# **CHAPTER TWO**

# **2. THEORY OF PRODUCTION**

Dear student, in this chapterwe will deal with how a firm/producer combines economic resources so as to maximize output from a given technology/input. This chapter, therefore, focuses on understanding of production function and production relationships.

## **2.1. Basic concepts in Production, Inputs and production period**

**Production:** is the process of changing economic resources into output. It is transformation of input into output. Example, change in form (raw material changed into finished goods), change in time (storage) and change in place (transportation).

All inputs can be divided into two categories such asfixed and variable inputs.

**Fixed inputs**: are inputs whose quantity cannot be varied during the period under consideration. Fixed resources exist only in the short run and in the long run they are zero. Example. Plant, equipment, building etc.

**Variable inputs**: are inputs whose quantity can be changed during the period under consideration.Variable resources exist both in the short run and in the long run. Example. Labour, power, transportation etc.

In economics, production period is classified as: Short Run and Long run production period

### ***1. Short run production period***

The short-run production period describes the maximum quantity of good or service that can be produced by a set of inputs, assuming that at least one of the inputs is fixed at some level. In the short run inputs are classified in to two. These are; fixed and variable input.

Consider a short run production process in which there are only two factors of production; labor and capital, where capital is the fixed factor and labor is the variable factor. The production function in this case is defined by. The bar on K indicates that capital is constant and variation in output depends on variation in labor L.

###  ***2. Long run production period***

In the long run, all factors of production are variable. Therefore, producer can alter their output by varying all factors. The problem to the firm is finding the most efficient way of producing output. Suppose that a production process involves just two factors labor (L) and capital (K). In this case the production function is defined as: .With two variable factors L and K, can be used to produce a given level of output.

## **2.2. Production Function**

The production function is a systematic way of showing the relationship between different amounts of a resource or input that can be used to produce a product and the corresponding output. That is, it is the physical relationship between input and output. The relationship shows the rate of transformation of input to output.

Whatever the name is, a production function shows the amount of output that would be produced by using different amounts of a variable input. It can be presented in the form of:

* A table/tabular presentation or tabulation
* Graph
* Mathematical equation.

**A). A table/tabular presentation or tabulation**

 Short run production function may be represented as in Table 2-1.

Table 2-1: Short run production function

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Units of input(labour in hour) | Capital | TPP | APP | MPP |
| 1 | 5 | 5 | 5 | - |
| 2 | 5 | 11 | 5.5 | 6 |
| 3 | 5 | 18 | 6 | 7 |
| 4 | 5 | 25 | 6.25 | 7 |
| 5 | 5 | 30 | 6 | 5 |
| 6 | 5 | 32 | 5.3 | 2 |
| 7 | 5 | 32 | 4.3 | 0 |
| 8 | 5 | 28 | 4.5 | -4 |

**TPP (Total physical product)**: It is the amount of product produced by different quantities of the variable input used.

**APP (Average physical products):** It is possible to calculate the average amount of output or TPP-produced by each unit of input at each input level. This value is called average physical product (APP). APP is calculated by the formula:

APP = 

**MPP (Marginal physical products):**

Marginal means additional or extra. MPP is the additional or extra TPP-produced by using an extra unit of input. It requires measuring changes in both out-put and input.

Marginal physical product is calculated as:

MPP =

**B) Mathematical presentation of production function**

y=f(x) where y=dependent variable (output resulting from the production process)

 x = an aggregate independent variable (input that we change)

 f= function

y = f (x1|x2----------- xn) for short run production

Where, x1 = the variable/ input, example, fertilizer

X2-xn=all fixed inputs for short period of time (e.g. land, labour, capital, etc.)

Therefore, the variation of y depends on the variable input x1.

**C) Graphical Illustration of a production function**



Figure 2-1 Graphical illustration of a production function

As shown in the above figure TPP or output increases at an increasing rate as the input level is increased from zero. As the input level is increased further, TPP continues to increase, but now at a decreasing rate, and eventually begins to decline absolutely as too much variable input is used relative to the amount of fixed inputs available. As TPP increases at increasing rate, both MPP and APP are increased (MPP is increasing along with APP).Where TPP changes from increasing at increasing rate to increasing at a decreasing rate, MPP reaches at maximum and declines continuously having a value of zero where TPP reaches its maximum. APP increases over slightly longer ranges than MPP before beginning to decline.

