

Unit 3

- I. Choose the correct answer (each question carries 1 mark)
1. The formula of production is
 - a) **$q = f(L, K)$**
 - b) $q = d(p)$
 - c) $y = f(x)$
 - d) None of the above
 2. In the short run, a firm
 - a) Can change all the inputs
 - b) **Cannot vary all the inputs**
 - c) Can keep the inputs fixed
 - d) None of the above
 3. The change in output per unit of change in input is called
 - a) **Marginal product**
 - b) Average product
 - c) Total product
 - d) Product
 4. Cobb=Douglas production function is
 - a) $q = (x, x)$
 - b) **$q = (x^a_1, x^b_2)$**
 - c) $q = (x_1, x_2)$
 - d) $q = (0)$
 5. $TC =$
 - a) TVC
 - b) TFC
 - c) **TFC + TVC**
 - d) $AC + MC$
- II. Fill in the blanks (each question carries 1 mark)
1. In the long run, all inputs are **variable**
 2. **Average Product** is defined as the output per unit of variable input.
 3. Marginal product and Average product curves are **U-shape** in shape.
 4. SMC curve cuts the AVC curve at the **minimum** point of AVC curve from below.
 5. **Isoquants** is the set of all possible combinations of the two inputs that yield the same maximum possible level of output.

III. Match the following (each question 1 mark)

A	B
CRS	$\frac{\Delta TC}{\Delta C}$
SAC	Long run average cost
LRAC	Short run average cost
TFC + TVC	Constant returns to scale
SMC	TC

A	B
CRS	Constant Returns to Scale
SAC	Short Run average cost
LRAC	Long run average cost
TFC + TVC	TC
SMC	$\frac{\Delta TC}{\Delta C}$

IV. Answer the following questions in a sentence / word (each question carries 1 mark)

1. What do you mean by Total product?

This relationship between the variable input and output, keeping all other inputs constant, is often referred to as Total Product (TP) of the variable input. Here x_1 and x_2 are inputs

If we keep the second factor constant and vary the first factor, we get the following value for q

$$q = f(x_1; \bar{x}_2)$$

2. What is Average product?

Average product is defined as the output per unit of variable input. Here x_1 is the input. We calculate it as

$$AP_1 = \frac{TP}{x_1} = \frac{f(x_1 - \bar{x}_2)}{x_1}$$

3. Give the meaning of Marginal product.

Marginal product of an input is defined as the change in output per unit of change in the input when all other inputs are held constant. When factor 2 is held constant, the marginal product of factor 1 is

$$MP_1 = \frac{\text{change in output}}{\text{change in input}}$$

$$= \frac{\Delta q}{\Delta x_1}$$

4. Write the meaning of cost function of the firm.

For every level of output, the firm chooses the least cost input combination. This output-cost relationship is the cost function of the firm.

5. What is total fixed cost.

The cost that a firm incurs to employ these fixed inputs is called the total fixed cost (TFC).

$$TFC = TC - TVC$$

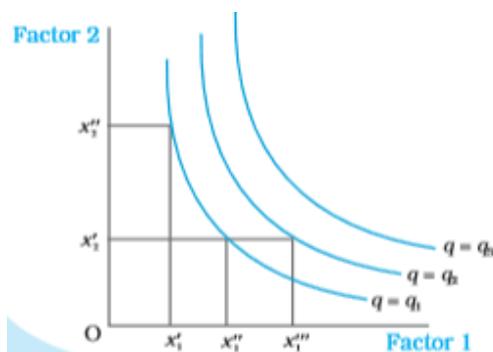
6. What is average fixed cost?

The average fixed cost (AFC) is defined as the total variable cost per unit of output. We calculate it as

$$AFC = \frac{TFC}{q}$$

V. Answer the following questions in 4 sentences. (each question carries 2 marks)

1. What is Isoquant?



It is just an alternative way of representing the production function. Consider a production function with two inputs factor 1 and factor 2. An isoquant is the set of all possible combinations of the two inputs that yield the same maximum possible level of output. Each isoquant represents a level of output and is labelled with that amount of output.

2. Give the meaning of the concepts of short run and long run.

In the short run, a firm cannot vary all the inputs. One of the factors – factor 1 or factor 2 – cannot be varied, and therefore, remain fixed in the short run. To vary the output level, the firm can vary only the other factor

In the long run, all factors of production can be varied. A firm to produce different levels of output in the long run may vary both the inputs simultaneously. So, in the long run, there is no fixed input.

