HSS 201: Economics for Engineers

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All about Production Decisions

1. Production Technology: A practical way to convert inputs into outputs.
2. Cost Constraints: Prices of the factors (or inputs) used in production.
3. Input Choices: Given the production technology, and the factor prices, the producer must know how much of each input to use in producing its output.

The Production Function

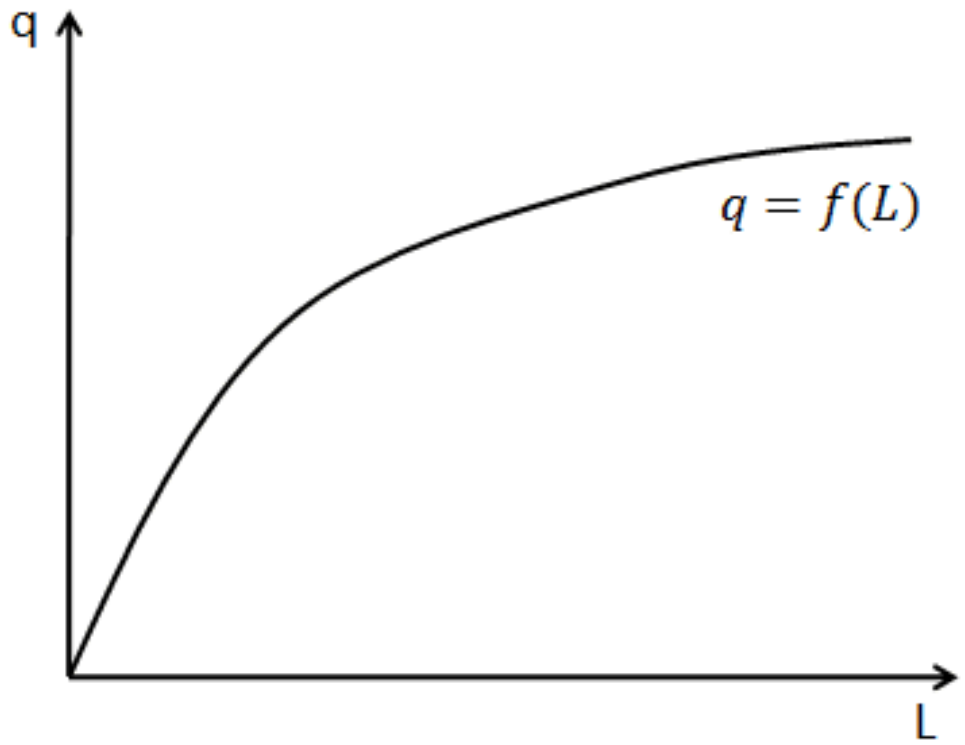
A production function indicates the highest output q that a firm can produce for every specified combination of inputs.

To keep our analysis simple, we focus only on two inputs, Labour (L) and Capital (K). We then write the production function as: $q = F(K, L)$.

The production function allows inputs to be combined in varying proportions, so that output can be produced in many ways. In other words, it also tells us abou the underlying technology.

Production function defines what is technically feasible when firms operate efficiently

The Production Function



L: Labour; q: Output

The Concept of Short Run and Long Run

Production plans that are *immediately* feasible and those that are *eventually* feasible.

The short run refers to a period of time in which the quantities of one or more factors of production cannot be changed. In other words, there is at least one factor of production that is fixed.

The long run refers to a period of time in which the quantities of all factors are variable. In other words, there is no fixed input.

Technological Change

It refers to a change in the underlying techniques of production. A product can be innovated in the following ways:

1. Process Innovation: It refers to a change in the method of production. E.g., Use of new Equipment

2. Product Innovation: it refers to the introduction of a good or service that is new or has significantly improved characteristics or intended uses. E.g., Mobile Phones

The Production Analysis in the Short Run

In the short run, assuming that out of the two inputs (labour and Capital) required to produce quantity q, one is fixed. Mathematically,

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

Total Product: For each level of L, the maximum amount of ouptut that is produced.
Marginal Product: It is the change in output produced as the variable input is increased by one unit. Mathematically,

$$MP_L = \frac{dq}{dL}$$

Average Product: It is the output per unit of the variable input.

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

An Example

Let $q = K^{0.25}L^{0.75}$ and $K = 16$ in the short run. What is the equation for *total*, *marginal* and *average* product?

