

# Introduction to Microeconomics for Engineers and Technical Managers



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INTRODUCTION TO MICROECONOMICS  
FOR ENGINEERS AND TECHNICAL  
MANAGERS



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# 1. An Introduction to Economics – Microeconomics

## 1.1. What is economics? Microeconomics - Macroeconomics

*Why is economics important to you?* Every day we have to make economic decisions; for example, we go to the supermarket and buy different things, we save our money, or firms make investment decisions. Firms allocate limited resources to produce different products, seek to make profit, and try to maximize their profit. Economics can help good decision making.

There are several definitions of economics. Economics is actually one of the social sciences. Economics can be divided into two branches (Figure 1.1):

- **Microeconomics and**
- **Macroeconomics.**

**Microeconomics:** The branch of economics that deals with the functioning of individual industries and the behaviour of individual decision-making units – business firms, household and government.

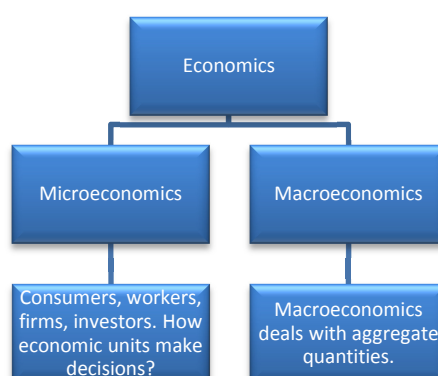
We can think of

- consumers,
- workers,
- (domestic or foreign) business firms,
- governmental units

as the decision makers of the economy.

Microeconomics deals with issues such as the market mechanism, business firm profit maximization, optimal consumer choice, allocation of scarce resources, perfect competition, market failure, and market equilibrium.

Figure 1.1 Economics can be divided in two parts: microeconomics and macroeconomics



There are three main tools of microeconomics (Besanko-Braeutigam, 2011: 6, 12, 20):

- Constrained optimization – an analytical tool for making the optimal choice, taking into account limitations or restrictions on choice.
- Equilibrium analysis – this is used to analyse and describe a condition or state that could continue indefinitely in a system, or at least until there is a change in some exogenous variable.
- Comparative statistics – analysis used to examine how a change in some exogenous variable affects the level of some endogenous variable in an economic system.

**Macroeconomics:** The branch of economics that deals with the operation of the economy as a whole. Macroeconomics focuses on the determinants of total national income, deals with aggregates such as aggregate consumption and investment and looks at the overall level of prices rather than individual prices.

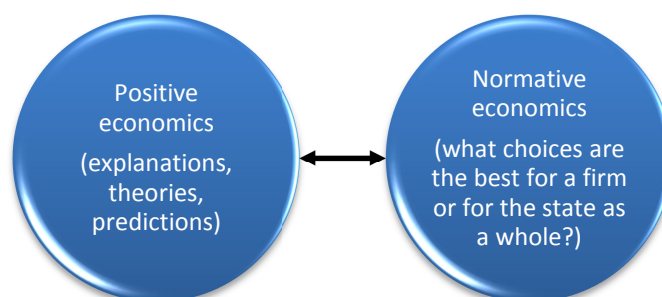
The economic units which have a similar part to play in the economy are referred to as economic sectors. Macroeconomics deals with the economy as a whole or with aggregates, such as the:

- household sector,
- business firm sector,
- government sector,
- banking sector,
- the rest of the world.

Macroeconomics treats issues and problems related to economic growth, sustainable development, employment, unemployment, inflation, economic and social institutional systems, and the business cycle. When we examine economic sectors, we disregard the relationships within the same sector. We ignore the circular flow of incomes, expenditures, and products within a sector, while concentrating on the circular flow of incomes, expenditures and goods and services between sectors.

We can distinguish between positive and normative economics (Figure 1.2). **Positive economics** focuses on facts and presents scientific statements about the economy and the actors of economy behaviour without value judgments. **Normative economics** (as opposed to positive economics) makes value judgments about the economy, more exactly what the economy should be like or what policy action and goals should be recommended.

Figure 1.2 Positive economics and normative economics



## 1.2. Markets, prices, income



Picture 1.

“We can divide individual economic units into two broad groups according to *function - buyers and sellers*. Buyers include consumers, who purchase goods and services, and firms, which buy labour, capital, and raw materials that they use to produce goods and services. Sellers include firms, which sell their goods and services; workers who sell their labour services; and resource owners, who rent land or sell mineral resources to firms. (Pindyck – Rubinfeld, 1998)”

The most important elements of the market are price, income, demand and supply.

We can establish that a market of a product is a group of buyers and sellers and a market contains their interactions. Generally sellers determine the supply of products or services, and buyers determine the demand for products or services.

### *Prices*



We can distinguish two prices: the nominal and the real price.

The nominal price of a product is simply its absolute price. For example, if you go to the supermarket to purchase a bottle of cola (1 litre), you have to pay 1.2 EUR for this product. This means that you pay the nominal price. The nominal price is not equal to the real price.

For example, suppose that the nominal price of one litre of cola was about 1 EUR in 2000 and it was about 1.2 EUR in 2013. These are the prices you would have had to pay in supermarkets in those years. The real price of a good is the price relative to an aggregate measure of prices. Generally the Consumer Price Index (CPI) is used as an aggregate measure.

### *Consumer price index - CPI*

The consumer price index is the amount of the cost of purchasing a “given market basket”, which includes consumer goods and services.

The GDP deflator is equal to the ratio of nominal GDP and Real GDP.

What is the difference between the gross domestic product deflator and the consumer price index?

Actually, the CPI contains a narrower set of goods and services than GDP. The GDP deflator is the price index of all the goods produced in the country, both consumption goods and investment goods, while the CPI only represents the prices of consumption goods.

Let’s assume that the market basket contains only 80 kilograms of bread, 20 litres of milk and 50 litres of petrol. In the base year, the cost of the market basket is 41 100 HUF. In the current year, the cost of these consumer goods is 51 600 HUF. We can calculate the consumer price index, if we divide the cost of the market basket for the current year by the base year cost of the same basket and then multiply this ratio by 100:

$$CPI = \frac{80\text{kg} \cdot 320\text{HUF/kg} + 20\text{l} \cdot 200\text{HUF/l} + 50\text{l} \cdot 440\text{HUF/l}}{80\text{kg} \cdot 250\text{HUF/kg} + 20\text{l} \cdot 180\text{HUF/l} + 50\text{l} \cdot 350\text{HUF/l}} \cdot 100 = 1.25547$$

The value of the price index is 1.256. This means that the cost of the market basket in the current year was 25.6% higher than its cost in the base year.

After correcting for inflation *if we respect the real price*, coca cola was more expensive in 2000 than 2013?

To find out, let's calculate the price year 2013 of coca cola in terms of 2000 Euros. For example CPI was 25.38 in 2000 and rose to about 38.07 in 2013. In 2000 Euros, the price of coca cola was therefore

$$\frac{25.38}{38.07} \cdot 1.2 = 0.8\text{ EUR} .$$

In real terms the price of coca cola was lower in 2013 than it was in 2000. Put another way, the nominal price of coca cola went up by about 20%, since the nominal price the nominal price of one litre of coca cola was 1 EUR in 2000 and it was 1.2 EUR in 2013. The CPI went up by 50%, which means that coca cola prices fell relative to inflation.

$$\text{Real price of coca cola in 2013} = \frac{CPI_{2000}}{CPI_{2013}} \cdot \text{nominal price in 2013} ,$$

The real price of coca cola in 2006 Euros:

$$\text{Real price of coca cola in 2010} = \frac{CPI_{2006}}{CPI_{2010}} \cdot \text{nominal price in 2010} ,$$

$$\text{Real price of coca cola in 2013} = \frac{CPI_{2006}}{CPI_{2013}} \cdot \text{nominal price in 2013} .$$

(On the basis of Pindyck – Rubinfeld, 2012)

### **Income/wages**

We can make a distinction between nominal and real wages.

#### **Example 1.1:**

Suppose Mary's nominal wage was 120 000 HUF last year, and the average price of one pair shoes was 10 000 HUF. If Mary purchased only shoes, she could buy 12 pairs. Suppose the price of shoes increased and now the price of one pair of shoes is 20 000 HUF. In this case Mary can buy only six pairs of shoes. Mary's nominal wage is not changed, but the real wage is lower than earlier, because the average prices of shoes went up.

$$\text{Percentage change in real wage} = \frac{\text{Percentage change in nominal wage}}{\text{Percentage change in price level (index)}}$$

### 1.3. Terms and Questions

consumer price index (CPI),  
economics,  
GDP deflator,  
macroeconomics,  
market,  
microeconomics,  
nominal price,  
nominal wage,  
normative economics  
positive economics,  
real price,  
real wage.

#### *Problems*

#### *Theoretical questions*

1. What is the difference between real and nominal wages?
2. Give the definition of a market.
3. How can we calculate the Consumer Price Index?
4. Explain how the real wage is calculated.
5. Explain what the difference is between the nominal price and the real price.
6. What is the difference between normative and positive economics? Give an example of each.
7. Which of the following statements refer to positive economic analysis and which to normative analysis?

- a) Frosty weather in Hungary can lead to an increase in the price of apples.
  - b) The government should increase taxes on cigarettes.
  - c) If the interest rate increases, investment will decrease.
  - a) It is very important to subsidize flood victims.
8. Which of the following statements belong to normative and which to positive economics?
- a) The inflation rate decreased by 3.1 percentage points last year.
  - b) The unemployment rate increased by 5.2 percentage points and should be reduced by the national employment policy.
  - c) The demand for labour is falling and it is time to reduce taxes on labour earnings and so, as a result, labour costs will fall too.
  - d) Improving the quality of health and life is a very important challenge in the European Union member states.
  - e) The value of GDP decreased by 4.2% last year.

**Calculation exercises**

9.

Fill in the table and give an explanation for the data:

The prices of apples/kg in HUF

	2010	2011	2012
<b>CPI</b>	3.2	3.6	2.8
<b>Nominal prices</b>	220		280
<b>Real prices (in 2010 HUF)</b>		292.5	

## 2. Supply and demand analysis

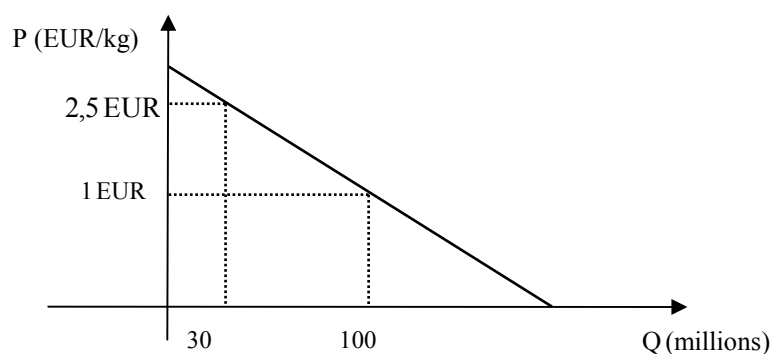
In this chapter, we analyse the demand and supply curve; we try to understand the market mechanism and determine the equilibrium point in a market. We describe the main characteristics of supply and demand.

### 2.1. The demand and supply curve

#### *The demand curve*

The demand curve shows the quantity of goods that consumers are willing to purchase at different prices. The demand curve for apples shows us the quantity of apples that consumers are willing to purchase at different prices (Figure 2.1).

Figure 2.1 The demand curve for apples



The vertical axis shows the price of apples, measured in Euros per kilogram. The horizontal axis shows the total quantity demanded in a given period.



For example, if the price of apples is 1 EUR per kilogram, the quantity demanded is 100 million kilograms, while if the price is 2.5 EUR the demand for apples would be only 30 million kilograms (Figure 2.1).

The demand curve represents the aggregate demand for apples from all the apple buyers in the market. Apples can be an intermediate good or a final good. If apples are an intermediate good, this means that the demand for apples depends on the demand(s) of producers, who use apples in their production process, such as when they produce apple juice.

The demand curve (Figure 2.1) shows that if the price is higher, the quantity demanded is lower. There is a negative relationship between price and the quantity demanded. This means that the slope of the demand curve is downward, because consumers are willing to buy more if the price is lower. The higher the price of a given product, the lower the quantity demanded, if all other factors that influence demand are fixed. It is very important to remember that many other factors can affect the quantity demanded, such as consumers' income, consumer tastes, prices of complementary goods and substitute goods, and prices of the factors of production.

When we draw the demand curve (Figure 2.1), we suppose that other factors, with the exception of price, are constant.

The general form of the demand curve is the following:

$$Q^D = Q^D(p).$$

*Quantity demanded* is the amount of a good that consumers are willing and able to buy. The *demand curve* is a graph of the relationship between the price and quantity demanded of a given good.

### *The law of demand*

There is an inverse relationship between the price of a given good and the quantity demanded of the good when all other factors influencing demand are constant.

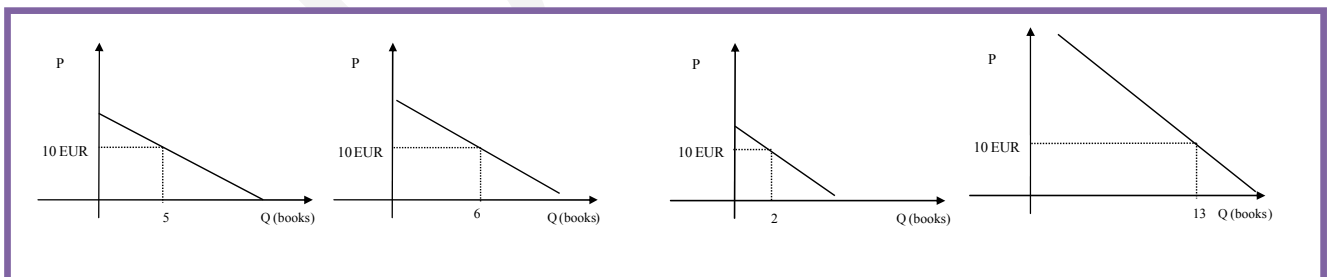
### *Market demand and individual demand*



Picture 4.

The market demand is the sum of individual demands. When we wish to determine the market demand curve, we have to add the individual demand curve horizontally. Let's assume that the market for economics textbooks has only three buyers (Figure 2.2). For example, if the price of economics book is 10 EUR, the first buyer is willing to buy 5 books. The second consumer's demand is 6 books, and the third consumer demands only 2 books. In this case the aggregate demand is 13 books at a price of 10 EUR (Figure 2.2).

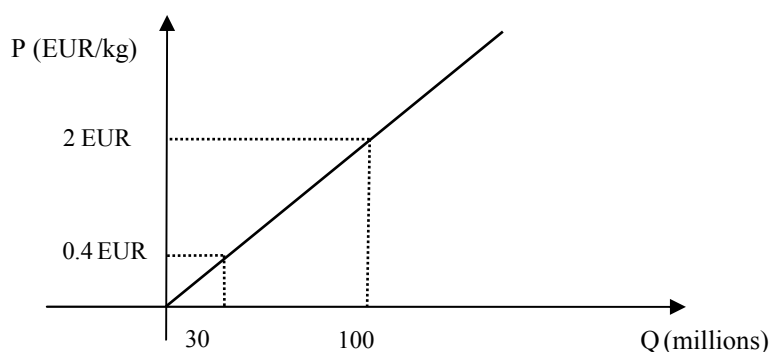
Figure 2.2 Market demand curve



### *Supply curve*

The supply curve shows the quantity of goods that suppliers are willing to sell at different prices. The supply curve of apples shows us the quantity of apples that suppliers are willing to sell at different prices (Figure 2.3).

Figure 2.3 The supply curve of apples



The vertical axis shows the price of apples, measured in Euros per kilogram. The horizontal axis shows the total quantity supplied in a given period.

For example, if the price of apples is 2 EUR per kilogram, the quantity supplied is 100 million kilograms, while if the price is 0.4 EUR the supply of apples would be only 30 million kilograms.

The supply curve represents the aggregate supply of apples from all the apple suppliers in the market.

The supply curve (Figure 2.3) shows that if the price is higher, the quantity supplied is higher too. There is a positive relationship between price and quantity supplied. This means that the supply curve slopes upward, because more suppliers are willing to produce more products and sell if the price is higher. At a higher price more firms can expand production in the short run, employing more workers or introducing overtime work. The higher the price of a given product, the higher the quantity supplied, if all other factors that influence supply are constant. It is very important to remember that many other factors can affect the quantity supplied, such as prices of the factors of production and the prices of other goods. When we draw the supply curve (Figure 2.3), we suppose that other factors, with the exception of price, are constant.

The general form of the supply curve is the following:

$$Q^S = Q^S(p).$$

*Quantity supplied* is the amount of a good that producers are willing and able to sell. The *supply curve* is a graph of the relationship between the price and quantity supplied of a given good.

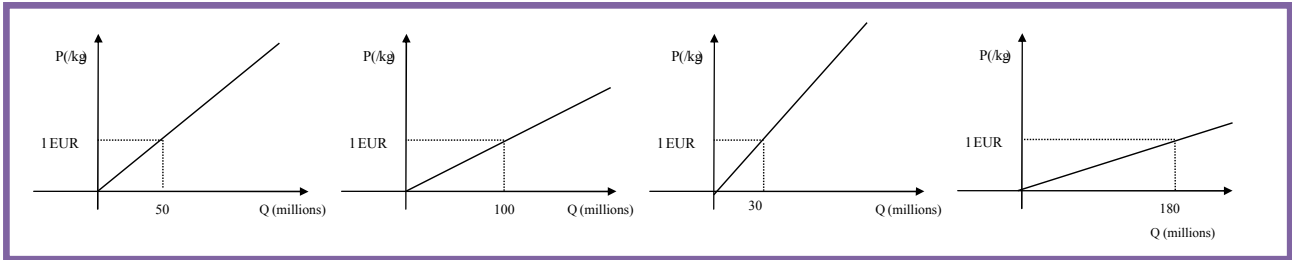
#### *The law of supply*

There is positive relationship between the price of a given good and the quantity demanded of the good when all other factors influencing demand are constant.

#### **Market supply and individual supply**

Similarly to the demand curve, the market supply is the sum of the suppliers' supply. When we would like to determine the market supply curve, we have to add the individual supply curve horizontally (Figure 2.4).

Figure 2.4 Market supply curve



**Law of demand and supply**

There is a negative (positive) relationship between price and quantity demanded (supplied) when all other factors that influence demand (supply) are held fixed.

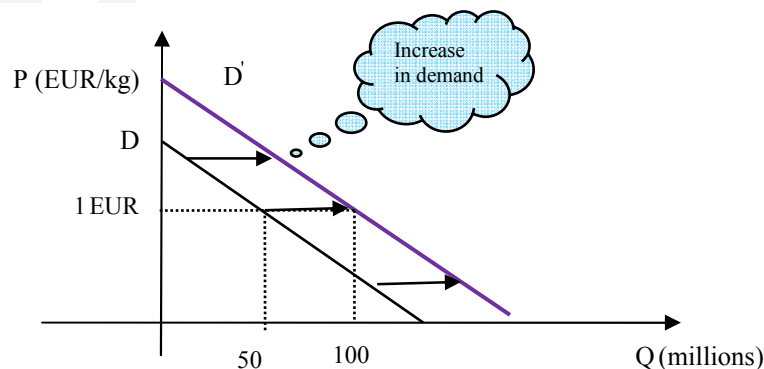
**2.2. Shifts in demand and supply**

As we mentioned, the supply of products and demand for products are determined by the price and other factors such as costs of production, the price of complementary goods or substitute goods, and consumer’s preferences. So far in this chapter, we have supposed that all factors, except for the price of the good, are fixed. Often we want to analyse the effect of change in other variables on the demand or supply curve.

**Shifts in the demand curve**

Suppose that the consumers’ income increases; in this case consumers are able to buy more goods than before, and so the quantity demanded increases at the same price level (Figure 2.5). The demand curve shifts to the right. This is called an increase in demand. If the price of a substitute good decreases, the quantity demanded of the given good decreases, because the substitute good is, relatively speaking, cheaper than before, and the demand for this good may increase. In this case the demand curve shifts to the left, and the quantity demanded decreases at every price.

