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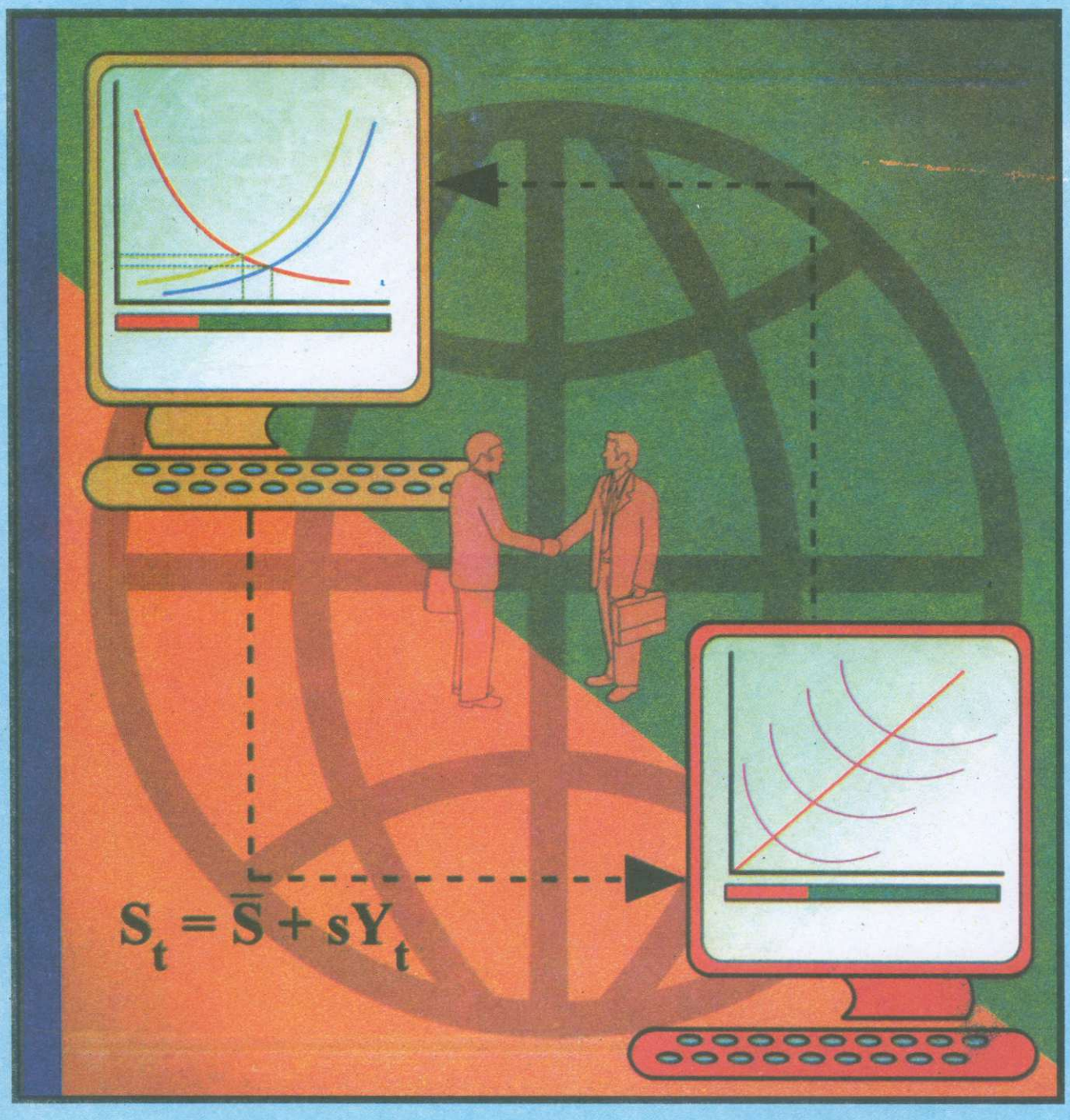
MEC - 101
MICROECONOMIC ANALYSIS



Price and Output Determination 3

"शिक्षा मानव को बन्धनों से मुक्त करती है और आज के युग में तो यह लोकतंत्रा की भावना का आधार भी है। जन्म तथा अन्य कारणों से उत्पन्न जाति एवं वर्गगत विषमताओं को दूर करते हुए मनुष्य को इन सबसे ऊपर उठाती है।"

- इन्दिरा गाँधी

"Education is a liberating force, and in our age it is also a democratising force, cutting across the barriers of caste and class, smoothing out inequalities imposed by birth and other circumstances."

- Indira Gandhi

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MEC-101
Microeconomic Analysis

Block

3

PRICE AND OUTPUT DETERMINATION

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BLOCK 3 PRICE AND OUTPUT DETERMINATION

Introduction

In this block, we discuss price and output determination in two extreme forms of market, viz., perfect competition and monopoly. It may be useful to note that these two markets are idealised structures with the features that are rarely encountered in the real world. A closer approximation to such theorisation of the market behaviour is that of monopolistic completion as well as oligopoly, which exhibits the features of both. Therefore, we include it in this block to demonstrate the contrasting decision marketing processes.

Unit 7 highlights the features of perfect competition and extends the discussion to price and output determination in it. We deliberate that neither the producer nor consumer has any control over the price of a commodity in this market. In contrast, the market structure where the producer decides the price of product is presented in **Unit 8**. The features of a pure monopoly market are discussed along with welfare loss that is witnesses in it. In the next unit of block, i.e., **Unit 9** we take up the output and price decisions in the presence of both competition and imperfection. The market under monopolistic competion is formulated where producers strive to differentiate their products from of their rivals and resort to selling costs like advertisement to draw customers. Extending the presentation a similar structure with few producers engaged production of close substitutes but deciding the prices and quantity of production after the inclusion of rivals' decisions we introduce the oligopoly market in **Unit 10**. Consequently, determination of output and price different from extreme market structures of perfect completion and pure monopoly is analysed in the block.

UNIT 7 PERFECT COMPETITION

Structure

7.0 Objectives

7.1 Introduction

7.2 Perfect Competition

- 7.2.1 Short-run Equilibrium of Firm
- 7.2.2 Supply Curve of Firm and Industry
- 7.2.3 Short-run Equilibrium of Industry
- 7.2.4 Long-run Equilibrium of Firm and Industry

7.3 Let Us Sum Up

7.4 Key Words

7.5 Some Useful Books

7. 6 Answers or Hints to Check Your Progress

7. 7 Exercises

7.0 OBJECTIVES

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

- understand the market structure under perfect competition;
- the short-run and long-run equilibrium of the firm; and
- derive the price and output determination in such a market.

7.1 INTRODUCTION

A perfectly competitive market is assumed to have the following characteristics:

1) There are numerous buyers and sellers in the market, such that no single agent has the power to affect the market price. Thus, both the parties are price-takers.
2) The products sold in the market are identical.
3) There is perfect information among the buyers regarding price and output.
4) Any firm can enter the industry without incurring a cost. The resources can also freely move across the sectors. In other words, there is no entry barrier.

Each firm in this model is a profit maximiser. As the firms are price takers in the market, their decision variable is executed through output. Being price takers, they face an infinitely elastic market demand curve and can sell unlimited amount of output at that price.

7.2 PERFECT COMPETITION

We have already discussed the behaviour of consumers, demand analysis, cost and production. Next, the market structure may be taken up that comprises

perfect competition, monopoly, monopolistic competition, oligopoly and duopoly. As the market refers to a place or location where a product, is exchanged for money between sellers and buyers, a producer may be a price taker in a structure of perfect competition. Features of a perfectly competitive have been seen above. Let us discuss the process of attaining equilibrium in the market and see how a producer becomes a price taker in such a market.

7.2.1 Short-run Equilibrium of Firm

As the firms under perfect competition are all identical, we can consider any one firm to represent the rest.

Let q = quantity of output produced by the firm

C (q) = cost function

p = price per unit of the product

Π = profit.

Given these variables, the profit function of the firm would be,

$$\Pi = TR - TC = pq - C(q) \text{ and}$$

to maximise it we differentiate $\prod$ with respect to q and set the derivative equal to zero,

$$\partial\Pi/\partial q = p - \partial C/\partial q = 0$$

or, p = MC (the marginal cost)

Under perfect competition, a firm would produce up to that level of output where p equals MC. As the marginal revenue (MR) is equal to p, we have P = MC = MR at the profit maximising level of output

Diagrammatically we can represent these conditions as follows:

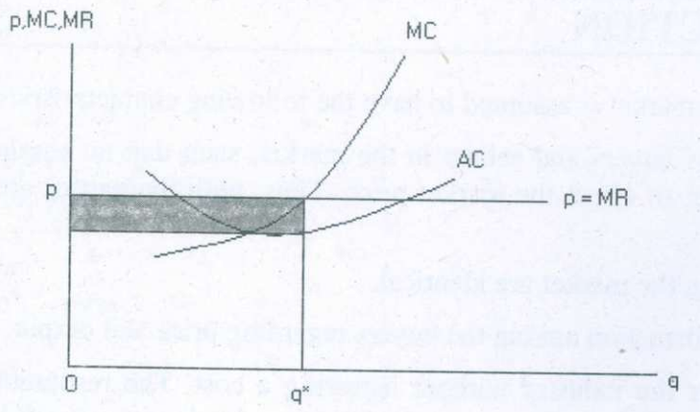

Fig. 7.1: Short-run Equilibrium of Firm

In the diagram, AC represents the short-run average cost curve of the firm and MC the marginal cost. MC intersects AC at the latter's minimum point. Given the price, p, MR and AR curves are given by the horizontal price line. The equilibrium point of the firm is the point where the MC curve cuts the price line. Dropping a perpendicular from the intersection point to the horizontal axis, we get the equilibrium output oq*. The shaded region represents the profit accruing to the firm with oq* level of output.

The point of intersection of MR and MC gives the stable equilibrium point. For any point other than q^* the firm would go back to the equilibrium output level. For a $q < q_*$, MC < MR, so that q would rise and for any $q > q_*$, MC > MR, q would fall.

In the short-run, the firm would make a profit given by the shaded area. This will be true for all the firms, because the firms are all identical.

Check Your Progress 1

1) What kind of a demand curve does a firm under perfect competition face?

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2) What is the short-run equilibrium condition for a firm under perfect competition?

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3) Prove that for a given price, p = AR = MR.

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7.2.2 Supply Curve of Firm and Industry

For a given price, the firm will produce only that much of output where MR = MC. Therefore, MC curve lying above the average variable cost (AVC) would give the supply curve of the firm. The portion of MC lying below the AVC would not represent the supply curve because in that region the firm would shut down. The reason for it is shown with the help of the following proof :

Suppose p< AVC

pq < (AVC)q

TR < TVC

TR < TC - TFC

TC – TR > TFC

the loss incurred by the firm is greater than the total fixed cost, so that if the firm shuts down, it will have to incur only the fixed cost.

Supply Curve of the Firm

Diagrammatically, the supply curve of the firm would be given by the rising part of the MC curve lying above the AVC curve. Below the AVC curve the supply curve would coincide with the vertical axis. Therefore, the supply curve would be broken one as shown in Figure 7.2.

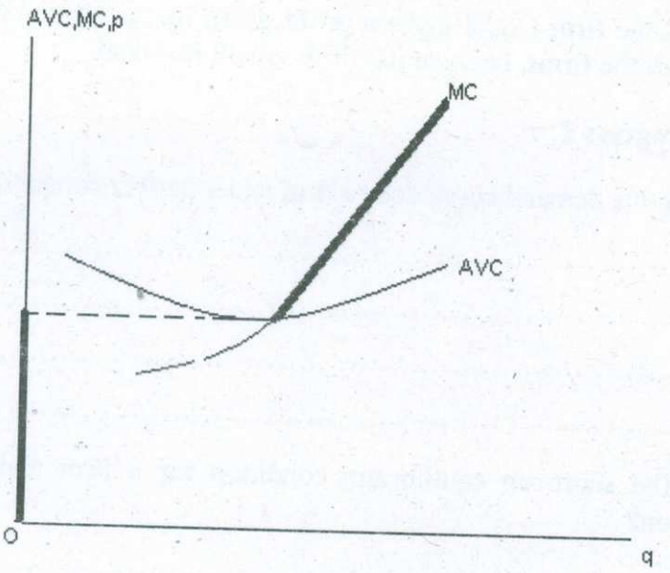

Fig.7.2: Supply Curve of the Firm

Mathematical Representation

Let the cost function of the i^{th} firm be $C = C_i(q_i)$

The marginal cost, $MC = \partial C_i(q_i)/\partial q_i = C_i'(q_i)$

Given the market price (p) the supply function of the firm is given by,

$S_i = s_i(p)$ for $p \geq \min AVC$

$= 0$ for $p < \min AVC$

The aggregate supply function or the supply function of the industry is given by

$S = \sum S_i(p) = S(p)$

Check Your Progress 2

1) What gives the supply curve of the firm?

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2) Why do we consider the portion of the MC above the AVC curve to represent the supply curve of the firm?

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Supply Curve of Industry

The industry supply can be obtained by summation of the supply of all the firms. Therefore, the industry supply would be,

$S = \Sigma\, q_i(p)$ over all N firms, where $i = 1,2,\ldots N$

If the firms are all identical then $q_i(p)$ is the same for all. Assuming $q_i = q$, total industry supply would be $S = N.q$

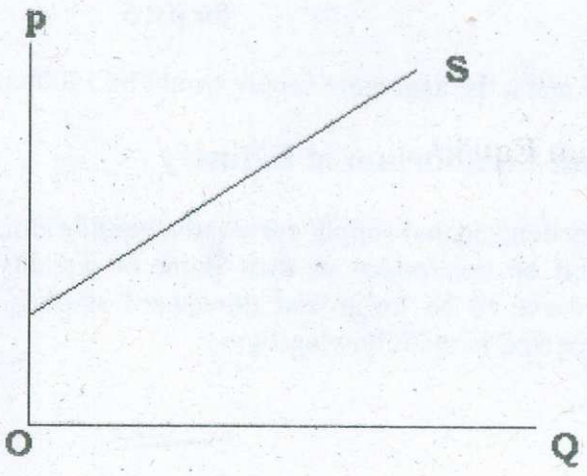

Fig.7.3: Supply Curve of the Industry

The industry supply curve S implies the summation of all the individual supply curves of the existing firms in the market.

A Numerical Example

Let the total cost curve be $C_i = 0.1q_i^3 - 2\,q_i^2 + 15\,q + 10$

Then , $MC_i = 0.3q_i^2 - 4q_i + 15$

Setting $MC_i = p$, we have,

$p = 0.3q_i^2 - 4q_i + 15$

This is a quadratic equation in q_i, therefore,

$q_i = [4 + (10+1.2p)]/0.6 \quad [4 - (10+1.2p)]/0.6$

The individual firm's supply function is relevant for all $p \geq$ minimum AVC.

The AVC function is $AVC_i = 0.1q_i^2 - 2q_i + 15$

The minimum point on the AVC is located by taking derivative with respect to q_i and setting the derivative equal to zero, as shown below

$d(AVC_i)/dq_i = 0.2q_i - 2 = 0$

Therefore, $q_i = 10$.

Substituting $q_i = 10$ in the AVC function we get,

minimum AVC = 5.

Therefore, the firm supply function is

$S_i = [4 \pm (1.2p - 2)]/0.6]$ for $p \geq 5$

$= 0$ for $p < 5$

If the industry consists of 100 identical firms, the aggregate supply function is

$S = 100 \times [4 \pm (1.2p - 2)]/0.6$ for $p \geq 5$

$= 0$ for $p < 5$

At a price of 22.5 units, the aggregate supply would be 1500 units.

7.2.3 Short-run Equilibrium of Industry

Given the industry demand and supply curves, the equilibrium price and output in the market will be determined at their point of equality. Assuming the market demand curve to be linear and downward sloping, the equilibrium condition is represented in the following figure:

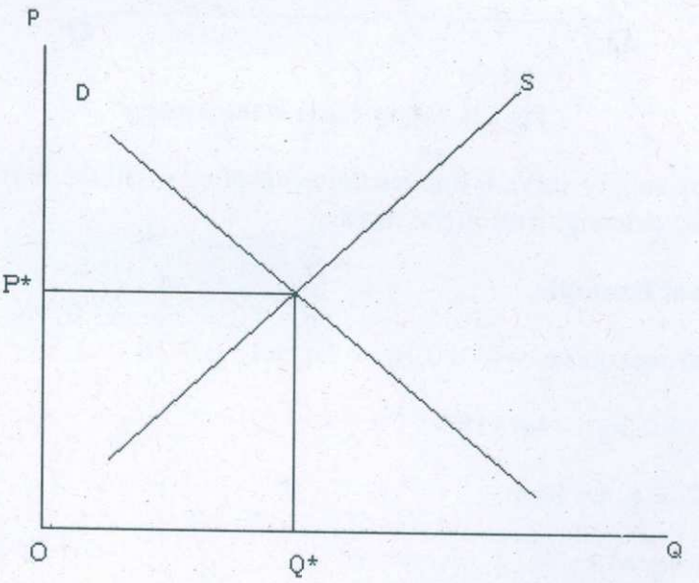

Fig.7.4: Industry Equilibrium

The equilibrium price and output in the industry are shown as op^* and OQ^* respectively.

Check Your Progress 3

1) Is there a difference between the demand curve faced by the firm and industry? Give reasons.

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7.2.4 Long-run Equilibrium of Firm and Industry

In the long-run, all the inputs available to the firms are variable, so that the concept of fixed cost is absent and the total cost (TC) equals the total variable cost (TVC). Therefore, we need only to deal with the long-run average cost (LAC = LTC/q). We assume the LAC to be U-shaped exhibiting the fact that at the low levels of output, the cost is falling and beyond a point, it rises.

We have stated above that a perfectly competitive market is characterised by free entry and exit of the firms. As in the short-run, the firms are making profits, there will be entry of new firms in the market. As a result, the industry supply would go up and price would fall. This would continue until the profits are driven down to zero.

Such a process is described in the following diagram.

