	Rival	Non-rival
Excludable	Private Good	Club Good
Non-excludable	Common good	Public good

Table 9.1: Categorization of goods along the dimensions of excludability and rivalry.

9.2 Public Goods

Most goods consider so far are private goods and this section introduces a so-called public goods. Although many public goods are provided by the public sector—and it will be shown why that is the case—the term as used in economics reflects the characteristics of the good and not its provider. Specifically, public goods can be consumed by more than one individual at the same time and use of the good cannot be prevented. The two prime examples illustrating public goods are national defense and light houses. National defense is provided by the public sector (i.e., national government) and it does not matter how many people live (and use) national defense, everyone consumes the same. It is also impossible to exclude a particular person living in a country to consume the good "national defense." The same argument can be made for light houses but with a subtle difference. Suppose that the lighthouse is owned and operated by a private person. Although the lighthouse is not in the hands of the public sector, it is still considered a public good since its use by ships cannot be prevented and it does not matter how many ships use it as a guidance for navigation.

Goods can be categorized—within the context of public goods—along two dimensions: Excludability and rivalry. Excludability refers to the characteristic of whether the use of the good by one person can be prevented or not. Imagine a streetlight whose use by people cannot be prevented. Rivalry refers to the characteristic that the consumption of the good by one person dpes (or does not) affect the consumption of another person. Consider the good national defense in this context. Person A "consuming" the good national defense does not affect person's B consumption as long as both live in the same country.

Additional categories are displayed in Table 9.1. A private good is both rival and excludable. The sandwich owned and eaten by one person illustrates a public good. The tragedy of the commons arises when rival goods are made non-excludable through common ownership. Club goods are non-rival but excludable; e.g. public swimming pools. Public goods lead to the problem of free-riding. That is, people enjoying the consumption of the good without paying for it. Thus, public goods are usually underprovided (if left to private markets).

9.2.1 Pubblic Goods in a Partial Equilibrium Setting

Suppose that the utility of a public good associated with its total quantity Q_T can be represented as follows for consumer can bet written as:

$$U_A(Q_T) = 10 \cdot Q_T - Q_T^2 = 10 \cdot (Q_A + Q_B) - (Q_A + Q_B)^2$$

And the utility for consumer B is expressed as:

$$U_B(Q_T) = 10 \cdot Q_T - \frac{Q_T^2}{2} = 10 \cdot (Q_A + Q_B) - \frac{(Q_A + Q_B)^2}{2}$$

The cost of acquiring the good is $C(Q_T) = 8(Q_A + Q_B)$. So the total benefit to society can be written as

$$B_S(Q_A, Q_B) = 20 \cdot (Q_A + Q_B) - 1.5 \cdot (Q_A + Q_B)^2 - 8 \cdot (Q_A + Q_B)$$

Solving the first-order conditions leads to $20 - 3 \cdot (Q_A + Q_B) = 8$. Thus, societal benefit is maximized if $Q_T = 4$. The key characteristic of a public good that the unit purchased by one consumer can also be consumed by all other consumers. So if $MB_a = 10 - 2q$, $MB_b = 10 - q$, and $MC = 8$, then we have

$$\begin{aligned} MB_a = MC \quad &\Rightarrow \quad Q = 1 \\ MB_b = MC \quad &\Rightarrow \quad Q = 2 \end{aligned}$$

But since individual A has already purchased 1 unit, individual B will free ride and they will end up with 2 units.

9.3 Asymmetric Information

Asymmetric information occurs if two or more parties engage in an transaction and at least one party has more information than the other. This causes high cost customer or low quality suppliers to participate in the market without the other party or parties knowing the cost and/or quality issue. The prime example for asymmetric information is the used car market. The seller has more information about the reliability and quality of the car than the buyer. There are multiple strategies to prevent or reduce asymmetric information. Some examples are:

- Used Car Market: Companies like Carfax that track the repair and accident history of cars can help uncover possible issues with a used car. Another example of market failure is the presence of asymmetric information. The prime example here is the used car market because two parties enter a contract where one party (buyer) is not fully informed.
- Life Insurance: An insurance company can require a health exam prior to selling a life insurance policy.
- Labor Market: Job interview are designed to reduce the asymmetric information for the employer. The potential job candidate has better information on their ability than the employer.

