Block 3
Equilibrium Under Perfect Competition

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THE PEOPLE'S
UNIVERSITY

UNIT 7 PROFIT MAXIMISATION BY A COMPETITIVE FIRM

Structure

7.0 OBJECTIVES

After going through this unit, you should be able to:

- revisit the characteristic features of a Competitive market structure;
- identify the concept of profit maximisation, that too in connection with the competitive market structure;
- define and derive a Profit function under perfect competition;
- explain the short-run and the long-run equilibrium at the firm and industry level; and
- analyse supply curves in the long-run and the short-run.

7.1 INTRODUCTION

One of the most fundamental assumptions of economic theory is that of benefit maximisation. For a consumer, the benefit is the utility received from consumption of commodity, whereas for a producer, it is the profit maximisation. Profits are simply the revenue received less of cost incurred in carrying out any business operation. For a firm, profits equal total revenue less total costs. Both— total revenue and total costs are determined by the output level produced by the firm. For a firm aiming at profits maximisation, the optimal output level produced is determined by the type of market it caters to *viz*. perfect competition, monopoly, monopolistic competition and oligopoly. In the present unit we take up a market structure characterised by perfect competition. The theoretical aspect of this market structure had already been comprehensively covered in Unit 9 of Introductory Microeconomics (BECC-101) course of Semester 1. Here, we intend to further analyse that theoretical content with the mathematical tools that you came across in your Mathematical Methods in Economics course of Semester 1 (BECC-102).

Initially we will revisit the characteristic features of a perfectly competitive market. Then we will briefly touch upon the concept of profit maximisation. The objective of profit maximisation will be further analysed in connection with the firm operating in perfectly competitive market structure. After deriving the profit function, profit maximisation approaches, that is the TR-TC and the MC-MR will be given some mathematical treatment. This treatment will be further carried forward to analyse, both the short-run and the long-run equilibrium conditions of both the firm and the industry under a perfect competition market structure. Towards the end, supply curves in the short-run and in the long-run will be explained.

7.2 PERFECT COMPETITION

You came across the following characteristic features of a Perfectly Competitive market structure in Unit 9 of your Introductory Microeconomics course in Semester 1 (BECC-101):

1) Very large number of buyers and sellers in the market;
2) Product sold by all the firms is 'Homogenous';
3) Free entry or exit of firms;
4) Perfect information for correct economic decisions available with all economic participants;
5) Perfect mobility of resources; and
6) No government intervention

A perfectly competitive market structure is said to prevail when firms do not have any power to influence the prevailing prices in the market. Firms are unable to influence price because the volume of output, which they sell in the market, is 'insignificantly small' as compared to the total size of the market. The output share of each firm is insignificantly small because the number of firms in the market is very large and each of them sells homogeneous product. Free entry and exit by the firms in the market allows each to earn only normal profits. On the top of that, availability of perfect information about products and their prices make sure that any change in prices will immediately be known to all buyers as well as to all sellers. In other words, price signals work perfectly in efficient allocation of resources in this market structure.

Perfect competition is an ideal market structure, which does not exist in reality, since no industry completely satisfies all the conditions mentioned above. Though markets for homogeneous agriculture produce like wheat, rice, *etc*. come close, but Government intervention in such markets keeps them from fully satisfying all the conditions of this market structure.

If such a market structure does not exist in reality then what is the need to study it? To understand this, we must define 'Efficiency'. Efficiency is said to be the ideal situation when nobody can be made better off without making someone else worse off. Perfect competition results in an efficient allocation of resources so that no re-organisation could make someone better off without making someone else worse off. After analysing this ideal structure, imperfections can be easily added to it to make it more realistic. So we study perfect competition to make comparison of an ideal market structure with less efficient and more realistic market structure(s) of that of a Monopoly, Monopolistic competition or Oligopoly. Such comparison after dropping the restrictive assumptions of the ideal market situation would help us in economising the use of resources according to priorities.

7.3 PROFIT MAXIMISATION

Most of the activities, be it production or consumption, are undertaken in expectations of some return. A consumer derives return in the form of utility attained from consumption of a commodity or a service, while for a producer that return is the profit earned from undertaking the production of that good or service. Profit is simply the amount left with the entrepreneur after he has paid for all the expenses incurred in the production process. It is given by:

Profit = Total Revenue – Total Costs

Total Revenue (TR) is the amount received by a producer from selling the commodity he deals in. It is given by the product of the quantity of a good sold and the price of that good (TR = Price × Quantity sold). The concept of TR is simple and clear, whereas Total Costs could be represented in terms of two variants— Explicit costs and the Implicit costs. Explicit costs are the costs that a producer pays for, like wages, rent, advertising, packaging, *etc*. On the other hand, Implicit costs are the opportunity costs of the resources supplied by the producer himself, like implicit salary for the entrepreneurial services of the producer, implicit rent of a factory building owned by the producer, *etc.* It is simply the value, the factors owned by the producer could have earned if he had chosen to rent them out instead of using them.

While calculating profits, when only explicit costs are considered, we get *Accounting* profits, given by Total Revenue – Explicit Costs. *Economic* profits on the other hand consider both, the explicit as well as the implicit costs. It given by:

Economic Profit = Total Revenue – (Implicit Costs + Explicit Costs).

Economic profit are always less than accounting profit for it takes into account implicit costs as well, which accounting cost does not.

Profit maximisation has been regarded as the sole objective of the business in any capitalist economy. It is as feasible as the utility maximisation objective of an individual consumer. At equilibrium, a firm in a perfectly competitive market earns zero economic profit. Considering the maximisation objective, why would a firm in such a market settle at zero economic profit? The explanation to this could be:

1) Zero economic profit condition implies that the firm in perfect competition is earning normal profits, wherein revenue earned is sufficient to cover both the implicit as well as the explicit costs; moreover

2) Free entry and exit of the firms in the industry ensures that all positive economic profits get competed away by new entrants, while economic losses get eliminated by exit of the loss-making firms from the industry— so that in the long-run all firms earn only zero economic profits.

Keeping the objective of profit maximisation in mind, let us now define the profit function under a perfect competition.

7.4 PROFIT FUNCTION

Profit function represents the maximum profit a firm may earn for various combinations of inputs and output prices. Before deriving such a function, you must be aware of the concepts of profit maximisation, both— in the long-run and in the short-run. This in turn will require your clear understanding of the fixed and the variable factors of production.

7.4.1 Fixed and Variable Factors

You are already familiar with the idea of fixed and variable factors of production. Fixed factor of production is present in fixed amounts, at least in the short run, like building, machines, *etc*. On the other hand, a variable factor can be used in different amounts even in the short run, for instance, labour, raw materials, *etc*. In the short run, firms can vary only the variable factors of production, whereas in the long run, all factors of production can be varied, *i.e.* all factors become variable in the long run. Thus, the short run and the long run time period is something which is defined by the extent and the timeliness of the variability of factors of production. Factors which could not be varied for a specific amount of time period, define the extent of short run time span for that firm to that extent of time period.

Presence of Fixed factors in the short run creates the possibility of a firm earning negative profits in the short run. This is because, even if firm decides to produce no output, it has to employ and pay for some fixed factors in the short run. But, in the long run, all factors become variable, this makes it possible for a firm to go out of business, i.e. produce no output and thus reduce its cost to zero, and earn zero profits.

7.4.2 Short-run Profit Maximisation

Consider a production function for a firm, given by

$$Q = f(\overline{K}, L)$$

Here, Q represents the amount of output produced, K and L are the two factors of production. Bar over input K signifies that it is fixed at a level, i.e., $K = \overline{K}$. Further let P be the price of the output Q, and let r and w be the prices of the factors K and L, respectively. We assume P, w and r as given.

Total Revenue (TR) equals Price × Output:

$$TR = P \times f(\overline{K}, L)$$

Total Cost (TC) is the cost incurred on employment of factors $\overline{K}$ and L at respective rates of r and w: $TC = r\overline{K} + wL$

Profit (π) will be given by TR – TC. Thus, short-run profit maximisation problem becomes

$$\text{Maximise} \quad \pi = Pf(\overline{K}, L) - r\overline{K} - wL$$

First-order condition for profit maximisation will be given by

$$\frac{\partial \pi}{\partial L} = 0$$

This gives the following equation for the profit-maximising choice of L, i.e. L*.

$$P f_L'(\overline{K}, L^*) = w \qquad (1)$$

Where, $f_L'(\overline{K}, L^*)$ is the Marginal Product (MP) of factor Lat L*, and consecutively $P f_L'(\overline{K}, L^*)$ gives the value of MP of factor L at L*.

Equation (1) gives a general rule—at the profit-maximising level of a factor (here L), value of marginal product of that factor [hereP $f_L'(\overline{K}, L^*)$] should equal that factor's price (here w).

The same condition can be derived graphically. Refer Fig. 7.1 below.The upward sloping concave curve represents the production function $Q = f(\overline{K}, L)$, where factor K is fixed.

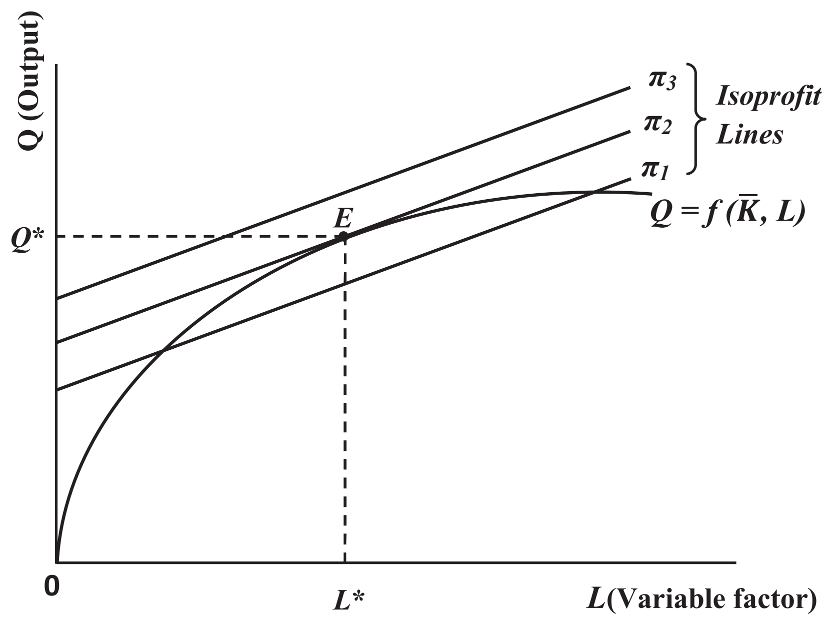

Fig. 7.1: Profit Maximisation

Now, Profit function is given by, $\pi = PQ - r\overline{K} - wL$

Expressing Q as a function of L, the above equation becomes:

$$Q = \frac{\pi}{P} + \frac{r}{P}\overline{K} + \frac{w}{P}L \qquad (2)$$

Equation (2) represents an Isoprofit line, where 'Iso' means equal. This line gives all the combinations of Q and L at which, level of profit remains equal or constant. Slope of the line is given by $\frac{w}{P}$, whereas intercept is $\frac{\pi}{P} + \frac{r}{P}\overline{K}$, a sum of profit and fixed costs to the firm. With fixed costs remaining fixed, for different values of π, we get different intercepts, and consequently a family of parallel isoprofit lines, represented by π_1, π_2 and π_3 in the figure. Now, profit maximisation occurs where the production function touches the highest possible isoprofit line. This is happening at point E in Fig. 7.2, where isoprofit line π_2 is tangent to production function. Tangency implies that at point E, slope of production function, given by $f_L'(\overline{K}, L)$ equals slope of isoprofit line π_2, given by $\frac{w}{P}$.

That is, at E $\quad f_L'(\overline{K}, L) = \frac{w}{P} \Longrightarrow P\, f_L'(\overline{K}, L) = w$

Thus, we get back the same condition that was given by Equation (1).

Dynamics of Change in Factor or Product Prices

Now let us examine the effects of changing input and output prices on the firm's input and output choices. First we take up the case when price of variable factor (i.e., L) changes. Suppose w (the price of factor L) rises. This will raise the slope of the isoprofit line (given by $\frac{w}{P}$), as you may notice in Fig. 7.2. Tangency of production function with the new steeper isoprofit line must occur to the left of the tangency with the flatter isoprofit line associated with lower w. This shows— as price of a factor rises, demand for it falls, that is, *the factor demand curve slopes downwards*.

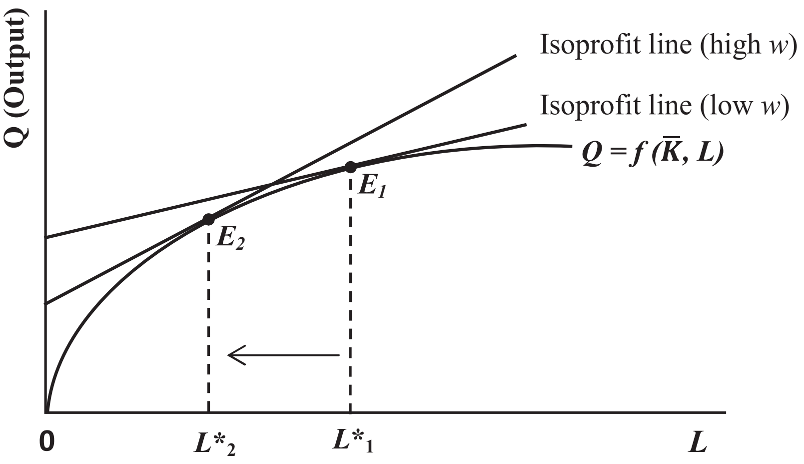

Fig.7.2: Change in Factor demand as factor price changes

What will happen, when price of fixed factor (i.e. K) changes? A change in r (the price of factor K) will not alter firm's demand for it, at least in the short run, as it remains fixed at a level given by $\bar{K}$. Also, as you may notice, a change in r will not alter the slope of the isoprofit line $\left(\frac{w}{P}\right)$. Therefore, there will be no change in choice of factor L or output Q. The change will come only in the profits earned by the firm.

Now we look into the case of change in output (Q) price. Suppose P (the output price) falls. This will again result in increasing the slope of the isoprofit line$\left(\frac{w}{P}\right)$. Tangency of the production function and the steeper isoprofit line, as you may notice in Fig. 7.3, will occur to the left of the tangency of production function and the flatter isoprofit line associated with higher P. Fall in employment of L with fixed K, will result in fall in output. This concludes— as price of output falls, production falls, that is, *the output supply curve slopes upwards.*

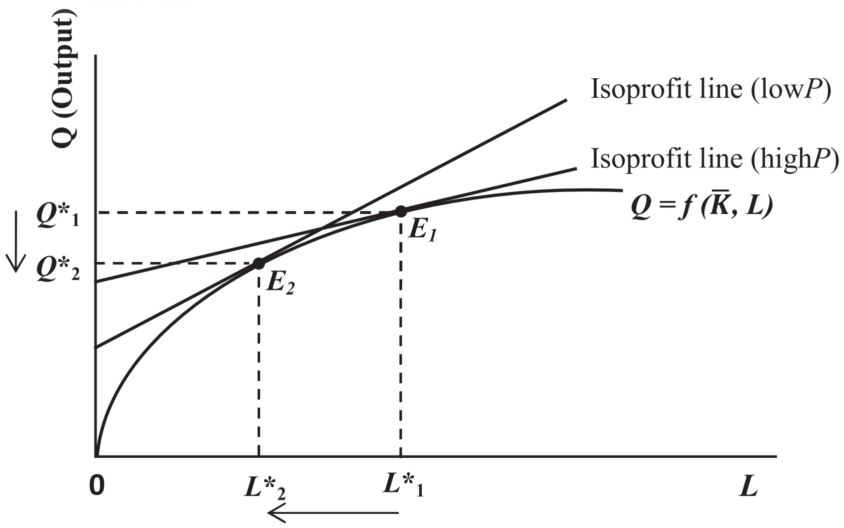

Fig. 7.3: Change in output demand as output price changes

7.4.3 Long-run Profit Maximisation

In the long-run, all inputs become variable for the firm. Thus, production function faced by the firm becomes

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

As you may notice here, K does not have a bar on top, indicating it could be varied, just like factor L, by the firm. Now, the long-run profit maximisation problem will be given by

$$\text{Maximise} \qquad \pi = Pf(K, L) - rK - wL \qquad (3)$$

First-order condition for profit maximisation will be given by

$$\frac{\partial \pi}{\partial L} = 0 \Longrightarrow P\, f_L'(K, L) = w \qquad (4)$$

$$\frac{\partial \pi}{\partial K} = 0 \Longrightarrow P\, f_K'(K, L) = r \qquad (5)$$

Where, $f_L'(K, L)$ is the Marginal Product (MP) of factor L, and consecutively $P\, f_L'(K, L)$ gives the value of MP of L. Similarly, $P\, f_K'(K, L)$ gives the value of MP of factor K. So we have Equations (4) and (5) to solve for the optimal L and K in terms of output and input prices (P, w, r). Let us denote the optimal values by L* and K*.

