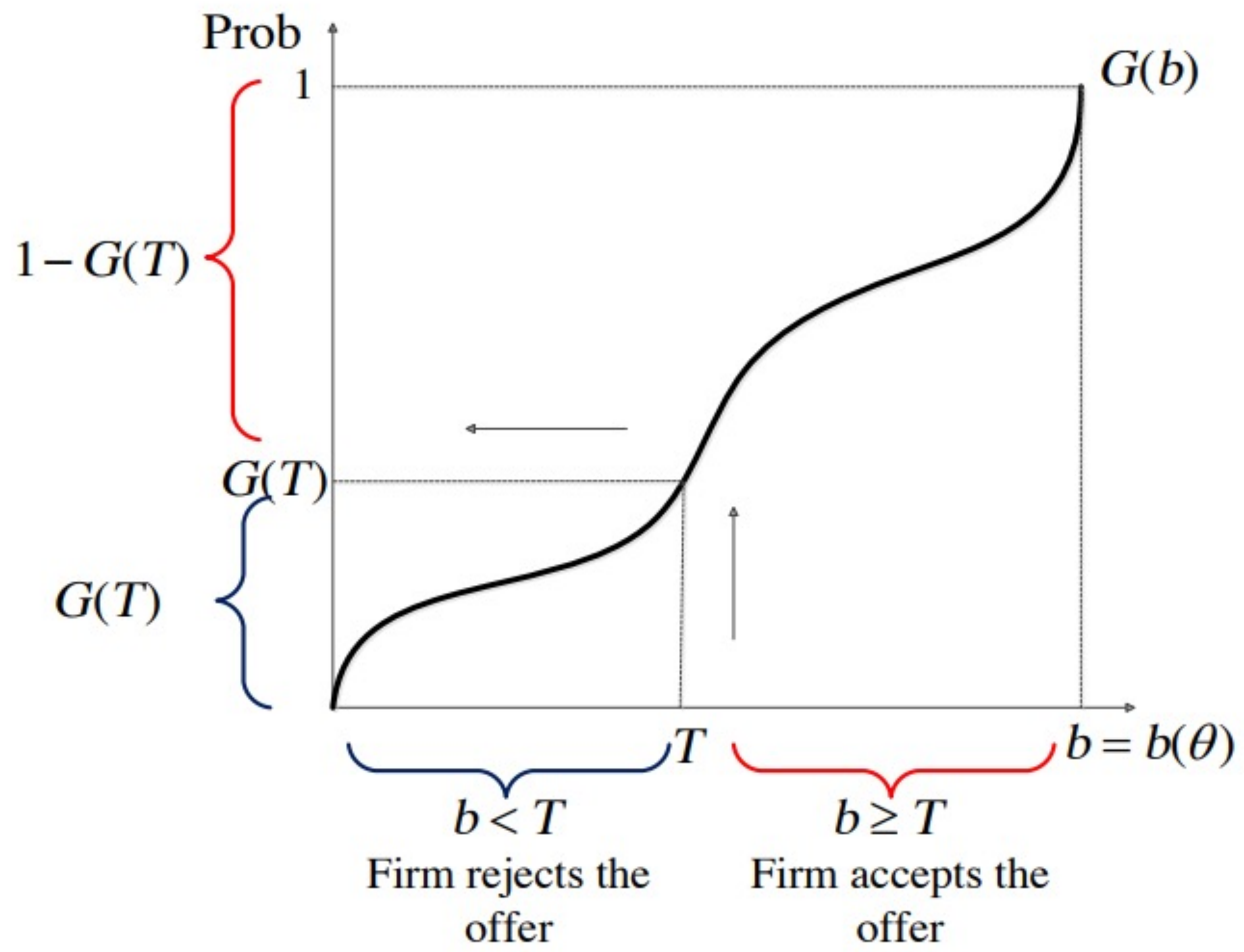
Presence of Asymmetric Information in Externality Problems

- In the absence of an agreement, the level of the externality remains at $x = 0$.
  - Consumer has the right to resource
- *Pareto optimal outcome*: the firm should be allowed to set a level of the externality $x = \bar{x}$ whenever $b > c$.
  - Intuitively, the firm is willing to pay the consumer more than the damage that the consumer suffers from the externality.
  - Hence, $x = \bar{x}$ would be agreed by a firm and consumer if they were perfectly informed about each other's marginal benefits and costs.

Presence of Asymmetric Information in Externality Problems

- Let us now start analyzing equilibrium strategies in this context.
- What amount should the consumer demand from the firm (a take-it-or-leave-it-offer) when his cost of the externality is exactly $c(\eta) = c$?
- A θ-type firm will agree to pay T iff its benefits, $b(\theta) = b$, satisfy $b \geq T$.
- Hence, the consumer knows the probability of the firm accepting the payment of T is equal to the probability that $b \geq T$, i.e., $1 - G(T)$.

Presence of Asymmetric Information in Externality Problems



Presence of Asymmetric Information in Externality Problems

- Hence, the consumer chooses the value of the offer T that maximizes his expected utility
$$\max_{T \geq 0} \; [1 - G(T)](T - c)$$
where
  - $1 - G(T)$ is the probability that an offer of T is accepted by the firm
  - $T - c$ is the net gain that a consumer (with cost c) obtains if the offer is accepted

- FOC wrt T yields
$$[1 - G(T_c^*)] - g(T_c^*)(T_c^* - c) \leq 0$$
and in interior solution, $[1 - G(T_c^*)] = g(T_c^*)(T_c^* - c)$.

Presence of Asymmetric Information in Externality Problems

- Re-arranging,

$$\frac{1-G(T_c^*)}{g(T_c^*)} + c = T_c^*$$

- Since the ratio $\frac{1-G(T_c^*)}{g(T_c^*)} \neq 0$, we have that $T_c^* > c$.
- This implies the firm rejects the consumer's offer when b satisfies $T_c^* > b > c$.
  - However, since $b > c$, Pareto optimality requires that the externality is increased until $x = \bar{x}$.
  - But in this setting the consumer's offer is rejected with positive probability for $T_c^* > b > c$.

Presence of Asymmetric Information in Externality Problems

- Complete information:
  - The firm and consumers are willing to bargain and have the externality produced when they are perfectly informed about their benefits and costs.
  - A welfare improvement for both parties.
- Asymmetric information:
  - The lack of information hinders the success of the mutually beneficial agreements.
  - Decentralized bargaining does not necessarily yield efficient outcomes.

Quotas under Incomplete Information

Quotas under Incomplete Information

- Unlike complete information settings:
  - Government intervention (quotas or taxes) does not necessarily achieve efficient outcomes when the agents are asymmetrically informed.
  - In addition, quotas or taxes are not perfectly substitutable between one another.

- For given η and θ, the aggregate surplus resulting from externality level x is

$$v(x,\eta) + \pi(x,\theta)$$

Quotas under Incomplete Information

- The Pareto optimal level of the externality $x(\eta, \theta)$ solves

$$\max_{x \geq 0} \ v(x, \eta) + \pi(x, \theta)$$

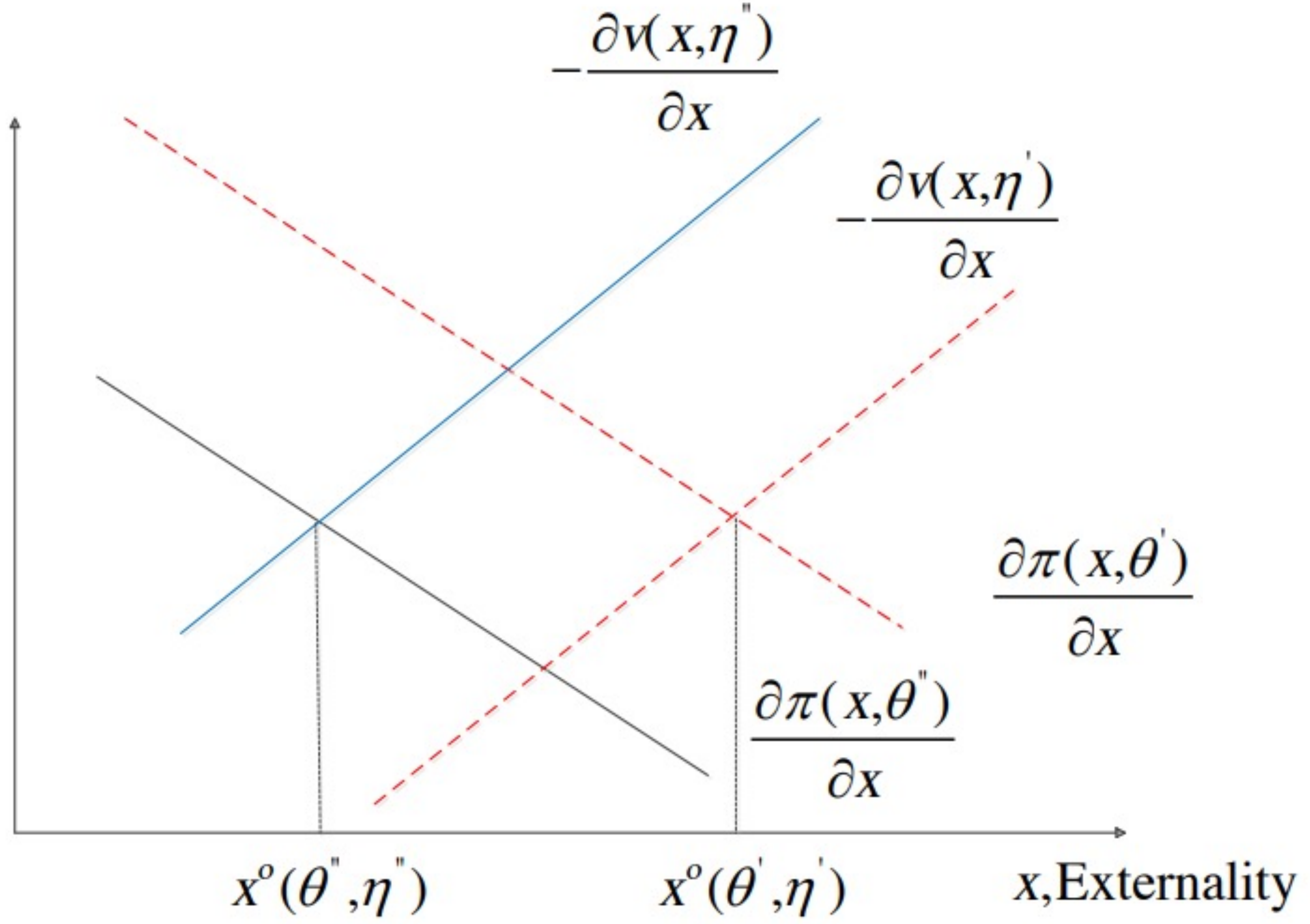
- FOC wrt x yields

$$\frac{\partial v(x,\eta)}{\partial x} + \frac{\partial \pi(x,\theta)}{\partial x} \leq 0$$

or, at an interior optimum,

$$\frac{\partial v(x,\eta)}{\partial x} + \frac{\partial \pi(x,\theta)}{\partial x} = 0$$

Quotas under Incomplete Information



Quotas under Incomplete Information

- Suppose that a quota is fixed at the level of the externality $x = \hat{x}$.
- The firm's PMP becomes

$$\max_{x \geq 0} \ \pi(x, \theta) \quad \text{s.t. } x \leq \hat{x}$$

- Let $x^q(\hat{x}, \theta)$ be the externality level that solves this PMP.
  - Since the PMP does not depend on η, $x^q(\hat{x}, \theta)$ is completely insensitive to η.
  - Thus, $x^q(\hat{x}, \theta)$ cannot be efficient.
  - The efficient level of externality is $x^0(\theta, \eta)$.