## **2.3. Type of Production Relationships**

The major type of production relationships fall under three categories, namely:

1. **Factor –product or input-output relationships:** this relationship is concerned with resource allocation to optimum production.

2. **Factor-factor or input–input** relationship or input combination: this relationship is concerned with minimizing cost at a given level of output.

3. **Product-product or output-output relationship** or enterprise combinations: this relationship is concerned with optimum combination of outputs for a given input level.

### ***2.3.1. Factor-Product relationships***

It is a systematic way of showing the relationship between different amounts of resource or input that can be used to produce a product and the corresponding output or yield of that product. It also shows that amount of output that would be produced by using different amounts of a variable input.

Economic theory gives us two types of factor-product relationship in production function.

1. Proportionate relationship: In this relationship - some inputs are fixed, while quantities of other inputs vary showing short-run relationship.

2. Scale relationship: In this relationship, all inputs vary no fixed input. It is for a longer period, showing long run relationship.

**1. Proportionate relationship:** the physical input-output relationship with one variable input with fixed inputs.

In this relationship, there are three stages of production. Those are

**Stage -I**

* it start from the origin to the point of APP at maximum(MPP=APP)
* more of fixed input, less of variable inputs comparatively(fixed inputs not fully utilized)
* MPPx>APPx
* MPP starts to decline
* Irrational region

**Stage-II**

* starts from MPP=APP(APP maximum) and ends up where MPP=0i.e. TPP is at maximum
* TPP increases at decreasing rate
* APP>MPP
* It is rational region

**Stage –III**

* starts ,where MPP=0 or TPP at its maximum
* TPP starts to decline
* MPP negative
* APPx>MPPx
* irrational region

**NB;**as shown in the graph above; TPP or out-put increases at an increasing rate as the input level is increased from zero. As the input level is increased further, TPP continues to increase, but now at a decreasing rate, and eventually begins to decline absolutely as too much variable input is used relative to the amount of fixed input/s available. This is due to the principle of diminishing returns.

## **The Law of diminishing returns:**

The law stated that, if increasing amount of one input is added to a production process, while all other inputs are held constant; the amount of output added per unit of the variable input will eventually decrease. The law is a generalization based on experience that the use of increased inputs leads to less than proportionate increase in output.

**How Much output to produce under the law of diminishing return**?

**(Rules of profit maximization)**

In this discussion, we will concentrate on finding the input level which maximized profit. There is also a related question. How much output should be produced to maximize profit?

To answer this question directly requires the introduction of two new marginal concepts namely marginal revenue (MR) and marginal cost (MC**).**

**Marginal revenue (MR):** Is defined as the change in income or the additional income received from selling one more unit of output. It is calculated from the equation

$$MR=\frac{∆totalrevenue}{∆totalphysicalproduct}$$

**Total Revenue (TR)** is the same as total income. Total revenue (TR) is used in place of total value product when discussing output levels**.**

**Marginal Cost (MC**)**:** Is defined as the change in cost or the additional cost incurred for producing another unit of output. It is calculated from the equation:

$$MC=\frac{∆totalinputcost}{∆totalphysicalproduct}$$

**The Decision Rule**- MR and MC are compared to find the profit maximizing output level. When MR is greater than MC, the additional unit of output increases profit as the additional income exceeds the additional cost. Conversely, if MR is less than MC, producing the additional unit of output will decrease profit. At the output level where MR=MC, profit will be at its maximum level. There is only one profit maximizing combination of input and output for a given production function and a given set of prices. If MR > MC, additional profit can be made by using more input. If MC > MR, less input should be used.

**Summary: Rule of profit maximization**

|  |
| --- |
| Optimum level of input use for profit maximization occurs at the point where marginal revenue is equal to marginal cost. i.e. MR=MC |

 Or net return= TR-TC, the value with high net return.

Table 3.2 Factor - product relationships and economic decisions Analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Input  | TPP | TR | TC | MR | MC | NR |
| 1 | 12 | 24 | 12 | 2 | 1 | 12 |
| 2 | 30 | 60 | 24 | 2 | 0.66 | 36 |
| 3 | 44 | 88 | 36 | 2 | 0.857 | 52 |
| 4 | 54 | 108 | 48 | 2 | 1.2 | 60 |
| 5 | 62 | 124 | 60 | 2 | 1.5 | 64 |
| 6 | 68 | 136 | 72 | 2 | 2 | 64 |
| 7 | 72 | 144 | 84 | 2 | 3 | 60 |
| 8 | 74 | 148 | 96 | 2 | 6 | 54 |

