U N I T

THEORY OF PRODUCTION AND COST

4

Unit Objectives

After completing this unit, you will be able to:

- comprehend and evaluate how firms combine economic resources so as to maximize output;
- realize stages and economic regions of production;
- explain the meanings and behaviours of various types of costs and integrate the relationship with production costs; and
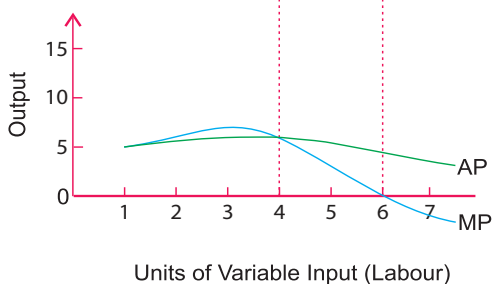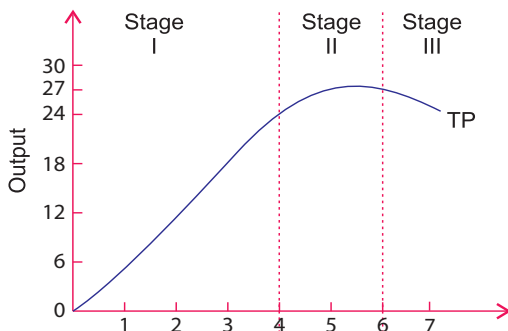- recognize the short run and long run production cost.

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INTRODUCTION

Based on our discussion in Unit 2, we know that the supply price of a given level of output depends upon the cost of production of the corresponding level of output. Cost of production, in turn, depends upon:

- *the physical relation between inputs and output and*
- *prices of inputs.*

Assuming that the prices of inputs are given, cost of production will depend upon the physical relationship between inputs and output. A study of the relationship between inputs and output is known as the '*theory of production*'. A study of the relationship between output and cost of production is what we call as '*theory of costs*'. In the present unit we discuss various aspects and elements of these two theories with a view to understand better the behaviour of firms (*producer behaviour*) in the production of goods and services.

4.1 THEORY OF PRODUCTION

At the end of this section, you will be able to:

- define production, input, and output;
- distinguish the differences between short-run and long-run production period;
- define production function;
- explain the concepts of production function with one variable input;
- distinguish the difference between total, average, and marginal product;
- show the relationship between average product and marginal product;
- describe the law of diminishing marginal product;
- identify and analyze the steps of productions;
- explain the concepts of production function with two variable input;
- define Isoquant curve schedule and map;
- state the basic characteristics of Isoquant;
- identify the economic region of production; and
- show the effects of technological change on production.

Key Terms and Concepts

- Input
- Short-run
- Long-run
- Production function
- Isoquant

Start up Activity

Discuss on the factors that affect production, pay a visit to the nearby farmland or factory and assess the factors that affect production.

Meaning of Production

Production is the transformation of resources (or inputs) into commodities (or outputs). For example, when we get wheat on a plot of land with the help of inputs like labour, capital and seeds, it is termed as production of wheat. Similarly, when, in a cloth mill, inputs like labour, capital and threads are transformed into cloth, it is called production of cloth. Similarly, in an economy, services are also produced. For instance, services of a teacher, an advocate, a doctor, a singer and servants are also called *production in economics*.

$$\text{Input} \xrightarrow{\textit{Production}} \text{Output}$$

Factors Affecting Production

Technology

A firm's production behaviour is fundamentally determined by the state of technology. Existing technology sets upper limits for the production of the firm, irrespective of the nature of output and size of the firm.

Inputs

Definition:

Inputs are economic resources that can be used in the production of goods and services.

There are wide variety of inputs used by the firms, like various raw materials, labour services of different kinds, machine tools, buildings, etc. All inputs used in production are broadly classified into four categories: *land, labour, capital* and *entrepreneurship*. The inputs can also be divided into two main groups – fixed and variable inputs. A *fixed input* is one whose quantity cannot be varied during the period under consideration. Plant and equipment are examples of fixed inputs. An input whose quantity can be changed during the period under consideration is known as a *variable input*. Raw materials, labour, power, transportation, etc., whose quantity can often be increased or decreased on short notice, are examples of variable inputs.

Definition:

Outputs are outcomes of the production process.

Period of Production

The variability of an input depends on the length of the time period under consideration. The shorter the time period, the more difficult it becomes to vary the inputs. Economists classify time periods into two categories: the *short-run* and the *long-run*.

i **Short-Run:** *Short-run refers to the period of time over which the amount of some inputs, called the 'fixed inputs', cannot be changed.* For example, the amount of plant and equipment, etc., is fixed in the short-run. This implies that an increase in output in the short-run can be brought about by increasing those inputs that can be varied, known as '*variable inputs*'. For example, if a producer wishes to increase output in the short-run, she/he can do so by using more of variable factors like labour and raw material.

ii **Long-Run:** *Long-run is defined as the time period during which all factors of production can be varied.* A firm can install a new plant or raise a new factory building. Long-run is the period during which the size of the plant can be changed. Thus, all the factors are variable in the long-run.

It may be noted that the distinction between the short-run and the long-run does not correspond to a specific calendar period, such as a month or a year. It is rather based on the possibility of input adjustments.

Activity 4.1

Make a visit to about 2-3 production centres in your locality and collect information about their products, inputs and other factors of production. Prepare a detailed report on your field-survey based project.

Production Function

Meaning of Production Function

The production function is purely a technological relationship which expresses the relationship between the output of a good and the different combinations of inputs used in its production. It indicates the maximum amount of output that can be produced with the help of each possible combination of inputs.

The production function is written mathematically as:

$$Q = f(x_1, x_2, x_3, ..., x_n) \tag{4.1}$$

where $x_1, x_2, x_3, ..., x_n$ are different inputs and Q is amount of output.

The production function is based on two main assumptions,

- *Technology does not change,*
- *Producers utilise their inputs at maximum levels of efficiency.*

Production Function with One Variable Input

Before we take up a detailed analysis of production function with one variable input, certain key terms used in the analysis must be clarified. These are total product (TP), marginal product (MP) and average product (AP). *The total product (TP) is the total amount of output resulting from the use of different quantities of inputs*. If we assume labour (L) to be the variable input assuming (capital, etc., held constant) then *marginal product of labour (MP_L) is defined as the change in total product (TP) per unit change in variable input, say labour (L),* that is,

$$MP_L = \frac{\Delta TP}{\Delta L}. \tag{4.2}$$

Where, ΔTP stands for change in total production
ΔL stands for change in labour input

Similarly, average product of labour may be defined as

$$AP_L = \frac{TP}{L}. \tag{4.3}$$

Where, TP *stands for total production*.

AP_L stands for average product for lobor.

Now let us consider a case where, for inputs like plant, machinery, floor space, etc., of a firm are all fixed, while only the amount of labour services (L) vary. That means that any increase or decrease in output is achieved with the help of changes in the amount of L. When the firm changes only the amount of labour, it alters the proportion between the fixed input and the variable input.

We go ahead with a hypothetical production schedule as shown in Table 4.1 below. Assume that capital is fixed at 1 unit, while L increases. Table 4.1 shows that the total product reaches a maximum of 27 when 6 units of labour are used.

The MP of labour for the 2nd unit of labour is 6. It then increases to 7 and ultimately becomes negative. Average product of labour also first increases and then falls.

Table 4.1:   Hypothetical Schedule of TP, MP and AP

Variable Input (L)	Total Product (TP)	Marginal Product (MP)	Average Product (AP)
0	0	—	—
1	5	5	5
2	11	6	5.5
3	18	7	6
4	24	6	6
5	27	3	5.4
6	27	0	4.5
7	25	-2	3.5

The above schedule can also be expressed graphically by drawing TP, MP and AP curves.
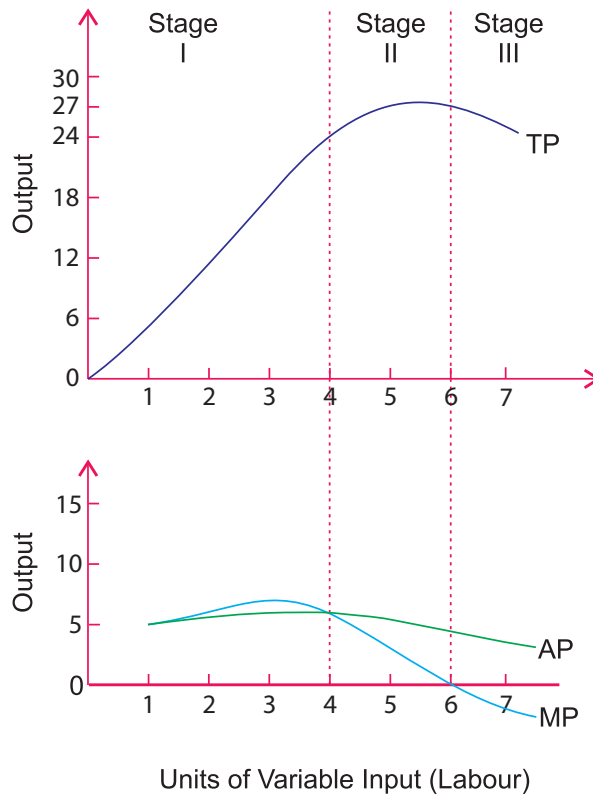
Figure 4.1: TP, MP and AP Curves Showing Three Stages of Production

