Theory of Production

- Production is an organized activity of transforming resources or inputs into finished products in the form of goods and services; the objective of production is to satisfy the demand for such transformed resources.
- Inputs used into production are broadly classified into **Land, labour, capital and enterprise.**
- They are also classified into Fixed inputs and variable inputs. **Fixed inputs** are those which cannot be changed in the short period of time. E.g. plants, equipment, etc.
- **Variable inputs** can be changed easily in the short period of time. E.g. raw materials, less-skilled workers etc.

Production Function

- The functional relationship between physical inputs (or factors of production) and output is called production function. It takes inputs as the explanatory or independent variable and output as the dependent variable. Mathematically, we may write this as follows:

$$Q = f\,(N,L,K,E,T)$$

Where, Q = Quantity produced

N = Land and other natural resources
L = Labour
K = Capital
E = Entrepreneur
T = Technology

- For simplicity, we consider only labour and capital and specify the production function as :

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

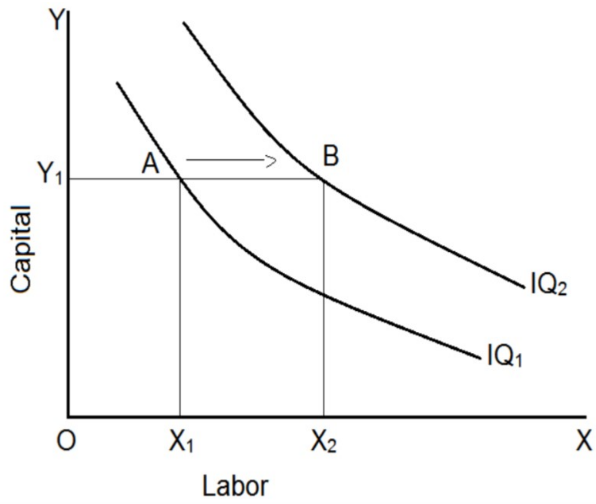
- Production function can be represented by an equation, graph or a schedule showing the maximum amount of a commodity that can pe produced from a given set of inputs.
- Knowledge of production function is important to compute least cost combinations for a given output or the maximum output combination for a given cost.

Isoquants

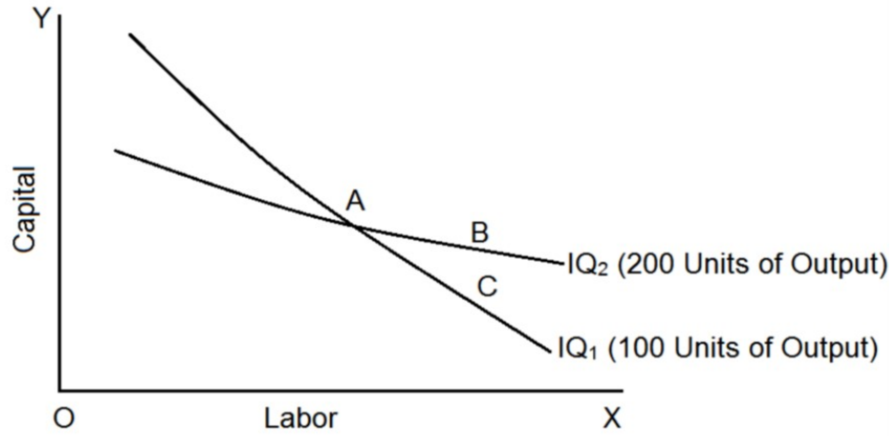
- Isoquants are the curves or lines that show all those combinations of factors which produce the same level of output. An Isoquant is also known as equal production curve or iso-product curve.