Total product is $q = 2L^{0.75}$.

Marginal product is $1.5L^{-0.25}$.

Average product is $2L^{-0.25}$

Production with One Variable Input (Or, in the Short Run

Labor	Capital	TP	AP_L	MP_L
0	10	0	-	-
1	10	10	10	10
2	10	30	15	20
3	10	60	20	30
4	10	80	20	20
5	10	95	19	15
6	10	108	18	13
7	10	112	16	4
8	10	112	14	0
9	10	108	12	-4
10	10	100	10	-8

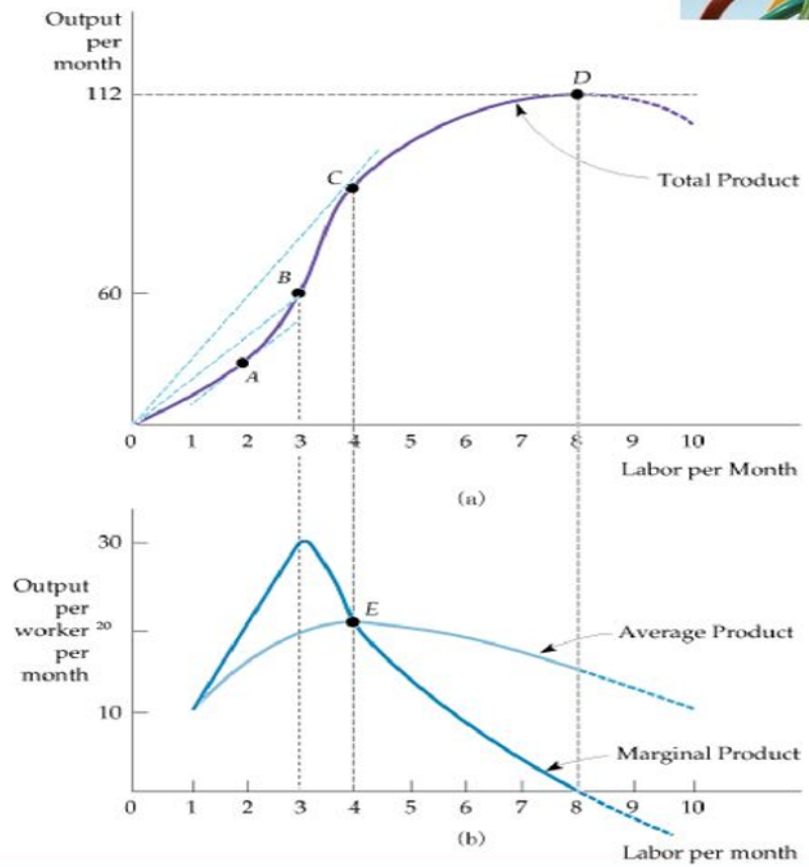
The Slopes of Product Curves

PRODUCTION WITH ONE VARIABLE INPUT

To the left of point *E* in **(b),** the marginal product is above the average product and the average is increasing; to the right of *E*, the marginal product is below the average product and the average is decreasing.

As a result, *E* represents the point at which the average and marginal products are equal, when the average product reaches its maximum.

At *D*, when total output is maximized, the slope of the tangent to the total product curve is 0, as is the marginal product.



The Law of variable Proportion

It is also known as the law of diminishing returns. It shows that in a given state of technology, with at least one input factor is variable, additional units of that particular variable input will yield increasing returns up to a certain point. After that additions of the variable input will yield diminishing returns.

The Three Stages of Production

Stage I: At first Total product increases at an increasing rate and then it starts to increase but at an decreasing rate. The point of inflection in Total product curve corrospondinds to the maximum point on the Marginal product curve. After that Marginal product curve starts to fall. While the Average product curve increases. Also, here the marginal and average product curve are equal when the average product curve is maximum.

Stage II: This stage begins when Stage I ends. The Total product curve continues to increase at an diminishing rate and reaches the maximum. Correspondingly, the marginal product curve continues to diminish rapidly and reaches zero when the Total product curve is at maximum. the average product curve starts to decline.

Stage III: The Total product decreases. The Marginal product is negative. The avergae product falls also.

The Production Analysis in the Long Run

Returns to Scale is the rate at which output increases as inputs are increased proportionately.