Relationship Between Total Product, Marginal Product, and Average Product

The relationship between MP and AP:

- *When MP > AP, this means that AP is rising,*
- *When MP = AP, this means that AP is maximum,*
- *When MP < AP, this means that AP is falling.*

Graphically, the relationships between the MP curve and AP curve are as follows (see Figure 4.1):

- *So long as the MP curve lies above the AP curve, the AP curve is a positively sloping curve, AP rises*
- *When the MP curve intersects the AP curve, AP is at maximum,*
- *When the MP curve lies below the AP curve, the AP curve slopes downward, i.e., AP declines.*

The relationship between TP and MP:

- *When TP increases at an increasing rate, marginal product increases,*
- *While TP increases at a diminishing rate, MP declines,*
- *When total product reaches its maximum, marginal product becomes zero,*
- *When TP begins to decline, MP becomes negative.*

Stages of Production

The short-run production function (with one variable input) can be divided into three distinct stages of production. We may use Figure 4.1 to explain these stages. Stage I runs from zero units of variable input to the level where AP of labour is maximum. Stage II follows stage I and then proceeds to the point where MP_L of labour is zero (i.e., TP_L is maximum). Stage III continues on from that point. In Figure 4.1, Stage I ranges from zero to 4 units of labour, Stage II begins from 4 units to 6 units of labour and Stage III lies beyond 6 units of labour.

It is obvious that no 'rational' firm will choose to operate either in Stage I or in Stage III. In Stage I the firm is underutilising its fixed capacity, so in this stage marginal product of variable input rises (i.e., each additional unit of the variable factor contributes more to output than the earlier units). It is therefore profitable for the firm to keep on employing additional units of the input. In Stage III, the

firm over utilises its fixed capacity. In other words, it would have so little fixed capacity relative to the variable input it uses that the marginal contribution of each additional unit of the variable is negative. It is therefore inadvisable to use any additional units. Even if the cost of variable input is zero, it is still unprofitable to move into Stage III. It can, thus, be concluded that Stage II is the only relevant range for a rational firm.

For the sake of convenience, we can represent the three stages of production in tabular form as follows:

Table 4.2:

| Stage	Total Product	Marginal Product	Average Product
I	Initially increases at an increasing rate and subsequently at a diminishing rate	Increases first, and reaches the maximum	Increases throughout the stage and reaches the maximum
II	Continues to increase at a diminishing rate, and eventually reaches the maximum	Starts to decrease and eventually becomes zero	From the maximum begins to decrease
III	Diminishes	Is negative	Continues to decrease but is always positive

The Law of Diminishing Marginal Returns

The law states that *as more and more of one factor input is employed, assuming all other input quantities held constant, a point will eventually be reached where additional quantities of the varying input will yield diminishing marginal contributions to total product*.

Table 4.3:

Variable Factor (Units of Labour)	Total Product	Marginal Product
1	20	20
2	35	15
3	45	10
4	50	5

Observe from Table 4.2 and Figure 4.2 that when more and more units of labour are employed with a given quantity of a fixed factor, TP increases at a diminishing rate or MP continuously falls. That is why the shape of the MP curve is downward sloping.
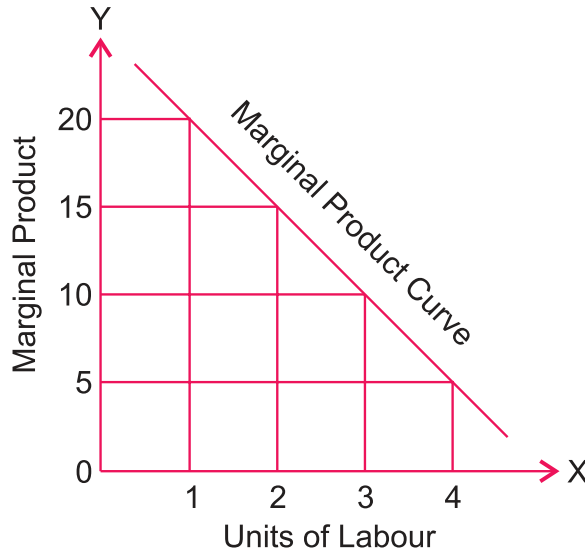
Figure 4.2: Marginal product curve

Note that:

- ○ *the law operates only if technology does not change*
- ○ *the law starts to operate after the MP curve reaches its maximum (see Figure 4.1)*
- ○ *the law is universal because the tendency of diminishing return is all pervading, and so it applies sooner or later in every field of production.*

Production Function with Two Variable Inputs

We now discuss a more general case where the firm increases its output by using more of two inputs that are substitutes for each other, say, labour and capital. The two-variable-input case may be taken either as a short-run or a long-run analysis of a production process, depending on what assumption is made about the nature of the firm's inputs. If the firm uses only two inputs and both of them are variable, then this is a case of long-run analysis. In contrast, if more than two inputs are used but only two of them are variable (and the others fixed), then this would be taken as a short-run analysis.

Let us assume a firm wants to produce 20 units of output by using two variable inputs, X and Y (say labour and capital respectively). It can do so by employing different combinations of X and Y. We show these combinations in Table 4.4.

Table 4.4:   Factor Combinations to Produce a Given level of Output (Isoquant Schedule)

| Factor Combinations	labour (units)	Capital (units)	Output (units)
A	1	12	20
B	2	8	20
C	3	5	20
D	4	3	20
E	5	2	20

To start with, factor combination A consisting of 1 unit of labour X and 12 units of capital Y produces the given 20 units of output. Similarly, combination B consisting of 2 units of labour and 8 units of capital, combination C consisting of 3 units of labour and 5 units of capital, combination D consisting of 4 units of labour and 3 units of capital, and combination E consisting of 5 units of labour and 2 units of capital are capable of producing the same amount of output, i.e., 20 units.

A tabular representation of the various combinations of two variable inputs which give the same level of output is called an isoquant schedule or equal product schedule.

Isoquant

An isoquant is a curve representing the various combinations of two inputs that produce the same amount of output. An isoquant is also known as an iso-product curve*, equal-product curve*, or *production indifference curve*. An isoquant may, therefore, be defined as a *curve which shows the different combinations of the two inputs that produce a given level of output*.

Using the data given in Table 4.4, we can construct an isoquant or equal product curve. By plotting different combinations of labour and capital required to produce 20 units of output and then joining these points by a curve, we get an isoquant (Figure 4.3).
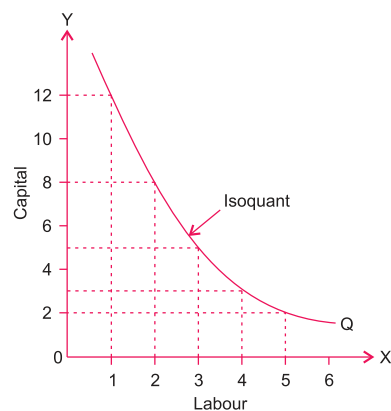
Figure 4.3: Isoquant

Any combination of labour and capital on the above isoquant gives 20 units of output.

4.1 THEORY OF PRODUCTION

Isoquant (or Equal-Product) Map

For each level of output, there is a different isoquant. *When the whole array of isoquants is represented on a graph, it is called an Isoquant Map* (Figure 4.4). It shows how outputs vary as the factor inputs are changed. A higher isoquant represents a higher level of output. However, the distance between any two isoquants does not measure the absolute difference in the volume of output they represent.
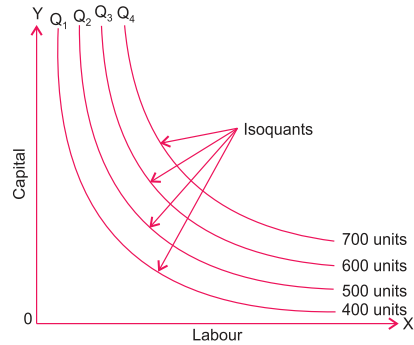
Figure 4.4: Isoquant Map

Properties of Isoquants

○ *An isoquant is downward-sloping to the right*, *(i.e., negatively inclined), implying that if more of one factor is used, less of the other factor is needed for producing the same level of output.*

○ *No two isoquants intersect or touch each other. If two isoquants intersect or touch each other it means that there is a common point on the two curves (point A in Figure 4.6). This common point would imply that the same amount of labour and capital can produce two levels of outputs (example, 60 and 70 units, here), which is impossible.*
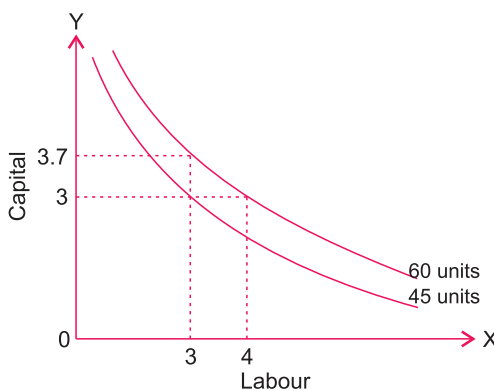
Figure 4.5: Higher Isoquant vs. Lower Isoquant
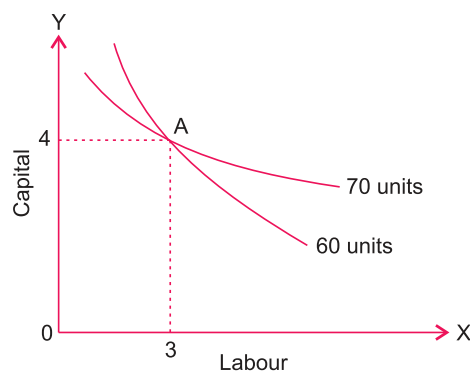
Figure 4.6: Intersection of Isoquants (impossible condition)

○ *Isoquants are convex to the origin. The property of convexity implies that the slope of the isoquant diminishes from left to right along the curve. Convexity of an isoquant is the result of the principle of diminishing*

marginal rate of technical substitution (MRTS) of one factor in place of the other. We discuss MRTS more in a later sub-section.

