# MICRO ECONOMICS

**SUBJECT : ECONOMICS**
**CHAPTER NUMBER: 3(3.1)**
**CHAPTER NAME :PRODUCTION AND COST( PRODUCTION FUNCTION)**



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# PRODUCTION FUNCTION

## Production Function

### Definition of Production Function

The term production function means **physical** relationship between inputs used and the resulting output. Production function is a purely **technical** relation which connects the quantity of inputs required to produce a good and the quantity of output produced.

**Production function is the process of getting the maximum output from a given quantity of inputs in a particular time period. It includes only technically efficient combinations of inputs** (*i.e.*, those which minimise the cost of production).

A **production function** is an expression of quantitative relation between change in inputs and the resulting change in output. It is expressed as:

$$Q = f(i1, i2 \ldots\ldots in)$$

Where $Q$ is output of a specified good and $i1$, $i2$ .....$in$ are the inputs usable in producing this good. To simplify let us assume that there are only two inputs, labour ($L$) and capital ($K$), required to produce a good. The production function then takes the form:

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

# PRODUCTION FUNCTION

**Short-run and Long-run Production Function**

There are two *types* of production function:

**(*a*) Short-run Production Function. It refers to production in the short-run where there is at least one factor in fixed supply and other factors are in variable supply.** In short-run, production will increase when more units of variable factors are used with the fixed factor. **Fixed factors** refer to those factors whose supply cannot be changed during short-run. *For example,* land, plant, factory building, minimum electricity bill, etc.

**(*b*) Long-run Production Function. It refers to production in the long-run where all factors are in variable supply.** In the long-run, production will increase when **all** factors are increased in the same proportion. Variable factors refer to those factors whose supply can be varied or changed. *For example*, raw materials, daily wages, etc.

# PRODUCTION FUNCTION

## DIFFERENCE BETWEEN SHORT RUN AND LONG RUN

| BASIS OF DIFFERENCE | SHORT PERIOD PRODUCTION FUNCTION | LONG PERIOD PRODUCTION FUNCTION |
|---|---|---|
| MEANING | It explains the technical relationship between outputs and inputs in the short run. | It explains the technical relationship between inputs and outputs in the long run. |
| KNOWN AS | The short period production function is also known as variable proportions type production function as in this the capital- labour ratio changes. | The long period production function is also known as constant proportions type production function as in this capital- labor ratio remains constant and do not change. |
| LAW APPLICABLE | The short run production function can be explained with the help of Law of returns to factor. | The long run production function can be explained with the help of Law of Returns to scale. |
| CURVE | The curve of short period production function is straight line parallel to horizontal axis. | The curve of long run production function is upward sloping curve. |
| NATURE OF FACTORS | In this, One factor 'land' is fixed and other factor 'labour' is variable. | In this, both factors are variable. |

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## Variable Factors and Fixed Factors

**Variable Factors**

Variable Factors refer to those factors, which can be changed in the short run. For example, raw material, casual labour, power, fuel, etc.

Variable factors vary directly with the level of output. As output increases, requirement for variable factors also rises and vice-versa. It must be noted that variable factors are not required in case of zero output.

**Fixed Factors:**

Fixed factors refer to those factors, which cannot be changed in the short run. For example, plant and machinery, building, land, etc.

The quantity of fixed factors remain same in the short run irrespective of level of output, i.e. they do not change, whether the level of output rises, falls or becomes zero.

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## Types of Production Function:

The distinction between fixed and variable factors helps us to study the two types of production function:

### 1. Short Run Production Function (Variable Proportion Type):

It studies the effect on output, due to change in variable input, assuming no change in other factors. As there is change in variable input only, the ratio between different inputs tends to change at different levels of output. This relationship is explained by the 'Law of Variable Proportions'.

### 2. Long Run Production Function (Constant Proportion Type):

It studies the effect on output, due to change in all the factor inputs. As all inputs are variable in the long run, the ratio between different inputs tends to remain the same at different levels of output. This relationship is explained by the 'Law of Returns to Scale'.

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## Concept of Product

Product or output refers to the volume of goods produced by a firm or an industry during a specified period of time.