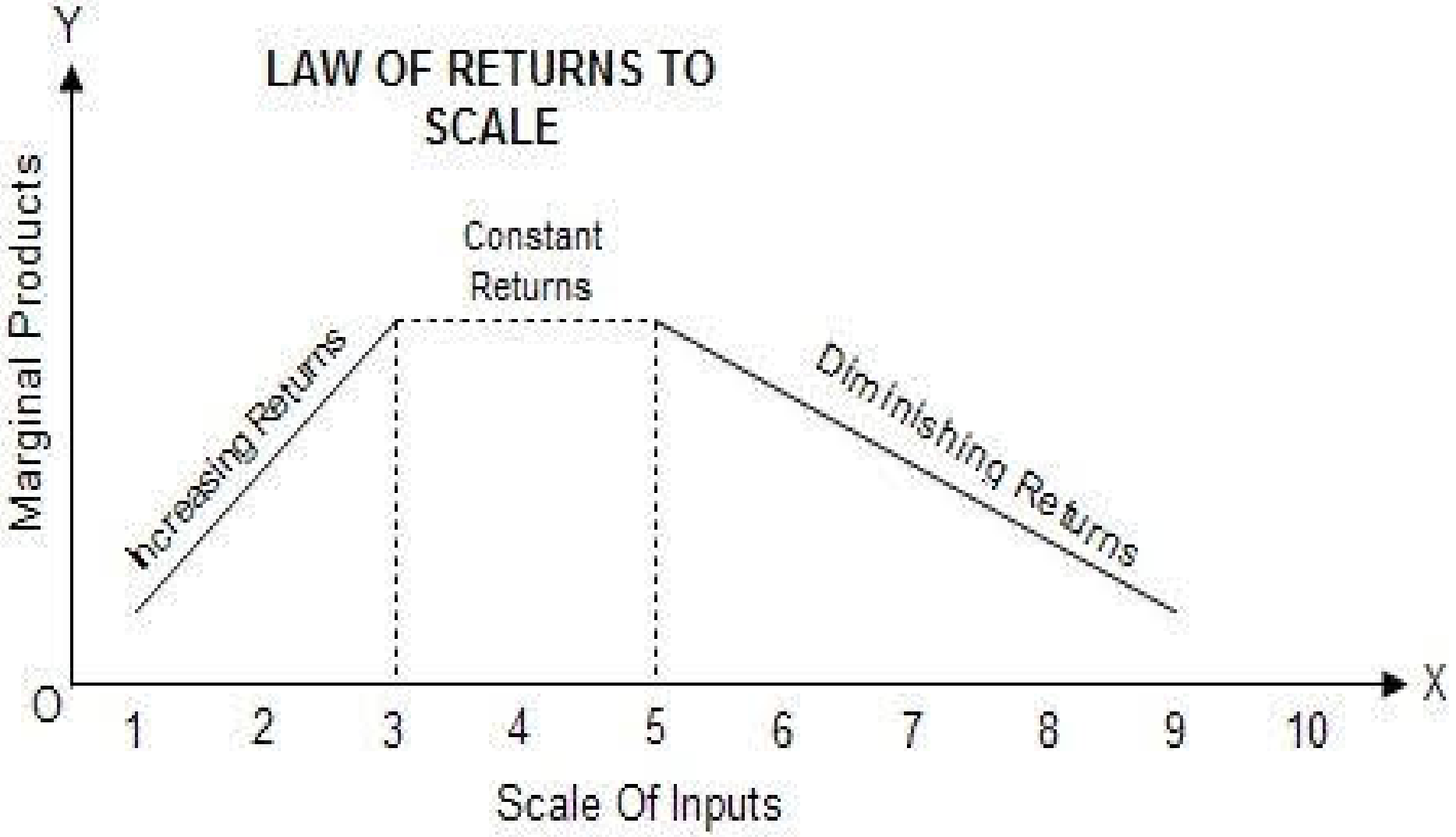
Increasing Returns to Scale (IRS): If output more than doubles when inputs are doubled. This arises when larger scale of operation allows employees of firms to work according to their specialization. If a firm is experiencing IRS then that firm can produce at a relatively less cost. Because of this the firm which is experiencing IRS, it can control the price.

Constant Returns to Scale (CRS): If output doubles when inputs are doubled. With CRS, the size of the firms operation does not affect the productivity of its factors. As one plant using a particular production process can easily replicated, two plants produce twice as much output.