Economic Region of Production

Economic theory states that the producer operates on the efficient ranges of output. These are the ranges over which the marginal products of the inputs are diminishing but positive. When the marginal products of inputs are negative, the methods of production are considered inefficient. The efficient range of output is represented by the portion of an isoquant that has a negative slope, while the inefficient combinations of inputs are represented by the positively sloped portions of an isoquant. A positive slope of an isoquant means that merely to maintain the same level of output, the firm must use more of both of the inputs. What is happening in this situation is that the marginal product of one of the inputs is negative (i.e., its additional use will lead to a fall in output), so in order to maintain the output at the same level, more of the other inputs (having positive marginal product) must be used.
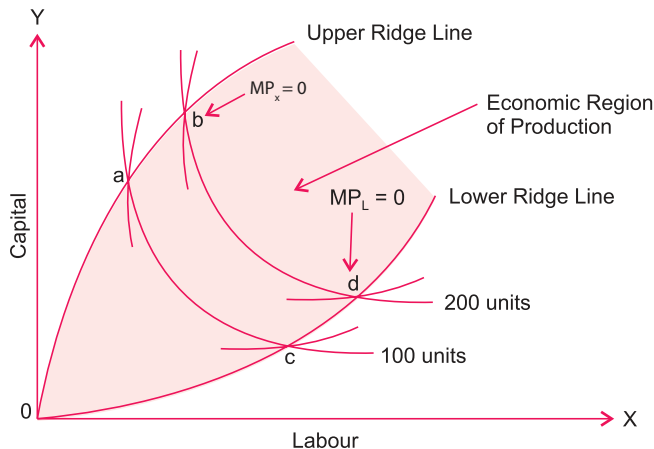
Figure 4.7: Economic Region of Production (Ridge Line)

In order to separate the efficient ranges of output from the inefficient ranges, we need to draw lines between the negatively sloped and the positively sloped portions of the isoquants. Such lines are known as ridge lines. *A ridge line is the locus of points of isoquants where marginal product of input is zero*. In Figure 4.7, the upper ridge line joins all such points (for example, a, b, etc.) where marginal product of capital (MP_k) is zero, while the lower ridge line joins points where marginal product of labour (MP_L) is zero (points c, d, etc.). The production techniques are technically efficient inside the ridge lines. Outside the ridge lines, the marginal products of inputs are negative, i.e., more of both inputs are required

to produce a given level of output. Obviously, no rational producer would like to operate outside the ridge line. Thus, *the economic region of production is the region bounded by the ridge lines*.

Marginal Rate of Technical Substitution (MRTS)

Marginal rate of technical substitution in the theory of production is similar to the concept of marginal rate of substitution in the indifference curve analysis of consumer behaviour. A marginal rate of technical substitution is the rate at which factors can be substituted at the margin without altering the level of output. More precisely, *marginal rate of technical substitution of labour for capital may be defined as the number of units of capital which can be replaced by one unit of labour, the level of output remaining unchanged*. The concept of marginal rate of technical substitution can be easily understood from Table 4.5.

Table 4.5:   Marginal Rate of Technical Substitution

Factor Combinations	Units of Labour (L)	Units of Capital (K)	MRTS of L for K
A	1	12	—
B	2	8	4
C	3	5	3
D	4	3	2
E	5	2	1

Each of the input combinations, A, B, C, D and E, yields the same level of output. Moving down the table from combination A to combination B, 4 units of capital are replaced by 1 unit of labour in the production process without any change in the level of output. Therefore, MRTS of labour for capital is 4 at this stage. Switching from input combination B to input combination C involves the replacement of 3 units of capital by an additional unit of labour, to keep output remaining the same. Thus, MRTS is now 3. Likewise, MRTS between factor combinations C and D is 2, and between factor combinations D and E is 1.

$$\text{MRTS of labour for capital} = \frac{\Delta K}{\Delta L} = \frac{\text{Amount of capital given up}}{\text{Amount of labor used}} \quad (4.4)$$

ΔK represents change in units of capital and ΔL, change in units of labour.

An important observation that we can make from the above discussion is that marginal rate of technical substitution diminishes as more and more labour is substituted for capital. In other words, as the quantity of labour used is increased and the quantity of capital employed is reduced, the amount of capital that must to be replaced by an additional unit of labour, so as to keep the output constant, diminishes. This is known as the *Principle of Diminishing Marginal Rate of Technical Substitution*.

> **Note:**
> - MRTS at a point on an isoquant = the slope of the isoquant at that point.
> - The property of diminishing MRTS results in convexity of the isoquant.

Returns to Scale (Production with all Variable Inputs)

In the previous sections we have discussed how output varies with a change in one or two variable inputs. What happens if all inputs (factors of production) are made to change?

In the short run, some factor inputs can be varied while the others remain fixed. But in the long run, time is sufficient enough to vary all the factor inputs. In other words, no input or factor is fixed in the long run. When all factor inputs can be varied, keeping their proportion constant, it is called a change in the scale of operations. The behaviour of output consequent to such changes in the quantities of all factor inputs in the same proportion (i.e., keeping the factor proportions unaltered) is known as '*returns to scale*'. Alternatively when all the factors required for production of a commodity are increased in a given proportion, the scale of production increases and the change caused in return (output) is called return to scale. In such a situation, three types or stages of returns are usually noticed.

- *Increasing Returns to Scale*. It occurs when output increases by a greater proportion than the proportion of increase in all the inputs.
- *Constant Returns to Scale*. It happens when output increases by the same proportion as of inputs increase.
- *Diminishing Returns to Scale*. It occurs when output increases by a smaller proportion than the proportion of in input increases.

We illustrate these three stages with the help of following hypothetical schedule.

Table 4.6:   Returns to Scale

Sr. No.	Scale of Inputs	Total Product (mts)	Marginal Product (mts)	Returns to Scale
1	2 labourers + 1 machine	200	200	Increasing
2	4 labourers + 2 machines	500	300	
3	6 labourers + 3 machines	900	400	
4	8 labourers + 4 machines	1400	500	Constant
5	10 labourers + 5 machines	1900	500	
6	12 labourers + 6 machines	2400	500	
7	14 labourers + 7 machines	2800	400	Decreasing
8	16 labourers + 8 machines	3100	300	
9	18 labourers + 9 machines	3300	200	
10	20 labourers + 10 machines	3400	100	

We assume here that the firm is employing only two factors, namely, labour and capital. Labour is measured in man-hours, capital in machine-hours, and output in metres. As shown in the table, 2 units of labour and 1 unit of machine produce 200 metres of cloth in the beginning.

We can also represent the three stages of returns diagramatically by converting the above Table 4.6 into the following diagram.
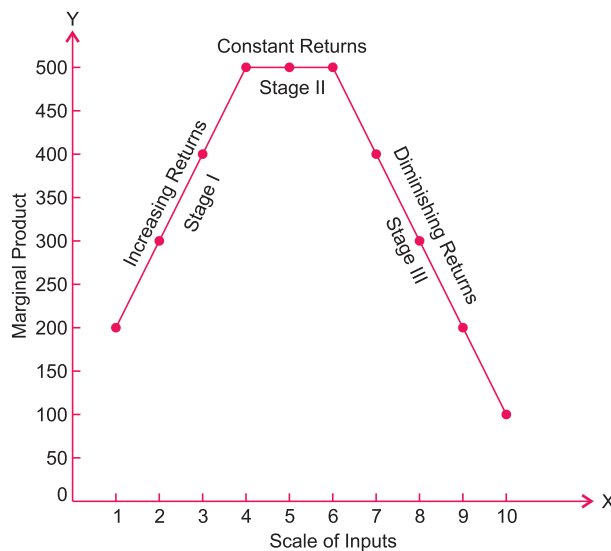
Figure 4.8: Returns to Scale

Reasons for Increasing and Decreasing Returns

Reasons for operation of increasing returns to scale are:

- *Greater division of labour and specialisation which increases productivity.*
- *Use of more productive specialised machinery.*

Reasons for operation of diminishing returns to scale are:

- *The main reason for operation of diminishing return to scale is difficulty in management and coordination when scale of operation becomes bigger and bigger.*

Effect of Technological Change on Production Function

Technological change refers to a change in the underlying techniques of production, as occurs when a new process of production is invented or an old process is improved. In such situations, the same output is produced with fewer inputs or more output is produced with the same inputs. These changes in technology are called technological progress or innovation in processes.
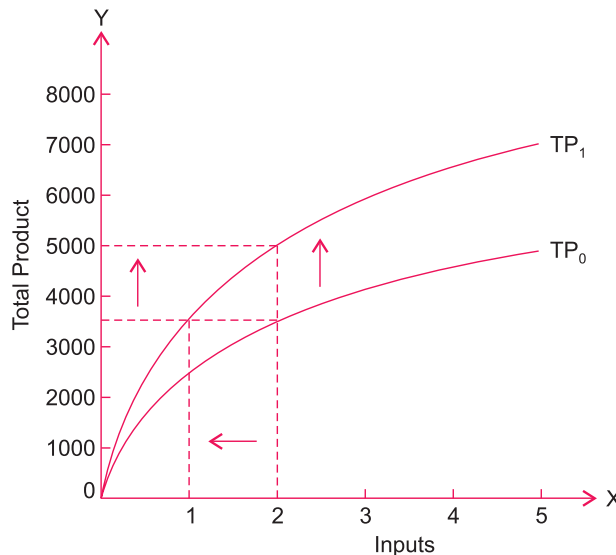
Figure 4.9: Technological Progress Shifts Production Function Upward

Graphically, the effect of *innovation in processes* is shown with an upward shift of the production function. This shift shows that the same output may be produced by using fewer factor inputs, or more output may be obtained with the same inputs.