Figure 2.5 Shift in the demand curve



Any change that increases the quantity which consumers wish to buy at any given price shifts the demand curve to the right. If we suppose that all influencing factors of demand for a good are constant, except for the price, the changes in prices are transmitted to the changes in the quantity demanded. In this case there is a movement on the curve; if the price increases the demand decreases.

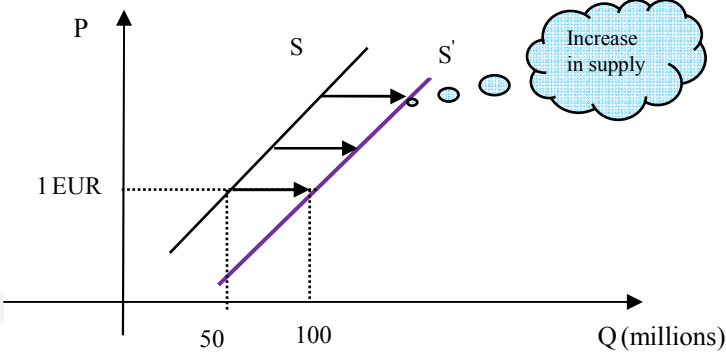
**Shifts in the supply curve**



Picture 5.

The quantity supplied of frozen yoghurt increases as the price of frozen yoghurt increases too, on condition that other things remain constant. Suppose that one factor of yoghurt production changes, for example, the price of fruit decreases. In this case the suppliers of frozen yoghurt are willing to produce more frozen yoghurt, because production can be more profitable. This means the quantity supplied increases (Figure 2.6). The supply curve shifts to the right. This is called an increase in supply. If the price of frozen yoghurt cartons increase, the production is relatively less profitable and the supply of frozen yoghurt may decrease. In this case the supply curve shifts to the left, and the quantity supplied decreases at every price.

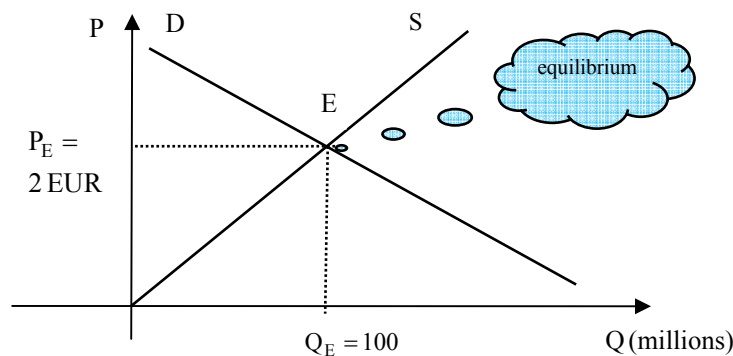
Figure 2.6 Shift in the demand curve



**2.3. Market equilibrium – The equilibrium of supply and demand**

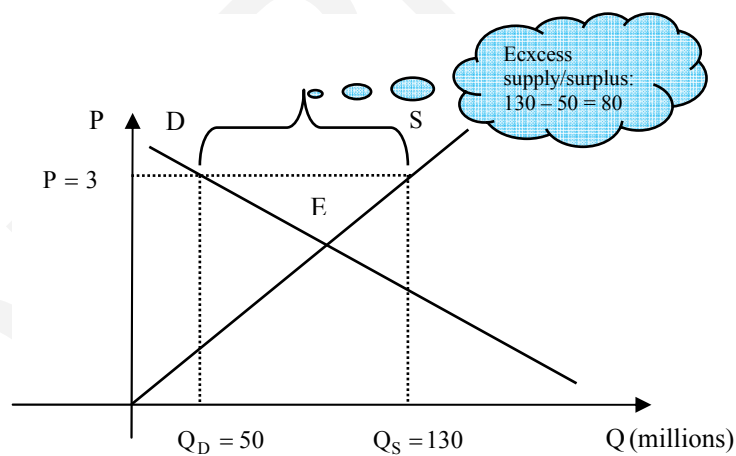
Let’s draw the demand and supply curve in the same coordinate system. The demand curve and supply curves intersect each other at the equilibrium (E) point (Figure 2.7). At the E point, the market is in equilibrium, the price is called the equilibrium price and the quantity is called the equilibrium quantity. The equilibrium price and quantity are determined by the intersection of demand and supply curves (Figure 2.7). The equilibrium price is called the market-clearing price, because, at this price, there is no longer a tendency for change. At the equilibrium point, the quantity sellers want to supply is equal to the quantity consumers want to purchase.

Figure 2.7 Market equilibrium



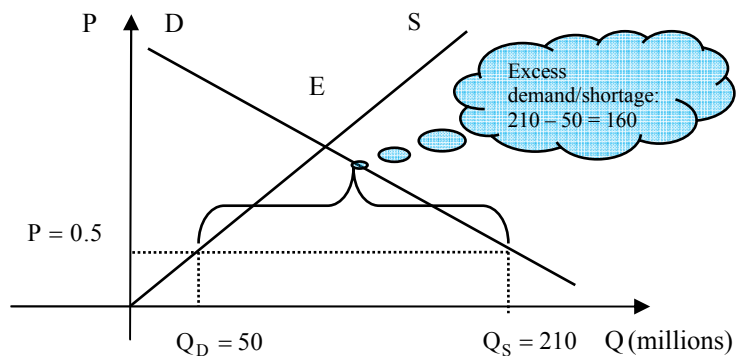
If the price is greater than the equilibrium price, the quantity demanded is lower than the quantity supplied. When the price is above the equilibrium point, suppliers are willing and able to sell a greater quantity than buyers want to purchase (Figure 2.8). This situation is called surplus (excess supply), i.e., the quantity supplied is greater than the quantity demanded. In the case of a surplus, suppliers are not able to sell all the quantity that they want. This means that they decrease their prices and the market price decreases until the market reaches its equilibrium.

Figure 2.8 Market surplus



If the price is lower than the equilibrium price, the quantity demanded is greater than the quantity supplied. In this case the price can be found below the equilibrium point; suppliers are willing and able to sell a smaller quantity than buyers want to buy (Figure 2.9). This market situation is called a shortage (excess demand), i.e., the quantity demanded is greater than the quantity supplied. In the case of a shortage, buyers are not able to purchase all the quantity that they want. Suppliers increase their prices and the price grows until the market reaches equilibrium.

Figure 2.9 Market shortage



**Equilibrium:** a situation in which the market price ( $P_E$ ) has reached the level at which quantity supplied equals quantity demanded ( $Q^S = Q^D$ ). The intersection of the supply and demand curves determines the market equilibrium.

**Equilibrium price:** the price ( $P_E$ ) that balances quantity supplied and quantity demanded.

**Equilibrium quantity:** the quantity supplied ( $Q_S$ ) and the quantity demanded ( $Q_D$ ) at the equilibrium price.

**Excess supply – surplus:** a situation in which the quantity supplied is higher than the quantity demanded ( $Q^S > Q^D$ ).

**Excess demand – shortage:** a situation in which the quantity demanded exceeds the quantity supplied ( $Q^S < Q^D$ ).

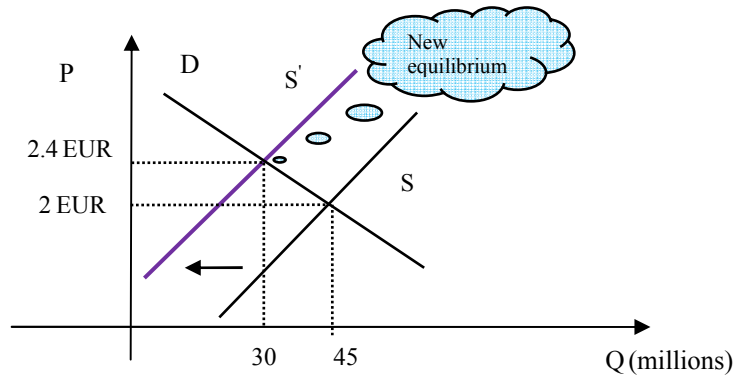
(Mankiw, 2008: 78)

### *Analysis of changes in equilibrium*

Suppose that one year ago in the spring the weather was very bad. There was a hailstorm. It seems that the hailstorm spoilt the apricot harvest, and the price of apricots increased. How does this event affect the market for apricot jam?

The change in the price of apricots affects the supply curve of apricot jam, in the sense that apricots are a very important ingredient of the jam. The increased price raises the cost of production, and reduces the quantity produced that firms sell, at any given price. The supply curve shifts to the left because the amount that firms are willing and able to sell is reduced at every price (Figure 2.10). In this case the equilibrium price increases and the equilibrium quantity decreases, because the quantity demanded is lower at higher prices.

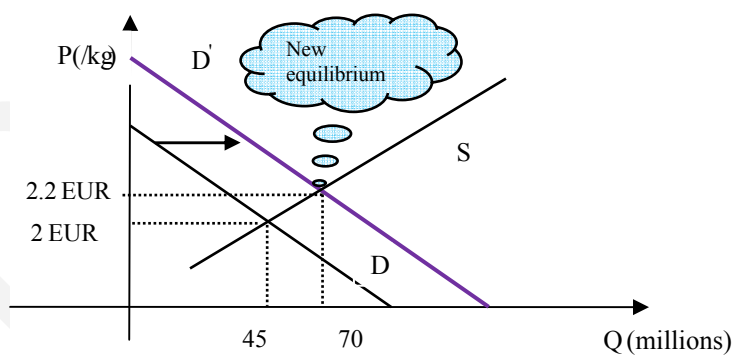
Figure 2.10 A shift in supply



Suppose that one autumn consumers' demand for apricot jam increases. How does this event affect the market for apricot jam?

The increased demand means that buyers want to purchase more jam at any given price. While the supply curve is unchanged, the demand curve shifts to the right (Figure 2.11). The demand curve shifts to the right because, at every price, the amount that buyers are willing and able to buy has increased (Figure 2.11). The increased quantity demanded raises the price of apricot jam. In this case, the equilibrium price increases and the equilibrium quantity also increases. The equilibrium price increases from 2 EUR to 2.2 EUR and the equilibrium quantity increases from 45 to 70 jars (Figure 2.11).

Figure 2.11 A shift in demand



## 2.4. Terms and Questions

demand curve,  
equilibrium,  
equilibrium price,  
equilibrium quantity,  
excess demand,  
excess supply,  
law of demand,  
law of supply,  
market demand,  
market equilibrium,  
market supply,  
quantity demanded,  
quantity supplied,  
shifts in demand,  
shifts in supply,  
supply curve  
surplus.

### *Problems*

#### ***Theoretical questions***

1. What is the difference between market demand and individual demand?
2. Give the definition of the demand curve.
3. How can we calculate the equilibrium quantity?
4. Explain how the equilibrium price is calculated.
5. Give the definition of the quantity supplied.
6. Explain how to derive the demand curve.

7. What happens to the demand curve if consumers' disposable incomes rise?
8. What happens to the supply curve if the costs of production increase?
9. Explain the law of demand.
10. What is the law of supply?

### ***Calculation exercises***

11.  
Which of the following demand functions obey the law of demand?

- a)  $Q^D = 500 - 2 \cdot P$ ,
- b)  $Q^D = 500 + 2 \cdot P$ ,
- c)  $Q^D = 800 - 2 \cdot P^{1/2}$ ,
- d)  $Q^D = 3 \cdot P + 1000$ ,
- e)  $Q^D = -4 \cdot P + 1200$ ,
- f)  $Q^D = -5 \cdot P - 1600$ .

12.  
The demand for a good is represented by  $Q^D = 500 - 2 \cdot P$ , where  $P$  is the price of the given good. The supply curve is the following:  $Q^S = 250 + 3 \cdot P$ .

- a) Graph the demand and supply curves and show the equilibrium price and quantity.
- b) Compute the equilibrium price and quantity.

13.  
Consider the market for a good, which can be expressed as:

Demand function:  $Q^D = 30 - P$

Supply function:  $Q^S = 10 + P$

- a) What are the equilibrium price and quantity?
- b) Illustrate the equilibrium in a diagram.
- c) Show and compute the surplus if  $P = 20$ .

14.

An economist has estimated three relationships for a given market:

Market 1  $Q^S = 5400 + 720 \cdot P$  and  $Q^D = 10650 - 798 \cdot P$

Market 2  $Q^S = 2700 + 12 \cdot P$  and  $Q^D = 3000 - 12 \cdot P$

Market 3  $3 \cdot Q^S = 3000 + 12 \cdot P$  and  $Q^D = 9000 - 18 \cdot P$

- a) Find the equilibrium price and quantity where possible.
- b) Explain your solution briefly.

15.

Suppose that the demand and supply for sweet cakes are as follows:  $Q^D = 1000 - 4 \cdot P$ ,  $Q^S = 200 + 16 \cdot P$ , where  $P$  is the price of the given good,

- a) Plot the demand and supply curves on a graph and show the equilibrium price and quantity.
- b) Compute the equilibrium price and quantity.
- c) Now, suppose that a change in the price of savoury cakes causes demand to become:  $Q^D = 800 - 4 \cdot P$ .  
Compute the new equilibrium price and quantity. What has changed?
- d) Suppose that the government introduces a tax of 20% (of the sales price) levied on consumers. This means that consumers have to pay an additional 20% for one box of cakes. Calculate the new equilibrium price and quantity and compare it to the first equilibrium. What has changed?

### 3. Utility function - Marginal utility theory

In this chapter, we focus on consumer choice and consumer's utility. We try to understand the concept of marginal utility. We can distinguish two types of ranking: cardinal and ordinal. Cardinal ranking shows the intensity of a consumer's preferences. We can measure the utility of one consumer basket. The cardinal approach to consumer behaviour assumes that the utility obtained from consuming a unit of a good can be measured. Ordinal rankings show the order in which consumers rank baskets.



Picture 6.

Suppose we have the possibility to choose from among three baskets (*A*, *B*, *C*). Basket '*A*' contains three kilograms of apples and two kilograms of pears. Basket '*B*' contains two kilograms of apples and three kilograms of pears. Basket '*C*' contains four kilograms of apples and one kilogram of pears. If the consumer prefers basket '*A*' to basket '*B*' and prefers basket '*B*' to basket '*C*', the order of the three baskets is the following: *A*, *B*, *C*.

In this case, we do not know by how much the consumer prefers *A* to *B* or *C*.

In this chapter we suppose that the utility of one consumer's basket can be measured.

#### 3.1. The concept of utility – Total Utility (TU)

Let's assume that Richard is very hungry and would like to eat some sandwiches. If Richard does not consume a sandwich, he does not get satisfaction from consuming sandwiches ( $TU=0$ ) (Table 3.1). If he consumes 1 sandwich, he gets 8 'units' of satisfaction, which is his total utility. If he consumes one more sandwich, he gains less satisfaction (Table 3.1).



Picture 7.

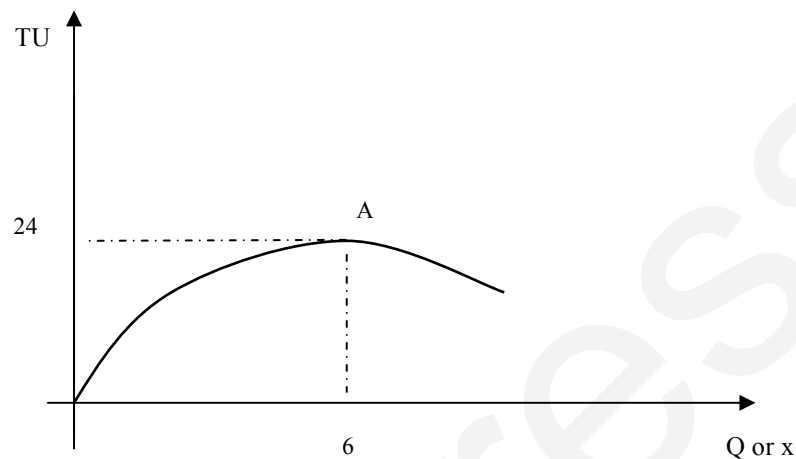
Table 3.1 Richard's utility from consuming sandwiches (daily)

Q	TU	MU
0	0	-
1	8	8
2	14	6
3	18	4
4	21	3
5	23	2
6	24	1
7	22	-2

This means that Richard's total utility from consuming one more sandwich increases. However the increment in total utility decreases until total utility reaches the maximum point. After the maximum point total utility declines (Table 3.1; Figure 3.1).

Try to plot Richard's utility function. Denote as  $x$  the number of sandwiches ( $Q$ ) he buys on Monday, and as  $y$  the total utility ( $TU$ ) that Richard obtains from buying  $x$  sandwiches (Figure 3.1). Total utility shows the level of Richard's satisfaction if he consumes one sandwich.

Figure 3.1 Richard's total utility function



Consumers purchase goods and services because they get satisfaction from them. Economists call this satisfaction *utility*.

**Utility** is the level of satisfaction that consumer gets from consuming a good.

The utility function (Figure 3.1) illustrates that Richard is more satisfied if he eats more sandwiches, until he has eaten six. After consuming six sandwiches Richard's satisfaction decreases. This means that the total utility increases to point  $A$ .

**Utility function** measures the level of satisfaction a consumer receives from any basket of goods or/and services.

**Total utility** is the total satisfaction a consumer receives from all those units of a good consumed within a given period.

## 3.2. Marginal Utility (MU)

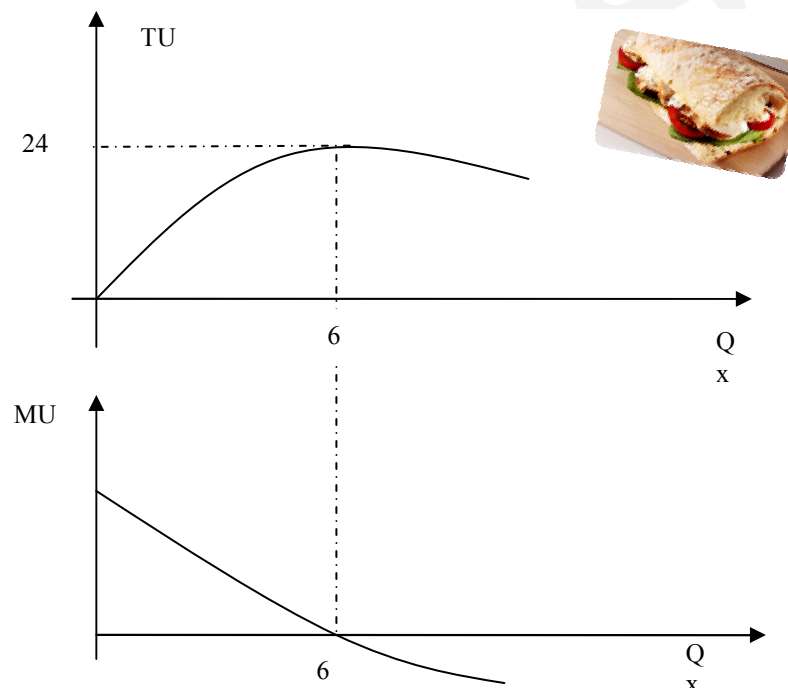
Generally we want to know how the level of Richard's satisfaction will change in response to a change in the level of consumption. The marginal utility measures the change in total utility as the level of consumption rises.

**Marginal utility (MU)** is the additional satisfaction gained from consuming one extra unit within a given period of time.

$$MU_x = \frac{\Delta TU}{\Delta x}$$

The more goods Richard consumes, the larger will be his total utility. However, as he becomes more satisfied, each extra unit that he consumes will probably give him less additional utility than previous units. This means that his marginal utility decreases as he consumes more. This is known as the principle of *diminishing marginal utility*. For example, the second sandwich gives Richard less additional satisfaction than the first sandwich and the third sandwich gives him less satisfaction than the second sandwich (Figure 3.2).

Figure 3.2 Total and Marginal utility



At a certain level of consumption, Richard's total utility will be at a maximum, and marginal utility will be zero. Richard desire for sandwiches may be fully satisfied at 6 per day.

The marginal utility at a given point is represented by the slope ( $\frac{\Delta U}{\Delta x}$ ) of a line that is tangent to the total utility curve at that point.

