



Notes

PRODUCTION FUNCTION

When you go to the market to buy commodities such as note-books, fountain pens, shirts, bread, butter, fruits, vegetables etc. do you ever think about how these things came into the market. In previous lessons, you have studied about consumers, who constitute one part of the market and demand goods and services to satisfy their wants. Now, you will study the other part of the market - the producers or firms who produce goods and services for the satisfaction of consumers' wants. A producer or firm combines various factors inputs like land, labours, capital, entrepreneurship and other inputs like raw material, fuel etc. to produce goods and services that are demanded by the consumers. Man can neither produce a physical product nor can he destruct. Man can change only the form of a physical product. He can create utilities only. Thus production means creation or addition of utility. Any activity that makes a product more useful is called production. In this lesson you will study about how these inputs are combined to produce goods and services.



OBJECTIVES

After completing this lesson, you will be able to:

- explain the meaning of production;
- define production function;
- understand the meaning of production function in the short run known as law of variable proportions;
- understand the different concepts of production and show their relationships;
- differentiate between fixed and variable factors of production or inputs; and
- explain the reasons of operation of the laws of production.

**Notes****17.1 MEANING OF PRODUCTION**

Production may be defined as a process through which a firm transforms inputs into output. It is the process of creating goods and services with the help of factors of production or inputs for satisfaction of human wants. In other words, 'transformation of inputs into output' whereby value is added, is broadly called production. Whatever is used in the production of a commodity is called input. For example, in the production of wheat, the use of land, seed, fertilizer water, pesticides, tractors, labour etc. are inputs and wheat is output. The relationship between inputs and output of a commodity depends upon the state of technology because with the help of advanced technology more can be produced with the help of same inputs or same output can be produced with the help of less inputs.

Before defining production function we should understand the following concepts related to production function:

(a) Short run and long run

Short run refers to a time period in which a firm does not have sufficient time to increase the scale of output. It can increase only the level of output by increasing the quantity of a variable factor and making intensive use of the existing fixed factors. On the other hand long run refers to the time period in which the firms can increase the scale of output by increasing the quantity of all the factor inputs simultaneously and in the same proportion.

The distinction between fixed and variable factors is relevant only in the short run but this distinction disappears in the long run.

(b) Fixed factors and variable factors

Fixed factors are those factors of production whose quantity can not be hanged with change in the level of output. For example, the quantity of land, machinery etc. can not be hanged during short run.

On the other hand, variable factors are those factors of production whose quantity can easily be hanged with change in the level of output. For example, we can easily change the quantity of labour to increase or decrease the production.

(c) Level of production and scale of production

When any firm increases production by increasing the quantity of one factor input where as the quantity of other factor inputs keeping constant; it increases the level of production. But on the other hand, when the firms increases production by increasing the quantity of all the factors of production simultaneously and in the same proportion, it increases the scale of production.

17.2 DEFINITION OF PRODUCTION FUNCTION

In economics, production function refers to the physical relationship between inputs and output under given technology. In other words, production function is a mathematical functional/technical/engineering relationship between inputs and output such that with a given combination of factor inputs and technology at a given period of time, the maximum possible output can be produced. Such as land, labour, capital and entrepreneurship.

If there are two factor inputs: labour (L) and capital (K), then production function can be written as:

$Q_x = f(L, K)$ where Q_x is the quantity of output of commodity x, f is the function and L and K are the units of labour and capital respectively. It says that quantity of output depends on units of labour and capital used in production.

Here two points are worth considering. Firstly, production function must be considered with reference to particular period of time i.e. short period and long period. Secondly, production function is determined by state of technology.

(i) Short run production function

A production function that shows the changes in output when only one factor is changed while other factor remains constant is termed as a short run production function. In the above example of production function, Labour (L) is considered as the variable factor which can be changed to influence the level of output. The other factor capital (K) is a fixed factor which can not be changed. The underlying theory to the short run production function is the “Law of variable proportion or Returns to a factor”. This law will be discussed later in this chapter.

(ii) Long run production function

A long run production function studies the impact on output when all the factors of production can be changed simultaneously and in the same proportion. So in the long run size of operation of the firm can be expanded or contracted depending on the fact that the factors of production are increased or decreased. The underlying theory to the long run production function is the returns to scale which will be discussed later in this lesson:



INTEXT QUESTIONS 17.1

- (i) What is meant by production?
- (ii) Define a production function.



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- (iii) Distinguish between short-run production function and long-run production function.

