Chapter 7

Public Goods

Contents:

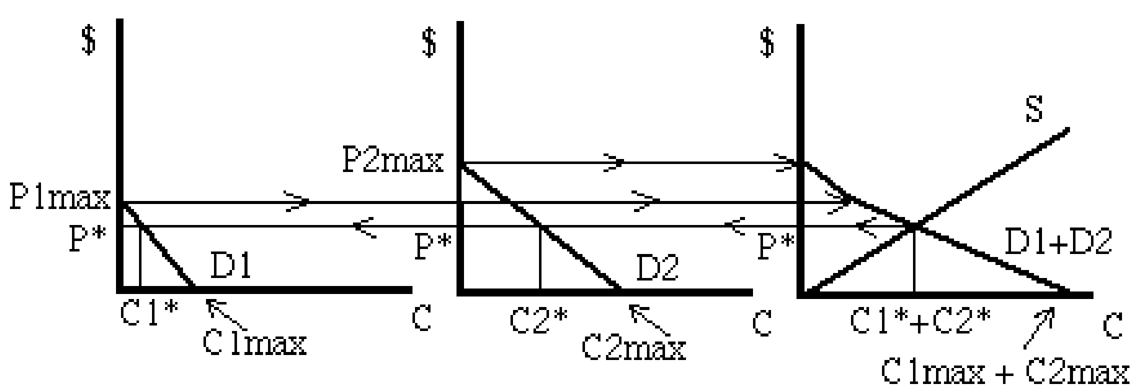
General Overview

Public goods are goods or services that can be consumed by several individuals simultaneously without diminishing the value of consumption to any one of the individuals. This key characteristic of public goods, that multiple individuals can consume the same good without diminishing its value, is termed **non-rivalry**. Non-rivalry is what most strongly distinguishes public goods from private goods. A pure public good also has the characteristic of **non-excludability**, that is, an individual cannot be prevented from consuming the good whether or not the individual pays for it. For example, fresh air, a public park, a beautiful view, national defense.

Graphically, non-rivalry means that if each of several individuals has a demand curve for a public good, then the individual demand curves are summed **vertically** to get the **aggregate demand curve** for the public good (see Figure 7.2). This is in contrast to the procedure for deriving the aggregate demand for a private good, where individual demands are summed **horizontally** (see Figure 7.1).

Figure 7.1

Deriving Aggregate Demand for Private Good



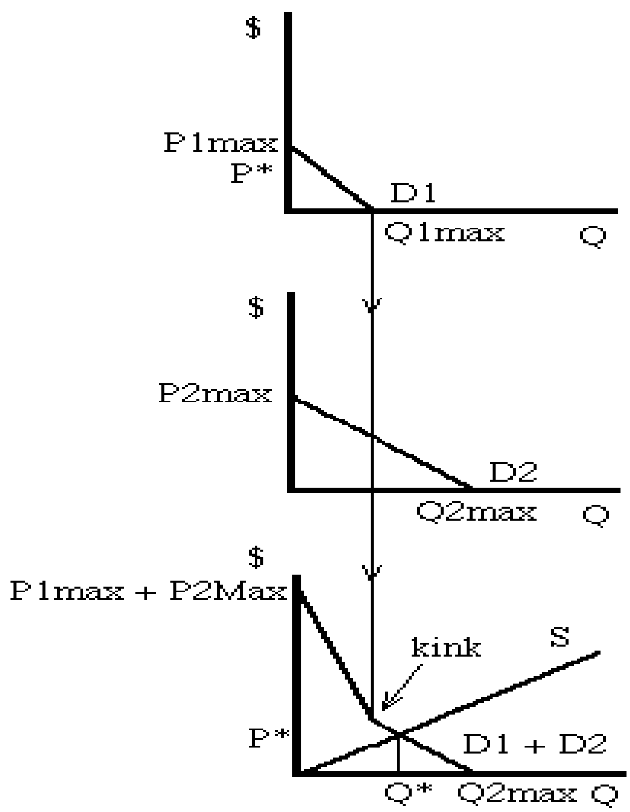
Why Private Goods Are Summed Horizontally:

- <u>Exclusive</u>: once you buy it, you own it and can consume it as you please.
- <u>Rival</u>: a good taken off the shelf it isn't there for other people to consume.

