CHAPTER 3

PRODUCTION AND COSTS

❖ Production Function

The production function of a firm depicts the relationship between the inputs used in the production process and the final output, with a given level of technology. Production function is written as

$Q_x = f(L, K)$

Where,

L = Units of labour

K = Units of capital

Q_x = Units of output of x produced

❖ Types of factors of Production

The various types of factors of production are classified as:

1) **Variable factors of production**

   Those factors which can be increased or decreased, according to the need of increase or decrease in the output, are called variable factors. For example, labour.

2) **Fixed factors of production**

   Those factors which remain constant with the change in the output are called fixed factors of production. For example, capital

❖ SHORT RUN AND LONG RUN

In short run, the output can be increased (decreased) only by employing more (less) of variable factors like labour, with a given level of fixed factor. The law which explains this concept of short run is called *law of variable proportions or returns to factors*. The short run production function is expressed as $Q_x = f(L, \overline{K})$

In long run, 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 change in the level of output. The law which explains this concept of long run is called *returns to scale*. The long run production function is expressed as $Q_x = f(L, K)$

❖ **Isoquant/Iso-product curve**

The curve which depicts different input combinations to yield the same maximum possible level of output, with a given level of technology is called isoquant curve. Throughout an isoquant curve, we have the same level of output produced but with different input combinations.

❖ **Marginal rate of technical substitution (MRTS)** is that rate at which one input (say labour) can be substituted for other input (say capital) for producing the same level of production. MRTS is the slope of isoquant curve. It is represented as

$$MRTS = \frac{\Delta K}{\Delta L}$$

ΔK = change in units of capital

ΔL = change in units of labour

❖ **Properties of Isoquant curve**

1) Negative slope from left to right.
2) Convex to the origin because of the diminishing marginal rate of technical substitution.
3) Higher isoquant curve from the origin represent higher output level.

Total Product

It is defined as the sum total of output produced by a firm with all the units of inputs- both variable and fixed factors. Total product is also called as total physical product (TPP).

$TP = \sum Q_x$

❖ **Average Product**

It is defined as the output produced by per unit of variable factor employed, i.e., labour.

$$AP = \frac{TP}{L}$$

- **Marginal Product**

  It is defined as an additional output due to the employment of an additional unit of labour.

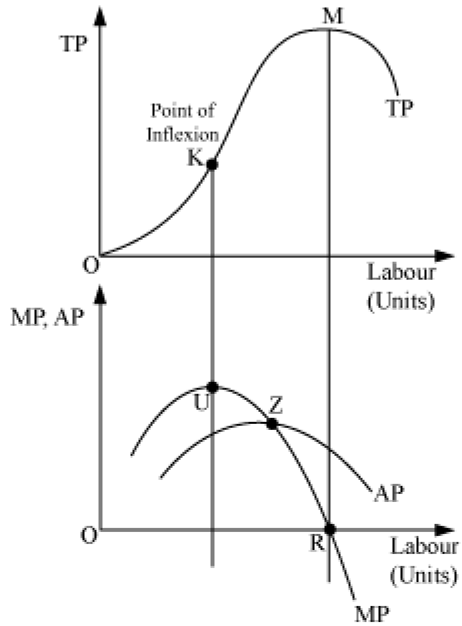
$$MP_L = \frac{\Delta TP}{\Delta L} = \frac{Change\ in\ output}{Change\ in\ labour\ unit}$$

or $MP_L = TP_n - TP_{n-1}$

- **Relationship between TP, AP and MP curves.**

1) TP increases at an increasing rate till the point of inflexion. Later, it increases but at a decreasing rate. At inflexion point, MP attains its maximum and thereafter, falls, while AP continues to rise.
2) AP attains its maximum point where MP intersects AP and AP = MP.
3) TP continues to rise but at a decreasing rate and becomes constant at its maximum point, while MP on the same time is zero, i.e. when TP is maximum MP is zero.
4) When TP starts falling, MP is negative.
5) Both AP and MP are derived from TP.

   $AP = \frac{TP}{L}$, $MP = TP_n - TP_{n-1}$ and both AP and MP are inverse U–Shaped curves



- **Law of Variable Proportions– Returns to a Factor**

  According to this law, if more and more of variable factor (labour) is combined with the same quantity of fixed factor (capital) then initially the total product will increase. However, after a certain point of time, total product will become smaller and smaller.