Before studying the law of variable proportions we have to understand the three measures of production and their relationships because without understanding these measure of production, the concepts of laws of production can not be clearly understood.

There are mainly the following three measures of production:

- (a) Total product or total physical product denoted by TPP.
- (b) Average Product (AP) or Average physical product denoted by APP.
- (c) Marginal Product (MP) or marginal physical product denoted by MPP.

(a) Total Physical Product (TPP)

TPP is the total amount of a commodity that is produced with a given level of factor inputs and technology during a given period of time. For example, 2 units of labour combined with 2 units of capital can produce 26 fans per day. Here 26 fans is the total physical product which is produced with the given level of inputs (labour and capital)

(b) Average Physical Product (APP)

APP is the output produced per unit of input employed. It can be obtained by dividing TPP by the number of units of variable input. So $APP = TPP/L$ where L is the units of labour. For example, if 10 workers make 30 chairs per day, the APP of a worker per day will be $30 \div 10 = 3$ chairs. If the productivity of a factor increases, it implies that the output per unit of input has increased.

(c) Marginal Physical Product (MPP)

MPP of an input is the additional output that can be produced by employing one more unit of that input while keeping other inputs constant. For example, if ten tailors can make 50 shirts per day and 11 tailors can make 54 shirts per day, the marginal product of 11 workers will be $54 - 50 = 4$ shirts per day.

We can further clarify the above three concepts of production with the help of the following table 17.1.

Table showing TPP, APP and HPP of fans per day in short run.

Table 17.1

Fixed factor (Capital units)	Variable factor (Labour units)	TPP (units)	APP (units)	MPP (units)
(1)	(2)	(3)	(4)	(5)
2	1	10	10	10
2	2	26	13	16
2	3	48	16	22
2	4	68	17	20
2	5	85	17	17
2	6	96	16	11
2	7	98	14	2
2	8	98	12.25	0
2	9	90	10	-8

The above table shows values of TPP, APP and MPP for different units of variable factor. For example, if we know the TPP of all the units of variable factor we can calculate APP by dividing TPP by the number of units of a variable factor. So $APP = TPP / \text{units of variable factor}$. For example in table 17.1 the TPP of 2 units of labour is 26, the APP will be $26 \div 2 = 13$. In the same way we can calculate APP of all the units of a variable factor. We calculate MPP of 2 units labour by deducing TPP of 1 unit. From the TPP of 2 units labour i.e. $26 - 10 = 16$ units. So $MPP_n = TPP_n - TPP_{n-1}$. If we know APP of all the units of a variable input we can calculate TPP by multiplying APP by the units of variable factor. In the above table APP of 4 units of labour is 17. TPP will be $17 \times 4 = 68$ units. In the same way we can calculate TPP of all other units of variable factor. So $TPP = APP \times L$ where L is the units of labour. If we know MPP of all the units of a variable we can calculate TPP by summing up the MPP of all the units of variable factor. For example, in table 17.1 the MPP of 1, 2, 3 and 4 units of labour are 10, 16, 22 and 20 respectively, the TPP of 4 units of labour can be derived by summing up the MPP of these 4 units of labour i.e. $10 + 16 + 22 + 20 = 68$ units. TPP of all other units can be calculated in the same manner. Remember that for the 1 unit of labour TPP, APP and MPP are equal. So we can give the following formulas to calculate TPP, APP and MPP.

$TPP = \sum MPP$ (Sum of MPP of all the units of a variable factor)

or $TPP = MPP_1 + MPP_2 + MPP_3 + \dots + MPP_n$

or $TPP = APP \times L$ where L indicates units of labour

$APP = \frac{TPP}{L}$ where L indicates units of labour



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Producer's Behaviour



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$MPP = \frac{\Delta TPP}{\Delta L}$ where ΔTPP is change in TPP and ΔL is change in units of labour

or $MPP_n = TPP_n - TPP_{n-1}$ for example, MPP of 2 units = TPP of 2 units – TPP of 1 units of labour

17.4 RELATIONSHIP BETWEEN TPP AND MPP

The relationship between TPP and MPP can be explained as given below:

- As long as MPP increases, TPP increases at an increasing rate.
- When MPP falls but remains positive, TPP increases but at a diminishing rate.
- When MPP becomes zero, TPP is maximum.
- If MPP becomes negative, TPP starts decreasing.

17.5 RELATIONSHIP BETWEEN APP AND MPP

- As long as MPP is greater than APP, APP increases.
- When MPP is equal to APP, APP is maximum and constant.
- When MPP is less than APP, APP decreases.
- MPP can be zero and negative but APP is never zero or negative.

