

NCERT Solution

Chapter-03 (Microeconomics)

Production and Costs

Ans1: The production function of a firm depicts the relationship between the inputs used in the production process and the final output. It specifies how many units of different inputs are needed in order to produce the maximum possible output. Production function is written as:

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

Where,

Q_x represents units of output x produced.

L represents units of labour employed.

K represents units of capital employed.

The above equation explains that Q_x units of output x are produced by employing L and K units of labour and capital respectively and by a given technology. As the given level of technology appreciates, the output will increase with the same level of capital and labour units.

Ans2: Total product is defined as the sum total of output produced by a firm by employing a particular input. It is also known as the Total Physical Product and is represented as TP

$$= \sum Q_x$$

Where, \sum represents summation of all outputs and Q_x represents units of output x produced by an input.

Ans3: Average product is defined as the output produced by per unit of variable factor (labour) employed. Algebraically, it is defined as the ratio of the total product by units of labour

$$\text{employed to produce the output, i.e. } AP = \frac{TP}{L}$$

Where,

TP = Total Product

L = units of labour employed

Ans4: Marginal Product is defined as the additional output produced because of the employment of an additional unit of labour. In other words, it is the change in the total output brought by employing one additional unit of labour. Algebraically, it is expressed as the ratio of the change in the total product to the change in the units of labour employed, i.e.

$$MP_L = \frac{\Delta TP}{\Delta L} = \frac{\text{Change in total product}}{\text{Change in labour units}}$$

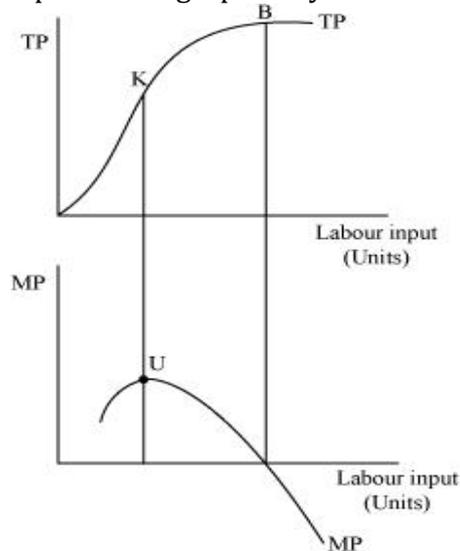
$$\text{Or, } MP_L = TP_n - TP_{n-1}$$

Where,

TP_n = Total product produced by employing n units of labour

TP_{n-1} = Total product produced by employing (n - 1) units of labour

Ans5: Relationship between marginal products (MP) and the total product (TP) can be represented graphically as



- 1) TP increases at an increasing rate till point K, when more and more units of labour are employed. The point K is known as the point of inflexion. At this point MP (second part of the figure) attains its maximum value at point U.
- 2) After point K, TP increases but at a decreasing rate. Simultaneously, MP starts falling after reaching its maximum level at point U.
- 3) When TP curve reaches its maximum and becomes constant at point B, MP becomes zero.
- 4) When TP starts falling after B, MP becomes negative.
- 5) MP is derived from TP by: $MP = \frac{\Delta TP}{\Delta L}$

Or, $MP = TP_n - TP_{n-1}$

Ans6: Short Run: In short run, a firm cannot change all the inputs, which means that the output can be increased (decreased) only by employing more (less) of the variable factor (labour). It is generally assumed that in short run a firm does not have sufficient or enough time to vary its fixed factors such as, installing a new machine, etc. Hence, the output levels vary only because of varying employment levels of the variable factor.

Algebraically, the short run production function is expressed as

$$Q_x = f(L, \bar{K})$$

Where,

Q_x = units of output x produced

L = labour input

\bar{K} = constant units of capital

Long Run: In long run, a firm can change all its inputs, which means that the output can be increased (decreased) by employing more (less) of both the inputs – variable and fixed factors. In the long run, all inputs (including capital) are variable and can be changed according to the required levels of output. The law that explains this long run concept is called return to scale. The long run production function is expressed as

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

Both L and K are variable and can be varied.

