MARKET FAILURES

General remarks

MARKET FAILURES

- The minimal state intervenes only to ensure the smooth functioning of the economy. Whether this intervention is able to achieve efficiency depends upon the structure of the economy.
- Efficiency will be achieved in the idealised competitive economy – an economy with no market power in which equally-informed agents interact only with the 'market'.
- Outside of this setting, there are many circumstances in which efficiency will not be achieved.

MARKET FAILURES

- **Market failure** is said to arise when efficiency is not achieved.
- The sources of market failure are:
- Imperfect competition
- public goods
- externalities
- asymmetric information.
- These sources of market failure will be discussed in the next two lectures.

MARKET FAILURES

- When market failure is present, the argument for considering whether government intervention would be beneficial is compelling. But this does not imply that intervention will always be beneficial.
- In every case, it must be demonstrated that the public sector has the ability to improve upon what the unregulated economy can achieve. This may not be possible if the choice of policy tools is limited or government information is restricted.
- It must be recognised that the actions of the state, and the policies that it can choose, are often restricted by the same features of the economy that make the market outcome inefficient.

MARKET FAILURES

- **Public goods**

Introduction

- National defence: all inhabitants are simultaneously protected
- Radio broadcast: received simultaneously by all listeners in range of the transmitter
- These are both public goods
- If many consumers benefit from a single unit of provision the efficiency theorems do not apply

Definitions

- A pure public good satisfies:
  - ***Nonexcludability*** If the public good is supplied, no consumer can be excluded from consuming it
  - ***Nonrivalry*** Consumption of the public good by one consumer does not reduce the quantity available for consumption by any other
- A private good is excludable at no cost and is perfectly rivalrous

Definitions

	Rivalrous	Non-Rivalrous
Excludable	Private Good	Club Good
Non-Excludable	Common Property Resource	Public Good

Figure 5.1: Typology of goods

Public Goods:

A simple presentation

OPTIMAL PROVISION OF PUBLIC GOODS

- Pure public goods have two traits:
  - They are non-rival in consumption: The marginal cost of *another person* consuming the good is zero, and does not affect your opportunity to consume the good.
  - They are non-excludable: There is no way to deny someone the opportunity to consume the good.
- **Table 1** gives some examples.

Defining pure and impure public goods

		Is the good rival in consumption?	
		Yes	No
Is the good excludable?	Yes	Ice cream	Cable tv
	No	Crowded city sidewalk	National defense

Optimal Provision of Private Goods

- Consider a private good, like ice cream.
- **Figure 1** shows the market for ice cream cones, assuming that the alternative use of the money is buying cookies at €1 each.
  - This makes cookies the ***numeraire good***.

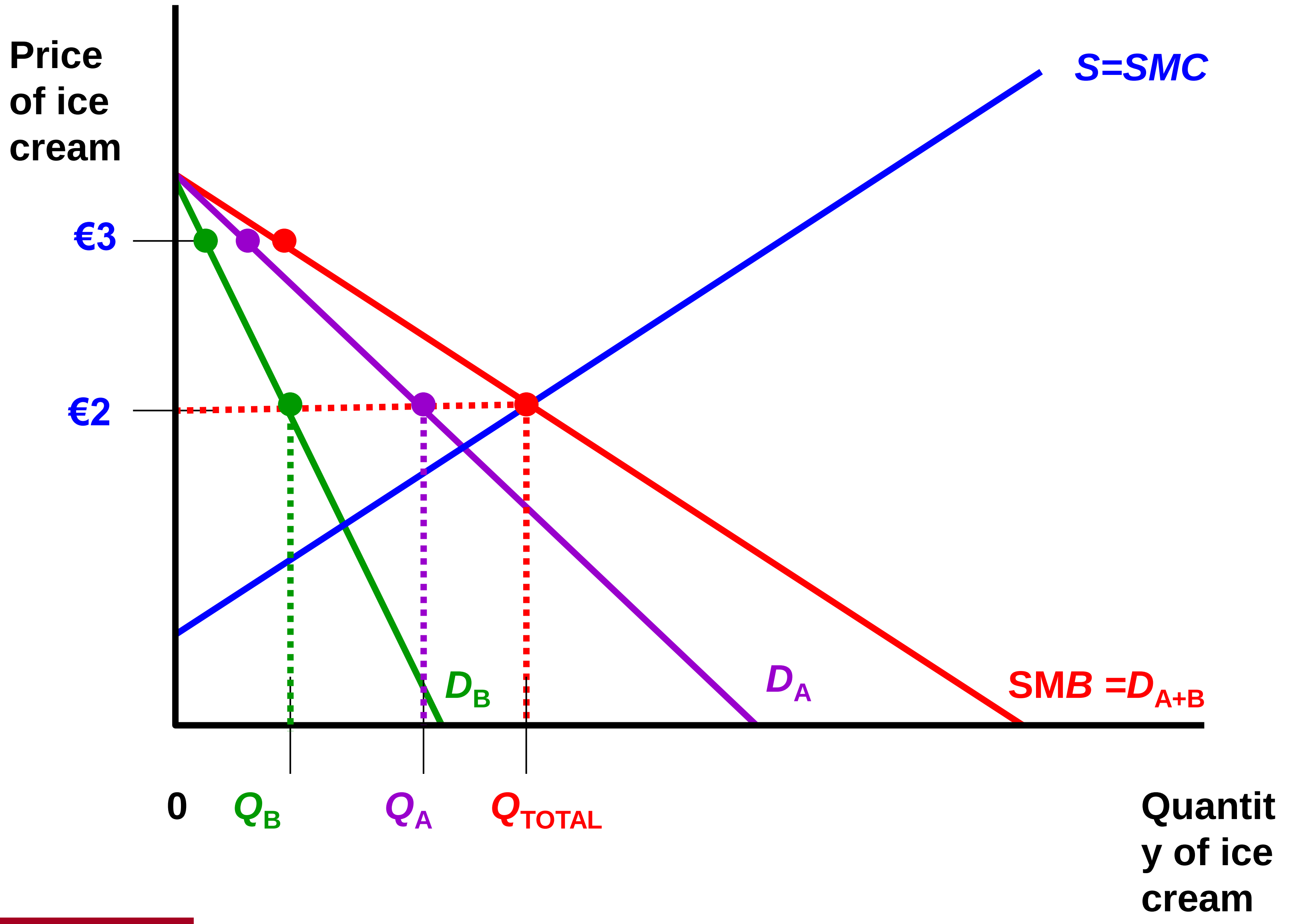


Figure 1 Demand for a private good

Optimal Provision of Private Goods

- In this figure, as price adjusted, each person changed his quantity consumed.
- For a private good, *consumers demand different quantities at the same market price.*

Optimal Provision of Private Goods

- We can also represent this relationship mathematically. A has preferences over cookies (*C*) and ice cream (*IC*):

$$U_A(C, IC)$$

- As does B:

$$U_B(C, IC)$$

Optimal Provision of Private Goods

- Utility maximization requires that each of their indifference curves is tangent to the budget constraint. For A, we have:

$$\frac{MU_{IC}^{A}}{MU_{C}^{A}} = MRS_{IC,C}^{A} = \frac{P_{IC}}{P_{C}}$$

- For B we have:

$$\frac{MU_{IC}^{B}}{MU_{C}^{B}} = MRS_{IC,C}^{B} = \frac{P_{IC}}{P_{C}}$$

Optimal Provision of Private Goods

- Recall that in equilibrium, the price of ice cream is €2, and the price of cookies is €1 (because it is the numeraire good).
- In equilibrium each person must be indifferent between trading two cookies to get one ice cream.

Optimal Provision of Private Goods

- On the supply side, ice cream cones are produced until the marginal cost equals the marginal benefit, which equals the price in a competitive market.

$$MC_{IC} = P_{IC}$$

- Recall that P_C=€1, meaning:

$$MRS^{A}_{IC,C} = MRS^{B}_{IC,C} = P_{IC} = MC_{IC}$$

Optimal Provision of Private Goods

- The private market equilibrium in this case is socially efficient.
- The *MRS* for any quantity of ice cream equals the *SMB* of that quantity–the marginal value to society equals the marginal value to any individual in the perfectly competitive market.