The relationship among TPP, APP and MPP can also be explained with the help of the following table. 17.2

Table 17.2: Hypothetical schedule of TPP, APP and MPP

Land (Fixed factor)	Units of variable Factor (labour)	TPP (Units)	APP (Units) (TPP/L)	MPP (Units) ($\Delta TPP/\Delta L$)
1 Acre	0	0	—	—
1 Acre	1	2	2	2
1 Acre	2	6	3	4
1 Acre	3	12	4	6
1 Acre	4	20	5	8
1 Acre	5	25	5	5
1 Acre	6	29	4.8	4
1 Acre	7	31	4.4	2
1 Acre	8	31	3.9	0
1 Acre	9	29	3.2	–2



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In the above table 17.2 MPP is increasing upto 4 units of labour and TPP is increasing at an increasing rate. MPP is decreasing but remains positive from 5th to 8th unit of labour so TPP is increasing at a diminishing rate. For 8th unit of labour MPP is zero where TPP is maximum. But for 9th unit of labour MPP becomes negative so TPP also starts decreasing.

In the same way upto 4 units of labour MPP is greater than APP, so APP is increasing. At 5th units of labour $MP = APP$ so APP is maximum and constant. At 6th units of labour MPP is less than APP, So APP is decreasing.

Relationship among TPP, APP and MPP (through diagram)

To understand the relationship among TPP, APP and MPP, let us consider the following diagram.

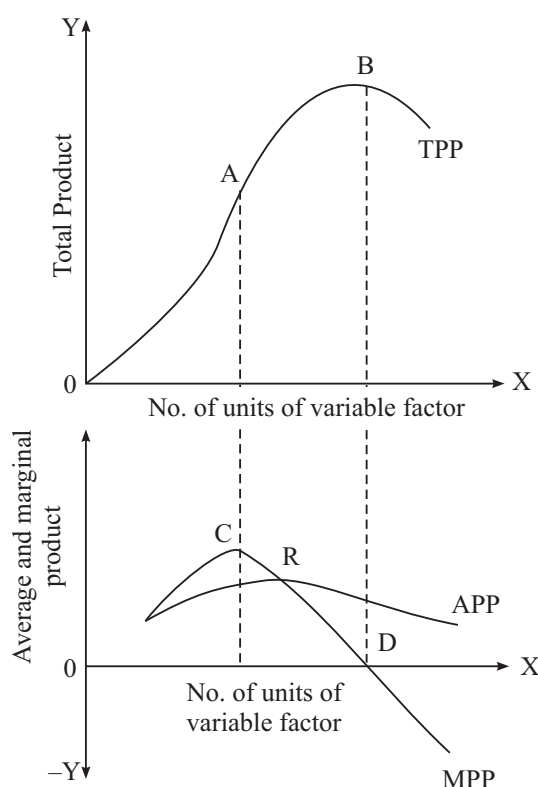


Fig. 17.1

In the above figure 17.1 TPP increases from point O to point B. There are two phases of this increase in TPP. First, from O to A in which TPP increases at an increasing rate. In this phase in the lower portion of the diagram MPP increases up to point



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C. So we can conclude that when MPP increases TPP increases at an increasing rate. Second phase of increase in TPP is from A to B in which TPP increases at a diminishing rate. In the lower portion of the diagram, MPP decreases from point C to point D but it remains positive. So we can conclude that when MPP falls but remains positive, TPP increases at a diminishing rate. At point B on TPP curve, TPP is maximum. In the lower portion of the diagram MPP is zero at point D. So we conclude that where MPP is zero, TPP is maximum. After point B, TPP falls. After point D MPP becomes negative and TPP falls.

In the lower portion of the above figure 17.1, APP and MPP curves have been drawn. Before point R on APP curve, MPP is greater than APP, so APP increases. At point R MPP is equal to APP. At this point, APP is constant and maximum. After point R on APP curve, MPP curve is below APP curve, so we can say that when MPP is less than APP, APP falls.



INTEXT QUESTIONS 17.2

1. What are primary inputs? Give example.
2. What are secondary inputs? Give example.
3. Define variable factors of production.
4. What are fixed factors of productions? Explain with example.
5. Distinguish between fixed and variable factors of production.
6. Can total product ever decline? If yes, when?
7. What happens to TPP when MPP is zero?
8. What happens to TPP when MPP increases?
9. Explain the relationship between TPP and MPP.
10. What is the relationship between APP and MPP?