- **Law of Diminishing Marginal Product**

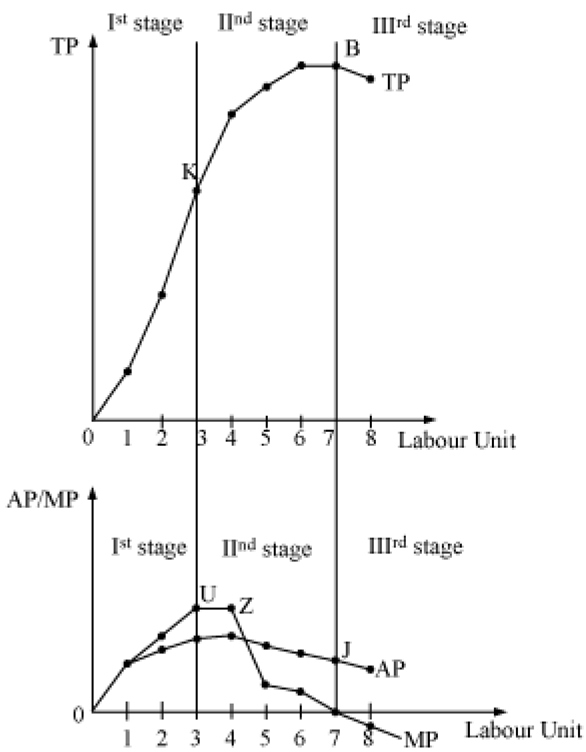
  According to this law, if the employment of variable factor keeps on increasing along with the constant level of fixed factor, then initially marginal product will increase but after a point the marginal product of the variable factor starts to fall.. After this point the marginal product of any additional variable factor can be zero or even negative.

- **Assumptions of Law of Variable Proportions**

  1) Technology level remains constant
  2) The units of variable factors are homogeneous.
  3) One of the inputs must be fixed.
  4) No change in the input prices – wages and interests.

- **Stages of Production**

Stages	Stage's Name	TP	AP	MP	Range
I	Increasing Returns to a factor	TP increases at an increasing rate till *K*	AP continues to increases	MP also rises but at a faster rate than AP and becomes maximum.	From 0 to point *K*
II	Diminishing Returns to a factor	Increases at a decreasing rate and attains maximum	AP becomes maximum	MP cuts AP from at its maximum point and then falls to become zero.	From *K* to point *B*
III	Negative Returns to a factor	TP starts to fall	AP continues to fall	MP continues to fall and becomes negative.	From *B* onwards



Stages of Production

- **Reasons for Increasing Returns to a Factor**

  1) Underutilisation of fixed factor
  2) Increasing specialisation of labour

  This stage is known as *non-economic zone*.

- **Reasons for Decreasing Returns to a Factor**

  1) Fuller utilisation of fixed factor
  2) Imperfect substitutability between labour and capital

  This stage is called *economic zone* as any rational producer would always like to operate in this zone.

- **Exception to the Law of Variable Proportion**

  1) Appreciation of level of technology
  2) Discovery of substitutes of fixed factors.

- **Viable and Feasible Stage of Production**

The viable and feasible stage of production refers to the economically efficient phase of production. While in the first stage, the MP of labour is positive, production can be increased by employing more labour with the same quantity of fixed factor. On the other hand, in the third stage, the MP of labour is negative, which implies that production can be increased by reducing or shedding the number of labour. Thus, it can be seen that the stage second is the only viable and economically feasible stage where MP and AP both falls but remains positive and hence, a producer or firm would always like to operate.

❖ **Return to Scale**

According to the law of returns to scale, when all the inputs are increase in the same proportion, the output also increases. However, this increase may be at an increasing, constant or at a decreasing rate.

Three aspects of the Law of Returns to Scale are :

1) Increasing Returns to Scale (IRS);
2) Constant Returns to Scale (CRS); and
3) Decreasing Returns to Scale (DRS).

Let $Q_x = f(L, K)$

Now if both the inputs are increased 'n' times, the new output Q'_x will be

$Q'_x = f(nL, nK)$

If $f(nL, nK) > n \cdot f(L, K)$, then the production function shows IRS.