We sum private goods horizontally, because consumers cannot consume the same units. Rivalry in consumption is what makes the market pricing system so incredibly effective, and why the invisible hand hypothesis can work. A price is a per unit charge for a good, so that, when goods are consumed away due to a rivalry between consumers, supply shortages will tend to correct the market by driving up prices as consumers compete for the few remaining goods. Similarly, a supply surplus will cause firms to lower the price of the good until an equilibrium is met that will clear the market**.** Public goods, however, cannot be so easily and efficiently priced.

<u>Figure 7.2</u>

Deriving Aggregate Demand for Public Good



Aggregate demand in the economy for a public good is the vertical sum of individual demand curves. Demand is summed vertically, because all individuals can enjoy the same. Therefore, for each marginal unit of water quality:

aggregate demand = the sum of individual value for the unit

Almost no good or service is completely non-rival. On the other hand, many goods are not completely rival either. Hence, non-rivalry as a characteristic of a public good is a relative, not an absolute concept. However, for the purpose of discussion, we often use the notion of a pure public good.

A number of environmental amenities have public good characteristics. For example, we will discuss the socially optimal level of provision of regional air quality, a relatively pure public good. We will also discuss non-use values, which are types of environmental benefits that are also public goods.

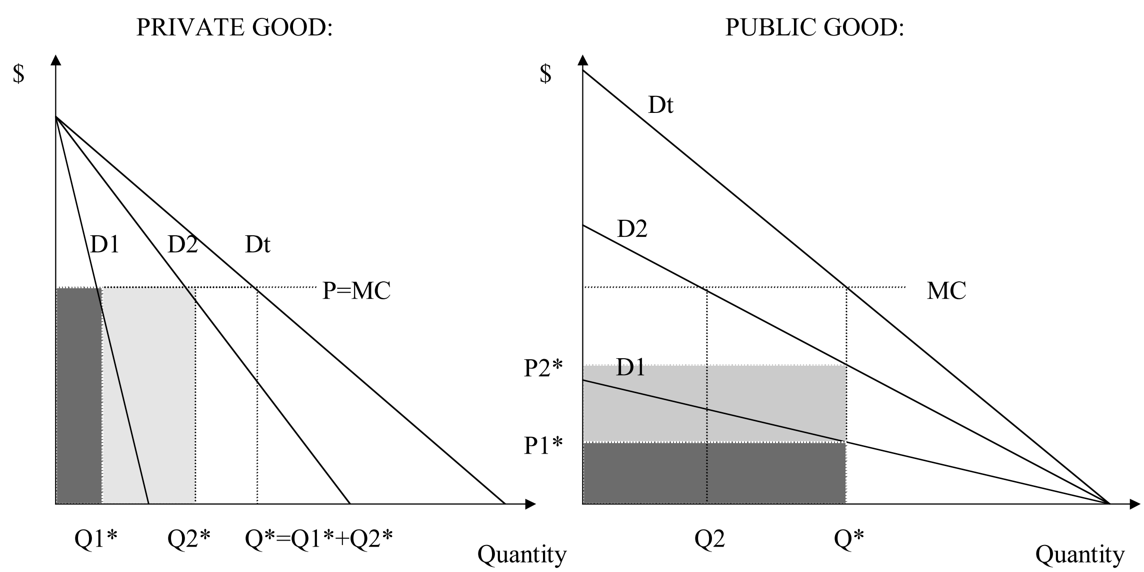
Many environmental issues can be thought of in terms of public goods. For example, the reason the Coase Theorem may not work can be thought of in terms of public goods; if air and water resources were private goods, they could be traded efficiently in a market. We will now show why inefficiencies can arise in the provision of public goods.