Optimal Provision of Public Goods

- Now consider the tradeoff between a public good, like tanks, and a private good like cookies.
- **Figure 2** shows the market for tanks, assuming that the alternative use of the money is buying cookies at €1 each.

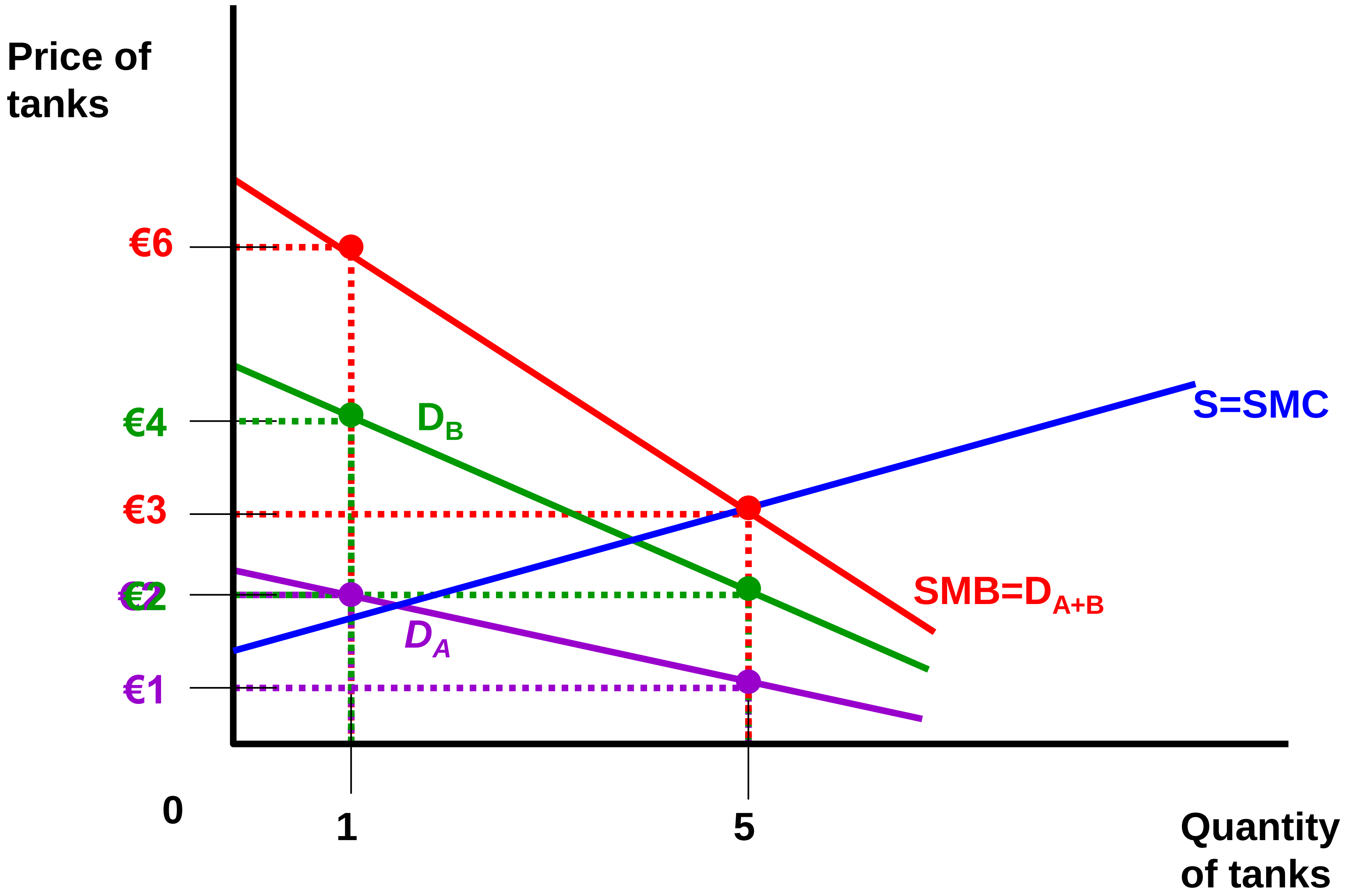


Figure 2 Demand for a public good

Optimal Provision of Public Goods

- Unlike the case of private goods, where aggregate demand is found by summing the individual demands horizontally, with public goods, aggregate demand is found by summing *vertically*.
- That is, holding quantity fixed, what is each person's willingness to pay?

Optimal Provision of Public Goods

- We can also represent this relationship mathematically. A has preferences over cookies (C) and tanks (T):

$$U_A\left(C, \boldsymbol{T}\right)$$

- As does B:

$$U_B\left(C, \boldsymbol{T}\right)$$

Optimal Provision of Public Goods

- To A, the marginal tank is worth:

$$\frac{MU_T^A}{MU_C^A} = MRS_{TC}^A$$

- For B, the marginal tank is worth:

$$\frac{MU_T^B}{MU_C^B} = MRS_{TC}^B$$

Optimal Provision of Public Goods

- The social marginal benefit (SMB) of the next tank is the sum of A and B's marginal rates of substitution:

$$\sum_i MRS^i_{TC}$$

- Where "i" represents each person in society.

Optimal Provision of Public Goods

- The social marginal cost (SMC) is the same as earlier: the marginal cost of producing a tank:

$$MC_M^T$$

- Efficiency therefore requires:

$$\sum_i MRS^i_{T,C} = MC_T$$

Optimal Provision of Public Goods

- That is, social efficiency is maximized when the marginal costs are set equal to the sum of the marginal rates of substitution (rather than each individual's *MRS*).
- This is because the good is *non-rival*. Since a unit can be consumed by all consumers, society would like the producer to take into account all consumers' preferences.

PRIVATE PROVISION OF PUBLIC GOODS:
Private-sector Underprovision

- In general, the private sector *underprovides public goods* because of the ***free rider problem***.
- Consider two people, A and B, and two consumption goods, ice cream and fireworks.
- Set the prices of each good at €1, but fireworks are a public good. Assume that A and B have identical preferences.

Private-sector Underprovision

- A and B benefit equally from a firework that is provided by either of them.
  - *What matters is the total amount of fireworks*.
- Each person chooses combinations of ice cream and fireworks in which his own *MRS* equals the ratio of price.

Private-sector Underprovision

- For both A and B, they set:

$$MRS_{F,IC} = 1, MU_{IC} = MU_F$$

- Whereas optimal provision requires:

$$\sum_i MRS^i_{F,IC} = 1$$

Private-sector Underprovision

- With identical preferences:

$$2\left(\frac{MU_F}{MU_{IC}}\right) = 1,\ MU_F = \frac{MU_{IC}}{2}$$

- Recall that marginal utilities diminish with increasing consumption of a good.
- In this example, optimal provision would require that fireworks are consumed until their utility equals *half* the marginal utility of ice cream.
- Thus, each individually buys too much ice cream privately.

When Is Private Provision Likely to Overcome the Free Rider Problem?

- While the free-rider problem clearly exists, there are also examples where the private market is able to overcome this problem to some extent.
- But the private market may still fall short of the socially optimal amount.

Can Private Providers Overcome the Free Rider Problem?

- Examples of private provision of a public good:
  - Privately financed fireworks displays.
  - Privately owned British lighthouses until 1842.

Private Provision

- Each consumer has an incentive to rely on others to provide the public good
- The reliance on others is called ***free-riding***
- This leads to inefficiency since too little public good is provided
- All consumers will benefit from providing more public good

Private Provision

- Consider two consumers who allocate their incomes between a private good and a public good
- The consumers take prices as fixed.
- Each consumer derives a benefit from the provision of the other.
- This introduces strategic interaction into the decision processes.
- The Nash equilibrium has to be found.

Private provision

- The consumers have income levels M^1 and M^2. Income must be divided between purchases of the private good and the public good.
- Both goods are assumed to have a price of 1.
- With x^h used to denote purchase of the private good by consumer h and g^h to denote purchase of the public good, the choices must satisfy the budget constraint

$$M^h = x^h + g^h.$$

- The link between consumers comes from the fact that the consumption of the public good for each consumer is equal to the total quantity purchased,
- $g^1 + g^2$.