Thus, profits are maximised, when firm makes optimal choices of factors K and L, at a level where value of marginal product of each factor equals its price.

Factor Demand Function

Given the input and output prices (*i.e.*, given the values of w, r and P), Equations (4) and (5) can be solved for the two unknowns— K* and L* as a function of these prices. The resulting function, called the *Factor Demand function*, gives the relationship between price of a factor and profit maximising choice of that factor.

Thus, factor demand function for input L will be given by:

$$L^* = F^*(P, w, r) \qquad (6)$$

and that for input K will be given by: $K^* = G^*(P, w, r)$ (7)

Here, F* and G* simply denote profit maximising functions of the output and input prices.

Profit Function

From Equation (3), (6), and (7), we get the *Profit function* of a perfectly competitive firm as a function of the output and the input prices:

$$\pi^*(P, w, r) = P\, f\,[G^*(P, w, r), F^*(P, w, r)] - r\, G^*(P, w, r) - wF^*(P, w, r)$$

Profit function, given by $\pi^*(P, w, r)$ gives maximum profit that could be earned by a perfectly competitive firm as a function of P, w and r.

7.4.4 Profit Function for Cobb-Douglas Technology

A Cobb-Douglas production function for two inputs x and y, Q = f (x, y) can be written in the following form:

$$Q = x^a y^b \tag{8}$$

where Q is the output produced with employment of two factor inputs x and y; a and b are the positive constants. A firm in perfect competition maximises its profits (π) given by:

$$\pi = P\,f(x, y) - w_1x - w_2y \tag{9}$$

where P is the price of the output Q; w_1 and w_2, the prices of the factors inputs x and y, respectively. The first-order conditions of profit maximisation are given by:

$$\frac{\partial\pi}{\partial x} = p\frac{\partial f(x,y)}{\partial x} - w_1 = 0 \Longrightarrow Pax^{a-1}y^b = w_1 \tag{10}$$

$$\frac{\partial\pi}{\partial y} = p\frac{\partial f(x,y)}{\partial y} - w_2 = 0 \Longrightarrow Pbx^a y^{b-1} = w_2 \tag{11}$$

Given the prices (i.e., P, w_1 and w_2), Equations (10) and (11) give profit maximising factor choices of inputs x and y, respectively. Both these equations can be solved to derive factor demand functions of inputs x and y.

On dividing equation (10) by (11), we get

$$\frac{Pax^{a-1}y^b}{Pbx^a y^{b-1}} = \frac{w_1}{w_2} \Longrightarrow y = \frac{bw_1}{aw_2}x \tag{12}$$

Substituting value of y from Equation (12) in Equation (10), we get

$$Pax^{a-1}\left(\frac{bw_1}{aw_2}x\right)^b = w_1 \Longrightarrow Pa^{1-b}b^b w_1^{b-1}w_2^{-b}x^{a+b-1} = 1$$

$$\Longrightarrow Pa^{1-b}b^b w_1^{b-1}w_2^{-b} = \frac{1}{x^{a+b-1}}$$

This above equation could be further solved to get profit-maximising firm's demand for input x as a function of price of output (P) and prices of both the inputs (w_1 and w_2).

$$x^{1-a-b} = Pa^{1-b}b^b w_1^{b-1}w_2^{-b}$$

$$\Longrightarrow x =$$

$$\left(P^{1/1-a-b}\right)\left(a^{1-b/1-a-b}\right)\left(b^{b/1-a-b}\right)\left(w_1^{-(1-b)/1-a-b}\right)\left(w_2^{-b/1-a-b}\right) \tag{13}$$

Now, value of x can be substituted in Equation (12) to get factor demand function for input y.

$$y = \left(P^{1/1-a-b}\right)\left(a^{a/1-a-b}\right)\left(b^{1-a/1-a-b}\right)\left(w_1^{-a/1-a-b}\right)\left(w_2^{-(1-a)/1-a-b}\right) \tag{14}$$

Now, inserting both the factor demand functions in our production function given by Equation (8), we get the perfectly competitive firm's *Supply curve*.

$$Q^* = \left(P^{a+b/_{1-a-b}}\right)\left(a^{a/_{1-a-b}}\right)\left(b^{b/_{1-a-b}}\right)\left(w_1^{-a/_{1-a-b}}\right)\left(w_2^{-b/_{1-a-b}}\right) \qquad (15)$$

Supply curve given by Equation (15) gives a perfectly competitive firm's profit maximising output quantity (Q*) as a function of price of output (*P*), and prices of inputs (w_1 and w_2).

Equations (13), (14) and (15) can then be substituted in Equation (9) to get the profit function π* (P, w, r), given as follows:

$$\pi\,(P, w, r) = \left(P^{1/_{1-a-b}}\right)\left(w_1^{-a/_{1-a-b}}\right)\left(w_2^{-b/_{1-a-b}}\right)$$
$$\left(a^a b^b - a^{1-b} b^b - a^a b^{1-a}\right)^{1/1-a-b}$$

7.4.5 Properties of the Profit Function

1) Profit function π (P, w, r) is non-decreasing in output prices (P).

   If P´ ≥ P, then π (P´, w, r) ≥ π (P, w, r).

2) Profit function is non-increasing in input prices (w and r).

3) Homogeneous of degree one in P, w and r.

   π (tP, tw, tr) = *t* π(P, w, r) for all t ≥ 0

4) Convex in *P*, *w* and *r*.

   Let $p'' = tp + (1-t)p'$ for $0 \le t \le 1$

   Then $\pi(p'') \le t\pi(p) + (1-t)\pi(p')$

5) Continuous in P, w and r for P, r, w > 0.

6) Derivative property of profit function (Hotelling's Lemma):

   i) If we take the partial derivative of profit function with respect to output price (p) we get the output supply function *i.e.*, $\frac{\partial \pi(P,w,r)}{\partial p} = q(p,w,r)$.

   ii) If we take negative of the partial derivative of profit function with respect to input price (say w) we get the factor demand function for labour *i.e.*, $-\frac{\partial \pi(P,w,r)}{\partial w} = L(p,w,r)$. Similarly If we take negative of the partial derivative of profit function with respect to input price (say r) we get the factor demand function for capital i.e., $-\frac{\partial \pi(P,w,r)}{\partial K} = K(p,w,r)$.

Example 1

1) A firm has the following total-cost and demand functions:

$$C = \frac{1}{3}Q^3 - 7Q^2 + 111Q + 50$$

$$Q = 100 - P$$

   a) Write out the Total Revenue function in terms of Q.

b) Formulate the total profit function (π) in terms of Q.

c) Find the profit-maximising level of output Q*.

d) What is the maximum profit?

Solution

a) Total Revenue = P × Q

$TR = (100 - Q) \times Q = 100Q - Q^2$

b) Total Profit Function (π) = TR – TC

$\pi = 100Q - Q^2 - (\frac{1}{3}Q^3 - 7Q^2 + 111Q + 50)$

$\pi = 100Q - Q^2 - \frac{1}{3}Q^3 + 7Q^2 - 111Q - 50$

c) $\frac{\partial \pi}{\partial Q} = 100 - 2Q - Q^2 + 14Q - 111 = 0$

$-Q^2 + 12Q - 11 = 0$

$-1(Q^2 - 12Q + 11) = 0$

$Q^2 - 11Q - Q + 11 = 0$

$Q(Q - 11) - 1(Q - 11) = 0$

$Q = 1$ or $Q = 11$

$$\frac{\partial^2 \pi}{\partial Q^2} = -2Q + 12$$

$$\text{If } Q = 1 \text{ then } \frac{\partial^2 \pi}{\partial Q^2} = -2 + 12 = 10 > 0$$

$$\text{If } Q = 11 \text{ then } \frac{\partial^2 \pi}{\partial Q^2} = -2 \times 11 + 12 = -10 < 0$$

Hence, profit is maximised when Q = 11

d) Maximum Profit $= 100 \times 11 - (11)^2 - \frac{1}{3} \times (11)^3 + 7 \times (11)^2 - 111 \times 11 - 50$

$= 1100 - 121 - 443.6 + 847 - 1221 - 50 = 1947 - 1835.6$

$= 111.4$

Hence, the maximum profit is Rs. 111.4

Check Your Progress 1

1) Explain the factors that drive profits to zero in perfectly competitive markets in the long-run.

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2) A firm's demand function for good is given by, $P = 300 - 2Q$, where P stands for price and Q for quantity, whereas its total cost (TC) function is given by, $TC = 200 + 8Q$. Derive the profit function of this firm as a function of output (Q).

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3) A production function of a firm is given by $Q = f(L)$, where Q is the output produced and L is the labour input. Considering 'w' as the price of factor L, analyse and illustrate the effect of fall in w on the output produced.

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4) Consider the following production function of a firm for good X, $f(L) = 300L - L^2$, where L stands for labour factor. Assume price of good X be Rs. P and that of factor L be Rs. w. Determine the following:

a) Factor demand function for L

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b) Profit function

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5) Given a Cobb-Douglas production function of the form, $Q = K^{0.4}L^{0.4}$. Assuming output price to be P, and price of K and L be r and w, respectively, derive the expression for the profit function as a function of output and input prices.

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7.5 PROFIT MAXIMISATION APPROACHES

Firm is said to be in equilibrium when it has no incentive to change its level of output. Such a level of output of the firm is indicated at a point where firm is experiencing maximum level of profit. There are two approaches to determine firm's equilibrium level of output, or in other words, its profit maximisation output level:

i) Total Revenue-Total Cost (TR-TC) Approach

ii) Marginal Revenue-Marginal Cost (MR-MC) Approach.

7.5.1 Total Revenue-Total Cost Approach

Difference between Total Revenue (TR) and Total Cost (TC) gives us profit. When the gap between TR and TC is largest, firms would be earning maximum profit in money terms. So let us try to understand shape, slope and position of TR and TC curve.

As discussed previously MR and AR are equal and constant under perfect competition. Slope of TR curve is given by MR, which is constant and positive because prices cannot be negative; hence we have TR curve as an upward sloping linear curve. At zero quantity, TR would be zero hence TR curve would start from the origin and will continue to rise with slope equal to MR. TC on the other hand is non-linear curve, as total cost depends upon the returns to factors of production. If returns to factors of production are increasing at increasing rate then TC will increase at decreasing rate and if returns to factors of production are increasing at decreasing rate then TC will increase at increasing rate. The fixed costs are assumed away for the sake of simplicity. But, we will bring them back in the numerical example towards the end of this sub-section.

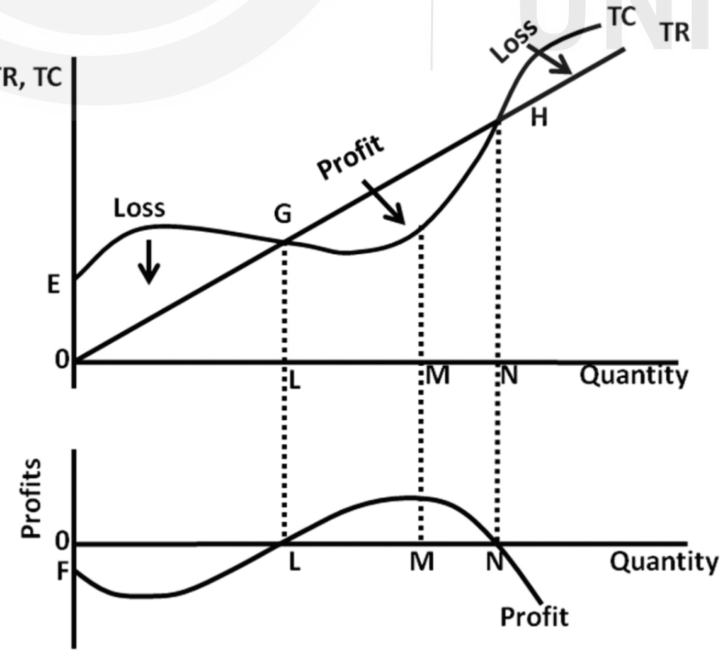

Fig. 7.4: Equilibrium of a firm using TR-TC approach

We will have TR and TC curve under perfect competition as shown in Fig. 7.4. Equilibrium will be at level of output where vertical distance between TR and TC curve is largest, indicating maximum profit [Profit (π) = TR − TC]. This occurs at point M. As you may notice in the figure, at point M, we also have slope of TR curve equal to the slope of TC curve.

Hence, this approach requires, $\frac{dTR}{dQ} = \frac{dTC}{dQ}$

The above condition reads— derivative of *total revenue* with respect to Q is equal to the derivative of *total cost* with respect to Q.

Up to L-level of output and beyond N-level of output, TC > TR, hence firm will experience loss. Between L- and N-level of output firm is experiencing positive money profit. At both these levels of output, firm is experiencing neither profit nor loss, because TC = TR and this indicates break-even point or level of output.

It is to be observed that by looking at above figure it cannot be revealed what is the price which firm would charge for its equilibrium level of output. We need to do some simple calculation by dividing TR associated with equilibrium level of output by level of output to determine equilibrium price, $TR = P \times Q \Longrightarrow P = \frac{TR}{Q} = AR$. This became major limitation of this TR-TC approach. It is also not easy to determine maximum vertical gap between TR and TC. This takes us to another approach (MR-MC approach) where these limitations are addressed.

7.5.2 Marginal Revenue-Marginal Cost Approach

To determine equilibrium for perfectly competitive firm, we need to find the level of output that would maximise its profit. To maximise its profits for each unit of increased output, firm compares additional revenue generated by selling that unit of output [that is marginal revenue (MR)] with additional cost incurred in producing that unit of output [the marginal cost (MC)]. As long as,

- MR > MC, additional production adds to profit, thus firm should produce this additional unit of output.
- MR < MC, additional production reduces profit, thus firm should not produce this additional unit of output, instead decreasing production would add to firm's profits.
- MR = MC, additional production does not impact profit, hence it provides a point where firm is indifferent in increasing or decreasing level of output, hence defines its equilibrium level of output.

  Using calculus we can derive this condition mathematically,

$$\text{Profit } (\pi) = TR - TC$$

  First-order maximisation condition is given by:

$$\frac{d\pi}{dQ} = 0$$

$$\frac{dTR}{dQ} - \frac{dTC}{dQ} = 0$$

$$\frac{dTR}{dQ} = \frac{dTC}{dQ}$$

Derivative of TR with respect to Q is nothing but the MR, whereas derivative of TC with respect to Q is MC, so that, profit maximisation problem gives us the following necessary condition:

$$MR = MC$$

To determine sufficient or the second-order condition, we need to differentiate profit function again.

We have, $\frac{d\pi}{dQ} = \frac{dTR}{dQ} - \frac{dTC}{dQ}$ or $\frac{d\pi}{dQ} = MR - MC$

Now, taking second derivative of the above expression, we get

$$\frac{d^2\pi}{dQ^2} = \frac{d^2TR}{dQ^2} - \frac{d^2TC}{dQ^2} \text{ or } \frac{d^2\pi}{dQ^2} = \frac{dMR}{dQ} - \frac{dMC}{dQ}$$

Second-order profit maximisation condition is:

$$\frac{d^2\pi}{dQ^2} \leq 0$$

That is, $\frac{dMR}{dQ} - \frac{dMC}{dQ} \leq 0$

Or, $\frac{dMR}{dQ} \leq \frac{dMC}{dQ}$

The above condition says that at profit maximisation output level, slope of MR ≤ slope of MC, which implies MC curve should cut MR curve from below.

This above arguments can also be understood through following Fig. 7.5.