## The concept of product can be looked at from three different angles:

(i) Total Product

(ii) Marginal Product

(iii) Average Product

## Total Product (TP):

Total product refers to total quantity of goods produced by a firm during a given period of time with given number of inputs. For example, if 10 labours produce 60 kg of rice, then total product is 60 kg. In the short-run, a firm can expand TP by increasing only the variable factors. However, in the long-run, TP can be raised by increasing both fixed and variable factors.

Total Product is also known as 'Total Physical Product (TPP)' or 'Total Return' or 'Total Output'.

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# PRODUCTION FUNCTION

## Concept of Product
## Average Product (AP):

Average product refers to output per unit of variable input. For example, if total product (TP) is 60 kg of rice, produced by 10 labours (variable input), then average product will be 60 /10 = 6 kg.

AP is obtained by dividing TP by units of variable factor.

Average Product (AP) = Total Product (TP) / Units of Variable factor (n)

TP in terms of AP will be:

TP = AP x Units of Variable Factor

Average Product is also known as 'Average Physical Product (APP)' or 'Average Return'.

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## Concept of Product
## Marginal Product (MP):

Marginal product refers to addition to total product, when one more unit of variable factor is employed.

$MP_n = TP_n - TP_{n-1}$

Where, $MP_n$ = Marginal product of $n^{th}$ unit of variable factor;

$TP_n$ = Total product of n units of variable factor;

$TP_{n-1}$ = Total product of (n – 1) units of variable factor;

n = number of units of variable factor.

For example, If 10 labours make 60 kg of rice and 11 labours make 67 kg of rice, then MP of $11^{th}$ labour will be:

$MP_{11} = TP_n - TP_{10}$

$MP_U = 67 - 60 = 7$ kg

Marginal Product (MP) is also known as 'Marginal physical product (MPP)' or 'Marginal Return'.

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# PRODUCTION FUNCTION

## Concept of Product

## One More way to Calculate MP:

We know, MP is the change in TP when one more unit of variable factor is employed. However, when change in variable factor is greater than one unit, then MP can be calculated as:

MP = Change in Total Product/ Change in units of Variable Factor = $\Delta TP/\Delta n$

Suppose 2 labours produce 60 units and 5 labours produce 90 units, then MP will be:

MP = TP of 5 labours – TP of 2 labours / 5 labours – 2 labours

MP =90 – 60/5-2 = 30/3 = 10 30 units

**TP is summation of MP:**

Total Product can also be calculated as the sum of marginal product.

It means, $TP_n – MP_1 + MP_2 + MP_3 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots MP_n$

Or, TP = $\sum MP$

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# PRODUCTION FUNCTION

## Law of Variable Proportions

Law of Variable Proportions or LVP is one of the most important laws of production. It shows the nature of rate of change in output due to a change in variable factors.

In the short run, when one input is variable and all other inputs are fixed, the firm's production function exhibits the law of variable proportions. This law shows the nature of rate of change in output due to a change in only one variable factor of production.

## Statement of Law:

Law of Variable Proportions (LVP) states that as we increase quantity of only one input keeping other inputs fixed, total product (TP) initially increases at an increasing rate, then at a decreasing rate and finally at a negative rate.

Law of Variable Proportions is also known as 'Law of Returns' or 'Law of Returns to Factor' or 'Returns to Variable factor'.

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# PRODUCTION FUNCTION

## Assumptions of Law of Variable Proportions:

1. It operates in short run, as factors are classified as variable and fixed factor;

2. The law applies to all fixed factors including land;

3. Under law of variable proportions, different units of variable factor can be combined with fixed factor;

4. This law applies to the field of production only;

ADVERTISEMENTS:

5. The effect of change in output due to change in variable factor can be easily determined;

6. It is assumed that, factors of production become imperfect substitutes of each other beyond a certain limit;

7. The state of technology is assumed to be constant during the operation of this law;

8. It is assumed that all variable factors are equally efficient.

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**Let us now understand the law with the help of an Example:**

Suppose, a farmer has 1 acre of land (fixed factor) on which he wants to increase the production of wheat with the help of labour (variable factor). When he employed more and more units of labour, initially output increased at an increasing rate, then at a decreasing rate and finally, at a negative rate.