Private provision

- Hence, when making the purchase decision, each consumer must take account of the decision of the other.
- This interaction is captured in the preferences of consumer h by writing the utility function as

$$U^h = (x^h, g^1 + g^2)$$

- The standard Nash assumption is now imposed that each consumer takes the purchase of the other as given when they make their decision.

Private Provision

- Let g^h be the provision of consumer *h*
- Fig. 5.1 shows the preferences of consumer 1
- Assume consumer 2 provides $\bar{g}^2$
- The utility of consumer 1 is maximized at $\hat{g}^1$
- Varying $\bar{g}^2$ traces out the locus of choices for consumer 1.
- This locus is known as the Nash reaction function (or best-response function)

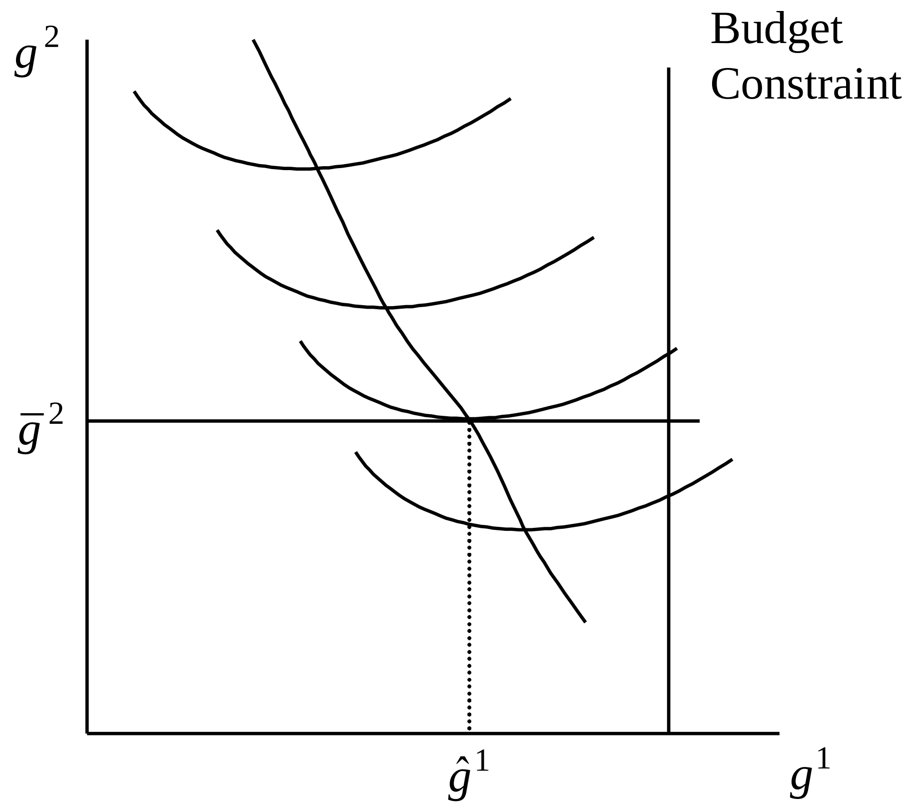


Figure 5.2: Preferences and choice

Private Provision

- Fig. 5.2 constructs the locus of choice for consumer 2
- If consumer 1 chooses to provide $\bar{g}^1$ consumer 2 chooses $\hat{g}^2$
- The locus of choices is given by the solid line
- This is the best-response function (Nash reaction function)

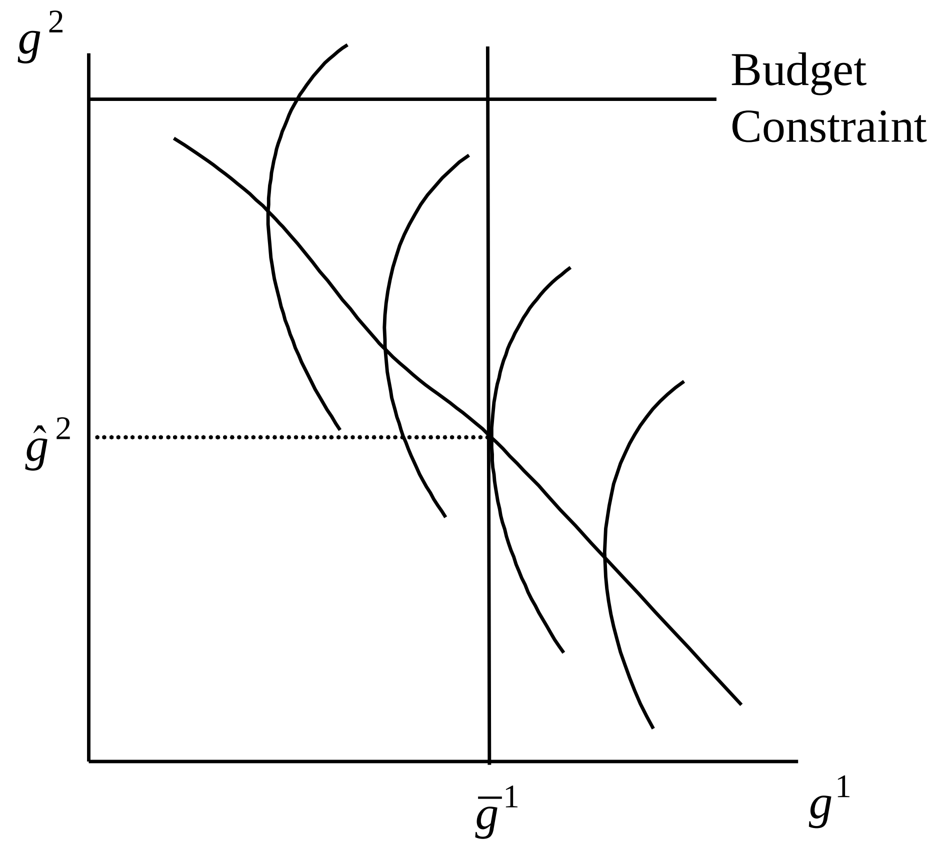


Figure 5.3: Best reaction for 2

Private Provision

- The Nash equilibrium is where the choices of the two consumers are the best reactions to each other
- Neither has an incentive to change their choice
- This occurs at a point where the best-response functions cross
- The equilibrium choices are $\hat{g}^1$ and $\hat{g}^2$
- The equilibrium is privately optimal