Assume that the demand for car insurance is $Q = 20 - 2 \cdot P$. The inverse demand is $P = 10 - Q/2$. Further, the marginal costs associated with a safe and unsafe drivers are $MC_S = 2$ and $MC_u = 6$, respectively. A perfectly competitive market without asymmetric information results in welfare maximizing marginal cost pricing. For the safe driver, this leads to:

$$2 = 10 - \frac{Q}{2}$$

Thus, quantity and price for safe drivers are $Q = 16$ and $P = 2$. Similarly, for the unsafe driver:

$$6 = 10 - \frac{Q}{2}$$

Thus, quantity and price for safe drivers are $Q = 8$ and $P = 6$. Calculating the consumer surplus from this pricing policy leads to $CS_S = \$128$ and $CS_U = \$32$. The total surplus of \$160. If the insurance company cannot determine in which category a driver falls, it has to charge a uniform price. Assuming an equal amount of safe and unsafe drivers, the company sets the price at \$4. It can be shown that this leads to a surplus of \$144, which is lower than the \$160 under no asymmetric information. This insurance problem is also illustrated in the video Asymmetric Information and Insurance Markets.

9.4 Exercises

1. ***Negative Production Externality I*** (***): Suppose that the inverse demand function for a particular good can be written as $P = 400 - 5 \cdot Q$ and that private marginal cost $PMC = 5 \cdot Q$. The additional external damage per unit produced is $D = 2 \cdot Q$. Support the answers to the questions below by using a graph.
   a. Calculate the market price, quantity, and deadweight loss.
   b. What are the efficient quantity and price?
   c. Calculate the per-unit tax that would achieve the efficient outcome.
2. ***Negative Production Externality II*** (***): Demand and supply for a good are written as $Q^D = 1000 - 5 \cdot P$ and $Q^S = 2 \cdot P - 100$, respectively. The external marginal cost is \$7. Support the answers to the questions below by using a graph.
   a. Calculate the market price, quantity, and deadweight loss.
   b. What are the efficient quantity and price?
   c. Calculate the per-unit tax that would achieve the efficient outcome.
3. ***Polluting Monopolist*** (***): John has a monopoly in the oil refinement market. The oil demand function is $P = 80 - Q$ and the marginal revenue is $MR(Q) = 80 - 2 \cdot Q$. The private marginal cost is $MC = 10$. During the refinement process, air, water, and soil pollution occurs at a constant cost of \$5 per unit of oil. Support the answers to the questions below by using a graph.
   a. What are the profit maximizing price and quantity?

   b. What are the efficient price and quantity?
   c. Calculate the deadweight loss associated with the monopoly situation? Should the government tax emissions? If yes, at what rate? If no, why?
4. ***Pollination*** (***): Pollination by bees is very important for plant reproduction and substantial fees are paid to beekeepers (Rucker et al., 2012). Imagine a beekeeper and an apple orchard farmer being neighbors. Note this is a situation of a positive externality. The beekeeper receives the revenue from selling honey but in the absence of any payments, does not receive any money for the bees pollinating nearby orchards or fields. Suppose that one beehive (H) can pollinate one hectare. The pollination of an hectare without the bees costs \$20. The beekeeper can sell the honey from a beehive at \$50. The total cost of the beekeeper is $TC = H^2 + 20$ and marginal costs $MC = 2 \cdot H$. Support the answers to the questions below by using a graph.
   a. How many hives would the beekeeper maintain if operating independently of the farmer?
   b. What is the socially efficient number of hives?
   c. In the absence of transaction costs, what outcomes do you expect to arise from bargaining between the beekeeper and the farmer?
   d. How high would total transaction costs have to be to erase all gains from bargaining?
5. ***Efficient Polluting Monopolist*** (**): Externalities and monopoly power lead to a deadweight loss when looked at separately. Using a graph, illustrate the case where a polluting monopolist can be efficient in the absence of any intervention. Draw a linear demand function and the corresponding marginal revenue function. Next, draw an upward sloping marginal cost function starting at the origin (note that the result does not change if you draw the marginal cost function with an intercept). Determine the profit maximizing output and price. Next draw an external marginal cost function such that the initially determine quantity and output are efficient, i.e., with no deadweight loss.