

**INSTITUTE OF ENGINEERING,  
JIWAJI UNIVERSITY**



**THEORY OF PRODUCTION  
& PRODUCTION FUNCTION**

**UNIT-IV BE 8sem  
(EL-8103) Electronics**

**Submitted By  
Swati Dixit**

**Electronics Dep**

# Theory of Production and the Production Function

*“Knowledge is the only instrument of production that is not subject to diminishing returns – J. M. Clark, 1957.”*

## **Subject Matter:**

A firm's objective is profit maximization. If, in the short run, its total output remains fixed (due to capacity constraints) and if it is a price-taker (i.e., cannot fix the price or change price on its own as in a purely competitive market) its total revenue will also remain fixed. Therefore, the only way to maximize profit is to minimize cost. Thus profit maximization and cost minimization are the two sides of the same coin.

Moreover, supply depends on cost of production. The decision to supply an extra unit depends on the marginal cost of producing that unit. Perhaps the most important determinant of the firm's price- output decision in any market is its cost of production.

## **The Production Function:**

The production function shows the relation between input changes and output changes. It also shows the maximum amount of output that can be obtained by the firm from a fixed quantity of resources.

**The production function is expressed as:**

$$Q = f(K, L, \text{etc.})$$

Where Q is output (which is the dependent variable) and K and L are capital and labour inputs, respectively. We can think of other inputs as well, such as land. For the sake of convenience we assume here that the firm employs only

two factors of production— labour and capital. The firm's output is treated as a flow, i.e., so many units per period of time. The volume of output of the firm's product, per period of time, depends on the quantities of these factors that are used by the firm.

## **Factors of production**

- Economic resources are the goods or services available to individuals and businesses used to produce valuable consumer products.
- The classic economic resources include land, labor and capital. Entrepreneurship is also considered an economic resource because individuals are responsible for creating businesses and moving economic resources in the business environment.
- These economic resources are also called the factors of production. The factors of production describe the function that each resource performs in the business environment.

## **Land**

- Land is the economic resource encompassing natural resources found within the economy.
- This resource includes timber, land, fisheries, farms and other similar natural resources.
- Land is usually a limited resource for many economies. Although some natural resources, such as timber, food and animals, are renewable, the physical land is usually a fixed resource.
- Nations must carefully use their land resource by creating a mix of natural and industrial uses.
- Using land for industrial purposes allows nations to improve the production processes for turning natural resources into consumer goods.

## **Labor**

- Labor represents the human capital available to transform raw or national resources into consumer goods.

- Human capital includes all individuals capable of working in the economy and providing various services to other individuals or businesses.
- This factor of production is a flexible resource as workers can be allocated to different areas of the economy for producing consumer goods or services.
- Human capital can also be improved through training or educating workers to complete technical functions or business tasks when working with other economic resources.

## Capital

- Capital has two economic definitions as a factor of production.
- Capital can represent the monetary resources companies use to purchase natural resources, land and other capital goods.
- Monetary resources flow through a economy as individuals buy and sell resources to individuals and businesses.
- Capital also represents the major physical assets individuals and companies use when producing goods or services. These assets include buildings, production facilities, equipment, vehicles and other similar items.
- Individuals may create their own capital production resources, purchase them from another individual or business or lease them for a specific amount of time from individuals or other businesses.

## Entrepreneurship

- Entrepreneurship is considered a factor of production because economic resources can exist in an economy and not be transformed into consumer goods.
- Entrepreneurs usually have an idea for creating a valuable good or service and assume the risk involved with transforming economic resources into consumer products.
- Entrepreneurship is also considered a factor of production since someone must complete the managerial functions of gathering,

allocating and distributing economic resources or consumer products to individuals and other businesses in the economy.

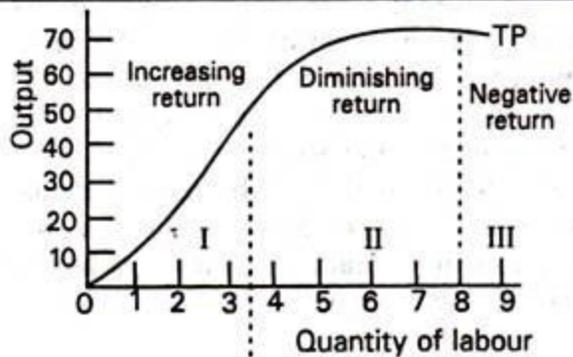
### **Returns to a Variable Factor in the Short-Run:**

In the short-run we study the behavior of output as more and more units of a variable factor (labour) are applied to a given quantity of a fixed factor. So output becomes a factor (capital) function of labour input alone. If this is so the short-run production function may be expressed as:  $Q = f(L)$ , where the symbols have their usual meanings.