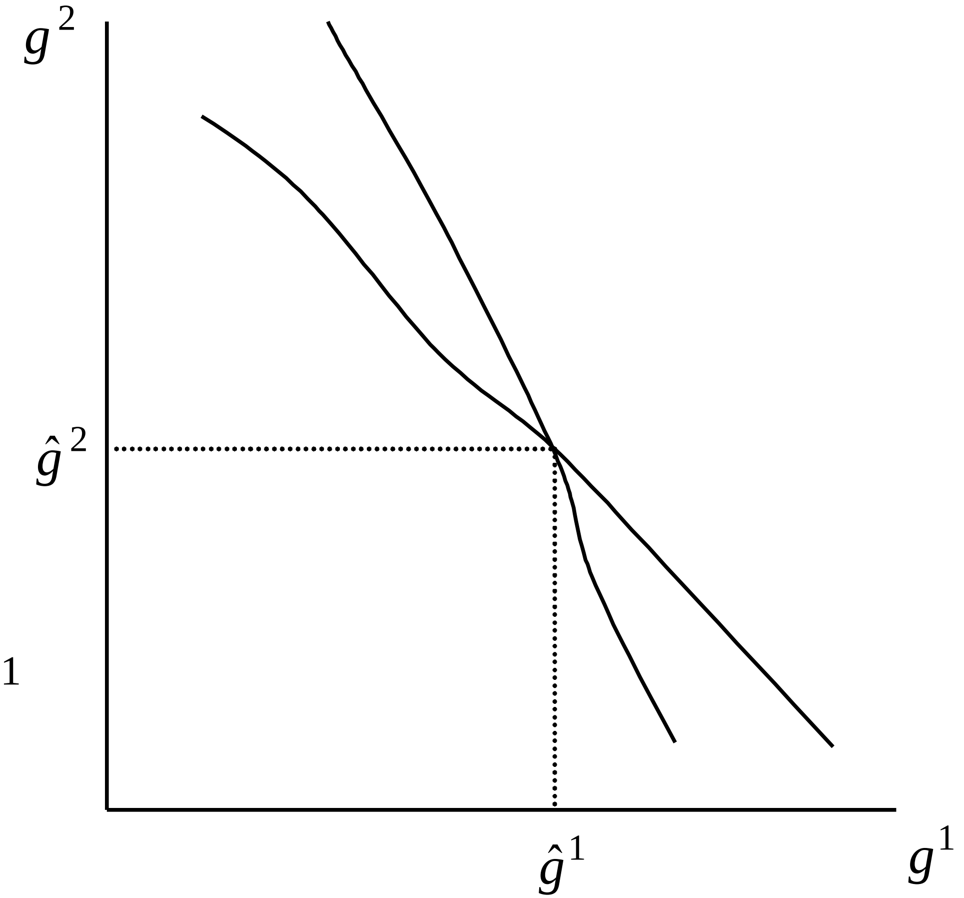


Figure 5.4: Nash equilibrium

Private Provision

- The private provision equilibrium is inefficient
- But it is privately rational
- A simultaneous increase in provision by both consumers gives a Pareto improvement
- The Nash equilibrium is therefore not Pareto-efficient, although it is privately efficient
- Pareto-efficient allocations are points of tangency between indifference curves

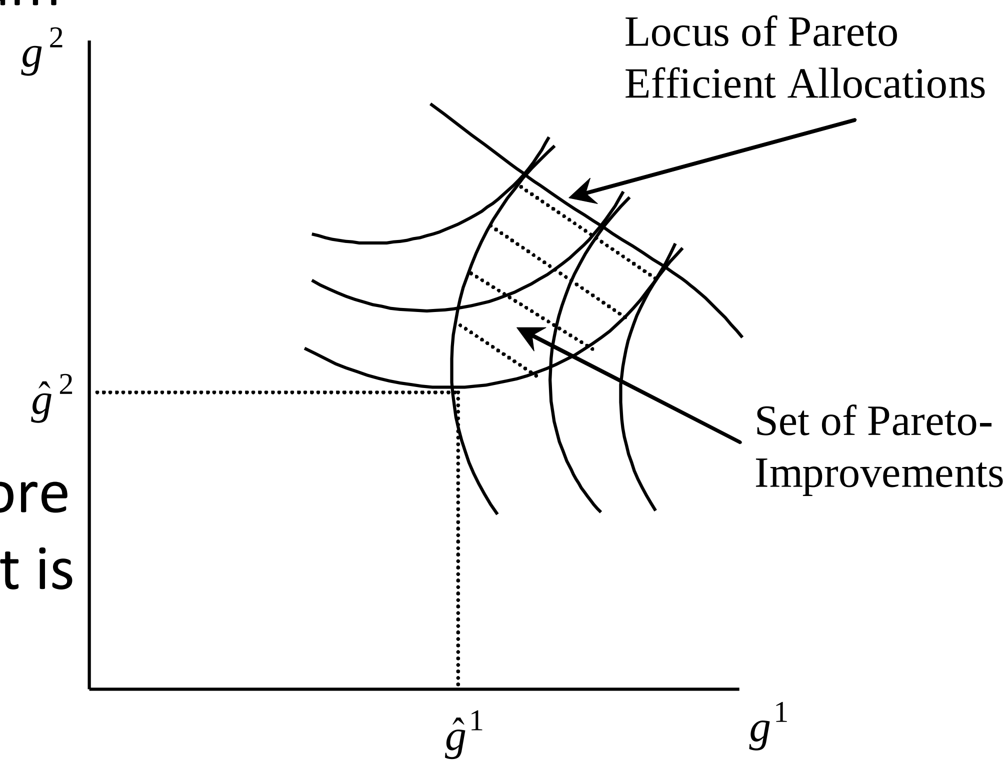


Figure 5.5: Inefficiency of equilibrium

Private provision

- Consequently, compared to Pareto-preferred allocations, the total level of the public good consumed is too low.
- Why is this so? The answer can be attributed to strategic interaction and the free-riding that results.
- The free-riding emerges from each consumer relying on the other to provide the public good and thus avoiding the need to provide themselves.
- Since both consumers are attempting to free-ride in this way, too little of the public good is ultimately purchased.
- In the absence of government intervention or voluntary cooperation, inefficiency arises.

Efficient Provision

- At a Pareto-efficient allocation the indifference curves are tangential
- This does not imply equality of the marginal rates of substitution because the indifference curves are defined over quantities of the public good purchased by the two consumers
- Instead the efficiency condition involves the sum of marginal rates of substitution and is termed the ***Samuelson rule***

Efficient Provision

- The tangency condition is

$$\frac{dg^2}{dg^1}\Big|_{U^1 const.} = \frac{dg^2}{dg^1}\Big|_{U^2 const.}$$

- Calculating the derivatives

$$\frac{U_x^1 - U_G^1}{U_G^1} = \frac{U_G^2}{U_x^2 - U_G^2}$$

- The marginal rate of substitution is $MRS_{G,x}^h \equiv \dfrac{U_G^h}{U_x^h}$

- By making the appropriate substitutions we get

Efficient Provision

- The tangency condition then becomes

$$MRS_{G,x}^{1} + MRS_{G,x}^{2} = 1$$

- This is the Samuelson rule
  - The sum of marginal rates of substitution is equated to the marginal rate of transformation between public and private goods
  - The marginal rate of substitution measures the marginal benefit to a consumer of another unit of public good
  - The marginal rate of transformation is the marginal cost of another unit

Efficient Provision

- For two private goods the efficiency condition is

$$MRS_{i,j}^{1} = MRS_{i,j}^{2}$$

- Why the difference?
  - An additional unit of a private good goes to either consumer 1 or consumer 2
  - Efficiency is achieved when both place the same marginal value upon it
  - An additional unit of public good benefits both consumers
  - The marginal benefits are therefore summed

A more general approach

- Suppose an economy with *N* individuals.
- Each individual has a utility function

$$U_i = U_i(X_i, G)$$

where X_i is the private good and G the public good.

- Suppose that each individual contributes the quantity G_i to the public good, so that

$$G = G_1 + G_2 + ... + G_N$$

Public goods: private provision

- With each individual having income

$$Y_i = P_X X_i + P_g G_i,$$

where P_X is the price of X and P_g the price of the public good, the question is what is the efficient quantity of $G_{i.}$

- If there is not a coordinating mechanism for the provision of the public good, then each individual will pursue the maximization of her welfare.
- When deciding so she will assume that:

Public goods: private provision

- She will choose quantity X_i and G_i
- Each of all other individuals use a constant quantity of public good G_j.
- Setting up the Lagrangian we have that:

$$L = U_i(X_i, G) + \lambda_i(Y_i - P_X X_i - P_g G_i)$$

- Maximizing with respect to X_i and G_i we get

Public goods: private provision

$$\frac{\partial U_i}{\partial G} - \lambda_i P_g = 0 \qquad \frac{\partial U_i}{\partial X_i} - \lambda_i P_X = 0$$

- and

$$\frac{\partial U_i / \partial G}{\partial U_i / \partial X_i} = \frac{P_g}{P_X}$$

- Which is the Cournot-Nash equilibrium
- Is it Pareto optimal?

Public goods: Optimal provision

- Suppose a social welfare function

$$W = \alpha_1 U_1 + \alpha_2 U_2 + \ldots + \alpha_N U_N$$

- Where $\alpha_i > 0$ is a positive weight on all individuals utilities.
- We choose X_i and G_i to maximize social welfare under the aggregate budget constraint.

$$\sum_{i=1}^{N} Y_i = P_X \sum_{i=1}^{N} X_i + P_g G$$

Public goods: Optimal provision

- The first order conditions are:

$$\sum_{i=1}^{N} \alpha_i \frac{\partial U_i}{\partial G} - \lambda P_g = 0 \qquad \alpha_i \frac{\partial U_i}{\partial X_i} - \lambda P_X = 0, \qquad i = 1, \ldots, n$$

$$\sum_{i=1}^{N} \frac{\lambda P_X}{\partial U_i / \partial X_i} . \frac{\partial U_i}{\partial G} = \lambda P_g$$

$$\sum_{i=1}^{N} \frac{\partial U_i / \partial G}{\partial U_i / \partial X_i} = \frac{P_g}{P_X}$$

- Which is the Samuelson rule.