3. Mention the types of Returns to scale.

- a) Constant returns to scale (CRS) is a property of production function that holds when a proportional increase in all inputs results in an increase in output by the same proportion.
- b) Increasing returns to scale (IRS) holds when a proportional increase in all inputs results in an increase in output by more than the proportion.
- c) Decreasing returns to scale (DRS) holds when a proportional increase in all inputs results in an increase in output by less than the proportion.

4. Name the short run costs.

In the short run, some of the factors of production cannot be varied, and therefore, remain fixed. The cost that a firm incurs to employ these fixed inputs is called the total fixed cost (TFC). Accordingly, the cost that a firm incurs to employ these variable inputs is called the total variable cost (TVC). Adding the fixed and the variable costs, we get the total cost (TC) of a firm

$$TC = TVC + TFC$$

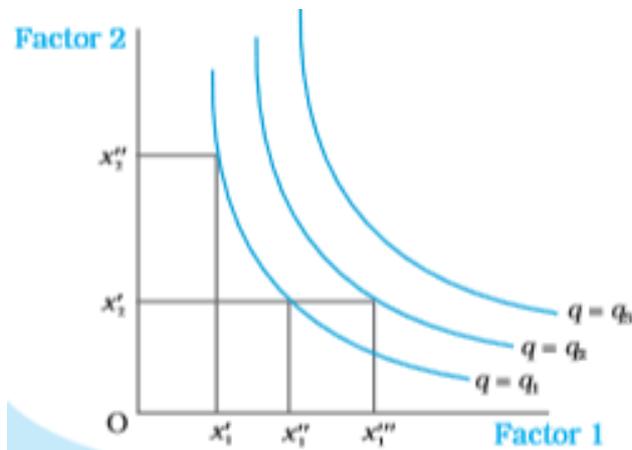
5. What are long run costs?

In the long run, all inputs are variable. The total cost and the total variable cost therefore, coincide in the long run. Long run average cost (LRAC) is defined as cost per unit of output, i.e

$$LRAC = \frac{TC}{q}$$

Answer the following questions in 12 sentences. (each question carries 4 marks)

1. Explain Isoquant with the help of the diagram.



It is just an alternative way of representing the production function. Consider a production function with two inputs factor 1 and factor 2. An isoquant is the set of all possible combinations of the two inputs that yield the same maximum possible level of output. Each isoquant represents a level of output and is labelled with that amount of output.

In the diagram, we have three isoquants for the three output levels, namely $q = q_1$, $q = q_2$ and $q = q_3$ in the inputs plane. Two input combinations (x'_1, x'_2) and (x''_1, x'_2) give us the same level of output q_1 .

If we fix factor 2 at x'_2 and increase factor 1 to x''_1 , output increases and we reach a higher isoquant, $q = q_2$.

When marginal products are positive, with greater amount of one input, the same level of output can be produced by using lesser amount of the other. Therefore, isoquants are negatively sloped.

2. Explain TP, MP and AP with the examples.

Factor		x ₂						
		0	1	2	3	4	5	6
x ₁	0	0	1	2	3	4	5	6
	1	0	1	3	7	10	12	13
	2	0	3	10	18	24	29	33
	3	0	7	18	30	40	46	50
	4	0	10	24	40	50	56	57
	5	0	12	29	46	56	58	59
	6	0	13	33	50	57	59	60

Total Product Suppose we vary a single input and keep all other inputs constant. Then for different levels of employment of that input, we get different levels of output from the production function. This relationship between the variable input and output, keeping all other inputs constant, is often referred to as Total Product (TP) of the variable input.

If we keep the second factor constant and vary the first factor, we get the following value for q

$$q = f(x_1; \bar{x}_2)$$

Let us again look at the table. Suppose factor 2 is fixed at 4 units. Now in the table, we look at the column where factor 2 takes the value 4. As we move down along the column, we get the output values for different values of factor 1. This is the total product of factor 1 schedule with $x_2 = 4$. At $x_1 = 0$, the TP is 0, at $x_1 = 1$, TP is 10 units of output, at $x_1 = 2$, TP is 24 units of output and so on. This is also sometimes called total return to or total physical product of the variable input.