This behaviour of output is shown in Table 5.1.

**Table 5.1: Law of Variable Proportions:**

| Fixed factor (Land in acres) | Variable Factor (labour) | TP (units) | MP (units) | Phase |
|---|---|---|---|---|
| 1 | 1 | 10 | 10 | 1st (Increasing |
| 1 | 2 | 30 | 20 | returns to a factor) |
| 1 | 3 | 45 | 15 | 2nd (Diminishing |
| 1 | 4 | 52 | 7 | returns to a factor) |
| 1 | 5 | 52 | 0 | |
| 1 | 6 | 48 | -4 | 3rd (Negative returns to a factor) |

Factor ratio keeps on changing: It must be noted that production is carried out under conditions of 'variable proportions', i.e. proportion between fixed and variable factor changes with every additional variable factor. In Table 5.1, the ratio between land and labour changes from 1:1 to 1:2, then to 1:3 and so on, with addition of more and more units of labour.

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## Assumptions of Law of Variable Proportions:

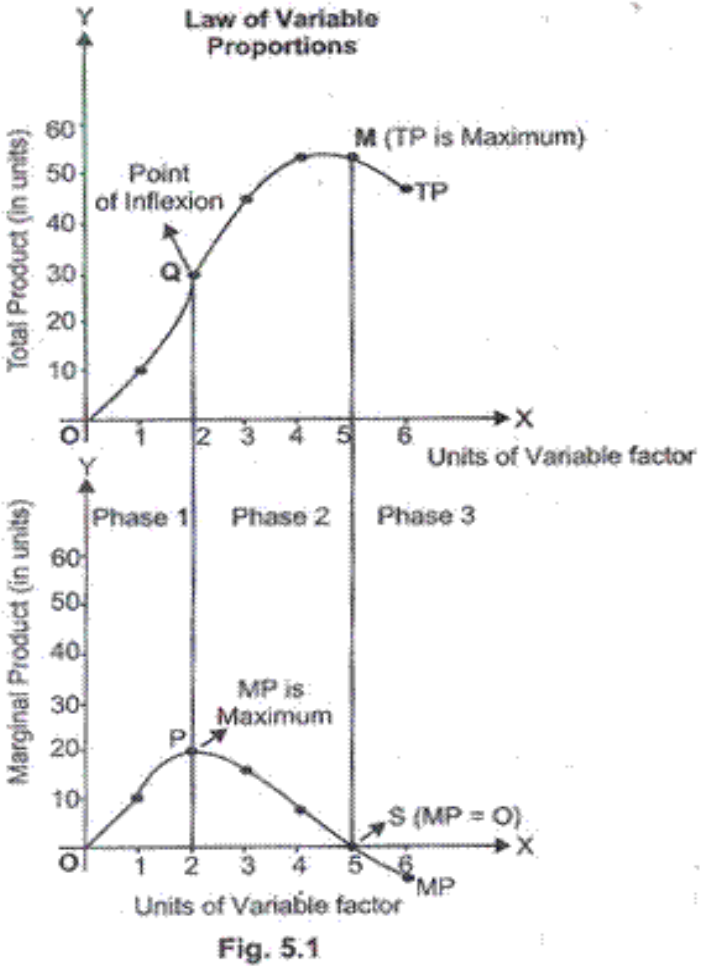


Fig. 5.1

i. Phase 1 (Between O to Q) TP increases at an increasing rate and MP also increases.

ii. Phase 2 (Between Q to M) TP increases at decreasing rate and MP falls. This phase ends when MP becomes zero and TP reaches its maximum point.

iii. Phase 3 (Beyond point M) TP starts decreasing and MP not only falls, but also becomes negative.

iv. Point of Inflexion (Point Q) Point 'Q' is known as point of inflexion as curvature of TP curve changes at this point. Till point Q, TP is concave shaped and beyond point Q, TP becomes convex shaped.