Ans7: Law of Diminishing Marginal Product:

According to this law, if the units of the variable factor keep on increasing keeping the level of the fixed factor constant, then initially the marginal product will rise but finally a point will be reached after which the marginal product of the variable factor will start falling. After this point the marginal product of any additional variable factor will be zero, and can even be negative.

Ans8: Law of Variable Proportions:

According to the law of variable proportions, if more and more units of the variable factor (labour) are combined with the same quantity of the fixed factor (capital), then initially the total product will increase but gradually after a point, the total product will start diminishing.

Ans9: Constant returns to scale will hold when a proportional increase in all the factors of production leads to an equal proportional increase in the output. For example, if both labour and capital are increased by 10% and if the output also increases by 10%, then we say that the production function exhibits constant returns to scale.

Algebraically, constant returns to scale exists when,

$$F(nL, nK) = n f(L, K)$$

This implies that if both labour and capital are increased by 'n' times, then the production also increases by 'n' times.

Ans10: Increasing returns to scale (IRS) holds when a proportional increase in all the factors of production leads to an increase in the output by more than the proportion. For example, if both the labour and the capital are increased by 'n' times, and the resultant increase in the output is more than 'n' times, then we say that the production function exhibits IRS.

Algebraically, IRS exists when,

$$F(nL, nK) > n f(L, K)$$

Ans11: Decreasing returns to scale (DRS) holds when a proportional increase in all the factors of production leads to an increase in the output by less than the proportion. For example, if both labour and capital are increased by 'n' times but the resultant increase in output is less than 'n' times, then we say that the production function exhibits DRS.

$$F(nL, nK) < n f(L, K)$$

Ans12: The functional relationship between the cost of production and the output is called the cost function. It is expressed as

$$C = f(Q_x)$$

Where,

C = cost of production

Q_x = units of output x produced

In other words, the output-cost relationship for a firm is depicted by the cost function.

The cost function depicts the least cost combination of inputs associated with different output levels.

Ans13:

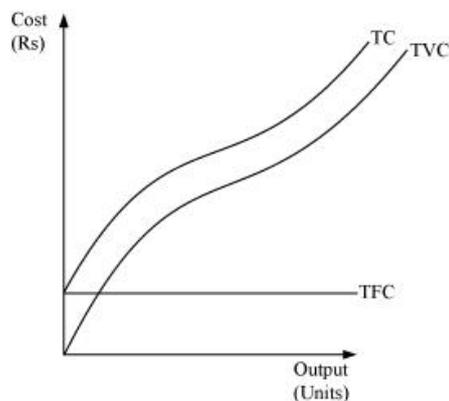
Total Fixed Cost: This refers to the costs incurred by a firm in order to acquire the fixed factors for production like cost of machinery, buildings, depreciation, etc. In short run, fixed factors cannot vary and accordingly the fixed cost remains the same through all output levels. These are also called overhead costs.

Total Variable Cost: This refers to the costs incurred by a firm on variable inputs for production. As we increase quantities of variable inputs, accordingly the variable cost also goes up. It is also called 'Prime cost' or 'Direct cost' and includes expenses like - wages of labour, fuel expenses, etc.

Total Cost (TC): The sum of total fixed cost and total variable cost is called the total cost.

Total cost = Total fixed cost + Total variable cost

$$TC = TFC + TVC$$



Relationship between TC, TFC, and TVC:

- 1) TFC curve remains constant throughout all the levels of output as fixed factor is constant in short run.
- 2) TVC rises as the output is increased by employing more and more of labour units. Till point Z, TVC rises at a decreasing rate, and so the TC curve also follows the same pattern.
- 3) The difference between TC and TVC is equivalent to TFC.
- 4) After point Z, TVC rises at an increasing rate and therefore TC also rises at an increasing rate.
- 5) Both TVC and TFC is derived from TC i.e. $TC = TVC + TFC$

Ans14: Average Fixed Cost: It is defined as the fixed cost per unit of output.