Activity 4.2

1   Discuss the effect of technological change on the production function.

2   Complete the following table:

Units of Labour	Total Product	Marginal Product	Average Product
1	50		
2	90		
3	120		
4	140		
5	150		
6	150		
7	140		
8	120		

3   Copy and complete the following table:

Units of Capital	Total Product	Average Product	Marginal Product
1			20
2			16
3			12
4			8
5			4

4   Using the information given in the following table, express graphically the behaviour of the TP, MP, and AP curves.

Land Fixed Factor (units)	Labour Variable Factor (units)	Total Product (units)	Marginal Product (units)	Average Product (units)
1	0	0	—	—
1	1	20	20	20
1	2	50	30	25
1	3	90	40	30
1	4	120	30	30
1	5	140	20	28
1	6	150	10	25
1	7	150	0	21.43
1	8	140	−10	17.5
1	9	120	−20	13.33

5   Identify the different output levels which mark the three stages of production in the following data:

Units of Variable Input	Total Product (TP) (units)
0	–
1	100
2	220
3	360
4	520
5	650
6	750
7	840
8	880
9	880
10	830
11	770

6   Calculate MRTS for each combination given in the following table:

Combination	Units of Capital (K)	Units of Labour (L)
A	1	15
B	2	10
C	3	6
D	4	3
E	5	1

Do you observe that MRTS diminishes as more and more capital is substituted for labour?

4.2 THEORY OF COST

At the end of this section, you will be able to:

- ☐ define cost;
- ☐ differentiate private and social cost;
- ☐ distinguish the difference between explicit and implicit cost;
- ☐ differentiate short-and long-run costs of production period;
- ☐ distinguish the differences among fixed, variable, and total costs;
- ☐ define marginal cost; and
- ☐ explain the long-run cost of production.

Key Terms and Concepts

- Production
- Cost
- Input
- Entrepreneurship
- Short run

- Long run
- Fixed cost
- Variable cost
- Total cost
- Marginal cost

Start-up Activity

Assume an old fashioned tannery which purchases hides and skins from near by society. The tannery discharges hazardous chemicals to human health and peasants have no means to mitigate its effects. Discuss what society gain and loss due to the presence of this tannery.

For producing a commodity, a firm requires various factor inputs as well as non-factor inputs. The expenditures the firm incurs on these inputs refers to the cost of production. However, in economics, we use different concepts relating to cost. There are different types of cost. Some of the important ones are discussed in the following paragraphs. Costs are the monetary values of expenditures that have been used to produce something.

Private Cost and Social Cost

In economic analysis we often distinguish between private cost and social cost. *Private cost refers to cost of production incurred by an individual firm in producing a commodity*. *Social cost,* on the other hand, *refers to the cost that the society has to bear on account of production of a commodity*. Social cost is a wider concept than private cost. It is the sum total of the cost incurred by the producers of goods and services (private cost) and the cost experienced by those who have to suffer because of the production of the commodity in terms of external cost.

Thus,

Social Cost = Private Cost + External Cost *(4. 5)*

'*External cost*' is the cost that is not borne by the firm, but is incurred by other members of the society or the entire society. Such costs are termed external costs from the firm's point of view and social costs from society's point of view. For instance, an oil refinery discharges its wastes into a river, causing water pollution;

mills and factories located in a city cause air pollution by emitting smoke; and buses and trucks and other vehicles cause both air and noise pollution. Such water, air and noise pollution cause health hazards and thereby produce pervasive costs to the entire society. These costs are not taken into account by the individual producers and, therefore, they are not part of the private cost. But the true cost to the society must include all such costs, regardless of who bears them. Thus, social cost differs from private cost to the extent of external cost.

Explicit Cost and Implicit Cost

Actual payments made by a firm for purchasing or hiring resources (or factor-services) *from the factor-owners or other firms are called explicit costs*. In other words, explicit costs are actual money expenses directly incurred for purchasing the resources. These are the costs which a cost accountant includes under the head expenses of the firm and are also known as accounting costs. Thus, examples of explicit costs are: payments for raw materials and power; wages to the hired workers; rent for the factory building; interest on borrowed money; expenses on transport and publicity, etc.

Besides purchasing resources from other firms, a producer uses his/her own factor services in the process of production. He/she generally does not take into account the costs of his/her own factors while calculating the expenses of the firm. The cost of using such factors is called implicit costs or imputed costs. Thus, *implicit costs refer to the imputed costs of the factors of production owned by the producer himself/herself*. They are called implicit costs because producers do not make payment to others for them. For instance, rent of his/her own land, interest on his/her own capital, and salary for his/her own services as manager, etc. are implicit costs.

The main difference between explicit costs and implicit costs is that in the former case, payment is made to others, while in the latter case payment is not made to others but the payments become due to the producer's own factors of production.

Economists define cost of production in a wider sense, i.e., in the sense of economic cost, which includes both explicit cost and implicit cost. Thus *economic cost is the sum total of explicit cost and implicit cost*.

Economic Cost = Explicit Cost + Implicit Cost   *(4.6)*

Activity 4.3

1   Identify two production units (producing goods or services) in your local area and list your economics workgroup, their explicit and implicit costs of production.

2   In discuss various production activities from the point of view of their social costs and private costs, and try to identify the cases where social costs could be lower than private costs. Make a list of some examples where social costs are higher than private costs and vice-versa.

Time Element and Cost

Time element has an important place in the analysis of cost of production. We usually consider two kinds of time periods. They are:

○ ***Short Run:*** *Short run is defined as a period of time during which production can be varied only by changing the quantities of variable factors and not of fixed factors. Land, factory buildings, heavy capital equipment, and services of high-category management are some of the factors that cannot be varied in a short period. That is why they are called fixed factors.*

On the other hand, there are some factor inputs that can be varied as and when required – for instance, power, fuel, labour, raw materials, etc. They are called variable factors. Accordingly, in short-run production, we have two types of costs - fixed costs and variable costs.

○ ***Long Run***. *Long run is defined as a period which is long enough for the inputs of all factors of production to be varied. In this period, no factor is fixed, and all are variable factors. Accordingly, in the long run, all costs are variable costs.*

Short-Run Cost of Production

Total Costs in the Short Run

There are three concepts concerning total cost in the short period: Total Fixed Cost, Total Variable Cost, and Total Cost. *Fixed cost is that cost which is incurred for fixed factors*. Fixed costs consist of salary of the permanent staff, interest on borrowed capital, rent of the factory buildings, depreciation of machinery, expenses for maintenance of buildings, property tax and license fees etc.

Variable cost is cost which is incurred for variable factors. The main types of variable cost are expenditures incurred for raw materials, wages and salaries paid to casual workers, operating expenses like electricity, and taxes such as excise duties, which depend upon the output produced.

Total cost of production is the sum of all fixed and variable costs. Corresponding to fixed and variable factors in the short-run, total cost is divided into two parts:

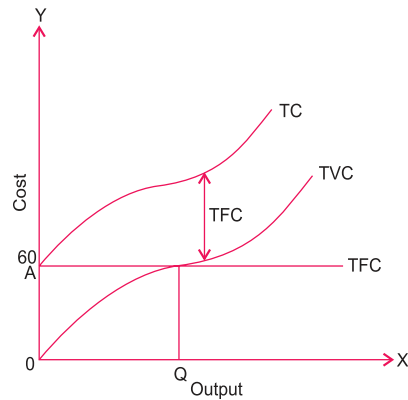* ★   Total fixed cost and
* ★   Total variable cost.

1   **Total Fixed Cost (TFC):** Total fixed cost refers to the total cost incurred by the firm for the use of all fixed factors. This cost is independent of output, i.e., it does not change with change in quantity of output. Fixed cost is also known as overhead cost. Even if the firm produces only one unit of output, the fixed cost are incurred. In fact, even if nothing is produced for some time in the short-run, fixed costs are incurred. That is why fixed cost is often known as 'unavoidable cost'. For example, a shop-keeper has to pay rent for the shop, no matter what the output or sale is during the month.

2   **Total Variable Cost (TVC):** Total variable cost refers to the total cost incurred by a firm for the use of the variable factors. These costs vary directly with changes in the volume of output, rising as more is produced and falling as less is produced. That is why variable cost is also known as 'avoidable cost'. For instance, if you want to produce more shirts, you have to buy more raw materials like yarn and hire more workers.