Quotas under Incomplete Information

- The level of the quota $\hat{x}$ is such that $\frac{\partial \pi(\hat{x},\theta)}{\partial x} > 0$ for all $\theta > 0$.

- Thus, the profit-maximizing level of the externality is $x^q(\hat{x}, \theta) = \hat{x}$.

- That is, the firm would like to increase the externality x beyond $\hat{x}$, but it cannot since it already reached the quota.

Quotas under Incomplete Information

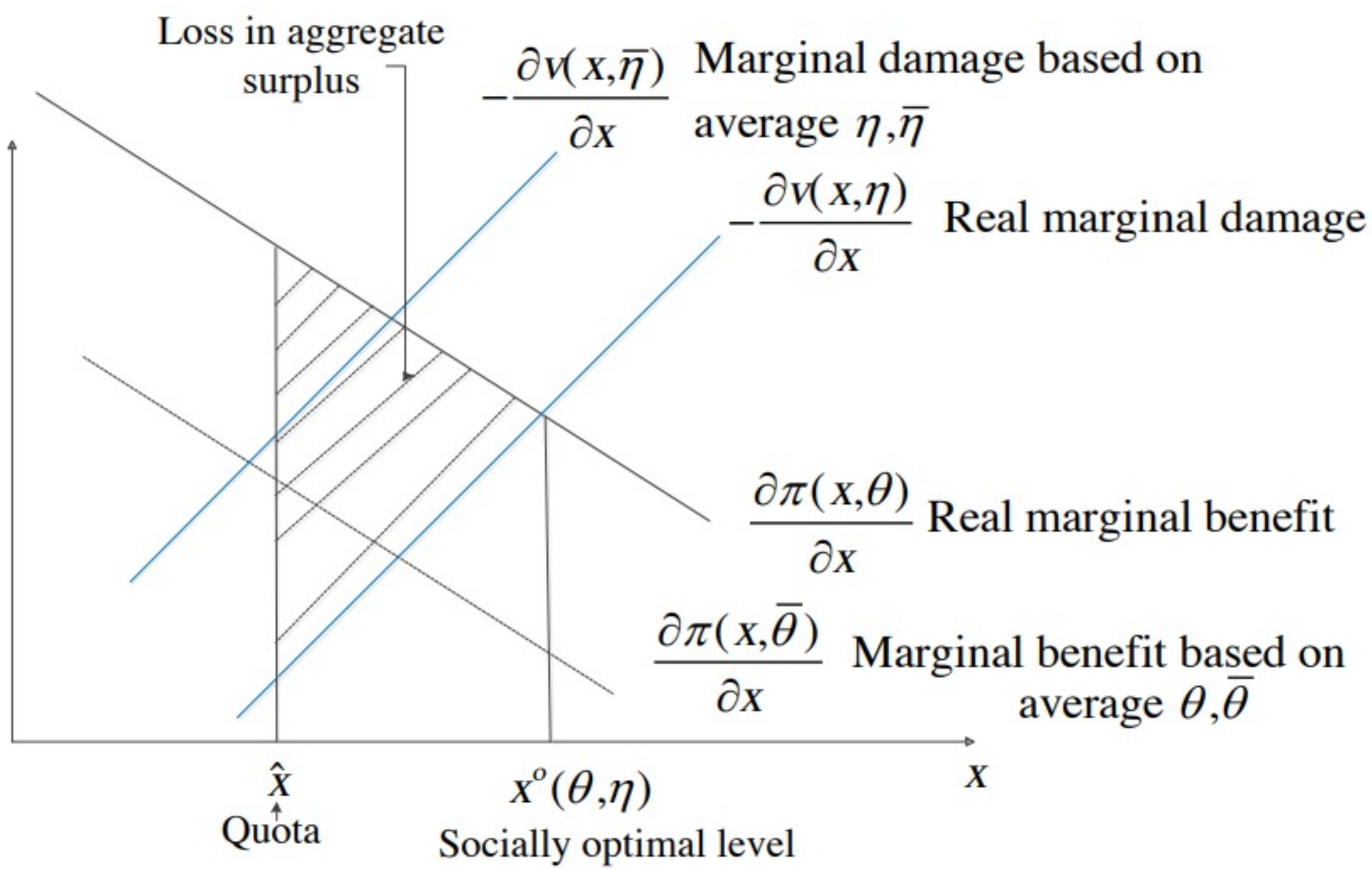
- The welfare loss of quota $\hat{x}$ relative to the socially optimal level of externality $x^0(\theta,\eta)$ is

$$\overbrace{[v(x^q(\hat{x},\theta),\eta)+\pi(x^q(\hat{x},\theta),\theta)]}^{\text{Aggregate surplus with the quota }\hat{x}} - \underbrace{v(x^0(\theta,\eta),\eta)+\pi(x^0(\theta,\eta),\theta)}_{\text{Aggregate surplus at the PO}}$$

or, more compactly,

$$= \int_{x^o(\theta,\eta)}^{x^q(\hat{x},\theta)} \left(\frac{\partial \pi(x,\theta)}{\partial x} + \frac{\partial v(x,\eta)}{\partial x}\right) dx$$

Quotas under Incomplete Information



Taxes under Incomplete Information

Taxes under Incomplete Information

- Suppose that the regulator imposes a tax t per unit of the externality.
- The firm's PMP becomes

$$\max_{x \geq 0} \; \pi(x,\theta) - tx$$

- FOC yields $\frac{\partial \pi(x,\theta)}{\partial x} \leq t$ or, in interior solution, $\frac{\partial \pi(x,\theta)}{\partial x} = t$.
- Let $x^t(t,\theta)$ denote the amount of the externality that solves the FOC (interior solution).
  - $x^t(t,\theta)$ is completely insensitive to η.
  - Thus, $x^t(t,\theta)$ cannot be efficient.

Taxes under Incomplete Information

- The welfare loss caused by the imposition of a tax relative to the socially optimal level of externality $x^0(\theta,\eta)$ is

$$\overbrace{[v(x^t(t,\theta),\eta)+\pi(x^t(t,\theta),\theta)]}^{\text{Aggregate surplus with tax } t} - \underbrace{v(x^0(\theta,\eta),\eta)+\pi(x^0(\theta,\eta),\theta)}_{\text{Aggregate surplus at the PO}}$$

or, more compactly,

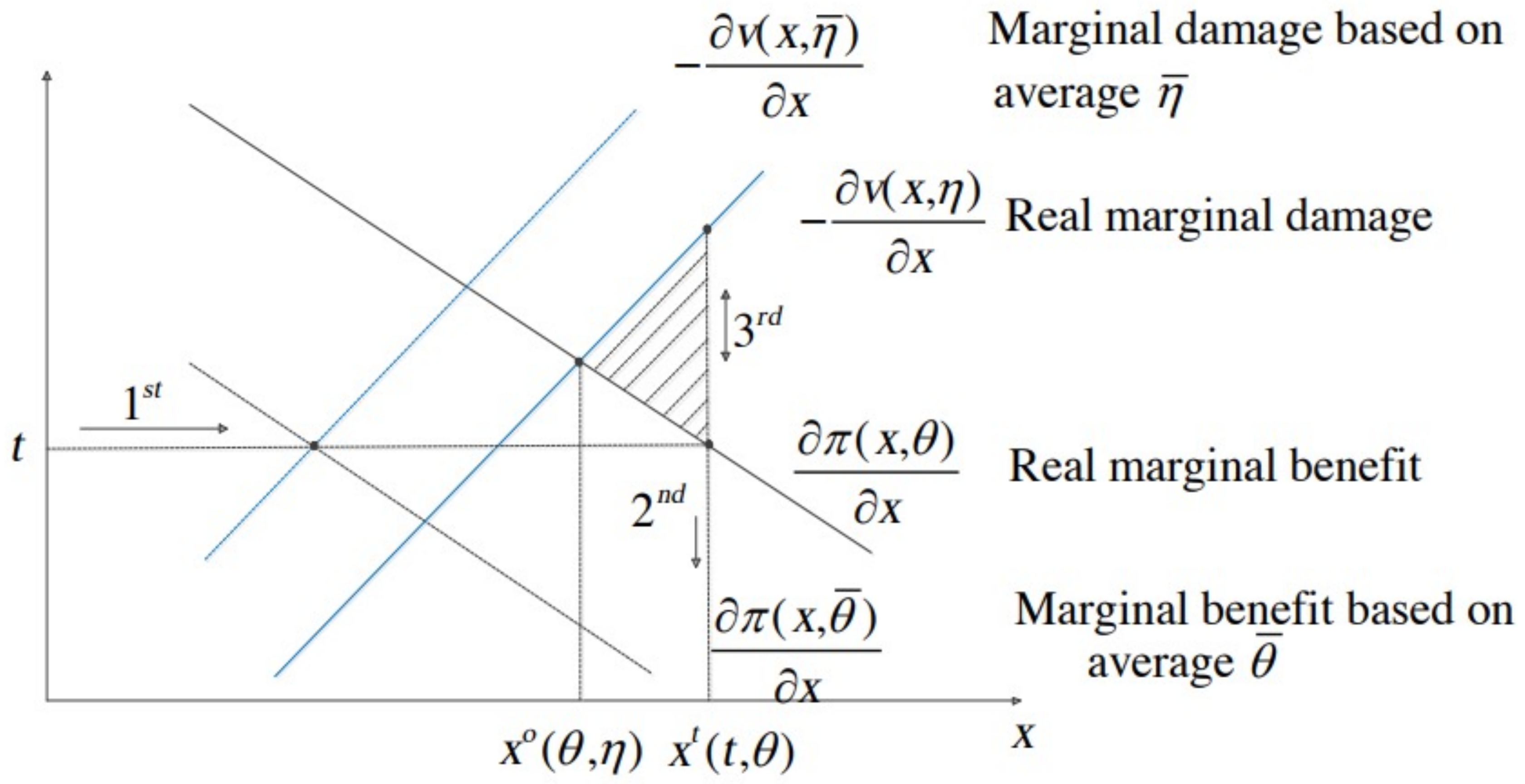
$$= \int_{x^o(\theta,\eta)}^{x^t(t,\theta)} \left(\frac{\partial \pi(x,\theta)}{\partial x} + \frac{\partial v(x,\eta)}{\partial x}\right) dx$$