The Production Analysis in the Long Run

Decreasing Returns to Scale (DRS): If output less than doubles when inputs are doubled. There is a decrease in productivity of all inputs. DRS is likely to be related with the problems of coordinating tasks and maintaining a useful line of communication between management and workers.

The Production Analysis in the Long Run



Some Practice Questions

Identify which among the following production functions exhibit IRS, CRS and DRS? Compute the Marginal Productivity of Labor also.

1. $q = 3L + 2K$
2. $q = (2L + 2K)^{\frac{1}{2}}$
3. $q = 3LK^2$
4. $q = L^{\frac{1}{2}}K^{\frac{1}{2}}$
5. $q = 4L^{\frac{1}{2}} + 4K$

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Total Revenue, Total Cost and Profit

Total Revenue: The amount that a firm receives after selling his produce.

Total Cost: The amount that is incurred by the firm in producing the goods he sells.

Profit = Total Revenue - Total Cost

A profit maximizing firm has two options

1. Output Maximization subject to Cost Constraint
2. Cost Minimization subject to Output Constraint

Opportunity, Explicit and Implicit Cost

Opportunity Costis the cost associated with the opportunities that are forgone by not putting the firm's resource to their best alternative use.

Example: Adobe, owns the office space in Noida. The accountant would therefore say that, there is no cost associated with the office space. However, the economist would have checked if the office space would have been rented out, how much income would Adobe have earned. This earning which Adobe has forgone is called the opportunity cost.

Wages and Salaries paid to laborers is also an opportunity cost. The money paid in the form of wages and salaries could be used to buy some machines that substitutes laborers.

Opportunity, Explicit and Implicit Cost

Explicit or Out of Pocket Cost: Input cost that require an outlay of money by the firm.

Implicit Cost: Input cost that do not require an outlay of money by the firm.

In economics, decision are taken based on both explicit and implicit cost. While in accounting, decision is taken based only on explicit cost.

Private and Social Cost

Private Cost: These are those cost that are concerned with the firm.

Social Cost: These cost are not borne by the firms. It is borne by the society as a whole.

There is a cement plant located in the slopes of a mountain. In the valley, however there is a catchment area of fish. As the cement factory produces, it pollutes the nearby river by throwing waste materials.

Cost of producing cement is the private cost; while the social cost is associated with the pollution.

Total, Marginal and Average Revenue

Total Revenue (TR) = $P \times Q$

Marginal Revenue (MR) = $\frac{dTR}{dQ}$

Average Revenue (AR) = $\frac{TR}{Q} = P$

Average Revenue of a firm is same thing as the demand curve of the consumer. Consumer face this from the firm. Thus, it means price of the product.

Short and Long Run Costs

- In short run, there are fixed, as well as, variable costs

- In long, there are only variable costs

Fixed and Variable Cost

- Fixed Cost (FC): The cost does not vary with the change in output level.

- Variable Cost (FC): The cost does vary with the change in output level.

Fixed and Sunk Costs

Fixed costs are those costs that are paid by a firm irrespective of the level of output. These costs can be avoided if the firm goes out of business.

Examples of FC are salaries and wages of CEOs, Board of Directors, among others; office rent.

Sunk Costs are those cost that *cannot be recovered*. The cost of factor equipment such as machinery cannot be recovered fully even if the firm shuts down.

Types of Short Run Costs

1. Total Cost (TC) = Total Fixed Cost (TFC) + Total Variable Cost (TVC)
2. Average Cost (AC) = $\frac{TC}{Q}$
   - AC = Average Fixed Cost (AFC) + Average Variable Cost (AVC)
   - AFC = $\frac{TFC}{Q}$
   - AVC = $\frac{TVC}{Q}$
3. Marginal Cost (MC) = $\frac{dTC}{dQ} = \frac{dTFC}{dQ} + \frac{dTVC}{dQ}$

A Firm's Short Run Costs

Output	FC	VC	TC	AFC	AVC	ATC	MC
0	50	0	50	-	-	-	-
1	50	50	100	50	50	100	50
2	50	78	128	25	39	64	28
3	50	98	148	16.7	32.7	49.3	20
4	50	112	162	12.5	28	40.5	14
5	50	130	180	10	26	36	18
6	50	150	200	8.3	25	33.3	20
7	50	175	225	7.1	25	32.1	25
8	50	204	251	6.3	25.5	31.8	29
9	50	242	292	5.6	26.9	32.4	38
10	50	300	350	5	30	35	58
11	50	385	435	4.5	35	39.5	85