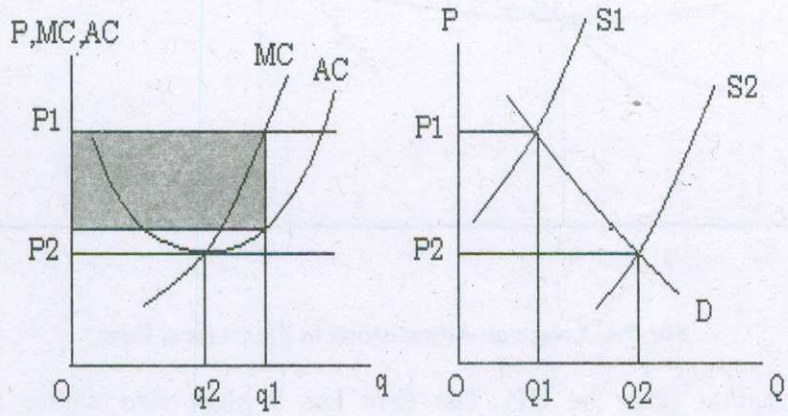

Fig.7.5: Long-run Profit of Competitive Firm

In Figure 5, at price. P1, the firm is producing an output q1 whereby it is making a profit shown by the shaded area. At price, P1, the industry output is Q1. As the existing firms are making profit, there will be entry into the market. As a result, the total supply in the market would go up and the price in market would fall. If at the new price the firms are still making some profit, then there will be further entry and market supply would go up. Consequently, the price would go down further level. This process would continue until the price falls to such a level that all profits are eliminated. From the diagram, the shaded area ceases to exist. This price is P2, where P = MC= AC and therefore profit is zero.

The zero profit scenario faced by the firms means that the economic profit is zero implying that the firms earn no more than they would elsewhere. In other words, the firms are breaking even at price P2.

At P2, as the firms are earning zero profit, there is no incentive for other firms to enter the industry. Hence, price P2 would represent an equilibrium price level with Q2 as the equilibrium output, with that the long-run equilibrium is characterised by a situation where the economic profits for the firms are zero.

Firm at the Long-run: Choice of Plant and the Adjustment Process

In the long-run, an entrepreneur can adjust the plant size. She has the scope to choose the optimal plant size, which would minimize the cost. The adjustment process is illustrated with the help of the following diagram.

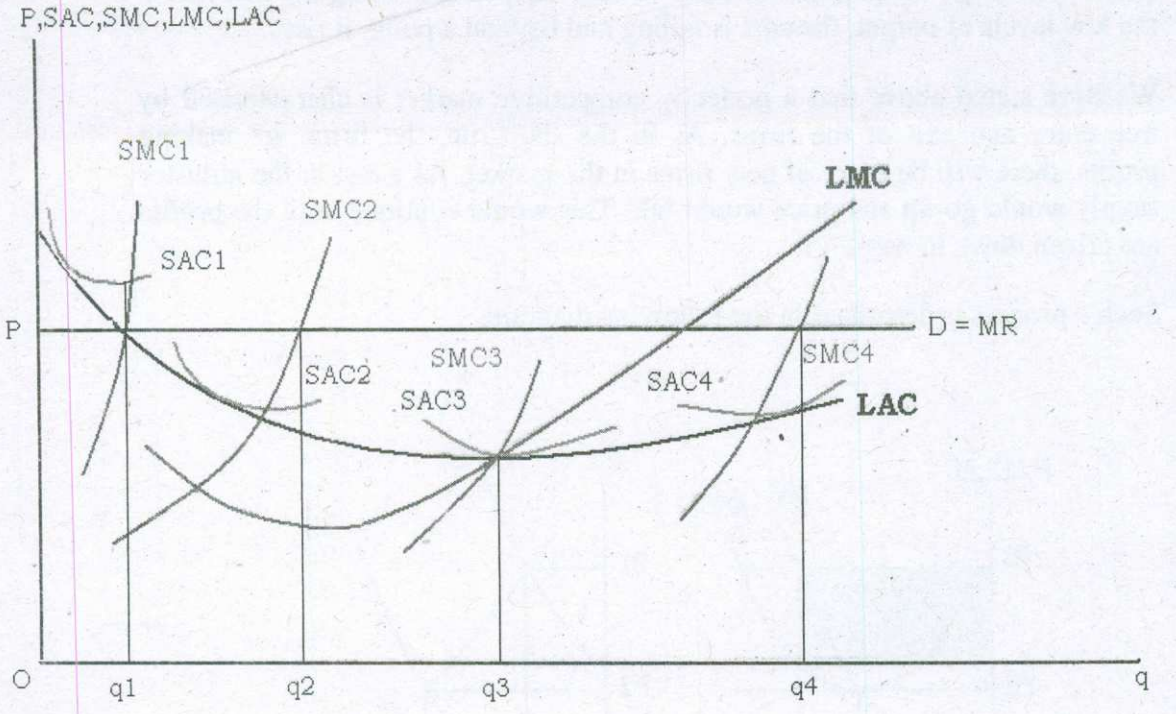

Fig. 7.6: Long-run Adjustments in Plants for a Firm

Let the market price be OP. The firm has a plant size whose costs are represented by short-run average cost (SAC1) and short-run marginal cost (SMC1). With this plant size, the short-run equilibrium occurs at point A where the firm produces oq1 amount of output. The firm makes a loss because the price line lies below the SAC1 curve. In such a situation, the firm has two options: to go out of business or to construct a plant of more suitable size.

In the long-run, the firm has the option of increasing the plant size so that it would construct a larger plant represented by SAC2 and SMC2 in the diagram. At the price OP, the firm with this new plant size would produce oq2 amount of output, which would give it some profit. With perfect knowledge about the future, the firm would decide to use the plant represented by SAC4 that gives it the most profit.

The long-run adjustment process and the choice of plant for the firm are shown in the figure below.

Suppose initially price is OP1 and the firm has only the plant3 represented by SAC3. Setting P = SMC, it produces OQ3 and earns some profit because OP3 > SAC3. As the firm is earning some profit, new ones would be attracted into the industry. As a result, the supply in it would go up from OQ3 to OQ1 and price would fall from OP3 to OP1. Consequently, the supply curve would shift from S3 to S1.

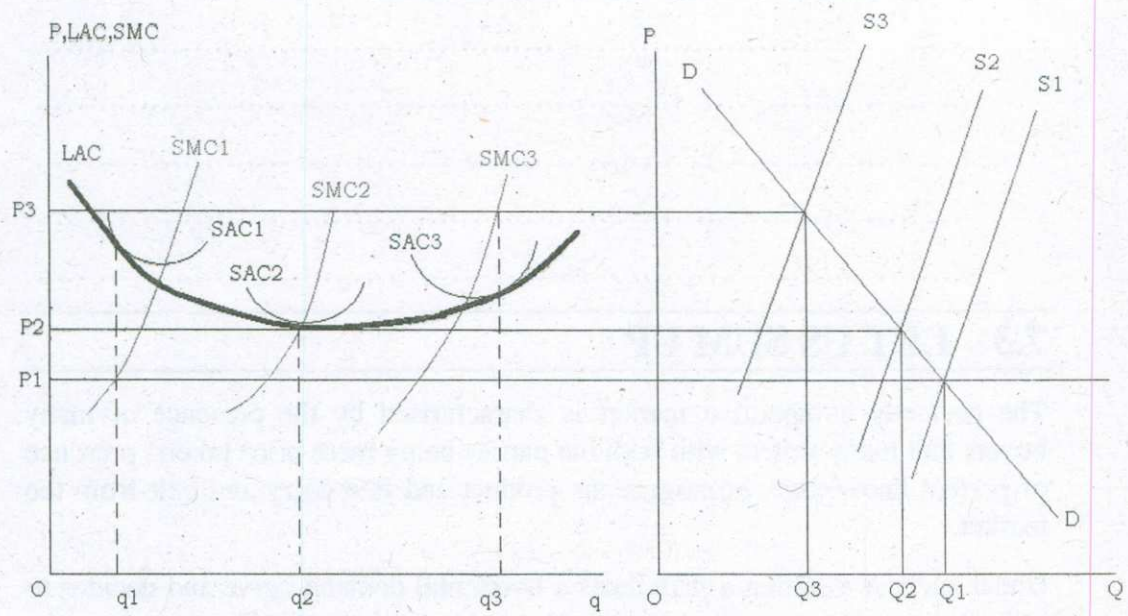

Fig. 7.7: Long-run Equilibrium in Industry

At price OP1, the representative firm is making a loss because OP1 < SAC1. Therefore, the existing firms would start moving out of the industry. As a result, the supply in the market would fall and the supply curve would shift backward from S1. Given the market demand curve DD, as the supply curve shifts, the price would fall.

Suppose the price settles at OP2. At this price, P2 = SMC2 = SAC2 so that the representative firm faces neither a loss nor a gain. The new firms neither would have any incentive to enter the market nor would the existing firms want to leave the industry. Hence, this would be the equilibrium situation with OP2 price and OQ2 output in the industry. The corresponding equilibrium output for the firm is oq2.

Check Your Progress 4

1) Describe the long-run equilibrium condition of the firm and industry.

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2) Which characteristic of the perfectly competitive market is responsible for the long-run equilibrium condition of p = min LAC?

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3) Which plant does a firm choose in the long-run?

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7.3 LET US SUM UP

The perfectly competitive market is characterised by the presence of many buyers and many sellers with both the parties being mere price takers, presence of perfect knowledge, homogeneous product and free entry and exit from the market.

Under such of a setting a firm faces a horizontal demand curve and decides to sell whatever it can at the given market price. Being a profit maximiser, the firm in the short-run, chooses to sell that amount of output for which the p = MC. As long as p> min AVC, the firm earns supernormal profit by producing and selling in the market.

In the long-run due to free entry and exit from the market, the long-run equilibrium for the firm occurs at the minimum point of LAC, whereby p= min LAC and thereby the supernormal profits are swept out. In the long-run, therefore, the firms just break even due to the phenomenon of free entry and exit from the market.

7.4 KEY WORDS

Price – takers: This means that the agents in the market take prices as given. They have no power to influence the market price.

Free Entry and Exit: This implies that any new firm is free to set up production in the market if it wishes to, and any existing firm can stop production and leave the industry.

Homogeneous Product: The product of one seller is identical to that of the other.

Perfect Knowledge: Consumers know the prices, producers know the costs and workers know the wage rate.

Zero profit: It means that the firms are covering only their total costs. These total costs are economic costs. In other words, firms are just able to cover their full opportunity cost. It implies that all factors of production are earning what they could in their best use.

Pure competition: A market structure slightly less stringent than perfect competition. Pure competition requires only a large number of traders and a homogeneous commodity.

7.5 SOME USEFUL BOOKS

1) Ferguson and Gould (1989), *Microeconomic Theory,* Irwin Publications in Economics; Homewood, IL: Irwin.

London: Macmillian.

3) Ferguson, C. E. (1969), *The Neoclassical Theory of Production and Distribution,* Cambridge: Cambridge University Press.

7.6 ANSWERS OR HINTS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) A typical firm under perfect competition faces a horizontal demand curve. So that at the given price, p, the firm can sell whatever amount it wishes to sell.

2) The short-run equilibrium condition is given by p = MC = MR = AR

3) Total Revenue (TR) = pq, therefore Average Revenue (AR) = TR/q = pq/q = p. Marginal Revenue (MR) = TR/q = p. Thus, p= AR= MR.

Check Your Progress 2

1) The rising part of the MC curve is the supply curve of the firm.

2) In the short-run the total cost of production consists of the variable as well as the fixed cost. If price falls below AVC, then for unit cost the revenue earned (which is price, p) is unable to cover the variable cost. If the producer shuts down, then one has to incur only the fixed cost. Otherwise, her loss would include both that from the variable cost as well as from the fixed cost. Being a profit maximiser the producer would never produce an output when p<AVC. Therefore, the supply is zero for p<AVC.

Check Your Progress 3

1) Yes. The demand curve that the firm faces is a horizontal straight line, whereas the demand curve of the industry is downward sloping. The firm is a price taker in the market so that it has to take as given whatever price is determined by the market and sell whatever amount it wants to in the market. This is not so for the industry as a whole.

Check Your Progress 4

1) In the long-run equilibrium condition is given by SAC = SMC = min LAC = LMC = p

2) The free entry and exit assumption.

3) The firm in the long-run eventually chooses that plant which is operated efficiently.

7.7 EXERCISES

1) The long-run cost function for each firm that supplies Q is $C = q^3 - 4q^2 + 8q$. Firms will enter the industry if profits are positive and leave if profits are negative. Describe industry's long-run supply function. Assume that the corresponding demand function is D = 2000 – 100p. Determine the equilibrium price, aggregate quantity and number of firms.

run cost function is

$C = 0.04q^3 - 0.8q^2 + 10q + 5.$

3) Construct an effective supply curve for an industry, which has two sources of supply: domestic production with the supply function

$S = 20 + 8p$

and an unlimited supply of imports at a fixed price of Rs. 20.

4) Discuss the assumptions of perfectly competitive market.

5) Assume that the total cost functions of representative firms in the two categories are

$C_{1i} = 0.04q_{1i}^3 - 0.8\ q_{1i}^2 + 10\ q_{1i}$

$C_{2i} = 0.04q_{2i}^3 - 0.8\ q_{2i}^2 + 20\ q_{2i}$

Assuming that there are 50 firms in each category, if the demand curve is given by $D = -100p + 2050$. Find the supply curve of firm and industry, equilibrium price, quantity, profits of the firms and the industry. How much output would the high cost firm produce?

Hints to Exercises

1) Firms will have a profit maximum of 0 if p = MC = AC, which occurs at the minimum point of the AC curve.

$AC = q^2 - 4q + 8$ and it reaches a minimum at q=2. So at that point p=4.

The long-run supply function is horizontal and the amount supplied is 2n where n is the number of the firms. At p = 4, the quantity demanded is 1600. Hence, 1600 = 2n. and n = 800.

2) $AVC = 0.04q^2 - 0.8q + 10$

Its minimum point is found by setting the derivative equal to zero. So,

$d(AVC)/dq = 0.08q - 0.8$

or, q = 10. At this point, AVC = 6 and $MC = 0.12q^2 - 1.6q + 10$. Substitute p = MC, multiply through out by 12.5 and solve for

$q = \{20 +/- 5\sqrt{(3p - 14)}\}/3.$

The positive branch gives output at which MC is increasing, hence

$S = 0$ if $p < 6$

$= \{20 +/- 5\ (3p - 14)\}/3$ if $p \geq 6$

3) The entire supply will come from domestic sources as long as its price is less than 20.When price reaches 20, domestic supply is 180. Thereafter the supply curve is horizontal. Domestic supply remains at 180, price remains at 20 and imports = (q – 180)

$\{20 +/- 5\ (3p - 14)\}/3.$

4) Do it yourself.

UNIT 8 MONOPOLY

Structure

8.0 Objectives

8.1 Introduction

8.2 Definition of a Monopoly

3.3 Factors Behind Generation of Monopoly

8.4 Demand and Revenue Functions of a Monopolist

8.5 Cost Function in Monopoly

8.6 Equilibrium of the Monopolist

- 8.6.1 Short-run Equilibrium
- 8.6.2 Long-run Equilibrium

8.7 Price Discrimination

- 8.7.1 Equilibrium of Discriminating Monopolist
- 8.7.2 Different Types of Price Discrimination

8.8 Welfare Aspects of Monopoly

8.9 Monopoly Control and Regulations

8.10 Multi-plant Monopolist

8.11 Bilateral Monopolist

8.12 Let Us Sum Up

8.13 Key Words

8.14 Some Useful Books

8.15 Answers to Check Your Progress

8.16 Exercises

8.0 OBJECTIVES

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

- determine the profit maximising price and output combination of a monopolist;
- compare the output and price under monopoly and perfect competition;
- answer how and why the monopolist charges different prices to different customers; and
- price and output decisions in multi-plant and bilateral monopolies.

8.1 INTRODUCTION

Other than perfect completion, which is characterised by a large number of buyers and large number of sellers, there is another extreme form of market structure called monopoly. Monopoly is characterised by a single seller who acts as a price setter. Monopolists are called price setters because they select their own price and supply the entire quantity demanded. The word monopoly

come from a Greek word 'monos polein', which means alone to sell. For the monopolist to have an effective control over the market, the monopolized product should not have any close substitutes.

8.2 DEFINITION OF MONOPOLY

We can define monopoly as a market structure where there is a single seller. Monopoly does not imply that there is a single producer, because monopolists need not produce their own output. There would be many producers who supply their product to monopolists. The essence of monopoly is that there is a single seller who sets the price. As an example, we can cite OPEC (Oil and Petroleum Exporting Countries) which consists of the major producers that collectively set the price of oil. A monopolist might not set a single price for all customers and may practice price discrimination, i.e., may charge different prices to different customers.

The type of monopoly we have been discussing is called pure monopoly where the seller has absolute control over the market. But in the practice that is not usually the case. To measure the control over the market by a particular firm economists have devised measures like 'monopoly power'. In this unit, we will be mainly discussing pure monopoly.

There also is 'natural monopoly' which arises from economies of scale. In case of few products (for example, gas production, electricity and telephone) the average cost of production declines over a large range of output and therefore, single firm can supply the output at a lower price than when there are more firms. It is called natural monopoly because of its emergence naturally from the type of product being sold.

8.3 FACTORS BEHIND GENERATION OF MONOPOLY

The main causes that lead to monopoly are:

i) Ownership of strategic raw materials or exclusive knowledge of techniques of production.

ii) Patent right on a product or on the process of production.

iii) Government licensing or the imposition of foreign trade barrier to restrict foreign competitors.

iv) The size of the market may be such that it cannot support more than one seller.

v) The producer may exhibit increasing returns to scale (as it happens in transport, electricity and communication) as a result cost of production declines when a firm operates on a large scale and this might throw out other producers who are unable to complete with the low cost firm.

vi) Practice of limit pricing may prevent new entries in a market and can create monopoly.

Thus, in monopoly market,

i) there is a single seller

ii) close substitutes of the product do not exist

iii) there is no free entry and exit as in perfect competition.

8.4 DEMAND AND REVENUE FUNCTIONS OF A MONOPOLIST

Since there is a single firm in the industry, the firm's demand curve is identical to the industry demand curve. Therefore, the demand curve of a monopolist in downward sloping. For the sake of simplicity in our analysis, we assume that the demand curve of a monopolist is a downward straight line.