Average product is defined as the output per unit of variable input. We calculate it as

$$AP_1 = \frac{TP}{x_1} = \frac{f(x_1 - \bar{x}_2)}{x_1}$$

In the table, we have already seen the total product of factor 1 for $x_2 = 4$. In the table we reproduce the total product schedule and extend the table to show the corresponding values of average product and marginal product. The first column shows the amount of factor 1 and in the fourth column we get the corresponding average product value. It shows that at 1 unit of factor 1, AP_1 is 10 units of output, at 2 units of factor 1, AP_1 is 12 units of output and so on.

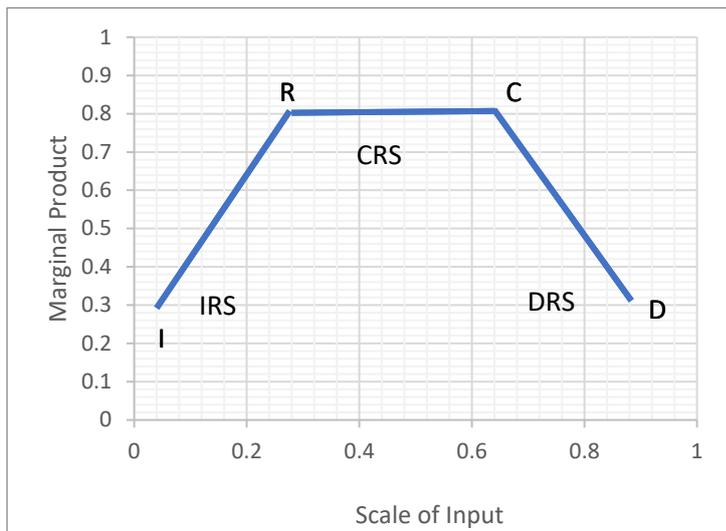
Marginal product of an input is defined as the change in output per unit of change in the input when all other inputs are held constant. When factor 2 is held constant, the marginal product of factor 1 is

$$MP_1 = \frac{\text{change in output}}{\text{change in input}} \\ = \frac{\Delta q}{\Delta x_1}$$

For example

If the input changes by discrete units, the marginal product can be defined in the following way. Suppose, factor 2 is fixed at \bar{x}_2 . With \bar{x}_2 amount of factor 2, let, according to the total product curve, x_1 units of factor 1 produce 20 units of the output and $x_1 - 1$ units of factor 1 produce 15 units of the output. We say that the marginal product of the x_1 th unit of factor 1 is

$$MP_1 = f(x_1; \bar{x}_2) - f(x_1 - 1; \bar{x}_2) \\ = TP \text{ at } x_1 \text{ units} - (TP \text{ at } x_1 - 1 \text{ unit}) \\ = (20 - 15) \text{ units of output} \\ = 5 \text{ units of output}$$



3. Write a brief note on returns to scale.
- a) Constant returns to scale (CRS) is a property of production function that holds when a proportional increase in all inputs results in an increase in output by the same proportion.
 - b) Increasing returns to scale (IRS) holds when a proportional increase in all inputs results in an increase in output by more than the proportion.

- c) Decreasing returns to scale (DRS) holds when a proportional increase in all inputs results in an increase in output by less than the proportion.

For example, suppose in a production process, all inputs get doubled. As a result, if the output gets doubled, the production function exhibits CRS. If output is less than doubled, the DRS holds, and if it is more than doubled, the IRS holds.

4. Explain the long run costs.

Overall, all inputs are variable. Long run average cost (LRAC) is defined as cost per unit of output, i.e.

$$LRAC = \frac{TC}{q}$$

Long run marginal cost (LRMC) is the change in total cost per unit of change in output. When output changes in discrete units, then, if we increase production from $q_1 - 1$ to q_1 units of output, the marginal cost of producing q_1^{th} unit will be measured as

$$LRMC = (TC \text{ at } q_1 \text{ units}) - (TC \text{ at } q_1 - 1 \text{ units})$$

5. The following table gives TP schedule of labour. Find the corresponding average product and marginal product

TP	0	1	35	50	40	48
L	0	1	2	3	4	5

L	TP	AP	MP
0	0	0	0
1	1	1	1
2	35	17.5	18.5
3	50	25	43.5
4	40	20	63.5
5	48	24	87.5

Formulas used are as follows

$$MP_1 = \frac{\text{change in output}}{\text{change in input}}$$

$$AP_1 = \frac{TP}{x_1} = \frac{f(x_1 - \bar{x}_2)}{x_1}$$

Where x_1 and x_2 are input factors

Answer the following questions in 20 sentences. (each question carries 6 marks)