3   **Total Cost:** Total cost is the cost incurred on all types of inputs – fixed as well as variable inputs – incurred in producing a given amount of output.

Table 4.7:   **Total Fixed Cost, Total Variable Cost, and Total Cost**

Output (Units)	TFC (Birr)	TVC (Birr)	TC (Birr)
0	60	0	60
1	60	40	100
2	60	76	136
3	60	102	162
4	60	132	192
5	60	170	230
6	60	222	282

$$TC = TFC + TVC \qquad\qquad (4.7)$$

Since total cost has total variable cost as one of the components which varies with change in output, the total cost will also change positively with change in output. Also, since total fixed cost, by definition, remains constant, the changes in total cost are entirely due to changes in total variable cost. Table 4.7 and Figure 4.10 explain the behaviour of various types of total cost in the short run.

Figure 4.10:   Behaviour of Short-Run Total Costs

TFC curve: As Table 4.7 shows, total fixed cost remains constant at Birr 60 for the entire range of output from 0 to 6 units. It does not change with change in output. The *TFC curve is a straight line parallel to the horizontal axis,* indicating the same amount of fixed cost at every level of output. Note that, in Figure 4.10, the TFC curve starts from point A on the Y-axis, indicating that the total fixed cost is incurred even if output is zero.

TVC curve: Total variable cost changes with change in output. Initially, it increases at a decreasing rate as total output increases (up to 3 units), and subsequently it increases at an increasing rate with increases in output (from the 4th unit onwards). The TVC curve is a positively sloping curve, showing that, as output increases, total variable cost also increases. But the rate of increase of TVC is not the same throughout. The *TVC curve is concave downward, up to the OQ level of output, indicating that the total variable cost increases at a decreasing rate, and subsequently* (beyond the OQ level of output) *it is concave upward, indicating that total variable cost increases at an increasing rate*. Also note that the TVC curve starts from the origin, which shows that when output is zero, total variable cost is also zero.

TC curve: Since total cost is the sum of total fixed cost and total variable cost, it is calculated in Table 4.7 by adding figures of column 2 and column 3 at different levels of output. The total cost varies directly with output because of increases in variable costs with increases in output. The TC curve has been obtained by adding up vertically the TFC curve and the TVC curve. Since a constant fixed cost is added to the total variable cost, the shape of the TC curve is the same as that of the TVC curve. Note that the TC curve originates not from 0, but from A because, at zero level of output, total cost equals fixed cost. The vertical distance between the TVC and TC curves equals the amount of the total fixed cost.

Average Costs in the Short Run

Average cost is simply the total cost divided by the number of units produced. Corresponding to the three types of total costs in the short run, there are three types of average costs. Average Fixed Cost, Average Variable Cost, and Average Total Cost.

- **○ *Average Fixed Cost (AFC):*** *Average fixed cost is the per-unit cost of the fixed factors. It is obtained by dividing the fixed cost by the total units of output.*

$$AFC = \frac{TFC}{Q} \qquad \textcolor{magenta}{(4.8)}$$

  Where Q represents the total units of output produced.

- **○ *Average Variable Cost (AVC):*** *Average variable cost is the per-unit cost of the variable factors of production. It is obtained by dividing the total variable cost by the total units of output.*

$$AVC = \frac{TVC}{Q} \qquad \textcolor{magenta}{(4.9)}$$

- **○ *Average Cost (AC) or Average Total Cost (ATC):*** *Average total cost or simply average cost is the per-unit cost of both fixed and variable factors of production. It is obtained by dividing total cost by the total units of output.*

$$AC \text{ or } ATC = \frac{TC}{Q} \qquad \textcolor{magenta}{(4.10)}$$

Also,
$$\begin{aligned}
AC &= \frac{TC}{Q} \\
&= \frac{TFC + TVC}{Q} \quad [\text{Since TC = TFC + TVC}] \\
&= \frac{TFC}{Q} + \frac{TVC}{Q} \\
&= AFC + AVC
\end{aligned}$$

$$AC \text{ or } ATC = AFC + AVC \qquad \textcolor{magenta}{(4.11)}$$

The following schedule (based on Table 4.8) , together with the corresponding average cost curves, explain the behaviour of various types of average costs in the short run.

4.2 THEORY OF COST

Table 4.8:   Behaviour of average cost

Output (Units)	TFC (Birr)	TVC (Birr)	TC (Birr)	AFC (Birr)	AVC (Birr)	ATC (Birr)	MC (Birr) $= (\Delta TC/\Delta Q)$
(1)	(2)	(3)	(4) (2 + 3)	(5) (2÷1)	(6) (3÷1)	(7) (4÷1) or (5+6)	(8) $(TC_n - TC_{n-1})$
0	60	0	60	–	–	–	–
1	60	40	100	60	40	100	40
2	60	76	136	30	38	68	36
3	60	102	162	20	34	54	26
4	60	132	192	15	33	48	30
5	60	170	230	12	34	46	38
6	60	222	282	10	37	47	52
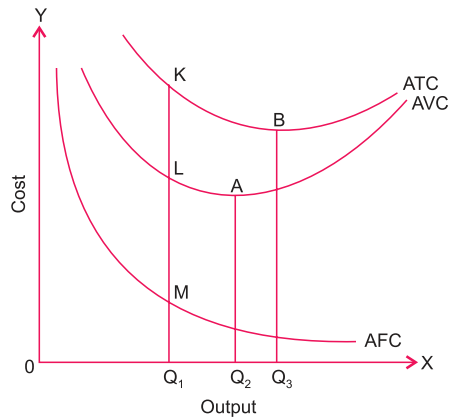
Figure 4.11:Behaviour of Average Costs

AFC Curve

It slopes downward throughout its length, from left to right, showing a continuous fall in average fixed cost with increases in output. For very small outputs, the average fixed cost is high, and for large outputs it is low. The curve approaches the X-axis but never touches it because the average fixed cost cannot be zero since total fixed cost is positive. Similarly, the AFC curve never touches the Y-axis because total fixed cost has a positive value even at very low levels of output.

AVC Curve

The behaviour of the average variable cost is derived from the behaviour of the total variable cost. The AVC curve slopes downward, up to output OQ_2 (the optimum capacity level of output), showing decreases in average variable cost, and it slopes upward beyond output OQ_2, indicating increases in average variable cost. In other words, the AVC curve is U-shaped. It is minimum at A, corresponding to optimum capacity level of output, OQ_2.

Why is the AVC Curve U-shaped? The U-shape of the AVC curve follows directly from the law of variable proportions. The average variable cost falls up to the optimum capacity level of output due to increasing returns, and it increases thereafter due to diminishing returns to the variable factor.

ATC Curve

Geometrically, the ATC Curve (or AC curve) can be obtained by adding the AFC and AVC curves. An ATC curve is the vertical summation of the AFC and AVC curves. Therefore, at each level of output, the ATC curve lies above the AVC curve at a distance equal to the value (height) of the AFC curve.

Following are some important observations about the ATC curve.

    ○ *The distance between the average cost curve and the average variable cost curve gets smaller as production increases. The ATC curve is far above the AVC curve at early levels of output because the average fixed cost is a high percentage of the average total cost. But the ATC curve tends to come closer to AVC at higher levels of output because average fixed cost now accounts for a relatively small percentage of average total cost. Notice that the ATC curve never touches AVC the curve because average fixed cost is always positive.*

    ○ *The ATC curve is U-shaped, indicating that average total cost falls initially, then reaches the minimum point, and then starts rising. It is U-shaped for the same reasons for which the AVC curve is U-shaped.*

Marginal Cost in the Short Run

Marginal cost is the addition to total cost as one more unit of output is produced. In other words, marginal cost is the addition to total cost of producing n units instead of $n - 1$ units.

$$MC_n = TC_n - TC_{n-1} \qquad\qquad (4.12)$$

Since the marginal cost is the change in total cost as a result of the change in output by one unit, it can be written as:

$$MC = \frac{\Delta TC}{\Delta Q} \qquad\qquad (4.13)$$

    Where, ΔTC is change in total cost, and ΔQ is change in the quantity of output.