Let the demand curve be given by

$X = a - bP$; a and b are positive

X: quantity demanded

P: price

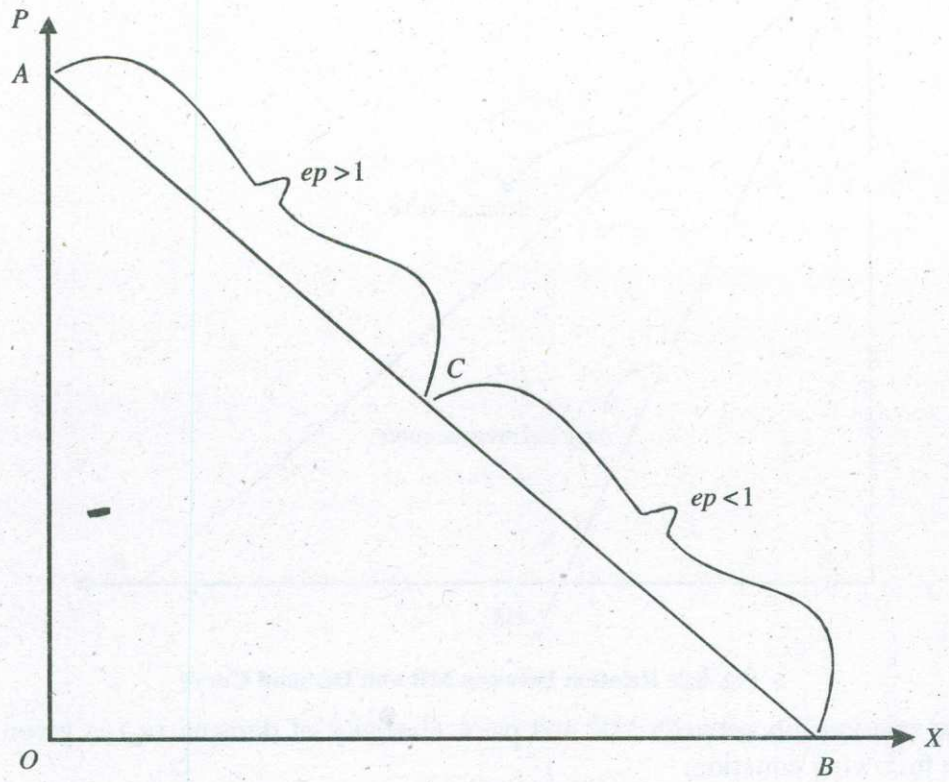

Fig. 8.1: Demand Curve of Monopolist

The slope of the demand function is given by $\frac{dP}{dX} = -\frac{1}{b}$

The price elasticity at any point on the demand curve is given by

$$e_p = \frac{dX}{dP}\frac{P}{X} = -b\frac{P}{X}$$

a) e_p at point $A \rightarrow \infty$

b) e_p at point $B = 0$

c) e_p at point $AC = BC = \frac{dX}{dP}\frac{P}{X} = -b.\frac{1}{b} = -1$

The total revenue of the monopolist is given by

$TR = P.X$

$$= \left(\frac{a}{b} - \frac{1}{b}X\right)X$$

$$= \frac{a}{b}X - \frac{X^2}{b}$$

The average revenue (AR) is

$AR = TR/X = PX/X = P = a - bX$

The marginal revenue (MR) is given by

$$MR = \frac{dTR}{dX} = \frac{a}{b} - \frac{2X}{b}$$

Clearly, the MR is a straight line having the same intercept as that of the demand curve but its slope is twice the slope of the demand curve.

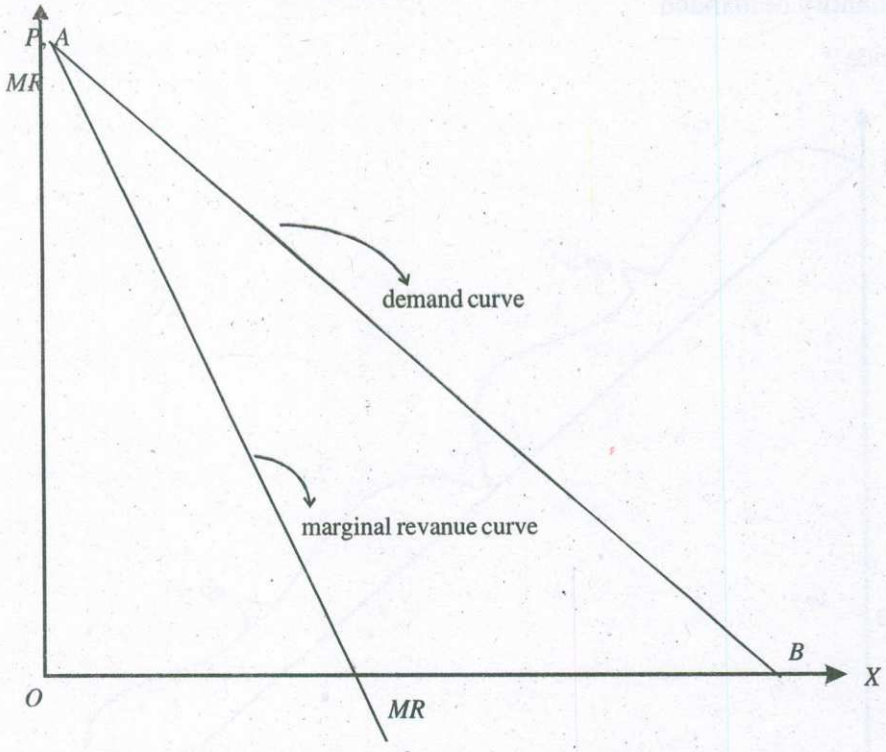

Fig. 8.2: Relation Between MR and Demand Curve

The relationship between MR and price elasticity of demand (e_p) is given by the following equation:

$$MR = P\left(1 - \frac{1}{e_p}\right)$$

8.5 COST FUNCTIONS IN MONOPOLY

In the theory of monopoly, the shape of the cost curves are the same as in the theory of perfect competition. The average variable cost (AVC), marginal cost (MC) and average total cost (ATC) curves are 'U' shaped, while the average fixed cost (AFC) curve is a rectangular hyperbola. However, in monopoly the particular shape of the cost curves do not make any difference to the determination of the equilibrium, provided that the slope of the MC curve is greater than that of the MR curve. Monopoly differs from the perfect competition in respect of the interpretation of the marginal cost curve. Unlike perfect competition, in monopoly the MC curve is not the supply curve of the producer. In fact, in monopoly there is no unique relationship between price and quantity supplied.

8.6 EQULIBRIUM OF THE MONOPOLIST

A monopolist is always guided by profit motives and therefore to reach the equilibrium, it maximises her profit.

8.6.1 Short-run Equilibrium

In the short-run, the monopolist cannot adjust it's plant size but it maximises its short run profit by equating MR and MC. The second order condition required for equilibrium is that MC cuts MR from below.

Mathematical Derivation of the Short-run Equilibrium

Let the demand function in X=g(p) and the inverse demand function is P= $f_1(X)$

The cost function of the monopolist is given by $C = f_2(X)$. If

π : profit, then

$\pi = TR - TC \left[\begin{matrix} TR : Total\ Revenue \\ TC : Total\ Cost \end{matrix}\right]$

i) First order conditions require

$$\frac{\partial \pi}{\partial X} = 0 \qquad \text{or,} \quad \frac{\partial TR}{\partial X} - \frac{\partial TC}{\partial X} = 0$$

$$\text{or, } MR - MC = 0 \left[\because \frac{\partial TR}{\partial X} = \text{marginal revenue}\right]$$

$$\text{or, } MR = MC$$

** Note that these conditions do not necessarily imply that monopolist can earn a profit. It depends upon the cost structure of the firm.

In the following figure, both the conditions MR= MC and MC cuts MR from below are met but the monopolist does not make any profit due to the cost structure.

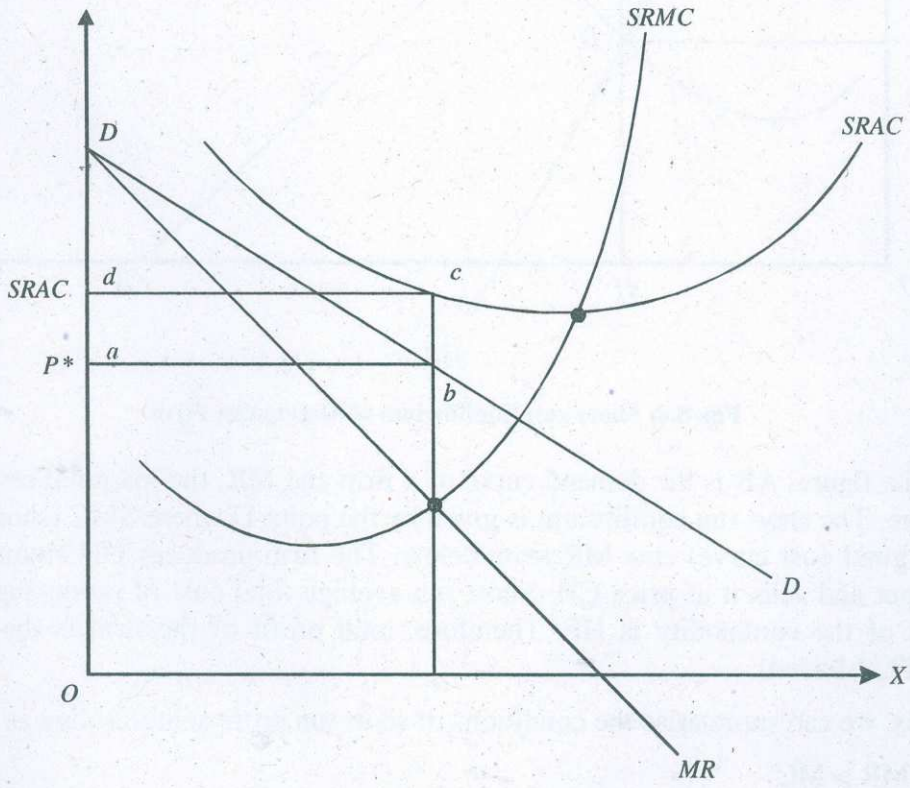

Fig. 8.3: Cost and Profit by Monopolist

Here SARC (short run average cost) > P^*(equilibrium price) of the monopolist. The monopolist makes a loss of the amount given by the area, |abcd|.

The second order condition for profit maximisations is given by,

$$\frac{\partial^2 \pi}{\partial X^2} < 0$$

or, $$\frac{\partial^2 R}{\partial X^2} - \frac{\partial^2 C}{\partial X^2} < 0$$

or, $$\frac{\partial (MR)}{\partial X} < \frac{\partial (MC)}{\partial X}$$

i.e., |slope of marginal revenue| < |slope of marginal cost|

The short-run equilibrium of a monopolist could be analysed graphically as well.

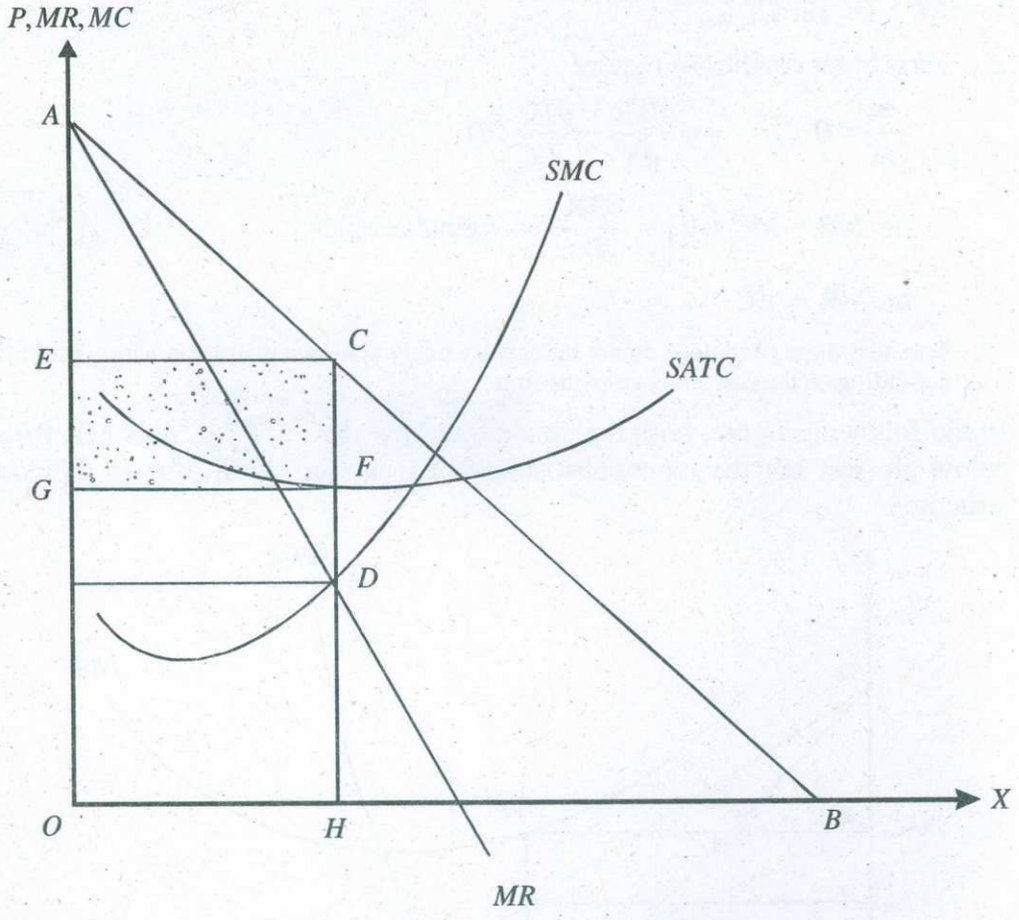

Fig. 8.4: Short-run Equilibrium of Monopolist Firm

In the figure, AB is the demand curve of a firm and MR, the marginal revenue curve. The short run equilibrium is given by the point D where SMC (short run marginal cost curve) cuts MR from below. The firm produces OH amount of output and sells it at price CH. Short run average total cost of producing OH unit of the commodity is HF. Therefore, total profit of the firm is the area EGFC (shaded).

Thus, we can summarise the conditions of short run profit minimisation as

i) MR > MC

ii) MC cuts MR from below.

8.6.2 Long-run Equilibrium

In the long run, the monopolist is endowed with the time to expand her plant or to use her existing plant at any level which maximises her profit. Unlike perfect competition, it is not necessary for the monopolist to reach a optimal scale (i.e., to build up her plant until she reaches the minimum point of long run average cost curve). But we can say for sure that a monopolist will most probably continue to earn supernormal profits even in the long run (given that entry is barred) and she will not stay in business if she makes losses in the long run. However, the size of the plant and degree of its utilization crucially depends upon the market demand conditions.

In the following three figures we depict three situations. In the first Figure 5, we show that the market size does not permit the monopolist to expand to the minimum point of LAC. In this case not only her plant is of suboptimal size but also is underutilised. The optimum use of the existing plant is at 'a' and the minimum point of long run average cost is given by 'b'. Since the firm utilises the capacity 'c', there is excess capacity.

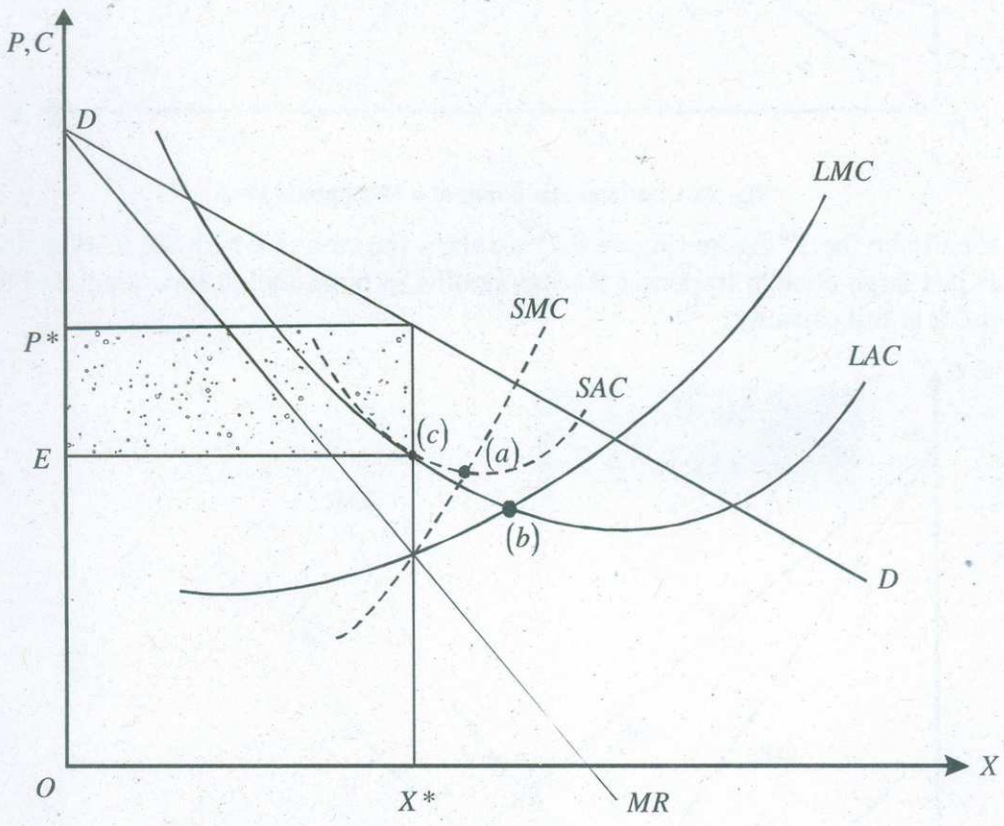

Fig. 8.5: Market Size and Monopoly Firm's Operation

In the 2nd figure (Figure 6) we show that the monopolist, in order to maximise profit, must build a plant size greater than the optimal size (to the right of minimum point of LAC) and will over utilise it. This happens when the market size is unduly large. Thus, the plant that maximizes the monopolist's profit leads to higher costs for two reasons: first, because it is larger than the optimal size and second, because it is over utilised. This is often the case with public utility companies operating at national level.