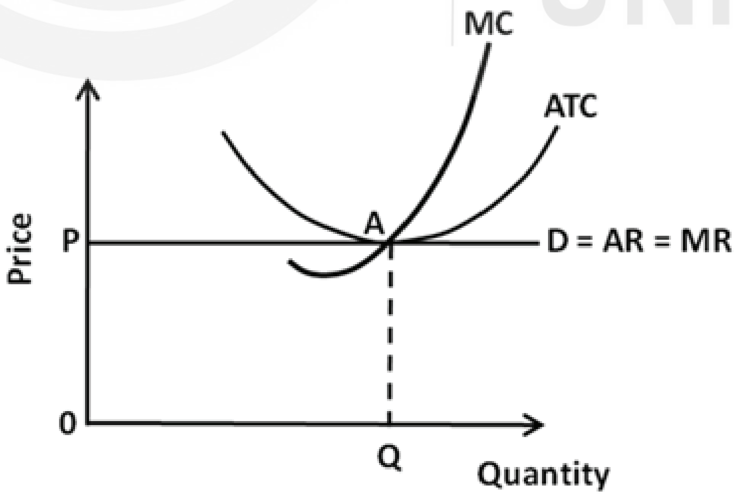

Fig. 7.5: Equilibrium of a firm using Marginal Revenue and Marginal Cost approach

In Fig. 7.5, MR and MC curves intersects at point A giving equilibrium level of output Q. At point A, both necessary and sufficient conditions are fulfilled. Thus, we get profit maximising level of output. Notice that at point A, MC is also cutting ATC at its minimum point, which is tangent to AR = MR curve. This results in the break-even level of output production, where the output produced results in zero economic profit.

Example 2

A firm has the following total revenue and total cost functions:

$$TR = 320Q - 2Q^2$$

$TC = 1800 + 50Q + 3Q^2$; where 1800 represents fixed cost component. Determine the level of output that would maximise profit earned by the firm.

Solution

Profit (π) = TR – TC

$$\pi = (320Q - 2Q^2) - (1800 + 50Q + 3Q^2)$$

$$\pi = -5Q^2 + 270Q - 1800$$

Maximisation of this equation is found by differentiating it with respect to Q and setting equal to 0:

$$\frac{d\pi}{dQ} = 0$$

$$\frac{d\pi}{dQ} = -10Q + 270 = 0$$

$$10Q = 270$$

$$\text{or} \quad Q = 27$$

So level of output which would maximise profit equals 27 units. Let's see whether equilibrium will be stable which maximises profit. For this we will have to verify sufficient condition or second order derivative condition.

$$\frac{d^2\pi}{dQ^2} \leq 0$$

$$\frac{d^2\pi}{dQ^2} = -10 < 0$$

So second order derivative condition is also satisfied, hence 27 units of output would maximise profit and it would be stable.

7.6 EQUILIBRIUM UNDER PERFECT COMPETITION: FIRM

7.6.1 Short-run Equilibrium

A perfectly competitive firm faces constant prices and horizontal demand curve. Firm has to decide in the short-run whether to produce or shut-down temporarily and how much to produce? In the long-run firm has to decide, whether to enter, stay or leave the industry; also whether to increase or decrease the plant size.

Two conditions of firm's equilibrium under perfect competition which has been derived in previous sections are:

At equilibrium point,

1) P (or AR or MR) = MC

2) Slope of MC should be greater than slope of MR.

These two conditions do not guarantee whether firm will shut down or continue to produce. To know whether firm will continue to produce or shut down in the short-run and how much it will produce, we must explore whether firm is making profit or loss. Consider the following expressions:

Profit (π) = TR – TC

AR = $\frac{TR}{Q}$

So, TR = (AR) × Q

Similarly, TC = (AC) × Q

Profit (π) = TR – TC

Profit (π) = (AR) × Q – (AC) × Q

Profit (π) = Q (AR– AC)

Where, AR is Average Revenue, AC is Average Cost, TR is Total Revenue, TC is Total Cost and Q is output.

If at equilibrium level of output, AR is greater than AC then firm is earning Profit. But if AR is lower than AC, then firm will incur loss, as shown in Fig. 7.6 (a) and 7.6 (b), respectively.

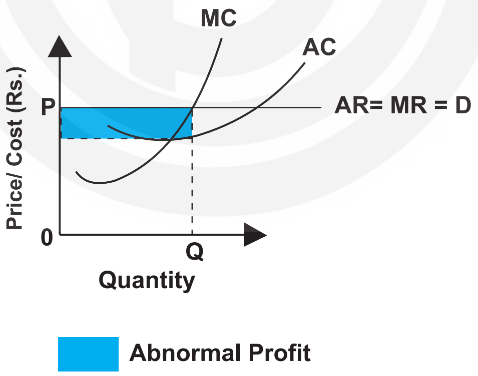

Fig. 7.6(a): Firm's Profit with equilibrium

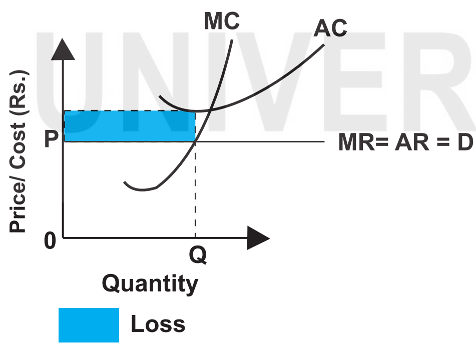

Fig. 7.6(b): Firm's Loss with equilibrium

Can firm continue producing output even if it is incurring losses? To answer this we must understand nature and difference between fixed cost and variable costs. Fixed cost is the cost which firm incur on fixed factor of production and fixed factor of production cannot be changed in the short-run. So once fixed cost has been incurred, even if firm shut-down its operation, it will have to bear fixed cost. While variable cost is the cost incurred on variable factor of production; therefore if firm has to continue producing output, then it will have to bear not only fixed cost but also variable cost. So as long as firm is recovering its variable cost, firm will continue to produce. Now, consider the following expression for Total cost:

Total Cost = Total Fixed Cost + Total Variable Cost

On dividing this equation by Q, we get the expression for the Average total cost (ATC) as a linear function of average fixed cost (AFC) and average variable cost (AVC).

ATC = AFC + AVC

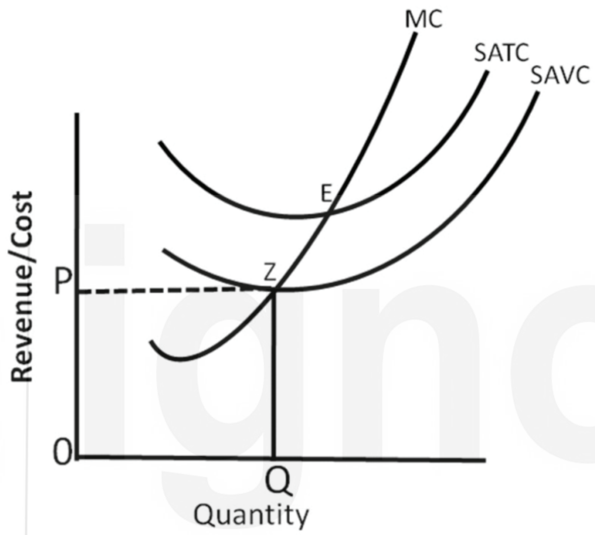

Fig. 7.7: Firm's decision to shut-down or continue production in short-run

A perfectly competitive firm takes prices as given because it does not have any control over prices. Consider Fig. 7.7 above. A firm facing market price P < SATC (Short-run Average Total Cost), suffers losses in the short-run. It may decide to continue or shut-down the production. This dilemma results because in the short-run firm incurs not only the variable cost but also the fixed cost. On shutting down, firm will get rid of the variable cost, but it will still have to bear the fixed cost.

The Short-run Average Variable Cost (SRAV) curve represents the variable cost incurred in the production process. As long as AR is greater than SAVC, firm is able to recover variable cost. Here, P < SATC, but it is equal to minimum SAVC. Thus, this firm though suffers a loss, will minimise its losses by continuing production, as it may recover some component of fixed cost. Point Z (where MC = minimum SAVC) represents the **Shut-down point**. If prices (AR) become less than SAVC at equilibrium level of output; firm will minimise its losses by shutting down, as now it is not able to recover even its variable cost. By shutting down, it will just have to suffer the loss from fixed costs and not any additional variable costs.

Point F, on the other hand represents **Break-even point**. Here, firm makes normal profit or zero economic profits, as TR = TC. Hence, even with short-run losses, firm will continue the production process, as long as market price it faces is above the minimum AVC of production. The moment market price falls below the shut-down point (Z here), firm decides to shut-down its operations in the short-run.

7.6.2 Long-run Equilibrium

In the long-run, all factors of production are variable, which means that there is no difference between variable cost and fixed cost, hence ATC becomes important in making production decisions. In the long-run firm faces decisions like— whether to enter, stay or leave the industry; and whether to increase or decrease the plant size.

If price (AR) is greater than AC then firms would be making super-normal profit, this would attract new firms to enter the industry and push the price down because of increased supply in the industry. On the other hand, if price (AR) is lower than AC, then some firms would leave industry because they are unable to recover their opportunity cost, in such case there will be a decline in supply which will push the price up. Hence in either situation, whether P (AR) is greater or lower than AC, firms would keep entering or leaving respectively till P or AR is equal to AC.

So in long-run, we have the following two conditions giving the equilibrium level of output:

i) P (or AR or MR) = MC and

ii) AR = AC

From these two equations we get, P = MC = AC. And since, MC and AC are equal only at the minimum of AC, so price line (or AR curve) should be tangent to AC curve at the long-run equilibrium level of output.

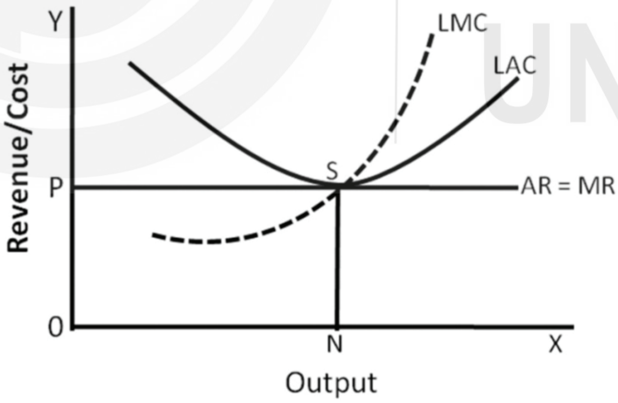

Fig. 7.8: Firm's Long-run equilibrium

Since in the long-run firm operates at the minimum of AC curve, this signifies that firm is operating with the plant of optimum size. When firm operates with optimum size, it means that it is enjoying all possible economies of scale or it has exhausted the economies of scale, and has no incentive to move to any other point.

7.7 EQUILIBRIUM UNDER PERFECT COMPETITION: INDUSTRY

An industry is said to be in equilibrium, when there is no tendency on its part to change the level of output. Output of an industry can change if existing firms changes their output or when the number of firms in industry changes, or may be both, simultaneously. Besides equality of demand and supply for its product, conditions, which would determine equilibrium of an industry, are as follows:

First, all firms in the industry must be in equilibrium simultaneously. Firm's equilibrium is determined by equality between MR and MC and slope of MC should be greater than slope of MR.

Second, the number of firms in an industry should not change, *i.e.*, there should not be any further entry or exit of any firm in the industry. This can happen only if all firms are earning normal profit. Normal profit is the minimum profit to induce firms to stay in the industry. This normal profit is also referred to as zero economic profit giving the maximum returns which firms could have earned from investing their money in some other alternatives.

7.7.1 Short-run Equilibrium

In the short-run, new firms can't enter or exit the industry, so number of firms will remain same. Industry will be in equilibrium when demand and supply of its product are equal and simultaneously all firms are in equilibrium whether they are earning profit or making losses.

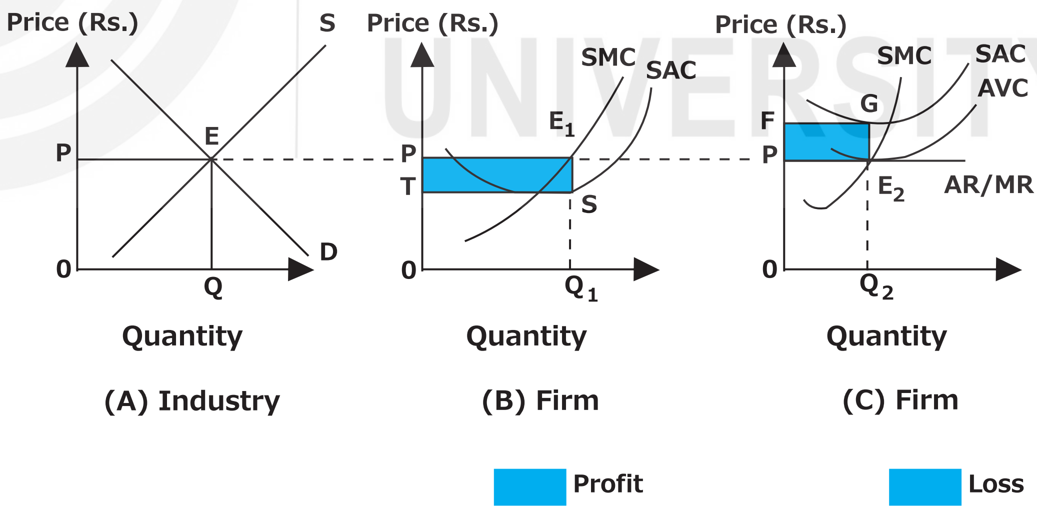

Fig. 7.9: Industry's short-run equilibrium

Fig. 7.9 (A) determines the equilibrium price or AR by the intersection of demand and supply. Firms take this equilibrium price or AR as given and tries to maximise their profit by adjusting output by equating MR with MC, and determining whether slope of MC is greater than slope of MR. This equilibrium level of output is indicated at point 'E_1' in Fig. 7.9 (B) where a firm is earning profit, and with point ' E_2' in Fig. 7.9 (C) where another firm is incurring loss.

7.7.2 Long-run Equilibrium

If existing firms are earning super normal profits, then they would expand their output and in the long-run new firms would enter the industry for making more than what they are earning in current investment. Entry of new firms and expansion of output by existing firms will lead to increase in supply by industry; hence supply curve would shift outward towards right as shown in Fig. 7.10. This shift in supply curve would lead to decline in prices. Prices would keep falling till there would be no new entry of firms and existing firms stop increasing their output. The point where prices and output stabilise— is the point of equilibrium in the industry, indicated by the point where prices become equal to minimum of average cost (AC). If prices are lower than AC then firms would be making losses and they will quit (exit) the industry. Hence, for the equilibrium of an industry, we must have following conditions.

i) Demand and supply in the industry should be equal.

ii) All firms must be in equilibrium *i.e.*, P = LMC

iii) Entry and exit of the firms must be ceased.

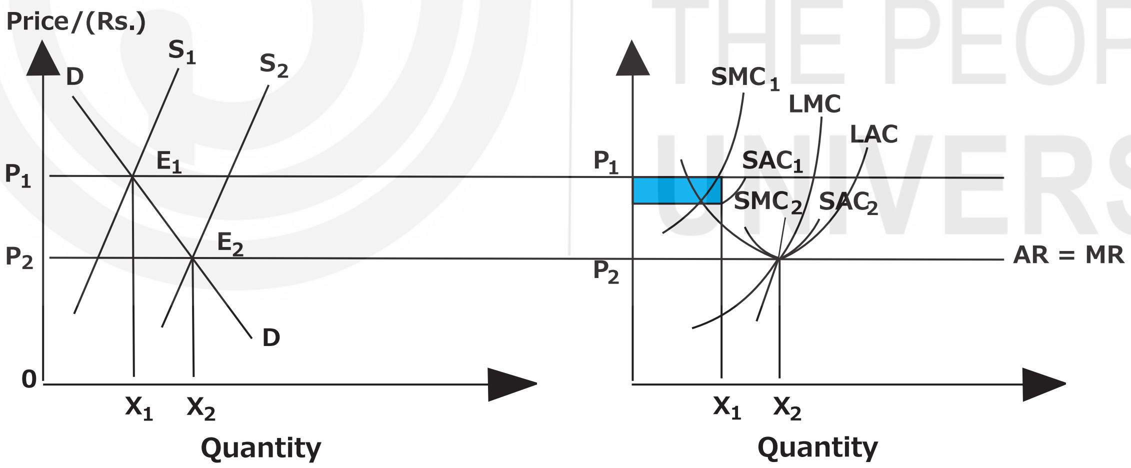

Fig. 7.10: Industry's long-run equilibrium

Consider Fig. 7.10, initially equilibrium in industry is depicted in the left hand side figure at point E_1, where demand and supply are equal. Point E_1 results in price level P_1 at which firm is in equilibrium by producing X_1 level of output and earning super normal profit. This is depicted in the right hand side figure. Super normal profits will attract new firm into industry forcing supply to increase. Increased supply in the industry would lead to decline in the price level. Price level would keep falling till it becomes exactly equal to minimum of LAC. At this new equilibrium, firm is earning just normal profit, hence entry of new firms would stop and all firms as well as the industry would be in equilibrium.