In Figure 4.12, the MC curve is the marginal cost curve.
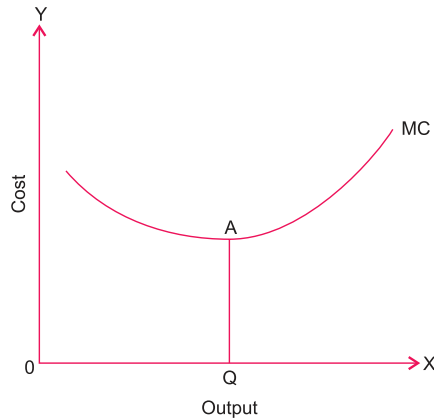
Figure 4.12:   Short-Run MC Curve

The following points should be noted with regard to marginal cost:

- *Marginal cost has nothing to do with fixed cost. It is associated with the variable cost and thereby with total cost.*

- *The MC curve is U-shaped. As output increases, the MC curve slopes downward (up to OQ units), them reaches the minimum (at point A) and then starts sloping upward beyond the OQ level of output. The U-shape of the MC curve is because of the law of variable proportions. It is negatively sloped in the initial stage of production due to increasing returns to a factor, and it is positively sloped thereafter due to decreasing returns.*

Relation Between Average and Marginal Cost

The relationship between average and marginal cost is shown graphically in Figure 4.13.
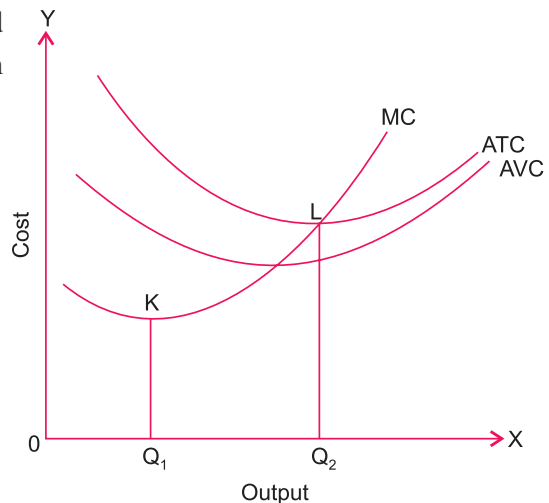
Figure 4.13:   Relationship between AC and MC

Some notable points are:

The average variable cost is the total variable cost divided by the total product, whereas marginal cost is the added cost involved for producing one more unit of product.

- *When the marginal cost is less than the average cost, the average cost falls with increases in output. It will be seen from Figure 4.13 that, as long as the MC curve lies below the ATC curve (up to OQ_2 amount of output), the ATC curve falls. Note the same relationship exists between the MC curve and the AVC curve.*

- *When the marginal cost is greater than the average cost, the average cost is rising. In Figure 4.13, the MC curve lies above the ATC curve beyond the OQ_2 level of output, and during this range the ATC curve is rising.*

- *When marginal cost is equal to average cost, the average cost is minimum. In Figure 4.13, the average cost is minimum for a while at point L on the ATC curve, and the MC curve cuts the ATC curve at this minimum point, showing that the marginal cost equals the average cost.*

4.3 RELATIONSHIP BETWEEN PRODUCTION AND COST

At the end of this section, you will be able to:

- show the relationship between production and cost.

Key Terms and Concepts

- Marginal cost
- Marginal product
- Total variable cost
- Average product
- Average cost
- Explicit cost
- Implicit cost

Start-up Activity

State the relationship between cost and production. State the various factor inputs in which a firm requires to expend in the process of production in your locality.

Analyses of production and cost are closely related. We can even say that the cost function is simply the production function expressed in money units. The basic rule that governs this relationship is that when marginal product is increasing, marginal cost is decreasing and vice versa. We illustrate the relationship between production and cost in the short run, through the following table.

Table 4.9:   Production and Cost in the Short Run

Units of Variable Input, Labour (L)	Total Product (Q)	Total Variable Cost (L × wage rate of Birr 100)	Marginal Cost (Birr) (ΔTVC/ΔQ)	Marginal Product (ΔQ/ΔL)
0	0	0	—	—
1	10	100	10.00	10
2	22	200	8.33	12
3	40	300	5.55	18
4	55	400	6.67	15
5	62	500	14.33	7
6	65	600	33.33	3
7	60	700	(–)20.00	(–)5

The cost of using variable input is determined by multiplying the units of variable input (labour) by its price. The table reveals that the total product (Q) first increases at an increasing rate and later on at a decreasing rate. Correspondingly, the total variable cost (TVC) first increases at a decreasing rate and then at an increasing rate. By plotting the data of the first three columns of Table 4.9, we get Figure 4.14, which reveals that the total variable cost and total product curves are mirror images of each other: points A_1, B_1, C_1, etc. match with points A_2, B_2, C_2, etc.
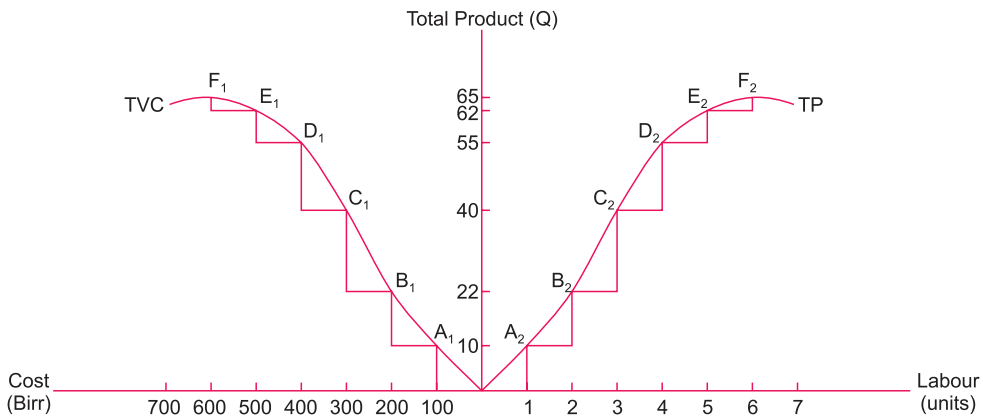
Figure 4.14:   Cost and Production Short Run

We may restate the relationship between cost and production (shown in Figure 4.14) in terms of marginal products and marginal cost. Comparison of columns 4 and 5 reveals that when MP is increasing, MC is decreasing, and while MP is decreasing, MC is increasing. MC increases in the ranges where production experiences diminishing returns. Note that just as the TVC and TP curves are mirror images of each other (as shown in Figure 4.14), MC and AVC curves are also mirror images of the MP and AP curves (as shown below).
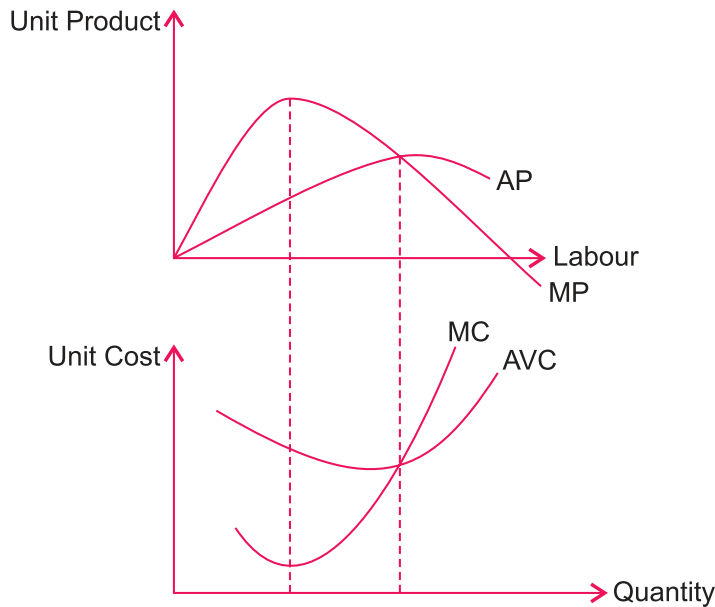
Figure 4.15:   Relationship Between Production and Cost

We may conclude that there is an inverse relationship between production and cost.

- ○ *TVC and TP of labour are inversely related.*
- ○ *AVC and AP of labour are inversely related.*
- ○ *MC and MP of labour are inversely related. Assuming that labour is the variable input and that the wage rate (W) is given, we give below an algebraic proof for the relationship between MC and MP.*

$$\Delta TVC = \Delta L \times W$$

Since $MC = \Delta TVC/\Delta Q$

$$\therefore MC = \frac{\Delta L \times W}{\Delta Q} = \left(\frac{\Delta L}{\Delta Q}\right)W = \left(\frac{1}{MP_L}\right)W = \frac{W}{MP_L} \qquad (4.13)$$

Where, $MP_L = \Delta Q/\Delta L$

Thus, assuming that the wage rate is given, MC and MP move in opposite directions, or are inversely related to each other.

Practical Work

1   Complete the following table:

Output (Units)	Total Cost (birr)	TFC (birr)	TVC (birr)	MC (birr)
0	20			
1	38			
2	50			

Solution:

Output (Units)	Total Cost (birr)	TC - TVC = TFC TFC (birr)	TC - TFC = TVC TVC (birr)	$\dfrac{\Delta TC}{\Delta Q}$ MC (birr)
0	20	20	0	—
1	38	20	18	38 – 20 = 18
2	50	20	30	50 – 38 = 12

2   The following table shows the total cost of production of a firm at different levels of output. Find out the average variable cost and the marginal cost at each level of output.

Output (Units)	0	1	2	3
Total Cost (birr)	60	100	130	150

Solution:

Output (Units)	TC (birr)	TFC (birr)	TVC = TC – TFC (birr)	AVC = TVC/Q (birr)	MC = ΔTC/ΔQ (birr)
0	60	60	0	—	—
1	100	60	40	40	100 – 60 = 40
2	130	60	70	35	130 – 100 = 30
3	150	60	90	30	150 – 130 = 20

3   The following table shows the marginal cost at different levels of output by a firm. Its total fixed costs are Birr 90.

Find its average total cost and average variable cost at each level of output:

Output (Units)	1	2	3
Marginal Cost (birr)	30	20	22

Solution:

Output (Units)	MC (birr)	TVC (birr)	TFC (birr)	TC	ATC	AVC
0	—	0	90	90	—	—
1	30	30	90	120	120	30
2	20	50	90	140	70	25
3	22	72	90	162	54	24

4   If total fixed cost is Birr 60, from the following table calculate total variable cost, total cost, average total cost and marginal cost.