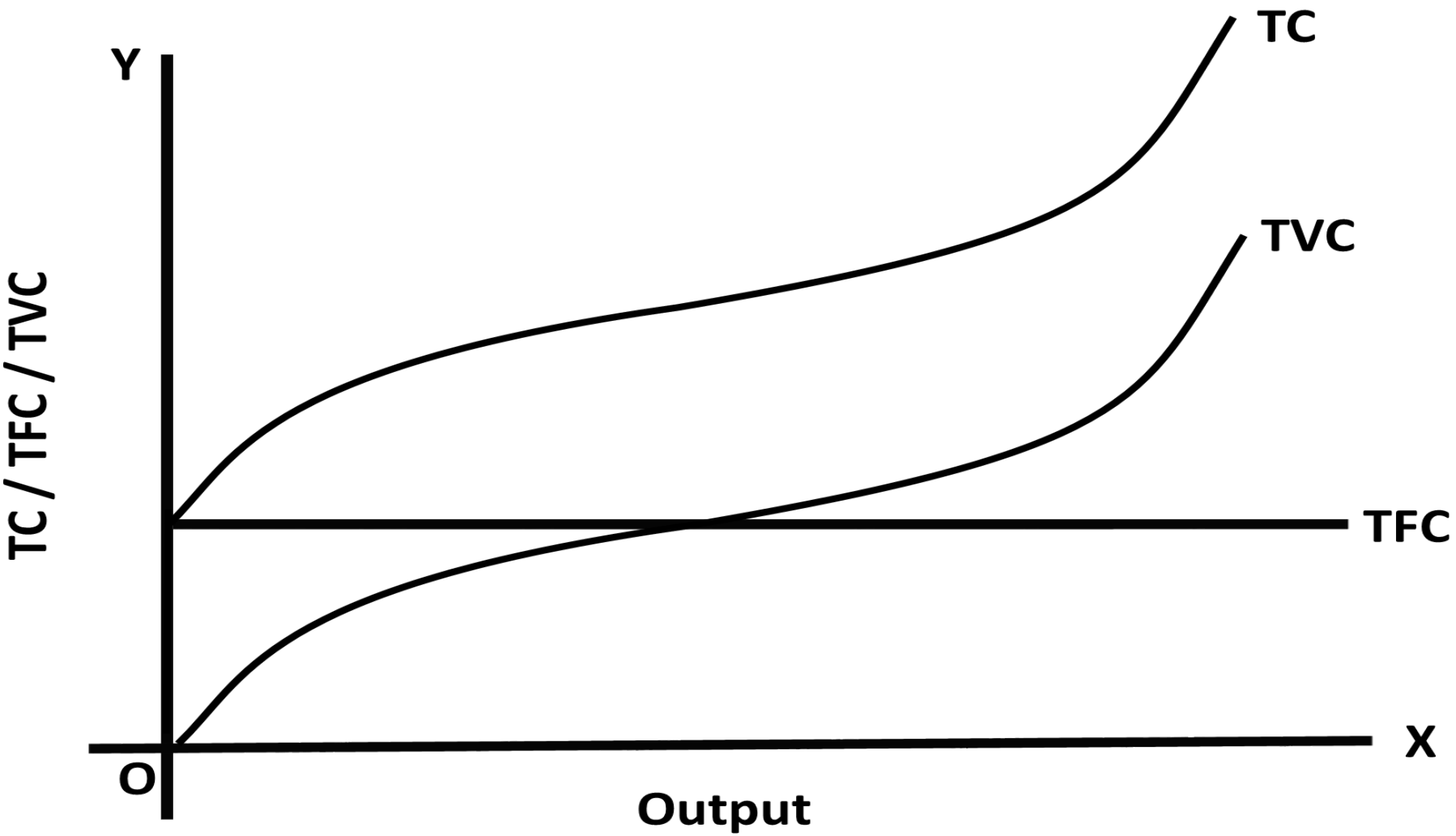
Arriving at Marginal Cost from Total Cost

At a prevaling wage rate, w, the firm can hire any amount of labor.