Cournot-Nash and Samuelson

- To better compare the Samuelson rule with that of Cournot-Nash we can rewrite the above condition as follows.

$$\frac{\partial U_i / \partial G}{\partial U_i / \partial X_i} = \frac{P_g}{P_X} - \sum_{j \neq i} \frac{\partial U_j / \partial G}{\partial U_j / \partial X_j}$$

- If X and G are normal goods then.

$$\sum_{j \neq i} \frac{\partial U_j / \partial G}{\partial U_j / \partial X_j} > 0$$

Cournot-Nash and Samuelson

- Which implies that the MRS of public for private good for individual i defined in the above equation is less that that defined by the Cournot-Nash equilibrium.
- It means that under the Samuelson rule a greater quantity of G and a smaller quantity of X are consumed than under the Cournot-Nash equilibrium.

Cournot – Nash

$$\frac{\partial U_i / \partial G}{\partial U_i / \partial X_i} = \frac{P_g}{P_X}$$

Samuelson rule

$$\frac{\partial U_i / \partial G}{\partial U_i / \partial X_i} = \frac{P_g}{P_X} - \sum_{j \neq i} \frac{\partial U_j / \partial G}{\partial U_j / \partial X_j}$$

Example: Solve the above with all individuals identical in utility and incomes and the utility function being $U_i = X_i^{\alpha} G^{\beta}$

Externalities

- Public goods are a classic example of the kinds of market failures economists cite as justification for government intervention.
- Externalities are the second primary category of market failure.
- An externality occurs when the consumption or production activity of one individual or firm has an *unintended impact on the utility or production* function of another individual or firm.

Externalities

- Individual *A plants a tree to provide* herself shade, but inadvertently blocks her neighbors' view of the valley.
- The pulp mill discharges waste into the river and inadvertently raises the costs of production for the brewery downstream.
- These activities may be contrasted with normal market transactions in which *A's action, say, buying the tree, has an impact on B, the seller* of the tree, but the impact is fully accounted for through the operation of the price system.

Externalities

- There is no market for the view of the valley or the quality of water in the river, and thus no price mechanism for coordinating individual actions.
- Given the existence of externalities, a non-Pareto-optimal allocation of resources often results.
- To see the problem more clearly, let us consider a situation in which two individuals A and B, and each consumes private good *X, and A consumes externality creating good E.*

Externalities

- Individual *A then purchases X and E so as to maximize her utility subject to the* budget constraint,

$$Y_A = X_A P_X + E_A P_E$$

- That is A maximises

$$L = U_A(X_A, E_A) + \lambda(Y_A - X_A P_X - E_A P_E)$$

Maximization with respect to *X and E yields the familiar first-order* condition for individual utility when there are two private goods:

$$\frac{\partial U_A / \partial E_A}{\partial U_A / \partial X} = \frac{P_E}{P_X}$$

Externalities

- But E is an activity that produces an externality and thus enters B's utility function also, even though B does not buy or sell E.
- We can solve for the Pareto-optimal allocation of X and E by maximizing one individual's utility, subject to the constraints that the other individual's utility is held constant, and the combined budget of the two individuals is not exceeded.

Externalities

$$L_{PO} = U_A(X_A, E_A) + \lambda[\overline{U}_B - U_B(X_B, E_A)]$$
$$+\mu(Y_A + Y_B - X_A P_X - X_B P_X - E_A P_E)$$

The presence of A's consumption of E, E_A, in B's utility function represents the externality nature of the E activity. Maximizing with respect to X_A, X_B, and E_A yields

$$\frac{\partial L_{PO}}{\partial X_A} = \frac{\partial U_A}{\partial X} - \mu P_X = 0$$

$$\frac{\partial L_{PO}}{\partial X_B} = \lambda(-\frac{\partial U_B}{\partial X}) - \mu P_X = 0$$

$$\frac{\partial L_{PO}}{\partial E_A} = \frac{\partial U_A}{\partial E} - \lambda \frac{\partial U_B}{\partial E} - \mu P_E = 0$$

Externalities

- Using the first order conditions to eliminate λ and μ we get

$$\frac{\partial U_A / \partial E}{\partial U_A / \partial X} + \frac{\partial U_B / \partial E}{\partial U_B / \partial X} = \frac{P_E}{P_X}$$

- or

$$\frac{\partial U_A / \partial E}{\partial U_A / \partial X} = \frac{P_E}{P_X} - \frac{\partial U_B / \partial E}{\partial U_B / \partial X}$$

•This last equation gives the condition for Pareto optimality;

•The condition for individual A's optimal allocation of her budget is.

$$\frac{\partial U_A / \partial E_A}{\partial U_A / \partial X} = \frac{P_E}{P_X}$$

Externalities

- This equation governs the determination of the level of E, since only A decides how much E is purchased.
- If activity E creates a positive externality, $\dfrac{\partial U_B / \partial E}{\partial U_B / \partial X} > 0$
- Then $$\frac{\partial U_A / \partial E}{\partial U_A / \partial X}$$

is larger than is required for Pareto optimality. A purchases too little E (and too much X) when E produces a positive external economy.

•Conversely, when E generates a negative externality,

$\dfrac{\partial U_B / \partial E}{\partial U_B / \partial X} < 0$ and A buys too much of E.

Externalities

- Although seemingly a separate category of market failure, the Pareto-optimality condition for an externality is identical to that for a pure public good.
- *The difference between a pure public good and an externality is that in the case of a public good all members of the community consume the same good, whereas for an externality the good (bad) consumed by the second parties may differ from that consumed by the direct purchaser*.

Externalities

- What is crucial to the issue of Pareto optimality is not that A and B consume precisely the same good, but that A’s consumption alters B’s utility in a manner not accounted for through the price system.
- B is not excluded from the side effects of A’s consumption, and it is this nonexcludability condition that joins public goods and externalities by one and the same Pareto-optimality condition.
- It is this nonexcludability condition that necessitates some coordination of A and B’s activities to achieve Pareto optimality.

Externalities: Internalization

- Consider two producers who each causes a positive externality for the other
  - A beekeeper and an orchard
- With no intervention each will ignore externality and produce too little
- If combined into a single firm they will internalize the externality and produce at the efficient level
- But this may cause monopoly
- It may require unwilling partners to cooperate

Externalities: Pigouvian tax

- One way to adjust A's consumption of E to bring about Pareto optimality is for the government to levy a tax or offer a subsidy to the E activity. If, for example, E generates a negative externality, a tax on E equal to