Output (Units)	1	2	3
AVC (birr)	20	15	20

Solution:

Output (Units)	TFC (birr)	AVC (birr)	TVC (birr)	TC (birr)	ATC (birr)	MC (birr)
0	60	—	0	60 + 0 = 60	—	—
1	60	20	20 × 1 = 20	60 + 20 = 80	80 ÷ 1 = 80	80 – 60 = 20
2	60	15	15 × 2 = 30	60 + 30 = 90	90 ÷ 2 = 45	90 – 80 = 10
3	60	20	20 × 3 = 60	60 + 60 = 120	120 ÷ 3 = 40	120 – 90 = 30

5   From the cost function of a firm given below, find out

i   Total fixed cost,   iii   Average variable cost,

ii   Total variable cost,   iv   Marginal cost.

Output (Units)	0	1	2	3	4
Total Cost (birr)	50	70	90	100	110

Solution:

Output (Units)	TC (birr)	TFC (birr)	TVC (birr)	AVC (birr)	MC (birr)
0	50	50	—	—	—
1	70	50	20	20	20
2	90	50	40	20	20
3	100	50	50	16.6	10
4	110	50	60	15	10

Activity 4.4

1   Assume that the MC of a firm is Birr 40 and its AVC is Birr 50. Identify the stage of production in which the firm is operating.

2   Given the cost function of a firm as: $C = 128 - 6Q + 2Q^2$, Compute the following:

   a   TFC

   b   TVC of producing 4 units

   c   AVC of producing 4 units

   d   ATC of producing 4 units

   e   MC of producing the 4th unit

3   The following data refer to the production department of a firm:

   a   Number of workers: 1000

   b   Wage rate per worker: Birr 25

   c   Cost of raw materials used: Birr 15000

   d   Rent of factory building: Birr 5000

   e   Interest paid: Birr 2000

   f   Expenses for fuel: Birr 2000

   g   Number of units produced: 700

   Compute AVC and AC for the firm.

4   From the data given below, calculate:

   a   Average fixed cost

   b   Average variable cost

   c   Marginal cost

Output (Units)	0	1	2	3	4	5
Total Cost (birr)	30	90	110	120	140	180

5   Cost function of a firm is given below:

Output (Units)	0	1	2	3	4	5	6
Total Cost (birr)	60	80	100	111	116	130	150

   Find out the following:

   a   Total fixed cost   d   Average variable cost
   b   Total variable cost   e   Marginal cost
   c   Average fixed cost

6 Is it correct to say that, when output is zero, total cost equals total variable cost? Discuss with your friends.

7 Is it correct to say that, when output changes, the change in total cost is greater than the change in total variable cost? Discuss in a group.

Long-Run Cost of Production

In the long runs all factors are variable, and thus there are no fixed costs. For the analysis of the long-run cost of production, we use only three types of curves: Long-Run Total Cost Curve (LTC), Long-Run Average Cost Curve (LAC), and Long-Run Marginal Cost Curve (LMC). Here also, LAC and LMC curves are U-shaped, but they are flatter than the short-run cost curves.
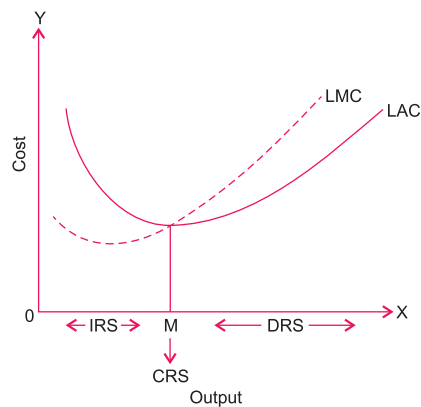
Figure 4.16:   Relation Between Production and Cost

Why is the LAC Curve U-shaped?

The U-shape of the LAC curve is because of returns to scale. As we increase the scale of operation in the initial stages, we get increasing returns to scales (IRS) as a result of economies of scale. Increasing returns to scale means that the increase in output is more than proportionate to the increase in factor inputs. Hence the LAC falls as output is increased (in the output range, to M in the diagram). But then, beyond a certain point, we get decreasing returns to scale (DRS) as a result of diseconomies of scale, and hence now LAC rises with increase in output. This happens at output levels higher than M in the diagram. When economies and diseconomies of scale offset each other, it is the stage of constant returns to scale (CRS). It happens at M level of output.

Note that the LMC curve is also U-shaped, for the same reasons, and that it cuts the LAC curve at its minimum point.

The Least Cost Rule

In the long run, cost of a product is the least cost of producing each level of output when all factors of production, including the plant, are variable.

To produce a product at the least cost, the firm should spend its money in such a way that the last Birr spent on each factor of production brings equal marginal product. That is,

$$(MP_L/P_L) = (MP_k/P_k) \qquad (4.15)$$

Where, MP_L and MP_k are marginal product of labour and capital, respectively, and P_L and P_k are the price of labour (wages) and price of capital (interest).

Note that the rule is similar to the rule of utility maximisation which we discussed in the previous unit.

Activity 4.5

1   If the price of labour is Birr 20 and price of capital is Birr 100 for a cost-minimising firm, calculate its MP_L given that $MP_K = 50$.

2   In the long run, a firm continues to produce even if it covers only its prime costs (variable costs) – discuss in a group.

U N I T   R E V I E W

UNIT SUMMARY

- ☐ *Production function* shows the maximum quantity of a commodity that can be produced per unit of time, with given amounts of inputs, when the best production technique is used. The nature of production function depends upon the time period allowed for adjustment of the inputs.
- ☐ *Short run* refers to the period of time in which the amount of some inputs cannot be changed.
- ☐ *Long run* is defined as the time period in which all factors of production can be varied.
- ☐ *Fixed factors* are those factors which remain unchanged at all levels of output.
- ☐ *Variable factors* are those factors whose quantity changes with change in output level.
- ☐ *Short run production function* refers to a situation where we study the change in output when only one input is variable and all other inputs are fixed. In this case, factor proportion is changed. This is the subject matter of the Law of Variable Proportions.
- ☐ *Long-run production function* studies the change in output when all the inputs used in the production of a good are changed simultaneously and in the same proportion. In this case, the scale of production is changed. This is the subject matter of returns to scale.
- ☐ *Total Product* (TP) refers to the total amount of a commodity produced during some period of time by combining different factors of production.
- ☐ *Average Product* (AP) of a variable factor refers to the output per unit of variable factor. Thus,

$$AP_L = \frac{TP_L}{L}$$

- ☐ *Marginal Product (MP)* of a variable factor may be defined as the change in total product resulting from the additional unit of a variable factor.

$$MP_L = \frac{\Delta TP_L}{\Delta L}$$

- ☐ *Returns to a factor* means change in physical output of a good when the quantity of one factor is increased while the quantity of other factors remains constant.
- ☐ *Law of Diminishing Marginal Returns* states that in all production processes, adding more of one factor of production, while holding one or more of other inputs constant, will at some point yield lower per

unit returns. Diminishing returns occurs in the short run when at list one factor is fixed.

- ☐ Three stages of production are:
  - ○ *Stage of Increasing Returns characterised by increasing AP, although with MP increasing initially, but falling later. TP increases at an increasing rate at first, and then at a decreasing rate. This stage is explained in terms of fuller utilisation of fixed factors and division of labour.*
  - ○ *Stage of Diminishing Returns is characterised by both AP and MP decreasing while TP increases at a diminishing rate. This is the actual stage of operation. This stage arises because of disturbances in optimum factor propositions and imperfect substitutability of factors.*
  - ○ *Stage of Negative Returns is characterised by diminishing TP; AP decreases but remains positive, and MP is negative. This stage is explained in terms of managerial problems.*
- ☐ *Marginal Rate of Technical Substitution (MRTS).* Given two inputs X, and Y, the marginal rate of technical substitution of X for Y represents the amount of X that a firm must add to replace the reduced amount of Y so as to maintain the same amount of output.
- ☐ When only two inputs vary, we can use isoquants to find the optimum input combination for the optimum level of output. An isoquant (or, Iso-product, or, equal-product curve) shows the various combinations of the two inputs at a given level of output. The slope of an isoquant is known as marginal rate of technical substitution ($MRTS_{L,k}$) and is equal to the ratio of (MP_L/MP_k).

$$MRTS_{L,K} = \frac{P_L}{P_K}$$

- ☐ An isoquant map represents the whole array of isoquants on a graph. *Properties of isoquants:*
  - ○ *downward sloping to the right*
  - ○ *no two isoquants intersect or touch each other*
  - ○ *Isoquants are convex to origin.*
- ☐ *Ridge Line.* It is the locus of points of isoquants where marginal product of inputs are zero. These lines are used to separate the efficient ranges (with positive slope of isoquants) from the inefficient ranges (with negative slope of isoquants). Thus, ridge lines indicate the boundaries of the efficient ranges of output on the isoquants.
- ☐ In an isoquant map, the ridge lines indicate the boundaries of the economic region of production.
- ☐ At equilibrium,
  - ○ *Returns to Scale. The addition of output that results from an increase in all inputs by some proportion. If the output increases by a greater proportion than the proportion of input increases, the firm*

is experiencing increasing returns to scale. If the output increases by the same proportion as the inputs, the firm is experiencing constant returns to scale. Finally, if the output increases by a smaller proportion than the increases in inputs, the firm is experiencing decreasing returns to scale.