- The *MU* curve slopes downward. This simply illustrates the principle of diminishing marginal utility.
- The *TU* curve starts at the origin, because zero consumption yields zero utility.
- The *TU* curve reaches its maximum point when marginal utility is zero. When marginal utility is zero there is no addition to total utility.

- Marginal utility can be derived from TU:

$$MU = \frac{\Delta TU}{\Delta Q}$$

- Marginal utility is the first derivative of total utility. In other words, marginal utility is the rate of the change of in total utility:

$$MU = \frac{dTU}{dQ}$$

- Marginal utility is the slope of the total utility function.

**Principle of diminishing marginal utility:** The marginal utility declines as consumption of good increases.

**Example 3.1.** Assume that we want to consume a given basket that contains two goods (x, y). Suppose that the total utility function is the following:

$$TU = 3 \cdot \sqrt{x}$$

The marginal utility is

$$MU = \frac{dTU}{dx} = \frac{d(3 \cdot \sqrt{x})}{dx} = \frac{3}{2 \cdot \sqrt{x}}$$

“The marginal utility of any one good is the rate at which total utility changes as the level of consumption of the good rises, holding constant the levels of consumption of all other goods. In the case in which only two goods are consumed and the utility function is  $U(x,y)$ , the marginal utility of x good  $MU_x$  measures how the level of satisfaction will change  $\Delta U$  in response to a change in the consumption of x good  $\Delta x$ , holding the level of y constant:

$$MU_x = \left. \frac{\Delta TU}{\Delta x} \right|_{y=\text{const}}$$

The marginal utility of y good  $MU_y$  measures how the level of satisfaction will change  $\Delta U$  in response to a change in the consumption of x good  $\Delta y$ , holding the level of x constant:

$$MU_y = \left. \frac{\Delta TU}{\Delta y} \right|_{x=\text{const}}$$

(Besanko - Braeutigam, 2011:82)

**Example 3.2.** Suppose that the total utility function is the following:

$$TU = 3 \cdot \sqrt{x \cdot y}.$$

The marginal utility of x good is  $MU_x = \frac{dTU}{dx} = \frac{d(3 \cdot \sqrt{x \cdot y})}{dx} = \frac{3 \cdot \sqrt{y}}{2 \cdot \sqrt{x}}$ , and the marginal utility of y good  $MU_y = \frac{dTU}{dy} = \frac{d(3 \cdot \sqrt{x \cdot y})}{dy} = \frac{3 \cdot \sqrt{x}}{2 \cdot \sqrt{y}}$ .

DUPress

### 3.3. Terms and Questions

cardinal ranking,  
marginal utility,  
ordinal ranking,  
principle of diminishing marginal utility,  
total utility,  
total utility function,  
utility.

#### *Problems*

#### *Theoretical questions*

1. What is the difference between cardinal ranking and ordinal ranking?
2. Give the definition of utility.
3. How can we calculate marginal utility?
4. Explain how the slope of the utility function at a given point is calculated.
5. Explain what the difference is between marginal utility and total utility.
6. How can the marginal utility function be illustrated?
7. Give the definition of marginal utility.
8. Give an example of ordinal rankings.
9. Give the definition of total utility.
10. Explain the principle of diminishing marginal utility.

### Calculation exercises

11.

You are given the following information about quantity and total utility data for consumption of x good:

Q	TU	MU
0	0	
1	80	
2	140	
3	180	
6	190	
8	195	

- Fill in the marginal utility column.
- Plot the total and marginal utility data on a diagram.

12.

A consumer's typical utility function for a good might be of the form:

$$TU = 80 \cdot Q - 2 \cdot Q^2,$$

where  $Q$  is the quantity of the good consumed.

- Calculate the missing values in the table.

Q	$80 \cdot Q$	$-2 \cdot Q^2$	TU	MU
0				
1				
2				
3				
4				
5				
6				

- Calculate the maximum level of total utility.
- Give the marginal utility function.

13.

Assume that Peter's utility function is:

$$TU = 30 \cdot Q - 5 \cdot Q^2$$

- Give the marginal utility function.
- What is the maximum of total utility?

14.

Consider the utility function:  $U(x, y) = x \cdot \sqrt{y}$ .

- Determine the marginal utility function for x goods.
- Determine the marginal utility function for y goods.
- Does the consumer believe that more is better for x goods?
- Does the consumer believe that more is better for y goods?
- Is the marginal utility of x diminishing?
- Is the marginal utility of y diminishing?

15.

You are given information about the quantity of cakes consumed, total utility and marginal utility:

Q (cakes)	TU	MU
0		
1	16	
2	24	
5	42	
6		5
8		3
10		
12	55	0
13	53	
14	49	

- Calculate the missing values in the table.

16.

Assume that Kate's utility function is:

$$TU = 500 + 100 \cdot Q - 12.5 \cdot Q^2$$

- Give the marginal utility function.
- What is the maximum of total utility?

## 4. Elasticity of demand – elasticity of supply

In this chapter, we examine the concept of elasticity, the types of elasticity often applied, and the relationship between total revenues and elasticity of demand. Elasticity measures how much consumers react to changes in variables such as prices and incomes.

### 4.1. Price elasticity of demand

The price elasticity of demand ( $\epsilon_{Q,P}$ ) measures the responsiveness of the quantity demanded of a good or service to changes in its price. The price elasticity of demand shows the percentage change in the quantity demanded caused by a 1 percent change in price:

$$\epsilon_{Q,P} = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}},$$



Picture 8.

$$\epsilon_{Q,P} = \frac{\Delta Q}{Q} : \frac{\Delta P}{P},$$

where percentage change in quantity:

$$\frac{\Delta Q}{Q} \cdot 100\%,$$

percentage change in price:

$$\frac{\Delta P}{P} \cdot 100\%.$$

$\Delta Q$  shows the change in quantity demanded and  $\Delta P$  shows the change in price. The change in quantity demanded is calculated by subtracting the previous (original) quantity demanded ( $Q_1$ ) from the new (changed) quantity demanded ( $Q_2$ ):

$$\Delta Q = Q_2 - Q_1.$$

Similarly, the change in price is equal to the difference between the new price and the original price:

$$\Delta P = P_2 - P_1.$$

How can we calculate the value of Q and P?

We can apply two methods to calculate elasticity of demand, and the value of Q and P.

The first method is the standard procedure:

$$\epsilon_{Q,P} = \frac{\Delta Q}{Q} : \frac{\Delta P}{P} = \frac{Q_2 - Q_1}{Q_1} : \frac{P_2 - P_1}{P_1}.$$

In this procedure we choose the original quantity and the original price to determine the price elasticity of demand. However, the new price and quantity is often used in this calculation.

The second procedure is the midpoint method:

$$\varepsilon_{Q,P} = \frac{\Delta Q}{Q} \cdot \frac{\Delta P}{P} = \frac{Q_2 - Q_1}{(Q_1 + Q_2)/2} \cdot \frac{P_2 - P_1}{(P_1 + P_2)/2}$$

This latter method is much better than using original (new) price and original (new) quantity, because we get different results using the different original values or new values. So, we apply only the midpoint method, calculating elasticity independently of the type of elasticity.

**Example 4.1:**

Suppose that the price of a given good is 12 EUR ( $P_1 = 12$ ) and the quantity demanded is 100 units ( $Q_1 = 100$ ). When the price increases to 18 EUR ( $P_2 = 18$ ), the quantity demanded decreases to 80 units ( $Q_2 = 80$ ). We calculate the price elasticity of demand:

$$\varepsilon_{Q,P} = \frac{\Delta Q}{Q} \cdot \frac{\Delta P}{P} = \frac{Q_2 - Q_1}{\frac{Q_1 + Q_2}{2}} \cdot \frac{P_2 - P_1}{\frac{P_1 + P_2}{2}} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 - P_1}{P_1 + P_2} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 + P_1}{P_2 - P_1} = \frac{80 - 100}{80 + 100} \cdot \frac{12 + 18}{18 - 12} = \frac{-20}{180} \cdot \frac{30}{6} = -0.5556.$$

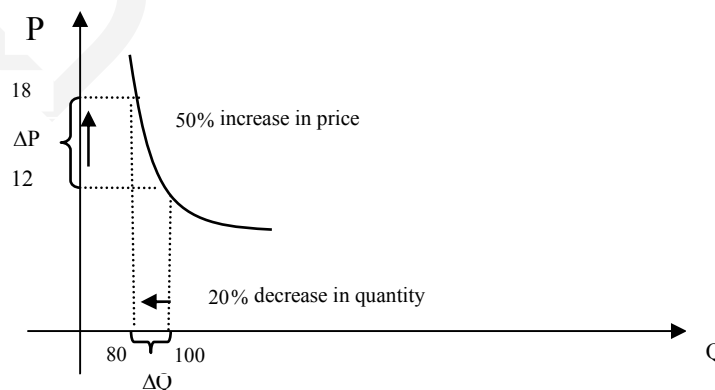
The value of the price elasticity of demand is negative, reflecting the fact that the demand curve is a downward sloping line, since there is a negative relationship between price and quantity. This means that the change in quantity demanded will always have the opposite sign to the change in price.

## 4.2. Types of price elasticity of demand

Economists generally determine the absolute value of the price elasticity of demand. According to the absolute value of price elasticity of demand, we can distinguish three types of price elasticity.

The demand is *inelastic* when the elasticity is less than 1, which means that the percentage change in the quantity demanded is less than the percentage change in the price (Example 4.1, Figure 4.1).

Figure 4.1 The price elasticity of demand - Inelastic



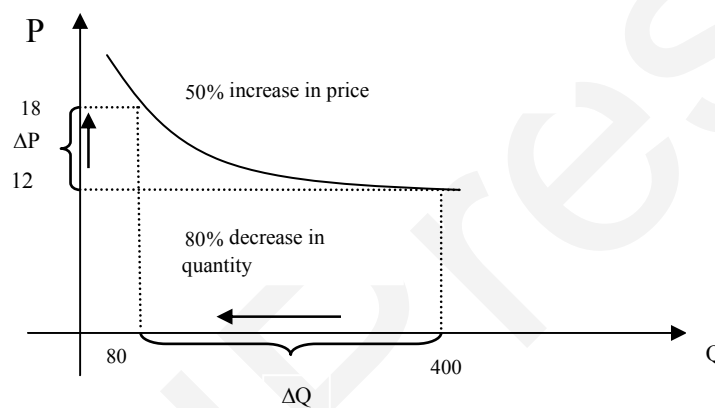
The demand is *elastic* when the elasticity is greater than 1, which means that the percentage change in the quantity demanded is greater than the percentage change in the price (Figure 4.2).

**Example 4.2:**

Suppose that the price of a given good is 12 EUR ( $P_1 = 12$ ) and the quantity demanded is 400 units ( $Q_1 = 400$ ). When the price increases to 18 EUR ( $P_2 = 18$ ), the quantity demanded decreases to 80 units ( $Q_2 = 80$ ). We calculate the price elasticity of demand:

$$\epsilon_{Q,P} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 - P_1}{P_1 + P_2} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 + P_1}{P_1 - P_2} = \frac{80 - 400}{80 + 400} \cdot \frac{12 + 18}{18 - 12} = \frac{-320}{480} \cdot \frac{30}{6} = -3.333.$$

Figure 4.2 The price elasticity of demand - Elastic



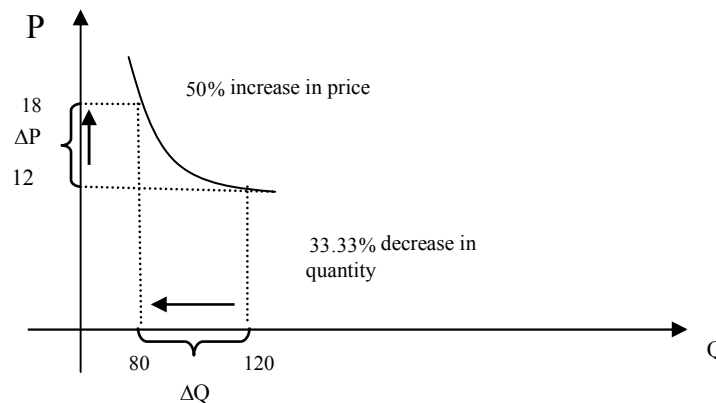
The demand is *unitary elastic* when the elasticity is equal to 1, which means that the percentage change in the quantity demanded is equal to the percentage change in the price (Figure 4.3).

**Example 4.3:**

Suppose that the price of a given good is 12 EUR ( $P_1 = 12$ ) and the quantity demanded is 120 units ( $Q_1 = 120$ ). When the price increases to 18 EUR ( $P_2 = 18$ ), the quantity demanded decreases to 80 units ( $Q_2 = 80$ ). We calculate the price elasticity of demand:

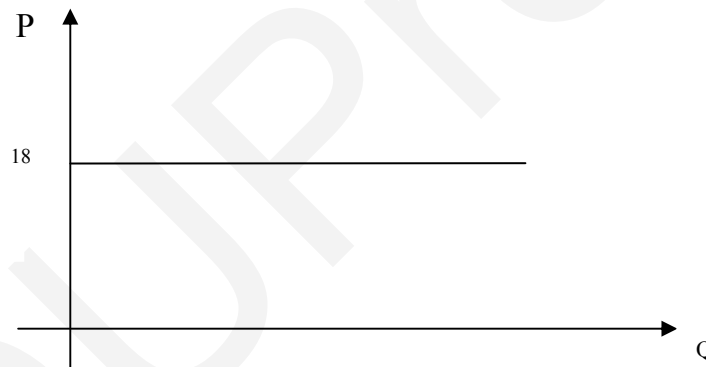
$$\epsilon_{Q,P} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 - P_1}{P_1 + P_2} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 + P_1}{P_1 - P_2} = \frac{80 - 120}{80 + 120} \cdot \frac{12 + 18}{18 - 12} = \frac{-40}{200} \cdot \frac{30}{6} = -1.$$

Figure 4.3 The price elasticity of demand – Unitary elastic



Two special cases of elastic and inelastic demand are when demand is perfectly elastic and when it is perfectly inelastic. **Perfectly elastic** (infinitely elastic) means that any change in the price of a good has a significant effect on quantity demanded. This means that the price elasticity of demand approaches infinity, and the demand curve is horizontal (Figure 4.4).

Figure 4.4 The price elasticity of demand – Infinitely elastic



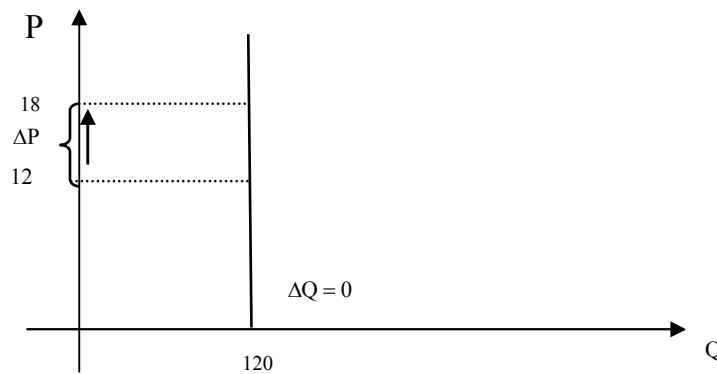
**Perfectly inelastic** means that any change in the price of a good has no effect on the quantity demanded. In this case, the quantity demanded is constant and the demand curve is vertical (Figure 4.5; Example 4.4).

**Example 4.4:**

Suppose that the price of a given good is 12 EUR ( $P_1 = 12$ ) and the quantity demanded is 120 units ( $Q_1 = 120$ ). When the price increases to 18 EUR ( $P_2 = 18$ ), the quantity demanded remains the same ( $Q_2 = 120$ ). We calculate the price elasticity of demand:

$$\epsilon_{Q,P} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 - P_1}{P_1 + P_2} = \frac{Q_2 - Q_1}{Q_1 + Q_2} \cdot \frac{P_2 + P_1}{P_1 - P_2} = \frac{120 - 120}{120 + 120} \cdot \frac{12 + 18}{18 - 12} = \frac{0}{240} \cdot \frac{30}{6} = 0.$$

Figure 4.5 The price elasticity of demand – Perfectly inelastic



### 4.3. Price elasticity of a linear demand curve

The general form of the linear demand curve is the following:

$$Q = a - b \cdot P,$$

where  $a$  and  $b$  are positive constants. Express the price from the previous equation:

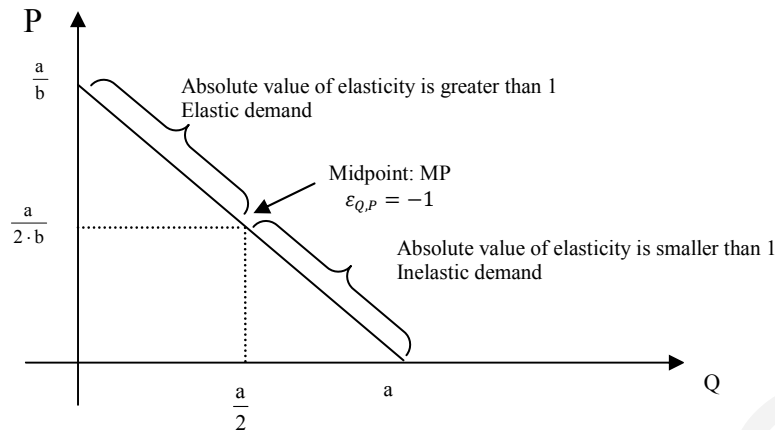
$$P = \frac{a}{b} - \frac{1}{b} \cdot Q.$$

The  $\frac{a}{b}$  expression is called the choke price. The choke price is the price at which the quantity demanded falls to 0. We substitute  $Q$  into the formula of the price elasticity of demand:

$$\varepsilon_{Q,P} = \frac{\Delta Q}{Q} : \frac{\Delta P}{P} = \frac{\Delta Q}{\Delta P} \cdot \frac{P}{Q} = -b \cdot \frac{P}{a-b \cdot P} = -b \cdot \frac{P}{b \cdot (\frac{a}{b} - P)} = -\frac{P}{\frac{a}{b} - P}. \quad (4.1)$$

According to the (4.1) equation the price elasticity of demand varies along a linear demand curve. The slope of the demand function is constant, being equal to the ratio of two parameters ( $\frac{a}{b}$ ). The slope of the demand curve shows the absolute change in quantity demanded due to the one unit change in the price. By contrast, the elasticity is not constant, it varies as we move from one point of the curve to another (Figure 4.6). The price elasticity of demand shows the percentage change in quantity demanded when the price changes by 1 percent.

Figure 4.6 Elasticity of a linear demand curve



If the price is equal to  $\frac{a}{2 \cdot b}$ , the price elasticity of demand is equal to -1. The price elasticity is given by the following formula (Figure 4.6):

$$\epsilon_{Q,P} = \frac{\Delta Q}{Q} : \frac{\Delta P}{P} = -\frac{P}{\frac{a}{b} - P} = -\frac{\frac{a}{2 \cdot b}}{\frac{a}{b} - \frac{a}{2 \cdot b}} = -\frac{\frac{a}{2 \cdot b}}{\frac{a}{2 \cdot b}} = -1.$$

Suppose that the price is greater than  $\frac{a}{2 \cdot b}$ . If the price is equal to  $\frac{3 \cdot a}{4 \cdot b}$ , the absolute value of the price elasticity of demand is greater than 1. In this case, the price elasticity of demand is given by the formula:

$$\epsilon_{Q,P} = \frac{\Delta Q}{Q} : \frac{\Delta P}{P} = -\frac{P}{\frac{a}{b} - P} = -\frac{\frac{3 \cdot a}{4 \cdot b}}{\frac{a}{b} - \frac{3 \cdot a}{4 \cdot b}} = -\frac{\frac{3 \cdot a}{4 \cdot b}}{\frac{a}{4 \cdot b}} = -3.$$

In this case, the demand is elastic, because the absolute value of the price elasticity is greater than 1 (Figure 4.6).