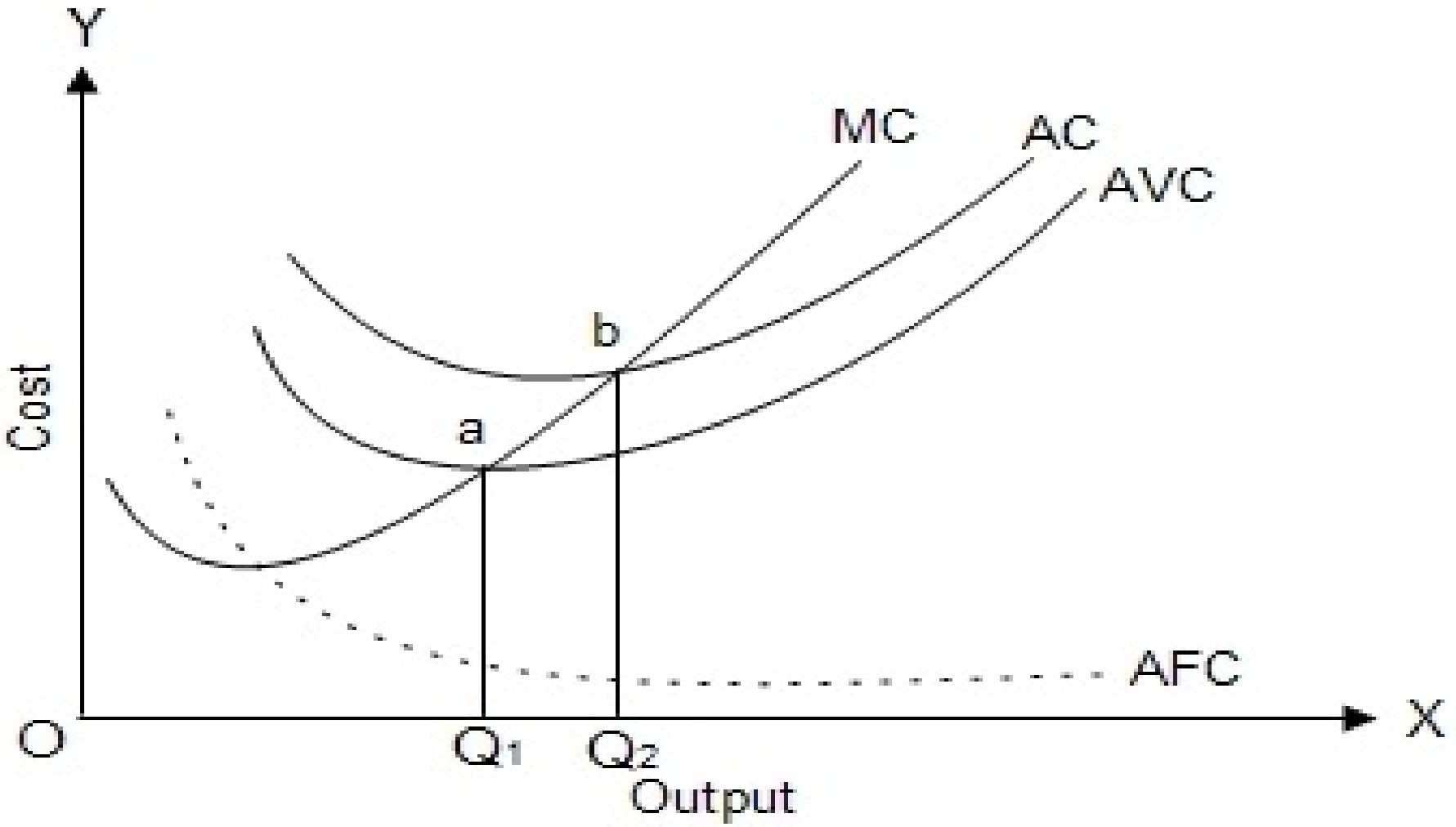
$$TC = wL + \overline{rK}$$
$$\frac{dTC}{dQ} = w\frac{dL}{dQ}$$
$$MC = w.\frac{1}{MP_L}$$

Recall, MP_L change in output resulting from a change in labor input. While $\frac{1}{MP_L}$ is extra labor needed to obtain an extra unit of output.