Heterogeneity, Non-Rivalry and Market Failure

Consider Two Goods with Identical Aggregate Demand:

- The first good is a private good, (i.e., Chicken Sandwiches)
- The second good is a public good, (i.e., Water Quality at Mono Lake)

Figure 7.3



Private Good: Notice that the market price is an efficient mechanism.

- The equilibrium price of a chicken sandwich is P=MC, so that each chicken sandwich costs $P. Consumers *compete* for the consumption of sandwiches, and, at a price of $P, will self-select socially optimal quantities. Consumer 1 eats Q1* sandwiches, consumer 2 eats Q2* sandwiches and Q1* + Q2* = Q*, the aggregate efficient level. The shaded regions show the total payment by each individual.

Public Good: Notice that the market price is no longer an efficient mechanism, because the stock of a public good is never "consumed away".

- The equilibrium price of water quality cannot be P=MC, because then Consumer 1 would not pay for any water quality improvements, Consumer 2 would pay for only Q2, and, since Q2 < Q*, the efficient level of water quality would not be met. To see what we would like to do, note the analogy to the case of the private good, recognizing that public goods are the mirror image. Thus, the social optimal solution would be to provide Q* and then charge each consumer a unit price equal to the individuals' marginal value at Q*, or, P1* and P2*. As in the case of private goods, the high demand individual will pay a larger amount than the individual with a lower willingness to pay for the good (shown as the shaded regions). Yet, such a solution may not be possible.

The reason inefficiency arises in providing public goods is that, unlike price, quantity is not an effective market mechanism:

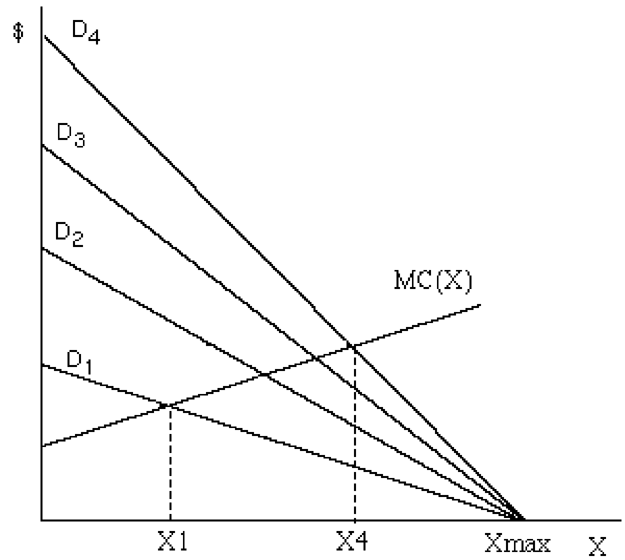
- For a given quantity, individuals will not automatically self-select their optimal price, but will instead wish to pay the lowest price possible when they cannot be excluded from consuming the good.

Non-Excludability and Market Failure

Public goods are a special concern to economists because there can be "market failure" in the private market provision of both pure and impure public goods. The primary cause of market failure involving public goods is **non-excludability**. Non-excludability means that the producer of a public good cannot prevent individuals from consuming it. Non-excludability is a relative, not an absolute, characteristic of most public goods. A good is usually termed non-excludable if the costs of excluding individuals from consuming the good are very high. Private markets often under-provide non-excludable public goods because individuals have the incentive to **free ride**, or to not pay for the benefits they receive from consuming the public good. With a free-rider problem, private firms cannot earn sufficient revenues from selling the public good to induce them to produce the socially optimal level of the public good.

Figure 7.4

Optimal Provision of a Non-excludable Public Good, The Free-Rider Problem, and Market Failure



D_1 = Demand of one individual for public good X.
D_2 = Total Demand of two individuals for public good X.
D_3 = Total Demand of three individuals for public good X.
D_4 = Total Demand of four individuals for public good X.
MC = Marginal cost of providing the public good X.

