Session 05

Production and Cost of Production

Content

Introduction

We studied in brief in previous sessions about the behavior of suppliers and how they contribute to the function of markets. Suppliers are economic agents. We call these units as firms in general. Behavior of firms can be understood using simple approaches. We will learn the theoretical basics and also learn a few practical examples.

A firm is an economic agent. It behaves to fulfil an objective and has a role in the economy. All economic agents want to maximize their objective. Firms engage in economic activities to get benefits. The benefit the firms want to get is known as profit. In case of firms the objective is to maximize profit. The firm is an economic agent that uses inputs and technology to produce a good or a service. We will learn in this session about input output relationships and cost relationships of a firm operating in a perfectly competitive market.

5.1 Roles of a Firm in the Economy

Firms as introduced in previous sessions are the other side of consumers. Consumers demand goods and services. The other-side is to produce goods and services. Firms has an economic role and are managed by people. Firms differ in size; output; geographical area; composition of ownership. The simplest example is an own-account worker undertaking activities all alone but producing goods and services. How can one individual decide to carry-out the functions needed?

Activity 5.1:

List ten firms operating in your village/town. Then describe what they do.

Firms operate to earn profits.

In this understanding we define the difference between the value of benefits generated by the activity and the values of all costs associated with this process. A simple mathematical expression of profit is as follows.

Profit = Total Revenue minus Total costs

The standard symbol to be used in mathematical expressions in economics is the lowercase Greek letter Pi (π). We also identify the difference in accounting profit and economic profit. In calculating economic profits all benefits and costs are included by considering their opportunity costs. The true values of all resources used are taken in calculation. However in accounting profit what is actually received in money terms and what was actually paid out is considered.

Why firms operate?

These are a large number of firms in an economy. Many of these firms produce more than one output (products or services or bundles of these two) during any given period. The output of a firm may be a final product that is used by consumers. The same output can be an intermediate product depending on its use. For example auto-diesel is a final product if it is used by you in running your car. It is an intermediate product, used as an input in

producing another good or service, if diesel is used by a private bus operator that produces public transportation (measured in passenger kilometers); or a fisher to operate catching fleet (output measured in t)' or if it is a direct input to generate electricity using a diesel generator. Agriculture; construction; goods transport; and many businesses especially during crisis times use diesel to generate other inputs that are needed in producing the final output.

Activity 5.2:

Select a product of your choice and list its uses and users. Identify weather they are final or intermediate products.

Economics Understanding a firm

Firms use factors of production to produce outputs. Firms buy inputs from factor owners or current owners of inputs.

5.2 Theory of the Firm

In this section, we will create a mathematical understanding of the common symbols in understanding firms and how to compute those.

We identify an output using a capital letter Y. There can exist many unique outputs that can be identified as separate from other outputs. These outputs are labeled using a subscript using capital Roman letters like A, B. C and so. Each output can also be quantified. Each output is sold in a market and has a price denoted as P_A, P_B, P_C, and so on.

Each output is produced using inputs. There are many different inputs used in producing any identified output (Y). These inputs can also be used in producing different outputs listed above. Inputs used in production can be quantified. We denote an input using an X. There are many inputs and these many inputs can be used in producing many outputs. We therefore use a subscript with a combination of two identifiers, i, to identify the input; followed by N as the label for the output in whose production the input is used. Therefore each input quantity can be noted as x_{iK}. The firm has to pay a price to get these inputs from the other economic entities that are owners of respective inputs. An input

price is identified as w, expressed in monetary units paid per one unit of input. So the costs of getting the inputs to produce an output identified as *A* are expressed as the sum of costs for each individual input. This is expressed mathematically as follows;

$$C_A = w_1X_{1A} + w_2X_{2A} + w_3X_{3A} + w_4X_{4A} + \ldots + w_nX_{nA} \ldots \quad (1)$$

As there are many outputs, there will be separate total costs for each of those.

Once produced, outputs are sold in markets. Noting the quantity produced of output A as Y_A and, assuming that the total quantity produced of *A* is sold in the market and all units sold received the same price. Price is expressed in monetary units received per one unit of output. Each unit of Y_A will receive a price noted as P_A.

So the firm receives from the market is P_AY_A. This is known as the revenue of the output produced R_A.