Suppose that the price is smaller than  $\frac{a}{2 \cdot b}$ . Let the price be  $\frac{a}{4 \cdot b}$ . In this case, the price elasticity of demand is given by the formula:

$$\epsilon_{Q,P} = \frac{\Delta Q}{Q} : \frac{\Delta P}{P} = -\frac{P}{\frac{a}{b} - P} = -\frac{\frac{a}{4 \cdot b}}{\frac{a}{b} - \frac{a}{4 \cdot b}} = -\frac{\frac{a}{4 \cdot b}}{\frac{3 \cdot a}{4 \cdot b}} = -\frac{1}{3}.$$

As we can see from the previous calculation, the absolute value of the price elasticity of demand is less than 1. This means that the demand is inelastic, if the price is less than  $\frac{a}{2 \cdot b}$  (Figure 4.6).

## 4.4. Total revenue and price elasticity of demand

Price elasticities of demand are often used by managements, companies, and governments to see how the changes in price effect total revenue. Price elasticities have been estimated for many products (Table 4.1; Table 4.2).

Table 4.1 Price elasticity of demand for air travel

*Computed Price Elasticities of Demand*

<i>City Pairs</i>	<i>Elasticity</i>
New Orleans to Austin, Texas	-0.490
New Orleans to Beaumont, Texas	-2.886
New Orleans to Birmingham, Alabama	-1.315
New Orleans to Columbus, Georgia	-2.437
New Orleans to Dallas, Texas	+0.264
New Orleans to El Dorado, Arkansas	-7.317
New Orleans to Greenville, Mississippi	-9.522
New Orleans to Gulfport, Mississippi	-3.150
New Orleans to Houston, Texas	-3.808
New Orleans to Huntsville, Alabama	-3.041
New Orleans to Little Rock, Arkansas	+1.345
New Orleans to Memphis, Tennessee	-3.131
New Orleans to Mobile, Alabama	+1.155
New Orleans to Nashville, Tennessee	-2.769
New Orleans to Panama City, Florida	-3.269
New Orleans to Tallahassee, Florida	-3.015
Atlanta to Greenville, South Carolina	+0.196
Atlanta to Knoxville, Tennessee	-2.350
Atlanta to Savannah, Georgia	-2.595

Source: J. M. Jung – E. T. Fujii (1976)

Table 4.2 Estimated price elasticity of demand for selected food and cigarettes

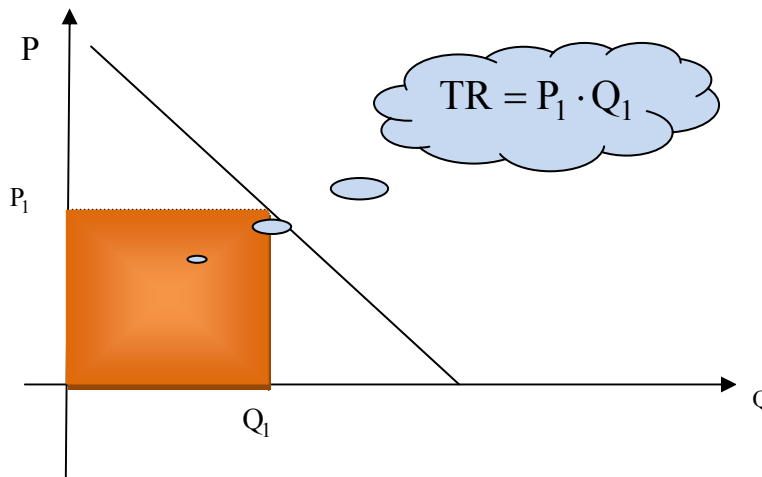
Food	Estimated price elasticity of demand
<b>Canned and cured seafood</b>	<b>-0.736</b>
<b>Cheese</b>	<b>-0.595</b>
<b>Ice cream</b>	<b>-0.349</b>
<b>Bread and bakery products</b>	<b>-0.220</b>
<b>Cookies and crackers</b>	<b>-0.188</b>
<b>Pet food</b>	<b>-0.061</b>
<b>Breakfast cereal</b>	<b>-0.031</b>
<b>Cigarettes</b>	<b>-0.107</b>

Source: Pagoulatos, E. – Sorensen, R. (1986)

Total revenue equals the price of the good times the quantity of the good sold (Figure 4.7):

$$TR = P \cdot Q.$$

Figure 4.7 Total revenue



Generally we might think that if prices rise, the total revenues rises too. However, when prices rise, the quantity demanded decreases. This means that the total revenues might increase or decrease; the change in total revenue depends on the degree of the changes in quantity demanded caused by the change in price.

If the demand is elastic, the percentage change in quantity demanded is greater in absolute value than the percentage change in price. When prices increase, the total revenue will decrease, because the degree of the reduction in the quantity demanded is greater than the rise in price (Table 4.3). By contrast, if the price decreases, the total revenue will increase.

If the demand is inelastic, the percentage change in quantity demanded is smaller in absolute value than the percentage change in price. When prices increase, the total revenue will increase, because the degree of the reduction in the quantity demanded is smaller than the rise in price (Table 4.3).

If demand is unitary elastic, the percentage change in price is equal to the percentage change in quantity demanded in absolute value (Table 4.3).

Table 4.3 How total revenue changes when prices change

Price elasticity of demand	Change in total (TR) revenue when price rises	Change in total (TR) revenue when price falls
elastic	decreases	increases
inelastic	increases	decreases
unit elastic	constant	constant

## 4.5. Income elasticity of demand



Picture 9.

The income elasticity of demand shows us how the quantity demanded changes as consumers' income changes, with all other variables unchanged. The income elasticity of demand equals the ratio of the percentage change in the quantity demanded to the percentage change of income, while all other variables are constant:

$$\epsilon_{Q,I} = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}},$$

$$\epsilon_{Q,I} = \frac{\Delta Q}{Q} : \frac{\Delta I}{I}$$

The formula for the income elasticity of demand using the midpoint method is the following:

$$\epsilon_{Q,I} = \frac{\Delta Q}{Q} : \frac{\Delta I}{I} = \frac{Q_2 - Q_1}{(Q_1 + Q_2)/2} : \frac{I_2 - I_1}{(I_1 + I_2)/2}$$

For most goods we would expect that the relationship between income and quantity demanded is positive (Table 4.4). This means that if consumer income rises, the quantity demanded for a given product rises too. By contrast, we can find the opposite relationship between income and quantity demanded. If the quantity demanded increases as a result of rising consumer income, the good is called a **normal good**. If the good is a normal good, the income elasticity of demand is positive. For example, a 15 percent increase in a university student's income may lead to the student purchasing 20 percent more textbooks. In this case, the income elasticity is 1.333. If higher incomes lower the quantity demanded of a good, the good is an **inferior good**. For example, in economically advanced countries in Asia, such as Japan and Taiwan, the income elasticity of rice is negative (Mankiw, 2009). Rice is an inferior good in these countries. The income elasticity of demand for inferior goods is negative (Table 4.4). There is an opposite relationship between income and quantity demanded. At higher incomes, consumers substitute certain products with higher quality and more expensive products, because they can afford to purchase them.

Table 4.4. Income elasticity of demand

Income elasticity of demand	goods	example
positive	normal	textbooks, cheese
negative	inferior	rice, fat, margarine
relatively high	luxury (superior)	caviar, diamonds



Picture 10.

## 4.6. Cross-price elasticity of demand

The cross-price elasticity of demand shows how the quantity demanded for good x changes as the price of good y changes, with all other variables unchanged. The cross-price elasticity of demand equals the ratio of the percentage change in the quantity demanded of good x to the percentage change of the price of good y, while all other variables are constant:



$$\epsilon_{Q_x, P_y} = \frac{\text{percentage change in quantity demanded of good x}}{\text{percentage change in price of good y}},$$

Picture 11.

$$\epsilon_{Q_x, P_y} = \frac{\Delta Q_x}{Q_x} : \frac{\Delta P_y}{P_y}$$

The formula for the income elasticity of demand using the midpoint method is the following:

$$\epsilon_{Q_x, P_y} = \frac{\Delta Q_x}{Q_x} : \frac{\Delta P_y}{P_y} = \frac{Q_{x2} - Q_{x1}}{(Q_{x1} + Q_{x2})/2} : \frac{P_{y2} - P_{y1}}{(P_{y1} + P_{y2})/2}$$

The cross-price elasticity of demand can be positive or negative. If the quantity demanded increases as a result of a rise in the price of another good, the goods are called **substitutes**. These include goods such as margarine and butter. A higher price for good y may cause an increase in the quantity demanded of good x. In this case consumers substitute the more expensive good y with good x. When two goods are substitutes, the cross-price elasticity of demand is positive. This means that there is a positive relationship between the price of good y and the quantity demanded of good x.

If the cross-price elasticity of demand is negative, the increase in the price of good y causes a fall in the quantity demanded of good x. There is an opposite relationship between the price of good y and the quantity demanded of good x. Good x and good y are **complements** if a higher price of good y decreases the quantity demanded of good x. Complements include automobiles and petrol (Table 4.5). If the changes in the price of good y have no effect on the change in the quantity demanded of good x, good x and good y are **independent goods**. For example, rubber and maps are independent goods.

Table 4.5. Cross-price elasticity of demand

Cross-price elasticity of demand	goods	example
positive	substitutes	apples and pears
negative	complements	automobiles and petrol
zero	independents	pens and sugar



Picture 12.

## 4.7. Price elasticity of supply

The price elasticity of supply shows us how the quantity supplied of a good changes as its price changes, with all other variables unchanged. The price elasticity of supply equals the ratio of the percentage change in the quantity demanded of good x to the percentage change in the price of good x, while all other variables are constant:

$$\epsilon_{Q^S,P} = \frac{\text{percentage change in quantity supplied}}{\text{percentage change in price}},$$

$$\epsilon_{Q^S,P} = \frac{\Delta Q^S}{Q^S} \cdot \frac{\Delta P}{P}$$

The formula for the income elasticity of demand using the midpoint method is the following:

$$\epsilon_{Q^S,P} = \frac{\Delta Q^S}{Q^S} \cdot \frac{\Delta P}{P} = \frac{Q^S_2 - Q^S_1}{(Q^S_1 + Q^S_2)/2} \cdot \frac{P_2 - P_1}{(P_1 + P_2)/2}$$



Picture 13.

The firm-level price elasticity of supply shows the response (sensitivity) of a firm's supply to price. The market-level price elasticity of supply shows us the sensitivity of the market supply of a given good to changes in price.

## 4.8. Terms and Questions

complement goods,  
cross-price elasticity of demand,  
elastic demand,  
elasticity of a linear demand curve,  
firm-level price elasticity of supply,  
income elasticity of demand,  
independent goods,  
inelastic demand,  
inferior good,  
infinitely elastic demand,  
luxury good,  
market-level elasticity of supply,  
midpoint method,  
normal good,  
perfectly elastic demand,  
perfectly inelastic demand,  
price elasticity of demand,  
price elasticity of supply,  
substitute goods,  
total revenue,  
unitary elastic demand.

### *Problems*

#### ***Theoretical questions***

1. What is the difference between a normal good and a luxury good?
2. Give the definition of the price elasticity of demand.
3. How can we calculate the cross-price elasticity of demand?
4. Explain how the total revenue is calculated.
5. Explain what the difference is between elastic demand and inelastic demand.

6. How can we calculate the price elasticity of demand?
7. Give the definition of the income elasticity of demand.
8. Explain how to derive the price elasticity of supply.
9. What happens to the total revenue if the price of a good with elastic demand rises?
10. What happens to the total revenue if the price of a good with inelastic demand falls?
11. Explain the midpoint method.
12. Give an example of an inferior good.
13. What are the main characteristics of complement goods?
14. Explain the relationship between the total revenue and the price elasticity of demand.
15. Give examples of substitutes goods.
16. How can we calculate the income elasticity of demand?
17. Give the different types of cross-price elasticity of demand?
18. Give examples of luxury goods.

### *Calculation exercises*

19.

Suppose the price of a good  $x$  is 12 EUR, and the quantity demanded of good  $x$  is 2400 units. If the price of good  $x$  increases to 20 EUR, the quantity demanded will decrease by 850 units.

- a) Determine the percentage change in price (using by the midpoint method).
- b) Calculate the price elasticity of demand.
- c) Is demand elastic or inelastic?

20.

Suppose the demand curve is:  $Q^D = 100 - 5 \cdot P$ .

- a) What is the price elasticity of demand at  $P = 2$ ?
- b) What is the price elasticity of demand at  $P = 8$ ?

21.

Suppose the price of good  $y$  is 24 EUR, and the quantity demanded for good  $y$  is 12 000 units. Suppose, too, that if the price of good  $y$  decreases to 16 EUR, the quantity demanded of good  $x$  will decrease by 1 400 units. The original quantity demanded of good  $x$  is 15 000 units.

- a) Determine the percentage change in price (using the midpoint method).
- b) Calculate the cross-price elasticity of demand.
- c) Are these goods substitutes?

22.

Suppose that the demand curve is as follows:  $Q^D = 100 \cdot P^{-\frac{1}{2}}$ .

- a) What is the price elasticity of demand at  $P = 4$ ?
- b) What is the price elasticity of demand at  $P = 100$ ?

23.

Suppose that the demand for a given product is given by:

$$Q^D = 80 - 2 \cdot P.$$

At what price will demand be unitary elastic?

24.

Suppose that consumers' average income is 4 000 EUR, and the quantity demanded of a special good is 500 000 units. Suppose, too, that if the income increases to 4500 EUR, the quantity demanded for the given good will decrease by 14 000 units.

- a) Determine the percentage change in income (using by the midpoint method).
- b) Calculate the income elasticity of demand.
- c) Is the special good an inferior or a luxury good?

25.

Suppose that the demand for pizzas at Peter's restaurant is given by:

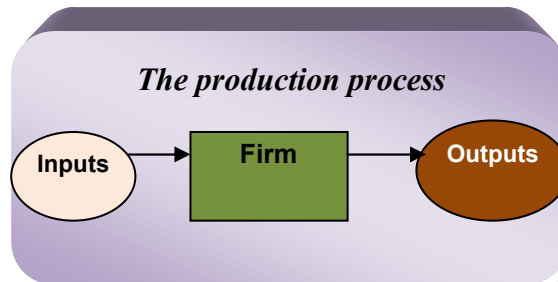
$$Q^D = 500 - 100 \cdot P$$

<b>P (EUR)</b>	<b><math>Q^D</math></b>	<b><math>\epsilon_{Q,P}</math></b>
1		
1.5		
2		
2.5		
3		

- a) Fill in the table.
- b) Plot the demand curve on a graph.
- c) At what price is demand elastic?
- d) At what price is demand inelastic?
- e) At what price is demand unitary elastic?

## 5. Production – production functions

In this chapter we examine the supply side of the goods market; we study the main components of production. Production is the process of the transformation of resources such as labour and capital into outputs.



Factors of production: inputs used to produce goods.

- **Labour:** this includes all working people of whatever type: electricians, doctors, unskilled workers, etc. The labour force is limited both in number and in skills.
- **Capital:** this includes all manufactured inputs: plant, tools, machinery, etc. Capital consists of all those inputs that have had to be produced in the first place. The world has a limited stock of capital: a limited supply of factories, machines etc.
- **Natural resources:** land and raw materials.
- **Human capital:** the skills and knowledge embodied in the abilities of the individuals in the labour force.

Firms produce goods and services using factors of production, and sell the goods produced to consumers.

### 5.1. The production function

The production function describes the relationship between the quantity of inputs used to produce goods and the quantity of the output (Figure 5.1).

The production function a mathematical representation that shows the maximum quantity of output a firm can produce given the quantities of inputs that it might employ.

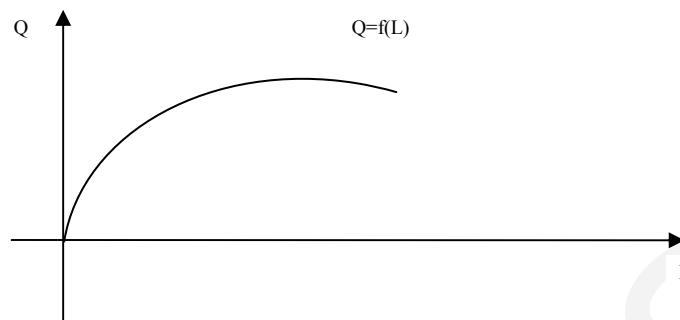
*(Besanko – Braeutigan, 2011)*

The general formula of the production function is as follows:

$$Q = f(L, K)$$

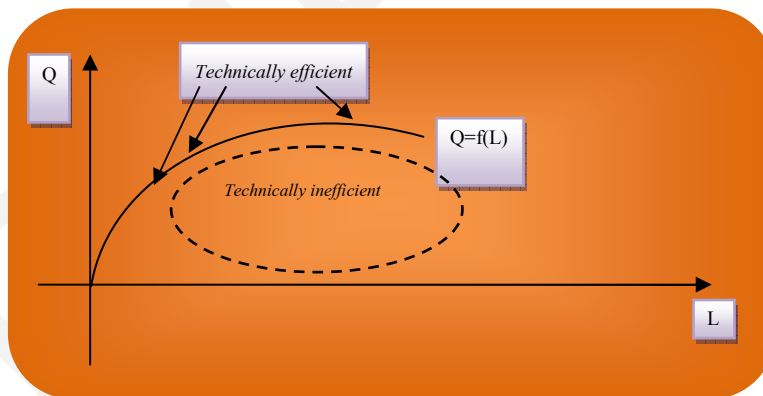
where  $Q$  is the quantity of output,  $L$  is the quantity of labour used to produce  $Q$ , and  $K$  is the quantity of capital used to produce  $Q$ . We disregard natural resources in our examination of production.

Figure 5.1 The production function



Points on and below the production function constitute a given firm's production set. If we suppose that the amount of capital used in the production is constant, points below the production function make up the technically inefficient range, because the firm produces less product using labour than it could (Figure 5.2).

Figure 5.2 Technical efficiency



Points on the boundary of the production function give the technically efficient range, because the firm produces as much as it possibly can use the given amount of labour (Figure 5.2).

“Production set is the set of technically feasible combinations of inputs and outputs.

**Technically inefficient:** The set of points in the production set at which the firm is getting less output from its labour than it could.

**Technically efficient:** The set of points in the production set at which the firm is producing as much output as it possibly can given the amount of labour it employs.

**Labour requirements function:** A function that indicates the minimum amount of labour required to produce a given amount of output  $L = g(Q)$ ”.

(Besanko – Braeutigan, 2011:203)

## 5.2. The total production function – the marginal and average product of labour

Instead of examining the effect of combinations labour and capital on output, we suppose that capital is unchanged and only one input can vary in the short run. Draw the production function for - considering all factors of production are constant except for labour (Figure 5.3).

A **total product function** with a single input shows how total output depends on the level “of the output”.

(Besanko – Braeutigan, 2011:203).

A firm manager always wants information about productivity and tries to improve it if it is possible. A firm manager’s decision can be informed by many indicators, such as the average product of labour, and the marginal product of labour.

What happens if the manager is able to take on more employees? Will the firm’s production increase or not?

The *average product of any output* shows the average amount of output per unit of input. The **average product of labour** ( $AP_L$ ) gives the average amount of output ( $Q$ ) per unit of labour ( $L$ ):

$$AP_L = \frac{\text{output}}{\text{quantity of output}} = \frac{Q}{L}.$$

Similarly, the *average product of capital* ( $AP_K$ ) gives the average amount of output ( $Q$ ) per unit of capital ( $K$ ):

$$AP_K = \frac{\text{output}}{\text{quantity of capital}} = \frac{Q}{K}.$$

*What happens if the manager is able to take on more employees? Will the firm’s production increase or not?*

The marginal product of any input shows the changes in total output as the quantity of a given input the firm uses is changed.