Check Your Progress 2

1) Explain the difference between Short-run and Long-run equilibrium of perfectly competitive firm.

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2) By defining concept of super normal profit, explain equilibrium of an industry in perfect competitive market structure?

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3) If each firm in an industry is operating where P = LMC, does it imply that the industry is in long-run equilibrium? Explain.

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4) The market demand for a particular type of carpet has been estimated as:

   $P = 40 - 0.25Q$, where P is price (Rs/meter) and Q is rate of sales (hundreds of meter per month). The market supply is expressed as: $P = 5.0 + 0.05$

   A typical firm in this market producing *q* units of output in hundreds of meter per month,has a total cost function given as: $C = 100 - 20.0q + 2.0q^2$.

   a) Determine the equilibrium market output rate and price.

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   b) Determine the output rate for a typical firm.

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c) Determine the rate of profit (or loss) earned by the typical firm.

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5) The cost function of firm is assumed to be

$C = 0.01x^3 + 250x$, where x is monthly output in thousands of units. Its revenue function is given by $R = 1500x - 2x^2$

a) Find the firm's total cost and marginal cost for producing 10 units.

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b) If the firm decides to produce with a marginal cost of Rs. 298, find the level of output per month and total cost to the firm.

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c) Find the firm's average and marginal revenue functions.

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d) If the firm decides to produce with marginal revenue of Rs. 1100, find firm's monthly output and monthly revenue.

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e) Obtain the firm's profit function and marginal profit function.

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f) Find the output required per month to make marginal profit equal to zero and find the profit at this level of output.

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g) Find the marginal revenue and marginal cost at this level of output and comment upon the result.

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6) State whether following statements are true or false.

a) In any market, the seller alone determines the price of the product that is bought and sold. Since the seller has the product, while the buyer does not have it, buyer must pay what the seller asks.

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b) A product's market demand curve generally slopes upward and to the right, if the product's price elasticity of demand is very large.

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c) Firm is a price taker in perfect competition.

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d) MR-MC approach to determine firm's equilibrium is better approach than TR-TC approach even though both gives same equilibrium level of output.

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e) A firm's total revenue can be determined by adding the values of MR for each unit sold?

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7.8 SUPPLY CURVES

Supply is the relationship between prices and quantity. Higher the price higher is an incentive to supply goods and services, reflecting a positive relationship between prices and quantity supplied. Thus, the supply curve is an upward slopping curve.

7.8.1 Short-run Supply Curve

In the short-run firms faces time constraint in which they cannot change all their factors of production. Some factors of production will be constant, so firms can only increase output by using variable factors of production more intensively. We have learnt while discussing equilibrium of a firm, that firm will produce till MC becomes equal to prices. We also know that firm under perfect competition is a price-taker, which makes price line horizontal and parallel to quantity axis. So if the firm has to decide how much to produce by equating MC with prices, then MC curve itself would become supply curve. We have also learnt that firm would not produce beyond a point where prices fall below short-run AVC. So portion of MC curve, which lies above minimum AVC (i.e., above the shut down point) in short-run, would become supply curve of the firm.

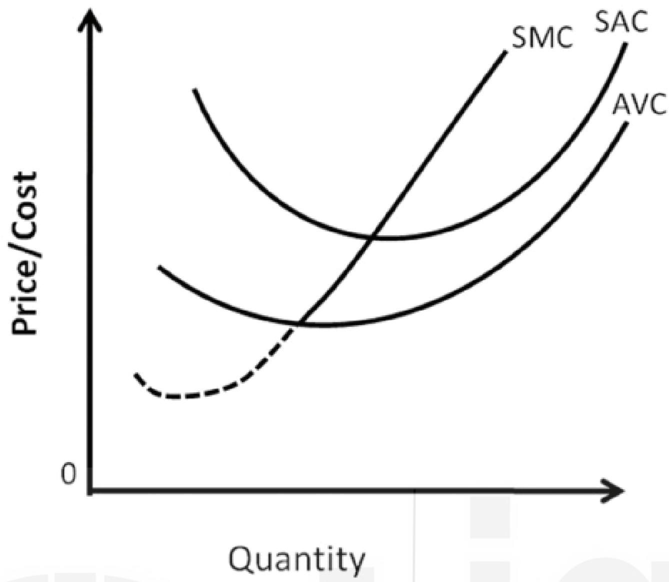

Fig. 7.11: Firm's short run supply curve

Assuming all firms in an industry are homogenous and have identical cost conditions, industry supply curve in the short-run can be derived by horizontally summing up the short run supply curve of all the existing firms. For example, if there are 10 firms operating in the industry, with same cost conditions and each producing 15 units of goods at price P_1, then industry supply at this price would be 15×10 = 150 units. Similarly, if at price P_2 each firm is producing 20 units, then industry supply will be 200 units. In this way we can determine industry supply at various prices (Refer Fig. 7.12).

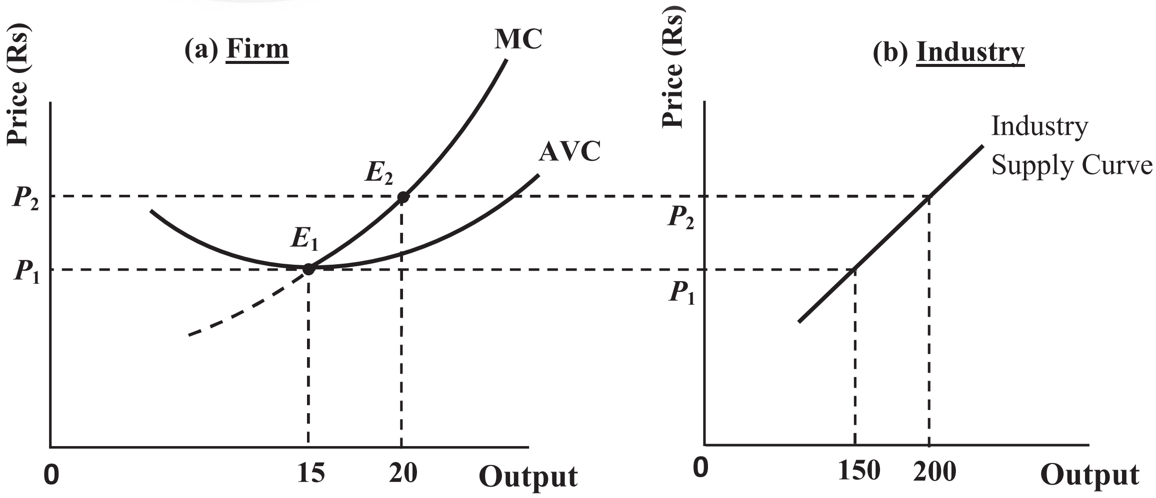

Fig. 7.12: Industry's Short-run supply curve derived by horizontally summation of individual firm supply curve

Example 3

Consider a firm in a competitive industry with the following short-run total cost (STC) curve, STC = $30Q^2 + 5Q + 300$. Assuming there are 120 such firms in the industry, derive

a) a typical firm's short-run supply curve;

b) Industry's short-run supply curve.

Solution

a) Short-run total cost curve given is composed of both, the variable cost and the fixed (or sunk) cost. Therefore, from the given STC, we have,

   Total variable cost (TVC) = $30Q^2 + 5Q$ and Total fixed cost (TFC) = 300

   Now, Average variable cost (AVC) = $\frac{TVC}{Q} \Longrightarrow AVC = \frac{30Q^2+5Q}{Q} \Longrightarrow AVC = 30Q + 5$

   Also, Short-run Marginal cost (SMC) = $\frac{d(STC)}{dQ} \Longrightarrow 60Q + 5$

   We just recalled— a firm's short-run supply curve is its SMC above the minimum point of AVC. Thus, we first find the minimum point of AVC, a point where SMC = AVC.

   Therefore, $60Q + 5 = 30Q + 5 \Longrightarrow Q = 0$.

   At Q = 0, minimum AVC is given by, 30(0) + 5 = 5.

   Putting value of minimum AVC in equation of SMC, we get the firm's short run supply curve S(P)— a function of price P, given by

$$\begin{cases} \frac{P-5}{60}, P \geq 5 \\ 0, \ \ 0 \leq P < 5 \end{cases}$$

b) Given 120 firms in the industry, Industry supply curve, for $P \geq 5$ will be given by $120 \times S(P) \Longrightarrow 120\left(\frac{P-5}{60}\right) = 2P - 10$.

7.8.2 Long-run Supply Curve

In long-run firms can change all its factors of production to vary level of output produced. We have learnt that firms in long-run would be in equilibrium at minimum point on the long-run average cost (LRAC) curve. We also know that Long-run marginal cost (LMC) curve passes through minimum point of LRAC. Firm equates MC with prices to determine its equilibrium, so in the long run firms would be producing only at one point where LRAC = LMC.

We cannot derive the long-run supply curve of the industry by horizontally summing up the existing firms output, because of the following reasons:

1) Firms in long-run produces only at one point *i.e.,* minimum of LRAC where LRAC= LMC. So entire LMC does not constitute long-run supply curve of firm.

2) The number of firms in long run does not remain fixed because of entry and exit of firms depending upon price and demand conditions.

3) With the increase in size of the industry, in the long-run, cost curves shifts because of external economies and diseconomies.

External economies accrue to the firm, if expansion in the supply of industry shifts cost curves downward. Shifting of cost curves downwards means that each level of output can be produced at lower cost. External economies can arise due to:

a) If the skill enhancement of workers takes place due to expansion in industry's output.

b) Better and efficient technology is used with the expansion in supply.

c) With the development of auxiliary industry, cost falls.

d) Betterment and improvement in knowledge leads to reduction in cost, etc.

External diseconomies accrue to the firm, when increase in the industry's output leads to upward shift in cost curves, indicating increase in cost of production for each level of output. One of the most important factors, which may lead to external diseconomies, is increase in prices of factors of production due to their increased demand with the expansion in output.

If external economies are greater than external diseconomies, then industry would experience net external economies. If net external economies prevail in the industry then it is known as decreasing cost industry.

If external diseconomies are greater than external economies then industry would experience net external diseconomies. If net external diseconomies prevail in the industry then it is known as increasing cost industry.

If external economies are exactly equal to external diseconomies then advantages from one are balanced out by disadvantages from other, leading to no change in cost conditions. When there is no change in cost curves even when there is expansion of supply in the industry, it is known as constant cost industry.

Therefore supply curve of an industry in long run will have different shape and slope depending upon type of industry.

- If there is increasing cost industry then its supply curve would be upward sloping.
- If there is decreasing cost industry then its supply curve would be downward sloping.
- If there is constant cost industry then its supply curve would be horizontal to quantity axis.

Let us try to understand these theoretical concepts using numerical example.

Example 4

The demand curve and long-run supply curve for cars cleaning in the local market are:

QD = 1,000 – 10P and QS = 640 + 2P. The long-run cost function for a cars cleaning business is: $C(q) = 3q^2$. The long-run marginal cost function is: MC(q) = 6q. If the cars cleaning business is competitive, calculate the optimal output for each firm. How many firms are in the local market? Is the car cleaning industry an increasing, constant, or decreasing cost industry?

Solution

To determine optimal firm output, we first must calculate the market price. To do so we set market demand equal to market supply and solve for price. That is:

$$Q^D = 1{,}000 - 10P = Q^S = 640 + 2P \Longrightarrow P = 30.$$

At this market price, 700 cars will be cleaned. Since the industry is competitive, we know the firms are price takers and will set their marginal costs equal to the market price. This gives us:

$$MC\ (q) = 6q = 30 \Longrightarrow q = 5.$$

Given each firm is cleaning 5 cars per period and there are a total of 700 cars cleaned each period in the market, there must be 140 firms. Since each firm's average costs are:

$$AC\ (q) = \frac{3q^2}{q} = 3q$$

Any increase in output raises the firm's average cost. Thus, each firm has increasing costs. Also, since the market supply curve is upward sloping in the long run, as output expands in the long run the industry is an increasing price industry.

Check Your Progress 3

1) Differentiate between external diseconomies and external economies of scale.

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2) Explain the shape of the long-run supply curve of a constant cost and increasing cost industry under perfect competitive market structure.

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3) Derive short-run supply curve of a firm under perfect competition.

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4) The demand for pizzas in the local market is given by: $Q^D = 25{,}000 - 1{,}500P$. There are 100 pizza firms currently in the market. The long-run cost function for each pizza firm is:

$$C(q, w) = \frac{10}{7}wq.$$

Where w is the wage rate pizza firms pay for a labour hour and q is the number of pizzas produced. The marginal cost function for each firm is:

$$MC(q, w) = \frac{10}{7}w.$$

If the current wage rate is Rs. 7 and the industry is competitive, calculate the optimal output of each firm given each firm produces the same level of output. Do you anticipate firms entering or exiting the pizza industry? Suppose that the wage rate increases to Rs. 8.40. Calculate optimal output for each of the 100 firms. Do you anticipate firms entering or exiting the pizza industry? What happens to the market output of pizzas with the higher wage rate? What happens to the market price for pizza?

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7.8 LET US SUM UP

We began the present unit by revising the features of a perfect competitive market structure. In a perfect competitive industry, a firm is a price-taker, so that it adjusts the quantity of output at the market determined price level. The quantity of output produced by the firm is determined by the profit maximisation objective of that firm. By profit we simply mean the amount received in excess of the amount spent in carrying out the production process. We came across two concepts of profit— accounting and economic profit. Accounting profit is total revenue less explicit costs. Economic profit on the other hand is total revenue less explicit as well as implicit costs. We saw how profit maximisation by a firm in a perfect competition entails zero economic profits.

We proceeded further in the unit by introducing the concept of a profit function. A profit function exhibits a relationship of maximum profit at various combinations of the prices of both the input and the output. Derivation of the function involved discussion about both, the short-run and the long-run profit maximisation conditions.

We proceeded further in the unit with the two approaches of profit maximisation under a perfect competitive market structure— TC-TR and MC-MR approach. TR-TC approach tells us that firm would maximise profit at a level of output where gap between TR and TC would be largest. MR-MC approach tells us that firm would maximise profit at an output level where MR = MC.

Subsequently, equilibrium conditions, both for the firm and the industry, in the long-run and in the short-run, were discussed along with some mathematical treatment. Perfectly competitive firm would be in short-run equilibrium at an output level where MR = MC and slope of MC is greater than slope of MR. Whereas, in the long-run perfectly competitive firm would be in equilibrium at a level of output where P = MC and P = AC *i.e.*, condition which closes all opportunities of entry or exit by any firm. Perfectly competitive industry would be in short-run equilibrium when (i) short-run demand and supply is equal in the industry and, (ii) all firms must be in equilibrium simultaneously. In the long-run, perfectly competitive industry would be in equilibrium if demand and supply in the industry are equal, all firms are simultaneously in equilibrium and there is no more entry or exit by the firms indicating zero economic profit.

By highlighting shut down and break-even points we derive the supply curve in short-run and long-run for firms and industries. In the short-run, portion of MC curve above AVC curve serves as the supply curve of the firm. Industry's supply curve in the short-run is derived by horizontally summing up the supply curves of all the existing firms in the industry. In the long-run, supply curve of an industry will have different shapes and slopes depending upon whether an industry is increasing cost, decreasing cost or constant cost industry. Finally, we concluded the unit by examining the role of external economies and external diseconomies and their impact on slope of supply curve for industry in long-run.

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7.11 ANSWERS OR HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Refer Section 7.3 and answer.

2) $-2Q^2 + 292Q - 200$

   Hint: Profit function = TR – TC, where TR = P×Q = $300Q - 2Q^2$ and TC = 200 + 8Q.

3) Refer Sub-section 7.4.2 and answer.

   Hint: Fall in w will decrease the slope of isoprofit line so that the tangency of new flatter isoprofit line will occur towards the right of steeper isoprofit line associated with higher w, implying a rise in labour factor employment and hence higher output production.