1. Explain the various short run costs with the help of a table.

Output	TFC	TVC	TC	AFC	AVC	SAC	SMC
0	20	0	20	N/A	N/A	N/A	N/A
1	20	10	30	20	10	30	10
2	20	18	38	10	9	19	8
3	20	24	44	6.7	8	14.667	6
4	20	29	49	5	7.25	12.25	5
5	20	33	53	4	6.6	10.6	4

The cost that a firm incurs to employ these fixed inputs is called the total fixed cost (TFC). Whatever amount of output the firm produces, this cost remains fixed for the firm. To produce any required level of output, the firm, in the short run, can adjust only variable inputs. Accordingly, the cost that a firm incurs to employ these variable inputs is called the total variable cost (TVC). Adding the fixed and the variable costs, we get the total cost (TC) of a firm

$$TC = TVC + TFC$$

The short run average cost (SAC) incurred by the firm is defined as the total cost per unit of output. We calculate it as

$$SAC = \frac{TC}{q}$$

we get the SAC-column by dividing the values of the fourth column by the corresponding values of the first column. At zero output, SAC is undefined. For the first unit, SAC is Rs 30; for 2 units of output, SAC is Rs 19 and so on

Similarly, the average variable cost (AVC) is defined as the total variable cost per unit of output. We calculate it as

$$AVC = \frac{TVC}{q}$$

$$AFC = \frac{TFC}{q}$$

$$SAC = AVC + AFC$$

We get the AFC-column by dividing the values of the second column by the corresponding values of the first column. Similarly, we get the AVC-column by dividing the values of the third column by the corresponding values of the first column. At zero level of output, both AFC and AVC are undefined. For the first unit of output, AFC is Rs 20 and AVC is Rs 10. Adding them, we get the SAC equal to Rs 30.

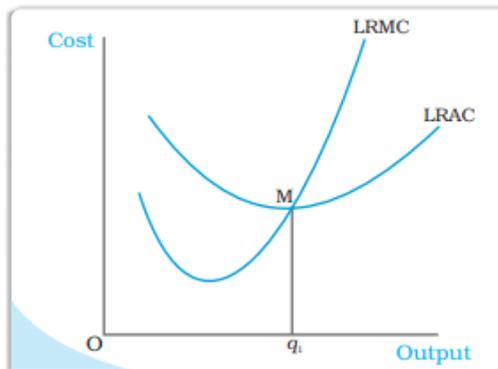
The short run marginal cost (SMC) is defined as the change in total cost per unit of change in output

$$SMC = \frac{\Delta TC}{\Delta q}$$

If output changes in discrete units, we may define the marginal cost in the following way. Let the cost of production for q_1 units and $q_1 - 1$ units of output be Rs 20 and Rs 15 respectively. Then the marginal cost that the firm incurs for producing q_1 th unit of output is

$$\begin{aligned} MC &= (TC \text{ at } q_1) - (TC \text{ at } q_1 - 1) \\ &= \text{Rs } 20 - \text{Rs } 15 = \text{Rs } 5 \end{aligned}$$

2. Explain the shapes of long run cost curves.



IRS implies that if we increase all the inputs by a certain proportion, output increases by more than that proportion. In other words, to increase output by a certain proportion, inputs need to be increased by less than that proportion. With the input prices given, cost also increases by a lesser proportion. For example, suppose we want to double the output. To do that, inputs need to be increased by less than double. The cost that the firm incurs to hire those inputs therefore

also need to be increased by less than double.

It must be the case that if IRS operates, average cost falls as the firm increases output. DRS implies that if we want to increase the output by a certain proportion, inputs need to be increased by more than that proportion. As a result, cost also increases by more than that proportion.

So, if DRS operates, the average cost must be rising as the firm increases output. CRS implies a proportional increase in inputs resulting in a proportional increase in output. So the average cost remains constant as long as CRS operates.