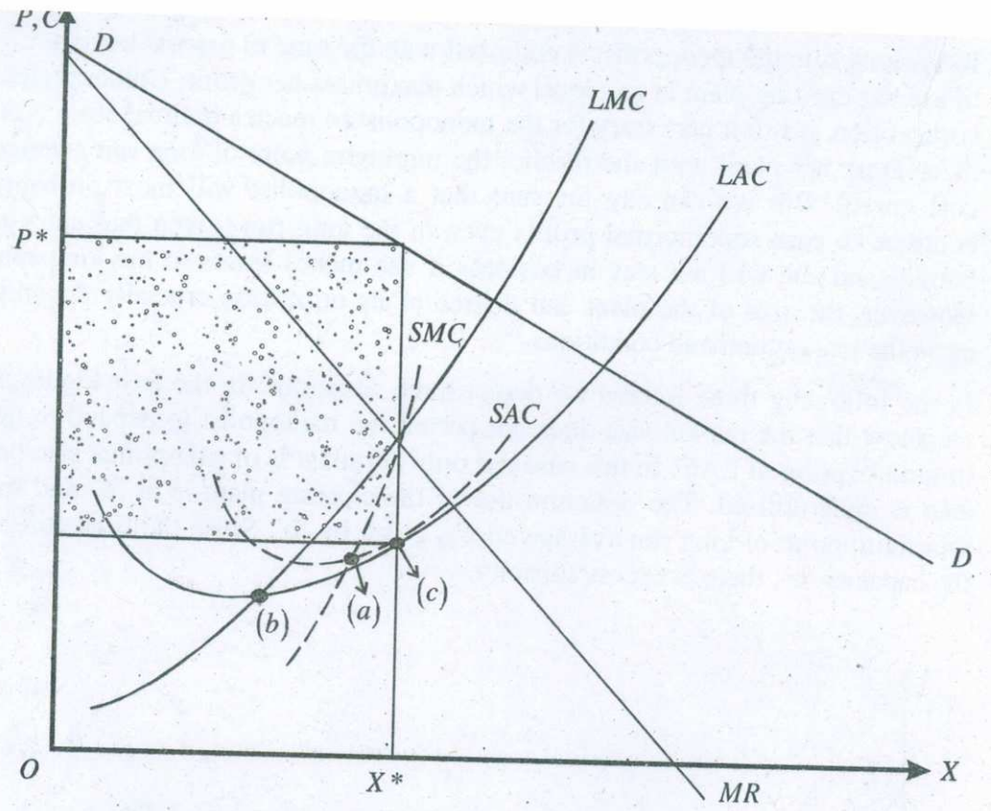

Fig. 8.6: Optimal Size Plant of a Monopolist Firm

Finally, in the 3rd figure (Figure 8.7) we show the case in which the market size is just large enough to permit the monopolist to build the optimal plant and to use it at full capacity.

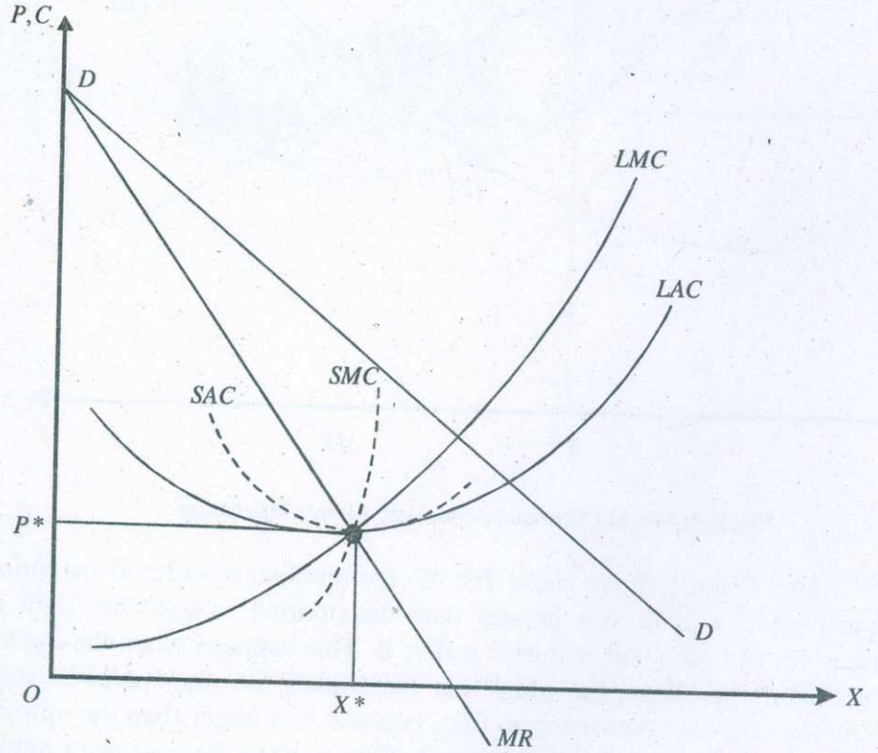

Fig. 8.7: Optimal Plant Size

Thus, there is no certainty that in the long run the monopolist will reach optimal plant size as in the case of perfect competition.

Whether a monopolist stays in business in the long run will depend on the long run average cost curve. She will exit in the long run unless all costs can be covered. Long run equilibrium for the monopolist requires that

LRMC = SRMC = MR

so that profit is maximised and P $\geqslant$ LRAC, and full opportunity cost is covered.

But if the monopolist is making profit, such a project provides an incentive for the new firms to enter the industry. If entry occurs, then the equilibrium position will change, and since there are more than one firm, there will be no longer a monopoly market structure. Thus, in the long run, for a profitable monopoly to survive, there must be barriers to entry. Sometimes these barriers are created at the time the monopoly is established. In other cases, the monopoly is created through threats and coercion. If a monopolist has a cost advantage over its rivals, then it can indulge in 'pre-emptive price' cutting to deter rivals from entering the market. This is explained in the following Figure 8.

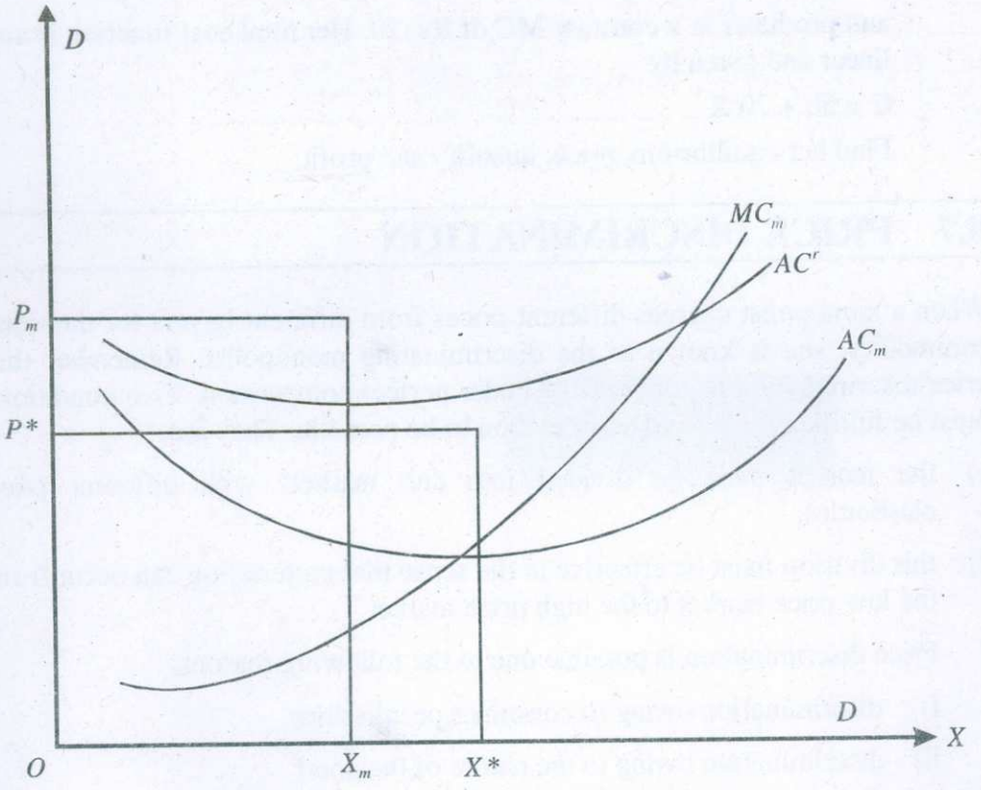

Fig. 8. 8: Excess Capacity Creation by Monopoly Firm

In the absence of any potential rival, the monopolist charges price P^M and produces X^M to maximise profit. However, if there is a rival with average cost curve AC^R threatening to enter, the monopolist lowers its price to P* and produces X*. At price P* the rival cannot cover it's cost and hence does not enter. Thus, P* is the 'pre emptive price'.

Generalising, we can say that a monopolist maximises profit in the long run by producing that output for which LRMC (long run marginal cost) equals marginal revenue and short run marginal cost. The optimal plant is the one whose short-run average total cost curve is tangent to the long run average cost curve at the point corresponding to long run equilibrium output. Another condition for the monopolist to stay in business is

LRAC $\leqslant$ Price

Check Your Progress 1

1) Establish the following relationship:

$$MR = P\left(1 - \frac{1}{e_p}\right)$$

where MR = marginal revenue

P = price

e_p = price elasticity of demand

2) If the monopolist demand function is

P = 200-10 X

and her cost curve is given by

$C = 5/2X^2 + 100X + 50$,

what are the monopoly profit maximising price and quantity?

3) Consider a monopolist who faces a linear demand curve,

P = 100 – 4X

and produces at a constant MC of Rs. 20. Her total cost function is also linear and given by

C = 50 + 20 X

Find her equilibrium, price, quantity and profit.

8.7 PRICE DISCRIMINATION

When a monopolist charges different prices from different buyers for the same commodity, she is known as the discriminating monopolist. Remember that price discrimination is not possible under perfect competition. Two conditions must be fulfilled for price discrimination to be possible. They are,

1) the market must be divided into sub markets with different price elasticities,

2) this division must be effective in the sense that no reselling can occur from the low price market to the high price market

Price discrimination is possible due to the following reasons:

i) discrimination owing to consumer peculiarities

ii) discrimination owing to the nature of the good

iii) discrimination due to distances and frontier barriers

iv) in some cases price discrimination occurs because of legal sanctions. For example, the State Electricity Board charges different rates for different uses.

When a consumer is unaware of the fact that other consumers get the same commodity at lower prices, or she might have a false notion that higher prices imply higher quality or the difference in prices is so small that she simply ignores it.

Again, goods which cannot be resold, such as electricity, gas transport, cinema show, or the service which cannot be resold, for example, the services of a physicians, are prone to price discrimination.

8.7.1 Equilibrium of a Discriminating Monopolist

Let us consider a monopolist who sells her output at two different markets. Let X_1 be the amount of output sold in the 1st market and X_2 is the amount of output sold in the 2nd market. Therefore, the total amount sold by the monopolist is $(X_1 + X_2)$

Let TR_1 and TR_2 are the total revenues obtained from the two markets.

Clearly, $TR_1 = TR_1 (X_1)$

$TR_2 = TR (X_2)$

But her total cost is given by

$C = C (X_1 + X_2)$

Profit of the discriminating monopolist is given by

$\pi = TR_1 + TR_2 - C$

$= TR_1 (X_1) + TR_2 (X_2) - C(X_1 + X_2)$

The first order condition of profit minimisation gives:

$$\frac{\partial \pi}{\partial X_1} = TR'_1(X_1) - C'(X_1 + X_2) = 0 \quad ...(1)$$

$$\frac{\partial \pi}{\partial X_2} = TR_2(X_2) - C'(X_1 + X_2) = 0 \quad ...(2)$$

From 1 and 2 we get

$TR_1' (X_1) = TR_2' (X2) = C' (X_1 + X_2)$

$MR_1 = MR_2 = MC$

Hence, the condition of profit maximization for a discriminating monopolist is given by marginal revenue in 1st market = marginal revenue in 2nd market= marginal cost

If $MR_1 > MR_2$, it is profitable for the monopolist to sell more in 1st market and this continues till $MR_1 = MR_2$.

Therefore, at equilibrium $MR_1 = MR_2 = MC$

The equality of marginal revenues does not mean the equality of prices in the two market as long as the price elasticity of demand is different in the both markets.

The second order condition requires that the principal minors of the Hessian determinant,

$$\begin{vmatrix} TR_1'' - C'' & -C'' \\ -C'' & TR_2'' - C'' \end{vmatrix}$$

alternate in sign beginning with the negative sign. This requires

$TR_1'' - C'' < 0$ and $TR_2'' - C'' < 0$

The equilibrium of a discriminating monopolist can be explained with the help of the following diagram.

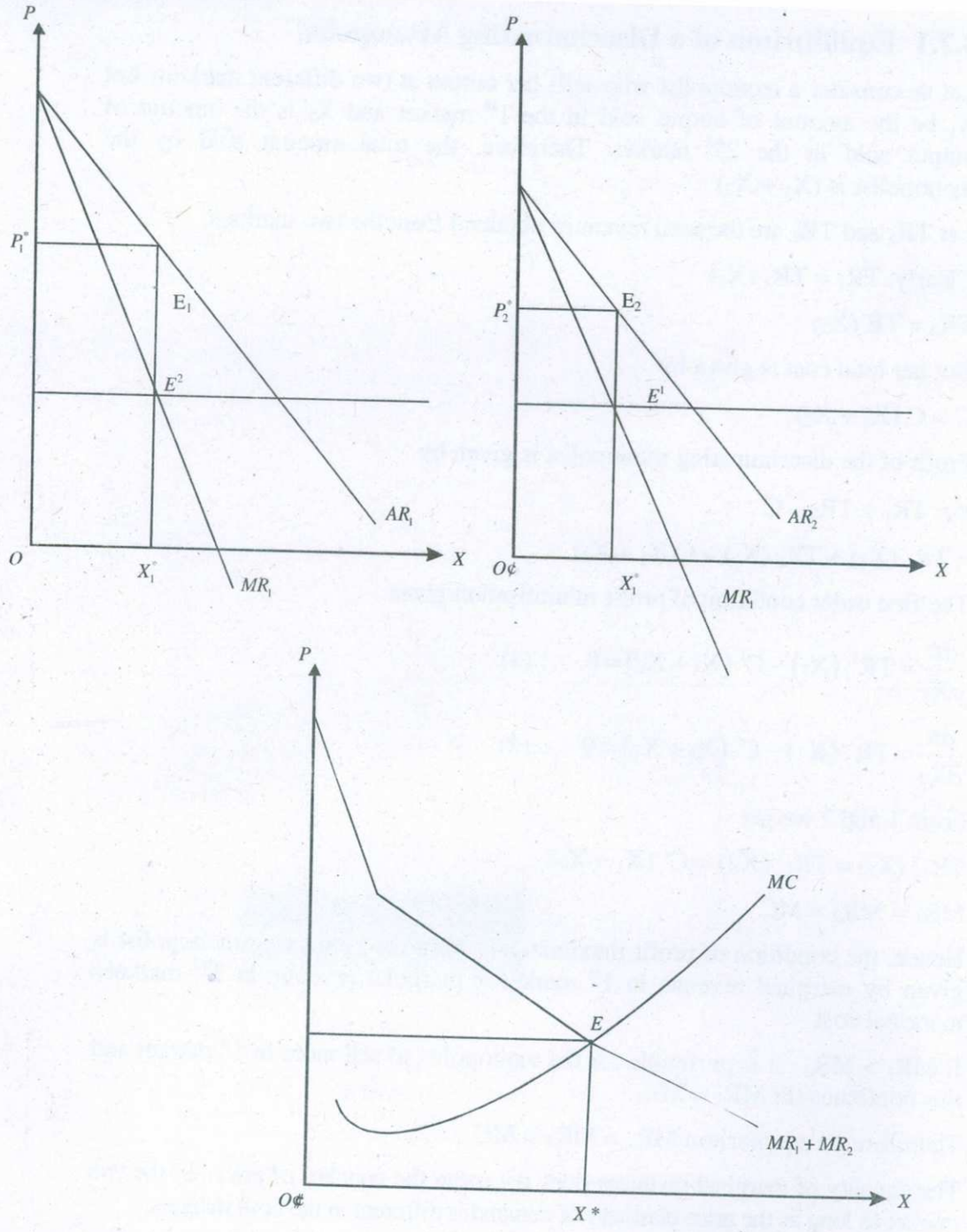

Fig. 8.9: Equilibrium of Discriminating Monopolist Market

In the first two panels of the diagram, we have drawn the MR curves of two markets. In the third panel, we obtained the combined MR curves by horizontally summing over MR_1 and MR_2. the combined MR and MC curves meet at the point E. We have drawn a horizontal line passing through E which cuts MR_1 and MR_2 at the point E_1 and E_2. At E_1, MR_1 = MC and at E_2, MR_2 = MC. Therefore, the conditions of profit maximization for a discriminating monopolist is satisfied at $E_1$and E_2, Accordingly, the monopolist will sell X* amount of output in market 1 at price P_1* and X_2* amount of output in market 2 at price P_2*

8.7.2 Different Types of Price Discrimination

Three types of price discrimination may be distinguished. They are personal, local and according to use.

Price discrimination is said to be personal when different prices are charged to different persons. For example, a surgeon many charge different amounts for the same operation from different patients.

Price discrimination is local when the seller charges different prices for the product from the people of different localities.

Discrimination is according to use when different prices are charged for different uses for a commodity. Rates of electricity and telephone are different for commercial and domestic purposes.

Apart from these three types of price discrimination, A.C. Pigou (The Economics of Welfare, 1920) thought of some other kinds of price discrimination. He identified three degrees of discriminating power leading to three types of price discrimination.

i) First degree price discrimination or perfect price discrimination is said to occur when the seller charges a different price for each unit of output. This involves charging different prices to different consumers as well as charging different prices for different units sold to the same consumer. The maximum price that someone is willing to pay for a unit of output is called the 'reservation price'. The perfectly discriminating monopolist charges the reservation price for each unit of output. Thus, the MR curve for the monopolist becomes the demand curve itself. In this case, the equal level of output which is given by the intersection of the demand curve and the MC curve, is the same as the output under perfect competition. This is shown in the following Figure 10.