Taxes under Incomplete Information

- The tax must be set at the point that maximizes aggregate surplus, evaluated at the average value of θ and η, $(\bar{\theta}, \bar{\eta})$, that is

$$t = -\frac{\partial v(x^o(\bar{\theta},\bar{\eta}),\bar{\eta})}{\partial x}$$

Taxes under Incomplete Information



Comparing Policy Instruments under Incomplete Information

Policy Comparison

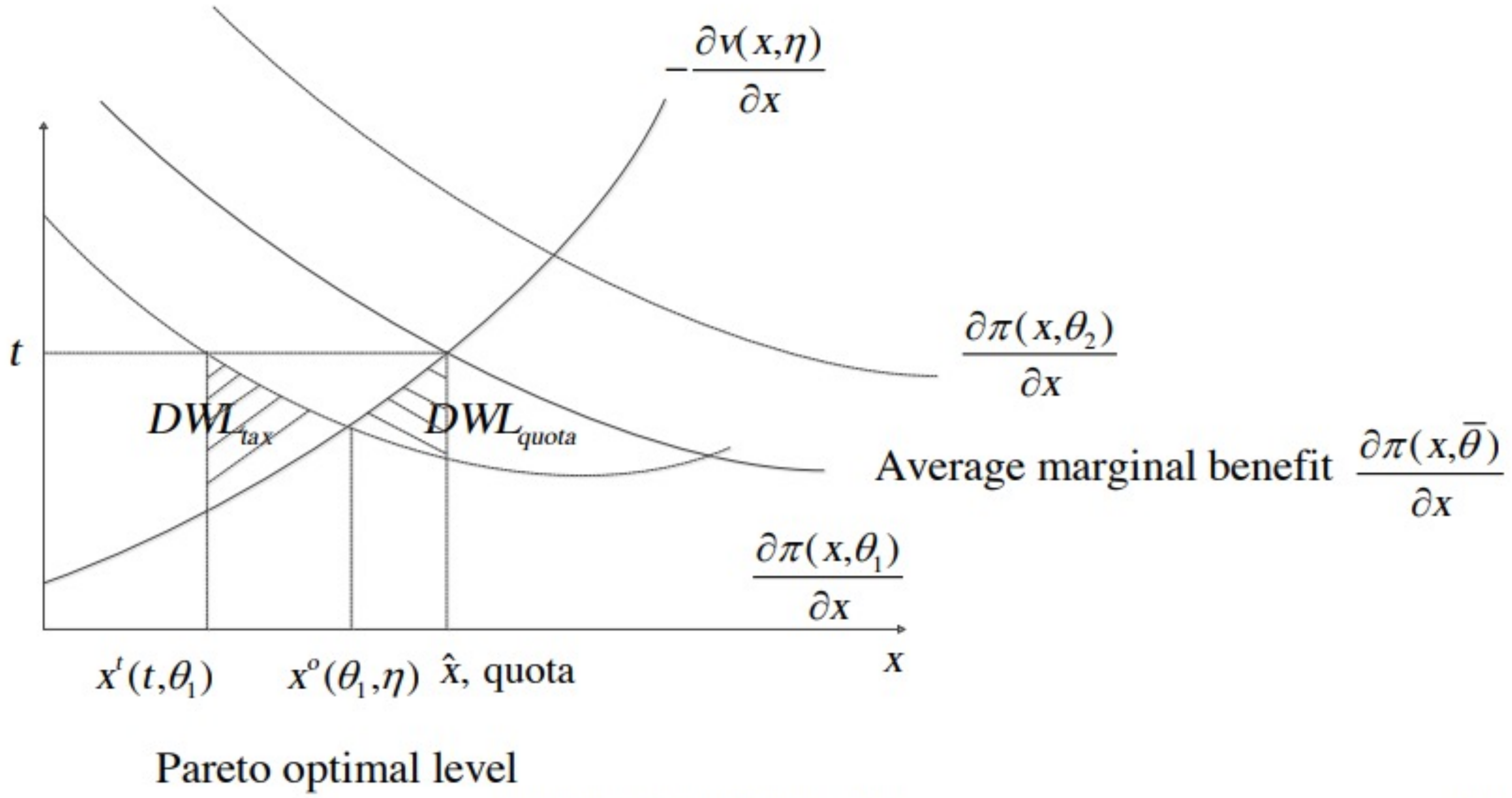
- Both quotas and emission fees create inefficiencies under incomplete information.
- Which instrument, despite being imperfect, performs better?
  - "second-best" policy
- It depends on the elasticity of the marginal damage and marginal benefit functions.
- Consider a setting where:
  - the realization of parameter θ is $\theta = \theta_1$
  - the regulator has relatively precise information about the marginal damage function, but he is uncertain about the firm's marginal benefit function.

Policy Comparison

- The regulator sets:
  - a quota $\hat{x}$ at the point where the observed marginal damage function, i.e., $-\frac{\partial v(x,\eta)}{\partial x}$, crosses the average marginal benefit function, i.e., $\frac{\partial \pi(x,\overline{\theta})}{\partial x}$.
  - an emission fee t at the height at which the observed marginal damage function, i.e., $-\frac{\partial v(x,\eta)}{\partial x}$, crosses the average marginal benefit function, i.e., $\frac{\partial \pi(x,\overline{\theta})}{\partial x}$.

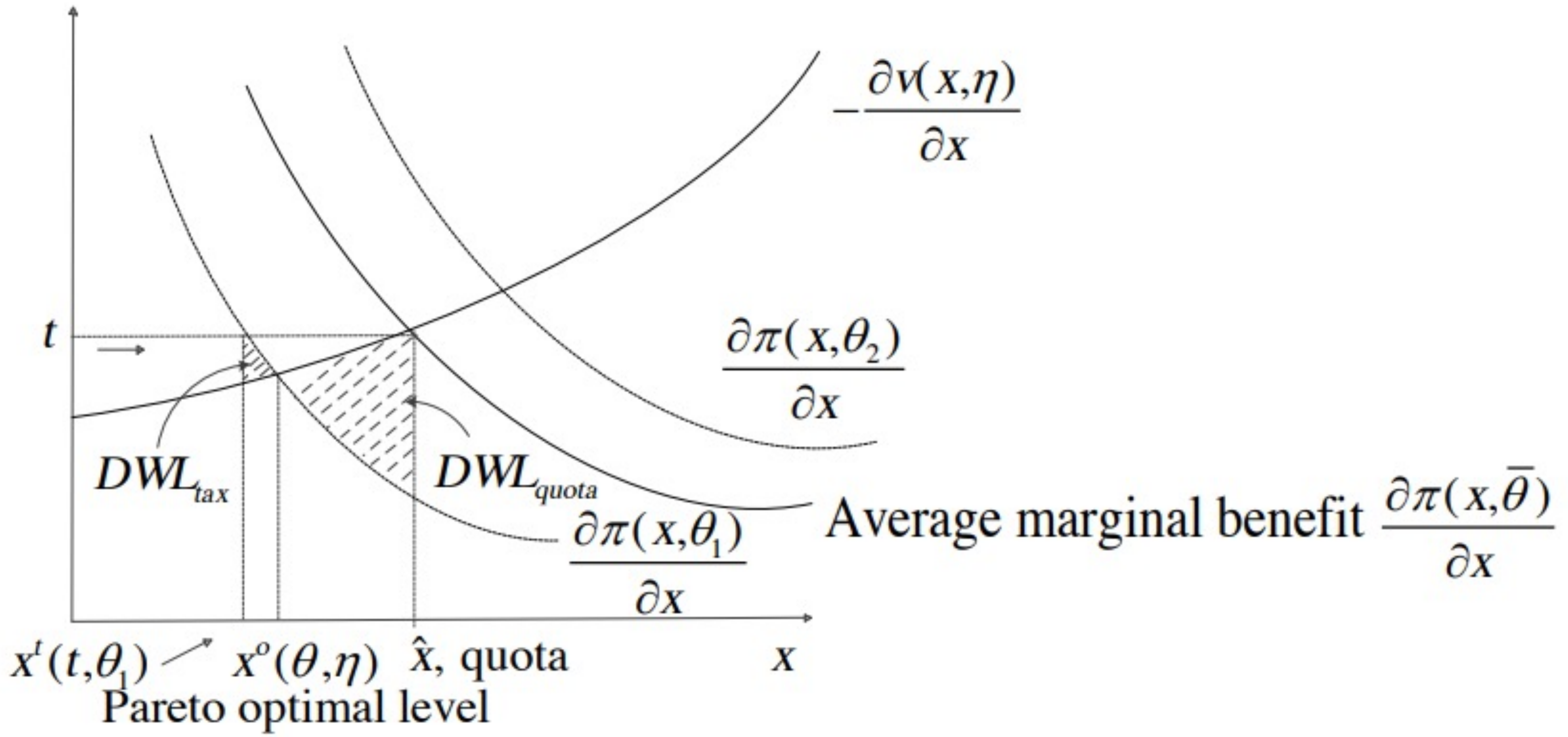
Policy Comparison

- The marginal damage function, i.e., $-\frac{\partial v(x,\eta)}{\partial x}$, is relatively sensitive to x.



Policy Comparison

- The marginal damage function, i.e., $-\frac{\partial v(x,\eta)}{\partial x}$, is not very sensitive to x.



Policy Comparison

- For a given elasticity of the marginal profit function, at the socially optimal level of the externality:
  - quota performs better than emission fee when the marginal damage function is relatively inelastic
  - emission fee performs better than quota when the marginal damage function is relatively elastic

Public Goods

Public Goods

- Before defining public goods, let us define two properties:
  - ***Non-excludability***: If the good is provided, no consumer can be excluded from consuming it.
  - ***Non-rivalry***: Consumption of the good by one consumer does not reduce the quantity available to other consumers.

	Rivalrous	Non-rivalrous
Excludable	Private Good	Club Good
Non-excludable	Common property resource	Public good

Public Goods

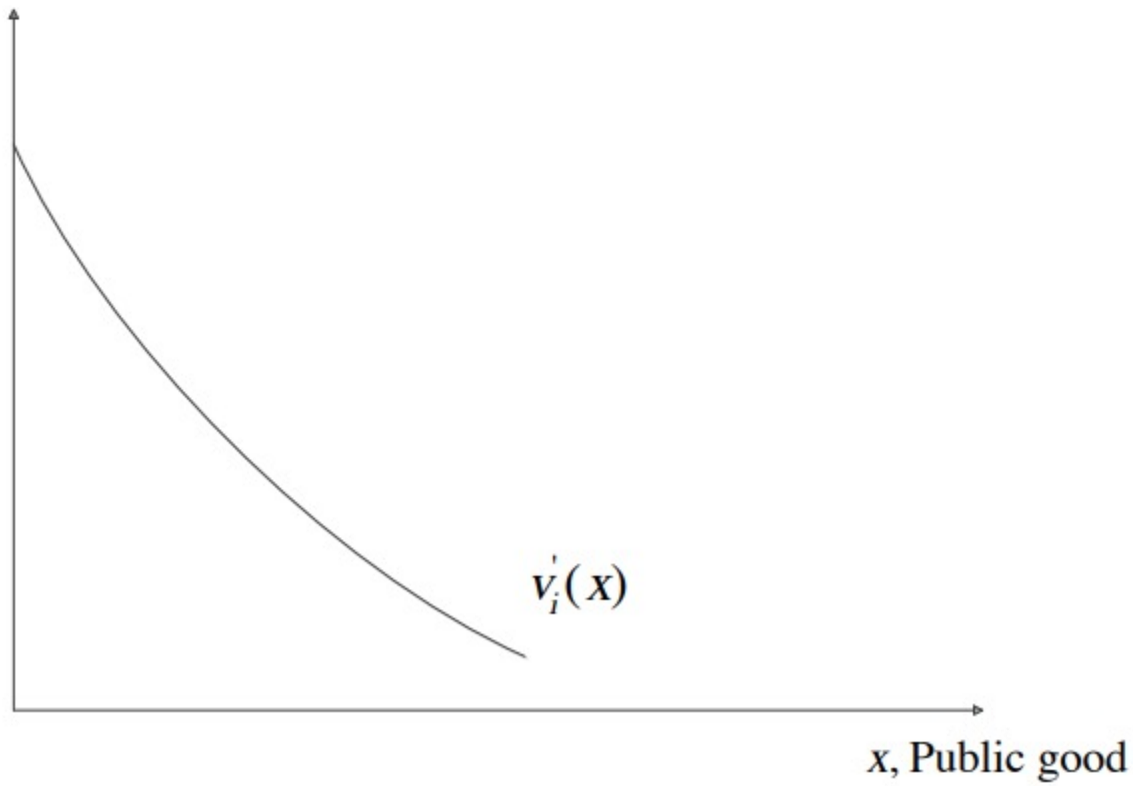
- ***Private goods***, e.g., an apple. These goods are rival and excludable in consumption.
- ***Club goods***, e.g., golf course. These goods are non-rival but excludable in consumption.
- ***Common property resources***, e.g., fishing grounds. These goods are rival but non-excludable in consumption.
- ***Public goods***, e.g., national defense. These goods are non-rival and non-excludable in consumption.