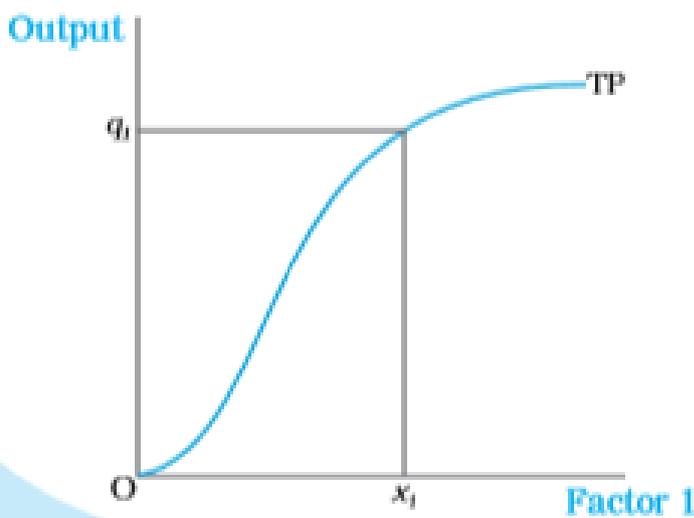
It is argued that in a typical firm IRS is observed at the initial level of production. This is then followed by the CRS and then by the DRS. Accordingly, the LRAC curve is a 'U'-shaped curve. Its downward sloping part corresponds to IRS and upward rising part corresponds to DRS. At the minimum point of the LRAC curve, CRS is observed.

Let us check how the LRMC curve looks like. For the first unit of output, both LRMC and LRAC are the same. Then, as output increases, LRAC initially falls, and then, after a certain point, it rises. As long as average cost is falling, marginal cost must be less than the average cost. When the average cost is rising, marginal cost must be greater than the average cost. LRMC curve is therefore a 'U'-shaped curve. It cuts the LRAC curve from below at the minimum point of the LRAC.

LRAC reaches its minimum at q_1 . To the left of q_1 , LRAC is falling and LRMC is less than the LRAC curve. To the right of q_1 , LRAC is rising and LRMC is higher than LRAC.

2. Explain the shapes of TP, MP and AP curves.

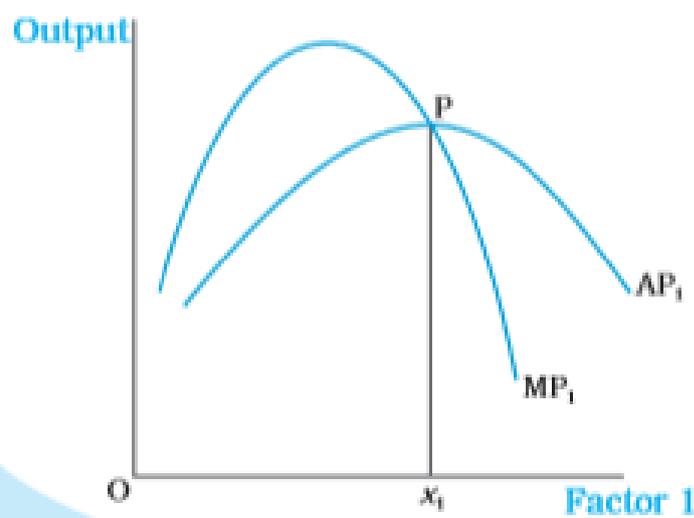
An increase in the amount of one of the inputs keeping all other inputs constant



generally results in an increase in output. The table above shows how the total product changes as the amount of factor 1 increases. The total product curve in the input-output plane is a positively sloped curve.

The diagram shows the shape of the total product curve for a typical firm. We measure units of factor 1 along the horizontal axis and output along the vertical axis. With x_1 units of

factor 1, the firm can at most produce q_1 units of output. According to the law of variable proportions, the marginal product of an input initially rises and then after a certain level of employment, it starts falling. The MP curve in the input-output plane, therefore, looks like an inverse 'U'-shaped curve.



For the first unit of the variable input, one can easily check that the MP and the AP are same. Now as we increase the amount of input, the MP rises. AP being the average of marginal products, also rises, but rises less than MP. Then, after a point, the MP starts falling.

However, if the value of MP remains higher than the value of the prevailing AP, the latter continues to rise. Once MP

has fallen sufficiently, its value becomes less than the prevailing AP and the latter also starts falling. So AP curve is also inverse 'U'-shaped.

If the AP increases, it must be the case that MP is greater than AP. Otherwise, AP cannot rise. Similarly, when AP falls, MP must be less than AP. It, therefore, follows that MP curve cuts AP curve from above at its maximum. The diagram shows the shapes of AP and MP curves for a typical firm. The AP of factor 1 is maximum at x_1 . To the left of x_1 , AP is rising, and MP is greater than AP. To the right of x_1 , AP is falling, and MP is less than AP.