If the firm produces more than one (multiple) outputs and all are sold in markets and the revenues are received. The total revenue of the firm during the period is the sum of revenues from each output.

$$TR = R_A + R_B + R_C + \ldots + R_N \ldots \quad (2)$$

And as the firm produces many outputs and the cost of each is found using (1), the total cost of the firm by engaging in production is

$$TC = C_A + C_B + C_C + \ldots + C_N \ldots \quad (3)$$

Now note that the difference between the TR and TC is what the firm receives by engaging in the activity after paying for all costs. This is known as profit. The main objective of the firm is to maximize profits (π).

$$\pi = TR - TC \ldots (4)$$

In economics Profit, (π) is the share of the firm after paying for all costs including the opportunity costs of operator owned inputs used for activities of production of the firm. The firm could maximize profit by increasing output (Y) for a given price (P) and /or reduce total cost of production. A loss of the firm may occur if the cost of production exceed total revenue. A manager of the firm could achieve this objective of profit (or loss) in firm through decision making involving, what to produce, how to produce, how much to produce, and when to produce the output.

5.3 Production Function

Production function is a mathematical relationship between amount of inputs used and amount of output produced by the firm as given in equation (5).

$$Y = X_1, X_2, X_3, \ldots X_n \quad \ldots \quad (5)$$

Where Y=output, X_1= labor, X_2= capital, X_3 through X_n are other inputs used in production.

Variable inputs and Fixed Inputs

Production inputs are classified into two types as a) variable inputs, and b) fixed inputs, depending on the firm's ability or intention of changing the quantity of units used in production. The firm can change quantity of a variable input if desired within a production period. However the amount of the input used cannot be changed within the production period if the input is a fixed input.

A production process is considered short-run if there is at least one variable input used during the production period concerned. All inputs are considered variable in the long run. Students have to pay special attention to remember that short-run and long-run distinction does not have a length in production period. As an example a firm would use same equipment and same number of labour to continue a production process over a long period of time.

5.4 Product Curves

The product curves consist of total product (*TP*), Average Product (*AP*) and Marginal product (*MP*) curves. *TP* is the total output can be produced at a given level of input whereas *AP* is equal to the *TP* divided by the level of inputs used and *MP* can be defined as the change in *TP* per unit change in input. Assuming a single variable production function of a firm $Y = f(L)$; where *Y*= quantity of paddy produced (kg bags) and *L* = person days of labor used, the corresponding Average Product (AP_L) and the Marginal Product (MP_L) can be defined as follows.

$$AP_L = {}^{Y}/_{L} \dots (6)$$

$$MP_L = {}^{\Delta Y}/_{\Delta L} \dots (7)$$

Table 5.1 is an example to demonstrate the relationship among total product (Y), of rice with single input of labor (L), and AP_L and MP_L.

Table 5.1: Relationship between input quantities of Labor (L), and output quantities (*Y*) in producing paddy.

Labor (L) Person days	Paddy output in 50kg bags, (Y)
0	0
1	4
2	10
3	18
4	24
5	27
6	29
7	30
8	30
9	29
10	27

The example is for paddy production in a 0.2 ha under major irrigated area in Anuradhapura District during *Yala* Season. Labor is quantified and reported as person days used for the activity during the season reported. Output is reported as number of

bags (of 50kg each). Reported here are only labor and output while an actual farm uses many more inputs and get multiple outputs. You may note that these are the widely used units in reporting.

We will use these values to understand the general relationship between a single variable input and a single output.

Activity 5.3:

i. Use a graph paper or a square-ruled paper. Using the values given in table 5.1 plot labor input in x axis and corresponding output values in Y axis.

ii. Calculate Average Product (*AP*) at each *X* value and *MP* as *X* value is changed to the current level of *X* from a previous level. Fill the blank table below. Then compare your calculations with the values given in the completed table at the end of this chapter.

iii. Now use the same values for *X* and plot values for *MP* and *AP* in the same graph.

iv. Observe *MP* and *AP* curves and match the following in their changes.

v. Note and report the differences in the value of *MP*, and *AP* as *X* is increased variation, and rate of increase in *MP* and *AP* Curves. Identify points in X axis at which the following combinations change. Draw vertical lines to reach the *TP* curve using the values computed by you.