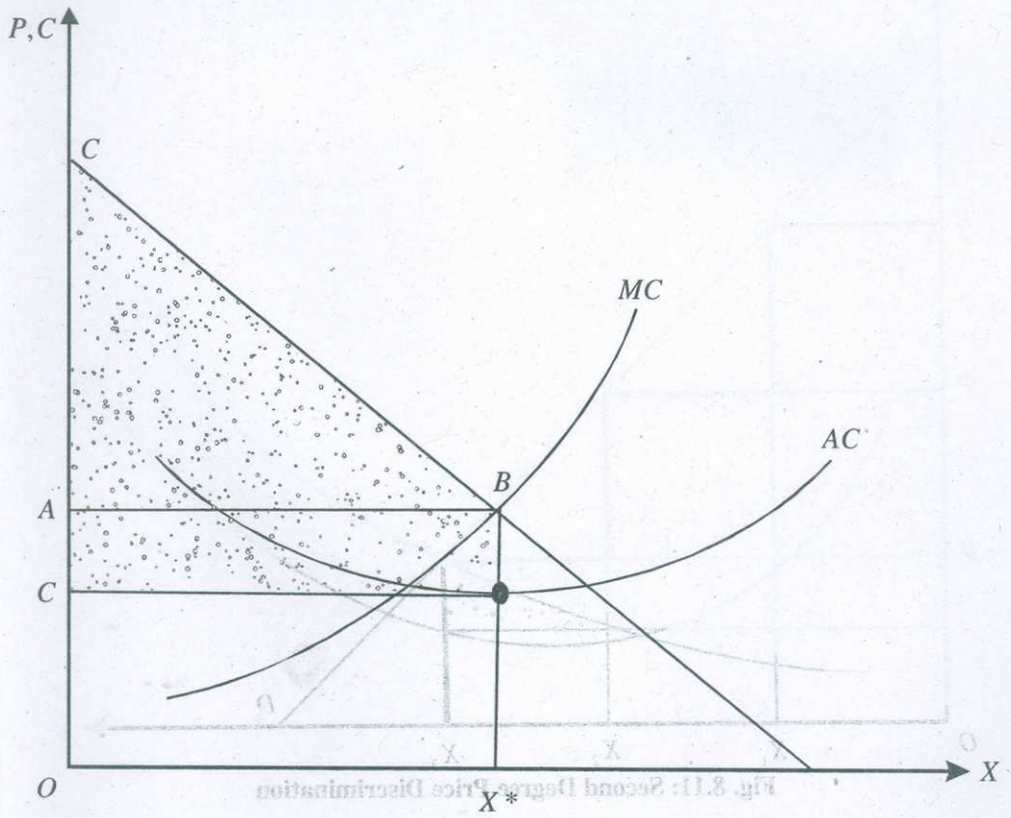

Fig. 8.10: First Degree Price Discrimination

The monopolist produces output OX* and its revenue is given by the area OX* BA. Since the monopolist charges a different price (the maximum possible price or the 'reservation price') for each unit, there is no unique equilibrium price. The dotted area represents the monopolist's profit. Thus,

in first degree price discrimination the monopolist extracts the whole consumer surplus.

First degree price discrimination is difficult to implement in practice. It can be used only for services for which no resale is possible.

ii) Second degree price discrimination occurs when the monopolist is able to charge several different prices for different ranges or groups of output. For example, in the following figure (Figure 11), each of first X_1 units of output are sold at a price of P_1. Units between X_1 and X_2 are sold at price P_2 and so on. Each additional unit sold from 1 through X_1 adds P_1 to the revenues. Similarly, each additional units sold between X_1 and X_2 adds P_2 to revenues and so on. Thus, the MR curve is a step function shown by the thick line. The monopolist equates MR and MC to maximizing profit, which is given by the intersection of the MC and MR curves. The monopolist produces X_3 units of output and the dotted area represents monopolist's profit.

iii) Third degree price discrimination occurs when the monopolist partitions the market demand into two or more groups of customers and then changes different prices to the different groups (the price is same for different persons within a group). What the monopolist is trying to exploit is the different price elasticities of demand for the different groups. Third degree price discrimination is possible only when the separate customer groups have different elasticities of demand.

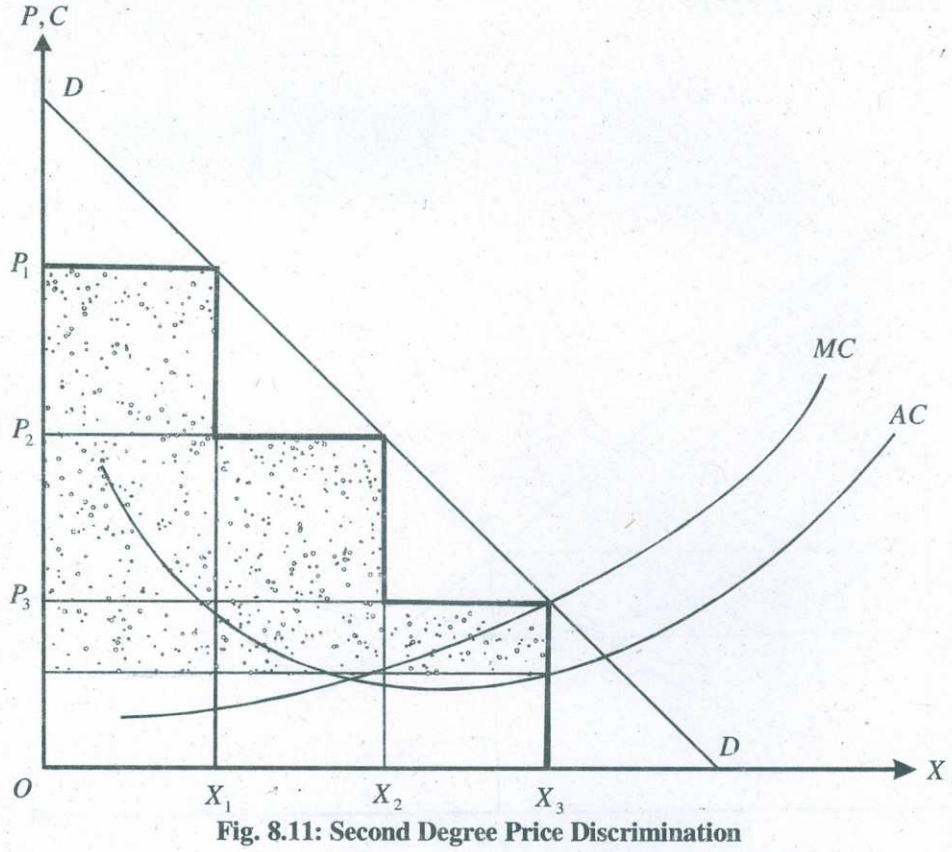

Fig. 8.11: Second Degree Price Discrimination

8.8 WELFARE ASPECTS OF MONOPOLY

Monopoly restricts output and charges a price higher than what would prevail under perfect competition. Such restriction of output results in a loss of consumer's and producer's surplus. By examining these losses we can determine the net welfare cost to the society from monopoly.

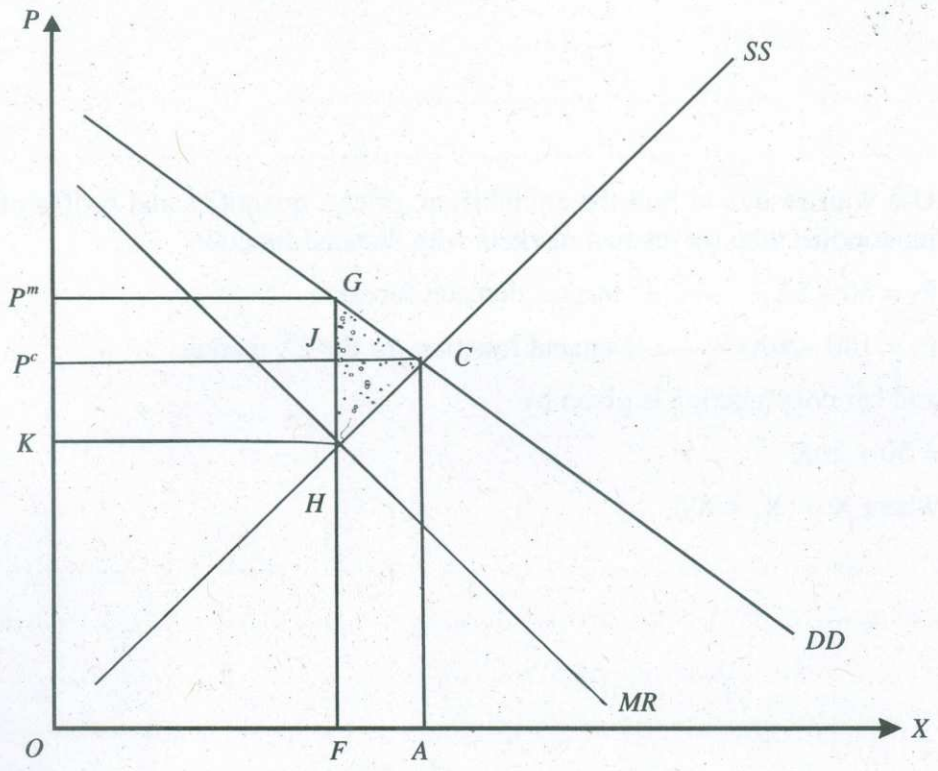

Fig. 8.12: Welfare Loss in a Monopoly

Consider the following figure where, DD is the demand curve, SS is the monopolist's MC curve as well as the competitive short run supply curve. MR is the monopolist's marginal revenue curve.

The competitive price is OP^c and quantity supplied under perfect competition is OA. The monopolist price and output are OP^m and OF respectively.

As we reduce output and increase price in going from perfect competition to monopoly, the loss in consumer surplus is equal to the area P^mGCPc. But the rectangles P^mGJP^c becomes part of revenue for the monopolist. This rectangle represents a transfer from consumer to the monopolist and therefore not a loss to the society. Thus, the area GJC is not a loss to the society. Again, from producer surplus point of view, the area JCH is net loss to the society. Therefore, the total net welfare loss to the society is the sum of the triangle GJC and JHC. This area (dotted) represents the excess of the value to the society over the output lost forever due to monopolization. This is often referred to as "dead weight loss".

Harberger used this theory to empirically measure the welfare costs of monopoly. He made some simplifying assumptions and found that (using data on manufacturing industries for 1924 to 1928 of USA) total welfare loss due to monopoly is about $59 million.

The very presence of monopoly profit induces others to waste resources in trying capture a part of this pie. This induces unproductive activities which lead to further waste of resources.

Check Your Progress 2

1) Can you derive the condition of profit maximisation for a price discriminating monopolist?

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2) Use your results to find the equilibrium, prices, quantities and profits of a monopolist who serves two markets with demand function

$P_1 = 80 - 5X_1$ -------- 1st market demand function

$P_2 = 180 - 20X_2$ -------- Demand function for the 2nd market

and her cost function is given by

$= 50 + 20X$

where $X = (X_1 + X_2)$.

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3) If e_i is the price elasticity of demand, verify that for the above problem the following equation holds

$$\frac{P_1}{P_2} = \frac{1 - \frac{1}{e_2}}{1 - \frac{1}{e_1}}$$

Can you explain why this equality holds?

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8.9 MONOPOLY CONTROL AND REGULATIONS

There may be many situations when generation of monopoly power is not desired as it reduces the welfare of the consumers and the production process is not optimal.

If the market size is small relative to the optimal size of plant, we have the case of 'natural monopoly', where market cannot support more than one optimally sized firm. Under these circumstances, the government many intervene either by itself undertaking the operation of the plant or by regulating the price that the private monopolist is allowed to charge. In both the cases, the government has to set the prices or the levels of different prices if price discrimination is practiced.

The monopoly price is given by P_m (which corresponds to MR = MC). Since P_m implies excess profit and exploitation of the buyers, the price regulated by the government must be set at lower than P_m. There are two alterative prices, the government can administer:

First, the government may set the price where MC = P, i.e., price OP. At this price, the output will increase from OX_m to OX_1 but still will allow some excess profit.

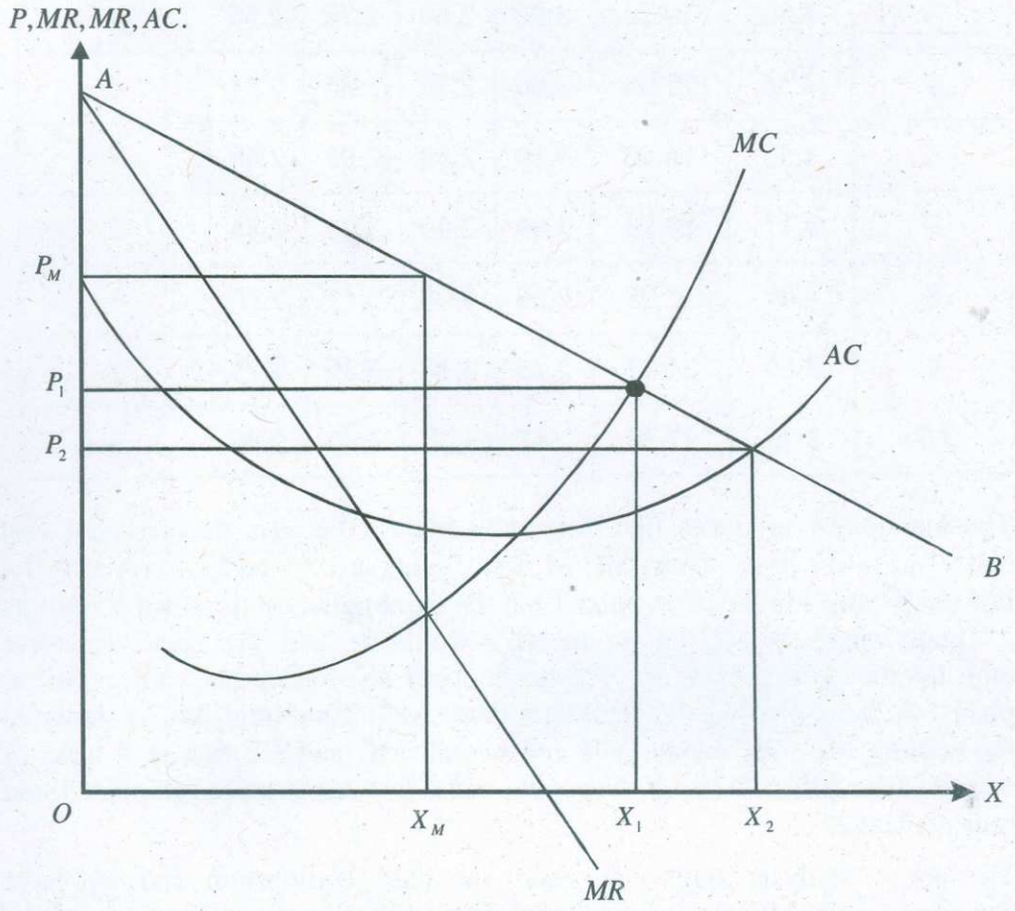

Fig. 8.13: Price Regulation of a Monopolist Firm

Secondly, the government may set a price equal to the average cost, i.e., price = OP_2. This leads to a higher output OX_2 and covers the total cost inclusive of a fair return on the capital.

Alternatively, the government may apply a price discrimination scheme. This solution has wide applications in the sectors like electricity, gas, railways and other government regulated monopolies. But this entails serious problems of equity and redistribution of income and of economic allocation of resources.

8.10 MULTI-PLANT MONOPOLIST

The monopolist may operate more than one plant, and the cost conditions may differ from one plant to another. In the following table MC_1 and MC_2 are the marginal costs of the first and the second plants. The combined marginal cost (MC) is obtained as follows:

Units of output	Price	Total revenue	MR	MC_1	MC_2	MC	Produced from Plant
1	6.00	6.00	6.00	2.30	2.45	2.30	1
2	6.50	11.00	5.00	2.40	2.55	2.40	1
3	5.10	15.30	4.30	2.50	2.65	2.45	2
4	4.80	19.20	3.90	2.60	2.75	2.50	1
5	4.56	22.80	3.60	2.70	2.85	2.55	2
6	4.35	16.10	3.30	2.80	2.95	2.60	1
7	4.17	29.19	3.09	2.90	3.05	2.65	2
8	4.01	32.08	2.89	3.00	3.15	2.70	1
9	3.87	34.83	2.75	3.10	3.25	2.75	2
10	3.73	37.30	2.47	3.20	3.35	2.80	1

The monopolist produces first 2 units in plant 1 because the marginal cost (MC) are lower there. Thus, MC of first 2 units are 2.3 and 2.4 respectively. For the 3rd unit MC is 2.5 in plant 1 but the monopolist can produce it from its 2nd plant where the MC for producing it would be 2.45. For each successive unit, the monopolist looks for whether it could be produced at a lower MC at plant 1 or 2 and chooses the plant with lower MC. The overall MC is shown in the column MC. We equate MR and overall MC and see that at 9 units of output MR = MC = 2.75. Of these nine units, five are produced in plant 1 and four in plant 2.

The above analysis applies to short run (SR, equilibrium and we have considered only MC not average total cost (ATC) for the two plants. If the fixed cost is very high in any plant, the monopolist will be facing losses and it will close down unprofitable plants.

In the long-run (LR) the monopolist with a single plant adjusts the plant size and produces the output where long-term marginal cost (LRMC) is equal to MR. Note that this point may not be the minimum point of the long run average cost curve as it is in case of perfect competition.

For monopoly, the long run equilibrium is given by:

LRMC = SRMC = MR and LRAC ≤ Price

For the multi-plant monopolist, the long run equilibrium condition is same except that the multi-plant monopolist might adjust not only the plant size but also the number of plants as well. She might close down unprofitable plants and open new ones.

8.11 BILATERAL MONOPOLY

A bilateral monopoly is said to exist when one producer has an output monopoly and there is only one buyer for the product. The following table will

help you to understand the concepts of perfect competition, monopoly and bilateral monopoly.

Market Structure	No. of Buyers	No. of Sellers
Perfect competition	Many	Many
Monopoly	Many	Single
Bilateral monopoly	Single	Single

Since there is only one demander and one seller, the price and quantity will be determined by negotiation. However, we can always find the upper and lower limits of price and quantities. We will consider the single seller as all powerful and the single buyer as all powerful, alternatively. The situation is described by the following figure.