If $f(nL, nK) = n \cdot f(L, K)$, then the production function shows CRS

If $f(nL, nK) < n \cdot f(L, K)$, then the production function shows DRS

❖ **Causes for Increasing Returns to Scale**

Increasing returns to scale implicitly implies reducing costs of production which may be attributed to economies of scale, which can be further categorised into two types:

1) **Internal Economies**

These refer to those cost reduction efforts which are created by the firm itself when output increases. These are limited and specific to a particular firm as these exist due to expansion in the firm's size.

Types of Internal Economies

a) Technical Economies

b) Managerial Economies

c) Financial Economies

d) Marketing Economies

e) Risk and Survival Economies

2) **External Economies**

These economies are not specific to any one firm and are shared by all the firms within an industry, when the scale of industrial production increases. These economies are exogenous to a particular firm and are beyond the control of the firm.

Types of External Economies

a) Economies of Concentration

b) Economies of Information.

c) Economies of Disintegration

❖ **Causes for Decreasing Returns to Scale**

Decreasing returns to scale implies increasing cost of production. This may be caused by diseconomies of scale. Diseconomies of scale exist when firm grows and expands beyond its optimum capacity.

Diseconomies of scale can be categorised into two categories:

1) Internal diseconomies

2) External diseconomies

❖ **Difference between Returns to Factor and Returns to Scale**

Basis of Differences	**Returns to a Factor**	**Returns to Scale**

1. Time Period	This law is applicable only in short run, when output can be varied only by varying variable factors of production.	This law is applicable only in long run, when output can be varied by varying all factors of production.
2. Production	According to this law, level of production can be changed.	According to this law, scale of production can be changed.
3. Different Stages of Production	There exists three stages - increasing returns, diminishing returns and negative returns to a factor.	There exists three stages- increasing returns, constant returns, and decreasing returns to a scale.
4. Factor Ratio	In this law, we assume that factor ratio remains constant.	In this law, we assume that factor ratio needs to change.
5. Nature of Production Function	This law refers to variable proportion types of production function.	This law refers to constant proportion types of production function.

❖ **Cost function**

The algebraic form which depicts the functional relationship between cost of production and output is called cost function. It is expressed as:

$C = f(Q_x)$

Where,

C = cost of production

Q_x = Units of output x produced

❖ **Cost Curve in Different Time Horizons**

According to different time horizons, the cost of production can be categorised into two different categories:

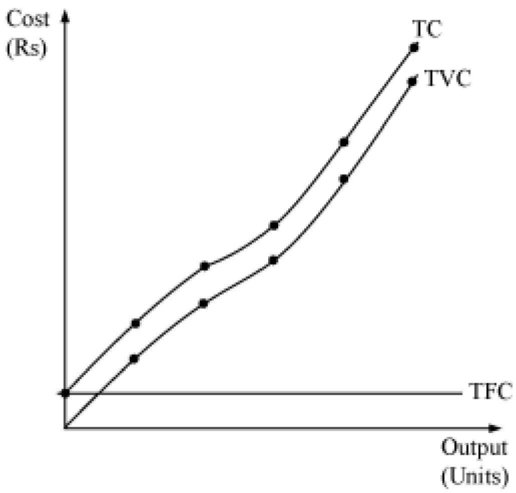
1) Short-run costs

Costs which are incurred in the short run for producing output are called short run costs.

a) **Total Fixed Cost (*TFC*) / Overhead costs**- Those costs which are incurred on fixed factors are called fixed costs. In short run, fixed factors cannot be varied. Thus, the fixed costs remain same (constant) throughout all output levels. For example, cost of machinery, buildings, depreciation on fixed assets, etc.

b) **Total Variable Cost (*TVC*) / Direct Costs** - Those costs which are incurred on variable factors are called variable costs or total variable costs.

c) **Total Cost** (***TC* or *STC***) = ***TFC* + *TVC***



d) **Average Cost**

Average cost is defined as the total cost per unit of producing output.

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

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

AC = Average Fixed Cost + Average Variable Cost

e) **Average Fixed Cost**

It is defined as the fixed cost per unit of output.