4) a) Factor demand function is given by, $L^* = 150 - \frac{w}{2P}$

   Hint: Derive it using First-order condition for profit maximisation, given by $\frac{\partial \pi}{\partial L} = 0 \implies P f'(L^*) = w$.

   b) Profit function is given by, $\left(150P - \frac{w}{2}\right)\left(150 - \frac{w}{2P}\right)$

   Hint: Substitute factor demand function $L^* = 150 - \frac{w}{2P}$ in the equation used for deriving the profit function, given by Pf (L) – wL.

5) Profit function is given by $P\left[\frac{(0.4P)^4}{w^2r^2}\right] - 2\frac{(0.4P)^5}{w^2r^2}$

   Hint: Refer Sub-section 7.4.4 and derive the function.

Check Your Progress 2

1) See Sub-section 7.6.1 and Sub-section 7.6.2.
2) See Sub-section 7.7.1
3) See Sub-section 7.7.2
4) a) Equate supply to demand to get Q.

   $40 - 0.25Q = 5.0 + 0.05Q$

   Q = 116.7 (hundreds of meters per month)

   P = 40 − 0.25(116.7) = Rs.10.825/meter

   b) The typical firm produces where MC equals P.

   $MC = -20 + 4q$

   q = 7.71 (hundreds of meters per month)

   c) The profit rate is as follows:

   TR = PQ = (10.825)(7.71) = 83.461

$TC = 100 - 20(7.71) + 2(7.71)^2 = 64.69$

Profit = Rs. 18.77 hundreds / month

5) a) C= Rs. 2510 and MC = $\frac{dC}{dx} = 0.01\times3x^2 + 250$ = Rs. 253.

Hint: x is monthly output in thousands of units, hence for 10,000 units, x = 10.

b) $MC = 0.03x^2 + 250 = 298 \Longrightarrow x = 40$

Total cost $C = 0.01\times(40)^3 + 250 \times 40$ = Rs. 10,640

c) $AR = \frac{R}{x} = 1500 - 2x$ and $MR = \frac{dR}{dx} = 1500 - 4x$

d) $MR = 1500 - 4x = 1100 \Rightarrow x = 100$. Hence, firms' monthly output is 1,00,000 units.

Monthly revenue = $1500 \times 100 - 2 \times (100)^2$= Rs. 1,30,000

e) $\pi = TR - TC$

$= 1500x - 2x^2 - 0.01x^3 - 250x$

$= 1250x - 2x^2 - 0.01x^3$

Marginal profit function = $\frac{d\pi}{dx} = 1250 - 4x - 0.03x^2$

f) $\frac{d\pi}{dx} = 1250 - 4x - 0.03x^2 = 0$

$x = \frac{-4 \pm \sqrt{16 - 4\times0.03 \times -1250}}{2 \times 0.03}$ = 148 approx.

Hence, the output required per month is 148000 units.

The profit at this level of output= Rs. 108774.08

g) MR =Rs. 908

MC =Rs.907.12 approx or around Rs. 908.

Hence, MR = MC at this level of output.

6) a) False, b) False, c) True, d) True, e) True

Check Your Progress 3

1) See Sub-section 7.8.2

2) See Sub-section 7.8.2

3) See Sub-section 7.8.1

4) To determine the optimal output of each firm in a competitive industry, we know each firm will set their marginal cost to the market price. In this case, the marginal cost is constant at Rs. 10. Thus, the market price must be Rs. 10. At this price, 10,000 pizzas are demanded. Since there are 100 firms in the industry and they divide the industry output equally, each firm is producing 100 pizzas each period. The average cost per pizza in the long-run is equivalent to the price firms receive, thus, the firms are earning only the normal profit. This implies there is no incentive for firms to enter or exit the industry. If the wage rate rises to Rs. 8.40, the marginal cost of producing a pizza rises to Rs. 12. This implies that in the long-run, the market price of pizza will be Rs. 12. At this price, consumers' quantity demanded of pizzas is 7,000. The optimal output for the 100 firms is 70 pizzas per firm. Since this is also a long-run equilibrium, there is no incentive for firms to enter or exit the industry. At the higher wage rate, the market output of pizzas decline. Also, the market price for pizzas increased by 20% when the wage rate increased by 20%.

UNIT 8 EFFICIENCY OF A COMPETITIVE MARKET

Structure

8.0 OBJECTIVES

After going through this unit, you will be able to:

- get an insight into the concept of Efficiency;
- explain the concept of Pareto Optimality in a General Equilibrium Framework;
- analyse equilibrium attainment through market trade;
- discuss a Competitive or Walrasian equilibrium in an Edgeworth box setting;
- estimate the set of competitive equilibrium prices and allocations;
- get an introduction to the algebra of General Equilibrium and the Walras' law;
- identify the Pareto optimality of a Competitive Equilibrium; and
- describe the two Fundamental theorems of Welfare Economics.

8.1 INTRODUCTION

Central Economic problem revolves around the notion of scarcity which arises when limited resources are rendered to satisfy unlimited wants. The mismatch between needs and means to satisfy those needs exists everywhere. Be it a consumer attempting to maximise his utility constrained by his limited budget, or a producer whose main concern is to maximise profit by minimising costs of production— all aim at attaining maximum gains from the limited resources. This is where originates the concept of Economic Efficiency.

Efficiency in literal sense refers to the process of outcome generation at lowest possible cost. This in turn results when resources are employed in the best possible way without any wastage. In Economics, Pareto optimality and efficiency are often used synonymously. An allocation is referred to as being Pareto optimal/efficient when there exit no alternate allocations which can make someone better off without making someone else worse off. The present unit begins with explaining the concept of Efficiency in a General Equilibrium framework. Subsequently, necessary tools of this framework encompassing the Edgeworth box, Pareto optimal allocation, and market trade leading to achievement of a Competitive Equilibrium, are discussed to explain the mechanism and the outcome of a free market. This theoretical stage is then followed by the algebra of General equilibrium, and later by the Walras' law.

The two bases, one — the concept of Pareto optimality or efficiency and the other — the mechanism of reaching a competitive equilibrium by a free market, will then be combined to establish the notion of "efficiency of a competitive market"— this will then be underlined by the First Fundamental theorem of Welfare Economics. The first fundamental theorem of welfare simply claims— a competitive equilibrium is Pareto efficient. This is equivalent to say, competitive equilibrium results in efficient resource allocation, so that no alternate allocation could enhance gain to someone without harming someone else. Possibility of social undesirability of Pareto optimal allocation also exists. This happens when the justice and fairness in terms of distribution of efficient allocation of resources are brought into consideration. The Second fundamental theorem of Welfare Economics then comes into picture. Under certain assumptions, it separates the goals of Efficiency and Equity, emphasising that a society may achieve any Pareto optimal resource allocation through appropriate initial resources redistribution and free trade.

8.2 THE CONCEPT OF EFFICIENCY

Scarcity of resources is the fundamental economic problem. As a rescue to this problem, Efficiency is concerned with optimal allocation of resources among different economic agents. In absolute terms, a situation can be called economically efficient if and only if— no one can be made better off without making someone else worse off. This is referred to as the Pareto efficient/optimal condition. An efficient condition could also be said to result when it becomes impossible to generate additional output unless amounts of factors employed are increased. In other words, it will not be wrong to say that in an efficient situation, production proceeds at the lowest possible per-unit cost. These statements claiming efficiency are not exactly equivalent, but they all dictate the idea that a system is said to be efficient if nothing more can be achieved given the available resources.

The equilibrium concepts you have used till now in the earlier units, are what is referred to as attainment of equilibrium by way of partial equilibrium analysis. As the name suggests, such equilibrium is achieved in one market holding what occurs in other markets, constant. This assumption would be correct when a market operates in isolation. A scenario of isolation does not exist in the present world. There exist complex interconnections between each market and firm. To get a broad view of the efficiency criterion in case of a competitive market, we will look into the general equilibrium framework. The criteria of efficiency will be discussed, based on which efficiency of a competitive market will be touched upon.

To set the stage for explaining the concept of efficiency in a general equilibrium framework, we will be adopting the following three essential assumptions that will simplify our analysis. Nonetheless, the results are still applicable in a general case.

1) Consumers and producers operate in competitive markets, implying all agents are price takers, and achieve equilibrium, given the prices.
2) There are only two goods which are produced using only two factors of production.
3) There are two consumers, each endowed with a certain quantities of the two goods which they will trade among themselves.

Initially, we will ignore production and will just consider attainment of equilibrium in consumption case. We will assume that the two consumers are each endowed with a certain quantities of the two goods, and then we will examine how they achieve equilibrium through trade with one another. This is what is typically termed a Pure Exchange economy. The approach adopted will be further extended to the efficiency attainment in production case and then to efficient allocation of two goods produced.

8.3 PARETO OPTIMALITY

Recall the concept of Pareto optimality that was introduced to you in Introductory Microeconomics (BECC-101). Named after the economist Vilfredo Pareto, *Pareto Optimality* refers to an economic arrangement where resources are allocated in such a way that there exist no alternative feasible resource allocation which will make one person better off without making someone else worse off. In this context, given a set of alternative allocations of resources, if a change from one allocation to another can make at least one individual better off without making any other individual worse off, it is referred to as *Pareto improvement*. Consequently, an allocation will be Pareto optimal when no further Pareto improvements can be made.

8.3.1 Edgeworth Box and Pareto Optimal/Efficient Allocations

Edgeworth box is a powerful graphical tool in General equilibrium analysis to study the goods trade in the market for attaining efficiency. In order to bring two agents in the market under one roof, it merges their indifference maps by inverting one of the agents ICs. The boxdepicts all possible consumption bundles for both consumers under examination (*i.e.* all feasible allocations), as well as preferences of both the individuals. Consider a hypothetical market situation with two consumers in the economy, A and B and consuming two goods, x and y. Let A's consumption bundle be given by $X_A = (x^A, y^A)$, where x^A denotes A's consumption of good x and y^A, of good y. Similarly, $X_B = (x^B, y^B)$ represents consumption bundle of consumer B. Furthermore, let $\omega_A = (\omega_x^A, \omega_y^A)$ denote an initial endowment bundle of consumer A and $\omega_B = (\omega_x^B, \omega_y^B)$ of consumer B.

Now assume, $\omega_A = (4, 1)$ and $\omega_B = (4, 5)$. An Edgeworth box is given in Fig. 8.1. Height of the box measures the total amount of good y in the economy (here, 6 units) and the width measures the total amount of good x (here, 8 units). Person A's consumption choices are measured from the lower left-hand corner (O_A), and that of person B's from the upper right-hand corner (O_B). Recall that any point inside the Edgeworth box indicates a particular distribution of the two goods among the two individuals. 'W' represents the initial endowment allocation. IC_A and IC_B are the Indifference curves representing preferences of consumer A and B, respectively.

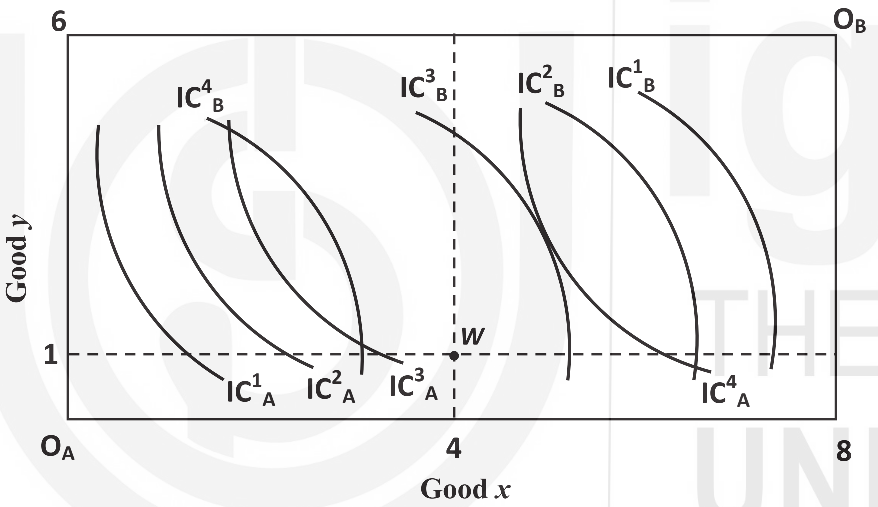

Fig. 8.1: Edgeworth Box

Important:

1) A pair of consumption bundles X_A and X_B is an *Allocation*.
2) An allocation is *feasible* (*i.e.* affordable), if and only if,

$$x^A + x^B = \omega_x^A + \omega_x^B$$
$$y^A + y^B = \omega_y^A + \omega_y^B$$

Now consider Fig. 8.2, notice that ICs of both individuals pass through W (*i.e.* the endowment). This implies that agents A and B are indifferent to their endowment allocation W compared to another points along the ICs passing through it. Further, note that all the consumption bundles to the north-east of the indifference curve that passes through W yield a higher level of utility for agent A.

Similarly, all points to the south-west of the inverted indifference curve passing through W are preferred by agent B. The lens-shaped area (the shaded region) formed by ICs of both the individual passing through W represents a set of allocation bundles that would make both consumer A and B better off compared to their initial endowment. This is what we referred to as the Pareto Improvement. Possibility of Pareto improvement in turn suggests that there can be a possibility of an equilibrium allocation, but will that be a unique one?

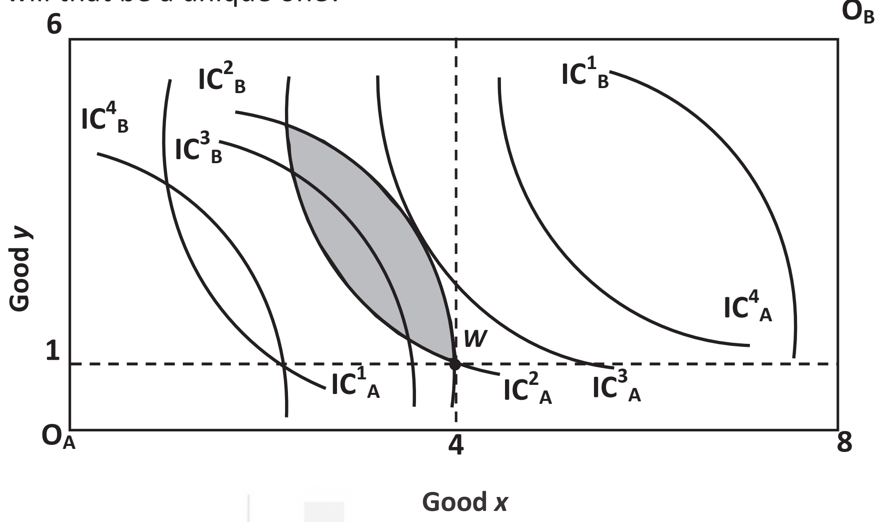

Fig. 8.2: Pareto Improvement Set

Suppose scope of Pareto improvement seizes at point Q (refer Fig. 8.3). It is easy to see that consumer A could achieve it by trading her endowment of good x to consumer B in return for her endowment of good *y*. Such a trade will allow agent A to reach a higher level of utility by consuming more units of good y than he was endowed with. Similarly, consumer B would enjoy higher utility by consuming more of good *x* than the amount he was endowed with. No reallocation from point Q can make one consumer better off without making the other worse off. An allocation of such kind is called *Pareto efficient/optimal* allocation, given the initial endowment bundle W and preferences of both the consumers. At such an allocation, all gains from trade are exhausted.

Notice that at Pareto efficient allocation Q, Marginal Rate of Substitution (MRS) is same for both the consumers. This is represented by the tangency of their respective ICs at Q. This tangency is necessary otherwise it will still be possible for them to trade to another level within the lens-shaped area.