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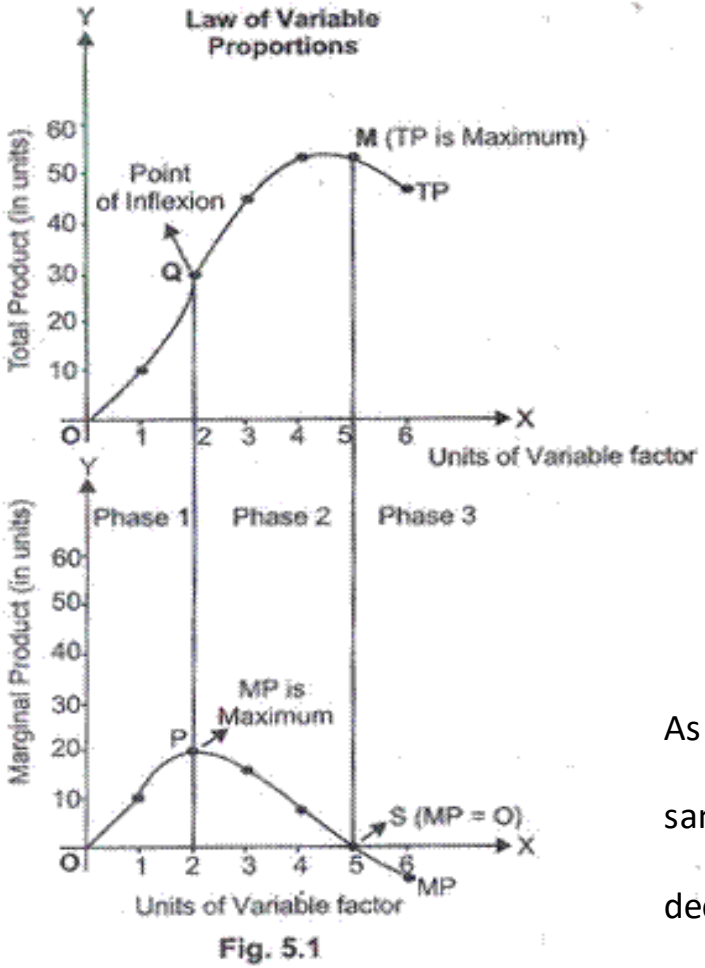
# PRODUCTION FUNCTION

## Assumptions of Law of Variable Proportions:

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As seen in Table 5.1 and Fig. 5.1, when farmer increases the labour on the same piece of land, then, initially TP rises at an increasing rate, then at a decreasing rate and finally it falls. The resulting relation between input and output is discussed in three phases:

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# PRODUCTION FUNCTION

## Assumptions of Law of Variable Proportions:

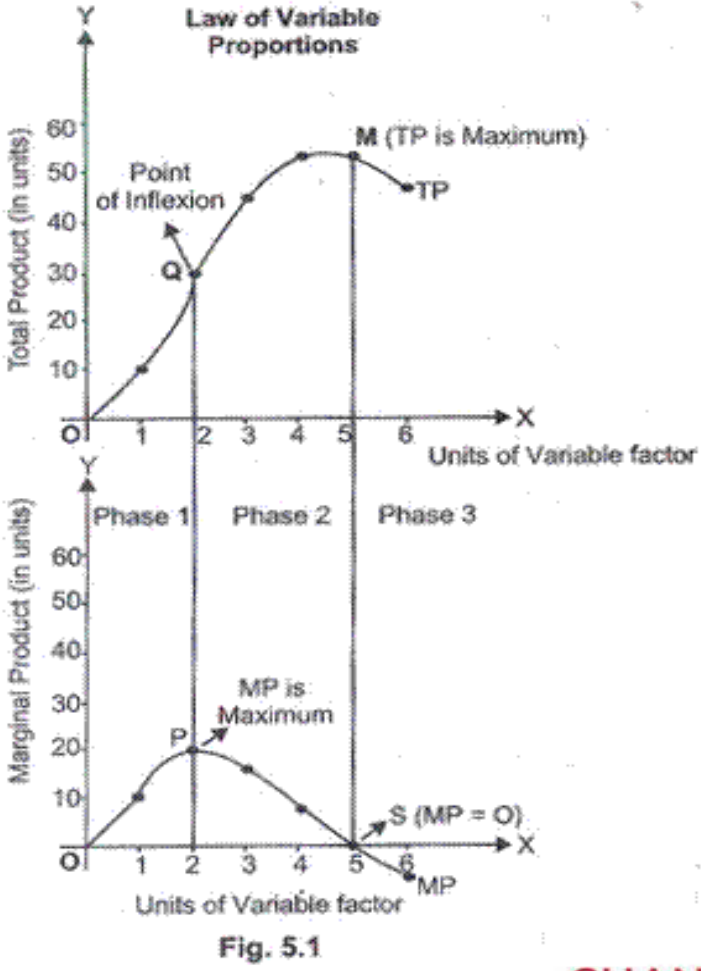


Fig. 5.1

**Phase 1: Increasing Returns to a Factor:**

In the first phase, every additional variable factor adds more and more to the total output. It means TP increases at an increasing rate and MP of each variable factor rises. As seen in given schedule and diagram, one labour produces 10 units, while two labours produce 30 units. It implies, TP increases at increasing rate (till point 'Q') and MP rises till it reaches its maximum point 'P', which marks the end of first phase.

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## Assumptions of Law of Variable Proportions:

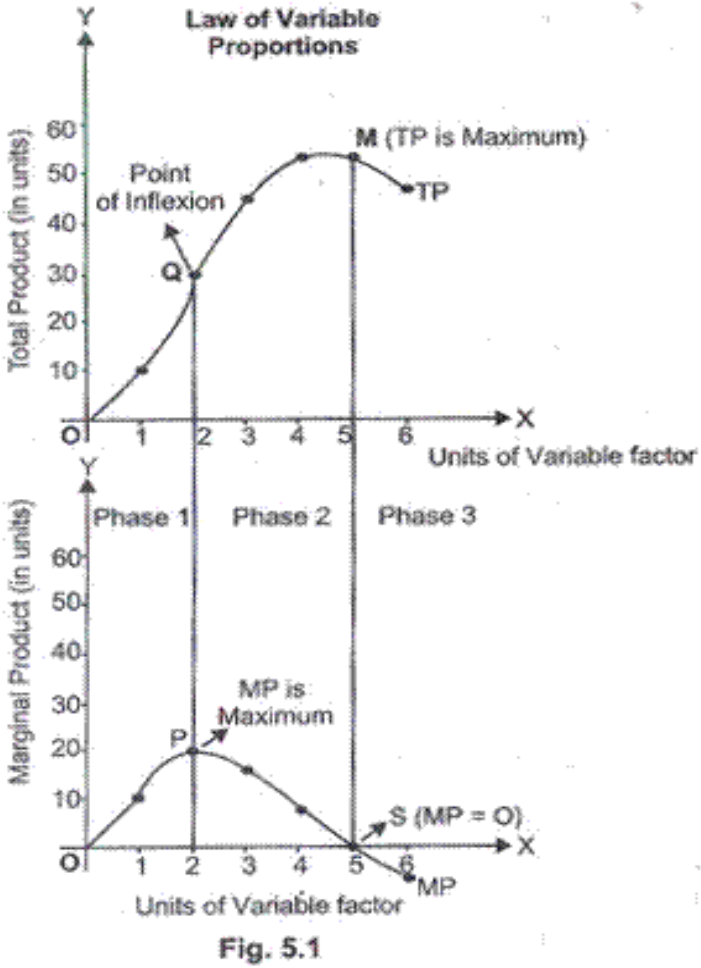


Fig. 5.1

### Phase 2: Diminishing Returns to a Factor:

In the second phase, every additional variable factor adds lesser and lesser amount of output. It means TP increases at a diminishing rate and MP falls with increase in variable factor. That is why this phase is known as diminishing returns to a factor. The second phase ends at point 'S', when MP is zero and TP is maximum (point 'M') at 52 units. 2nd phase is very crucial as a rational producer will always aim to produce in this phase because TP is maximum and MP of each variable factor is positive.