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

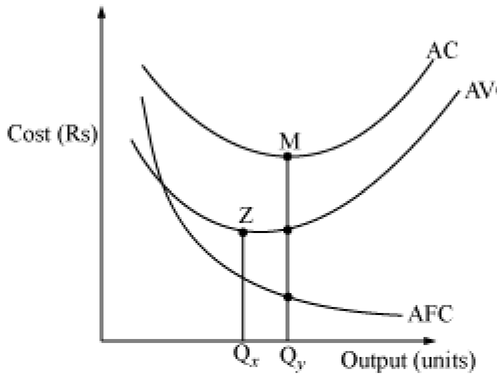
f) **Average Variable Cost**

It is defined as the variable cost per unit of output.

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

g) **Average Cost**

Superimposing the AFC and AVC in one figure, we get Average Cost.



In the graph AFC curve is continuously falling whereas the AVC graph initially falls, then stabilises and thereafter, increases. Vertically summing up AVC and AFC we derive AC curve.

❖ **U-Shaped Short Run Average Cost Curve**

Short run average cost curve is a U-shaped curve which implies that initially AC falls and reaches its minimum point and beyond this point, it raises. The reason behind AC being U-shaped can be attributed to the law of variable proportions.

Falling AVC together with falling AFC, contributes together to falling AC curve. However, later, as AFC becomes smaller and smaller, rising AVC leads to rising AC curve. Thus AC curve is a U-shaped curve.

❖ **Marginal Cost**

It is defined as the additional cost to the total cost or total variable cost which is incurred for producing one more unit of output. It is calculated in two ways:

1) $MC_n = TC_n - TC_{n-1}$

Where,

TU_n = Total utility achieved by consuming *n* units of a commodity

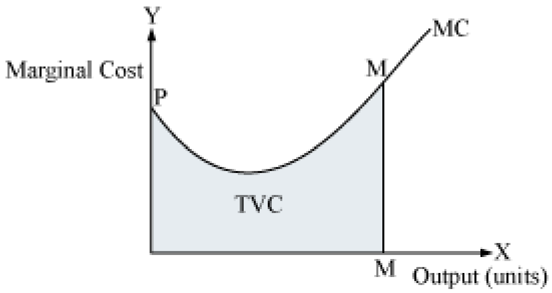
TU_{n-1} = Total utility achieved by consuming $(n - 1)$ units of a commodity

MU_n = Marginal utility achieved by consuming n^{th} units of a commodity

2) $MC = \dfrac{\Delta TC}{\Delta Q}$

It can also be said that the sum total of marginal cost is the total variable cost. That is

$\sum MC = TVC$



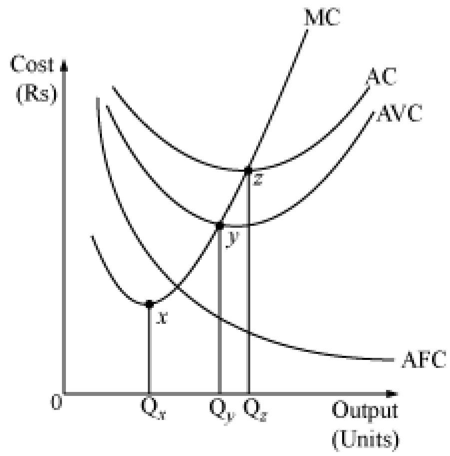
Geometrically, area (shaded region) under MC curve corresponding to different output levels indicates the TVC at that output level.

TVC = area of MNOP = $\sum_{i=1}^{n} MC$

Where,

i refers to the units of variable factors and ranges from one to *n*

- **Relationship between AFC, AVC, AC and MC curves**



❖ **Relationship between AC and MC**

1) When AC is falling, MC falls at a faster rate and MC remains below AC.
2) When AC is rising, MC rises at a faster rate and remains above AC.
3) When AC is at its minimum point, (z), MC is equal to AC.
4) MC curve intersects AC curve at its minimum point.
5) AC and MC are both U-shaped curves reflecting the law of variable proportions.
6) AC includes variable and fixed costs whereas MC includes only variable cost.
7) AC and MC are both derived from TC.