- *Technological change shifts the production function upward.*
- *Private cost refers to the cost incurred by an individual firm in producing a commodity.*
- *Social cost refers to the cost that society has to bear because of the production of a commodity.*
- *Explicit cost refers to money expenses incurred in purchasing or hiring the factor services.*
- *Implicit cost refers to the imputed value of the inputs owned by the firm and used by it in its own production.*
- *Economic cost consists of explicit cost and implicit cost.*
- *Total fixed cost is the total cost incurred on fixed factors. It does not change with change in output.*
- *Total variable cost is the total cost incurred on variable factors. It changes with change in output.*
- *TFC curve is a straight-line curve parallel to the horizontal axis.*
- *TVC curve is concave downward, up to some level of output, then concave upward.*
- *TC curve increases at a decreasing rate first and then at an increasing rate.*
- *AFC is the per-unit cost of the fixed factors.*
- *AFC curve slopes downward continuously from left to right.*
- *AVC curve is the per-unit cost of the variable factors.*
- *AVC curve is U-shaped due to the law of variable proportions.*
- *ATC (or simply AC) is the per-unit cost of all factors of production used in production.*
- *ATC curve is the vertical summation of the AVC and AFC curves. It is U-shaped.*
- *Marginal cost is the addition to total cost as one more unit of output is produced.*
- *MC curve is U-shaped due to the law of variable proportions.*
- *The relationship between AC and MC is:*
  - *when, MC < AC, AC falls;*
  - *when MC > AC, AC rises;*
  - *when MC = AC, AC is minimum.*
- *Long-run cost is the least cost of producing each level of output when all factors of production are variable. To produce a product at the least cost, the firm should spend its money in such a way that the last Birr spent on each factor of production brings equal marginal product.*

4.3   RELATIONSHIP BETWEEN PRODUCTION AND COST

○ *There is an inverse relationship between production and cost: TVC and TP are inversely related; AVC and AP are inversely related; MC and MP are inversely related.*
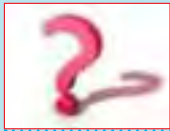
REVIEW EXERCISE FOR UNIT 4

I *Write detailed answers to the following questions*

1   Define production function. Explain two types of production function based on time period of production.

2   Explain the relationship between the average product and the marginal product, with the help of a diagram.

3   Explain the relationship between marginal product and total product, with the help of a diagram.

4   State and explain the law of diminishing marginal returns, with the help of an illustration.

5   Explain the law of variable proportions, with the help of total product and marginal product.

6   Using suitable diagrams, explain the three stages of production when one factor input is variable.

7   What are the reasons for the three phases of the law of variable proportions?

8   Discuss the production function with two variable inputs, using the concept of isoquants.

9   Describe the properties of isoquants, using diagrams.

10   Discuss the following concepts:

a   Economic region of production

b   Marginal rate of technical substitution

11   State and explain returns to scale.

12   Explain the meaning of increasing returns to scale and decreasing returns to scale, with the help of total physical product schedule.

13   Describe the effect of technological change on production function.

14   Explain the relationship between average total cost curve, average variable cost curve, and marginal cost curve.

15   Explain the concept of marginal cost. Does fixed cost affect marginal cost? Give reasons.

16   Explain the relationship between average cost and marginal cost, with the help of an appropriate diagram. Can the average cost rise when the marginal cost is diminishing?

17   Explain the relationship between total cost, average cost, and marginal cost, with the help of a cost schedule.

18   Why is the short-run average cost curve (SAC) U shaped?

19   Explain the shape of the long-run average cost curve (LAC).

20   Discuss the relationship between production and cost.

II   *Distinguish between the following:*

21   Returns to a variable factor and returns to scale

22   Increasing returns to a variable factor and increasing returns to scale

23   Diminishing returns to a variable factor and diminishing returns to scale

24   Fixed costs and variable costs

25   Private cost and social cost

III   *Write 'True' or 'False' for each of the following:*

26   When MP > AP, this means that AP is falling.

27   When MP = AP, this means that AP is minimum.

28   When TP increases at an increasing rate, MP increases.

29   An isoquant is a curve representing the various combinations of two inputs that produce different amounts of output.

30   Higher isoquants represents larger output.

31   MRTS increases as more and more labour is substituted for capital.

32   Technological progress shifts the production function downward.

33   Economic cost is the sum total of explicit cost and implicit cost.

34   In the short run, the AVC curve is U-shaped.

35   Production and cost are directly related to each other in the short run.

IV   *For each of the following, four choices are given, but only one of them is correct. Choose the correct one.*

36   The process of using different factors of production in order to make goods and services available is known as:

A	Investment	C	Consumption
B	Production	D	Resource

37   Any good or service that comes out of a production process, is known as:

A   Output   C   Labour

B   Input   D   Economic resource

38   When the short-run average product of labour is declining but positive, the marginal product of labour is:

A   Negative   C   Zero

B   Declining   D   Any of these is possible

39   When the short-run marginal product of labour is greater than the average product of labour:

A AP_L is increasing   C AP_L is equal to zero

B AP_L decreasing   D   None of these

40   When the short-run, MP_L is negative:

A   TP is also negative

B   TP is declining

C   TP is rising at a constant rate

D   TP is rising but at a diminishing rate

41   Suppose the average product of 6 workers is 150 units of a good and that of 7 workers is 170 units. The MP of the seventh worker equals:

A   200   B   270   C   290   D   220

V   *Write very short answers to the following questions*

42   What do you call the period in which:

a   the scale of plant cannot be altered;

b   the scale of plant can be altered?

43   Give two examples of variable factors.

44   Give two examples of fixed factors.

45   When the total physical product of a variable factor reaches its maximum, what will be the marginal physical product?

46   How does marginal physical product behave when total physical product starts to decline?

47   What will be the direction of marginal physical product when total physical product increases at an increasing rate?

48   When marginal physical product declines but it is neither zero nor negative, does total physical product also decline?

49   What will be the total physical product when:

     a   marginal physical product rises

     b   marginal physical product declines but remains positive

     c   marginal physical product is zero

     d   marginal physical product is negative

50   In which stage of the law of variable proportions will a producer produce?

51   When total product increases at a decreasing rate, what happens to marginal product?

52   Can average product be zero or negative?

53   Can marginal product be zero or negative?

54   When production increases in the same proportion as the increase in a variable factor, what do you call it?

55   When does scale of operation change?

56   Name the law expressing the relationship between the quantities of a variable factor and the quantities of output.

57   State whether the law of variable proportions operates in the short run or in the long run.

58   How many stages are there in the law of variable proportions?

59   What will be the shape of marginal product curve in the case of diminishing returns to a factor?

60   Give two examples of:

     a   explicit costs   c   fixed costs

     b   implicit costs   d   variable costs

61   What is the shape of the total fixed-cost curve?

62   When the AC curve is falling, what will be the position of the MC curve?

63   Can the AFC curve touch the X-axis?

64   What does the difference between total cost and total variable cost indicate in the short run?

65   Why are the TC and TVC curves parallel to each other?

66   Why do TC and TFC become equal at the zero level of output?

67   If TFC and TVC are given, how will you estimate the TC?

68   What does the difference between total cost and total fixed cost indicate in the short run?

VI *Numericals*

69 Study the following table:

Units of labour employed	1	2	3	4	5	6
Total Product (kg.)	10	24	50	75	95	108

Find out:

a   The average product when 6 units of labour are employed.
b   The marginal product of the 5th unit of labour employed.

70 Complete the following table:

Units of Labour	Total Product (kg.)	Marginal Product (kg.)	Average Product (kg.)
0	—		
1	5		
2	12		
3	21		
4	28		

71 Calculate MC from the information given below:

Output (Units)	1	2	3	4
AVC (Birr)	20	15	25	40

72 From the following data for a firm, find the

a   average fixed cost,   c   marginal cost:
b   average variable cost and

Output (Units)	0	1	2
Total Cost (Birr)	75	95	110

73 Complete the following table:

Output (Units)	Total Cost (Birr)	Total Variable Cost (Birr)	Marginal Cost (Birr)
0	12		
1	18		
2	21		

74 Calculate TFC, TVC, AVC and MC from the following:

Output (Units)	1	2	3
TC (Birr)	20	26	39
AFC (Birr)	6	3	2

75   Total fixed cost is Birr 120, and the marginal costs of different levels of output are given in the following table. Find out total cost, total variable cost, average total cost and average variable cost.

Output (Units)	1	2	3
Marginal Cost (Birr)	40	30	26

76   Calculate average cost and total cost, with the help of the following data:

Output (Units)	1	2	3
Marginal Cost (Birr)	10	8	6

77   From the table given below, calculate TFC, TVC, AFC, AVC, AC and MC.

Quantity Produced (Units)	Total Cost (Birr)
0	40
1	70
2	95
3	130
4	170
5	220

78   Assume the total cost of a producer of a commodity in the short - run is given by the equation:

$$TC = 30,000 + 15Q^2 + 5Q$$

where: TC = total cost, Q = level of out put

Using the given total cost find equations for:

a   variable costs

b   fixed costs

c   average variable costs

d   average fixed costs

e   average costs

f   marginal costs