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

Where, TFC = Total fixed cost

Q = Quantity of output produced

Average Variable Cost: It is defined as the variable cost per unit of output.

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

Where, TVC = Total variable cost

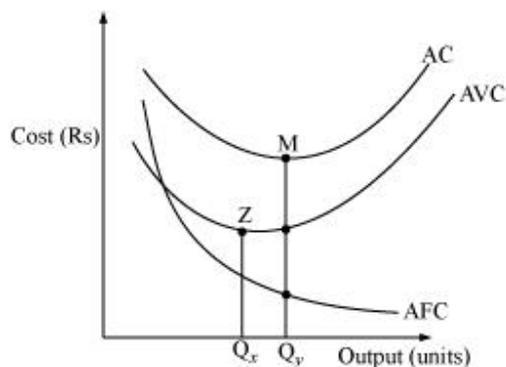
Q = Quantity of output produced

Average Cost: It is defined as the total cost per unit of output. Average cost is derived by dividing total cost by quantity of output.

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

AC is also defined as the sum total of average fixed cost and average variable cost.

$$AC = AFC + AVC$$



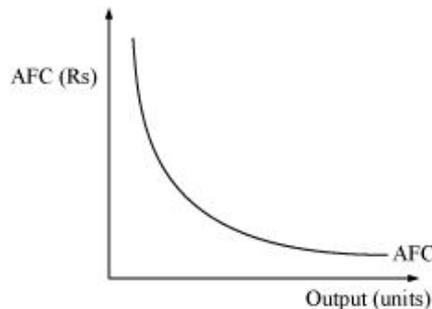
Relationship between AC, AFC, AVC:

- 1) AVC and AFC are derived from AC as $AC = AFC + AVC$.
- 2) The plot for AFC is a rectangular hyperbola and falls continuously as the quantity of output increases.
- 3) The minimum point of AVC will always exist to the left of the minimum point of AC; i.e., point 'Z' will always lie left to point 'M'.
- 4) AFC being a rectangular hyperbola falls throughout; this causes the difference between AC and AVC to keep decreasing at higher output levels. However, it should be noted that AVC and AC can never intersect each other. If they intersect at any point, it would imply that AC and AVC are equal at that point. However, this is not possible as AFC will never be zero because it is a rectangular hyperbola that never touches x-axis.
- 5) AC inherits shape from AVC's shape and it is because of law of variable proportions that both the curves are U-shaped.

Ans15: No, there cannot be any fixed cost in the long run. In the long run, a firm has enough time to modify factor ratio and can change the scale of production. There is no fixed factor as the firm can change quantity of all the factors of production and therefore there cannot be any fixed cost in the long-run.

Ans16: Average fixed cost curve looks like a rectangular hyperbola. It is defined as the ratio of TFC to output. We know that TFC remains constant throughout all the output levels and as output increases, with TFC being constant, AFC decreases.

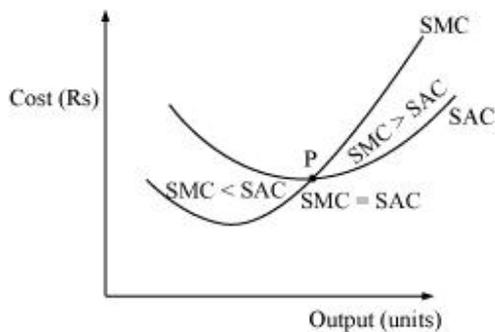
When output level is close to zero, AFC is infinitely large and by contrast when output level is very large, AFC tends to zero but never becomes zero. AFC can never be zero because it is a rectangular hyperbola and it never intersects the x-axis and thereby can never be equal to zero.