The socially optimal level of public good X with four consumers is X4. (Note that the optimal level of the public good with a very large number of individuals ("n" individuals) is Xmax.) Because of non-excludability, markets may fail to provide X4. Under private markets, each individual may wait for the others to purchase the public good so that he/she can "free-ride." In this case, the private market may provide no public good, because no one is willing to purchase it. For example, if individual 1 decides to purchase (and the others free-ride), the private market will provide a level of the public good equal to X1, where the marginal benefit of the purchasing individual equals the marginal cost of providing the public good. Notice that this is much less than the optimal level of provision of the public good, X4.

Optimal Provision with Homogenous Individuals

X = level of provision of a public good
n = number of homogeneous individuals in a society

(Inverse) demand of one individual: $D_i(X) = D(X)=a - bX$.

(Inverse) demand of n homogeneous individuals ("aggregate demand"):

$$nD(X) = n(a - bX) = na - nbX. \implies nTB(X) = \int nD(x)\,dx$$

(Inverse) Supply:

$$MC(X) = c + d\,X \quad \implies \quad TC(X) = \int MC(x)\,dx$$

The socially optimal level of provision of X occurs where nTB(X) - TC(X) is maximized, which is given by the solution to the problem:

$$\underset{X}{Max.}\left\{W(X) = \int_0^X nD(x)dx - \int_0^X MC(x)dx\right\}$$

The FOC for this problem is:

$$nD(X) = MC(X), \qquad \text{or} \qquad na - nbX = c + dX$$

Solving the FOC for X:

$$X^* = \frac{na - c}{nb + d}$$

Note that as n becomes very large, X* approaches the value a/b, which is the X intercept of aggregate demand (draw a little supply/demand graph and see how the intersection of supply and demand causes the optimal level of X to approach the value of a/b as the n becomes very large). For public goods, the X intercept of aggregate demand is the level of provision of the public good at which the marginal benefit to any individual of providing an additional unit of the public good is zero.

Numerical Example:

- Suppose a = 10, b = 1, c = 0, and d = 5.
- This gives us: nD(X) = n(10 – X) and MC(X) = 5X.

Examine what happens to X* as n increases:

n = 1 ==> D(X) = 10 - 1X. D(X) = MC(X) ==> X*(n=1) = 1.66

n = 5 ==> 5D(X) = 50 - 5X. D(X) = MC(X) ==> X*(n=5) = 5

n = 10 ==> 10D(X) = 100 - 10X. D(X) = MC(X) ==> X*(n=10) = 6.66

n = 100 ==> 100D(X) = 1,000 - 100X. D(X) = MC(X) ==> X*(n=100) = 9.5

Private Market Outcome for a Non-excludable Public Good

Private providers will provide public goods up to the point where the marginal benefit of one individual (the other individuals free ride) equals the marginal cost of providing the public good. The individual takes other agents' behavior as given (fixed), and solves the following problem:

$$\underset{X}{Max} \int_0^X \left\{ D_i(x) + \sum_{j \neq i} D_j(x) \right\} dx - TC(X)$$

$$\Leftrightarrow$$

$$\underset{X}{Max} \left\{ \int_0^X D_i(x)dx - \int_0^X MC(x)dx \right\}$$

with FOC: $D_i(X)=MC(X)$ or $a-bX=c+dX$

Solving for the level of the public good provided by a private market:

$$X^{Comp.} = \frac{a-c}{b+d}$$

Comparing X^{comp} with X^*, we find that $X^{comp} < X^*$. Hence, *the private market under-provides the public good.*

Other Mechanisms for Providing the Socially-Optimal Level of Public Goods

In those cases where the private market fails to provide the efficient level of public goods, provision of public goods requires **collective action**. People need to realize that a public goods situation exists and either raise contributions from private individuals to fund the public good or let the government provide the public good. Mechanisms to provide public goods include:

(1) **Civic responsibility, individual volunteerism, private fund raising and donation** (Examples: donations to the "Arts" for symphony halls, volunteer fire departments, nature reserves financed by groups such as the Nature Conservatory)

(2) **Private provision of excludable public goods** (Examples: movies, music concerts)

(3) **Public provision of excludable public goods through the use of entrance fees** (Example: entrance fees for a National Park)

(4) Public provision of non-excludable public goods through the use of general government tax revenues (Example: taxes earmarked for National Defense)

(5) Religious beliefs (Examples: church services are a public good; during the ceremony a basket is passed around for collections. Religion can prevent free-riding by convincing people that "God is watching".