Public Goods

- Consider I consumers, one public good x and L traded private goods.
- Every consumer i's marginal utility from the consumption of x units of a public good is $v_i'(x)$
  - Note that x does not have a subscript because of non-rivalry (every individual can enjoy x units of the public good)
- We consider the case of a public good, where $v_i'(x) > 0$ for every individual i
  - A "public bad" would imply $v_i'(x) < 0$ for every i
- We assume that $v_i''(x) < 0$, which represents a positive but decreasing marginal utility from additional units of the public good.

Public Goods

- Marginal benefit from the public good



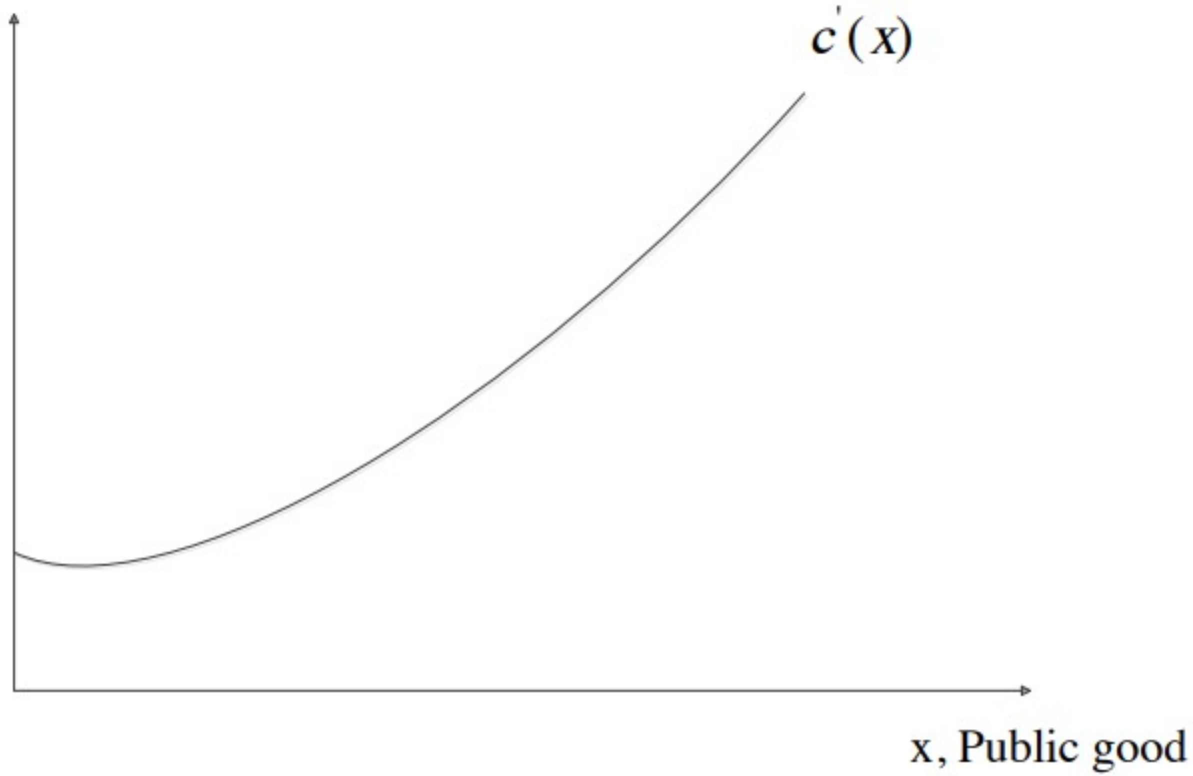
Public Goods

- We assume that the marginal utility from the public good, $v_i'(x)$, is independent on the private good.

- The cost of supplying x units of the public good is $c(x)$, where $c'(x) > 0$ and $c''(x) > 0$ for all x
  - That is, the costs of providing the public good are increasing and convex in x.

Public Goods

- Marginal costs from providing the public good



Public Goods

- Let us first find the Pareto optimal allocation

$$\max_{x \geq 0} \sum_{i=1}^{I} v_i(x) - c(x)$$

- FOC with respect to x yields

$$\sum_{i=1}^{I} v_i'(x^o) - c'(x^o) \leq 0$$

with equality if $x^o > 0$.

- SOCs are satisfied since

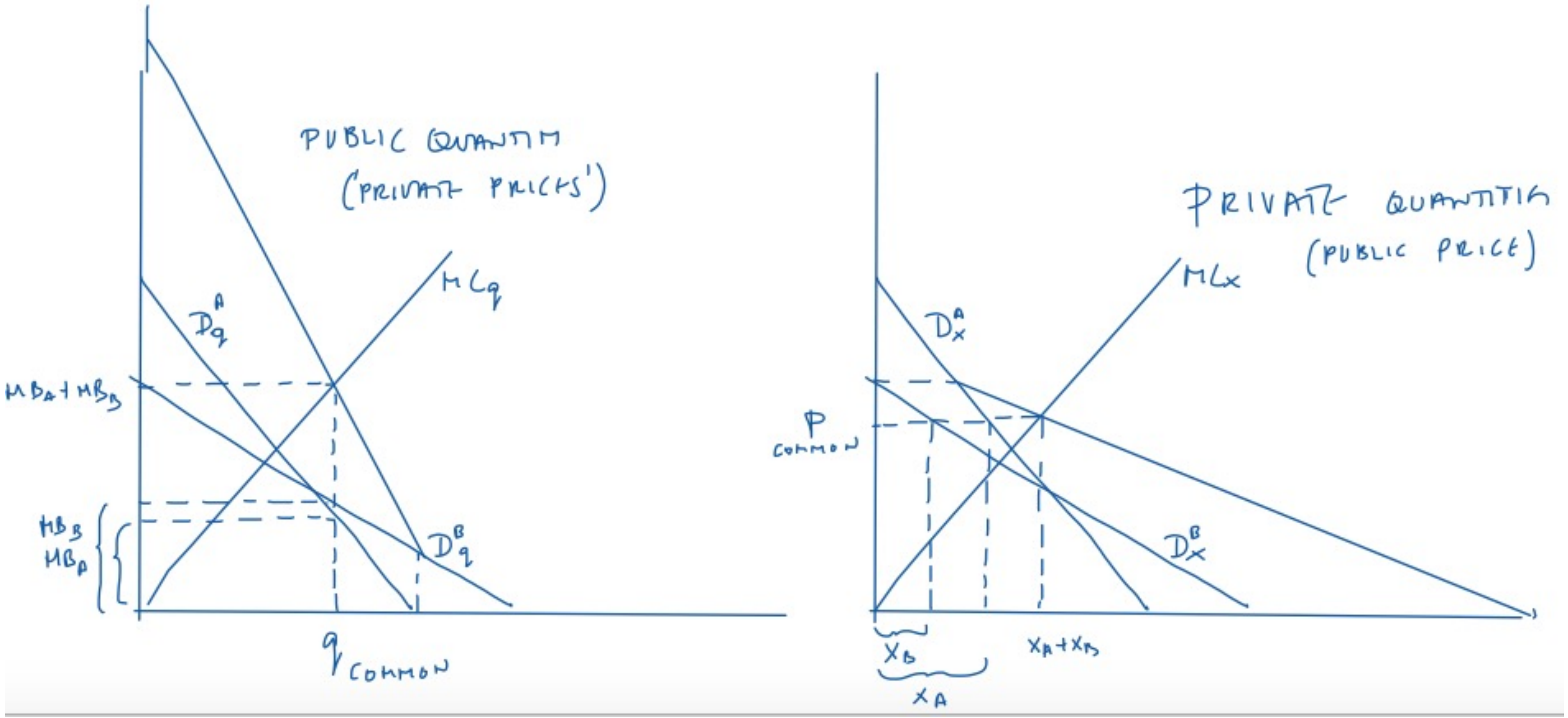
$$\sum_{i=1}^{I} v_i''(x^o) - c''(x^o) \leq 0$$

Public Goods

- In case of an interior solution, the optimal level of public good is achieved for the level of x^o that solves
$$\sum_{i=1}^{I} v_i'(x^o) = c'(x^o)$$
- That is, the sum of the consumers' marginal benefit from an additional unit of the public good is equal to its marginal cost (***Samuelson rule***).

- The Pareto optimal level of public goods does not coincide with that of private goods, where, for interior solutions,
$$v_i'(x_i^*) = c_j'(x_j)$$
- That is, every individual i's private marginal benefit from the private good is equal to its marginal cost.

Conditions for Pareto optimality in public good



Public Goods

- ***Example*** (Discrete public good):
  - Consider a public good with $x = \{0,1\}$, i.e., it is either produced or not.
  - Every individual i has a valuation $v_i(x) = \alpha_i x$ for the good, where $\alpha_i \geq 0$ is individual i's value for this good.
  - The total cost of producing good is $c \cdot x$, where $c > 0$.
  - The Pareto optimal condition requires

$$\sum_{i=1}^{I} v_i'(x) = c$$

Public Goods

- ***Example*** (continued):
  - In the discrete setting, the public good is produced if

$$\sum_{i=1}^{I} v_i'(x) > c$$

  - That is, if the aggregate marginal valuation for the public good is weakly higher than its marginal cost.

Inefficiency of the Private Provision of Public Goods

Inefficiency of the Private Provision of Public Goods

- Let us consider the case in which a market exists for the public good and that each consumer i chooses how much of the public good to buy, denoted as $x_i \geq 0$, taking as given a market price of p.
- The total amount of the public good purchased by all I individuals is hence $x = \sum_{i=1}^{I} x_i$.
- Consider a single producer of the public good with a cost function $c(x)$.

Inefficiency of the Private Provision of Public Goods

- Formally, at a competitive equilibrium price p^*, each consumer i's purchase of the public good, x_i^*, must solve

$$\max_{x_i \geq 0} \; v_i\left(x_i + \sum_{k \neq i} x_k^*\right) + w_i - p^* x_i$$

  - The first term reflects that individual i benefits from both the x_i units of the public good he purchases and $\sum_{k \neq i} x_k^*$ units of the public good that all other individuals acquire;
  - In determining his purchases of the public good, individual i takes the purchases of all the other individuals as given;
  - consumer i pays $p^* x_i$ when acquiring x_i units of the public good.

Inefficiency of the Private Provision of Public Goods

- FOC with respect to x_i yields
$$v_i'(x_i^* + \sum_{k \neq i} x_k^*) - p^* \leq 0$$
with equality if $x_i^* > 0$ (interior solution).
- For compactness, let x^* denote the total purchases of the public good, that is,
$$x^* = x_i^* + \sum_{k \neq i} x_k^*.$$
- Hence, the above FOC can be expressed as
$$v_i'(x^*) - p^* \leq 0$$
with equality if $x_i^* > 0$ (interior solution)

Inefficiency of the Private Provision of Public Goods

- On the other hand, the firm's PMP is
$$\max_{x \geq 0} \; p^* x - c(x)$$
- FOC with respect to x yields
$$p^* - c'(x^*) \leq 0$$
with equality if $x^* > 0$ (interior solution).
- Finally, the market clearing condition implies that the total amount of the public goods produced coincides with the amount consumed by all individuals.