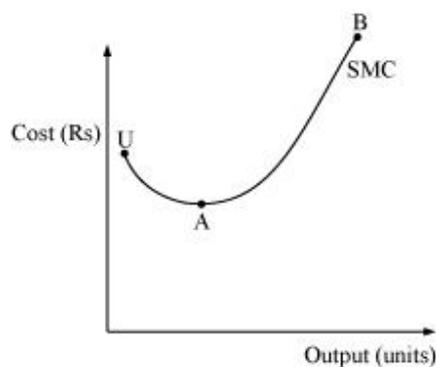
Ans17: The short run marginal cost (SMC), average variable cost (AVC) and short run average cost (SAC) curves are all U-shaped curves. The reason behind the curves being U-shaped is the law of variable proportion. In the initial stages of production in the short run, due to increasing returns to labour, all the costs (average and marginal) fall. In addition to this in the short run MP of labour also increases, which implies that more output can be produced by per additional unit of labour, leading all the costs curves to fall. Subsequently with the advent of constant returns to labour, the cost curves become constant and reach their minimum point (representing the optimum combination of capital and labour). Beyond this optimum combination, additional units of labour increase the cost, and as MP of labour starts falling, the cost curve starts rising due to decreasing returns to labour.

Ans18: SMC curve always intersect the AVC curve at its minimum point. This is because to the left of the minimum point of AVC, SMC is below AVC. SMC and AVC both fall but the former falls at a faster rate. At the minimum point K, AVC is equal to SMC. Beyond K, AVC and SMC both rise but the latter rises at a faster rate than the former and also SMC lies above AVC. Therefore, the only point where SMC and AVC are equal is where SMC intersects AVC, i.e., at the minimum point of the AVC curve.

Ans19: SMC curve intersects SAC curve at its minimum point. This is because as long as SAC is falling, SMC remains below SAC and when SAC starts rising, SMC remains above SAC. SMC intersects SAC at its minimum point P, where $SMC = SAC$.



Ans20:



The SMC curve is a U-shaped curve due to the law of variable proportions. In order to understand the reason behind the U-shape of SMC, let us divide the SMC curve (UAB) into three different parts according to the law of variable proportions:

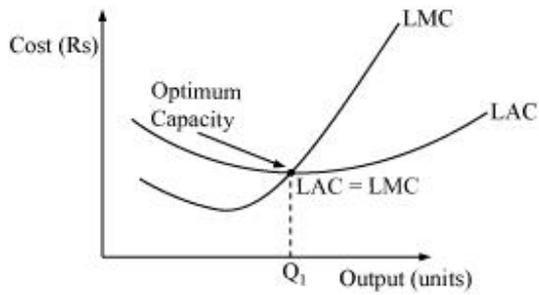
- (a) UA part corresponds to increasing returns to factor.
- (b) Minimum point A corresponds to constant returns to factor.
- (c) AB part corresponds to decreasing returns to factor.

In the initial production stages, the falling part of SMC (UA) is due to application of increasing returns to factor. Then the SMC stops falling and reaches its minimum point 'A' due to the existence of constant returns to a factor.

After the minimum point A, SMC starts rising (i.e. 'AB' part of SMC) due to the onset of decreasing returns of variable factor. This trend of SMC curve (initially falling, then becoming constant at its minimum point and then rising) makes it look like the English alphabet - 'U'.

Ans21: The long run marginal cost (LMC) and long run average cost (LAC) are U shaped curves.

The reason behind them being U-shaped is due to the law of returns to scale. It is argued that a firm generally experiences IRS during the initial period of production followed by CRS, and lastly by DRS. Consequently, both LAC and LMC are U-shaped curves. Due to IRS, as the output increases, LAC falls due to economies of scale. Then falling LAC experiences CRS at Q_1 level of output which is also called the optimum capacity. Beyond Q_1 level of output, the firm experiences diseconomies of scale and if the firm continues to produce beyond Q_1 level, the cost of production will rise.