The marginal product of labour shows the changes in total output as the quantity of labour changes:

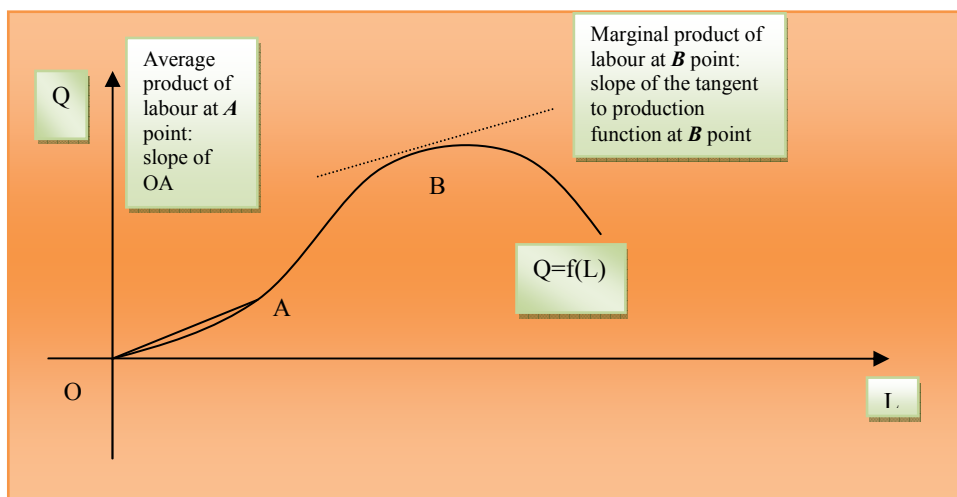
$$MP_L = \frac{\text{change in output}}{\text{change in quantity of output}} = \frac{\Delta Q}{\Delta L}.$$

The marginal product of capital shows the changes in total output as the quantity of capital the firm uses is changed:

$$MP_K = \frac{\text{change in output}}{\text{change in quantity of capital}} = \frac{\Delta Q}{\Delta K}.$$

The marginal product of labour can be written as  $\frac{\Delta Q}{\Delta L}$  the change in output  $\Delta Q$  resulting from a one unit increase in labour input  $\Delta L$ .

Figure 5.3 The total production function



The marginal product of labour at any point equals the slope of the line tangent to the production curve at that point (Figure 5.3). The average product of labour equals the slope of the line from the origin to the production curve at that point (Figure 5.3).

**“Increasing marginal returns to labour:** The region along the total production function where output rises with additional labour at an increasing rate.

**Diminishing marginal returns to labour:** The region along the total product function in which output rises with additional labour at a decreasing rate.

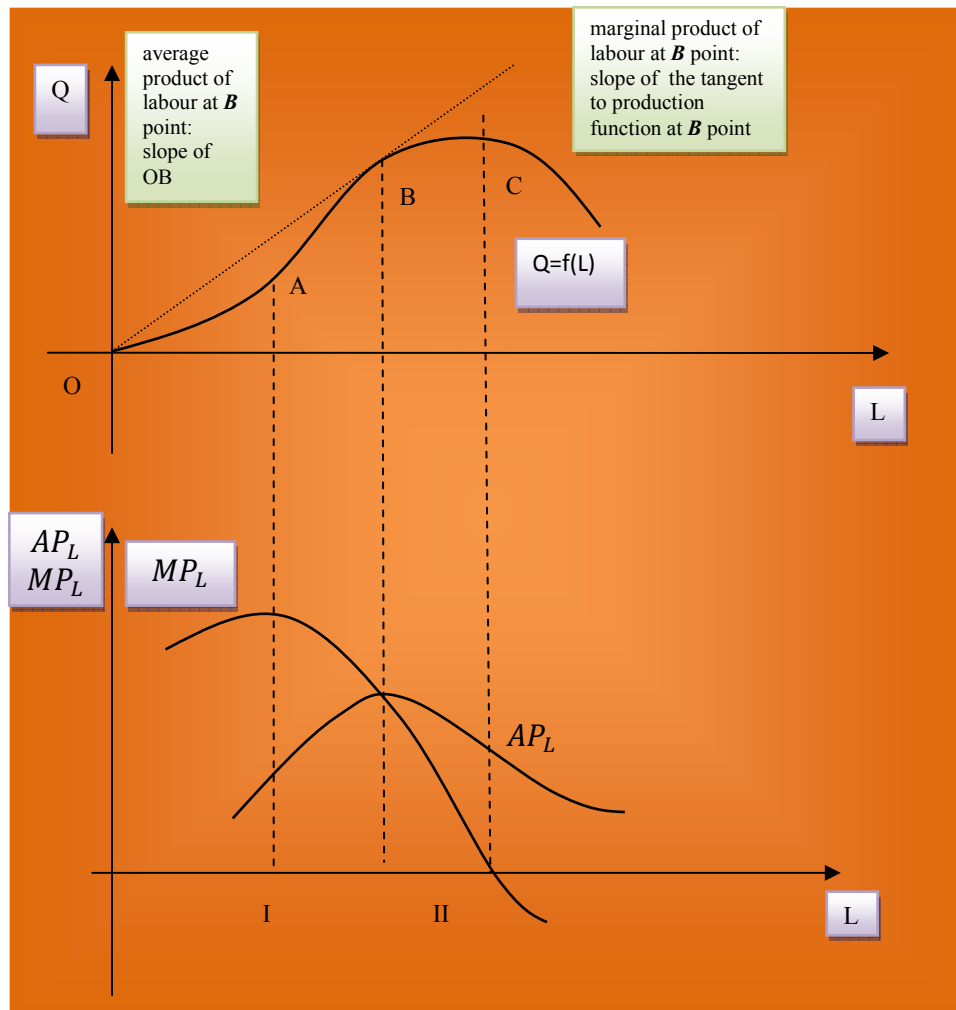
**Diminishing total returns to labour:** The region along the total product function where output decreases with additional labour.

**Law of diminishing marginal returns:** Principle that as the usage of one input increases, the quantities of other inputs being held fixed, a point will be reached beyond which the marginal product of the variable input will decrease”.

(Besanko – Braeutigan, 2011:206; 207).

The maximum point of the average product of labour can be found where the slope of a line from the origin is just tangent to the total product curve (Figure 5.4; point B). At the other points of the total production curve, the slope of a ray from the origin is smaller than the slope of the ray OB. The average product of labour increases to point B, and when the average product of labour reaches its maximum value it decreases. The marginal product of labour increases up until point A is reached (Figure 5.4), and beyond point A it starts decreasing. The marginal product of labour is equal to zero when the slope of the tangent of the total production function is zero (Figure 5.4; point C). At point A the total production curve reaches its maximum value. Beyond point C the marginal product of labour is negative, and the total production curve decreases.

Figure 5.4 The production function



There is a relationship between the average product of labour and the marginal product of labour.

“When average product is **increasing in labour**; marginal product is greater than average product. That is  $AP_L$  increases in  $L$ , then  $MP_L > AP_L$ .  
 When average product is **decreasing in labour**; marginal product is less than average product. That is  $AP_L$  decreases in  $L$ , then  $MP_L < AP_L$ .  
 When average product neither increases nor decreases in labour because we are at a point at which  $AP_L$  is at a maximum; then marginal product is equal to average product  $MP_L = AP_L$ ”.

(Besanko – Braeutigan, 2011:210).

**I.: Increasing returns to scale:** This occurs where a given percentage increases in inputs will lead to a larger percentage increases in output.

**II.: Decreasing returns to scale:** This is where a given percentage increases in inputs will lead to a smaller percentage increase in output.

- When the total product is increasing, the value of the marginal product is positive.
- When the total product falls, the value of the marginal product is negative.
- When the total product is at its maximum (its slope is zero), the marginal product is equal zero. An additional worker will add nothing to output so  $MP_L = 0$ .
- The marginal product between two points is equal to the slope of the production function between those two points.

*(Sloman, 2009)*

The relationship between marginal product and average product is the same as the relationship between the marginal of anything and the average of anything. To illustrate this point, suppose that the average height of students in your class is 160 cm. Now Mike Margin joins the class, and the average height rises to 161 cm. What do we know about Mike's height? Since the average height is increasing, the "marginal height" (Mike Margin's height) must be above the average. If the average height had fallen to 159 cm, it would have been because his height was below the average. Finally, if the average height had remained the same when Mike joined the class, his height would have had to exactly equal the average height in the class.

*(Besanko – Braeutigan, 2011:210).*

### 5.3. Terms and Questions

average product,  
average product of capital,  
average product of labour,  
capital,  
decreasing returns to scale,  
diminishing marginal returns to labour,  
diminishing total returns to labour  
factors of production,  
increasing marginal returns to labour,  
increasing returns to scale,  
law of diminishing marginal returns,  
labour,  
labour requirements function,  
marginal product,  
marginal product of capital,  
marginal product of labour,  
natural resources,  
production function,  
relationship between average product of labour and marginal product of labour,  
technically efficient,  
technically inefficient  
total production function.

#### *Problems*

#### ***Theoretical questions***

1. What is the difference between the average product of labour and the marginal product of labour?
2. Give the definition of the production function.
3. How can we calculate the average product of labour?
4. Explain how the marginal product of labour is calculated.

5. Explain what the relationship is between the total production function and the average product of labour.
6. How can we calculate the marginal product of capital?
7. Give the definition of the average product of capital.
8. Explain how to derive the marginal product of labour function.
9. Explain the law of diminishing marginal returns.
10. What does the expression 'technically efficient' mean?
11. Give the types of factors of production.
12. What is the difference between technically efficient and technically inefficient?
13. What is the difference between diminishing marginal returns to labour and increasing marginal returns to labour?

***Calculation exercises***

14. Fill in the following table.

L	Q	$AP_L$	$MP_L$
0	0		
1	50		
2	150		
4	200		
5	265		
8	320		
12	280		
18	250		

15.

Fill in the following table.

L	Q	AP <sub>L</sub>	MP <sub>L</sub>
2	50		
5		30	
8	280		
10			50
15			
20		30	15
30	660		
32		20	

16.

The production function can be expressed as an equation:

$$Q = -400 + 40 \cdot L - L^2$$

- Give the equation of the marginal product.
- Give the equation of the average product.
- Calculate the maximum point of the production function.
- Calculate the maximum point of the marginal product.
- Calculate the maximum point of the average product.

17.

You are given the following information about inputs:

L	K	Q	AP <sub>L</sub>	MP <sub>L</sub>	AP <sub>K</sub>	MP <sub>K</sub>
100	200		50			
120	150	1600				
130	130					
150	120			15		
150	100				20	10

- Calculate the missing values in the table.

18.

The production function is given by the following equation:

$$Q = -256 \cdot L^{\frac{3}{2}} + L^3.$$

- Write the equation of the marginal product function.
- Write the equation of the average product function.
- What is the maximum of the production function?
- What is the maximum of the marginal product?
- What is the maximum of the average product?

19.

Fill in the following table.

L	K	Q	AP <sub>L</sub>	MP <sub>L</sub>	AP <sub>K</sub>	MP <sub>K</sub>
1	6		200			
2	3	600				
3	2			50		
6	1					40

20.

Consider the following production functions in the table. For each production function shows whether the marginal product of labour and the marginal product of capital are diminishing, constant or increasing in the quantity of that input.

<i>Production function</i>	AP <sub>L</sub>	MP <sub>L</sub>	AP <sub>K</sub>	MP <sub>K</sub>	<i>Marginal product of labour</i>	<i>Marginal product of capital</i>
$Q = 3 \cdot L + 2 \cdot K$						
$Q = \sqrt{L \cdot K}$						
$Q = L^2 \cdot K^3$						
$Q = 10 \cdot \sqrt{\frac{L}{K}} + 5$						

## 6. The cost of production – in the short run

In this chapter we examine different concepts of costs that play a significant role in firms' decision making. We analyse the difference between fixed and variable costs, and between average and marginal costs. This topic will analyse how costs change as a firm changes the amount of a good produced.

### 6.1. Total, fixed and variable costs of production

In the short run, the total cost ( $TC$ ) of production has two main components: the variable costs ( $VC$ ) and the fixed costs ( $FC$ ) of production. The total cost can be calculated as the sum of the variable and fixed costs:

$$TC = VC + FC$$

#### *Fixed cost*

Depending on circumstances, fixed costs include expenditures, for example on rent, plant maintenance, and the wage of the gatekeeper. Fixed cost does not vary with the level of output (Figure 6.1) - it must be paid even if the firm does not produce output. This means that whether the firm produces 10 units of output per day or 10 000 units of output per day, the same fixed cost must be paid (Figure 6.1).

Figure 6.1 The fixed cost curve



Which costs are variable and which costs are fixed depends on the time horizon we are dealing with. Within a short period of time (for example one or two months) most costs are fixed. On the other hand, over a long time horizon – say two or three years – most costs are variable.

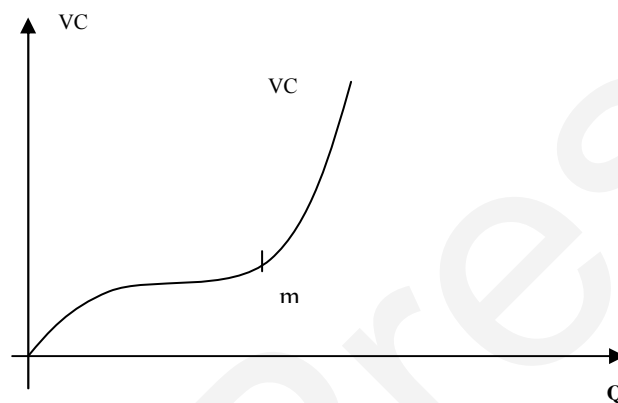
Firms need to know how total costs and variable costs increase with the level of output, in order to decide how much to produce.

### Variable cost

Costs that vary with the quantity of output that a firm produces are called variable costs (*VC*). Variable costs include expenditures on wages and raw materials - these costs increase as output increases. At zero output, the firm does not produce products, so no variable factors are used, and as a result the value of the variable cost is zero. This means that the variable cost curve starts from the origin.

The variable cost curve increases with output. If the firm produces more output, the variable cost is higher (Figure 6.2).

Figure 6.2 The variable cost curve



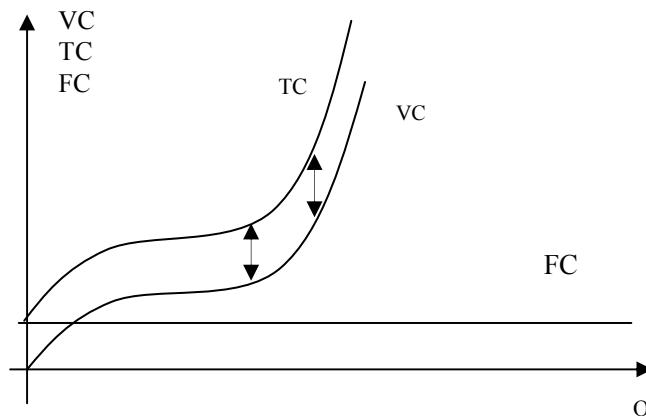
### Total cost

As we mentioned above, the total cost is equal to the sum of the variable cost and fixed cost:

$$TC = VC + FC$$

The total cost function can be derived from the vertical sum of the variable cost and fixed cost functions. As the fixed cost is constant, the shape of the total cost curve is the same shape as the variable cost (Figure 6.3).

Figure 6.3 The total cost curve



## 6.2. Average costs

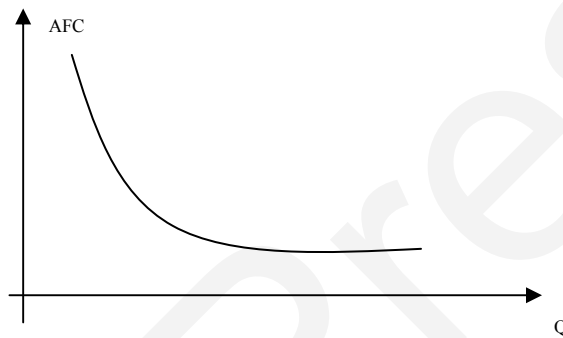
### *Average fixed cost*

The average fixed cost shows the amount of fixed cost for only one unit of product. Average fixed cost is equal to the fixed cost divided by the quantity of output:

$$AFC = \frac{FC}{Q}.$$

The average fixed cost curve decreases with the amount of output produced, since the fixed cost does not change as output rises (Figure 6.4). The average fixed cost cannot be zero if the value of the fixed cost is not equal to zero.

Figure 6.4 Average fixed cost curve



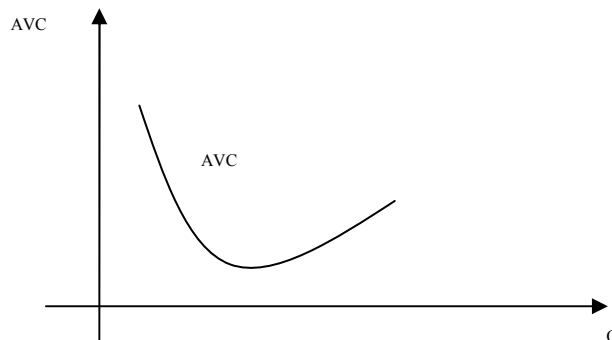
### *Average variable cost*

The average variable cost shows the amount of variable cost for only one unit of product. Average variable cost is the fix cost divided by the quantity of output:

$$AVC = \frac{VC}{Q}.$$

The average variable cost curve is U-shaped, since it decreases if the firm's average product increases, and the average cost increases as the firm's average product decreases (Figure 6.5).

Figure 6.5 Average variable cost curve



### Average cost

Managers often want to know the value of cost per unit, i.e. the cost of only one unit of output produced.

**Average (total) cost (AC)** is the total cost divided by the quantity of output:

$$AC = \frac{TC}{Q}$$

Similarly to the total cost, the average total cost has two main components: the average variable cost and the average fixed cost. The average total cost can be derived from the total cost:

$$TC = FC + VC \quad /:Q$$

$$\frac{TC}{Q} = \frac{FC}{Q} + \frac{VC}{Q}$$

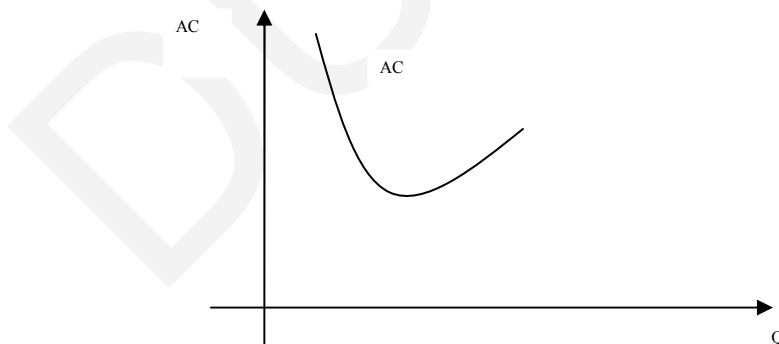
$$AC = AVC + AFC$$

The average total cost shows the per-unit cost of production. By comparing the average cost to the price of the product, we can determine whether production is profitable.

Thus if it costs a firm 2000 Euros to produce 100 units of a product, the average cost would be 20 Euros for each unit.

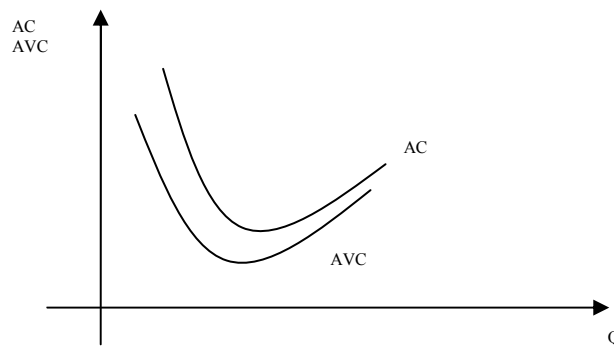
The average (total) cost curve is U-shaped, since the average (total) cost is the sum of the average fixed cost and the average variable cost (Figure 6.6). The average variable cost is also U-shaped.

Figure 6.6 Average (total) cost curve



The average total cost curve can be found above the average variable cost, since the average fixed cost is not zero.

Figure 6.7 Average (total) cost and average variable cost curve



However, the average variable cost curve approaches the average total cost curve as the level of output increases, since the average fixed cost decreases with output.

The vertical distance between two points of the average total cost curve and the average variable cost is equal to the average fixed cost (Figure 6.7).

### 6.3. Marginal cost

Marginal cost ( $MC$ ) shows the increase in total cost when the output rises by one unit:

$$MC = \frac{\Delta TC}{\Delta Q}$$

Marginal cost shows us how much it will cost to expand the firm's output by one unit.