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# PRODUCTION FUNCTION

## Assumptions of Law of Variable Proportions:

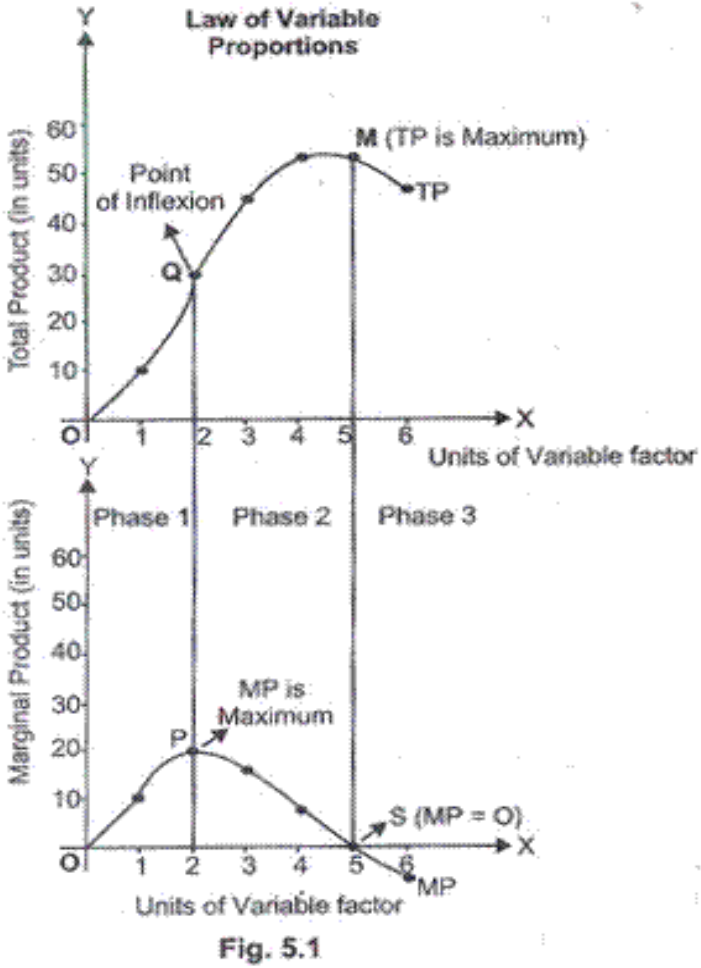


Fig. 5.1

### Phase 3: Negative Returns to a Factor:

In the third phase (starting from 6 units of labour), the employment of additional variable factor causes TP to decline. MP now becomes negative. Therefore, this phase is known as negative returns to a factor. In Fig 5.1, the third phase starts after point 'S' on MP curve and point 'M' on TP curve. MP of each variable factor is negative in the 3rd phase. So, no firm would deliberately choose to operate in this phase.

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# PRODUCTION FUNCTION

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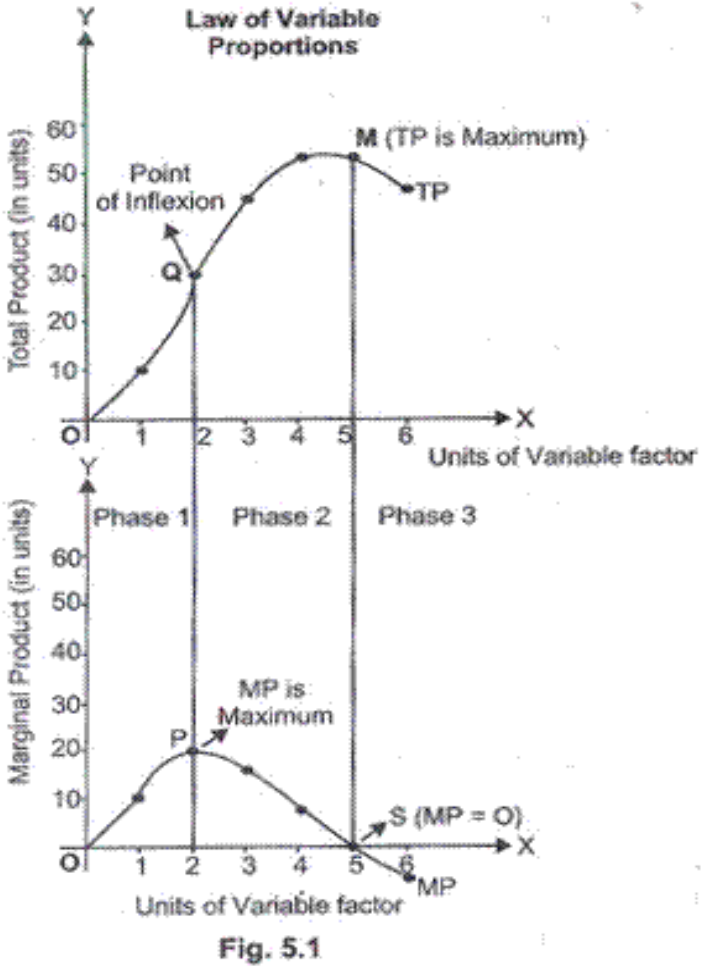