Ans22:

L	TP_L	$AP = \frac{TP}{L}$	$MP = TP_n - TP_{n-1}$
0	0	0	-
1	15	15	15
2	35	17.5	20
3	50	16.67	15
4	40	10	-10
5	48	9.6	-8

Ans23:

L	AP_L	$TP_L = AP \times L$	$MP_L = TP_n - TP_{n-1}$
1	2	$2 \times 1 = 2$	2
2	3	$3 \times 2 = 6$	$6 - 2 = 4$
3	4	$4 \times 3 = 12$	$12 - 6 = 6$
4	4.25	$4.25 \times 4 = 17$	$17 - 12 = 5$
5	4	$4 \times 5 = 20$	$20 - 17 = 3$
6	3.5	$3.5 \times 6 = 21$	$21 - 20 = 1$

Ans24:

L	MP_L	$TP_n = TP_{n-1} + MP_n$	$AP_L = \frac{TP_L}{L}$
1	3	3	$\frac{3}{1} = 3$
2	5	$3 + 5 = 8$	$\frac{8}{2} = 4$
3	7	$8 + 7 = 15$	$\frac{15}{3} = 5$
4	5	$15 + 5 = 20$	$\frac{20}{4} = 5$
5	3	$20 + 3 = 23$	$\frac{23}{5} = 4.6$

6	1	23+1=24	$\frac{24}{6} = 4$
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Ans25:

L	TC	TFC=TC-TVC	TVC=TC-TFC	$AFC = \frac{TFC}{Q}$	$AVC = \frac{TVC}{Q}$	SAC=AFC+AVC	SMC= $TC_n - TC_{n-1}$
0	10	10	0	-	-	-	-
1	30	10	20	10	20	30	20
2	45	10	35	5	17.5	22.5	15
3	55	10	45	3.33	15	18.33	10
4	70	10	60	2.5	15	17.5	15
5	90	10	80	2	16	18	20
6	120	10	110	1.66	18.33	19.99	30

Ans26:

L	TC	TFC=20	TVC=TC-TFC	$AFC = \frac{TFC}{Q}$	$AVC = \frac{TVC}{Q}$	SAC=AFC+AVC	SMC= $TC_n - TC_{n-1}$
1	50	20	30	20	30	50	30
2	65	20	45	10	22.5	32.5	15
3	75	20	55	6.66	27.5	34.16	10
5	95	20	75	5	18.75	23.75	20
5	130	20	110	4	22	26	35
6	185	20	165	3.33	27.5	30.83	55

Ans27:

L	SMC	TFC=100	$TVC_n = SMC_n + TVC_{n-1}$	TC=TFC+TVC	$AVC = \frac{TVC}{Q}$	SAC=AFC+AVC
0	-	100	-	100	-	-
1	500	100	500	600	500	600
2	300	100	800	900	400	450
3	200	100	1000	1100	333.33	366.67
5	300	100	1300	1400	325	350
5	500	100	1800	1900	360	380
6	800	100	2600	2700	433.33	450

Ans28: $Q = 5L^{\frac{1}{2}}K^{\frac{1}{2}}$ Equation (1)

L = 100 units of labour

K = 100 units of capital

Putting these values in equation (1)

$$Q = 5(100)^{\frac{1}{2}}(100)^{\frac{1}{2}}$$

$$= 5(10)(10)$$

= 500 units

Thus, the maximum possible output that the firm can produce is 500 units.

Ans29:

(a) $Q = 2L^2K^2$ (1)

L = 5 units of labour

K = 2 units of capital

Putting these values in equation (1)

$$Q = 2(5)^2(2)^2$$

$$= 2(25)(4)$$

$$Q = 200 \text{ units}$$

(b) If L = 0 units and K = 100 units

Putting these values in equation (1)

$$Q = 2(0)^2(100)^2$$

$$Q = 0 \text{ units}$$

Ans30: $Q = 5L + 2K$ (1)

If L = 0 and K = 10, then putting these values in equation (1)

$$Q = 5(0) + 2(10)$$

$$= 20 \text{ units of output}$$