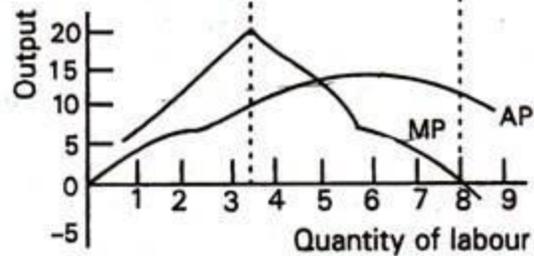
Table 6.1 illustrates the relationship between input changes and output changes in the short run. Three concepts bear relevance in this context, viz., total product (TP), average product (AP) and marginal product (MP). Here Q is total product. It refers to the total amount produced by all the factors employed in a fixed time period. AP is output per unit of input. It is calculated by dividing TP by the amount of the variable factor, e.g., labour (L).

**Table 6.1 : The relation among output and the quantity of a variable factor (labour) used in combination with a fixed factor (capital)**

Quantities of labour capital		Output <i>TP</i>	Output		Stages of production
(i)	(ii)		<i>AP</i>	<i>MP</i>	
(i)	(ii)	(iii)	(iv)	(v)	(vi)
		0			Increasing return to the variable factor (labour)
1	10	4	4	4	
2	10	10	5	6	
3	10	21	7	11	
4	10	40	10	19	Diminishing return to the variable factor
5	10	55	11	15	
6	10	60	10	5	
7	10	63	9	3	
8	10	64	8	1	Negative return to the variable factor
9	10	63	8	-1	



(i) Total product



(ii) Marginal and average product

**Fig. 6.1.** Total product, marginal product and average product of a variable factor, used with a fixed factor in the short run

So  $AP = TP/L = Q/L$ . is output per unit of labour or per worker. The marginal product is defined as the change in total product associated with a small change in the usage of the variable factor. It may be expressed as

$MP = \Delta Q/\Delta L$  where 'A' denotes any change.

Thus, MP is the ratio of the change in Q and change in L.

The data presented in Table 6.1 are shown graphically in Fig. 6.1. In Table 6.1 we show the total product that result from employing 1 to 9 units of labour

[Column (i)] in combination with a fixed quantity (10 units), of capital, [column (ii)].

Column (iv) shows the corresponding AP figures.

Each figure of column (iv) is arrived at by dividing each element of Column (iii) by the corresponding element of Column (i).

Column (v) gives the MP figures.

Each element in this column shows the contribution (addition) made to the total product (TP) by the one additional unit of labour. In other words, MP is the change in total product which results from a change in the usage of the variable factor (i.e., labour) by one unit. For example, when one unit of labour is employed, TP is 4. When two units are employed, TP is 10. Therefore, the anticipation of the said unit of labour is  $10 - 4 = 6$  units. This is the MP of labour.

### **The Law of Variable Proportions:**

**If we look at Table 6.1 carefully we can identify three stages of the production process in the short-run:**

(1) In the first stage, when additional units of labour are employed, TP increases more than proportionately and MP also increases. This is the stage of increasing return to the variable factor (labour).

(2) In the second stage TP increases no doubt, but not proportionately. In other words, the rate of increase of TP falls. This means that MP diminishes. This is the stage of diminishing return to the variable factor (labour). This is perhaps the most important stage of the production process in the short run.

(3) In the third stage, TP itself diminishes and the MP is negative. This is the stage of negative return to the variable factor (labour).

The three stages together constitute the Law of Variable Proportions. Since the second stage is most important from the practical point of view, we often ignore the other two stages in most discussions. This is why the Law of Variable Proportions is also known as the Law of Diminishing Returns, which is universally applicable.