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# PRODUCTION FUNCTION

## Phase of Operation:

A rational producer will always seek to operate in the 2nd phase of law of variable proportions.

i. In the 1st phase, employment of every additional unit of variable factor gives more and more output i.e. marginal product increases. It means, there is scope for more profits, if production is increased with more units of variable factor.

ii. In the 3rd phase, marginal product of each variable factor is negative. So, this phase is ruled out on the ground of technical inefficiency and a rational producer will never produce in the third phase.

This brings us to the conclusion that a producer will aim to operate in 2nd phase as TP is maximum and MP of each variable factor is positive.

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## Reasons for Increasing Returns to a Factor (Phase 1):

There are three important reasons for the operation of increasing returns to a factor:

### 1. Better Utilization of the Fixed Factor:

In the first phase, the supply of the fixed factor (say, land) is too large, whereas variable factors are too few. So, the fixed factor is not fully utilised. When variable factors are increased and combined with fixed factor, then fixed factor is better utilised and output increases at an increasing rate.

### 2. Increased Efficiency of Variable Factor:

When variable factors are increased and combined with the fixed factor, then former is utilised in a more efficient manner. At the same time, there is greater cooperation and high degree of specialization between different units of the variable factor.

### 3. Indivisibility of Fixed Factor:

Generally, the fixed factors which are combined with variable factors are indivisible. Such factors cannot be divided into smaller units. Once an investment is made in an indivisible fixed factor, then addition of more and more units of variable factor, improves the utilisation of fixed factor. The increasing returns apply as long as optimum level of combination between variable and fixed factor is achieved.

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## Reasons for Diminishing Returns to a Factor (Phase 2):

## The main reasons for occurrence of diminishing returns to a factor are:

### 1. Optimum Combination of Factors:

Among the different combinations between variable and fixed factor, there is one optimum combination, at which total product (TP) is maximum. After making the optimum use of fixed factor, the marginal return of variable factor begins to diminish. For example, if a machinery (fixed factor) is at its optimum use, when 4 labours are employed, then addition of one more labour will increase TP by very less amount and MP will start diminishing.

### 2. Imperfect Substitutes:

Diminishing returns to a factor occurs because fixed and variable factors are imperfect substitutes of one another. There is a limit to the extent of which one factor of production can be substituted for another.

For example, labour can be substituted in place of capital or capital can be substituted in place of labour till a particular limit. But, beyond the optimum limit, they become imperfect substitutes of one another, which leads to diminishing returns.

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## Reasons for Negative Returns to a Factor (Phase 3):

## The main reasons for occurrence of negative returns to a factor are:

### 1. Limitation of Fixed Factor:

The negative returns to a factor apply because some factors of production are of fixed nature, which cannot be increased with increase in variable factor in the short run.

### 2. Poor Coordination between Variable and Fixed Factor:

When variable factor becomes too excessive in relation to fixed factor, then they obstruct each other. It leads to poor coordination between variable and fixed factor. As a result, total output falls instead of rising and marginal product becomes negative.

### 3. Decrease in Efficiency of Variable Factor:

With continuous increase in variable factor, the advantages of specialization and division of labour start diminishing. It results in inefficiencies of variable factor, which is another reason for the negative returns to eventually set in.

Law of Variable Proportions is an extension of another famous law, known as 'Law of Diminishing Returns'.

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