Total Fixed and Variable Cost Curves



Average and Marginal Cost Curves



The Relationship between Average and Marginal Costs

$$TC = AC \times Q$$

$$\frac{dTC}{dQ} = \frac{dAC}{dQ}.Q + AC$$

$$MC = \frac{dAC}{dQ}.Q + AC$$

$$\frac{dAC}{dQ} = \frac{MC - AC}{Q}$$

1. If MC $>$AC, then $\frac{dAC}{dQ} > 0$
2. If MC = AC, then $\frac{dAC}{dQ} = 0$
3. If MC $<$AC, then $\frac{dAC}{dQ} < 0$

The Relationship between Average and Marginal Costs

1. The vertical distance between AC and AVCat every point on the curve is AFC

2. MC crosses AVC and AVC at their minimum points

Long Run Costs

All costs are variable cost. There are no fixed costs in the long run.

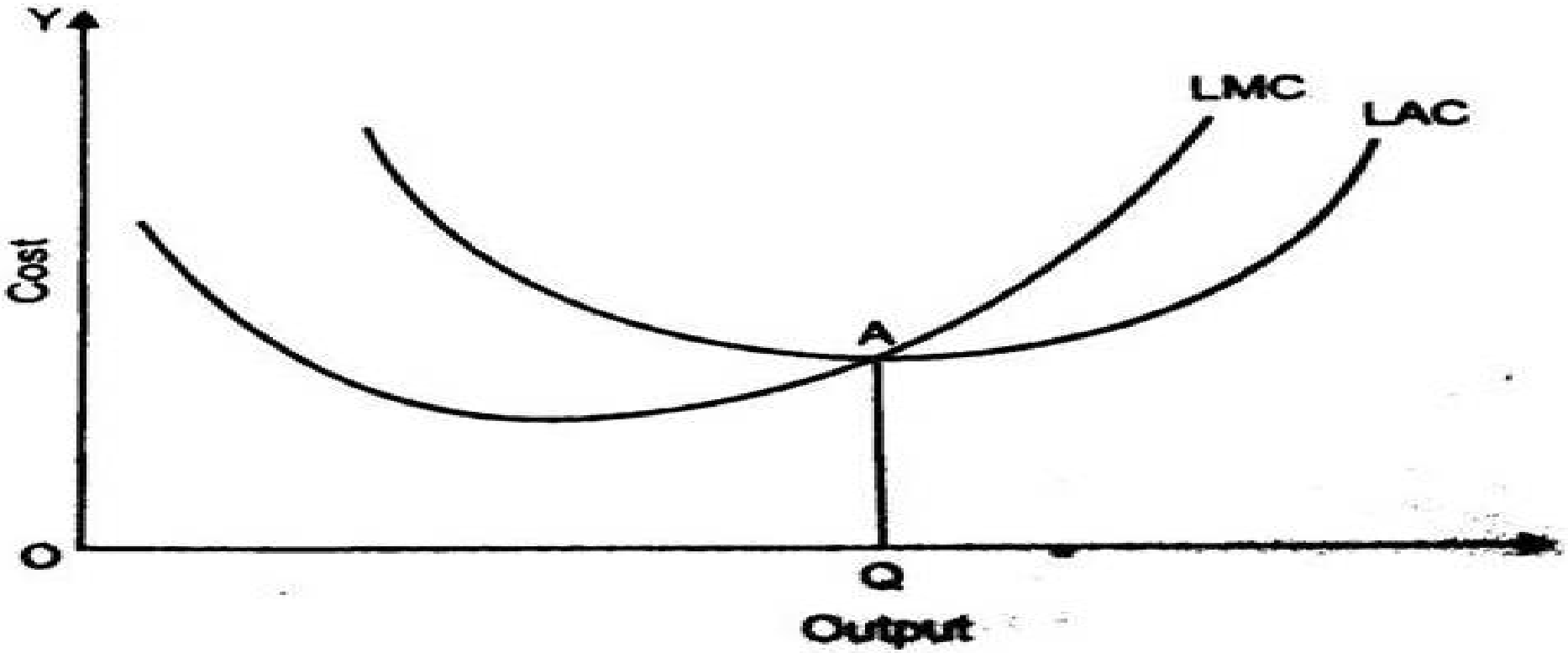
LC = Long Run Cost and LAVC = Long Run Variable Cost (LVC); LC = LVC

Long Run Average Costs (LAC) = Long Run Average Variable Costs (LAVC)