Properties of Isoquants

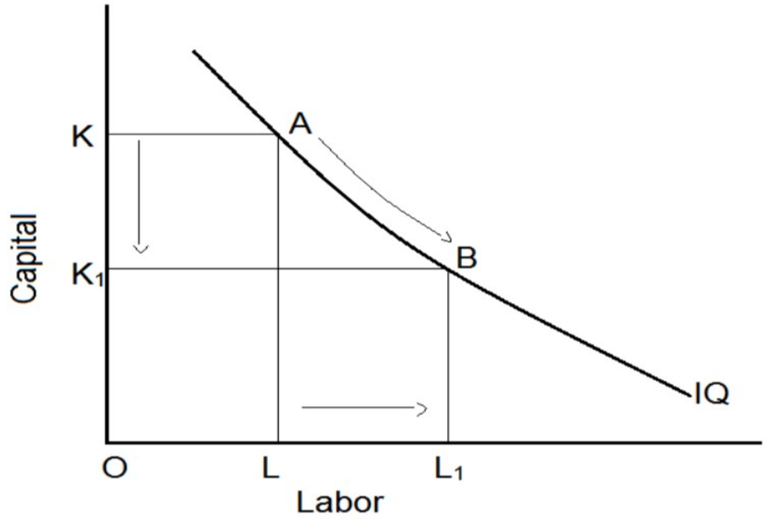
1. An isoquant which lies above and to the right of another shows a higher level of output. So, any point on a higher isoquant is always better than any point on a lower isoquant.



2. Isoquants cannot meet or intersect one another. If they did, then one combination of K and L would yield two different levels of output. The producer's technology is inconsistent. We rule out such events.



- 3. Isoquants slope downward over the relevant range of production. This negative slope indicates that, if the producer decreases the amount of capital employed, more labour must be added in order to keep the rate of output constant. Or, if labour use is decreased, capital use must be increased to keep output constant. Thus, the two inputs can be substituted for one another to maintain a constant level of output.

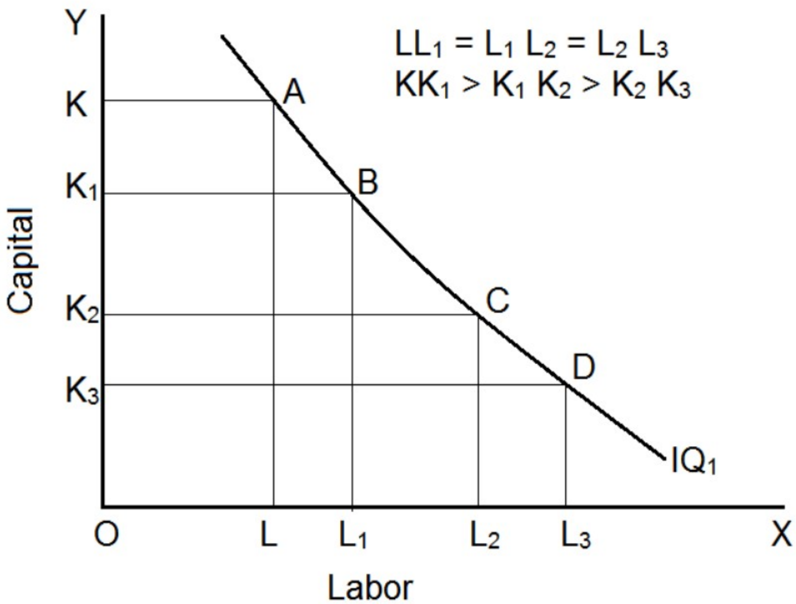


4. Isoquants are convex to the origin: An isoquant must always be convex to the origin. This is because of the operation of the principle of diminishing marginal rate of technical substitution. i.e. as more and more units of capital (K) are employed to produce given units of the product, lesser and lesser units of labor (L) are used. Hence diminishing marginal rate of technical substitution is the reason for the convexity of an isoquant.

- **The marginal rate of technical substitution (MRTS):**

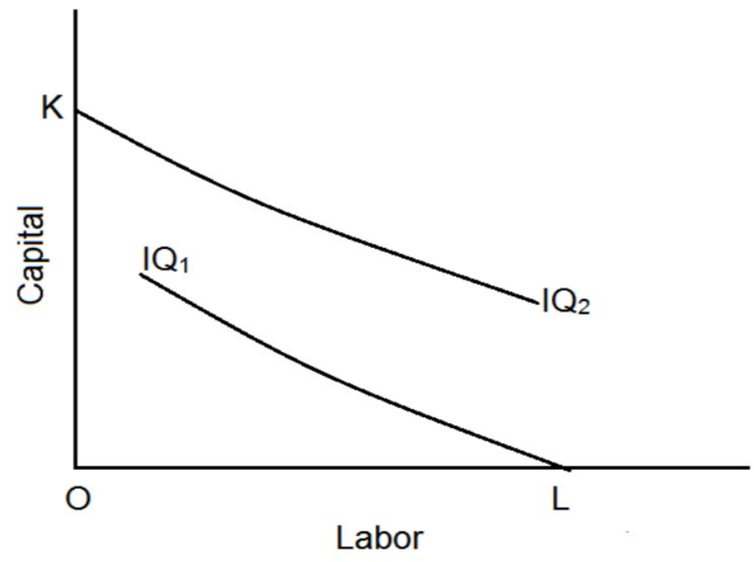
The rate at which one input can be substituted for another along an isoquant is called the marginal rate of technical substitution (MRTS), defined as:

$$MRTS_{L\ for\ K} = \Delta K/\Delta L = MP_L/MP_K$$



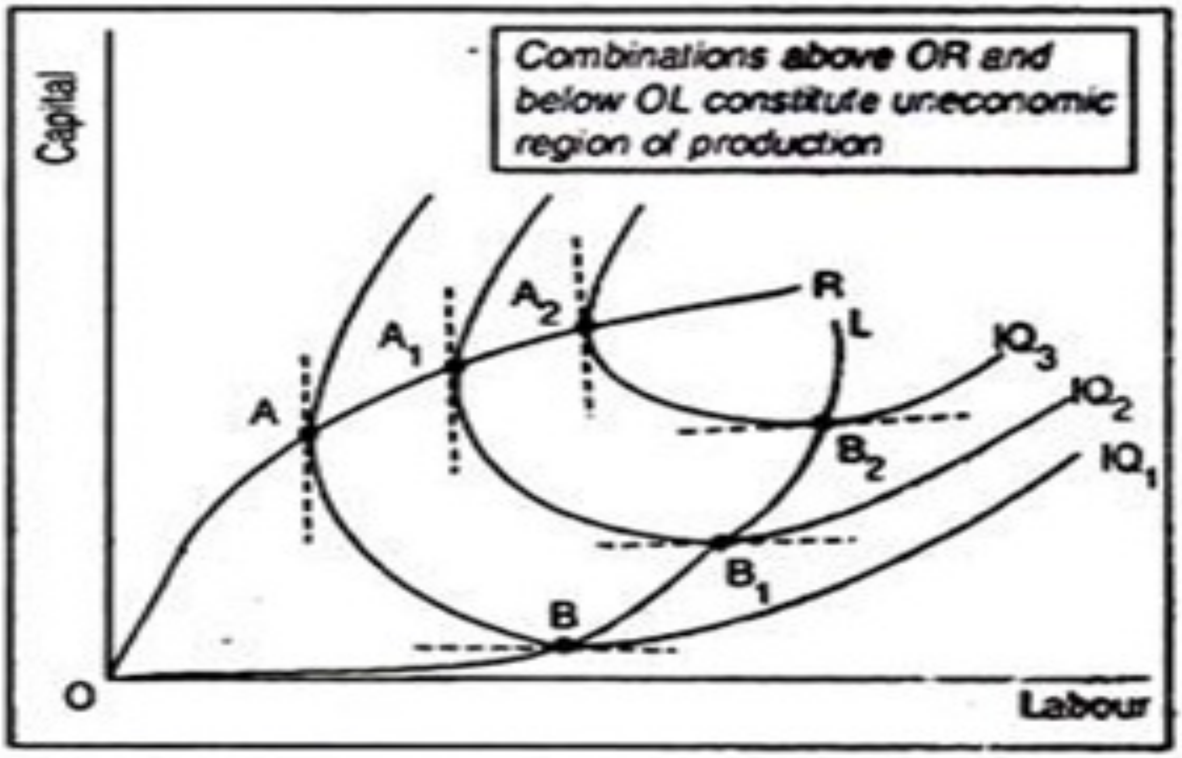
In this figure, $MRTS^{KL}$ diminishes from 5:1 to 4:1 and further to 3:1. This shows that as more and more units of labour are employed to produce 100 units of the product, lesser and lesser units of capital are sacrificed. Hence, diminishing marginal rate of technical substitution is the reason for the convexity of an isoquant.

5. No isoquant can touch either axis: If an isoquant touches the X-axis it would mean that the commodity can be produced with OL units of labor and without any unit of capital.