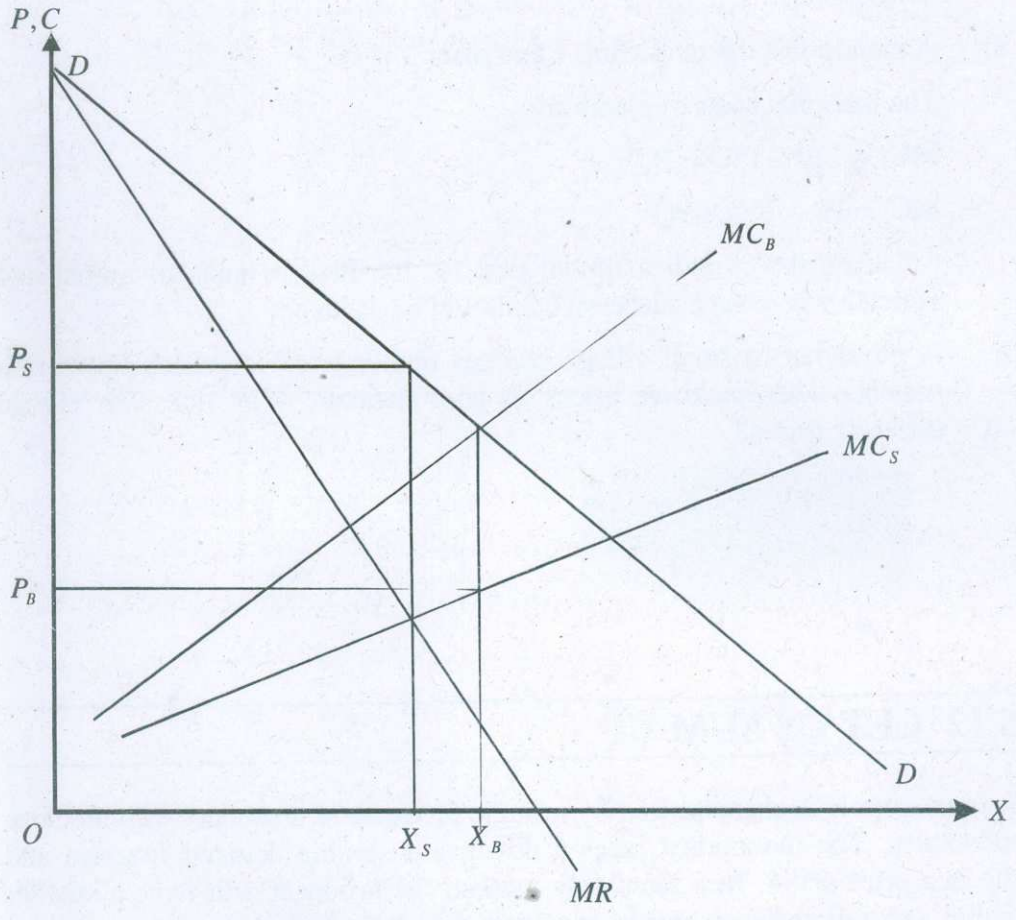

Fig. 8.14: Equilibrium in Bilateral Monopoly Firm

DD is the demand curve and MR is the marginal revenue curve. MC_S is the marginal cost curve of the single seller.

If the monopolist seller is all powerful, she will make the buyer behave as if there were many buyers. She will equate MC_S to MR and will produce X_S and will charge price P_S.

However, if the single buyers is the all powerful, she can make the monopolist behave like a perfect competitor. Thus, the MC_S would be the supply curve of the monopolist. Corresponding to this supply curve, we can construct the MC_B curve, which shows the marginal cost of buying an additional unit. MC_B exceeds the price because in order to purchase an additional unit, the buyer must pay a price and that higher price must pertain to all the units purchased. The buyer equates her marginal cost of buying an additional unit with the

marginal value of an additional unit (as given by the demand curve) and purchases X_B amount. Since the seller is behaving like a competitor with supply curve MCs, she will sell the X_B units at per unit price P_B.

The actual solution for the bilateral monopoly problem is indeterminate, depending on the bargaining power of the seller and the buyer.

Check Your Progress 3

1) Derive the conditions of profit maximisation for a multi plant monopolist?

.....

.....

.....

.....

2) A monopolist operates plant 1 and plant 2.

The marginal costs of plants are

$MC_1 = 120 - 15Q + 3Q^2$

$MC_2 = 90 - 26Q + 9Q^2$

Calculate the overall marginal cost for the first 10 units of output and indicate where each successive unit will be produce.

3) A physician in small village charges higher price for check up to rich patients whereas lower prices to poor patients. Why does she charge different prices?

.....

.....

.....

.....

8.12 LET US SUM UP

Pure monopoly is characterised by a single producer of a product with no close substitutes. The monopolist faces a downward sloping demand function and she is a price setter. In a monopoly market, the producer will have a smaller output and will charge a higher price than the equivalent competitive industry. A monopolist creates barrier for entry to survive in the long-run. There are instances of price discrimination in monopoly in order to extract the consumer surpluses as profits. A multi-plant monopolist produces each successive unit of output in plant that has the lowest marginal cost. With bilateral monopoly the market price and output is indeterminate.

8.13 KEY WORDS

Monopoly: A market structure where there is single seller of a product.

Natural Monopoly : There are few products which exhibit economies of scale, i.e., cost of production declines over a large range of output. Thus, while producing those products, a firm might experience low cost advantage over its

rivals. The cost advantage leads in creation of monopoly which is called 'natural monopoly'. (e.g, gas pipeline companies, telephone companies.)

Cartel: When more than one producer join hands to act like a single seller. The group of producers form a cartel (e.g., OPEC).

Excess Capacity : The output that corresponds to the minimum average total cost is called capacity. A producer producing an output smaller than that given by the minimum average total cost is said to be operating with excess capacity.

Entry Barrier: Preventing Entry. In the long run the monopolist creates entry barriers so that rivals cannot enter the industry. This may be done by:

i) Control over strategic raw materials required for production

ii) Product patent or process patent

iii) Acquiring exclusive rights to cater to a market from government

iv) Charging low prices

First Degree Price Discrimination: This is often termed as perfect discrimination. It means charging different prices to different customers and different price for different units brought by the same customer. The maximum price someone is willing to pay is charged by the monopolist.

Second Degree Price Discrimination: A market situation of charging different prices for different ranges or group of output.

Third Degree Price Discrimination: It occurs when the monopolists charges different prices to different groups of customers, while the price charge is same for each customer within a group.

Dead Weight Loss: The net welfare loss to the society due to the monopoly market structure.

Multi-Plant Monopolist: Monopolist operating more than one plant. There the cost conditions in each plant might differ.

Bilateral Monopoly: The market structure where there is a single seller and a single buyer for a product.

3.14 SOME USEFUL BOOKS

1) Ferguson and Gould (1989), *Microeconomic Theory*, Irwin Publications in Economics; Homewood, IL: Irwin.

2) Koutsoyiannis, A. (1979), *Modern Microeconomics*, Second edition, London: Macmillian.

3) Varian, Hal (1992), *Microeconomic Analysis*, W.W. Norton & Company, Inc., New York.

4) Henderson, Henderson & Richard E. Quandt (2003), *Microeconomic Theory: Mathematical Approach*, Tata McGraw-Hill Publishing Company Limited, New Delhi.

3.15 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) TR = PX

or, $\frac{dTR}{dx} = P + X\frac{dp}{dX}$

or, $MR = P\left(1 + \frac{X}{P}\frac{dp}{dX}\right)$

$= P\left(1 - \frac{1}{ep}\right)$ $\left[\because e_p = -\frac{dx}{dP}\frac{P}{X}\right]$

2) TR = P.X

TR = (200 –10X)X

MR = 200-20X

MC = 5X + 100

Clearly, the MC curve of the monopolist is a rising function of output (X)

Monopolist's equilibrium is obtained by equating MR and MC

200 –20X = 5 X + 100

or, -25X = -100

or, X = 4

P = 200- 10.4

= 160

3) Profit of the monopolist (π)

= $(100X = 4X^2)$ - (50 + 20X)

Setting MR = MC we get

100 – 8X = 20

X =10; p = 60, π = 350

Check Your Progress 2

1) If a monopolist caters to 2 markets, her profit is given by,

$\pi = R_1(X_1) + R_2(X_2) - C(X_1 + X_2)$.

$R_1(X_1)$: Revenue from market 1,

$R_2(X_2)$: Revenue from market 2,

X_1 : Output sold in market 1

X_2 : Output sold in market 2.

Setting the first order derivatives of π equal to zero,

$$\frac{\partial \pi}{\partial X_1} = R_1^1(X_1) - C^1(X_1 + X_2) = 0 \quad \ldots(1)$$

$$\frac{\partial \pi}{\partial X_2} = R_2^1(X_2) - C^1(X_1 + X_2) = 0 \quad \ldots(2)$$

i.e., $MR_1 = MR_2 = MC$

i.e., marginal revenue in each market much be equal to marginal cost.

$$\begin{vmatrix} R_1 - C'' & -C'' \\ -C'' & R_2'' - C'' \end{vmatrix}$$

alternate in size beginning with the negative sign, i.e.,

$R_1'' - C'' < 0$

$(R_1'' - C'')(R_2'' - C^4) - (C'')^2 > 0$

2) Setting MR in each market equal to MC, we get the following two equations:

$80 - 10X_1 = 20$; $180 - 40X_2 = 20$.

Solving these equations we get,

$X_1=6$ $P_1=50$ $e_1= 1.67$

$X_2 = 4$ $P_2= 100$ $e_2=1.25$.

Check yourself that the second order condition is satisfied.

3) Remember that the equilibrium condition for a price discriminating monopolist is

$MR_1 = MR_2$

$$\text{or, } p_1\left(1-\frac{1}{e_1}\right)=p_2\left(1-\frac{1}{e_2}\right)$$

[From Check Your Progress 1, problem no. 1]

$$\text{or, } \frac{p_1}{p_2}=\frac{\left(1-\frac{1}{e_2}\right)}{\left(1-\frac{1}{e_1}\right)}$$

Check Your Progress 3

1) Suppose a multi-plant monopolist operates in two plants. Her profit is given by

$\pi = R(X_1+x_2) - C_1(X_1) - C_2(X_2)$

X_i : amount of output produced in the ith plant, i=1,2.

$C_i(X_i)$: cost of producing X_i amount of output in the plant.

$R(X_1+X_2)$: revenue function of the monopolist.

In order to maximise profit, the monopolist will equate the 1st order partial derivatives of the profit function with respect to X_1 and X_2 to zero.

$$\frac{\partial \pi}{\partial X_1} = R'(X_1 + X_2) - c_1'(X_2) = 0$$

$$\frac{\partial \pi}{\partial X_2} = R'(X_1 + X_2) - C_2'(X_2) = 0$$

or, $R'(X_1 + X_2) = C_1'(X_1) = C_2'(X_2)$

The second order condition requires that thee principles minus of thee relevant Hessian determinant

$$\begin{vmatrix} R''-C_1'' & R'' \\ R'' & R''-C_2'' \end{vmatrix}$$

2) Do it yourself

3) The physian is practioning price discrimination; elaborate on this.

8.16 EXERCISES

1) Determine the maximum profit and corresponding price and quantity for a monopolist whose demand and cost functions are

   $P = 20-0.5q$

   $C= 0.04q^3 - 1.94q^2+32.96q$

   respectively.

2) What are the major differences between a monopolist and a perfectly competitive market structure?

3) A multinational firm operates two plants in different countries. The following table shows marginal costs in the two plants along with the price.

Output	Plant 1(MC_S)	Plant 2(MC_2)	Price(Rs)
1	1.2	0.2	5.5
2	1.8	0.3	4.5
3	2.4	0.4	4.0
4	2.5	0.7	3.6
5	2.9	1.5	3.3
6	3.0	2.4	3.0
7	3.1	2.8	2.7
8	3.2	3.0	2.4
9	3.4	3.2	2.1
10	3.8	3.3	1.8

   i) Construct the overall marginal cost.

   ii) Determine the profit maximising output in each plant.

4) The portion of the demand curve where the price elasticity of output is less than 1 is called its inelastic portion. Will a monopolist operate on the inelastic portion of the demand curve?

5) Explain that a discriminating monopolist will charge a higher price to the market with the less elastic demand.

UNIT 9 MONOPOLISTIC COMPETITION

Structure

9.0 Objectives

9.1 Introduction

9.2 Features of Monopolistic Competition

9.3 General Approach to Equilibrium

- 9.3.1 Short-run Equilibrium
- 9.3.2 Long-run Equilibrium

9.4 Chamberlain's Approach to Equilibrium

- 9.4.1 Model 1
- 9.4.2 Model 2
- 9.4.3 Model 3

9.5 Selling Costs

9.6 Excess Capacity under Monopolistic Competition

9.7 Criticism of Monopolistic Competition

9.8 Let Us Sum Up

9.9 Key Words

9.10 Some Useful Books

9.11 Answers to Check Your Progress

9.12 Exercises

9.0 OBJECTIVES

On going through this unit, you will

- understand the monopolistic competitive market structure;
- know the equilibrium of the market structure; and
- appreciate the social aspect of excess capacity creation and optimal output production.

9.1 INTRODUCTION

The earlier units (Perfect Competition) and (Monopoly) dealt with two 'extreme' cases of market structure. In reality, there are hardly few markets, which fit into such kinds of framework. Therefore, in the late 1920's economists became increasingly dissatisfied with the use of these market structures as analytical models of economic behaviour. The assumptions of perfect competition, mainly the assumption of homogenous products, did not resemble the real word. Sraffa, Chamberlin and Joan Robinson worked individually to get some alternatives to fit into the real word. The revolutionary book Chamberlin introduced a new market structure with the flavour of both competition and imperfection. He called this new market structure monopolistic competition.

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9.2 FEATURES OF MONOPOLISTIC COMPETITION

1) **Product Differentiation**

The theory of monopolistic competition is based on solid empirical fact that there are very few monopolists because there are very few commodities for which close substitutes do not exist. Similarly, there are very few commodities, which are entirely homogeneous.

Monopoly: Close substitute does not exist

Consider the market of detergent powders in India. The products of "Ariel and Surf" are not the same entities. Thus, in a sense they have monopoly character because they are the sole supplier of their respective products. However, since their products are close substitute of each other, they share the market of detergent powder.

P.C. – homogenes products does not exist

Thus, in reality products of different producers are heterogeneous. Along with that, products of the same industry are close substitutes of each other. Producers make their products different from others consciously so that their products to remain unique.

Product differentiation

There are many ways in which products could be differentiated. They might differ according to chemical composition, appearance, brand name, advertising, packing material etc.

2) **Industries and Product Groups**

Firms producing the close substitutes and product groups

In perfect competition, industry was defined as a collection of firms producing a homogeneous product. However, when each product is differentiated, one cannot define an industry by the above definition. We will call the firms producing close substitutes as product groups. For example, firm producing soap, shampoo and cigarette cannot be called industries

Difficulties of defines product groups chamberline: Product groups should include products which are close technological and economic ...

However, there is a problem in defining a product group. It is not precisely defined when firms enter a product group because the degree of substitutability is a relative concept. Chewing gum could be a substitute for cigarette for those who are trying to quit smoking but firms producing chewing gum would never enter the product groups of cigarette. Similarly, tea and coffee may be close substitutes. However, they do not enter the same product group. According to Chamberlin, 'product groups' should include products, which are close technological and economic substitutes. To him logical substitutes are those products, which can technically cover the same want, and economic substitutes are those products, which satisfy the some want and have similar price structure. An operational definition of product group is that the demand for each single product is highly elastic and it shifts appreciably when the prices of other products in the group change. In other words, products forming the group should have high price and cross elasticities.

Products forming the group should have high price and coers elasticities

3) **Free Entry and Exit into the product group**

Like perfect competition, firms may enter and leave the product group at their will. If the firms in the product group are earning supernormal profit, new firms will enter lured by the profit. Similarly, if existing firms are making looses, firms will quit.

4) **Large Number of Buyers and Sellers**

There are a large number of buyers and sellers in a monopolistic completive market.

5) **Non-Price Competition**

Since the products are slightly differentiated, in order to increase the demand for their products firms engage themselves in non-price competition, such as advertising or adding up some frills (free gifts etc.).

6) **Independent Behaviour**

The economic impact of one firm's decision is spread sufficiently evenly across the entire group so that the effect on any single competitor goes unnoticed. This implies rivalry is missing and competition is impersonal.

9.3 GENERAL APPROACH TO EQUILIBRIUM

As we defined earlier the grouped demand curve (demand) curve of the products which are close substitutes of each other) is negatively sloped. This grouped demand curve must somehow be divided up among the members of the group. All the firms in the group are identical, facing similar demand and cost conditions. If all charge the same price, they will have identical market shares.

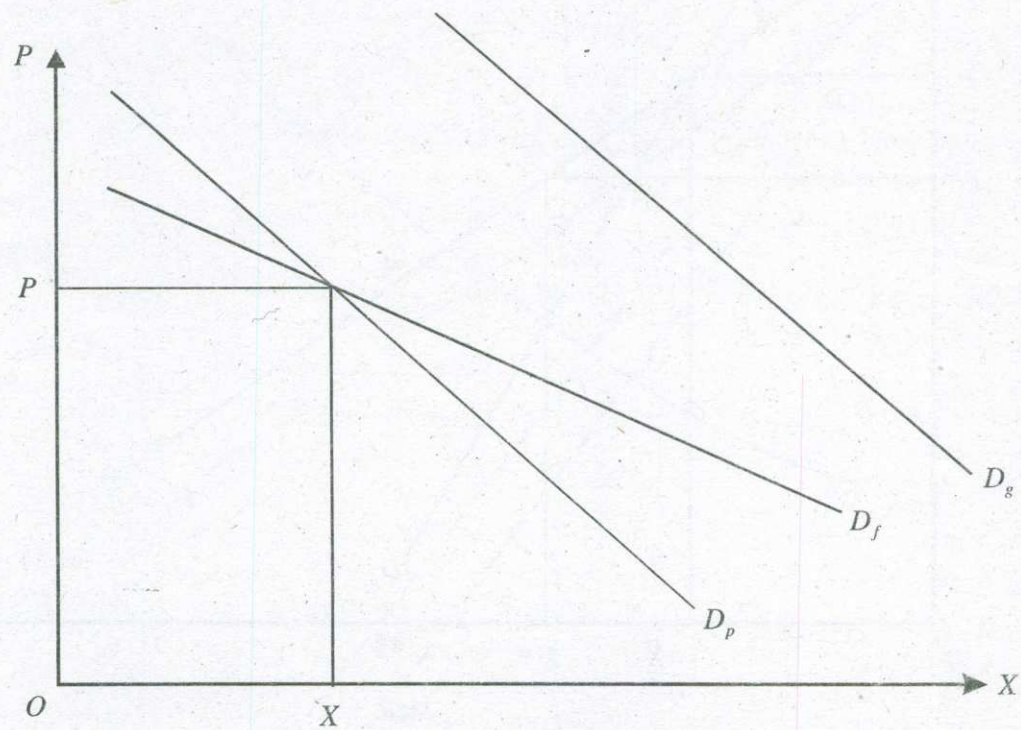

Fig. 9.1: Group Demand Curve in Monopolistic Competition

In the figure above, D_g is the grouped demand curve and D_p is the proportionate demand curve (when all the firms charge the same price). Dp is obtained horizontally dividing D_g by the number of firms.