Value of MP	Change in MP	Change in AP	Input Quantity
Positive	Increasing	Increasing	
Positive	Decreasing	Increasing	
Positive	Decreasing	Decreasing	
Negative	-	Decreasing	

Table 5.2: Total Product, Average Product and Marginal Product of labor in paddy production

Labor (L) Person days	Paddy output in 50kg bags, (Y = TP)	Average Product $AP_L = Y/L$	Marginal product $MP_L = \Delta Y/\Delta L$
0	0		
1	4	4.0	4
2	10	5.0	6
3	18	6.0	8
4	24	6.0	6
5	27	5.4	3
6	29	4.8	2
7	30	4.3	1
8	30	3.8	0
9	29	3.2	-1
10	27	2.7	-2

The following are the key points to learn from this example.

Paddy production increases at an increasing rate when one additional unit of labor input is added until the labor input reaches units.

From this point onwards, as additional units of labor are added, output increases at a decreasing rate till it reaches 30 units. This is the maximum level of output (*TP*)

As labor input is increased further output (*TP*) begins to decrease.

Relationships developed using computations are shown graphically in Figure 5.1.

The *MP* curve cuts the *AP* curve from above at the input level that gives the highest value of *AP*.

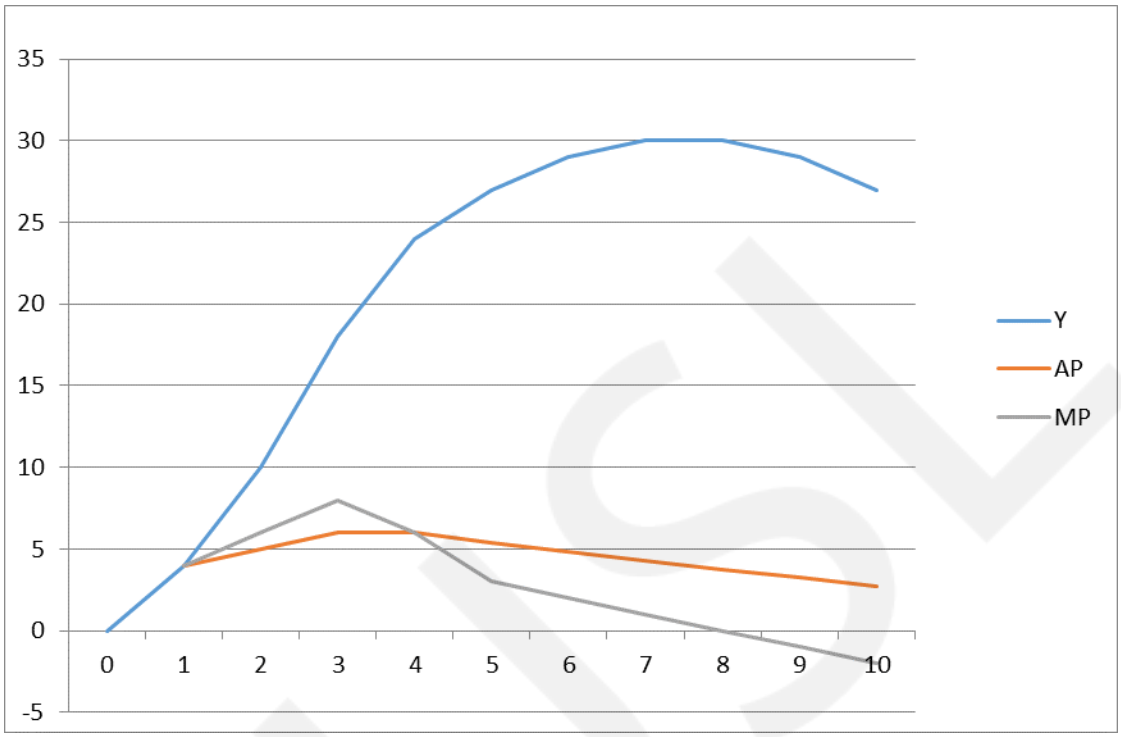

Figure 5.1: Product Curves

TP (Y), AP and MP curves are in the Y axis and quantity of labor (in person days) is in x axis.

This understanding on input output relations can be used in deciding the level of input that a firm should use in production.

Firm will not stop production by stopping the use of the variable input. If the firm is a logical decision maker it will not stop production at a level of input that an additional unit will increase the efficiency of that input.

In this example variable input is labor. It is measured in person days. Therefore, the efficiency (or Productivity) of labor is ⟦AP⟧_L=Y⁄L……. (6)

Number of units of output per one unit of variable input increases till *AP* reaches its maximum. This is also the intersection point of MP and AP. So the boundary of production has from lower end at the point *APP=MPP*

This understanding leads to the conclusion that producers do not stop adding the variable input before a level that make *AP* to be at maximum.