Ridge Lines: The Economic Region of Production

- An isoquant represents combinations of two inputs that yield the same level of output. However, not all points of an isoquant are relevant for production. Such points may be called **infeasible points**. One should consider only feasible portions of an isoquant.
- The marginal product of a particular factor may be negative if the quantity used is too large. For example, if too much labour is used there may be congestion and the efficiency of all the labourers may be affected. If the isoquant is backward bending and upward sloping, marginal product of any input will be negative, and, hence, this portion of the isoquant may be considered as economically non-sensible region of production. Only the negatively sloped segment of the isoquant is relevant for production or economically feasible.
- The area of rational operation may be shown by drawing two lines from the origin enclosing only those parts of the isoquants where each factor has a positive marginal product. Such lines are called **ridge lines.** Negative marginal products appear in that part of the isoquant which has a positive slope.



Combinations above OR and below OL constitute uneconomic region of production
Capital
Labour
O
R
L
A
A_1
A_2
B
B_1
B_2
IQ_1
IQ_2
IQ_3

- At point A on IQ_1, the firm employs certain units of labour and capital. Since the tangent to IQ_1 at point A is parallel to the vertical axis, marginal product of capital (MP_K) is zero. If more capital is used, marginal product of capital should be negative. In other words, beyond point A, MP_K is negative. At point B on IQ_1, MP_L is zero and beyond point B on IQ_1, MP_L is negative.
- Thus, points between A and B represent positive marginal productivities of both labour and capital. Here substitution between two inputs takes place. Similarly, points A_1 and A_2 on IQ_2 and IQ_3 describe zero MP_L while points beyond A_1 and A_2 describe negative MP_K. Points B_1 and B_2 on IQ_2 and IQ_3 represent zero MP_K and beyond B_1 and B_2 describe negative MP_L.
- A rational producer will produce in that region where marginal productivities of inputs are positive. By joining points A, A_1 and A_2 (i.e., points of zero marginal products) we get OR line and by joining points B, B_1 and B_2 (points of zero marginal products) we get OL line. These lines are called ridge lines. They give the boundaries of the economic region of production where input substitution takes place.

Least Cost Combination of Inputs

- The firm may produce a particular quantity of its product at each of the alternative input combinations that lies on the IQ for that quantity. Since the firm's goal is to maximise profit, the optimum input combination for producing a particular quantity of its product would be one that would produce the output at the minimum possible cost.
- The optimum input combination in this case is known as **the least cost combination of inputs**.
- There are two ways to determine the least cost combination:
    - Finding total cost of factor combinations
    - Geometric Method

- Finding Total Cost Of Factor Combinations:

Here we try to find the total cost of each factor combination by multiplying the price of each factor by its quantity and then summing it for all inputs.

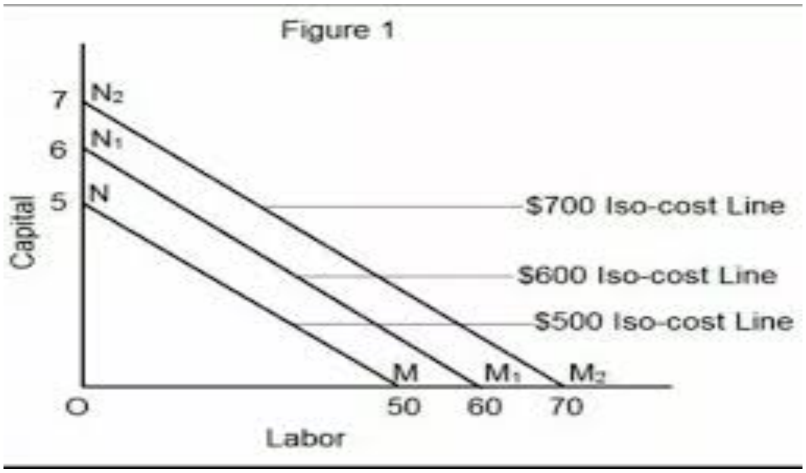
e.g. Following table shows two different techniques of producing 100 pairs of shoes. Assuming that there are just two possible techniques, it can be concluded that technique B is the least cost combination for producing the given output.