The Law states that **“when increasing quantities of a variable factor are used in combination with a fixed factor, the marginal and average product of the variable factor will eventually decrease.”** In our example AP increases until 5 men are employed. It declines thereafter. MP declines earlier. It rises until 4 men are employed and declines when 5 and more men are employed.

No doubt, the data presented in Table 6.1 are hypothetical. But the relationship shown among TP, MP and AP is widely applicable. From Table 6.1 we may also discover the relationship between MP and AP.

### **Three points may be noted in this context:**

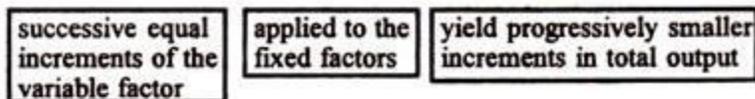
1. So long as MP exceeds AP, the AP must be rising.
2. Thus, it follows as a corollary of this that only when MP falls below the level of AP, does AP fall.

3. Since MP rises when MP is exceeding AP, while AP falls where MP is less than AP, it follows that where AP is at a maximum, it is equal to MP. This is why; the MP curve intersects the AP curve at the latter's maximum point. (The relation between the margin and the average is mathematical.)

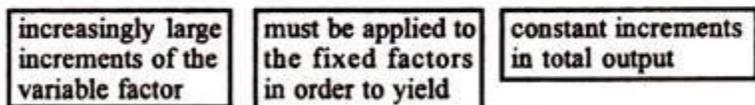
In this context we may note that MP can be zero or negative, but AP can never be so. AP may be very small but is always positive as long as TP is positive. However, such a situation does not carry any significance. In an example where 9 men are employed, TP falls. So no profit-maximising producer would consider employing so many workers.

There are two interpretations of the law of diminishing returns. See Fig. 6.2 which is self-explanatory.

**Firstly**



**Secondly**



**Fig. 6.2. Two Interpretations of the Law of Diminishing Returns**

## **Returns to Scale:**

### **Returns to Variable Factors in the Long Run:**

In the short run, the only way to change the volume of output is to alter the usage of the variable factor. A change in the quantities of the variable factor leads to a change in the factor proportions. The long run, however, refers to a period of time over which all the factors of production can be varied. When this is done, holding factor proportions constant, the production function-is said to exhibit returns to scale. For instance, a profit-maximizing firm might double the usage of both labour and capital.

When there is a change in the scale of operation of a business firm the law of diminishing returns does not operate. Since all factors are variable in the long run we may find that returns to scale increase decrease or remain constant.

The law of diminishing returns deals with short-run situations in which some factors of production are fixed in supply. However, in the long run, it is possible to vary the use of all factors of production employed. More land can be acquired, more machines installed and more buildings constructed.

This means that in the long run it is possible to change the scale of activities (operation) of a firm. The truth is that a change in the scale takes place when the quantities of all the factors are changed by the same proportion so that there is no change in the proportions in which they are combined.

It is to be noted that when the scale of production is changed, output changes are not proportionate. When a firm doubles its size, output may rise by more than 100%, exactly 100% or less than 100%. The relationship between changes in scale and changes in output are described as returns to scale.

It is widely believed that in a typical production activity, when scale of operations is first increased, increasing returns to scale are observed; ultimately, with the exhaustion of all economies, there is constant return to scale; if expansion is carried far enough, returns to scale decrease.

Table 6.2 shows increases in total output as the scale of production increases:

Table 6.2: Returns to Scale

Units of labour (no. of workers)	Units of capital (no. of machines)	Total output	Increase in the size of the firm	Increase in total output
2	1	10	} 100%	150%
4	2	25		
6	3	42	} 50%	68%
8	4	56		
10	5	67.2	} 33 $\frac{1}{3}$ %	33 $\frac{1}{3}$ %
12	6	78.0		

Table 6.2 shows that initially there is increasing return to scale, then constant return to scale and finally decreasing return to scale. A related point may also be noted in this context. There may be diminishing returns to a factor and increasing returns to scale at the same time.

Table 6.2 shows that the firm increases its size but the proportion between the factors remains unchanged (i.e., 1 unit of capital per 2 units of labour). As the size of the firm increases from 2 workers and 1 machine to 6 workers and 3 machines, it experiences increasing returns to scale (output increase more than proportionately).