*Example:*

Suppose that a firm is currently producing 100 units of output at a total cost of 2000 EUR. It now increases its output to 101 units and its total cost rises to 2030 EUR. It has thus incurred an extra cost of 30 EUR to produce this 101st unit. Thus the marginal cost of the 101st unit is 30 EUR:

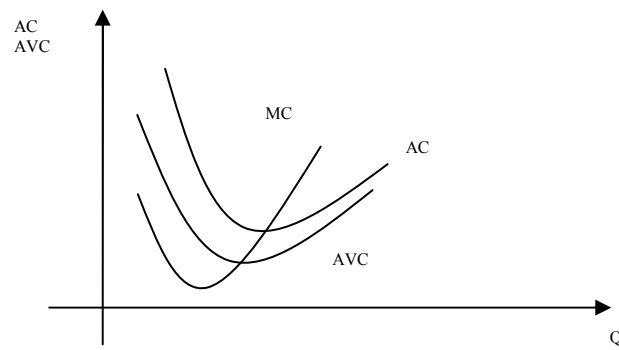
$$MC = \frac{\Delta TC}{\Delta Q} = \frac{2030 - 2000}{101 - 100} = \frac{30}{1} = 30.$$

The marginal cost can be expressed by the variable cost, since the firm's fixed cost does not change as the output changes. This means that the marginal cost is equal to the increase in the variable cost that results from one extra unit of output:

$$MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta VC + \Delta FC}{\Delta Q} = \frac{\Delta VC}{\Delta Q}$$

The marginal cost curve is a U-shaped curve too (Figure 6.8). The marginal cost curve decreases as total cost increases at a decreasing rate. The marginal cost curve increases as the total cost increases at an increasing rate.

Figure 6.8 Average (total) cost, average variable cost and marginal cost curves



The marginal cost curve crosses the average total cost curve and the average variable cost curve at their minimum point (Figure 6.8).

If the marginal cost can be found below the average (total) cost, the average cost falls. If the marginal cost is above the average cost, the average cost curve rises (Figure 6.8). Finally, if the average cost is at a minimum, the marginal cost curve intersects the average cost curve.

## 6.4. Terms and Questions

average fixed cost,  
average (total) cost,  
average variable cost,  
fixed cost,  
marginal cost,  
total cost,  
variable cost.

### Problems

#### *Theoretical questions*

1. What is the difference between the average variable cost and the average fixed cost?
2. Give the definition of marginal cost.
3. How can we calculate the average (total) cost?
4. Explain how marginal cost is calculated.
5. Explain what the difference is between the average variable cost and the marginal cost.
6. How can we calculate the average fixed cost?
7. What is the shape of the average (total) cost curve?
8. What is the shape of the average fixed cost curve.
9. What is the relationship between the average variable cost and the marginal cost?

10. How can the marginal cost be affected if the fixed cost increases?

**Calculation exercises**

11.

You are given the following information about a firm's fixed and variable costs:

Output (units)	Fixed cost	Variable cost	Total cost	Average fixed cost	Average variable cost	Marginal cost
0	2000					
1		30				
2		80				
3		120				
4		140				
5		180				
6		250				

a) Calculate the missing values in the table.

12.

Consider the following total cost function:

$$TC = 250 \cdot Q - 240 \cdot Q^2 + 3 \cdot Q^3.$$

- a) What is the equation of the variable and fixed cost function?
- b) What is the equation of the average cost and average variable cost function?
- c) What is the equation of the marginal cost function?
- d) At what level of output does the average cost curve reach a minimum?

13.

The following table shows the various costs of a firm. Fill in the table:

Q	TC	FC	VC	MC	AC	AVC	AFC
0	400						
1			100				
2					600		
3						400	
4							
5	1800			200			

14.

Consider the following total cost function:

$$TC = 49 \cdot Q - 8 \cdot Q^2 + 0.5 \cdot Q^3.$$

- Write the equation of the variable and fixed cost function.
- Write the equation of the marginal cost function.
- Write the equation of the average cost and average variable cost function.

15.

Suppose a competitive firm's cost function is given by the following equation:

$$TC(Q) = 100 + 10 \cdot Q - Q^2 + \frac{1}{3} \cdot Q^3.$$

- What is the firm's fixed cost?
- What is the firm's variable cost function?
- Determine the firm's marginal cost function.
- What is the firm's average cost function?
- What is the firm's AFC function?
- What is the firm's AVC function?

16.

Consider the total cost function:

$$TC = 3 \cdot q^2 - q + 4800.$$

- Give the marginal cost function.
- Give the average total cost function.
- Find the output at which average cost is minimized, and show that  $MC = AC$  at this output.

17.

The following table shows the various costs of a firm. Fill in the table:

Q	TC	FC	VC	MC	AC	AVC	AFC
0							
100			50				2
	280			0,6			
400						1,25	
500							
550	800			1,2			

## 7. Perfect competition

In this chapter, we learn the main characteristics of a perfectly competitive market and examine how firms make production decisions in competitive markets. We try to illustrate and understand the profit-maximization condition for a perfectly competitive firm. We examine how we can derive the firm's supply curve.

### 7.1. Competitive market – Perfect competition

A competitive market - often called a perfectly competitive market - has five main characteristics:

- **There are many buyers and many sellers in perfect competition.**  
Each seller's and buyer's market decisions have an inappreciable effect on the market price. One buyer's purchase is so small that the buyer has a negligible impact on the product price. One seller's input purchase and output production is so small that a firm as a seller of a product or as a buyer of input(s) has an inappreciable effect on the market price or input price.
- **Buyers and sellers are price takers.**  
The price is given for market actors. Each seller and buyer takes the market price as given. Consider the market for potatoes. No one consumer or producer can influence the market price of potatoes, since the amount purchased or produced by only one market actor is relatively small in relation to the size of the market.
- **Products are undifferentiated.**  
Firms produce an identical product in the given industry. Products are homogeneous. Assume one day you buy potatoes in the supermarket. You cannot decide who produced the potatoes. We are not able to make a difference between one product and another in the same industry.
- **Consumers have perfect information about the conditions of purchase such as the price and quality of the product. Firms have perfect information about the process, costs and technology.**
- **Firms can freely enter and exit the market.**  
There are no barriers that prevent a firm from entering the market. Similarly, there are no barriers that prevent a firm from exiting the market.

For example, agricultural markets such as the market for potatoes and fresh vegetables are closest to perfect competition.

## 7.2. Revenue and profit

First, we review the main concepts and formulas that are important to understand how a competitive firm maximizes its profit. In the next section of this chapter we examine the profit maximization condition in the competitive market.

A firm's total profit is equal to the difference between the total revenue and the total cost of production

$$T\pi = TR - TC$$

### *Total, average and marginal revenue*

Each firm tries to maximize its profit, and select the level of output at which the difference between total revenue and total cost is the greatest. First we review the concepts of total, average and marginal revenue.

**Total revenue (TR)** from the sale of a good is equal to the price of the good multiplied by the quantity of sold output ( $Q$ ):

$$TR = P \cdot Q$$



Picture 14.

For example, if a firm sells 2 000 units ( $Q$ ) per month at a price of 8 EUR each ( $P$ ), then its monthly total revenue will be 16 000 EUR.

**Average revenue (AR)** is the total revenue divided by the quantity sold:

$$AR = \frac{TR}{Q}$$

Average revenue shows the value that the firm receives per one product sold.

So if the firm earns 16 000 EUR ( $TR$ ) from selling 2 000 units ( $Q$ ), it will earn 8 EUR per unit:

$$AR = \frac{TR}{Q} = \frac{P \cdot Q}{Q} = P$$

**Marginal revenue (MR)** shows the change in total revenue when the output sold increases by one unit:

$$MR = \frac{\Delta TR}{\Delta Q}$$

$$MR = \frac{\Delta TR}{\Delta Q} = \frac{\Delta(P \cdot Q)}{\Delta Q} = P$$

Marginal revenue equals the price of the good. If a price-taking firm sells one unit of a good, the total revenue increases by the price of the good.

## Revenue curves when the price is given for the firms

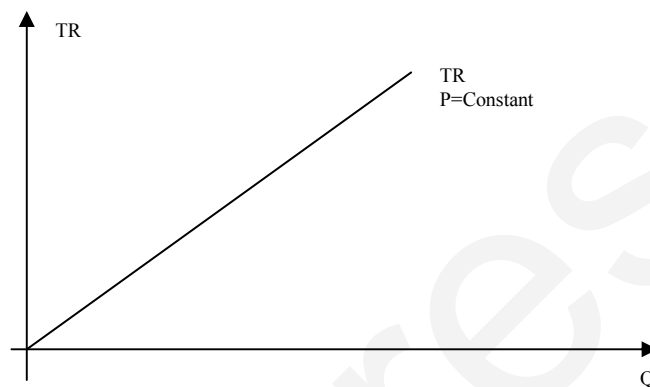
### Total revenue

The total revenue curve is a straight line, since the slope of the curve is constant. The price is constant; it does not depend on the quantity of output produced:

$$TR = P \cdot Q.$$

As price is positive, the total revenue curve increases proportionately with output (Figure 7.1).

Figure 7.1 Total revenue



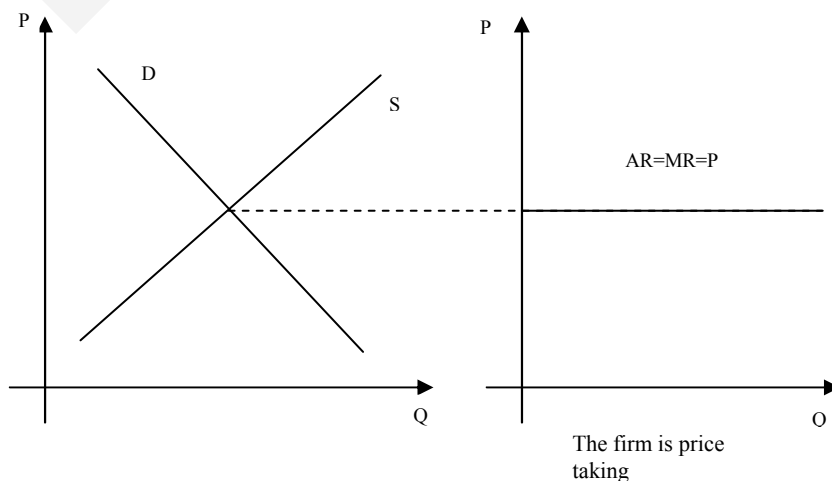
### Average and marginal revenue

In an earlier section in this chapter, we established that the competitive firm's average revenue and marginal revenue are equal to the price of the good:

$$MR = \frac{\Delta TR}{\Delta Q} = \frac{\Delta(P \cdot Q)}{\Delta Q} = P = AR.$$

Where the price is constant, the average revenue and marginal revenue curve are parallel to the horizontal ( $Q$ ) axis (Figure 7.2). The price can be determined by the intersection of supply and demand (Figure 7.2).

Figure 7.2 Average and marginal revenue



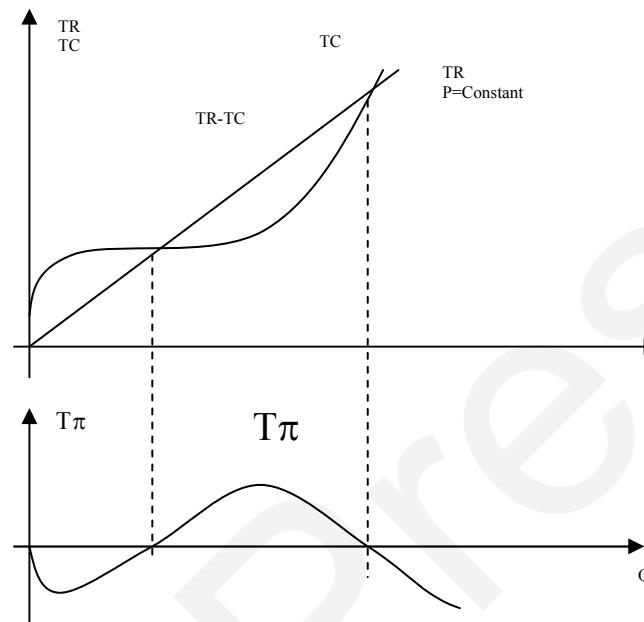
## Profit

Total profit is equal to the total revenue minus total cost (Figure 7.3):

$$\text{Profit} = T\pi = TR(Q) - TC(Q),$$

where the total profit is denoted by  $T\pi$ .

Figure 7.3 Total profit curve



**Average profit** is the total profit divided by the quantity sold:

$$A\pi = \frac{T\pi}{Q}.$$

**Marginal profit** shows the change in total profit when the output sold increases (or decreases) by one unit:

$$M\pi = \frac{\Delta T\pi}{\Delta Q}.$$

## 7.3. Profit-maximizing output

A competitive firm is a price taker, which means that the market price is given in a firm's profit-maximizing decision. A competitive firm wants to select the level of the quantity of output for which the profit is the greatest. Profit is the greatest if the difference between total revenue and total cost is the greatest too.

$$\max T\pi = \max(TR(Q) - TC(Q)) \implies Q?,$$

Profit is negative at a low level of output (Figure 7.4); in this case total revenue is lower than total cost. When total profit is negative total revenue is not enough to cover the amount of total cost. As output increases, profit increases until it reaches its maximum point at a level of  $Q^*$  (Figure 7.4). At this  $Q^*$  point the marginal revenue is equal to the marginal cost.  $Q^*$  is the profit-maximizing output, where the vertical distance between total revenue and total cost is the greatest (Figure 7.4).

Beyond the profit maximizing output, total cost increases, reflecting a decrease in total profit. In this case marginal revenue is lower than marginal cost.

The profit-maximizing condition can be derived algebraically:

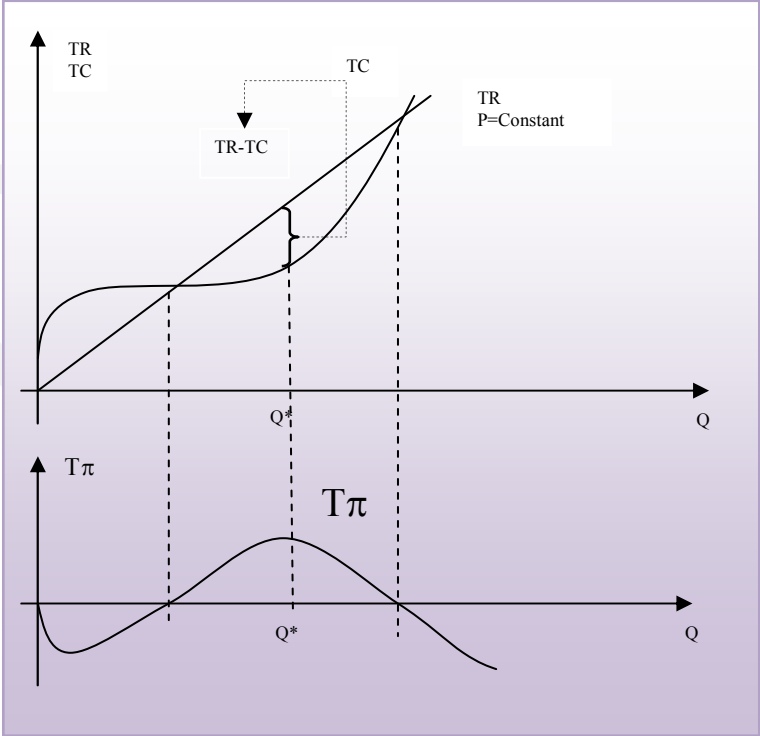
$$\max T\pi = \max(TR(Q) - TC(Q)) \implies Q^*,$$

$$\frac{dT\pi}{dQ} = \frac{d(TR-TC)}{dQ} = \frac{dTR}{dQ} - \frac{dTC}{dQ} = MR - MC = 0,$$

$$\begin{aligned} MR &= MC \\ MC &= P. \end{aligned}$$

A price-taking firm maximizes its profit, when it produces the level of quantity at which the marginal revenue is equal to the marginal cost.

Figure 7.4 Profit-maximizing output



Suppose that the price of a given product in the competitive market increases. In this case, the revenue from selling only one product is larger than the increment in the total cost of producing one more product. When the marginal revenue is larger than the marginal cost, the firm increases production until the marginal cost is equal to the price.

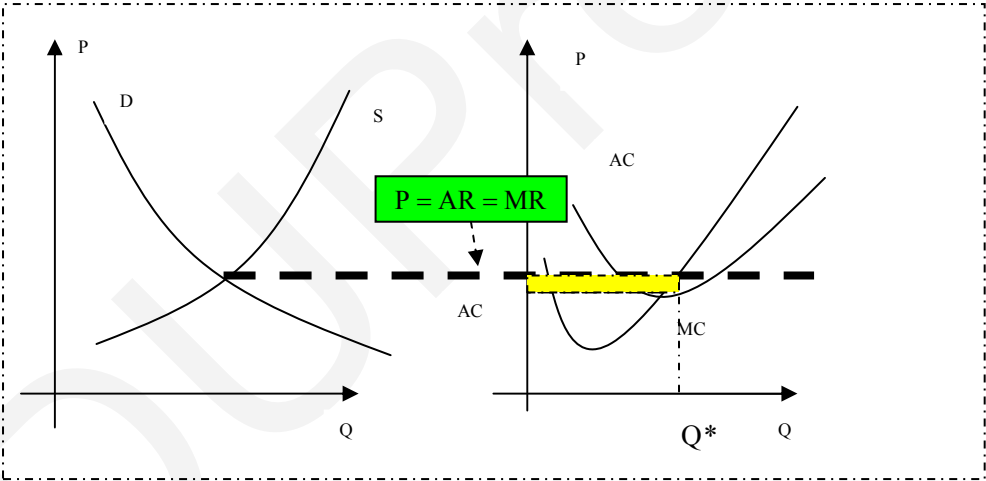
### 7.4. Short-run supply curve (shut-down point)

Assume that the price of a given product is greater than the cost of producing one product (Figure 7.5):

$$P < AC.$$

In the short run, a competitive firm maximizes its profits by producing the level of output  $Q^*$  at which its marginal cost is equal to the price. The profit is measured by the area of the yellow rectangle as shown in Figure 7.5. The profit is positive, when the price of a product is greater than the average cost of the product. This means that the total revenue is greater than the sum of the fixed cost and variable cost of production.

Figure 7.5 A competitive firm making a positive profit



: Total profit

When the price is equal to the minimum level of the average cost

$$P = AC_{\min},$$

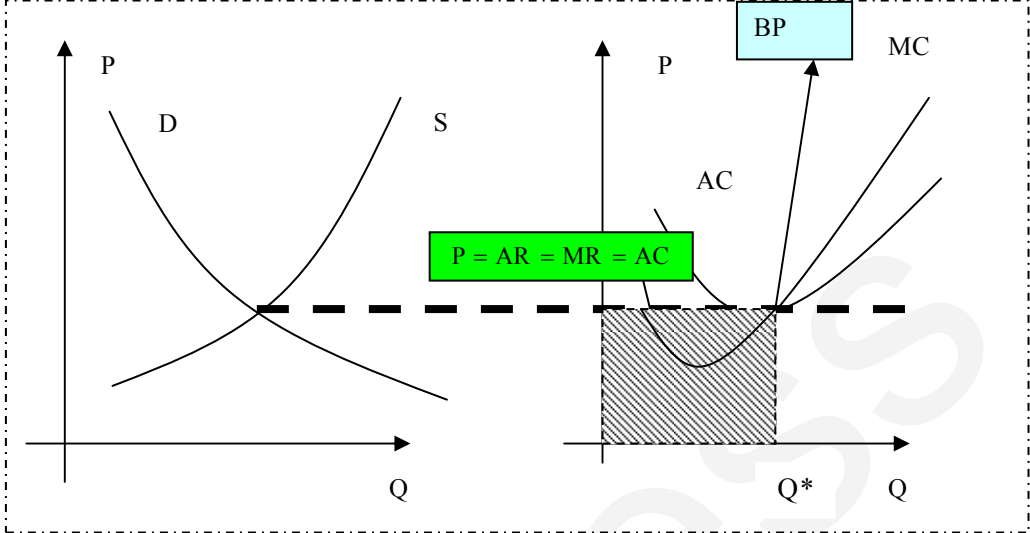
the total revenue is equal to the total cost (Figure 7.6). In this case the firm has no positive profit. The total profit is the following:

$$\text{Total profit is equal to zero: } T\pi = TR(Q) - TC(Q) = 0.$$

As we have mentioned, a competitive firm maximizes its profits by producing the level of output  $Q^*$  at which its marginal cost is equal to the price (Figure 7.6). The profit is zero when

the price of a product is equal to the minimum level of average cost. This means that the total revenue covers the sum of the fixed cost and the variable cost of production. This point is called the break-even point (Figure 7.6).