On the other hand *MP* is negative means additional output attributable to an additional unit of input is negative. This implies that such use of an input is a waste of resources. The same level of output can be achieved at two input levels. One level is lower than the other and is less costly. The producer can save the additional cost by operating at the level of inputs that is lower. Therefore any producer using input levels when MP is negative is an irrational producer.

This understanding allows us to conclude the following: Producers will operate in the region that input quantities lead to AP is highest from the lower bound and MP is non-negative at the upper bound. This region is known as the rational region of production.

Now we have identified a region that spans from () days to () days as the rational region. However, a decision should be made at the exact level of input at which the production should continue. Input level should not be higher than this.

We will switch to prices and markets at this point.

Producer sells his products in the market. Now consider that output of paddy can be sold at the market at LKR 1,500 a 50kg bag. The producer is a price taker in both input and output markets. As such, input and output prices will remain same at all levels of output and input.

We calculate the additional revenue received by additional production assessed as a result of an additional input quantity. This is known as the *VMP* (Value marginal Product).

$$VMP = MP * P \ldots \quad (7)$$

Now assume that MC = MR condition hold so the producer should stop adding more labor when VMP = MC

5.5 Cost of Production

Basics of Costs of Production

As discussed above there are two types of costs in the short run. If all inputs are accurately included the sum of fixed costs and variable costs will give all costs incurred in production in the short run.

The short run total cost is the sum of fixed cost and variable costs as given in equation (8).

$$TC = FC + VC \ldots \quad (8)$$

where *FC* = Fixed costs and *VC* = variable costs

TFC is a constant value at all levels of output and shown as a straight line parallel to X axis. The intercept is the value of *TFC*. *TVC* shows a sigmoidal shape. It increases at decreasing rate and then increases at an increasing rate. *TC* curve lies on a parallel position above the T*VC* curve as *TFC* is fixed and *TC* is the sum of *TVC* and *TFC*. Average cost curves can be calculated as functions of output as shown below.

$$Average\ Fixed\ Cost\ (AFC) = {}^{FC}/_{Y}$$

$$Average\ Varable\ Cost\ (AVC) = {}^{VC}/_{Y}$$

$$Average\ Total\ Cost\ (ATC) = AFC + AVC$$

$$Marginal\ Cost\ (MC) at\ a\ given\ level\ of\ Y = {}^{\Delta TC}/_{\Delta Y}$$

Graphical representation of the shapes (behavior) of average and marginal cost curves are given in Figure 5.2