17.6 LAW OF VARIABLE PROPORTIONS

The law of variable proportions is a short period production law. It is also called returns to a factor. Let us first understand the meaning of variable proportions. In a production process when only one factor is varied and all other factors remain constant, as more and more units of variable factor are employed, the proportion between fixed and variable factors goes on changing. So it is termed as the law of variable proportions. This law states that if you go on using more and more units of variable factor (labour) with fixed factor (capital), the total output initially

increases at an increasing rate but beyond a certain point, it increases at a diminishing rate and finally it falls. This law was initially called the law of diminishing returns Marshall who applied the law only in agriculture sector but modern economist called it the law of variable proportion and proposed its applicability to all the sectors of the economy.

Assumption of the law

The law operates under the following assumptions:

- (i) The firm operates in the short run.
- (ii) There is no change in technology of production.
- (iii) The production process allows the different factor ratios to produce different levels of output.
- (iv) All the units of variable factor are equally efficient.
- (v) Full substitutability of factors of production is not possible.

According to the law when we employ more and more units of a variable factor with the fixed quantity of other factors and technology, the marginal product of the variable factor first increases and then decreases. In other words, with employment of more and more units of a variable factor with fixed quantity of other factors, the total product first increases and then starts decreasing. It means that in short run labour is the only variable factor, Return to labour or marginal product of labour initially increases but as more units of labour are employed its MPP declines and may also become negative. There are three phases of returns to a variable factor which are discussed below.

(a) Phase I: Increasing Returns to a factor

In this phase TPP increases at an increasing rate and marginal product of variable factor, labour increases. In the end of this phase MPP is maximum. So, this is the phase of increasing returns to a factor.

(b) Phase II: Diminishing Returns to a factor

In this phase TPP increases but at a diminishing rate MPP declines but remains positive. At the end of this phase MPP is zero. At this point TPP is maximum. So, this is the phase of diminishing returns to a factor.

(c) Phase III: Negative Returns to a factor

In this phase, MPP declines and it becomes negative. Here the TPP also starts falling. It operates from the level of output where MPP of labour is zero but subsequently becomes negative. The table 17.2 given below illustrates the three phases of the law of variable proportions.

**Notes**

Table 17.2: Law of variable proportions

Units of land (Fixed input)	Units of labour (variable input)	TPP (units)	MPP (units)	Phases
1	1	3	3	TPP increase at an increasing rate → MPP is increasing (Phase I)
1	2	7	4	
1	3	12	5	
1	4	16	4	TPP increases at a diminishing rate and MPP falls but remains positive (Phase II)
1	5	19	3	
1	6	21	2	
1	7	22	1	
1	8	22	0	TPP falls and MPP becomes negative (Phase III)
1	9	21	-1	
1	10	20	-2	

This law can also be explained with the help of figure given below.

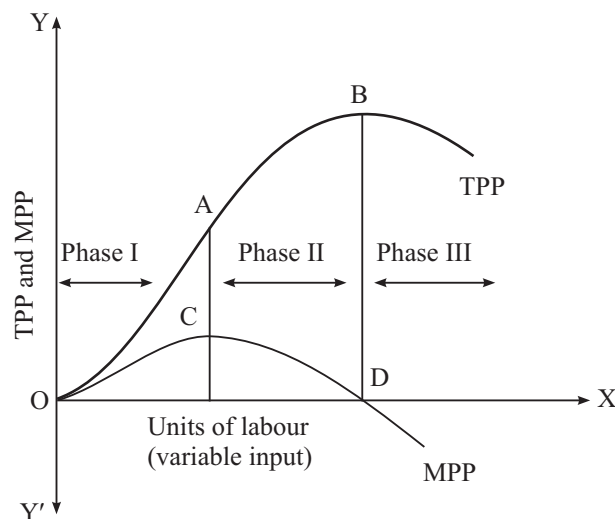


Fig. 17.2

The figure 17.2 given above shows that TPP increases from 0 to B but there are two parts of this increase. First is from 0 to A in which TPP increases at an increasing rate. This is in the I phase of the law. In this phase MPP increases from 0 to C.

In the second part from A to B TPP increases at a diminishing rate. This is in the II phase of the law. In this phase MPP decreases from point C to point D. At point D MPP is zero. TPP is maximum at point B.

After point B TPP starts falling. This is in III phase of the law. In this phase MPP becomes negative after point D.