Figure 7.6 Break-even point



When the price is equal to the minimum level of the average variable cost

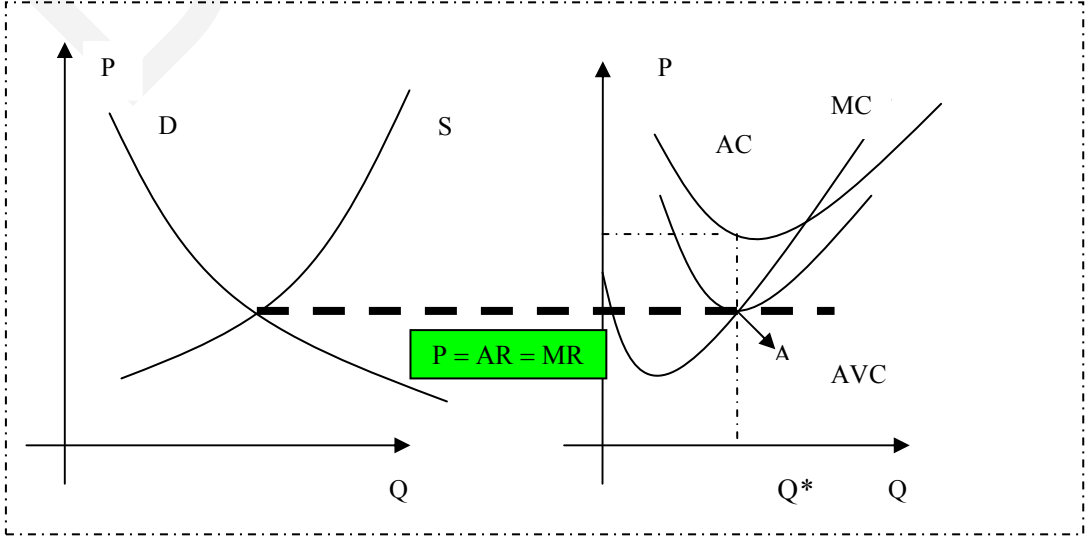
$$P = AVC_{\min}$$

the total revenue equals the variable cost (Figure 7.7). In this case the firm has no positive profit and the total revenue only covers the variable cost:

$$T\pi = TR(Q) - TC(Q) < 0.$$

In this case all fixed costs are sunk costs. In the short run, a competitive firm tries to minimize its losses by producing the level of output at which the marginal cost is equal to the price (Figure 7.7). This point is called the shut-down point (Figure 7.7: point A).

Figure 7.7 The shut-down point



“If the firm shuts down, it loses all revenue from the sale of its product. At the same time, it saves the variable costs of making its product (but must still pay the fixed costs). Thus, the firm shuts down if the revenue that it would get from producing is less than its variable costs of production; it is simply not worth producing a product which costs more to produce than the revenue generated by its sale. Doing so would reduce profit or make any existing losses even greater.”

(Mankiw – Taylor, 2011:294)

We have established that the firm does not produce any product below the shut-down point, where the marginal cost is equal to the average variable cost. This means that the firm’s supply curve is equivalent to its *MC* curve above the minimum level of the average variable cost (Figure 7.8).

The market supply curve is the horizontal sum of the supply curves of individual firms.

**“Short-run supply curve:** The supply curve that shows how the firm’s profit-maximizing output decision changes as the market price changes, assuming that the firm cannot adjust all of its inputs (e.g., quantity of capital or land).

**Shutdown price:**

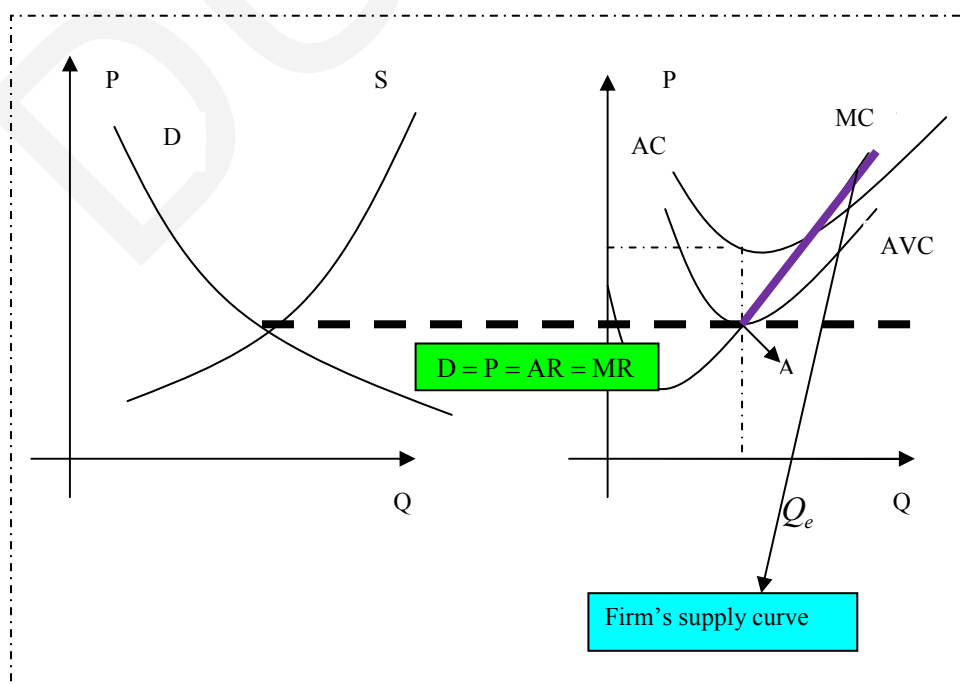
The price below which a firm supplies zero output in the short run.”

**Short-run market supply curve:**

The supply curve that shows the quantity supplied in the aggregate by all firms in the market for each possible market price when the number of firms in the industry is fixed.

(Besanko – Braeutigam, 2011:339;340;346)

Figure 7.8 Short-run supply curve



## 7.5. Producer surplus

The producer surplus equals the firm's total revenue minus its total non-sunk cost. The total cost can be divided into two parts: the sunk fixed cost and the non-sunk costs. According to the market situation, the level of the price and the non-sunk cost is equal:

$$NSC = VC + NSFC,$$

where  $VC$  is the variable cost and  $NSFC$  is the non-sunk fixed cost. The short-run total cost can be expressed by the sunk and non-sunk costs:

$$TC = \begin{cases} SFC + VC + NSFC, & \text{when } Q > 0 \\ SFC, & \text{when } Q = 0 \end{cases}$$

The variable cost is a non-sunk cost, because the amount of the variable cost is zero when the firm produces zero output. The sunk fixed cost is a fixed cost that the firm cannot avoid if it shuts down and produces zero output (Besanko – Braeutigam, 2011:337).

“Producer surplus is the difference between the amount that a firm actually receives from selling a good in the marketplace, and the minimum amount the firm must receive in order to willing to supply the good in the marketplace.”

“Producer surplus: A measure of the monetary benefit that producers derive from producing a good at a particular price.”

(Besanko – Braeutigam, 2011:371)

## 7.6. Terms and Questions

average revenue,  
average profit  
break-even point,  
competitive market,  
marginal revenue,  
marginal profit  
perfect competition,  
price-taking firm,  
producer surplus,  
profit,  
profit-maximizing output,  
short-run market supply curve,  
short run supply curve,  
shut-down point,  
sunk cost,  
sunk fixed cost,  
total revenue,  
total revenue curve,  
total profit curve.

### *Problems*

#### ***Theoretical questions***

1. What is the difference between the average revenue and the marginal revenue?
2. What are the main characteristics of a competitive market?
3. How can we calculate total profit?
4. Explain how the marginal revenue is calculated.
5. Explain what the difference is between the short-run market supply curve and the firm's supply curve.

6. Explain how to derive the profit-maximizing output.
7. What is the relationship between the competitive market price and marginal cost?
8. Under what condition will a firm exit a market?
9. Under what condition will a firm shut down temporarily?
10. What is meant by a price-taking firm?
11. What is the producer surplus?
12. What is meant by a sunk fixed cost?

### ***Calculation exercises***

13. A firm's short-run average cost curve is  $AC = \frac{180}{q} + 10 + 0.25 \cdot q$ , and the fixed cost is 180.
  - a) What is the firm's short-run total cost function?
  - b) What is the firm's short-run average variable cost function?
  - c) What is the firm's short-run marginal cost function?
  - d) What is the minimum level of the average cost?
  - e) What is the minimum level of the average variable cost?
  - f) What is the firm's short-run supply curve?
  
14. Peter's special chocolate cake shop operates in a competitive market. The short-run total cost curve is  $TC = 240 + q + 0.1 \cdot q^2$ , where  $q$  is the number of boxes of chocolate cake sold per day. All fixed costs are sunk. The market price of chocolate cakes is  $P = 5$  EUR per box.
  - a) What is the equation for the short-run marginal cost?
  - b) What is the short-run average cost curve of Peter's competitive firm?
  - c) How many boxes should Peter sell to maximize his profit?
  - d) What is Peter's short-run supply curve?

15. The garden gnome market contains 100 identical firms, all of whom have an identical short-run total cost curve:  $TC = 4 \cdot q + 0.1 \cdot q^2$ , where  $q$  is the number of garden gnomes produced by each firm. The market for garden gnomes is perfectly competitive. The market demand curve for garden gnomes is  $D(P) = 3400 - 4 \cdot P$ .

- a) What is the short-run market supply function?
- b) What is the short-run equilibrium price and quantity in this market?

16. A firm sells a good in a competitive market at a price of 800 EUR. The firm's fixed cost is 1 600 EUR.

- a) Fill in the following table.
- b) How much should the firm produce to maximize its profit?
- c) Plot the marginal revenue and the marginal cost curves on the same diagram.
- d) Illustrate the profit-maximizing quantity.

<b>q (Output)</b>	<b>TR (Total revenue)</b>	<b>TC (Total Cost)</b>	<b>Profit</b>	<b>MR (Marginal Revenue)</b>	<b>MC (Marginal Cost)</b>
0	0				
1					100
2					80
3					120
4					300
5					500
6					800
7					1120
8					1540

17. Kate's photographic service operates in a competitive market. The short-run total cost curve is  $TC = 180 + 0.2 \cdot q + 0.01 \cdot q^2$ , where  $q$  is the number of photographs made per day. All fixed costs are sunk. The market price of a photograph is 1 EUR each.

- a) What is the equation for the short-run marginal cost?
- b) What is the short-run average cost curve of Peter's competitive firm?
- c) How many boxes should Peter sell to maximize his profit?
- d) What is Peter's short-run supply curve?

18. A firm's short-run total cost curve is  $TC = 500 + 5 \cdot q + 0.5 \cdot q^2$ , and the firm has non sunk fixed costs  $NSFC = 242$ .

- a) What is the firm's short-run average cost function?
- b) What is the firm's short-run sunk fixed cost?
- c) What is the firm's short-run average variable cost function?
- d) What is the firm's short-run marginal cost function?
- e) What is the firm's short-run average non-sunk cost function?
- f) What is the minimum level of average non-sunk costs?
- g) What is the firm's short-run supply function?

19. A specialist software-making industry consists of 80 producers. All firms produce with the identical short-run total cost curve:  $TC = 85 + 0.1 \cdot q + q^2$ , where  $q$  is the number of software programmes developed per year. The market demand curve is given by:

$D(P) = 2516 - 2 \cdot P$ . The fixed cost is sunk.

- a) What is the equation for the short-run marginal cost?
- b) What is a firm's short-run supply function?
- c) What is the short-run market supply curve?
- d) Calculate the short-run equilibrium price and quantity.

20. A mobile crane hire company operates in a perfectly competitive market. The market price is 200 EUR per crane hired. The short-run total cost curve is  $TC = 180 + \frac{12.5 \cdot q^2}{5}$ , where  $q$  is the number of mobile cranes hired per day.

- a) What is the equation for the short-run marginal cost?
- b) What quantity should the company produce if it wants to maximize its profit?
- c) Draw the company's total revenue and total cost curves on the same diagram.
- d) Draw the total profit function and illustrate the profit-maximizing output.

21. A swimming-pool manufacturer firm works in a perfectly competitive market. All firms produce with an identical long-run total cost curve:

$TC = 5000 \cdot q - 100 \cdot q^2 + q^3$ , where  $q$  is the number of swimming-pools made per year. The market demand curve is given by:  $D(P) = 7250 - 2 \cdot P$ .

- a) What is the equation for long-run marginal cost?
- b) What is the equation for long-run average cost?
- c) Calculate the long-run equilibrium price and quantity.
- d) Calculate the number of individual firms.

22. A firm operates in a perfectly competitive market. The information about the firm's production can be found in the following table:

Output q	Total Revenue TR	Total Cost TC	Profit	Marginal Revenue MR	Marginal Cost MC
0		1600			
1		2550			150
2		2670			
3		2850			
4				1200	450
5					750
6			1950		
7			1470		

- a) Fill in the table.  
 b) How much should the firm produce to maximize its profit?  
 c) Plot the marginal revenue and the marginal cost curves on the same diagram.

23. A firm operates in a perfectly competitive market. The market price of the good produced by the firm is 100 EUR per product. The short-run variable cost curve is  $VC = 30 \cdot q + \frac{3 \cdot q^2}{2}$ , where q is the number of the product sold. The firm's fixed cost is 1 200 EUR.

- a) What is the equation for the short-run total cost?  
 b) What is the equation for short-run marginal cost?  
 c) What is the equation for the short-run average cost?  
 d) What is the equation for the short-run average variable cost?  
 e) What is the equation for the short-run average fixed cost?  
 f) What is the equation for the total revenue and total profit?  
 g) What quantity should the company produce if it wants to maximize its profit?  
 h) Plot the company's total revenue and total cost curves on the same diagram.  
 i) Plot the total profit function and illustrate the profit-maximizing output.

24. The total cost and total revenue curves for each competitive firm in an industry can be described by the following equation:

$$TR = 72 \cdot q,$$

$$TC = 12 + 24 \cdot q + 3 \cdot q^2.$$

- a) What is the fixed cost?  
 b) Plot  $TR$ ,  $TC$  and  $T\pi$  on a diagram.

- c) Determine the  $AR$ ,  $MR$ ,  $MC$ ,  $AC$ ,  $AVC$ ,  $AFC$ , and total profit functions.
- d) Calculate the maximum profit output and the amount of profit at that output.
25. Consider a typical firm in a perfectly competitive industry in the short run. The total cost function:  $TC = q^3 + 125 \cdot q + 2000$ . Price is 2 825 Forints.
- a) What is the firm's output?
- b) What is the breakeven quantity?
- c) Determine the price range in which the firm is loss-making.
26. A perfectly competitive firm has a cost of production of  $TC = 480 - 16 \cdot q + \frac{q^2}{2}$ , the market price of the output is  $P = 20$ .
- a) Write the profit function of the firm.
- b) What is the marginal revenue?
- c) What is the marginal cost?
- d) What is the optimum level of production for  $q$ ?
- e) What is the total revenue from producing and selling  $q$ ?
- f) What is the total cost of producing  $q$ ?
- g) What is the profit at the optimum level of production?
27. The demand and supply functions ( in the competitive market):
- $$D(P) = 60 - P ,$$
- $$S(P) = 30 + 2 \cdot P .$$
- A perfectly competitive firm has an average cost of production of  $AC = \frac{120}{q} + 10 + 2 \cdot q$ .
- a) Write the total cost, and the average variable and average fixed cost functions.
- b) What is the marginal revenue?
- c) What is the marginal cost,  $MR$ ,  $AR$ ,  $VC$ , and  $FC$ ?
- d) What is the optimum level of production for  $q$ ?
- e) What is the total revenue from producing and selling  $q$ ?
- f) What is the total cost of producing  $q$ ?
- g) What is the profit at the optimum level of production?
- h) How many firms are there in the market?

28. A company discovers the following economic information about its price and cost functions:

$$\begin{aligned}MC &= 20 \cdot q, \\FC &= 2000, \\P &= 400.\end{aligned}$$

- Derive the profits function for the firm.
- What is the breakeven quantity?
- At what output level would profits be maximized?

29.

Consider a typical firm in a perfectly competitive manufacturing industry in the short run. The variable cost function is:

$$AC = 2 \cdot q^2 - 10 \cdot q + 18.$$

- What is the shut-down quantity and price?

30. The demand curve in a perfectly competitive industry is:  $Q = 184050 - 10 \cdot P$ . The 'ABC' firm operates in this market and its costs functions are as follows:

$$\begin{aligned}MC &= 6 \cdot q + 5, \\FC &= 1200.\end{aligned}$$

The firm produces at its breakeven point.

- What is the total cost?
- What is the variable cost?
- What is the firm's output?
- How many firms operate in the industry?
- Determine the price range within which the firm is loss-making (but produces).
- What is the supply function?

31. A firm's average cost function in an industry with perfect competition:

$$AC = q^2 + \frac{444}{q}.$$

- What is the output and the total profit of the firm, if the price is 27 Ft per unit?

## 8. Monopoly

We now continue our study of microeconomics with the examination of a monopoly market, and we analyse the monopolist's profit-maximizing price and quantity. We examine what the difference is between a monopoly and a monopsony.

### 8.1. Monopoly and monopsony

The main characteristics of monopoly:

- **There is only one seller, but many buyers on the market.**  
One buyer's purchase of goods is so small that a buyer has a negligible impact on the product price. The monopoly does not have many real competitors, and therefore it can influence the market price of its good.
- **A monopoly is a price maker.**  
The monopoly is the only seller in an industry, and therefore the monopoly can determine the market price of its good. The price is not given for the monopoly.
- **The market actors do not have perfect information about the production process and technology of the product.**
- **Firms face market barriers when firms want to enter the market.**  
There are barriers that prevent the firm from entering the market. Similarly, there are barriers that prevent the firm exiting the market.

A monopsony is a market that has many sellers, but only one buyer. On the other hand, a monopoly is a market that has only one seller, but many buyers.

“If you own a personal computer, it probably uses some version of Windows, the operating system sold by the US Company, Microsoft Corporation. When Microsoft first designed Windows many years ago, it applied for and received a copyright, first from the US government and then from many governments of the world. The copyright gives Microsoft the exclusive right to make and sell copies of the Windows operating system. So if a person wants to buy a copy of Windows, he or she has little choice but to give Microsoft the price that the firm has decided to charge for its product. Microsoft is said to have a *monopoly* in the market for Windows.“

*(Mankiw – Taylor, 2011:308)*

The reasons for the development of a monopoly include:

- A firm faces market barriers when it wants to enter the market.

If firms face barriers when they want to enter the market, this contributes to the sole market position of monopoly.

- Monopolies can arise when only one firm is the owner of the key resources.
- Monopolies can arise if the government gives a firm the exclusive right to produce a certain good.
- An industry is a **natural monopoly** when a single firm can supply a good or services to an entire market at a lower cost than could two or more firms. A natural monopoly arises when there are economies of scale over the relevant range of the monopoly. (Mankiw – Taylor, 2011:311)

An example of a natural monopoly is the provision of transport by rail. To provide transport by rail to residents of a country, a firm must build a new railway system. If several firms were to compete in the provision of railway services, each firm would have to pay the fixed cost of building the railway system.