Inefficiency of the Private Provision of Public Goods

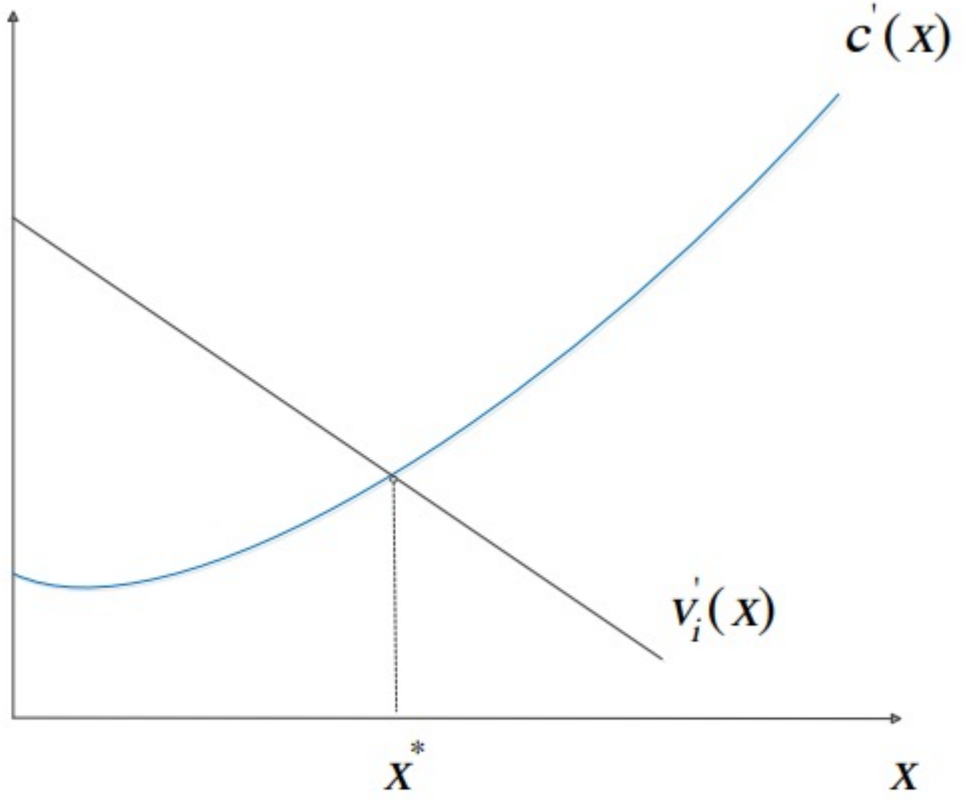
- Combining the FOCs for consumers and the firm, we obtain

$$v_i'(x^*) = c'(x^*) \text{ if } x^* > 0,$$
$$v_i'(x^*) < c'(x^*) \text{ if } x^* = 0$$

- Intuitively, individual i increases his consumption of the public good until the point in which his marginal benefit from the public good equals the marginal cost.

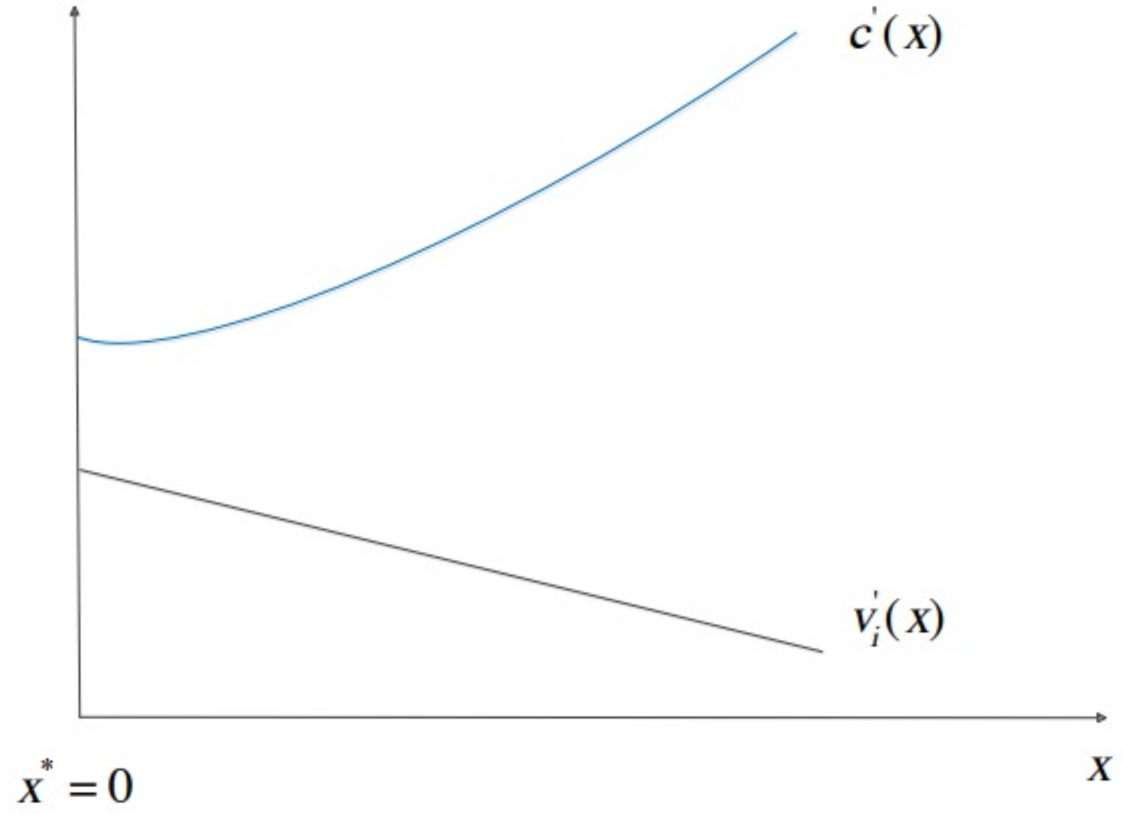
Inefficiency of the Private Provision of Public Goods

- Equilibrium level of public good (interior solution).



Inefficiency of the Private Provision of Public Goods

- Equilibrium level of public good (corner solution).



Inefficiency of the Private Provision of Public Goods

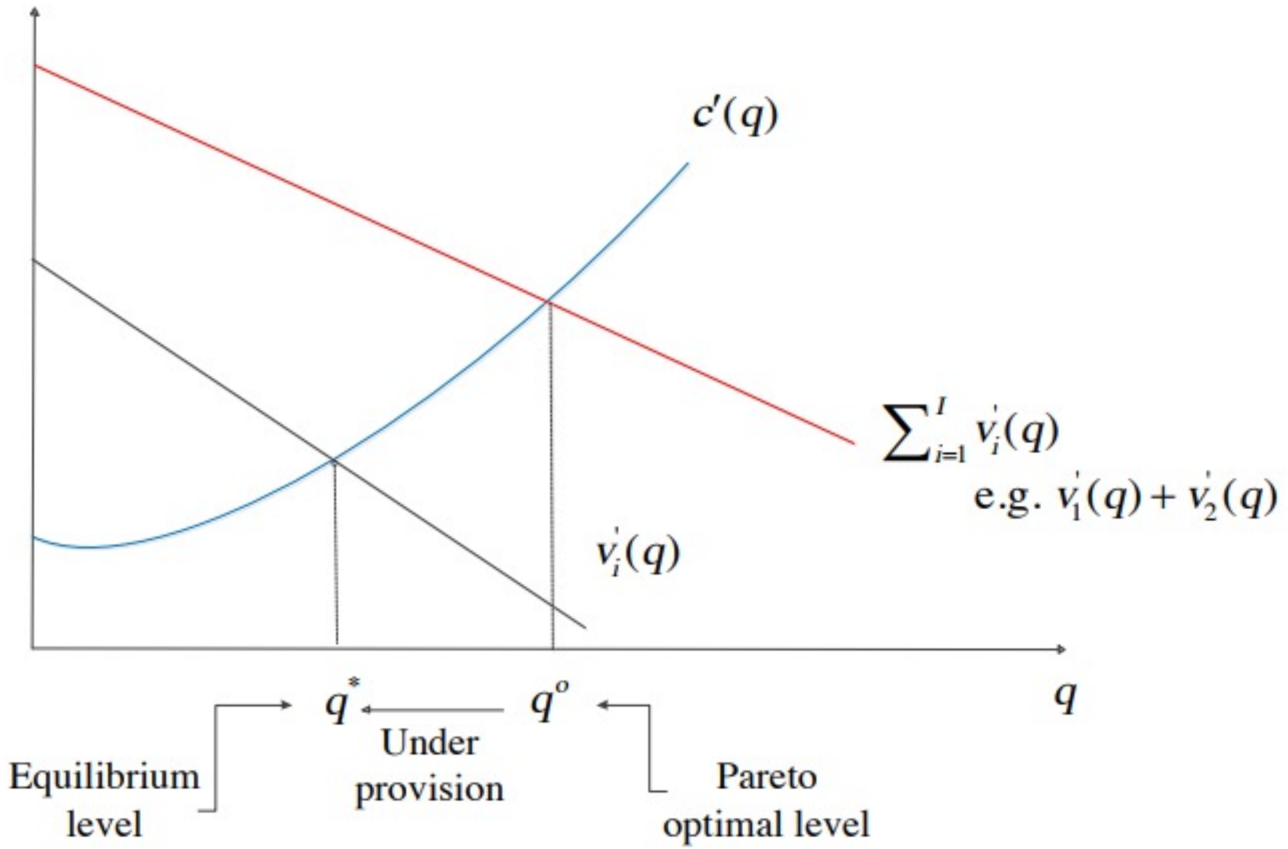
- However, at the Pareto optimality, we must have

$$\sum_{i=1}^{I} v_i'(x^o) = c'(x^o)$$

- That is, the summation of the marginal benefit that all individuals obtain from the public good must equal the marginal cost.
- Hence, there is an *underprovision* of the public good in the competitive equilibrium relative to the optimal allocation.
  - *Exception*: when the marginal cost curve is not vertical, i.e., $c''(x) \neq +\infty$.

Inefficiency of the Private Provision of Public Goods

- Pareto optimal and equilibrium level of public good



Inefficiency of the Private Provision of Public Goods

- *Intuition*:
  - Each individual's purchase of the public good benefits not only him, but also all other individuals in the economy.
  - Each individual does not internalize the positive externalities that his individual purchase of the public good generates on other individuals.
  - Hence, each individual does not have enough incentives to purchase sufficient amounts of the public good.
  - This leads to the *free-rider problem*, whereby the public good in underprovided.

Inefficiency of the Private Provision of Public Goods

- ***Example*** (Private contributions to a public good):
  - Consider an economy with two individuals $i = \{1,2\}$, with quasilinear utility function
$$u_i(x, y_i) = y_i + \alpha_i \log(x)$$
    where
    - $\alpha_i > 0$ denotes the value that individual i assigns to total contributions to the public good, $x = x_i + x_j$
    - y_i is a composite private good commodity
    - Assume that $\alpha_1 > \alpha_2$
  - For simplicity, the price of both private and public good is 1, thus entailing a budget constraint $x_i + y_i = w$ for every individual i.