Technique	Capital (units)	Labour (units)	Capital Cost ₹	Labour Cost ₹	Total Cost ₹
1	2	3	4	5	6
A	6	10	500 × 6 = 3000	400 × 10 = 4000	7000
B	2	14	500 × 2 = 1000	400 × 14 = 5600	6600

- Geometric Method:

Least cost combination can be determined with the help of isoquant map and **iso-cost lines.**

- Isoquant map shows all possible combinations of labour and capital that can produce different levels of output.
- Iso-cost lines show various combinations of labour and capital that firm can buy for a given amount of money at the given factor prices. Following figure shows the iso-cost lines.
- The slope of the iso-cost line is $P_L/P_{K.}$



Law of Variable Proportions

- The law examines the behaviour of the production in the short run where output can be increased by increasing the quantity of the variable inputs, keeping other factors constant.
- This law is also known as **the law of diminishing marginal returns.**
- This law states that, if successive units of a variable input are added to a constant quantity of a fixed input then the total output obtained varies in magnitude in three different phases.

- The law is based on following **assumptions**:

1. Fixed factors: Some factors of production remain constant. E.g. land or physical capital
2. Variable Factors: These are inputs whose supply can be increased in the short run. Increase in production is possible by combining more units of variable factors with given quantity of fixed factors. E.g. Labour
3. Homogeneity of variables: All the units of variable factors are of the same efficiency.
4. Technology is given and constant.

Behaviour of TP, AP, MP

Table : Law of variable proportions

Units of Fixed Factor CAPITAL	Units of Variable factor LABOUR	Ratio of Factors	Total Product	Average Product	Marginal Product	Stages of the Law
10	1	10:1	10	10	10	**Stage I** Increasing Returns to Factor
10	2	10:2	30	15	20	
10	3	10:3	60	20	30	
10	4	10:4	80	20	20	**Stage II** Diminishing Returns to Factor
10	5	10:5	90	18	10	
10	6	10:6	90	15	0	
10	7	10:7	85	12.1	-5	**Stage III** Negative Returns to Factor

We assume labour to be a variable factor and all other factors to be fixed.

- **Total Product (TP) =** It's the total amount of output produced by all the variable inputs applied in combination with the fixed inputs. In the given table, TP increases till the 5th unit of labour. It reaches maximum at the 5th unit and remains constant between 5th and 6th unit. Thereafter, TP declines.
- **Average Product (AP) =** It is obtained by dividing the total output by the units of total variable factor (labour). The average product continues to rise till the 3rd unit of labour, remains constant between 3rd and 4th units and then declines.

$$\mathbf{AP = TP/TVF}$$

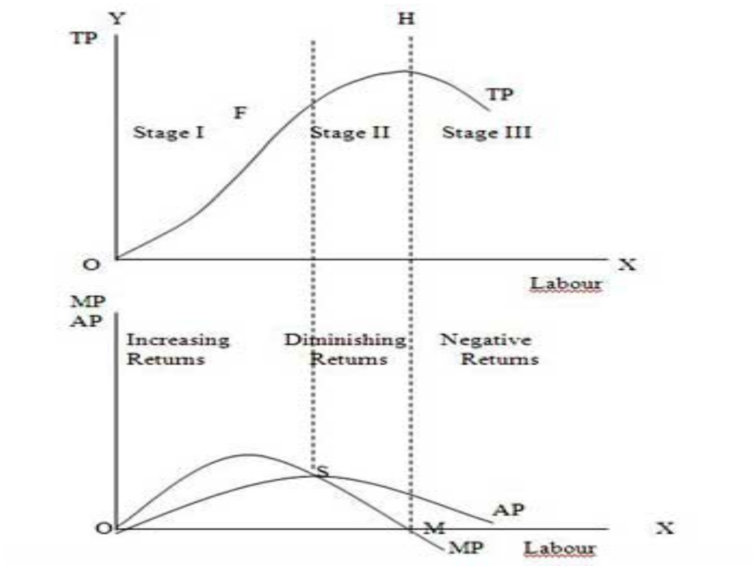
- **Marginal Product (MP) =** It is the additional output produced by an additional unit of variable factor. It is equal to a change in total output divided by the change in total variable factor employed.

$$\mathbf{MP = \Delta TP/\Delta TVF}$$

Or

$$\mathbf{(TP_n - TP_{n-1})}$$

- Marginal Product increases till the third unit of labour. Thereafter, it falls and becomes zero at the 6th unit of labour. At 7th unit marginal product of labour is negative.
- This shows the working of the law of diminishing marginal returns. It can be explained with the following diagram.