## 8.2. The monopoly profit-maximization condition

### *The total revenue, average revenue and marginal revenue of a monopoly*

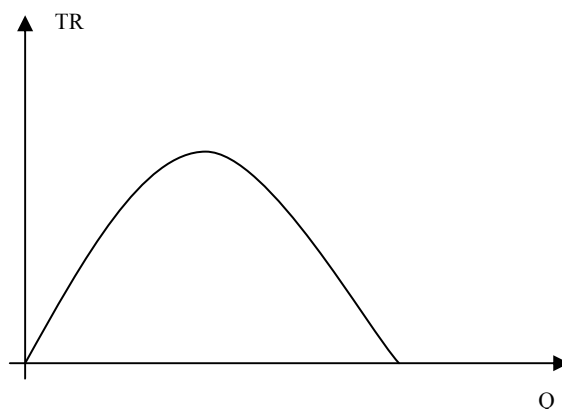
As we have mentioned in the previous chapter, competitive firms are price takers, so they have no significant effect on the market price. This means perfectly competitive firms face horizontal demand curves. By contrast, a monopoly faces a downward sloping demand curve, since it is the sole producer and seller in the market. This means that the monopoly's average revenue is the market demand curve (Figure 8.2); it determines the price of sold product. The market demand curve is given by the following equation:

$$P = a - b \cdot Q .$$

The total revenue is equal to the price multiplied by the amount of output, this means that the monopolist's total revenue curve is not a straight line (Figure 8.1). By contrast, in the case of perfect competition, the total revenue curve is a straight line:

$$TR = P \cdot Q = a \cdot Q - b \cdot Q^2 .$$

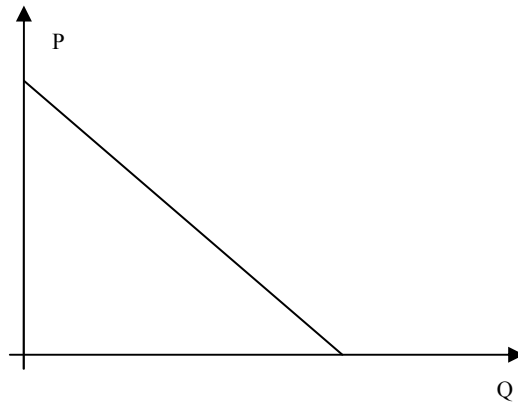
Figure 8.1 Total revenue of a monopoly firm



The average revenue is the ratio of the total revenue and the quantity of output produced:

$$AR = \frac{TR}{Q} = \frac{P \cdot Q}{Q} = P = a - b \cdot Q.$$

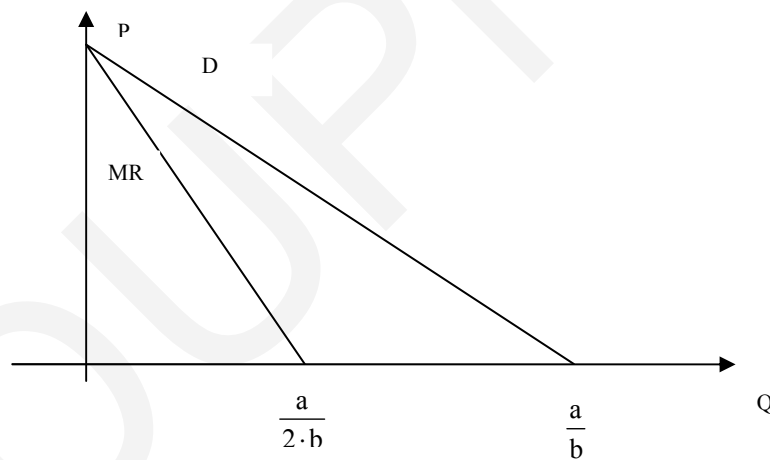
Figure 8.2 Average revenue for monopoly firm



Marginal revenue is given by:

$$MR = \frac{\Delta TR}{\Delta Q} = a - 2 \cdot b \cdot Q.$$

Figure 8.3 Marginal revenue for monopoly firm



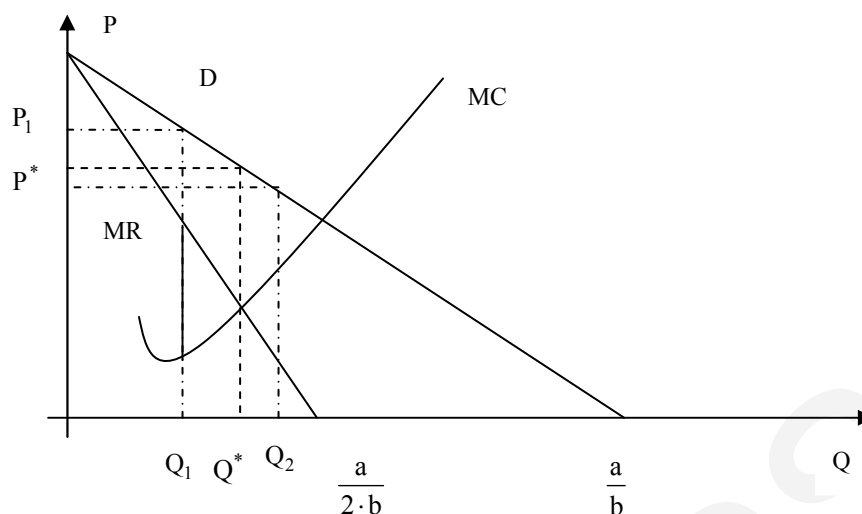
### The monopolist's output decision

The monopolist's output decisions depend on the total revenue and the cost of production. A monopoly maximizes its profit by producing and selling the quantity at which marginal revenue equals marginal cost:

$$MR(Q^*) = MC(Q^*).$$

The profit-maximizing output is determined by the intersection of the marginal cost curve and the marginal revenue curve (Figure 8.4).

Figure 8.4 Profit maximization for a monopoly



“Marginal revenue and marginal cost are equal at quantity  $Q^*$ . Then from the demand curve, we find the price  $P^*$  that corresponds to this quantity  $Q^*$ . How can we be sure that  $Q^*$  is the profit-maximizing quantity? Suppose the monopolist produces a smaller quantity  $Q_1$  and receives the corresponding higher price  $P_1$ . Marginal revenue would exceed marginal cost, so if the monopolist produced a little more than  $Q_1$ , it would receive extra profit ( $MR-MC$ ) and thereby increase its total profits. In fact, the monopolist could keep increasing output, adding more to its total profit until output  $Q^*$ , at which point incremental profit earned from producing one more unit is zero. So the smaller quantity  $Q_1$  is not profit maximizing, even though it allows the monopolist to charge a higher price. The larger quantity  $Q_2$  is likewise not profit maximizing. At this quantity marginal cost exceeds marginal revenue, so if the monopolist produced a little less than  $Q_2$ , it would increase its total profit (by  $MC-MR$ ). The monopolist could increase its profit even more by reducing output all the way to  $Q^*$ .“

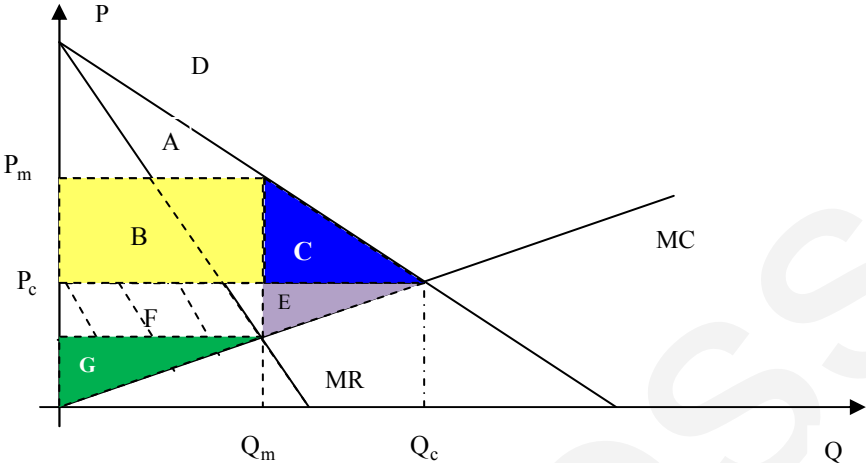
(Pindyck – Rubinfeld, 2012:361)

### 8.3. The Welfare cost of Monopoly

We have examined the condition for profit-maximization in a competitive market and in a monopoly. A firm reaches its profit-maximizing output when marginal revenue equals marginal cost. As we established in the previous chapter, in the case of a competitive market the price is equal to the marginal revenue, so it also equals the marginal cost. However, in the case of a monopoly the price is higher than the marginal cost. We examine a situation of consumer surplus in which a good is produced by a competitive industry and when it is produced in a monopoly. Assume that the competitive market firm's cost curves and the monopoly's cost curves are the same. The Figure 8.5 shows the equilibrium price and quantity ( $P_c, Q_c$ ) in the perfectly competitive market. The competitive price is equal to the marginal cost; it is found where the marginal cost curve intersects the market demand curve (Figure

8.5). The equilibrium point is the intersection of the market demand curve and market supply curve. We examined how the competitive firm’s market supply curve can be derived from its marginal cost curve.

Figure 8.5 Equilibrium for a Monopoly and a Competitive Market



The monopoly profit-maximizing output occurs where the marginal cost curve intersects the marginal revenue curve (Figure 8.5). The monopolist’s price is greater than the perfectly competitive price, and the perfectly competitive industry supplies a greater output than the monopoly does. Figure 8.5 shows the consumer surplus for a competitive market and a monopoly. The consumer surplus in the competitive market is the area contained within  $A+B+C$ , while the monopoly consumer surplus is the area  $A$  (Figure 8.5). The producer surplus for a monopoly is the area  $B+F+G$  (Figure 8.5), while the producer surplus for a competitive industry is the area  $E+F+G$ . The net benefit of the monopoly is the area  $A+B+G+F$ , while for a competitive industry it is  $A+B+C+E+F+G$ . The deadweight loss is the difference between the net economic benefit that would arise if the market were perfectly competitive and the net economic benefit attained with a monopoly. The deadweight loss is equal to the area  $C+E$  (Figure 8.5).

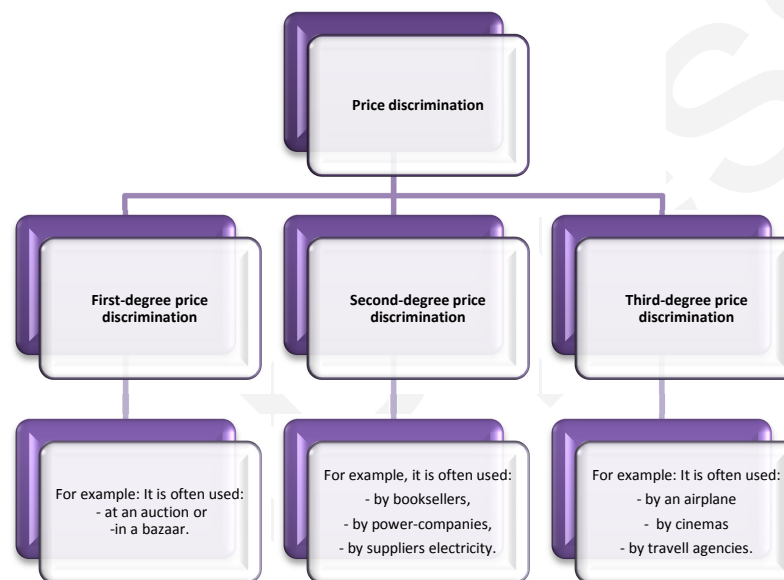
## 8.4. Price discrimination

Assume that the monopolist has the possibility to apply price discrimination. This means that the monopoly firm charges different prices to different customers. Price discrimination is a price-determining practice in which the monopolist sells the same good or service at different prices to different customers.

### Examples of price discrimination

There are three major types of price discrimination (Figure 8.6):

Figure 8.6 The different types of price discrimination



- **First-degree price discrimination** is where the firm charges each consumer the maximum price that the consumer is willing to pay for each unit. The customer's reservation price is the maximum price that the consumer is willing and able to pay for each unit.
- **Second-degree price discrimination** is where the firm charges customers different prices according to the quantities purchased. This means that the price per unit decreases if the customer purchases more units. For example, electricity companies in some countries charge a high price for the first kilowatts purchased up to a certain number, while additional kilowatts are charged at a much lower rate.
- **Third-degree price discrimination** is where the firm charges different prices to different consumer groups. Consumers can be divided into two or more independent markets and different prices are charged in each market. For example, the price of a bus ticket is different for adults and children.

## 8.5. Terms and Questions

average revenue of a monopoly,  
consumer surplus,  
dead-weight loss,  
equilibrium for monopoly,  
first-degree price discrimination,  
marginal revenue of a monopoly,  
monopolist's output decision,  
monopoly,  
monopsony,  
natural monopoly,  
price discrimination,  
producer surplus,  
profit maximization condition of a monopoly,  
second-degree price discrimination,  
third-degree price discrimination,  
total revenue of a monopoly  
welfare cost.

### *Problems*

#### ***Theoretical questions***

1. What is the difference between a monopoly and a monopsony?
2. Give the definition of a natural monopoly.
3. How can we calculate the monopolist's profit-maximization output?
4. Give an example of a state-created monopoly.
5. Explain the difference between a natural monopoly and a monopsony.
6. Give an example of second-degree price discrimination.
7. What is a monopolist's total revenue function?

8. Explain what the difference is between first-degree price discrimination and third-degree price discrimination.
9. Explain how to derive the monopolist's marginal revenue function.
10. What is the monopolist's profit maximization condition?
11. What is second-degree price discrimination?
12. Give an example of a monopsony.
13. What is deadweight loss?
14. Give an example of third-degree price discrimination.
15. What is the difference between a monopolist's producer surplus and a competitive firm's producer surplus?

### ***Calculation exercises***

16. Suppose that the market demand curve is given by  $Q = 250 - 4 \cdot P$ .
  - a) Give the inverse market demand curve.
  - b) Draw a diagram showing the market demand curve.
  - c) What is the monopolist's total revenue function?
  - d) What is the monopolist's marginal revenue function?
  - e) Give the slope of the market demand curve and the marginal revenue curve.
  
17. Suppose that the market demand curve is given by  $Q = 2700 - 3 \cdot P$ . The monopolist's marginal cost curve is  $MC = 2 \cdot Q + 100$ .
  - a) Give the inverse market demand curve.
  - b) What is the monopolist's total revenue function?
  - c) What is the monopolist's marginal revenue function?

d) What are the profit-maximizing price and quantity for the monopolist?

18. A monopoly is a sole seller in a market.

a) Fill in the following table.

b) How much should the firm produce to maximize its profit?

Q (Output)	TR (Total revenue)	TC (Total Cost)	Profit	MR (Marginal Revenue)	MC (Marginal Cost)
0	0	1200			
10		1250		190	
20		1400		170	
30	5100		3450		
40	6400				35
50	7500	2450			45
60		3000		90	
70		3650			
80		4400	5200		
90		5250	4650		
100		6200	3800		
110	9900		2650		105
120	9600		1200		115

19. Suppose that a monopolist has the demand function  $Q = 1000 - 5 \cdot P$ . The monopolist's total cost curve is  $TC = \frac{1}{2} \cdot Q^2 + 4 \cdot Q + 800$ .

a) What is the monopolist's marginal cost function?

b) What is the monopolist's average cost curve?

c) What is the monopolist's total revenue function?

d) What is the monopolist's marginal revenue function?

e) What are the profit-maximizing price and quantity for the monopolist?

f) Is the monopolist profitable?

g) Calculate the price elasticity of demand at the profit-maximizing price.

20. Suppose a monopolist faces the following market demand curve:  $P = 240 - 10 \cdot Q$ . The monopolist's average variable cost is  $AVC = 5 \cdot Q + 120$ , and average fixed cost is  $AFC = \frac{50}{Q}$ .

a) What are the monopolist's total cost, fixed cost and variable cost curves?

- b) What is the monopolist's average cost curve?
- c) What is the monopolist's marginal revenue function?
- d) Calculate the profit-maximizing price and quantity for the monopolist.
- e) What is the value of the profit?

21. Suppose the monopolist has the demand function  $Q = 500 \cdot P^{-4}$ . The marginal cost is constant at 100 units.

- a) What is the price elasticity of demand?
- b) What is the monopolist's optimal price?

22. Suppose that a monopolist has the demand function  $Q = 500 - 4 \cdot P$ . The monopolist's total cost curve is  $TC = \frac{1}{2} \cdot Q^2 + 5 \cdot Q + 180$ .

- a) What is the monopolist's marginal cost function?
- b) What is the monopolist's average cost curve?
- c) What is the monopolist's total revenue function?
- d) What is the monopolist's marginal revenue function?
- e) What are the profit-maximizing price and quantity for the monopolist?
- f) Calculate the profit-maximizing price and quantity under perfect competition, if the supply curve is  $P = 4 \cdot Q$ .
- g) Calculate the consumer surplus under monopoly.
- h) Calculate the producer surplus under monopoly.
- i) Calculate the consumer surplus for the competitive market.
- j) Calculate the producer surplus for the competitive market.
- k) What is the deadweight loss due to monopoly?

23. Suppose that a monopolist's marginal cost curve is given by  $MC = 4 \cdot Q + 100$ . The market demand function is  $P = 200 - \frac{1}{2} \cdot Q$ .

- a) What is the monopolist's marginal revenue function?
- b) Calculate the profit-maximizing price and quantity for the monopolist.
- c) Calculate the profit-maximizing price and quantity under perfect competition, if the supply curve is  $P = 100 + 4 \cdot Q$ .
- d) Calculate the consumer surplus under monopoly.
- e) Calculate the producer surplus under monopoly.
- f) Calculate the consumer surplus for the competitive market.
- g) Calculate the producer surplus for the competitive market.
- h) What is the deadweight loss due to monopoly?

24. Suppose that a monopolist's marginal cost curve is given by  $MC = \frac{1}{2} \cdot Q$ . The market demand function is  $P = 400 - 2 \cdot Q$ .

- a) What is the monopolist's marginal revenue function?
- b) Calculate the profit-maximizing price and quantity for the monopolist.
- c) Calculate the consumer surplus under monopoly.
- d) Calculate the producer surplus under monopoly.

25. A monopoly produces products in either two of plants. The marginal costs for the two plants are  $MC_1 = 60 + 2 \cdot Q_1$ , and  $MC_2 = 20 + 4 \cdot Q_2$ . The market demand curve is  $P = 100 - 2 \cdot Q$ .

- a) Calculate the monopolist's optimal price and quantity.
- b) Calculate the optimal division of the monopolist's quantity between the two plants.

26. Suppose the monopolist's marginal cost is constant at 500 units. The market demand function is  $Q = 250 \cdot P^{-2}$ .

- a) What is the price elasticity of demand?
- b) What is the monopolist's optimal price?

27. Suppose that a monopolist's total cost curve is given by  $TC = 2.5 \cdot Q^2 + 450$ . The market demand function is  $P = 200 - \frac{5}{2} \cdot Q$ .

- a) What is the monopolist's marginal cost curve?
- b) What is the monopolist's average cost curve?
- c) What is the monopolist's marginal revenue function?
- d) Calculate the profit-maximizing price and quantity for the monopolist.
- e) Calculate the profit-maximizing price and quantity under perfect competition, if the supply curve is  $P = 4 \cdot Q$ .
- f) Calculate the consumer surplus under monopoly.
- g) Calculate the producer surplus under monopoly.
- h) Calculate the consumer surplus for the competitive market.
- i) Calculate the producer surplus for the competitive market.
- j) What is the deadweight loss due to monopoly?

28. A monopoly produces products in either two of plants. The marginal costs for the two plants are  $MC_1 = 5 \cdot Q_1 + 120$ , and  $MC_2 = 2 \cdot Q_2 + 40$ . The market demand curve is  $P = 250 - Q$ .

- a) Calculate the monopolist's optimal price and quantity.
- b) Calculate the optimal division of the monopolist's quantity between the two plants.

29. A monopoly is a sole seller in a market.

- a) Fill in the following table.
- b) How much should the firm produce to maximize its profit?

Q (Output)	TR (Total revenue)	TC (Total Cost)	Profit	MR (Marginal Revenue)	MC (Marginal Cost)
0	0	1200	-1200		
10	2900	1250	1650		
20		1400	4200		
30		1650	6450		
40		2000	8400		
50		2450	10050		
60				190	55
70				170	65
80				150	75
90		5250		130	
100		6200		110	
110	20900				105
120	21600				115

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