i.e. $AC = \dfrac{TC}{Q}$ and $MC = \dfrac{\Delta TC}{\Delta Q}$

❖ **Relationship between AVC and MC curves**

1) When AVC is falling, MC falls at a faster rate and remains below AVC curve.
2) When AVC is rising, MC rises at a faster rate and remains above AVC curve.
3) When AVC is at minimum point (y), MC is equal to AVC.
4) MC curve cuts AC at its minimum point (z).
5) The minimum point of MC curve (x) will always lie left to the minimum point of AVC curve (y).
6) AVC and MC are both derived from TVC.

$$AVC = \frac{TVC}{Q} \text{ and } MC = \frac{\Delta TVC}{\Delta Q} \text{ or } \frac{\Delta TC}{\Delta Q}$$

❖ **Relationship between TC and MC curve**

1) When TC rises at a decreasing rate, marginal cost is decreasing.
2) When TC rises at an increasing rate, MC rises.
3) When TC becomes constant and reaches its maximum point, MC becomes zero.
4) While TC consists of both variable and fixed costs (i.e. TVC and TFC), MC consists of only variable costs.
5) TC curve is an inverse S-shaped curve, whereas MC curve is inverted U-shaped.
6) MC is derived from *TC,i.e.*

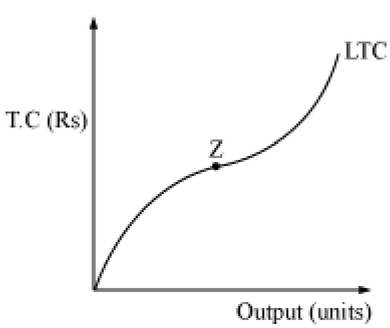
$$MC = \frac{\Delta TC}{\Delta Q}$$

MC is the slope of TC curve.

❖ **Long Run Costs**

The costs which are incurred in the long run for producing output are called long run costs. As in long run all factors of production are variable, i.e., the output level can be varied by varying capital and/or labour, so there is no concept of fixed costs in the long run and all costs are variable costs. Three important long run costs are:

1) Long Run Total Cost (LTC)
2) Long Run Average Cost (LAC)
3) Long Run Marginal Cost (LMC)



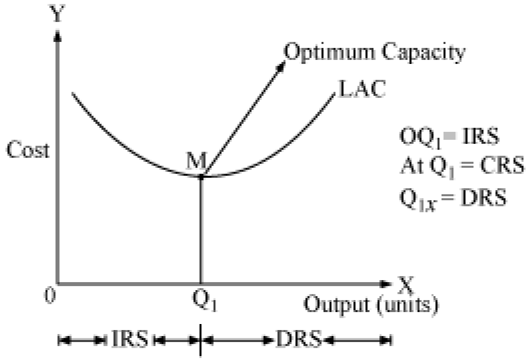
Note: *It should be noted that unlike short run TC, the LTC starts from origin when output is zero, as there are no fixed costs in the long run.*

❖ **Long-Run Average Cost**

LAC shows the cost of producing per unit of commodity when all factors are variable.

❖ **U-Shaped LAC**

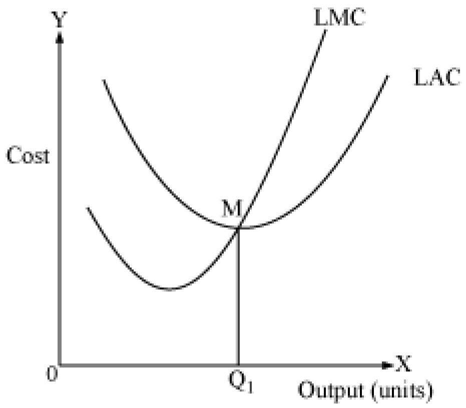
The U-shape of LAC can be attributed to the *law of returns to scale*. Initially LAC falls due to IRS and attains its minimum point at M (which represents optimum capacity) corresponding to Q_1 level of output due to CRS and finally rises due to DRS.



❖ **Long-run Marginal Cost**

LMC is the additional cost to the long-run total cost which is incurred to produce one more unit of output when all factors are variables. LMC curve is also U-shaped curve due to returns to scale.

❖ **Relationship between LMC and LAC**



1) When LAC is falling, LMC is also falling but at a faster rate and remains below LAC.

2) When LAC is rising, LMC is also rising but at a faster rate and remains above LAC.
3) When LAC is constant (i.e. at minimum point M) LMC equals LAC.
4) LMC cuts LAC at its minimum point.