- ***Stage 1. Stage of Increasing Returns***: In this stage, total product increases at an increasing rate up to a point. This is because the efficiency of the fixed factors increases as additional units of the variable factors are added to it.
- In the figure, from the origin to the point F, slope of the total product curve TP is increasing i.e. the curve TP is concave upwards up to the point F, which means that the MP of labour rises. Rising marginal product also pulls up the average product.
- The point F where the total product stops increasing at an increasing rate and starts increasing at a diminishing rate is called **the point of inflection.** Corresponding vertically to this point of inflection marginal product of labour is maximum, after which it diminishes. **This stage is called the stage of increasing returns** because the average product of the variable factor increases throughout this stage, marginal product of the variable factor rises in a significant part of this stage. Rising average product indicates increase in the efficiency of labour. The marginal product of the variable factor is equal to the average product of the factor at point 'S'.
- This stage ends at the point where the average product curve reaches its highest point.

- ***<u>Stage 2. Stage of Diminishing Returns:</u>*** In this stage, total product continues to increase but at a diminishing rate until it reaches its maximum point H where the second stage ends. In this stage both the marginal product and average product of labour are diminishing but are positive, the former falling at faster rate.
- This is because the fixed factor becomes inadequate relative to the quantity of the variable factor. At the end of the second stage, i.e., at point M marginal product of labour is zero which corresponds to the maximum point H of the total product curve TP. This stage is important because the firm will seek to produce in this range.
- ***<u>Stage 3. Stage of Negative Returns:</u>*** In stage 3, total product declines and therefore the TP curve slopes downward. Marginal product of labour is negative and the MP curve falls below the X-axis. In this stage the variable factor (labour) is too much relative to the fixed factor.

The relations among TP, AP and MP are used to define three stages of production:

- Stage I is known as the stage of increasing returns where TP increases at an increasing rate, because AP and MP rise. However, MP exceeds AP throughout this stage.
- Stage II is called the diminishing stage since both AP and MP decline but are positive. This is the most crucial stage as far as the decision to produce is concerned.
- Stage III is called the stage of negative returns where TP declines and MP becomes negative.

The relationship between AP and MP:

AP increases as long as MP is greater than AP till the point S. At point S, AP is at maximum.

- AP decreases when MP < AP. Beyond the point S, AP is declining.
- AP is at its maximum when AP = MP. MP curve cuts AP from above when AP is at its maximum.
- AP continues to be positive even when MP is zero or negative.

The nature of three stages of production:

I. Stage I: MP > 0, AP is rising, MP first rising, later falling. MP > AP — increasing stage;

II. Stage II. MP > 0, MP and AP are falling. MP < AP, but TP is increasing because MP > 0 — diminishing stage.

III. Stage III: MP < 0 and AP and TP are falling — negative stage.

- **Increasing returns** are due to the fact that in the initial stage of production, fixed factors are in abundance as compared to the variable factors. The fixed factors can be used effectively by increasing the quantity of variable factors.
- **Diminishing returns:** Increasing returns to the factors come to an end when the producer reaches the point where fixed factors are fully and efficiently used. When more units of variable factor are added, the fixed factor starts becoming inadequate. Thus every additional unit of variable factor gets less and less of fixed factor to work with, and therefore their productivity falls. Thus the diminishing returns are due to disproportion in the combination of fixed and variable factors.
- **Negative Returns:** It is the result of too many variable factors working on fixed factor.

The Stage of Operation

- A producer does not operate in Stage I. In this stage, the marginal product increases with an increase in the variable factor.
- Therefore, the producer can employ more units of the variable factor to efficiently utilize the fixed factors. Hence, the producer would prefer to not stop in Stage I but will try to expand further.
- Producer doesn’t like to operate in Stage III either. In this stage, there is a decline in total product and the marginal product becomes negative. In Stage III, he incurs higher costs and also gets lesser revenue thereby getting reduced profits.
- Any rational producer avoids the first as well as third stages of production. Therefore, **producers prefer Stage II** – the stage of diminishing returns. This stage is the most relevant stage of operation for a producer according to the law of variable proportions.
- However, he will not extend the production to the point where MP = 0. He will operate in the area where MP is positive.