Inefficiency of the Private Provision of Public Goods

- ***Example*** (continued):
  - Using the budget constraint $x_i + y_i = w$, or $y_i = w - x_i$, and the fact that $x = x_i + x_j$, we can rewrite the above UMP as the following unconstrained program

$$\max_{x_i \geq 0} \; w - x_i + \alpha_i \log(x_i + x_j)$$

  - Taking FOC with respect to x_i yields

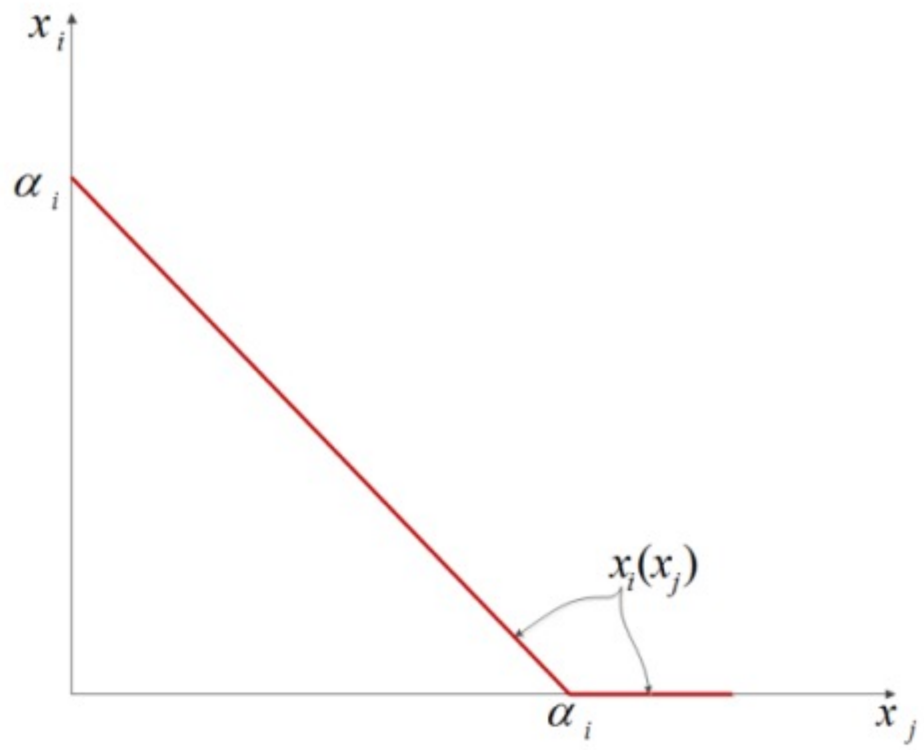
$$-1 + \frac{\alpha_i}{x_i + x_j} = 0$$

  - Solving for x_i produces BRF $x_i(x_j)$

$$x_i(x_j) = \begin{cases} \alpha_i \;\text{ if }\; x_j = 0 \\ \alpha_i - x_j \;\text{ if }\; x_j > 0 \end{cases}$$

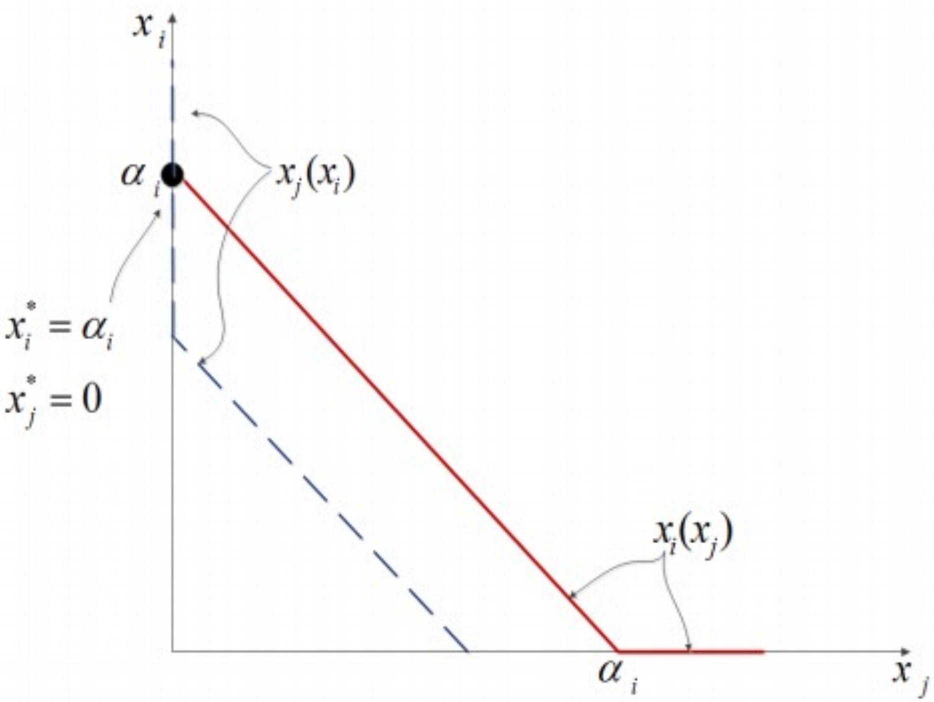
Inefficiency of the Private Provision of Public Goods

- ***Example*** (continued):
  - Individual i's BRF $x_i(x_j)$.
  - Individual j's BRF $x_j(x_i)$ is analogous.



Inefficiency of the Private Provision of Public Goods

- ***Example*** (continued):
  - The equilibrium level of (x_i^*, x_j^*) is obtained by simultaneously solving the two BRFs, $x_i(x_j)$ and $x_j(x_i)$.
  - Hence, $x_1^* = \alpha_1 > 0$ and $x_2^* = 0$, since $\alpha_1 > \alpha_2$.



Inefficiency of the Private Provision of Public Goods

- ***Example*** (continued):
  - In contrast, a social planner would maximize total welfare by solving

$$\max_{x_i, x_j} \; w - x_i + \alpha_i \log(x_i + x_j)$$
$$+ w - x_j + \alpha_j \log(x_j + x_i)$$

  - FOC:

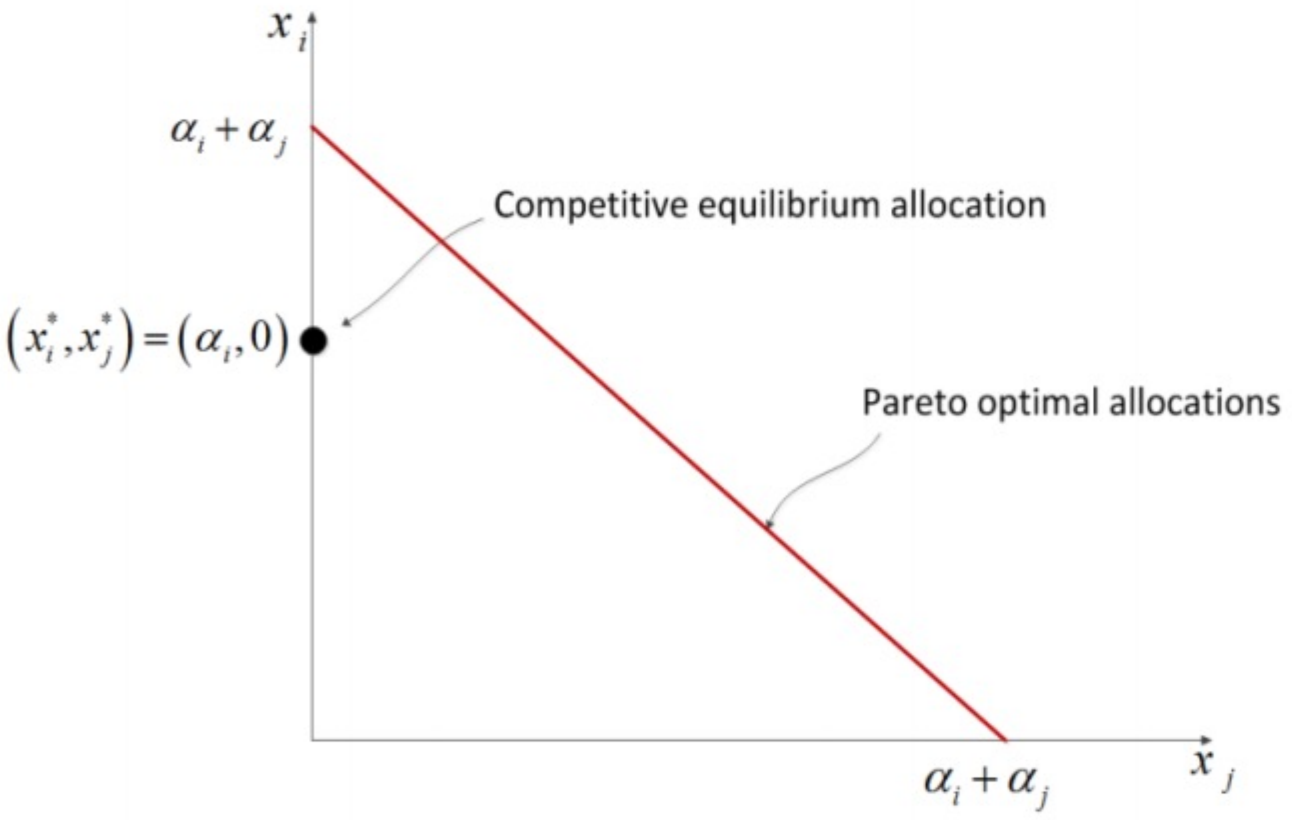
$$-1 + \frac{\alpha_i + \alpha_j}{x_i + x_j} = 0$$

  - Solving for x_i, we obtain a continuum of Pareto optimal allocations

$$x_i^{SO} = \alpha_i + \alpha_j - x_j^{SO}$$

Inefficiency of the Private Provision of Public Goods

- ***Example*** (continued):



Remedies to the Under-Provision of Public Goods

Remedies to the Under-Provision

- ***Quantity-based intervention***: a direct governmental provision of the public good
- ***Price-based intervention***: taxes or subsidies
  - Assume two consumers with benefit functions $v_1(x_1 + x_2)$ and $v_2(x_1 + x_2)$, respectively, where x_i denotes the amount of the public good purchased by consumer i.
  - Similarly to our analysis of externalities, we can design a subsidy s_i per unit of the public good purchased by every consumer i that induces him to take into account the positive external effect of his purchases of public.

Remedies to the Under-Provision

– Hence, the subsidy must be $s_i = v'_{-i}(x^o)$, where $v'_{-i}(x^o)$ reflects the marginal benefit that all other individuals obtain from enjoying x^o units of the public good.

– Note that this analysis is equivalent to that of imposing a tax $t_i = -v'_{-i}(x^o)$ per unit of the public good when the overall amount of public good falls below x^o, as we next describe.

Remedies to the Under-Provision

- Every consumer i's UMP becomes that of selecting $\tilde{x}_i$ for a given level of $\tilde{x}_j$

$$\max_{x_i \geq 0} \underbrace{v_i(x_i + \tilde{x}_j) + \underbrace{s_i x_i}_{\text{subsidy}}}_{\text{Total utility from } x_i} - \underbrace{\tilde{p} x_i}_{\text{cost}}$$

- Taking FOC with respect to x_i yields

$$v_i'(\tilde{x}_i + \tilde{x}_j) + s_i - \tilde{p} \leq 0$$

with equality if $\tilde{x}_i > 0$ (interior solution).