A change in scale from 6 people and 3 machines to 8 people and 4 machines yields constant returns to scale (size and output change by the same percentage). Any further growth in the size of the firm yields decreasing returns to scale because output increases less than proportionately.

## **Increasing Returns to Scale:**

A situation of increasing returns to scale can be attributed to two considerations indivisibilities of some factors and advantages of specialization.

### **1. Indivisibilities:**

The inability to divide certain factor units into smaller units without either complete loss of usefulness in production or partial loss in efficiency results in a relatively low output per unit of input when operations are conducted on a very small scale.

In other words, in some instances it is not possible to adjust all factors in the same proportion upward or downward. Certain types of capital goods, for example, will not perform their function if they are built on too small a scale, since weight is important in their operation. This is true of various types of capital equipment used in road construction.

Similar patterns are found in warehouse construction; doubling the building material will more than double the amount of usable space. With rectangular building costs of walls will need to increase only 50 per cent for the capacity of the area to double.

Indivisibilities are not confined to capital goods. Labour also is not completely divisible. One operator may be required for each machine, regardless of its size. A freight train requires one engineer, regardless of the tonnage of the train; there is no way of using a fraction of an engineer on a train of light tonnage.

Within limits, in small enterprises, employees may be used to perform several different tasks. But as a practical matter, there are severe limitations to such possibilities. A switchboard operator may serve as receptionist and do some stenographic work, but she can scarcely be used at the same time as an elevator operator and window cleaner.

A clerk in a store may be busy only 2-3 hours a day. Yet he must be paid for the entire day. In any type of business, it is difficult to utilize each worker to the maximum of his productivity at all times. As an establishment grows, the percentage of labour time not utilized should fall, if management policies are effective.

Indivisibilities are also encountered in advertising, research work, and financing. Advertising on a small scale is relatively less effective than on a much larger scale. Industrial research activities cannot be carried on effectively on a small scale. Indivisibilities are also found in the financing of a business. The cost of floating a bond issue, for example, is to a large extent independent of the size of the issue.

Thus, this method of financing — the cheapest method when large, amounts of capital are to be obtained — is expensive to a firm until it has expanded beyond a certain size. The refusal of many investors to consider the bonds of any except well-known companies increases the difficulty of bond financing by small firms.

## **2. Specialization:**

The other and closely related cause of increasing returns to scale is the advantage offered by specialization. In a very small business, employees must perform a wide variety of tasks. As the size of enterprise increases, each employee can be used in a relatively specialized job, with a consequent increase in output per worker. The advantages of specialization of labour have been recognized since the days of Adam Smith.

The primary advantages include the greater skill acquired with specialization, the avoidance of wasted time in shifting from one task to another, and the employment of persons best suited to particular types of work. In managerial activity as well as in other phases of work, advantages of specialization are encountered.

As a firm grows in size, personnel relations will be conducted by a specialist; traffic management will be in the hands of a full-time traffic expert instead of being performed by a person who also has various other tasks. Specialization is also possible with capital equipment.

Increasing returns are very important in steel, cement, and automobile industries, while they are of much less importance in agriculture and retailing.

### **Decreasing Returns to Scale:**

As a firm continues to expand its scale of operations, beyond a certain point there is apparently a tendency for returns to scale to decrease, and thus a given percentage increase in the quantities of all factors will bring about a less than proportional increase in output. It is believed, however, on the basis of actual studies, that a long phase of constant returns is usually observed.

Decreasing returns to scale for the firm itself are usually attributed to increased problems and complexities of large-scale management. Continued increases in entrepreneurial activity beyond a certain point encounter more and more serious problems and difficulties. An increasing percentage of the total labour force will be required in administrative work, in order to provide coordination of the activities of the enterprise and necessary control over the large numbers of employees.

A growing concern, once it reaches substantial size, encounters a fundamental problem of management; final authority for basic policy must remain in the hands of a group of men who control the operation of the business. Yet these men are far removed from the actual level of operations. They are forced to make decisions on the basis of second hand information, on subjects with which they have no direct contact. Furthermore, substantial delay can occur in the making of decisions as the size of the firm increases.

The causes of falling efficiency as the size of the firm increases are described as diseconomies of scale. One possible cause of such diseconomies seems to be the limited supply of entrepreneurs.