The Relationship Between Wealth and Public Good Provision

One of the beneficial aspects of an unequal income distribution is that some rich people have the ability to finance public goods through donation, volunteering and charity. Of course, this is not necessarily what happens. In order for voluntary donation to occur, members of society, especially rich individuals, need to have community spirit and a sense of moral obligation (which they may lack). However, there are many historical examples where the rich have financed the provision of public goods:

- Music and the Arts were financed by kings and knights.
- The rich educated themselves—collected books and preserved knowledge.
- The rich can buy expensive early versions of new products, hence generating incentives for R&D oriented towards innovation due to larger monetary incentives.
- The Church introduced mechanisms for public goods provision.
  - -Monks, nuns, priests serve as a "public good."
  - -Religious beliefs provided incentives to public good provisions.
  - -Education.

Government Provision of Non-Excludable Public Goods Through Taxes

The government can correct market failure and provide the socially optimal level of a public good by financing the provision of public goods with tax revenue. Public financing of public goods may be the only option in cases where the public good is non-excludable and, therefore, entry fees cannot be charged (we cover the entry fee case later). In fact, one could argue that the only role for government in a society is to provide non-excludable public goods such as National Defense and Social Welfare Programs.

<u>The Specification of Congestion Costs in Public Goods Models</u>

Of course, most public goods are not pure public goods. For example, although roads are used simultaneously by many people, and are public goods, an increasing number of users can reduce the benefits to each individual due to **congestion costs**. Congestion costs, or negative congestion externalities, are a type of externality that can occur with public goods. Congestion costs can be a problem for several environmental amenities and natural resources. For example, the benefits to each viewer of a scenic vista may be reduced if the overlook site becomes crowded. Similarly, if too many fishing boats crowd together over a school of fish, then the costs to each fisherman of catching the fish may increase due to accidental collisions, inefficiently short trawling runs, nets damaged by other boats' propellers, etc.

However, congestion can also create benefits in some cases. Positive congestion externalities occur often in the provision of information networks. For example, consider the "information highway". When the first individual subscribed to email, the value of the service was equal to zero, since there was no one out there to send messages to. As subscription to the service increased, however, the value of email increased due to the positive congestion externality.

In an economic model, the existence of a negative congestion externality means that the benefit each individual gains from consuming a public good decreases with the number of individuals consuming the public good. For example, if X is the level of provision of a public good, N is the number of people consuming the public good, and $B_i(X,N)$ is the benefit to an individual associated with consuming a public good at a level of X when N individuals are using the public good, then the existence of congestion costs implies that:

$$dB_i/dN < 0$$

that is, the benefit to an individual of consuming the public good decreases as the number of individuals consuming the public good increases. Note the contrast to a pure public good, where $dB_i/dN=0$ due to non-rivalry.

Hence, when building an economic model involving congestible public goods, the functional form we choose to represent the benefits to an individual of consuming a public good should have the property that the benefits to an individual decrease as the number of individuals consuming the public good increases. For example, consider the following functional form for the benefits to an individual of consuming a congestible public good:

$$B_i(X,N) = \frac{a + bX - cX^2}{N},$$

where the parameters a,b,c > 0.

When we maximize benefits with respect to N, we find that:

$$\frac{dB_i}{dN} = \frac{-(a + bX - cX^2)}{N^2},$$

Since the expression is negative, this implies a negative congestion externality.

But what about the fishing example, where we noted that congestion led to increased costs rather than to decreased benefits? If we simply re-define the benefits from fishing as the net benefits, or profits, from fishing, then we can note that the profits from fishing decrease as the costs of fishing increase, and $dB_i/dN < 0$ would still be a necessary condition for the presence of congestion costs.