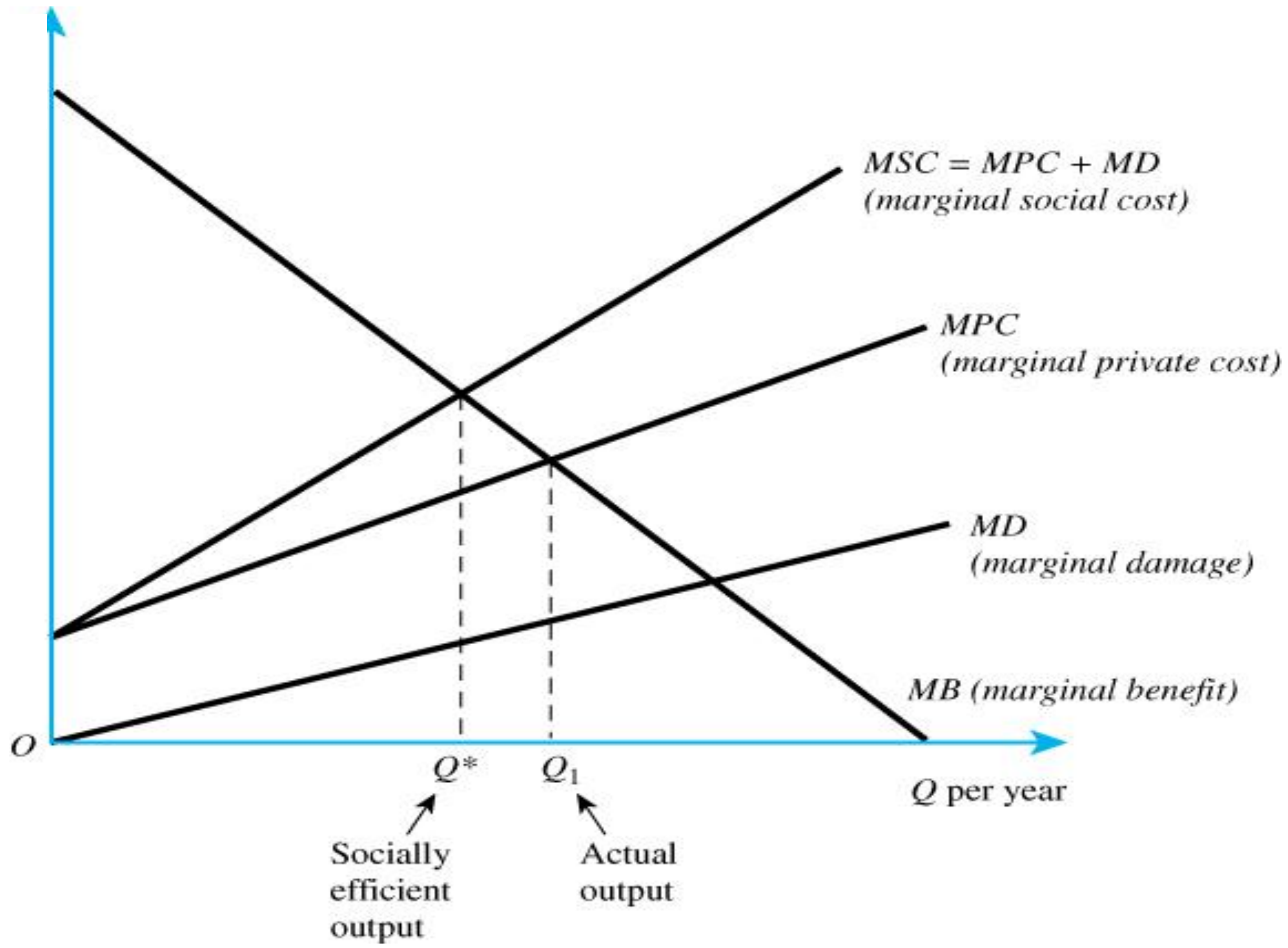
$$\frac{\partial U_B / \partial E}{\partial U_B / \partial X}$$

raises the price of E relative to X by precisely the amount necessary to achieve Pareto optimality. Alternatively, a subsidy to A for each unit of E she consumes, less than the amount implied by $\frac{\partial U_A / \partial E_A}{\partial U_A / \partial X} = \frac{P_E}{P_X}$ achieves the same effect.

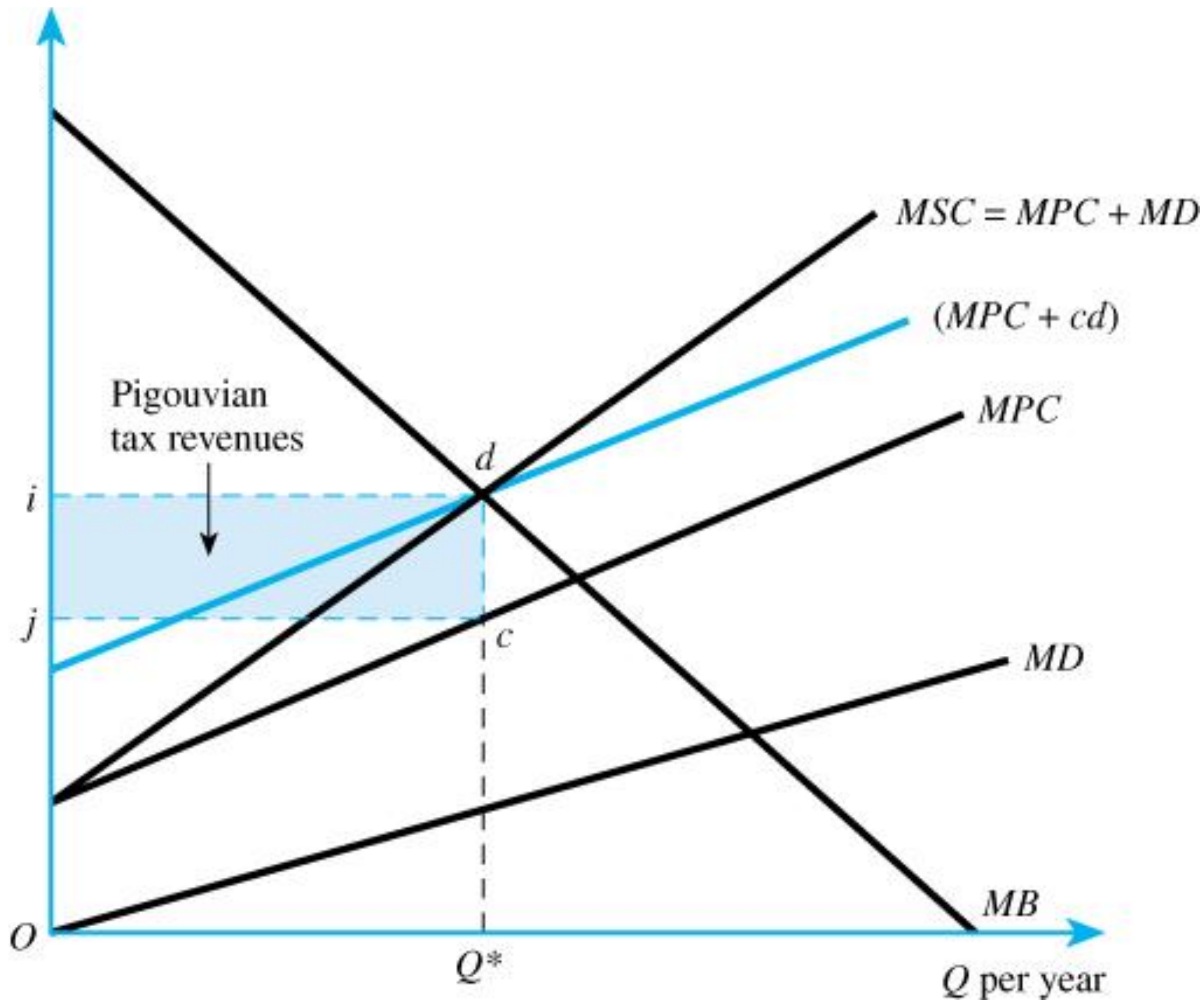
Externalities: Pigouvian tax

- The existence of a government to correct for externalities by levying taxes and offering subsidies is a traditional explanation for government intervention most frequently associated with the name of Pigou.
- Taxation should be seen as putting a price on the externality.
- Diagrammatically, we have