A firm, however, does not perceive D_p to be its demand curve. If the current price is $\bar{P}$, and quantity is X, then the firm perceives its curve as D_f. Note that D_f is more elastic than D_p. It is actually the demand curve of the firm if all of the rest continue to charge the same price. D_f is more elastic because if one firm reduces it's prices and others do not, then the firm will be able to sell more than its market share (given by D_p). Similarly, if a firm charges higher prices while others do not, it will be able to sell less than what is given by D_p.

In monopolistic competition, there are a large number of firms and therefore each firm thinks that its price changes will go unnoticed. That is why firms behave naively.

9.3.1 Short-run Equilibrium

Consider the following figure where D_p and D_f are as defined earlier

MC: firm's marginal cost curve

MR: marginal revenue curve corresponding to firm's perceived demand curve

Consider for time being that all the firms are charging $\bar{P}$. Therefore, all firms have an incentive to charge P* where they could sell only X*. Thus, the perceived demand curve will shift to the left to intersect at A. The MR_f will also shift to the left and profit maximising output-price combination will change.

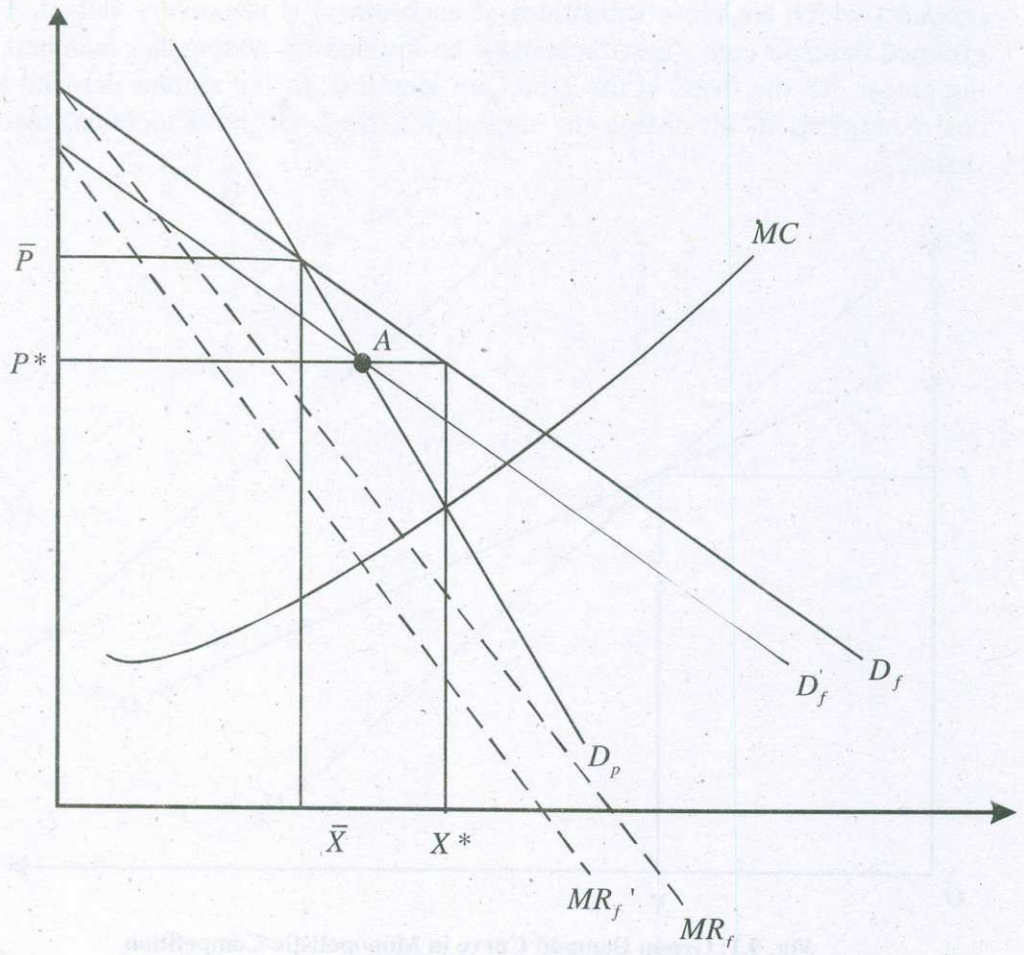

Fig. 9.2: Short-run Equilibrium in Monopolistic Competition

The short-run equilibrium for the monopolistically competitive firms is shown in the following figure. It can be seen that (Xe, Pe) is the equilibrium output-price combination, as $MR_f = MC$ holds and the firm is on its perceived demand curve.

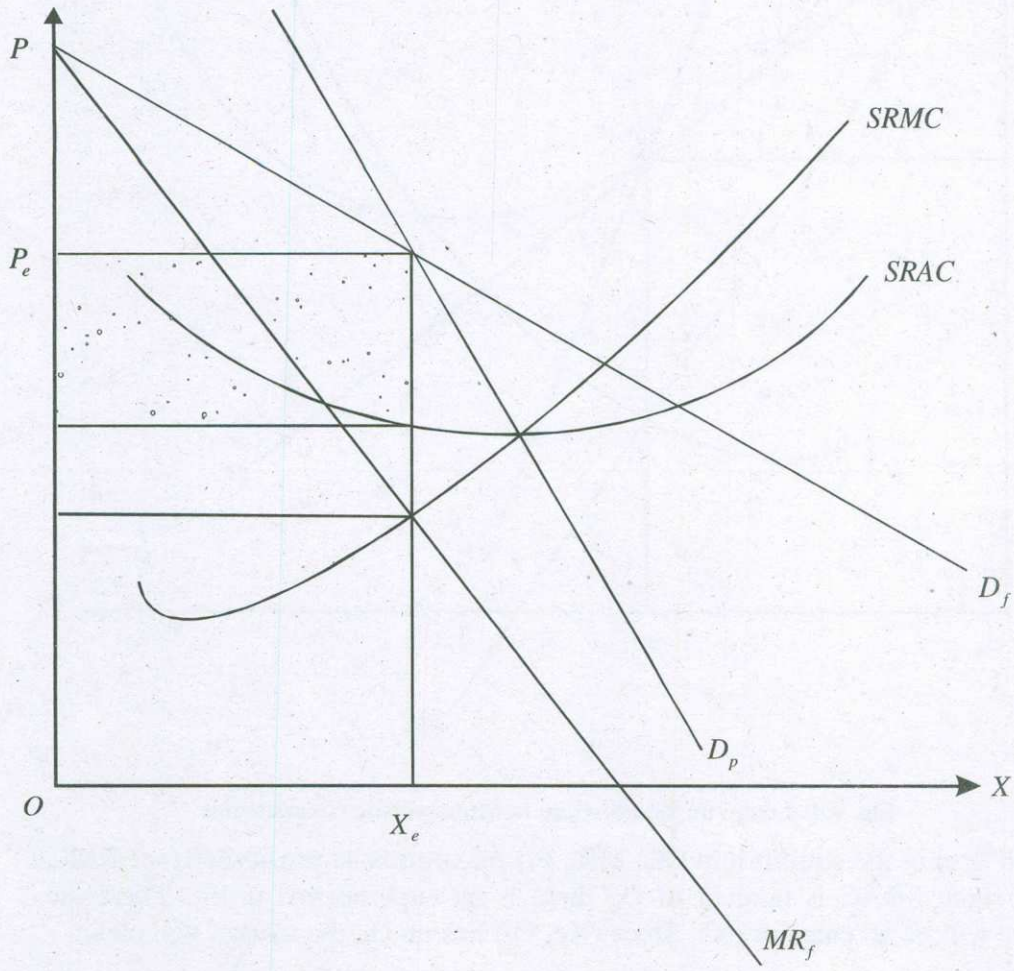

Fig. 9.3: Profit in Short-run Monopolistic Competition

The dotted area shows the amount of profit accruing to each firm.

9.3.2 Long-run Equilibrium

The short-run super normal profit will attract new firms to the product group since there is no entry barrier (if in short run firms are incurring loss, they will quit).

If more firms enter the product group, the proportionate demand curve will shift to the left and would become steeper. This will continue till all the profit is wiped out.

The long-run equilibrium is depicted in the following figure:

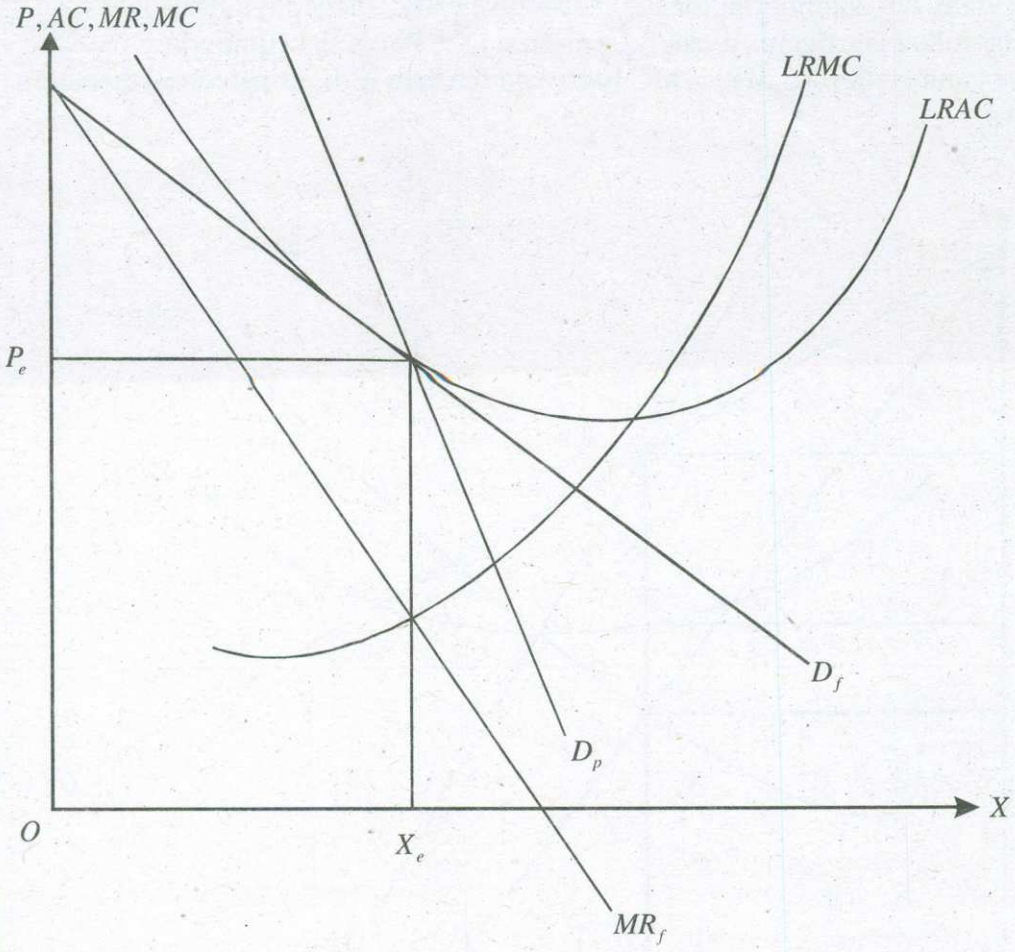

Fig. 9.4: Long-run Equilibrium in Monopolistic Competition

Each firm in the equilibrium (X_e, MR_f, P_e) maximises its profit (MR_f = LRMC) and since LRAC is tangent to D_f, there is no supernormal profit. Therefore, there will be no entry or exit. Since (Xe, Pe) lies on D_p, the market will clear.

9.4 CHAMBERLIN'S APPROACH TO EQUILIBRIUM

1) **Assumptions**

The basic assumptions of Chamberlin's large group model are the same as those of pure competition with the exception of the homogeneous product. They are as follows:

i) There are a large number of sellers and buyers in the 'group'

ii) There is free entry and exit in the group

iii) The goal of the firm is profit maximisation both in the short-run and long-run

iv) The products of the seller are differentiated, yet they are close substitute of each other

v) The prices of factors and technology are given

vi) The firm is assumed to behave as if it knew its demand and cost curves with certainty

vii) The long-run consists of a number of identical short-run periods, which are assumed to be independent of each other. It implies

decisions of present period do not affect that of the future. Neither they are affected by that of past period's.

viii) Finally, Chamberlin makes his 'heroic' assumption that both demand and cost curves for all products are uniform throughout the group. This requires that consumer preferences are evenly distributed among the sellers and the cost conditions (even though products are differentiated) are same in among the producers. Chamberline heroic assumption: both demand cost curves for all products are uniform in the ground.

2) **Cost Curves**

The average variable cost (AVC), marginal cost (MC) and the average total cost (ATC) curves are "U" shaped. This implies there is a single output level, which is optional (note: the output level corresponding to the minimum point of ATC is called the optimal output level).

Chamberlin introduced the concept of 'selling cost', which is incurred to promote the sell of a product. He assumed that it is 'U' shaped. We will discuss this concept in detail.

3) **Demand Curves**

Product differentiation while Sraffa first introduced that product differentiation could be a basis for downward sloping demand curve, Chamberlin suggested that demand is not determined by the prices alone. Apart from price, the selling activities and the product itself are the major determinants of demand, according to Chamberlin.

The effect of product differentiation is that the producer has some discretion in the determination of prices. The producer is not a price taker but she enjoys some degree of monopoly power.

4) **Equilibrium of the Firm**

As a result of product differentiation, the demand curve of an individual firm is negatively sloped. If the firm increases its price, it will lose some of its customers. However, by reducing price if will attract new customers, who were customers to other firms.

Since there are large number of firms, if one firm reduces price the loss of other firms (as they loose customer) will be negligible. Thus, other firms might be indifferent to price charged by a single firm. The demand curve dd is drawn on the above assumption that firms would not change or react to individual firms price decisions.

In short, Chamberlin-firm acts like a monopolist and maximises its profit equating MR and MC.

Chamberlin developed two different models of equilibrium.

In the first model, the existing firms are in short run equilibrium realising supranational profits. They do not have any incentive to change their prices.

In the second model, it is assumed that the member of firms in the industry is optimal and long run equilibrium is achieved by price adjustments.

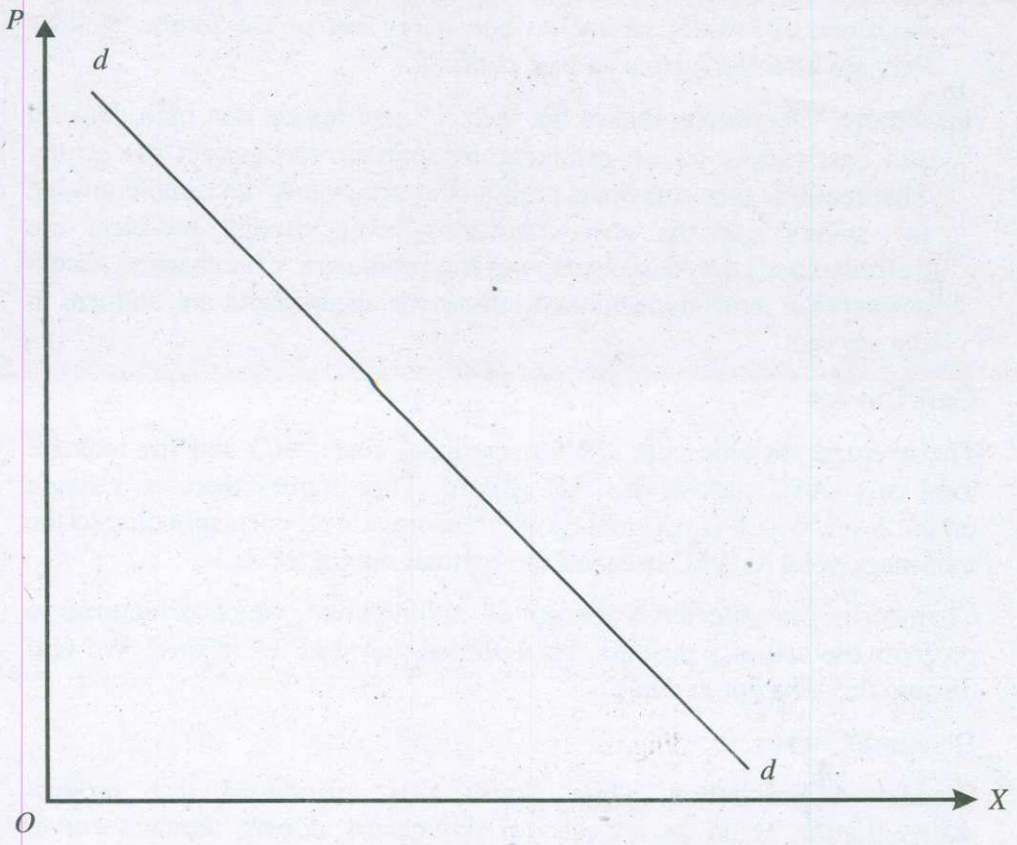

Fig. 9.5: Product Differentiation and Equilibrium of Firm

The third model is a combination of the first two, where long-run equilibrium is achieved by price adjustments by the existing firms and by new entry.

9.4.1 Model 1

We assume that each firm is in short-run equilibrium maximising its profit.