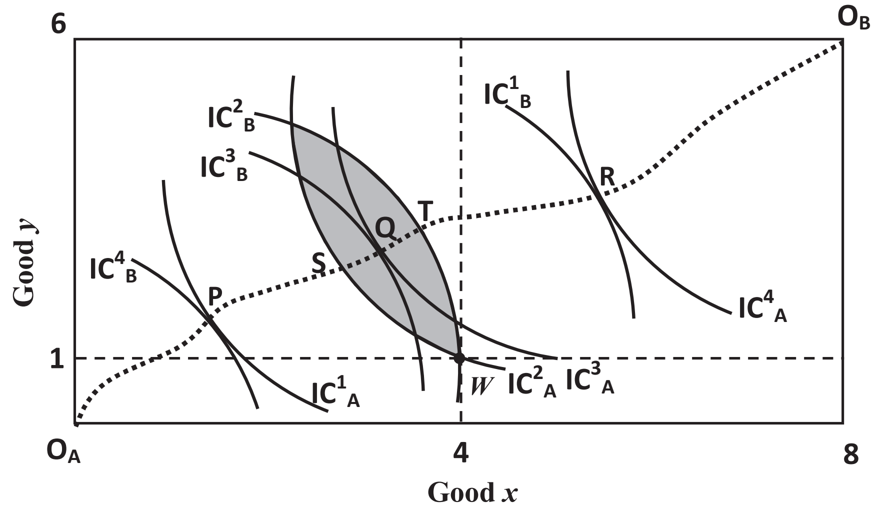

Fig. 8.3: Pareto Optimal Allocation and the Contract Curve

Remember that, Pareto efficient point (Q) is not unique. We attained such an allocation for the given initial endowment W. With change in the endowment, there will be a resultant change in the optimal bundle. Thus, there exists infinite number of efficient points— the set of which is called a *Pareto Set* or the *Contract Curve*(dotted line in Fig. 8.3). A Pareto set is composed of all the possible allocations resulting from mutually advantageous trade from any given endowment. This curve will stretch from A's origin to that of B's. It is a locus of all the points where ICs of the agents will be tangent. Points P, Q, and R, represent three such points.

Please note: For a given endowment (here W), there exists a subset of Pareto set (here, curve ST) inside the lens-shaped region formed by ICs passing through that endowment.

Example 1

Consider two individuals A and B with their preferences represented by the utility function, $U^A = (x^A)\ (y^A)$ and $U^B = (x^B)\ (y^B)^2$, respectively, where x and y are the two goods in the market. The initial endowment of individual A and B are given by $\omega^A = (1, 1)$ and $\omega^B = (2, 1)$, respectively. Compute the Pareto set.

Solution: A Pareto set consist of all those allocations of two goods at which indifference curves of the two individuals are tangent. This implies, a Pareto set is composed of all those allocations at which MRS of individual A and MRS of individual B are equal, *i.e.*, $MRS^A = MRS^B$.

For an allocation to be feasible, we require,

$$x^A + x^B = \omega_x^A + \omega_x^B = 1 + 2 = 3 \quad \Rightarrow \quad x^B = 3 - x^A \qquad \text{(i)}$$

$$y^A + y^B = \omega_y^A + \omega_y^B = 1 + 1 = 2 \quad \Rightarrow \quad y^B = 2 - y^A \qquad \text{(ii)}$$

Pareto Optimality implies, $\quad MRS^A = MRS^B$

$$\Rightarrow -\frac{\frac{\partial U^A}{\partial x^A}}{\frac{\partial U^A}{\partial y^A}} = -\frac{\frac{\partial U^B}{\partial x^B}}{\frac{\partial U^B}{\partial y^B}}$$

$$\Rightarrow -\frac{y^A}{x^A} = -\frac{y^B}{2x^B} \qquad \text{(iii)}$$

From (i), (ii) and (iii), we get, $-\frac{y^A}{x^A} = -\frac{2-y^A}{2(3-x^A)}$

$$\Rightarrow 6y^A - 2x^Ay^A = 2x^A - x^Ay^A$$

$$\Rightarrow \; y^A = \frac{2x^A}{6-x^A}$$ is the required Pareto Set.

8.3.2 Market Trade for Equilibrium Attainment

Now, let us discuss the mechanism to be adopted in order to reach an optimal/efficient allocation (like Q) on the contract curve. Recall the procedure involved for attaining equilibrium by a consumer that we learnt in Unit 2. An individual attains equilibrium when his indifference curve is tangent to his budget constraint. That is, when slope of IC (which is MRS) =

slope of budget constraint [which is the Price ratio$\left(\frac{P_x}{P_y}\right)$, with P_x and P_y being prices of good x and good y, respectively]. We have just learnt— a contract curve is nothing but a locus of all equilibrium allocations so that MRS between two goods (say x and y) is equal among two consumers (say A and B). This equality does not happen at all price ratios, but only at the one where the market clears, i.e. at price ratio $\left(\frac{P_x}{P_y}\right)^*$ so that $MRS^A = MRS^B = \left(\frac{P_x}{P_y}\right)^*$.

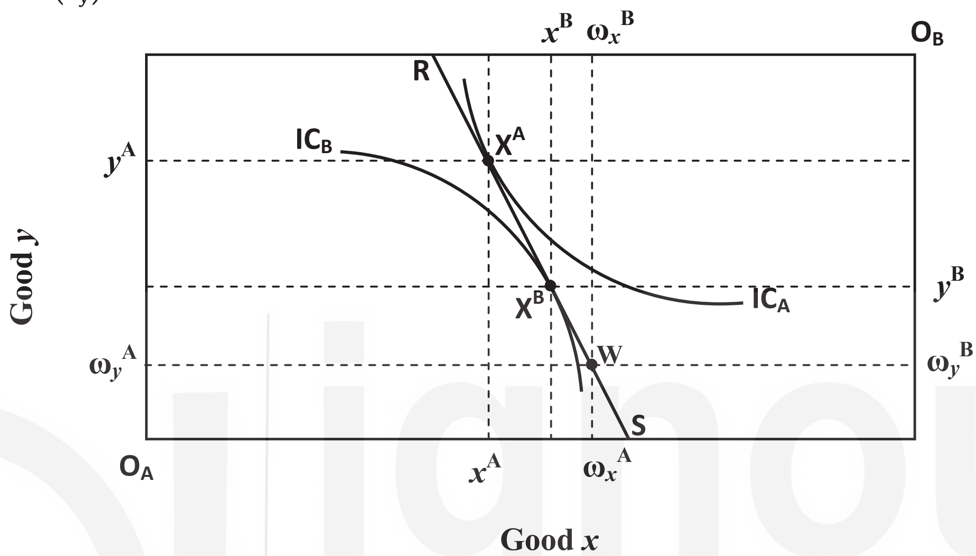

Fig. 8.4: Non-competitive Equilibrium

Consider a market situation represented by an Edgeworth box in the Fig. 8.4. Given the two individuals (A and B), participating in the consumption of two goods (x and y), in order to maximise the utility, represented by their ICs (IC_A and IC_B, for individual A and B, respectively). Let the initial endowment be represented by bundle W = $((\omega_x^A, \omega_y^A), (\omega_x^B, \omega_y^B))$. Budget line RS represents a price ratio $\frac{P_x}{P_y}$ at which both the individual decides to trade with each other. At this price ratio, individual A demands bundle $X^A = (x^A, y^A)$ and individual B demands bundle $X^B = (x^B, y^B)$. As you may notice,

Demand for Good 1 is feasible, only when	$x^A + x^B = \omega_x^A + \omega_x^B$
Demand for Good 2 is feasible, only when	$y^A + y^B = \omega_y^A + \omega_y^B$

In other words, feasibility condition requires, excess demand of individual A (or B) for good i (where i ∈ x, y) must match excess supply of individual B (or A) for that good. But in Fig. 8.4, this is not the case, as excess supply of good x by individual A, denoted by e_x^A (= $\omega_x^A - x^A$) is greater than excess demand for good x by individual B, given by e_x^B (= $x^B - \omega_x^B$). Similar situation exists for good y. Hence, the above situation depicts a situation of Disequilibrium in the exchange market.

Symbolically, $x^A + x^B \neq \omega_x^A + \omega_x^B$ and $y^A + y^B \neq \omega_y^A + \omega_y^B$.

Check Your Progress 1

1) Explain the concept of Economic Efficiency? Is it same as Pareto optimality?

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2) In a two-good two-individual economy, two individuals A and B are represented by identical Cobb-Douglas utility function $U_i = x_i^{1/3} y_i^{2/3}$, where i ∈ (A, B), and x and y are the two goods in the market. The initial endowment of individual A and B are given by $\omega^A = (1, 2)$ and $\omega^B = (2, 1)$, respectively.

   a) Draw an Edgeworth box for this economy, and mark the Endowment bundle.

   b) Compute the Pareto Set.

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3) "A non-competitive equilibrium is inefficient," elucidate this statement with the help of appropriate diagram.

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8.4 COMPETITIVE EQUILIBRIUM

In Fig. 8.4, there is disequilibrium in the market due to presence of excess demand for good y and excess supply for good x. The prices in the above market need to be recalibrated to the point where aggregate demand for a good equals its aggregate supply, *i.e.* when amount of a good demanded by one individual is exactly equal to the amount supplied by the other. Only then, the market is in a *Competitive Equilibrium*. This equilibrium is also called *Walrasian Equilibrium*.

In Edgeworth box setting, a competitive equilibrium results when ICs of both the individuals become tangent to each other at the ongoing price ratio. This happens on the contract curve, at the price ratio which equilibrate the trade for utility maximisation, given the initial endowment. One such equilibrium is given by point E in Fig. 8.5, where the budget line through the endowment point passes through the tangency of the ICs of the two individuals A and B. Point E ensures that both individuals attain maximum utility by reaching their highest possible IC through trade, given their initial endowment bundle W. Trade leading to equilibrium outcome happens at a unique price ratio $\left(\frac{P_x}{P_y}\right)^*$ given by the slope of the budget line passing through common tangency point and the initial endowment bundle W.

Thus at equilibrium, the following must be true:

$$MRS^A = MRS^B = \left(\frac{P_x}{P_y}\right)^* \text{ or } \frac{MU_x{}^A}{MU_y{}^A} = \frac{MU_x{}^B}{MU_y{}^B} = \left(\frac{P_x}{P_y}\right)^*$$

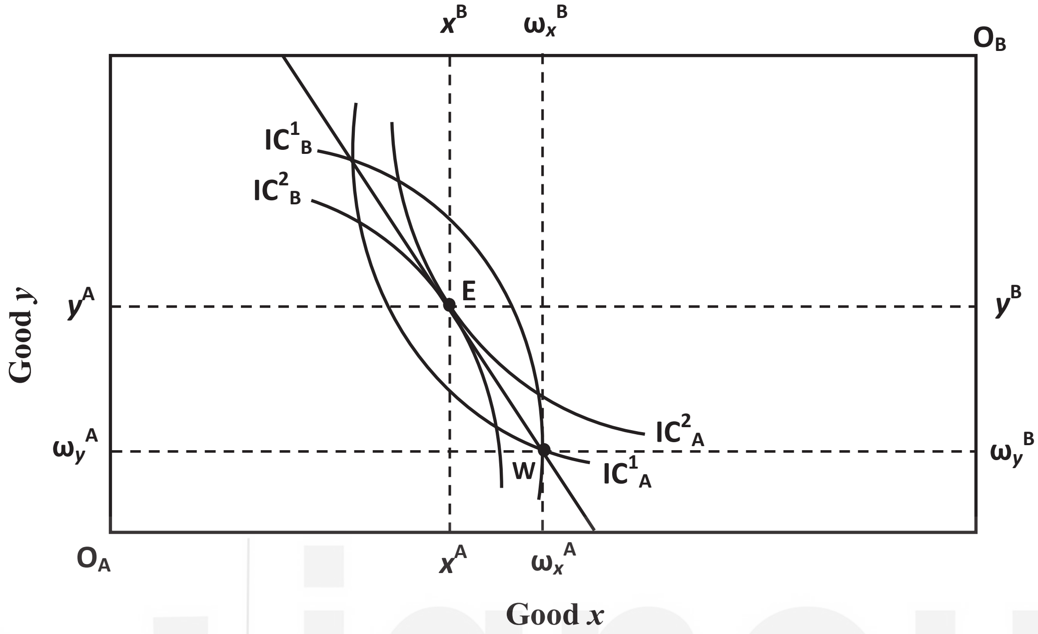

Fig. 8.5: Competitive Equilibrium

Note:

A price ratio $\left(\frac{P_x}{P_y}\right)$ and an allocation given by $[(x^A, y^A), (x^B, y^B)]$ is a competitive equilibrium if the following condition holds:

I) Each consumer is maximising his/her utility given his/her budget set, and

II) The demand for and the supply of each good are equal, *i.e.* markets clear.

Example 2

Consider the same market situation we considered above in example 1, with two individuals A and B. Given their utility functions and endowments same as was there in Example 1, find the competitive equilibrium in this economy.

Solution: Given the utility functions, we need to first ascertain the demand functions of both the agents for goods x and y. Assume income as M, and P_x and P_y be the prices of good x and goody, respectively. Let $P_x = 1$ (i.e., we are considering good x to be a numeraire good)*.

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* Let A be any individual with his initial endowment bundle for good x and y as ($\omega_x{}^A$, $\omega_y{}^A$). Let consumption bundle at P_x and P_y, (i.e.at the prices of good x and good y), be (x^A, y^A) respectively. Then, Budget constraint faced by this individual will be given by: $P_x x^A + P_y y^A = P_x \omega_x{}^A + P_y \omega_y{}^A$, where $P_x \omega_x{}^A + P_y \omega_y{}^A$ represents income of the individual. Notice that proportional increase in prices (P_x and P_y) leave no effect on this budget constraint, implying only the price ratio $\left(\frac{P_x}{P_y}\right)$ matters here. This allows us to normalise the price of any one good to 1, which then become the numeraire good. Another explanation to why we consider the assumption of a numeraire good is given under the Sub-section 8.5.2.

Demand functions of individual A for two goods x and y will be given by the solution of the following constrained optimisation problem:

Maximise $U^A = (x^A)\,(y^A)$

subject to $M^A = P_x \times x^A + P_y \times y^A$

We employ the Lagrange approach to solve the above optimisation problem:

$$\mathcal{L} = (x^A)\,(y^A) + \lambda\,(M^A - P_x x^A - P_y y^A)$$

The First order (or necessary) conditions will result in:

$$\frac{\partial \mathcal{L}}{\partial x^A} = 0 \Longrightarrow (1)(x^A)^0\,(y^A) = \lambda P_x \Longrightarrow y^A = \lambda P_x \quad (1)$$

$$\frac{\partial \mathcal{L}}{\partial y^A} = 0 \Longrightarrow (1)(x^A)\,(y^A)^0 = \lambda P_y \Longrightarrow x^A = \lambda P_y \quad (2)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = 0 \Longrightarrow M^A = P_x x^A + P_y y^A \quad (3)$$

From Equations (1) and (2), we get

$$P_y y^A = P_x x^A \quad (4)$$

From Equations (3) and (4), we get

$$M^A - P_x x^A = P_x x^A$$

$\Longrightarrow x^A = \frac{1}{2}\frac{M^A}{P_x}$, which is the demand function of individual A for good x. (5)

From (3) and (5), we get the demand function of individual A for good y as $y^A = \frac{1}{2}\frac{M^A}{P_y}$.

Similar approach can be applied for finding the demand functions of individual B for good x and y, which will be given by $x^B = \frac{1}{3}\frac{M^B}{P_x}$ and $y^B = \frac{2}{3}\frac{M^B}{P_y}$, respectively.

Now we solve for the competitive equilibrium:

In Equation (5), M^A is the income of individual A, which can be ascertained from the value of his endowment bundle $(\omega_x^A, \omega_y^A) = (1, 1)$,

i.e., $M^A = (\omega_x^A)\,P_x + (\omega_y^A)\,P_y = 1 + P_y$ 6)

As we assumed $P_x = 1$, from Equations (5) and (6) we get,

$$x^A = \frac{1}{2}(1 + P_y) \quad 7)$$

Similarly, demand function of individual A for good y will become:

$$y^A = \frac{1}{2}\frac{M^A}{P_y} = \frac{1}{2}\left(\frac{1+P_y}{P_y}\right) \quad 8)$$

Demand functions of individual B for good *x* and good y, with $M^B = (\omega_x^B)\,P_x + (\omega_y^B)\,P_y = 2 + P_y$, where $(\omega_x^B, \omega_y^B) = (2,1)$, will be:

$$x^B = \frac{1}{3}\frac{M^B}{P_x} = \frac{1}{3}(2 + P_y) \text{and } y^B = \frac{2}{3}\frac{M^B}{P_y} = \frac{2}{3}\left(\frac{2+P_y}{P_y}\right) \qquad 9)$$

A competitive equilibrium price ratio will result in a price ratio $\left(\frac{P_x}{P_y}\right)$ at which market clears, *i.e.*, aggregate demand for a good equals the aggregate supply of that good (which is nothing but the endowment of that good).