17.7 REASONS BEHIND DIFFERENT PHASES OF THE LAW OF VARIABLE PROPORTIONS

In phase I, we get increasing returns to a variable input because greater use of variable inputs makes it possible to utilize fixed indivisible factor more efficiently and also to introduce a greater division of labour and specialization. It leads to optimum combination of fixed and variable inputs.

In phase II, we get diminishing returns to a variable input because in this stage the proportion between variable and fixed inputs has crossed the optimum proportion between them and a variable input such as labour has less and less fixed input to work with.

In phase III, the variable input becomes too much relative to fixed inputs which obstructs the production process and therefore results in fall of TPP. because MPP becomes negative. So, phase III is called the stage of negative returns to variable factor. So phase III is called the stage of negative returns to variable factor.

17.8 LAW OF DIMINISHING MARGINAL PRODUCT

The law of variable proportions is an extension of the law of diminishing returns to a factor. The law of diminishing returns to a factor states that as more and more units of a variable factor are employed with fixed factors and technology, its marginal product eventually declines. The difference between this law and the law of variable proportions is that the former does not take into account increasing returns to a factor. According to the law of diminishing returns to a factor, the firm can operate only in phase II and III of the law of variable proportions. Hence the law of diminishing returns to a factor is a part of more general law of variable proportions. In figure 17.2, the law of diminishing returns to a factor operates after point A on TPP curve and point C on MPP curve.

Early economists believed that the diminishing returns to a factor sets in only in agriculture as land was fixed. It did not apply in industry as this sector continuously underwent technical upgradation. However, industry can postpone setting in of diminishing returns with technical advances. If technical advancements do not take place there is no increase in the efficiency of the factor inputs, then diminishing returns shall be applicable even in industry. According to modern economists, diminishing returns under the law of variable proportions are universally applicable to both the agriculture and industrial sectors.

**Notes**



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WHAT YOU HAVE LEARNT

- Production is the process of converting inputs into output.
- A production function shows the technical relationship between inputs and output.
- Fixed factors are those whose quantity does not change with change in output.
- Variable factors are those whose quantity changes with change in output.
- TPP is defined as the total output that is produced in a given time with given inputs and technology.
- APP is the output per unit of input.
- MPP is the addition to TPP by the employment of one additional unit of input.
- Relationship between TPP and MPP
 - (i) When MPP increases, TPP increases at an increasing rate.
 - (ii) When MPP decreases but remains positive, TPP increases at a diminishing rate.
 - (iii) When MPP is zero, TPP is maximum.
 - (iv) When MPP becomes negative, TPP starts decreasing.
- Relationship between TPP and MPP:
 - (i) As long as MPP is greater than APP, APP increases.
 - (ii) When MPP is equal to APP, APP is constant and maximum.
 - (iii) When MPP is less than APP, APP decreases.
- The law of variable proportion states that as the additional units of a variable factor are combined with a given level of fixed factors and technology, the MPP of the variable factor first increases and then declines.
- There are three phases of the law of variable proportions:
 - (i) In phase I, increasing returns to a factor occur; return MPP is increasing and TPP increases at an increasing rate.
 - (ii) In phase II, diminishing returns to a factor occur; taken MPP is declining but remains positive and TPP increases at a diminishing rate.
 - In phase III, negative returns to a factor occur when MPP is negative and TPP starts falling.



TERMINAL EXERCISE

1. Define production
2. Define production function
3. Distinguishes between short period and long period production functions.

4. What is meant by IPP?
5. Define APP.
6. Define MPP.
7. Explain the relationship between TPP and MPP.
8. Explain the relationship between APP and MPP.
9. Explain the law of variable proportions with the help of a schedule and a diagram.
10. What are the reasons of the operation of law of variable proportions?
11. What are general shapes of APP and MPP?
12. Distinguish, between fixed factors and variable factors.

**Notes****ANSWERS IS INTEXT QUESTIONS****17.1**

- (i) Reads section 17.1
- (ii) Reads section 17.2
- (iii) Read sections 17.2 (i) and (ii) Basic concepts

17.2

- (i) Read section 17.3 (i) (Primary inputs)
- (ii) Read section 17.3 (ii) (Secondary inputs)
- (iii) Read section 17.3 (i) Variable inputs)
- (iv) Read section 17.3 (ii) Fixed inputs)
- (v) Read section 17.3
- (vi) Read section 17.4
- (vii) Read section 17.4
- (viii) Read section 17.4
- (ix) Read section 17.4
- (x) Read section 17.5