Externalities: Pigouvian tax



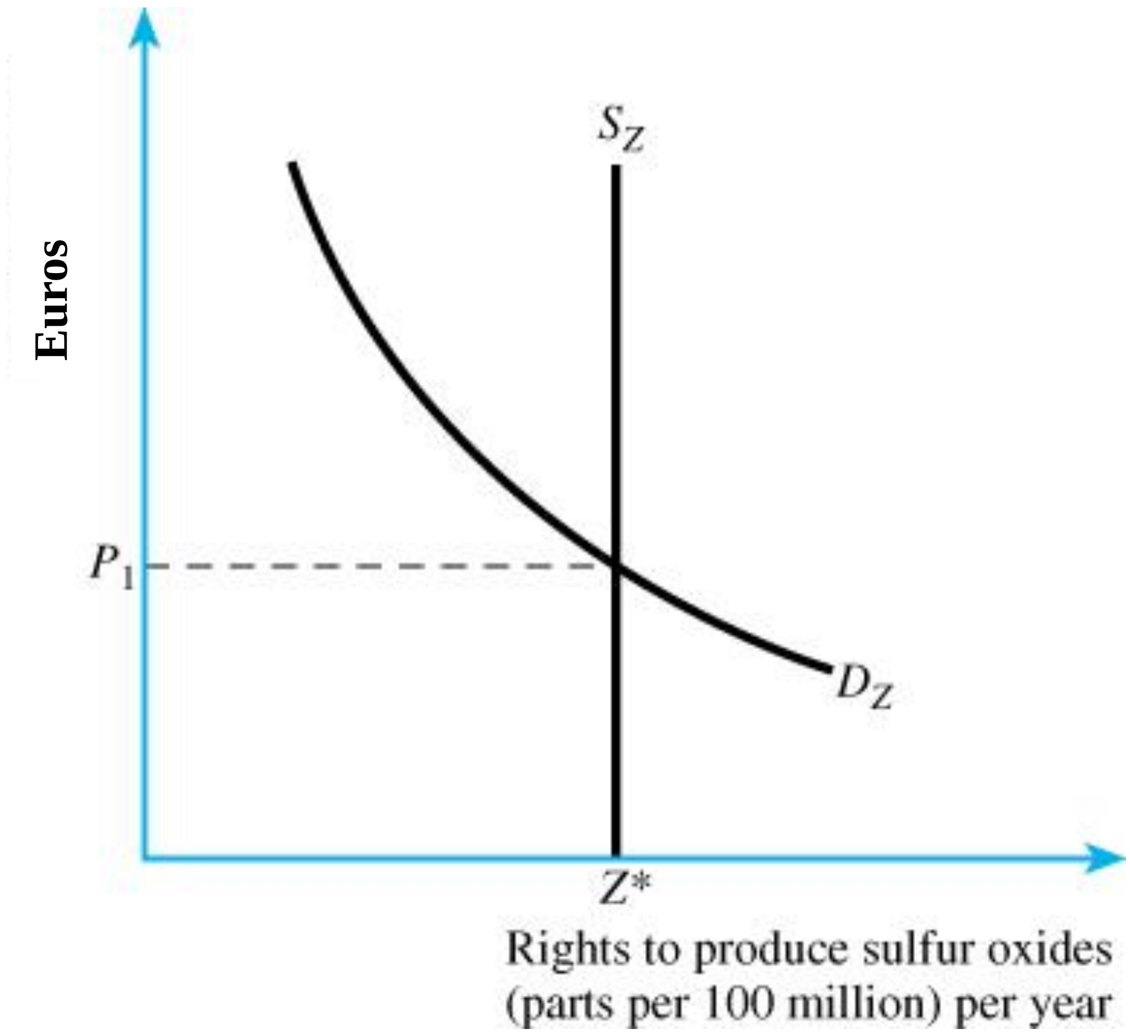
Externalities: Pigouvian tax



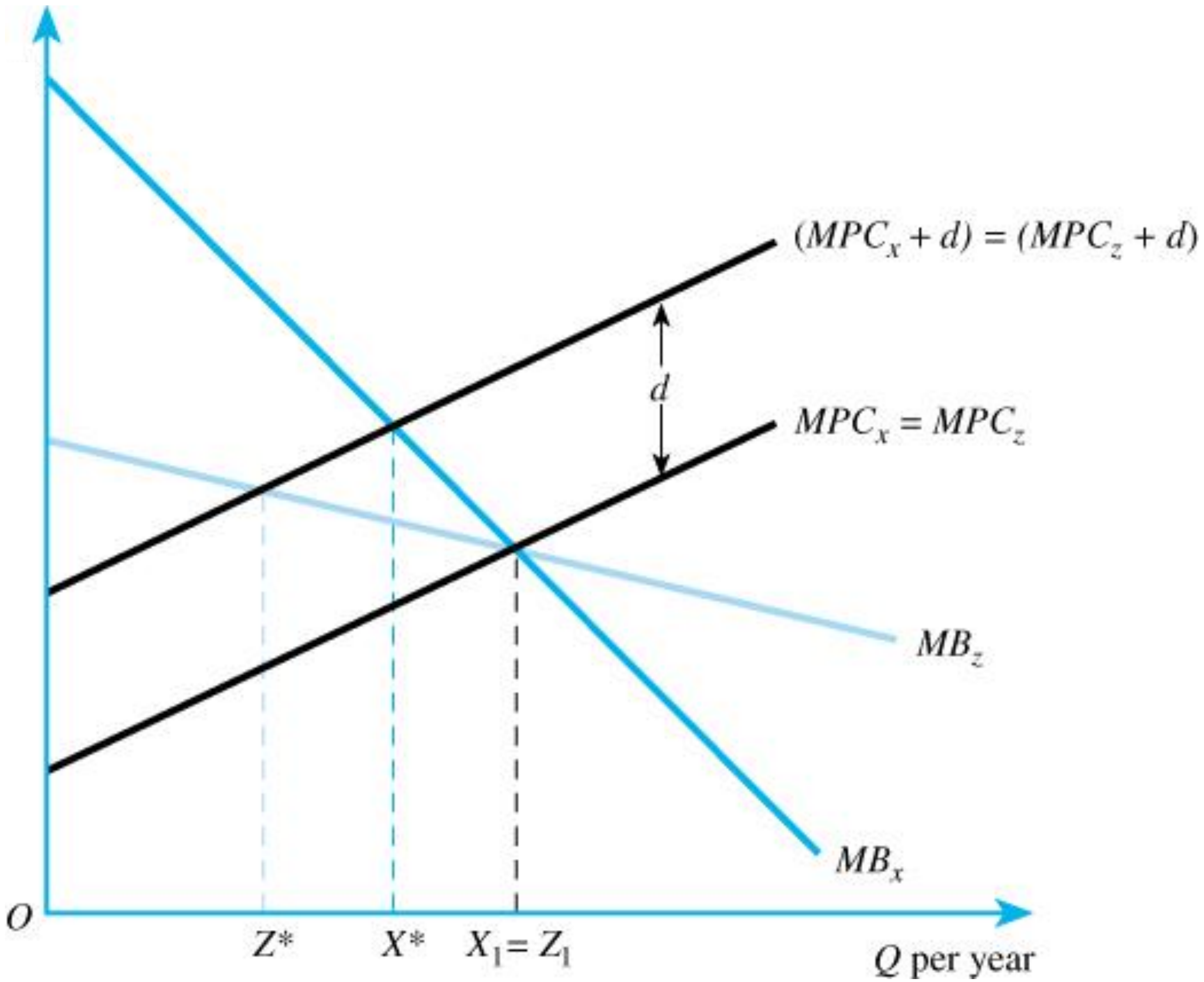
Pigouvian Taxation

- Pigouvian taxation appears a simple solution
  - A tax is paid equal to the marginal damage
  - A subsidy is received equal to marginal benefit
- There are limitations to the argument
  - Taxes may need to be differentiated between consumers, firms, and goods
  - Without sufficient differentiation the externality is only partially corrected
  - Intervention may also be required markets for related goods