Thus, at equilibrium, in case of good x,

$$x^A + x^B = \omega_x^{\ A} + \omega_x^{\ B}$$

$$\frac{1}{2}(1 + P_y) + \frac{1}{3}(2 + P_y) = 3 \qquad [\because \omega_x^{\ A} + \omega_x^{\ B} = 3]$$

$$P_y = \frac{11}{5}$$

From this, we can ascertain equilibrium allocation using the demand functions given by Equations (7), (8) and (9):

$$x^A = \frac{8}{5}, \quad y^A = \frac{8}{11}, x^B = \frac{7}{5} \text{ and } y^B = \frac{14}{11}$$

Competitive equilibrium price ratio $\left(\frac{P_x}{P_y}\right)^*$ will be given by $\left(\frac{5}{11}\right)$, and competitive equilibrium allocation bundle will be given by $\left[\left(\frac{8}{5},\frac{8}{11}\right),\left(\frac{7}{5},\frac{14}{11}\right)\right]$.

Check Your Progress 2

1) Explain the concept of a Walrasian equilibrium with the help of an Edgeworth box.

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2) In a two-good two-individual economy, two individuals A and B are represented by identical Cobb-Douglas utility function $U_i = x_i^{1/3} y_i^{2/3}$, where i∈(A, B), and x and y are the two goods in the market. The initial endowment of individual A and B are given by $\omega^A = (1, 2)$ and $\omega^B = (2, 1)$, respectively. Find Competitive equilibrium price ratio and goods allocation of this economy.

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8.5 GENERAL EQUILIBRIUM AND WALRAS' LAW

8.5.1 Algebra of General Equilibrium

Market economies are composed of a complex dynamic system of different economic agents, making supply and demand decisions over different commodities or factor types in order to maximise their own interests. General Equilibrium theory advocates that such pursuit of private interest by all the economic units with different motivations, integrated through a system of free markets, will result in an efficient/optimal allocation of goods and services in the economy. By General equilibrium it is meant simultaneous equilibrium in all the markets, that is, the prevalence of equilibrium in the economy as a whole. A General Equilibrium results in an array of prices for all goods so that supply equals demand simultaneously for each good in the economy. We establish the algebra of such equilibrium below:

Assuming two commodities (x and y) and two agents (A and B) in the economy, then a typical array of prices is given by a two-dimensional vector such as (P_x, P_y). Let the demand function for agent A be $x^A(P_x, P_y)$ and $y^A(P_x, P_y)$ for commodity x and commodity y, respectively. Similarly for agent B will be given by $x^B(P_x, P_y)$ and $y^B(P_x, P_y)$; further their endowment bundle be (ω_x^i, ω_y^i), where $i \in \{A, B\}$.

General Equilibrium in the economy would be established by a price vector (P_x^*, P_y^*), so that Aggregate Demand = Aggregate Supply, for each commodity. That is,

$$x^A(P_x^*, P_y^*) + x^B(P_x^*, P_y^*) = \omega_x^A + \omega_x^B \text{ and}$$

$$y^A(P_x^*, P_y^*) + y^B(P_x^*, P_y^*) = \omega_y^A + \omega_y^B$$

The above equation can be arranged in terms of Excess demand functions for the two agents:

$$[x^A(P_x^*, P_y^*) - \omega_x^A] + [x^B(P_x^*, P_y^*) - \omega_x^B] = 0 \text{ and} \qquad (10)$$

$$[y^A(P_x^*, P_y^*) - \omega_y^A] + [y^B(P_x^*, P_y^*) - \omega_y^B] = 0 \qquad (11)$$

Where, $[x^A(P_x^*, P_y^*) - \omega_x^A]$ is the excess demand for commodity x by agent A, similarly $[x^B(P_x^*, P_y^*) - \omega_x^B]$ is the excess demand for commodity x by agent B. Equation (10) simply says, equilibrium calls for the sum of the excess demands for commodity x by both the agents to sum to zero. In other words, at equilibrium, one agent's demand for a good must equal another agent's supply of that good. This is another way of looking at the condition of feasibility of the demand for a commodity. Equation (11) can be interpreted in a similar way.

Above equations can also be presented as follows:

$$e_x^A(P_x, P_y) + e_x^B(P_x, P_y) = 0$$

Where $e_x^A(P_x, P_y) = [x^A(P_x^*, P_y^*) - \omega_x^A]$ and $e_x^B(P_x, P_y) = [x^B(P_x^*, P_y^*) - \omega_x^B]$. Similarly, for commodity y, Equation becomes

$$e_y^A(P_x, P_y) + e_y^B(P_x, P_y) = 0$$

Further let $e_x^A(P_x, P_y) + e_x^B(P_x, P_y) = z_x(P_x, P_y)$ and $e_y^A(P_x, P_y) + e_y^B(P_x, P_y) = z_y(P_x, P_y)$, then General Equilibrium condition can be stated more precisely as:

$$z_n(P_x, P_y) = 0 \text{ , where } n \in \{x, y\}$$

8.5.2 Walras' Law

Walras' Law is given by:

$$P_x z_x(P_x, P_y) + P_y z_y(P_x, P_y) \equiv 0$$

The law simply says that for all prices (and not just the equilibrium prices) the value of aggregate excess demand is identically zero. The proof of the law is as follows:

Feasibility of demand by agent A requires:

$$P_x x^A(P_x, P_y) + P_y y^A(P_x, P_y) \equiv P_x \omega_x^A + P_y \omega_y^A$$

$$\Longrightarrow P_x [x^A(P_x, P_y) - \omega_x^A] + P_y [y^A(P_x, P_y) - \omega_y^A] \equiv 0$$

$$\Longrightarrow P_x e_x^A(P_x, P_y) + P_y e_y^A(P_x, P_y) \equiv 0 \qquad 12)$$

Similar equation holds for feasibility of demand by agent B:

$$P_x e_x^B(P_x, P_y) + P_y e_y^B(P_x, P_y) \equiv 0 \qquad (13)$$

Adding Equations (12) and (13), we get

$$P_x e_x^A(P_x, P_y) + P_y e_y^A(P_x, P_y) + P_x e_x^B(P_x, P_y) + P_y e_y^B(P_x, P_y) \equiv 0$$

$$\Longrightarrow P_x [e_x^A(P_x, P_y) + e_x^B(P_x, P_y)] + P_y [e_y^A(P_x, P_y) + e_y^B(P_x, P_y)] \equiv 0$$

$$\Longrightarrow P_x z_x(P_x, P_y) + P_y z_y(P_x, P_y) \equiv 0 \text{ (the } \textit{Walras' Law}\text{)}$$

Significance of the Walras' law— Given that a set of prices bring equilibrium in any one of the markets (let say in market for good x), then as per Walras' law the remaining markets (here market for good y) would be necessarily in equilibrium. In other words, the law claims that if demand equals supply in one market then the same must be true for the other market as well.

From the identity of the law $P_x z_x(P_x, P_y) + P_y z_y(P_x, P_y) \equiv 0$, if $z_x(P_x, P_y) = 0$, that is, if market for good x is in equilibrium so that supply equals the demand for good x. Given that both P_x and P_y are positive, for the identity of Walras' law to hold true, then $z_y(P_x, P_y)$ must also equal 0. It turns out that if demand equals supply in all but one market, i.e. in (n−1) markets, then demand must equal supply in the n^{th} market as well. This has an added advantage to it, for an economy with n goods, one of the prices can be chosen as numeraire price (a price relative to which all the other prices are measured), leaving the need to find only (n−1) relative equilibrium prices. This becomes possible from the Walras' law identity that states all markets would be in equilibrium for any set of prices. This is to say, if markets are in equilibrium at a price vector $(P_1, P_2, P_3, \ldots P_n)$, then for any constant $k \in R^+$ (set of positive real numbers), markets will remain in equilibrium for a price vector $(kP_1, kP_2, kP_3, \ldots kP_n)$. Now, if we take $k = (1/P_n)$ then P_n becomes the numeraire price which will then result in a price vector of (n−1) relative equilibrium prices, given by $\left(\frac{P_1}{P_n}, \frac{P_2}{P_n}, \frac{P_3}{P_n}, \ldots 1\right)$.

8.6 THE EFFICIENCY OF COMPETITIVE EQUILIBRIUM

On combining Pareto Optimality (Section 8.3) and Competitive Equilibrium (Section 8.4) conditions, efficiency of a competitive equilibrium can be verified. In a competitive equilibrium, the amount supplied of a good equals the amount demanded. This eliminates the scope for further gains from trade or any reallocation— which is nothing but the condition that needs to hold for an efficient allocation. Competitive equilibrium E in Fig. 8.5 is efficient with each individual A and B reaching the highest possible IC given their initial endowment W, so that neither A nor B can be made better off without making the other individual worse off. A general proof verifying efficiency of a competitive equilibrium is as follows:

Consider the similar situation that we have been considering so far, of a two good (x and y) and two individuals (A and B), with initial endowment W = $[(\omega_x^A, \omega_y^A), (\omega_x^B, \omega_y^B)]$. Further let trade at price ratio $\rho = \left(\frac{P_x}{P_y}\right)$leads to competitive equilibrium bundle E = $[(x^A, y^A), (x^B, y^B)]$.

Now, suppose equilibrium bundle E is not Pareto efficient. This would mean that there exists an alternate allocation which will be strictly preferred by A and B to (x^A, y^A) and (x^B, y^B), respectively. Let it be given by$[(x_a^A, y_a^A), (x_a^B, y_a^B)]$. That is,

For individual A, $(x_a^A, y_a^A) \succ (x^A, y^A)$

For individual B, $(x_a^B, y_a^B) \succ (x^B, y^B)$

The preferred allocation must be feasible, that is,

$$x_a^A + x_a^B = \omega_x^A + \omega_x^B \text{ and } y_a^A + y_a^B = \omega_y^A + \omega_y^B \quad (14)$$

Now, since individual A prefers (x_a^A, y_a^A) to (x^A, y^A), and given that at price ratio $\rho = \left(\frac{P_x}{P_y}\right)$ he opted for (x^A, y^A), then at ρ, bundle (x_a^A, y_a^A) must be unaffordable for A. This implies

$$P_x x_a^A + P_y y_a^A > P_x \omega_x^A + P_y \omega_y^A \quad (15)$$

The above equation simply means that the money value of bundle (x_a^A, y_a^A) at the given price ratio exceeds the money value of bundle (x^A, y^A) opted by A at that price ratio. Similarly for individual B the following relation will hold:

$$P_x x_a^B + P_y y_a^B > P_x \omega_x^B + P_y \omega_y^B \quad (16)$$

Adding (15) and (16), we get

$$P_x x_a^A + P_y y_a^A + P_x x_a^B + P_y y_a^B > P_x \omega_x^A + P_y \omega_y^A + P_x \omega_x^B + P_y \omega_y^B$$

$$P_x(x_a^A + x_a^B) + P_y(y_a^A + y_a^B) > P_x(\omega_x^A + \omega_x^B) + P_y(\omega_y^A + \omega_y^B) \quad (17)$$

Using Equation (14), the LHS of Equation (17) becomes

$$P_x(\omega_x^A + \omega_x^B) + P_y(\omega_y^A + \omega_y^B) > P_x(\omega_x^A + \omega_x^B) + P_y(\omega_y^A + \omega_y^B)$$

This is an inconsistency as both the right hand side and left handside of the above inequality are actually the same. This logical inconsistency implies that the presumption of allocation $[(x_a^A, y_a^A), (x_a^B, y_a^B)] \succ [(x^A, y^A), (x^B, y^B)]$ cannot be true. This gives us the following important theorem.

8.6.1 The First Fundamental Theorem of Welfare Economics

As per First Fundamental Theorem of Welfare Economics, all competitive equilibria or Walrasian equilibria are Pareto Efficient. The theorem claims that a competitive equilibrium will exhaust all gains from trade so that an efficient allocation is attained from any given initial endowment. This theorem confirms to the result of the classical theory, *viz.* the Adam Smith's "invisible hand" hypothesis, as per which invisible hand of the market forces of demand and supply will achieve most efficient level of production, consumption and distribution of good in the society. First fundamental theorem of welfare economics supports the case for "free markets" or "*Laissez-faire*", where there exists no control by the government on production or consumption that may interfere with the free market. Only when the market mechanism fails to achieve an efficient resource allocation (which is the case of market failure resulting from monopoly, externalities, or public goods), the government intervention is justified.

However, the First Fundamental theorem — which talks about the Pareto efficiency of a competitive equilibrium — says nothing about equity or fairness of the resulting efficient resource allocation among the agents of a society. Pareto efficiency merely indicates that no one can be made better off without making someone else worse off, it gives no consideration to the distributive effects of the resultant efficient allocation. The point to note here is— Laissez-faire may produce many different Pareto optimal outcomes, with some being fairer than others, so that not all of them may be equally desirable by the society. For instance, the outcome in which one individual A has all the units of commodity x in a single commodity market is Pareto efficient, since there will be no way to make some other individual better off without making A worse off. But such an optimal allocation may not be equitable or socially desirable. This is where the need for rectifying the distributional inequities of Laissez-faire comes. Now we proceed towards a socially desirable Pareto optimum solution, with an approach which is converse to that of the first fundamental theorem of welfare economics, *i.e.*, we are considering the allocation problem from efficiency to equilibrium. Given Pareto Efficient equilibrium, as long as individual preferences are convex, there exists a set of prices at which this equilibrium becomes competitive or Walrasian equilibrium. This is known as the Second Fundamental Theorem of Welfare Economics which we further explain below.

8.6.2 The Second Fundamental Theorem of Welfare Economics

The second fundamental theorem of welfare economics suggests that the issues of efficiency and equity are distinct, and that they can be addressed simultaneously. As per this theorem, any socially desirable optimal allocation can be reached by way of the market mechanism modified with the help of lump-sum transfers. Assuming all agents (individuals and producers) are self-interested price takers, then as per Second Fundamental Theorem of Welfare Economics, almost any Pareto optimal equilibrium can be achieved through the competitive mechanism, provided appropriate lump-sum transfers (which do not change the agents' behaviour) are made among agents.

Consider Fig. 8.6 below, where we have two Pareto efficient allocations E and E′. If it is felt that equilibrium E′ is somehow better in terms of being more fair or just than equilibrium E, then a lumpsum transfer of good X from individual A to B and simultaneously a transfer of good Y from B to A, changing the endowment from W to W′, can be made. The price system can then be allowed to generate a Pareto efficient outcome E′, given the new endowment W′. Thus, as per the second welfare theorem— given all agents have convex preferences, after an appropriate assignment of endowments through redistribution, a society may achieve any Pareto efficient resource allocation as competitive equilibrium, that is, through market mechanism.

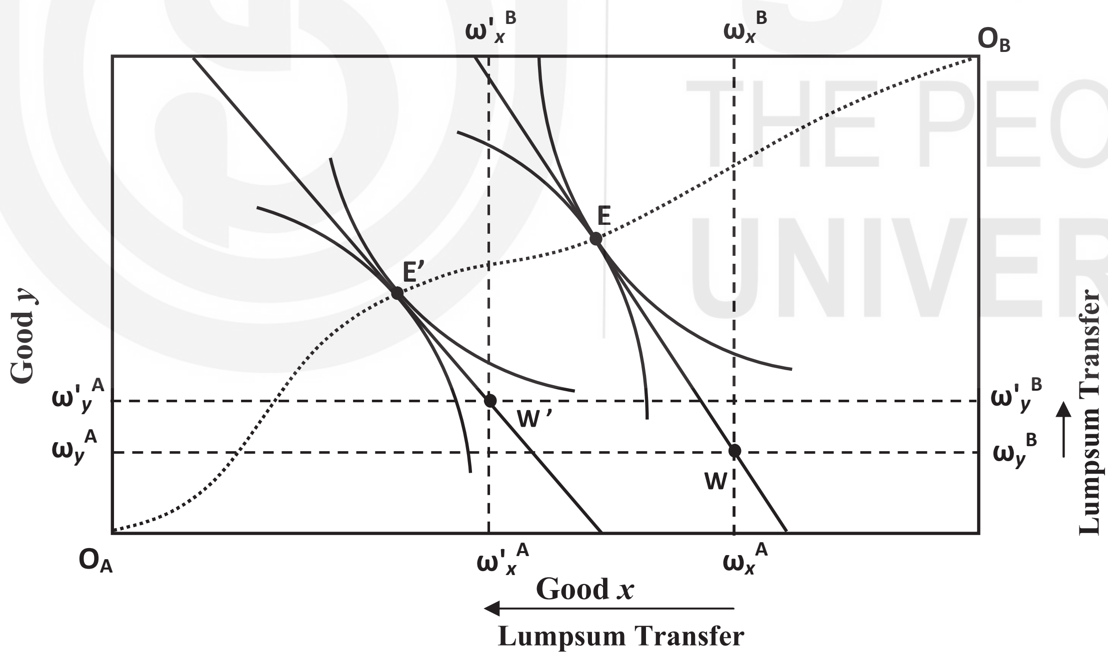

Fig. 8.6: Second Fundamental Theorem of Welfare Economics

Check Your Progress 3

1) a) State and prove the Walras' Law.

b) In an economy consisting of five markets dealing in five different commodities, determination of relative equilibrium prices in just four markets will suffice as an overall general equilibrium. Briefly explain this claim with reference to the Walras' law.