LAC = $\frac{LC}{Q}$ and LAVC = $\frac{LVC}{Q}$

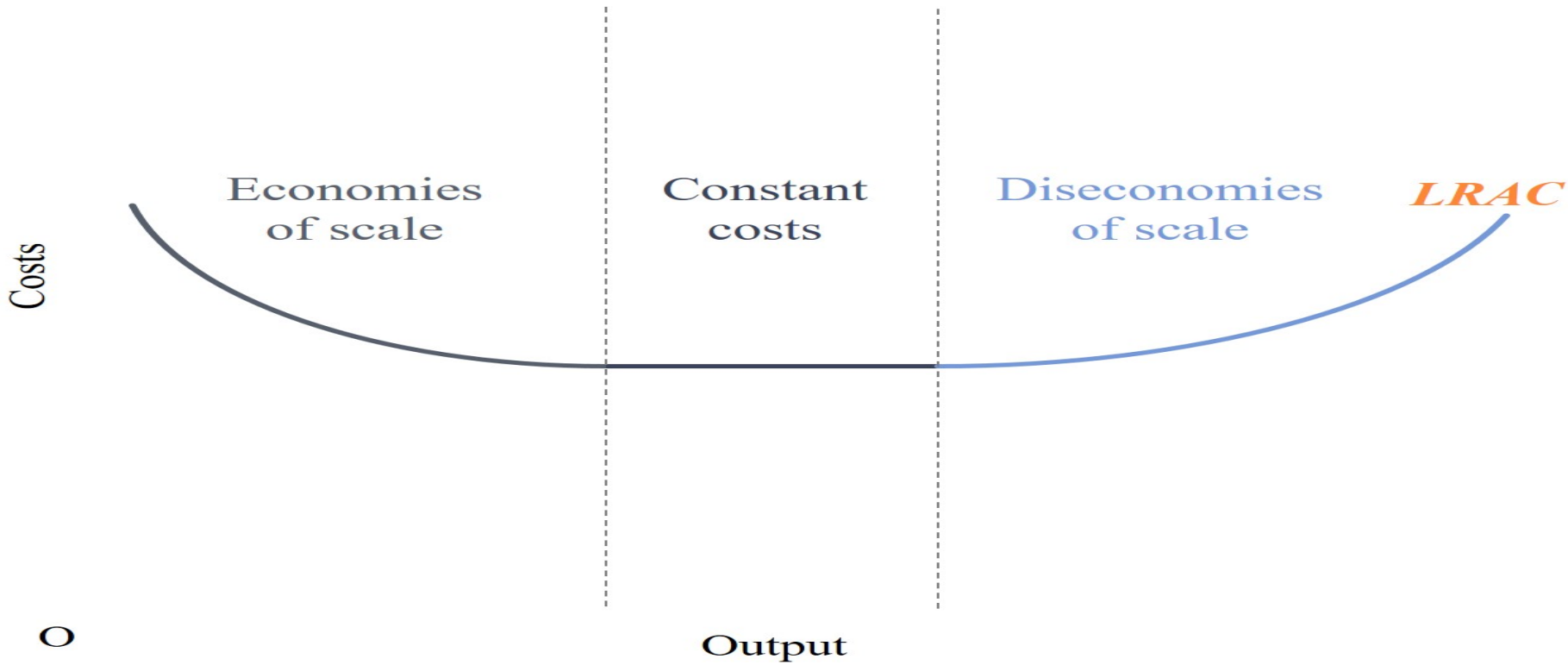
Long Run Marginal Cost (LMC) = $\frac{dLC}{dQ}$

Shape of LAC and LMC Curves



Any point above the LAC curve represents attainable level of cost, and any point below the curve represents unattainable level of cost.

Shape of the LAC and Economies of Scale



Minimum point on the LAC curve is called the minimum efficient scale of production.

Deriving the Long Run Average Cost Curve

7.4 LONG-RUN VERSUS SHORT-RUN COST CURVES

The Relationship Between Short-Run and Long-Run Cost

Figure 7.9

Long-Run Cost with Economies and Diseconomies of Scale

The long-run average cost curve LAC is the envelope of the short-run average cost curves SAC_1, SAC_2, and SAC_3. With economies and diseconomies of scale, the minimum points of the short-run average cost curves do not lie on the long-run average cost curve.