Price per unit of input to be = birr 12

Price per unit of product = birr 2

We can see from the table that profit is maximized where:

* MR=MC

Profit it maximized at Birr 64 by using 6 units of inputs. i.e. MR=MC (2=2)

**Scale relationship**

* Under scale relationship we assume that all inputs are variable and none of fixed inputs
* All the inputs such as land, labour, capital and management which go into production are increased at the same proportion.
* Here we talk about return to scale

 Y= f(x) where Y= yield

 x= is the aggregate of all the input factors

**Return to scale:** Refers to the direction of change in output when all inputs vary (change) in the same proportion. It describes how the output level changes as all inputs change in direct proportion.

**Constant return to scale:** When the proportionate increase in all inputs results in an equally proportionate increase in output (double- double).

**Increasing return to scale**: When the proportionate increase in output is greater than proportionate increase in input (Example, 2 times output, 1.5 times in input).

**Decreasing return to scale:** When the proportionate increase in output is less than proportionate increase in input (Example, 1.5 times output, 2 times in input).

### **2.3.2. Factor-Factor Relationship (the question of input substitution)**

It implies that the combination of two or more inputs for a given level of output with the objective of minimizing cost.

One of the most important or the basic decisions a farm manager must make is how to produce a given product. Most products require two or more inputs in the production process, but the manager can often choose the input combination or ratio to be used. The problem is one of determining if more of one input can be economically substituted for the less of another and what is the least cost combination of inputs to produce a given amount of output.

Substitution of one input for another occurs frequently in production process. The manager must select that combination of inputs, which will produce a given amount of output or do a certain task for the least cost. In other words, the problem is to find the least cost combination of inputs, as this will maximize the profit from producing a given amount of output. The manager is always asking the question: how inputs are be combined to produce the given amount of product at a minimum cost.

***The question is how much each of be combined to produce the given amount of product at minimum cost.***

***A least –cost input combination is determined by finding the point where the* Slope of iso-quant*is equal to the* Slope of iso- cost.**

Then to deal about the least cost combination of two inputs, we have to know the concept of iso-quant and iso-cost line.

 Let us see the definition of the following terms for the understanding of the problem:

1. Iso-quant
2. Iso-cost

1). ***Iso-quant:*** It is another expression of iso-product curve, which represents various combination of two inputs that yield a given (the same) level of output.

***Slope of iso quant***

 The slope of iso quant is the marginal rate of substitution of one input for another. The $substitution ratio =\frac{Amount of X2 replaced}{Amount of X1 added}=\frac{ΔX2}{ΔX1}$-- it is the marginal rate of substitution of X1 for X2.

c). **I*so-cost line:*** we call it equal cost line, which indicating all possible combination of two inputs that can be purchased with a given amount of investment fund.

***Slope of iso-cost***

The slope of an iso-cost line is expressed as the ratio of the price of one input to the price of another input i.e.**-------** when X1 is on the X-axis and X2 is on the Y axis.

Example.1. Assume that a firm combination of two inputs (X1&X2) for producing 20 liter of milk. Let that price X1=Br.11/kg; price of X2=Br.1/kg. Then find the least cost combination of two inputs that maximizes profit in the table below.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Combination | (X2) in kg | (X1) in kg | ΔX2 | ΔX1 | ΔX2/ ΔX1(MRS) | Cost ofproduction | Outputlevel |
| 1 | 40 | 0 | - | - | - | 40 | 20 |
| 2 | 24 | 1 | 16 | 1 | 16 | 35 | 20 |
| 3 | 13 | 2 | 11 | 1 | 11 | 35 | 20 |
| 4 | 6 | 3 | 7 | 1 | 7 | 39 | 20 |
| 5 | 2 | 4 | 4 | 1 | 4 | 46 | 20 |
| 6 | 0 | 5 | 2 | 1 | 2 | 55 | 20 |

We said that least cost combination of two inputs is determined by finding the point where the Slope of iso-quantis equal to the Slope of iso- cost. Therefore, the price ratio (the slope of iso cost) is 11. Thus, the farmer can maximize his profit by using 13 kg of X2 and 2 kg of X1 with a minimum cost of 35.00.

## **3. Product- Product Relationship (Output-Output Relationship)**

In product –product relationship the basic decision to be made by a farm manager is what to produce or what combination of enterprises will maximize profit.