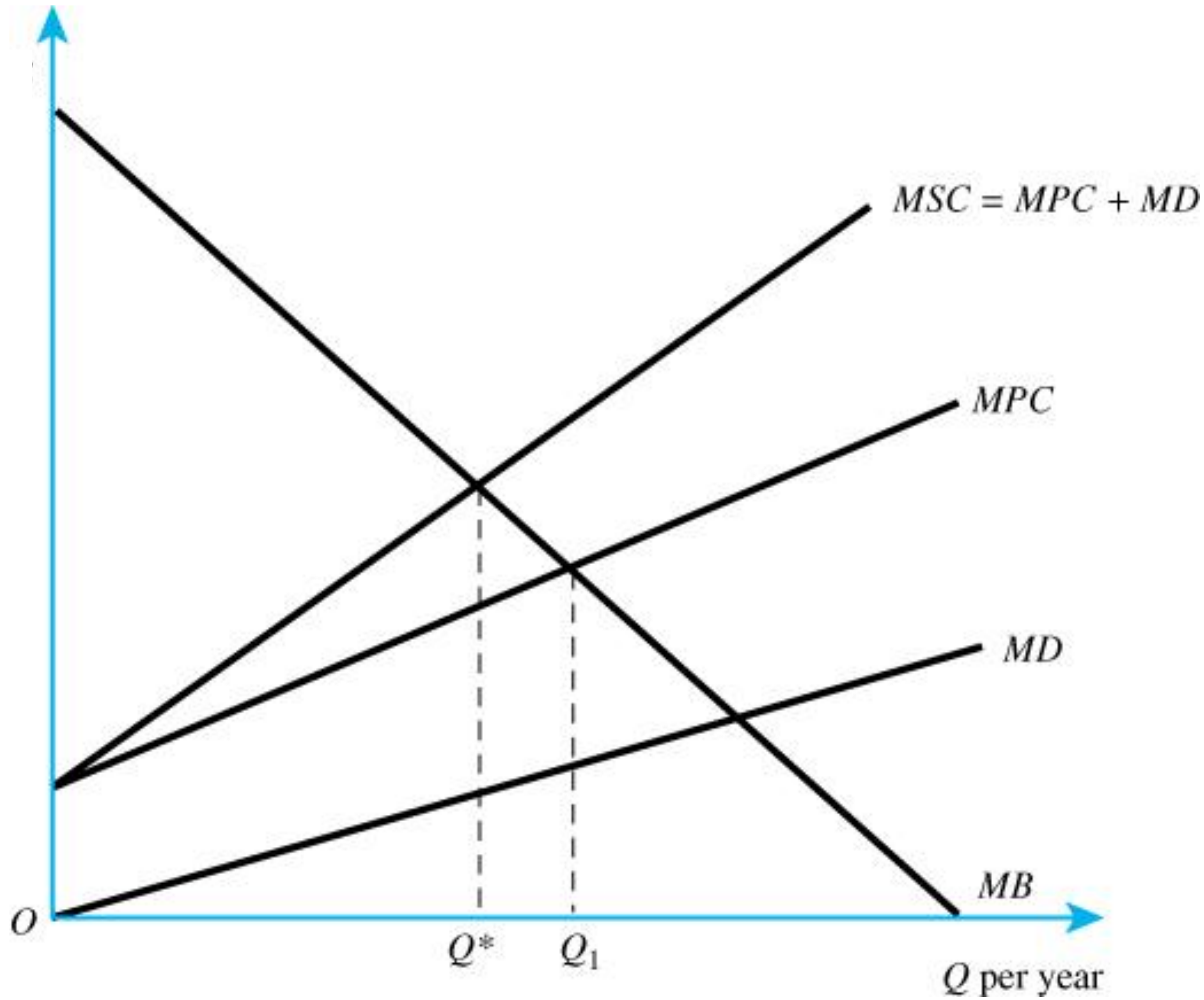
Externalities: Creating a market



Externalities: Regulation



Externalities: The Coase theorem



The Coase Theorem

- The Coase Theorem proposes that economic agents will solve externality problems without intervention
- The theorem can be stated as follows:
  - "In a competitive economy with complete information and zero transaction costs, the allocation of resources will be efficient and invariant with respect to legal rules of entitlement."
- Legal rules of entitlement (or *property rights*) determine ownership in the economy

The Coase Theorem

- Coase sees externalities as arising through the absence of property rights
  - Pollution occurs when there is no right to clean air or clean water
- If there was a property right anyone suffering an externality would be paid compensation
- The compensation is a price for the externality
- Competitive trading will ensure the correct price emerges and efficiency is achieved

The Coase Theorem

- The theorem also asserts that the equilibrium is invariant to assignment of property rights
- Will a firm pollute the atmosphere of a neighbouring house?
  - Only if the benefit from doing so exceeds the compensation required by the householder
  - This applies whether the firm has the right to pollute or the householder has the right to clean air
- The final distribution of income will be different
- Equilibrium will be unaffected by the allocation of property rights if there are no income effects

The Coase Theorem

- The practical limitations of the Coase theorem are:
  - The lack of clear property rights
  - Transaction costs in reaching compensation agreements
  - The potential thinness of the market implying bilateral bargaining and potential inefficiency with incomplete information
  - Potential monopoly power
- The Coase theorem suggests a resolution to the externality problem but there are reasons why the market may not function

Externality Example

- The Tragedy of the Commons arises from the common right of access to a resource. The inefficiency to which it leads results again from the divergence between the individual and social incentives that characterizes all externality problems.
- Consider a lake that can be used by fishermen from a village located on its banks. The fishermen do not own boats but instead can rent them for daily use at a cost ***c***.

- If B boats are hired on a particular day, the number of fish caught by each boat will be F*(B),* which is decreasing in B.

Externality example

- A fisherman will hire a boat to fish if they can make a positive profit. Let ***w*** be the wage if they choose to undertake paid employment rather than fish, and let $p = 1$ be the price of fish so that total revenue coincide with fish catch $F(B)$.
- Then the number of boats that fish will be such as to ensure that profit from fishing activity is equal to the opportunity cost of fishing, which is the forgone wage ***w*** from the alternative job (if profit were greater, more boats would be hired and the converse if it were smaller).

Externality Example

- In the figure the equilibrium number of boats solves
  $\pi = F(B^*) - c = w$
- The optimal number of boats for the community, B, must be that which maximizes the total profit for the village, net of the opportunity cost from fishing. Hence B^o satisfies

  Max B[F(B) - c - w]:
- This gives the necessary conditions
  $F(B^o) - c + BF'(B^o) = w$
- Since an increase in the number of boats reduces the quantity of fish caught by each, $F'(B^o) < 0$, which implies $B^o < B^*$
- In equilibrium there are too many boats
- Each fisherman ignores the negative externality
- The tax can restore efficiency

Externality Example

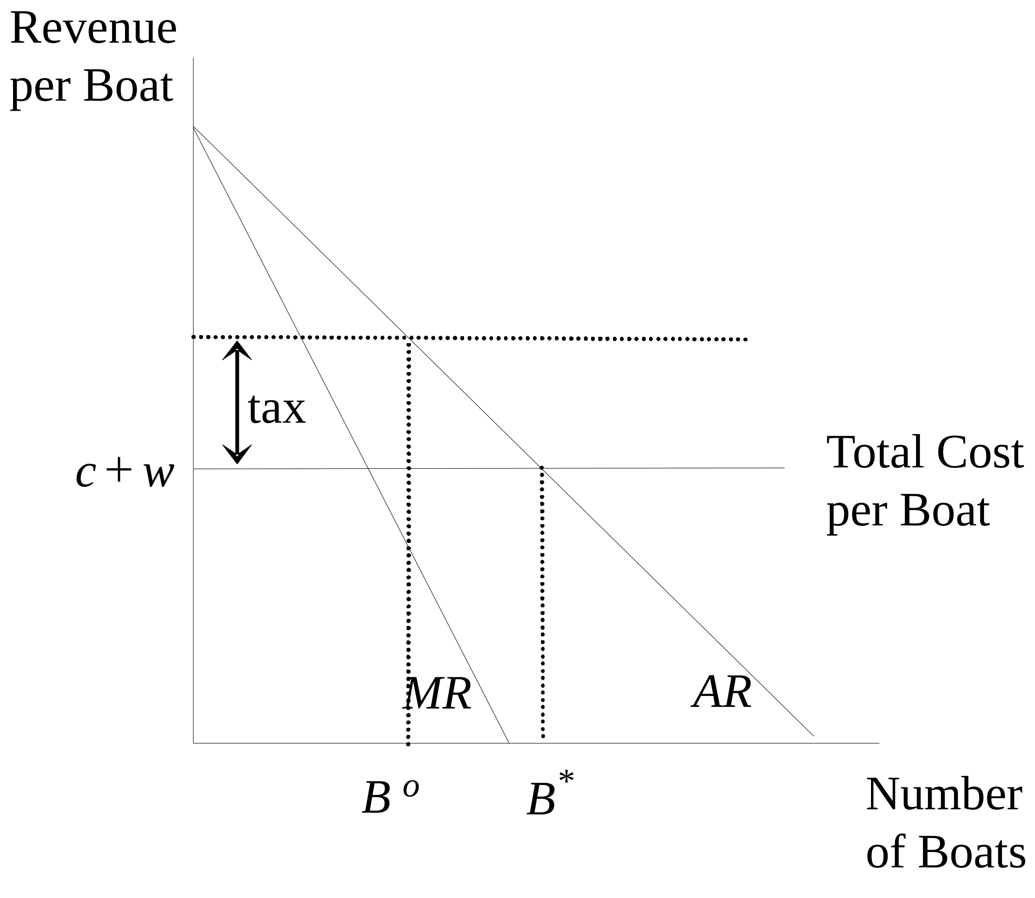


Figure Tragedy of the Commons