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2) Walrasian equilibrium is Pareto optimal, do you agree? Answer with appropriate proof for your claim.

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3) The Second Fundamental Theorem of Welfare Economics treats the concepts of efficiency and equity distinctly. Explain.

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8.7 LET US SUM UP

Efficiency or Pareto optimality is the situation of maximum outcome with minimum costs. In economic theory, Pareto optimality is attained when it becomes impossible to make someone better off without making someone else worse off. Such a condition is a characteristic feature of a Competitive or a Walrasian equilibrium. The present unit explained this feature within a General Equilibrium framework, where free market trade resulted in a Pareto optimal/ efficient competitive equilibrium.

We used the tools like an Edgeworth box, to explain the condition for Pareto Optimality and the market trade mechanism, in order to arrive at competitive equilibrium. It was followed by the algebra of General equilibrium, which was then followed by the Walras' law. Subsequently, a formal algebraic proof was provided to establish that competitive equilibrium is Pareto optimal/ efficient. This was further demonstrated in terms of efficiency and equity by the First and the Second Fundamental theorems of Welfare Economics.

8.8 ANSWERS OR HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Economic Efficiency refers to a state of optimal allocation of scarce resources among different economic agents. Yes, both Pareto Optimality and Economic efficiency mean the same. They both refer to reaching a best possible allocation of scarce resources, so that no

reallocation can make someone better off without making someone else worse off.

2) a) Refer Section 8.3 and draw.

b) Pareto set is given by $x_a = y_a$ or $x_b = y_b$.

Hint: Refer Example 1 under Sub-section 8.3.1. A Pareto set is composed of all those allocations at $MRS^A = MRS^B$. Here, $MRS^A = \frac{1}{2}\frac{y_a}{x_a}$ and $MRS^A = \frac{1}{2}\frac{y_b}{x_b}$.

3) Refer Sub-section 8.3.2 and answer.

Check Your Progress 2

1) Refer Section 8.4 and answer.

2) $x_a = y_a = \frac{5}{3}$ and $x_b = y_b = \frac{4}{3}$, and equilibrium price ratio $\left(\frac{P_x}{P_y}\right)^* = \frac{1}{2}$.

Hint: Refer Example 2 under Section 8.4 and answer. Demand functions of each individual for each good will be given by: $x^A = \frac{1}{3}\frac{M^A}{P_x}$; $y^A = \frac{2}{3}\frac{M^A}{P_y}$; $x^B = \frac{1}{3}\frac{M^B}{P_x}$; $y^B = \frac{2}{3}\frac{M^B}{P_y}$. These can then be solved to find the equilibrium price ratio and the associated quantity demanded of each good.

Check Your Progress 3

1) a) Refer Sub-section 8.5.2 and answer.

b) This is true, that for an economy of five markets, estimation of relative equilibrium prices of just four markets will be adequate for determining an overall general equilibrium. This claim is based on the Walras' Law identity: $P_x z_x(P_x, P_y) + P_y z_y(P_x, P_y) \equiv 0$, which holds true for any price vector and not just equilibrium price vector. That is, if all the five markets are in equilibrium at a price vector given by $(P_1, P_2, P_3, P_4, P_5)$, then they will also be at equilibrium at a relative price vector given by $\left(\frac{P_1}{P_5}, \frac{P_2}{P_5}, \frac{P_3}{P_5}, \frac{P_4}{P_5}, 1\right)$. Thus, relative equilibrium prices of just four markets will then be required to be estimated for overall general equilibrium.

2) Refer Section 8.6 and answer.

3) Refer Sub-section 8.6.2 and answer.

8.10 REFERENCES

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KEY WORDS

Average Cost Function	:	Derived by dividing cost function with the output level, average cost function determines per unit minimum cost of producing a specific level of output, given the per unit factor prices.
Average Revenue (AR)	:	TR per unit of goods and services is AR, which is determined by dividing TR with total output.
Break-even	:	Level of output where TR = TC or AR = AC and Economic profits are zero or firm is earning normal profits.
Completeness	:	For all available alternative bundles A and B, the consumer should be able to make a categorical statement as to whether he regards A to be at least as good as B, B to be at least as good as A, or both. That means our consumer does not suffer from lack of information.
Consumer Surplus	:	A measure of consumer's benefit, it is given by the difference between the amount the consumers are willing and able to pay for a good or service and the amount that they actually pay.
Compensating Variation	:	As a monetary measure of utility change, it tells us how much money should be given to the individual to compensate him or her for the price change.
Constant Returns to Scale (CRS)	:	When all factors of production are increased in a given proportion, output increases in exactly the same proportion.
Capital Deepening Technical Progress	:	Technical progress is capital-deepening (or capital using) if along line on which K/L ratio is constant, $MRTS_{LK}$ increases.
Concave Function	:	A function f(x) is said to be concave on an interval if, for all *a* and *b* in that interval, $f(ta + (1-t)b) \geq t f(a) + (1-t) f(b)$ for $t \in [0,1]$.
Conditional Factor Demand Functions	:	A function of factor prices and output, specifying cost minimising levels of factors employed to produce a specific level of output at the given per unit factor prices.
Constrained Optimisation	:	It is the process of finding the optimal values of certain variables, that is,

		optimising them with respect to one or a series of constraints.
Cost Function	:	It is given by, C (w, r, Q*) = L*(w, r, Q*) w + K* (w, r, Q*) r. A function of factor prices and output, cost function gives the minimum cost of producing a specific level of output (Q*), given the per unit factor prices (w and r).
Cost Minimisation	:	A basic rule determining the optimal mix of factors to produce a specific level of output at the least cost.
Convex Function	:	A function f(x) is said to be convex on an interval if, for all *a* and *b* in that interval, f (t a + (1 − t) b) ≤ t f (a) + (1 − t) f (b) for t ∈[0,1].
Contract Curve	:	It is a set of all Pareto optimal allocations of resources among two economic agents in the Edgeworth box.
Discrete Good	:	A good available only in discrete amounts, i.e. 1,2,3….. etc.
Decreasing Returns to Scale (DRS)	:	When all factors of production are increased in a given proportion, output increases proportionately less than inputs.
Equivalent Variation	:	As a monetary measure of utility change, it tells us how much money should be taken away from the individual at the original price to have the equivalent effect on his utility as that of a price change.
Expected Utility	:	Expected utility of an event having two or more possible outcomes occurring with some probabilities, is a weighted average of the utilities of each of its possible outcomes (with respective probabilities as weights).
Expected Value	:	It is the average value that a random variable takes, given the probability of occurrence of each value.
Elasticity of Technical Substitution	:	Given by the ratio of proportionate change in factor-proportions (or input ratios) to the proportionate change in marginal rate of technical substitution.
Expansion Path	:	A locus of efficient (or minimum cost) factor combinations, given by the tangency between the isoquant curves and the isocost lines, for different output levels.

Equilibrium : Equilibrium indicates state of balance. Firm is said to be in equilibrium when it has no incentive to change its level of output.

External Diseconomies : External diseconomies accrue to the firm, when increase in the industry's output leads to upward shift in cost curves, indicating increase in cost of production for each level of output.

External Economies : External economies accrue to the firm, if expansion in the supply of industry shifts cost curves downward, i.e., reduces cost for each level of production.

Efficiency : It is the state resulting in maximum possible outcome from employment of minimum possible inputs.

Edgeworth Box : A tool of General equilibrium analysis, it is used to analyse market trade between two economic agents trading in two different commodities.

Firm : A Unit which employs factors of production to produce goods and services.

Gamble : A game of chance or an event with uncertain outcomes.

General Equilibrium : A simultaneous equilibrium situation in all the markets of the economy. *Please note*: General Equilibrium is also sometimes referred to as the Competitive or Walrasian Equilibrium.

Homogenous Function : A function f (x) is homogenous of degree k if $f(tx) = t^k f(x)$ for all $t > 0$.

Homothetic Function : A monotonic transformation of a Homogeneous function. $f(x)$ is homothetic if and only if $f(x) = g(h(x))$ where $h(\,.\,)$ is homogenous of degree 1 and $g(\,.\,)$ is a monotonic function.

Homogenous : Identical in all respects.

Indifference : If a consumer finds bundle A to be at least as good as bundle B and bundle B to be at least as good as bundle A, he is said to be showing indifference between A and B.

Indifference Curve : A locus of all the bundles that give equal level of utility or satisfaction to the consumer.

Indifference Map	:	A set of indifference curves in the commodity space.
Intertemporal Budget Constraint	:	Budget constraint that an individual faces when he has to make decision over two or more time periods. As per it lifetime consumption equals lifetime income.
Intertemporal Decision-making	:	When decision is made across the time periods.
Intertemporal Preferences	:	Preferences of an individual over bundles of intertemporal consumption, that is, preference for consumption in different time periods.
Isoquants	:	Isoquants are contour lines representing all those input combinations which are capable of producing the same level of output.
Isocost Line	:	This shows all the different combinations of two inputs that a firm can purchase or hire with given input prices and budget.
Increasing Returns to Scale (IRS)	:	When all factors of production are increased in a given proportion, output increases proportionately more than inputs.
Long-run Production Function	:	Technical relationship showing maximum output that can be produced by a set of inputs, assuming quantities of all inputs vary.
Linear Homogeneous Production Function	:	Homogeneous production function of first degree implies that if all factors of production are increased in a given proportion, output also increases in the same proportion. This represents the case of constant returns to scale.
Labour Deepening Technical Progress	:	Technical progress is labour-deepening if, along a radial through the origin (with constant K/L ratio), $MRTS_{LK}$ increases.
Long-run Cost Function	:	Given by, C_L (W, Q) =W X (W, Q), it gives the minimum cost of producing a specific level of output, given the factor prices, in the long-run, that is when all the factors become variable.
Long Run	:	It is a production period in which all factors of production (inputs) can be changed to increase output. None of the inputs will remain fixed.

Marginal Rate of Substitution	:	The rate at which the consumer can substitute one commodity for the other in his/her consumption bundle without changing the utility, or while remaining on the same indifference curve.
Marshallian Demand Curve	:	Marshallian demand curve gives the quantity of good demanded by a consumer at each price, given the income or wealth situation, and assuming all the other factors impacting demand for a good as constant.
Marginal Rate of Technical Substitution (MRTS)	:	MRTS is the rate at which one input can be substituted for another input with the level of output remaining constant.
Marginal Cost Function	:	Derived as a partial derivative of the cost function with respect to the output level, marginal cost function determines minimum addition to the total cost from producing an additional unit of output.
Marginal Cost (MC)	:	Change in Total cost (TC) incurred when there is very small change in quantity (Q) produced, which is determined by dividing change in TC with change in Q.
Marginal Revenue (MR)	:	Change in TR when there is very small change in quantity (Q) sold, which is determined by dividing change in TR with change in Q.
Market	:	Any medium through which buyers and sellers interact to exchange their goods and services.
Non-Discrete Good	:	Also called continuous goods, such goods can be purchased and sold in any amounts, like 0.1, 1.1, 1.5, …etc., and not just in discrete amounts.
Numeraire Good	:	A good in terms of which the prices of all the other goods are expressed. The price of such a good then becomes Re. 1. For example, consider two goods X and Y, with their prices being Rs. 5 and Rs. 10, respectively. If good X is to be considered as a numeraire good, then price of good Y will be Rs. 2X.
Neutral Technical Progress	:	Technical progress is neutral if it increases the marginal product of both factors by same percentage so that $MRTS_{LK}$ (along any radial) remain constant.

Normal Profit	:	It is minimum amount of profit that entrepreneurs are seeking to invest their resources in production. It is their transfer earning which indicates their returns from opportunity cost.
Output Elasticity	:	It measures responsiveness of output to change in quantity of a factor (or input). For a production function, Q = f (L), output elasticity is given by: $\frac{\%\text{ change in } Q}{\%\text{ change in } L}$.
Probability Distribution	:	It is a schedule representing values a random variable takes, along with their probability of occurrence.
Perfectly Elastic Demand	:	Even if there is negligible change in prices, quantity would change by very large amount.
Pareto Optimality	:	An efficient allocation of resources, so that no further reallocation could make someone better off without making someone else worse off.
Pareto Improvement	:	It is referred to the reallocation of resources making at least one individual better off without making someone else worse off.
Quasi-linear Preferences	:	Preferences represented by the utility function of the form, U(x, y) = y + v(x), where y and x are the two goods, and *v*(*x*), a function of good x. Such preferences are called quasi-linear because the utility function is linear in one good (y) and non-linear in the other (x).
Reflexivity	:	Consumer has fully reflected on available choices, has no confusion, he does not waver in his assessment of any bundle A, that is, he does not end up regarding bundle A as inferior to itself.
Reservation Price	:	It is the limit to the price of a good or a service. From buyer's point of view it is the maximum price that a buyer is willing to pay; and from seller's point of view, it is the minimum price that a seller is willing to accept for selling a good or service.
Risk Aversion	:	A person who is not ready to take risk is called a risk averse individual and this behaviour is termed as risk aversion.

Risk Neutrality : A person who neither likes nor dislikes risk is called a risk neutral individual and this behaviour is called risk neutrality.

Risk Preference : Completely opposite to risk aversion is risk preference, where an individual prefers to take risk.

Strict Preference : If a consumer finds bundle A to be at least as good as bundle B but B is not at least as good as bundle A, he is said to be not indifferent between bundles A and B. Here, he strictly prefers bundle A over B.

Short-run Production Function : Technical relationship showing maximum output that can be produced by a set of inputs, assuming quantity of at least one of the inputs kept constant.

Short-run Cost Function : Given by, C_S (W, Q, X_F) =W_V X_V (W, Q, X_F) + $W_F X_F$, it gives the minimum cost of producing a specific level of output, given the factor prices, in the short-run, that is when there exist some fixed and some variable factors of production.

Short Run : It is a production period in which all factors of production (inputs) cannot be changed to increase output. Some inputs remain fixed.

Shut down : It is level of output where AR is equal to the minimum Average Variable Cost (AVC) and losses are equal to total fixed cost.

Super Normal Profit : It is also known as Economic profit, that is, firms are earning more than normal profit or greater than their opportunity cost.

Scarcity : It refers to the fundamental economic problem arising from the fact that resources are limited but society's demand for them is unlimited.

Transitivity : This property amounts to expecting consumer to be consistent in his choices. If bundle A is at least as good as B and bundle B is at least as good as C, then bundle A should be at least as good as C.

Total Revenue (TR) : TR is total proceeds from the sale of quantities of the product in the market. TR is determined by multiplying quantity with prices.

Uncertainty : It simply means lack of certainty, that is, when probability of occurrence of an event is not 1. Certain events occur with probability 1.

Von Neumann-Morgenstern Theorem	:	In decision theory, the von Neumann-Morgenstern utility theorem shows that, under certain axioms of rational behaviour, a decision-maker faced with risky (probabilistic) outcomes of different choices will behave as if he or she is maximising the expected value of some function defined over those outcomes. This function is known as the von Neumann-Morgenstern utility function.
Weak Preference	:	Whenever a consumer finds bundle A to be at least as good as bundle B, we say, he has weakly preference for bundle A over B.
Walras' Law	:	Aggregate value of the excess demands across all the markets must equal zero. This implies, for general equilibrium to exist in a market economy— excess demand in any one market must be matched by an equal value of excess supply in some other market or markets.

SOME USEFUL BOOKS

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4) *Pindyck, Robert S. and Daniel Rubinfield, and Prem L. Mehta (2006), Micro Economics, An imprint of Pearson Education*
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