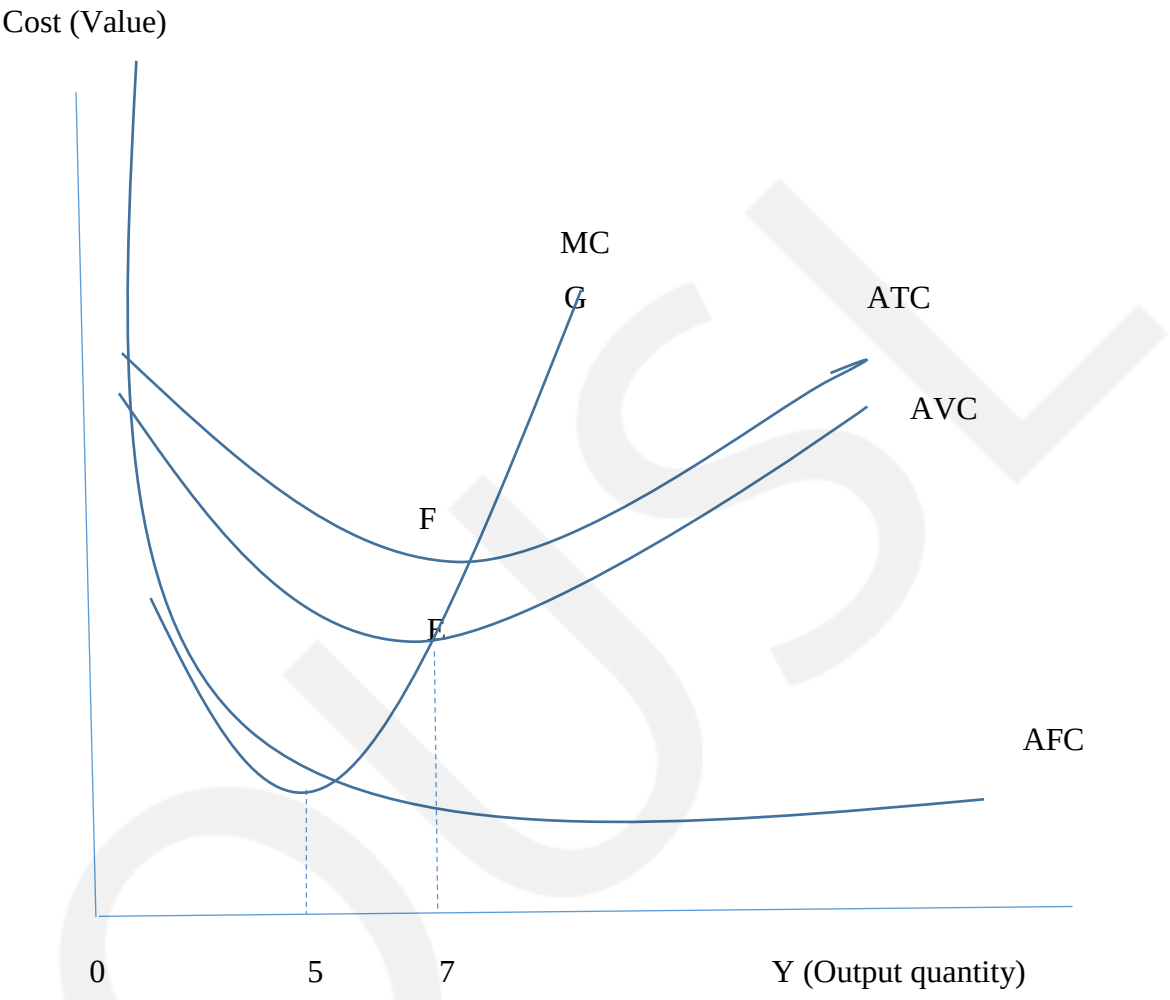

Figure 5.2 –Cost Curves: *AFC; AVC; ATC*; and *MC*

The average fixed cost curve takes the shape of a hyperbola. AFC continues to fall as output increases as one value is in the numerator is constant while the value of the he denominator is increasing. So the share of fixed cost assigned to one unit of output diminishes as output increases.

As output level increases; The *AVC* and *ATC* curves fall and come to a minimum value. Both curves then rises with increasing output levels. The *MC* curve is also a secondary curve which falls initially and then rises. The point at which *MC* curve crosses the *ATC* curve is the efficient scale of production. (Refer to the numerical example in the appendix and note that the quantity of output (8) with the minimum *ATC* (LKR. 31.80).
Relationship between *ATC* and *MC* are given in Table

MC< ATC	ATC falls		
MC=ATC	ATC is at minimum		
MC>ATC	ATC rises		

Marginal cost curve above the minimum point of average variable cost EG is the short run supply curve (S) of the firm.
As many decisions are fixed in the short run but variable in the long run a firms long run cost curves differ from its short run cost curves.

Summary

In this session we learned about firms. Firms are economic entities that produce outputs using inputs and technology. In this session we assumed that producers behave as price takers in both these markets.
Producers behave to maximize profit. Outputs are sold in output markets. They receive revenue as benefits. Inputs are purchased from product markets. The difference between benefits and costs is the profit.
Production relationships can be explained using a production function and they also can be shown graphically. Short run is a situation in which there is at least one variable input. Rational producers do not stop adding more inputs until the average product reaches its maximum. It is also not rational to use inputs once the marginal product is negative since

the same output can be received at a lower input level. Profit maximizing input level in a single variable input is *VMP* = Price of input.

Costs are described as functions of output. Level of fixed costs explaining the costs for fixed inputs does not vary with output. Total revenue is the amount of money that a firm receives by sale of its output (Y). The total cost of production (TC) is the value of inputs used by the firm in production. The difference is firm's profit.

Objectives

- To understand and appreciate the role of firms in an economy
- To get learn the behavior of a firm reaching its objectives
- To build a mathematical and graphical explanation of different types of input-output relationships
- To understand decision making rules of a firm operating in a perfectly competitive market
- To understand patterns of different types of costs associated with production