Remedies to the Under-Provision

- Using the market clearing condition $\tilde{x} = \tilde{x}_i + \tilde{x}_j$, and the fact that in a competitive equilibrium the PMP implies $\tilde{p} = \tilde{c}'(\tilde{x})$, the above FOC becomes
$$v_i'(\tilde{x}) + s_i \leq c'(\tilde{x})$$

- Finally, note that for a subsidy s_i to be optimal, we need
$$s_i = v_{-i}'(x^o) = v_j'(x^o)$$

  which allows us to rewrite the above FOC as
$$v_i'(x^o) + v_j'(x^o) \leq c'(x^o)$$

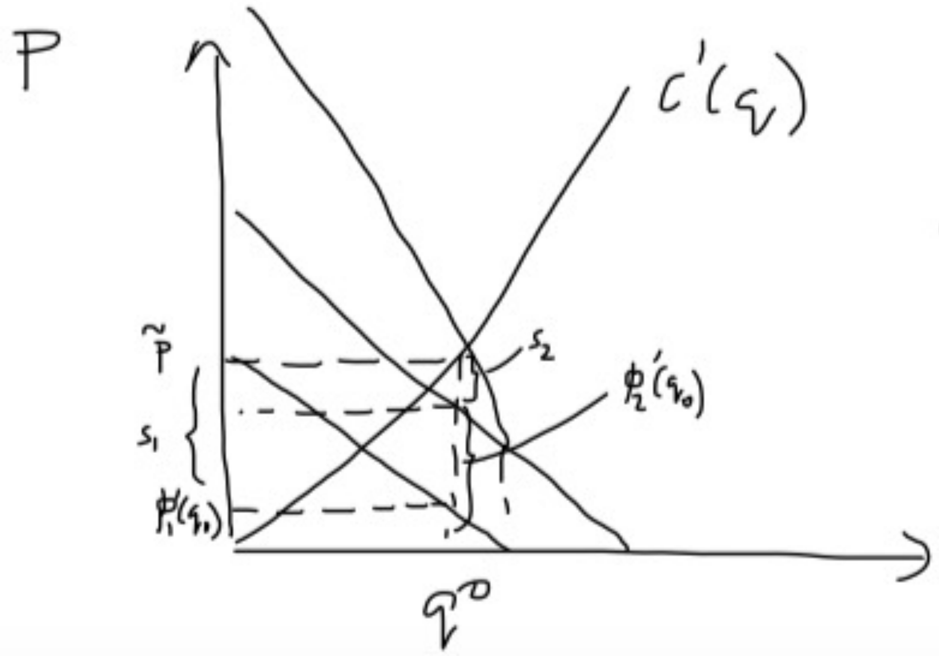
Remedies to the Under-Provision

- Hence, we need a subsidy $s_i = v'_{-i}(x^o)$ which, for the case of only two consumers i and j, implies $s_i = v'_j(x^o)$.
- In the case of N individuals, the subsidy to consumer i would be

$$s_i = v'_j(x^o) + v'_k(x^o) + \cdots = \sum_{j \neq i} v'_j(x^o)$$

- The introduction of a subsidy might seem an effective and easy solution to the under-provision problem in public goods.
- However, the regulator might not have access to information about the marginal benefits of the public good for every consumer.

Public good remedies



$$\phi_1(q_0) + s_1 = \tilde{p} = \phi_2(q_0) + s_2$$

$$s_1 = \phi_2(q_0), \qquad s_2 = \phi_1(q_0)$$

Lindahl Equilibria

Lindahl Equilibria

- Private provision of a public good results in inefficiencies, i.e., $x^* < x^0$.
  - This can be solved by the use of quantity-based or price-based regulation.
- There is, however, a market solution that *in principle* can achieve optimality.
- Consider a market where every individual's consumption of the public good is a distinct commodity with its own market.
- Denote the price of this personalized good by p_i, which can differ across consumers.

Lindahl Equilibria

- If consumer i faces a price p_i^{**}, his UMP is

$$\max_{x_i \geq 0} \; v_i(x_i) + w_i - p_i^{**} x_i$$

- FOC wrt x_i yields

$$v_i'(x_i^{**}) - p_i^{**} \leq 0$$

with equality if $x_i^{**} > 0$.

- Hence, at the aggregate level,

$$\sum_{i=1}^{I} v_i'(x_i^{**}) \leq \sum_{i=1}^{I} p_i^{**}$$

Lindahl Equilibria

- On the other hand, the firm produces a bundle of I goods (one for each consumer), with PMP

$$\max_{x \geq 0} \underbrace{\sum_{i=1}^{I} (p_i^{**} x)}_{\text{Total revenue}} - c(x)$$

- FOC wrt x yields

$$\sum_{i=1}^{I} p_i^{**} - c'(x^{**}) \leq 0, \text{ or}$$

$$\sum_{i=1}^{I} p_i^{**} \leq c'(x^{**})$$

with equality if $x^{**} > 0$ (interior solution).

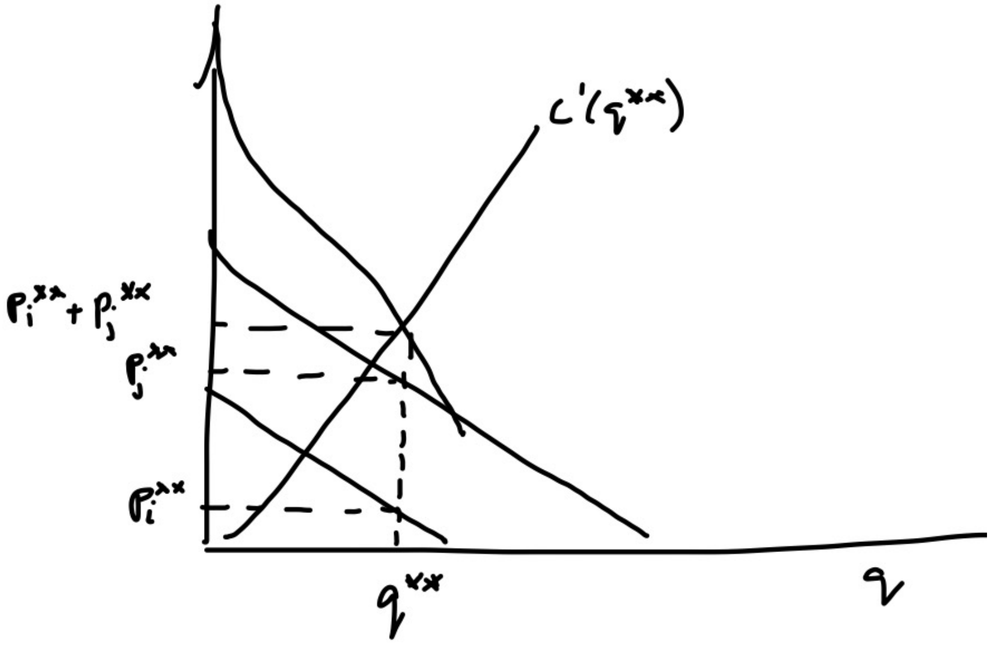
Lindahl Equilibria

- Using the condition we found for consumers, i.e., $\sum_{i=1}^{I} v_i'(x_i^{**}) \leq \sum_{i=1}^{I} p_i^{**}$, with the above condition, we have

$$\sum_{i=1}^{I} v_i'(x_i^{**}) \leq \sum_{i=1}^{I} p_i^{**} \leq c'(x^{**})$$
$$\Rightarrow \sum_{i=1}^{I} v_i'(x_i^{**}) \leq c'(x^{**})$$

  which implies that the equilibrium level of the public good that every consumer purchases is exactly the efficient level, i.e., $x^{**} = x^{o}$.
- This type of equilibrium in personalized markets for the public good is usually known as the ***Lindahl equilibrium***.

Lindahl equilibrium



Lindahl Equilibria

- *Why do we obtain efficiency?*
  - First, we define personalized markets for the public good.
  - Second, each consumer, taking the price of his personalized good as given, fully determines his own level of consumption of the public good.
  - Positive externalities are eliminated.

Lindahl Equilibria

- *Are these personalized markets for the public good realistic?*
  - We need excludability between the different personalized public goods, which might only be applicable to very specific public goods
    - e.g., some forms of health care, college education, etc.
  - Even if excludability was possible, personalized markets would be monopsonistic (there is only one buyer on the demand side)
    - Thus, the price-taking assumption is difficult to support.

Appendix 1:
More General Policy Mechanisms

More General Policy Mechanisms

- In the presence of incomplete information, standard policy tools (e.g., quotas and emission fees) entail welfare losses.

- Let us examine more general policy mechanisms that try to maximize social surplus in the context of incomplete information.

- We consider mechanisms in which we ask agents to self-report their types.

More General Policy Mechanisms

- We ask the firm:
  - What is your benefit from increasing the externality level from $x = 0$ to $x = \bar{x}$, i.e., $b = b(\theta)$, given your private observation of θ
- We ask the consumer:
  - What is your damage from the externality, i.e., $c = c(\eta)$, given your private observation of η?

More General Policy Mechanisms

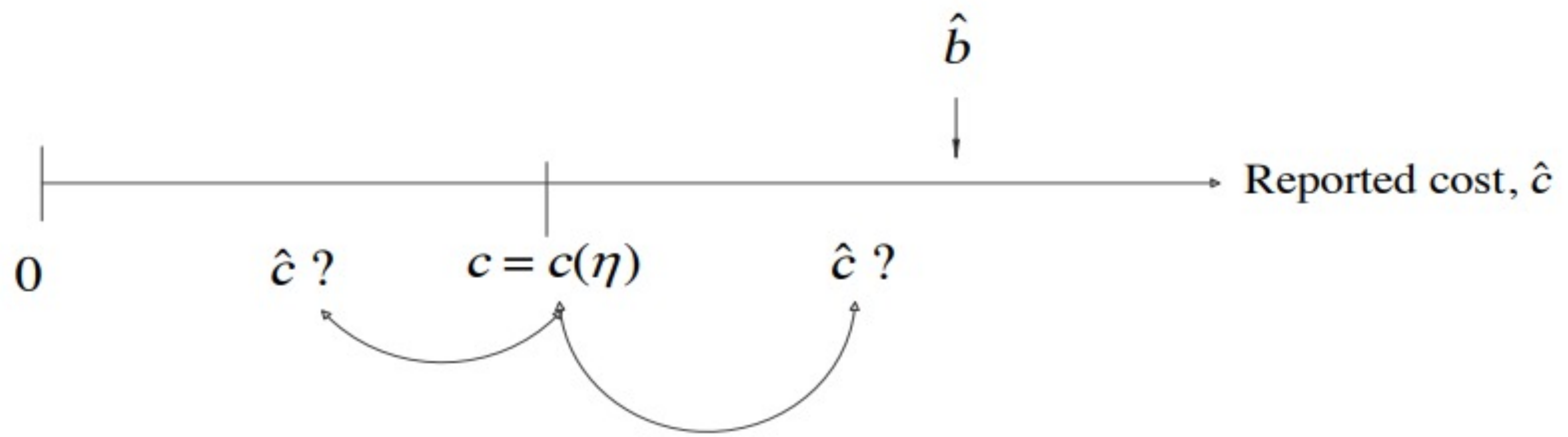
- The mechanism we are interested in focuses on providing incentives to all parties to guarantee that a truth-telling equilibrium emerges.
- ***Groves-Clark-Vickrey (GCV) mechanism***:
  - The regulator declares that it will set the level of the externality at $x = \bar{x}$ if $\hat{b} > \hat{c}$.
    - If this is the case, the government pays $\hat{b}$ to the consumer and charges $\hat{c}$ to the firm.
    - Not a typo!
  - Otherwise, the regulator keeps the level of the externality at $x = 0$.

More General Policy Mechanisms

- Wouldn't this type of mechanism induce firms to *underreport* their benefits?
  - That is, stating a benefit $\hat{b} < b$, in order to reduce the compensation that they have to provide to those consumers affected by the externality.
- Also, wouldn't this type of mechanism induce consumers to *overestimate* their damages?
  - That is, stating a cost $\hat{c} > c$, in order to guarantee that the externality is not allowed or, if allowed, they are substantially compensated for the cost they suffer.

More General Policy Mechanisms

- ***Consumer***:
  - Consider a consumer with a real cost $c = c(\eta)$.
  - Let us examine consumer's optimal announcement, $\hat{c}$, given a firm's report of a benefit $\hat{b} > c$.