A choice must be made from among all possible producers which may include vegetables, wheat, soybeans, cotton, beef cattle, hogs, poultry, and others. It is a question of allocation of the scarce resources among different producer. Natural factors like, climate, soil, range vegetation, and limits of other available inputs may restrict the choice of possible enterprises.

In product - product relationship the manageris identify combination of these crops would give maximum profit.For profit maximization at a given level of input, the choice indicators are:

Substitution ratio () equal to Price ratio (**)**.

The general equilibrium conditions for a given level of inputs require knowledge of two relationships;

1. Iso- revenue– choice function
2. production possibility curve

**A).*Iso- revenue***: Indicates the different combinations of two products, which can give the same amount of revenue or income.

The slope of iso-revenue is represented by the ratio of prices of two competitive products.

**B*). production possibility curve:*** represents a locus of all possible combinations of two products which can be produced from a given amount of input.

The slope of the production possibility curve represents the marginal rate of product substitution.

***So* profit maximization occur at *Slope of production possibility curve = slope of iso-revenue line***

**Example**: assume there are only 10 units of inputs given. The price of maize is birr 7 per quintal and that of wheat is birr 10 per quintal. What is the profit maximizing combination? (Price of input is 40 Birr per unit).

*Table 5. Product-Product relationship*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Yield of Maize (Y1) | Yield of wheat (Y2) | ΔY1 | ΔY2 |  | Return from maize | Return from wheat | Total return | Totalcost | Profit |
| 0 | 78 | - | - | - | 0 | 780 | 780 | 400 | 380 |
| 10 | 76 | 10 | 2 | 0.2 | 70 | 760 | 830 | 400 | 430 |
| 20 | 72 | 10 | 4 | 0.4 | 140 | 720 | 860 | 400 | 460 |
| 30 | 67 | 10 | 5 | 0.5 | 210 | 670 | 880 | 400 | 480 |
| 40 | 60 | 10 | 7 | 0.7 | 280 | 600 | 880 | 400 | 480 |
| 50 | 48 | 10 | 12 | 1.2 | 350 | 480 | 830 | 400 | 430 |
| 60 | 28 | 10 | 20 | 2 | 420 | 280 | 700 | 400 | 300 |
| 70 | 0 | 10 | 28 | 2.8 | 490 | 0 | 490 | 400 | 90 |

Table 5 above shows that profit maximizing combination is 40 units of maize and 60 units of wheat with a maximum profit of 480 birr.

## **Enterprise or Product Combination**

 Enterprise is a single line of production. It is the production of crop or livestock.The basic product combination are:

 1. Main enterprise

 2. Antagonistic enterprise

 3. Joint enterprise

 4. Competitive enterprise

 5. Supplementary enterprise

 6. Complementary enterprise

These are the six types of enterprise combination among different products.

1. **Main enterprise**: It is the one which provides the most important source of income/revenue on a farm. It uses a very large portion of the farm resource (land, labour, capital & management).
2. **Antagonistic enterprise**: the production of one product has an adverse effect on the production of another.One enterprise produces on the expense of the other. Example, eucalyptus tree & cereal production.
3. **Joint enterprise:** result from the same production process. They are produced together. The production of one enterprise without the other is impossible. E.g. milk and caw, mutton and wool. All agricultural production includes joint producers.
4. **Competitive enterprises:** Are those enterprises which compete for the same resources at the same season (labour, land, capital & management). Example, wheat, teff and barley are sown with the same season. These crops compete with each other for the resources in the same season. The marginal product of one increases, while that of the other decreases. The marginal rate of substitution of one for the other is negative, (ΔY2/ΔY1<0). This means an increase in Y1 will be possible with a decrease in Y2.
5. **Supplementary enterprises:**  if the change in the level of one output (Y1) accompanied with no effect on the other Output (Y2), they are supplementary output.They do not affect each other and do not compete in the use of resource
6. **Complementary products:** relationship exist when a change in the level of one output (Y1) accompanied by the change in the other output (Y2) in the same direction. That means, as one increase, the other increases, too. The production of one provides input for other output. E.g. livestock and corn.

Generally, when the =****this is for two enterprises and one input.

* = marginal rate of substitution.
* >0 two enterprises are complementary.
* <0 two enterprises are competitive /substitute.
* = 0 two enterprises are supplementary.

Crop (Y2)

B C

A D

Poultry (Y1)

 Figure 2.2 type of enterprise

* From point A to B two enterprises are complementary.
* From point B to C two enterprises are supplementary.
* From point C to D two enterprises are competitive.