More General Policy Mechanisms

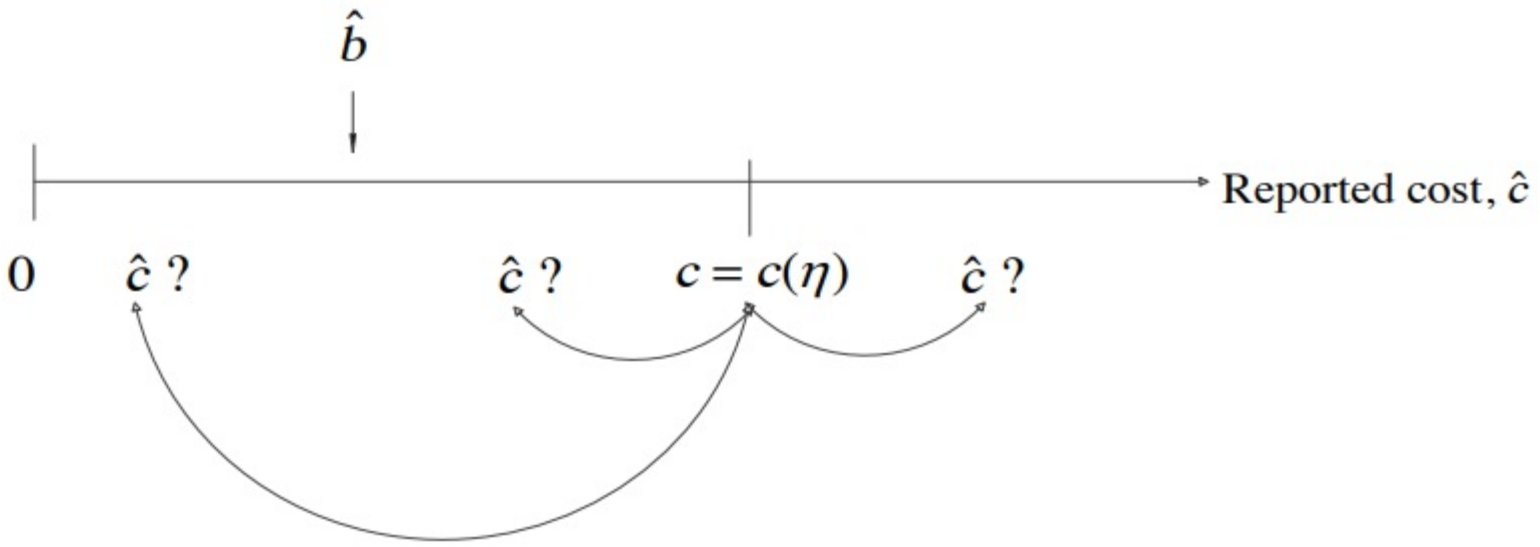
- The consumer does not have incentives to slightly over-report her cost, i.e., $c < \hat{c} < \hat{b}$, or underreport it, i.e., $\hat{c} < c$, since in both cases the compensation she receives is $\hat{b}$.
  - The compensation that the consumer receives is unaffected by her report, inducing the consumer to truthfully reveal her cost $c = c(\eta)$.

More General Policy Mechanisms

- If the consumer over-reports her costs, i.e., $\hat{c} > \hat{b}$, the regulator would decide to not allow the externality, i.e., $x = 0$.
  - Such outcome yields a lower payoff for the consumer than the above outcomes, whereby a report $\hat{c} = c$ yields a compensation of $\hat{b}$ from the firm.

More General Policy Mechanisms

- Let us now examine consumer's optimal announcement, $\hat{c}$, given a firm's announcement of a benefit $\hat{b} < c$.



More General Policy Mechanisms

– If the consumer over-reports her costs, i.e., $\hat{c} > \hat{b}$, the regulator would decide to not allow the externality, i.e., $x = 0$.

– If the consumer slightly underreports her cost $\hat{c}$, i.e., $\hat{b} < \hat{c} < c$, the externality is still not allowed by the regulator, given that reports satisfy $\hat{c} > \hat{b}$.

– Finally, an extreme underreport of her costs, i.e., $\hat{c} < \hat{b}$, is not sensible either:

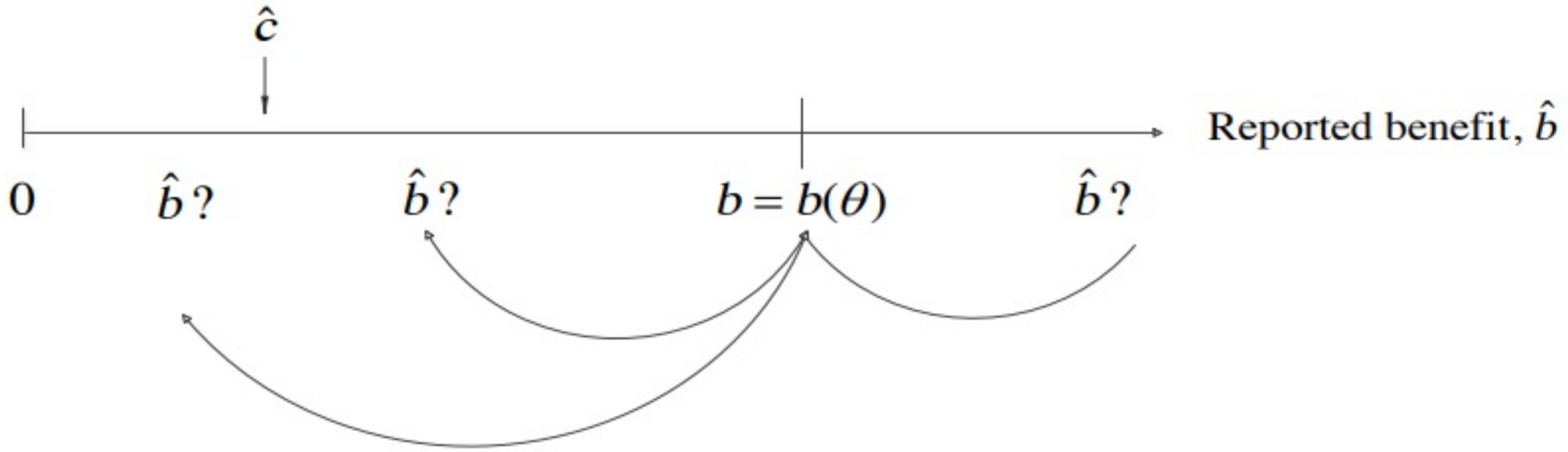
  - While the externality is now allowed (since $\hat{b} > \hat{c}$), the consumer receives a subsidy $\hat{b}$ below her true cost c, i.e., $c > \hat{b}$.

More General Policy Mechanisms

- Hence, the consumer has incentives to truthfully reveal the damage she suffers from the externality, $\hat{c} = c(\eta)$, regardless of the precise report $\hat{b}$ that the firm makes.
  - That is, truthfully reporting her cost is a weakly dominant strategy for the consumer.

More General Policy Mechanisms

- ***Firm***:
  - Consider a firm with a real benefit $b = b(\theta)$.
  - Let us first examine firm's optimal announcement, $\hat{b}$, given a consumer's report of a cost $\hat{c} < b$.



More General Policy Mechanisms

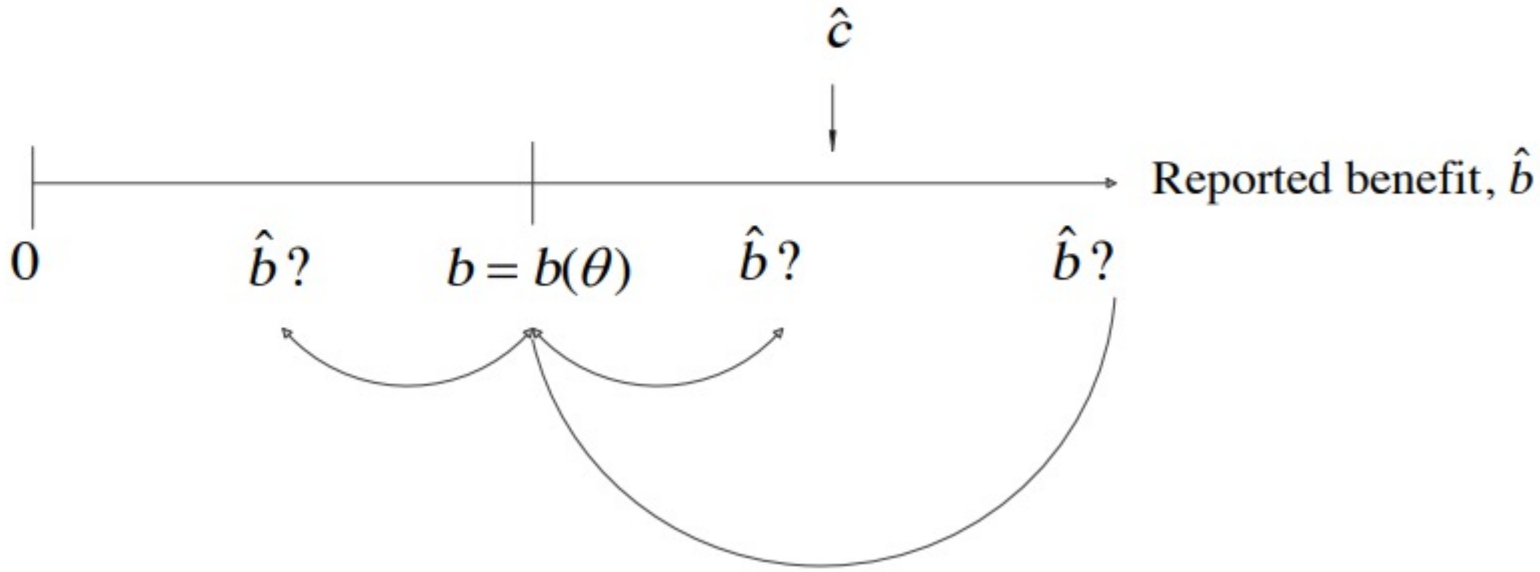
- The firm has no incentives to over-report its true benefit b, i.e., $\hat{b} > b$.
  - The firm would have to pay the same compensation to the consumer, $\hat{c}$, and the externality would still be allowed since reports satisfy $\hat{b} > \hat{c}$.
- The firm has no incentives to slightly underreport its true benefit, i.e., $\hat{c} < \hat{b} < b$.
  - The compensation that the firm has to pay is still $\hat{c}$ and the externality is allowed, since reports still satisfy $\hat{b} > \hat{c}$.

More General Policy Mechanisms

- Finally, the firm has no incentives to extremely underreport its true benefit, i.e., $\hat{b} < \hat{c}$.
  - In this case, the externality would not be allowed by the government given that reports satisfy $\hat{b} < \hat{c}$.

More General Policy Mechanisms

- Let us now consider the case where consumer's report $\hat{c}$ lies above the firm's true benefit b, i.e., $\hat{c} > b$.



More General Policy Mechanisms

- If the firm over-reports its benefit, i.e., $b < \hat{c} < \hat{b}$, the externality would be allowed (since $\hat{b} > \hat{c}$).
  - However, the firm has to pay a compensation $\hat{c}$ to the consumer which is higher than the real benefit the firm obtains from the externality, i.e., $b < \hat{c}$.
- If the firm slightly over-reports its benefits, i.e., $b < \hat{b} < \hat{c}$, or underreports it, i.e., $\hat{b} < b < \hat{c}$, the externality will not be allowed given that reports would now satisfy $\hat{b} < \hat{c}$.

More General Policy Mechanisms

- Hence, the firm prefers no externality whatsoever, i.e., $x = 0$.
  - The true benefit that the firm obtains from the externality b lies below the cost $\hat{c}$ that the consumer declared to experience.
- Hence, truthfully reporting its benefit from the externality is a weakly dominant strategy for the firm.