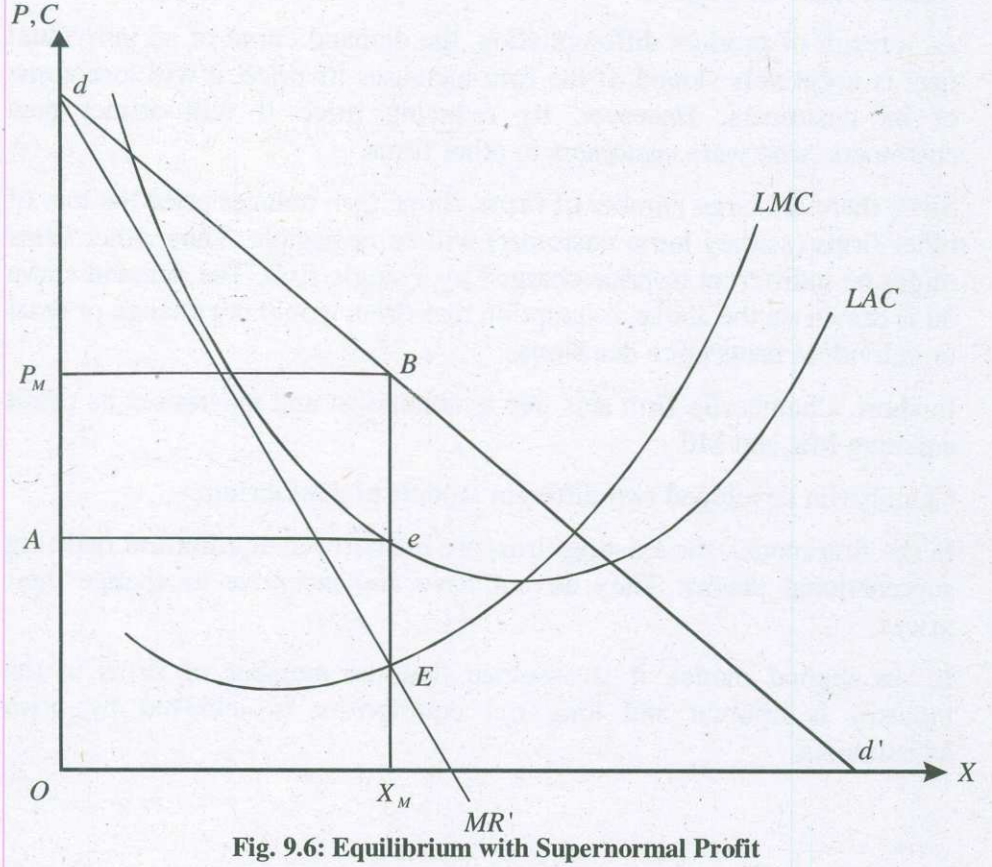

Fig. 9.6: Equilibrium with Supernormal Profit

dd': firm's demand curve

E:. equilibrium point given by MR= MC.

P_M: price corresponding to MR=MC.

X_M: output corresponding to MR = MC

Area P_M ACB: total profit

Since there are no entry barriers, new firms will enter and the demand curve of the individual firm will shift down from dd. However, the cost curves would not change due to new entrants. For each entry, there will be a corresponding shift in the demand curve and for each shift, there will be a price adjustment. This process will continue till there is supernormal profit. The supernormal profits will be wiped out when the demand curve of the firms is tangent to the average cost curve. Consequently, the profits earned will be normal and there will be no further entries.

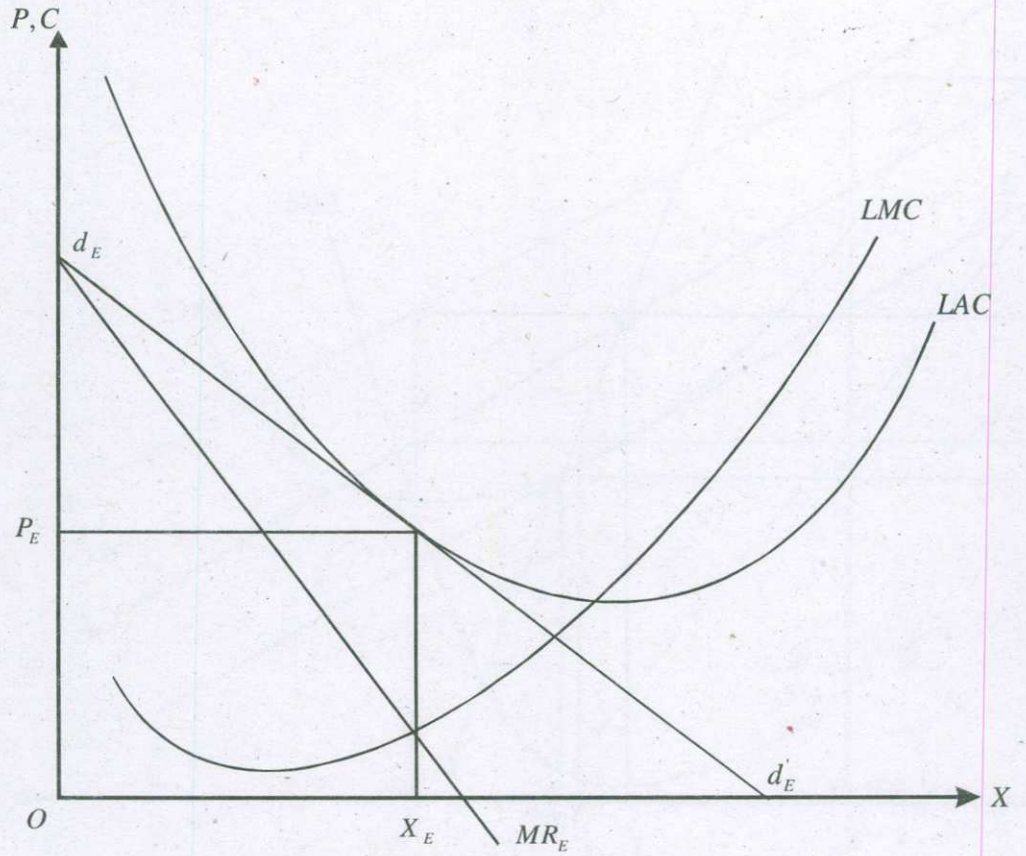

Fig. 9.7: Equilibrium with Normal Profit

9.4.2 Model 2

In this model, it is assumed that the number of firms is such that there is no supernormal profit. Therefore, there is no entry and exit.

In the model, we consider a demand curve labelled DD shown in the following Figure 9.8. The demand curve shows the actual sales of the firm at each price after accounting for the adjustments in price made by other firms. DD is called 'share of the market demand curve: DD is obtained as a locus of points of shifting dd' curves, as competitions also simultaneously charge their price. DD is steeper than dd curve (why?). A movement along DD shows changes in actual sales of existing firms as all of them adjust their price simultaneously (and more importantly) identically, with their share remaining constant. Shift in DD is caused by entry and exit of firms.

We start with the non-equilibrium position of a firm (X_0, Po). The firm, in an attempt to maximise profit lowers its price to P_1 expecting to increase the sell. However, all the firms adjust to this price change by lowering theirs by the same proportion. As a result, d_1d_1 shifts downward to d_2 d_2 and instead of X_0, only X_1 amount of output is sold (notice that: (X_1, P_1) is on DD')

Again, in order to maximise profit, firm reduces its price once more to P_2, but as a consequence of the price adjustment by the others, it could sell only X_2 (though wished to sell X_0). Here we assume that the firm is naive and does not take lessons from the past. This process ultimately stops when dd' has shifted enough to the left to be tangent to the LAC.

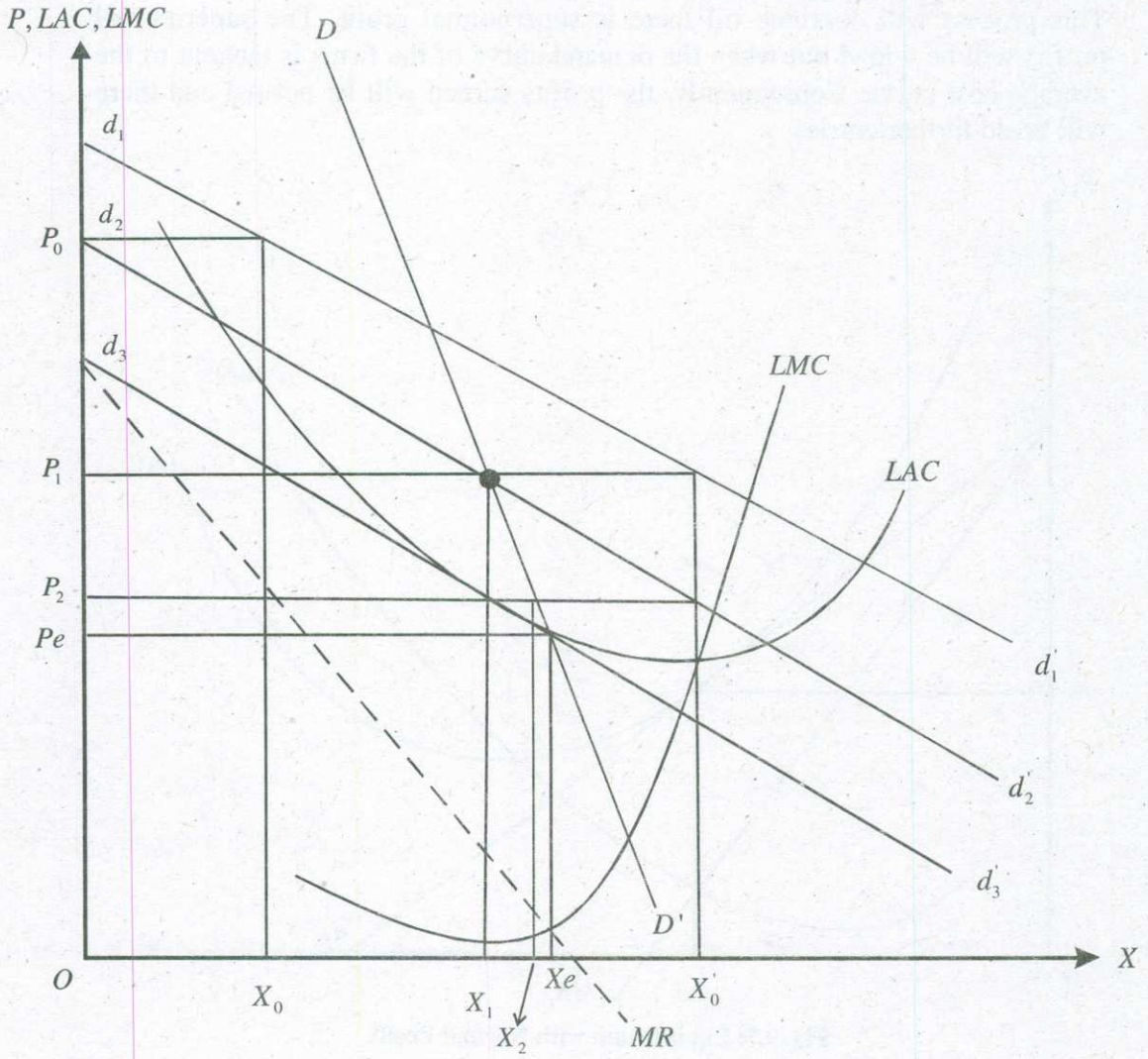

Fig. 9.8: Equilibrium in Monopolistic Competition

9.4.3 Model 3

Chamberlin argued that in practice equilibrium is achieved by price adjustments of existing firms (as in model, 2) as well as new entry (as in model 1). Equilibrium is stable if the dd' is tangent to the average cost curve and expected sales are equal to the actuals (i.e., the dd' curve cuts the DD' at the point of tangency of dd' and LAC).

We start with the point e_1 (see Figure 9.9) where there is abnormal profit. New firms are **alternated** until D_1D_1' shifts to D_3D_3'. Some might take e_2 as a long run equilibrium with (P, X) price output combination since only normal profit is earned these. However, this is not true. Each firm believes d_1d_1 is its demand curve and if prices are lowered, output sold goes up and hence profit will

increase. However, each firm having the same incentive to reduce price. As a result, dd' slides down and each firm realises a loss instead of profit

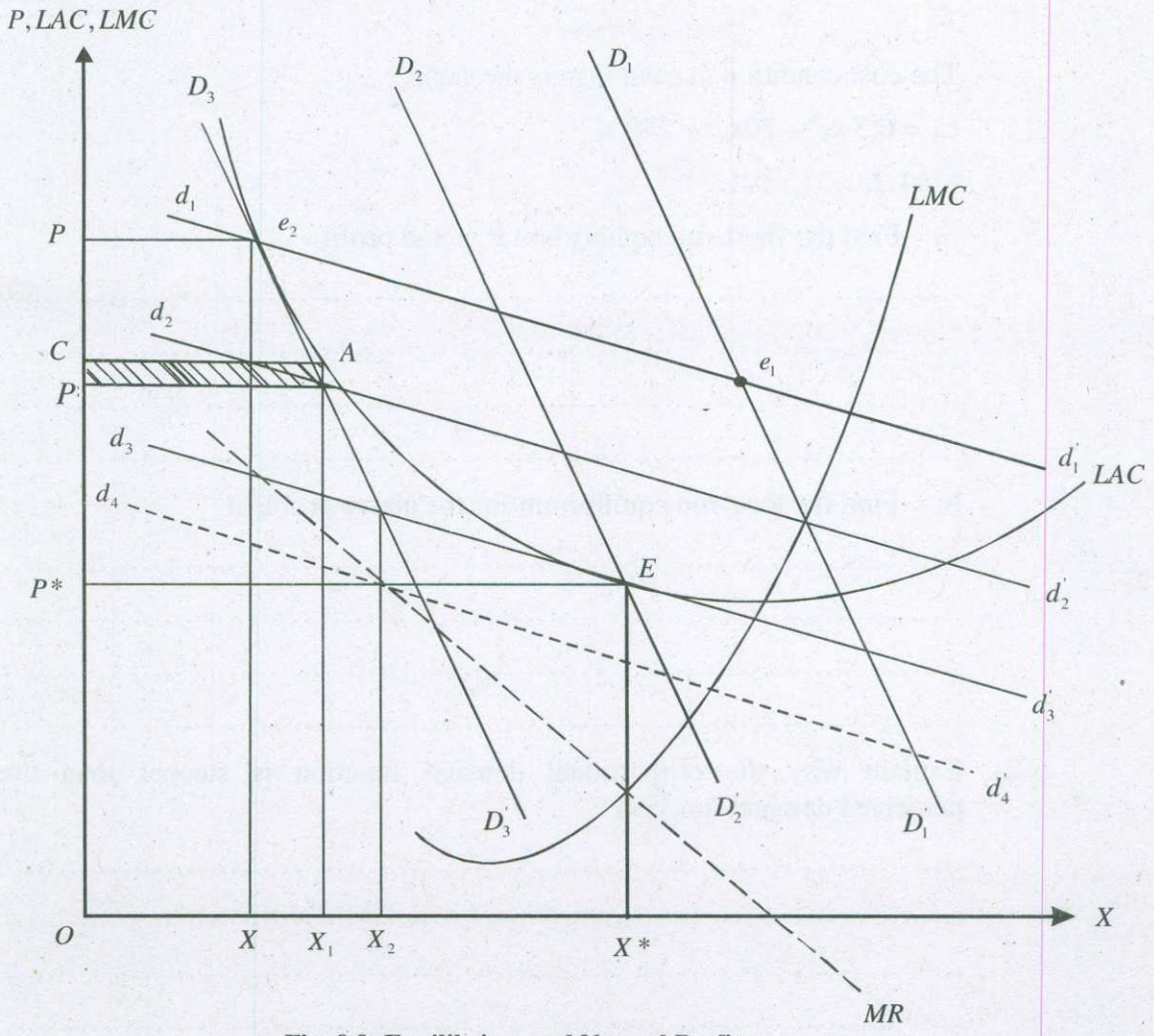

Fig. 9.9: Equilibrium and Normal Profit

For example, see that at position d_2d_2. The firm has reduced price to P' but others have not done similarly and X_1 is produced with a total loss equal to the shaded area CP'BA. Each firm still believes that it can achieve positive profit by cutting price. The loss in fact increases further as D_2D_2 slides down along D_1D_1'. The process would end when dd' becomes tangent to the LAC. This will happen if the firms produce X*. However, still there are too many firms and their share is X_2 (given by intersection of D_3D_3' and d_3d_3'). Firms in order to achieve X^*, (to maximize profit since at X*, MR=MC) reduce price. As a result, d_3 d_3 slides down further to the left and with increasing losses. The firms, which cannot bear this loss, quit D_3D_3 and move to the right to D_2D_2. Exit will continue till d_3d_3'becomes tangent to LAC, and D_2D_2' cuts d_3d_3' at the point of tangency. The point E is the table equilibrium where (P^*, X^*) is the equilibrium price quantity combination. Firms earn normal profit and no entry or exit takes place

Check Your Progress 1

1) Suppose there is a monopolistic competition market with 101 firms. The market demand function is given by

$$P_k = 150 - x_k - 0.02 \sum_{\substack{i=1 \\ i \neq k}}^{k} x_i$$

We start with the non-equilibrium position of a firm (X_0, Po). The firm, in an attempt to maximise profit lowers its price to P_1 expecting to increase the sell. However, all the firms adjust to this price change by lowering theirs by the same proportion. As a result, d_1d_1 shifts downward to d_2 d_2 and instead of X_0, only X_1 amount of output is sold (notice that: (X_1, P_1) is on DD').

$\sum_{\substack{i=1 \\ i \neq k}}^{k} x_i \rightarrow$ all other firms reaction

The cost condition in each firm is the same,

$C_k = 0.5\ x_k^3 - 20x_k^2 + 270\ x_k$

K =1,2, ... 101,

a) Find the short-run equilibrium P, x and profit.

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b) Find the long-run equilibrium for the above problem.

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2) Explain why the proportional demand function is steeper than the perceived demand function.

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3) What is the difference between 'industry' and 'product group'? Can you give an example of product group in the context of Indian market?

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9.5 SELLING COSTS

Under monopolistic competition, each firm incurs a certain amount of selling cost to inform the customer about its product. A firm under monopolistic competition has, therefore, three variables at its disposal, viz., price, quantity and selling expenditure. Let us examine how selling cost enters into the determination of equilibrium output of a firm and how the optimum amount of selling cost is determined.

Under monopolistic competition, quantity demanded will be a function of both price and selling cost

i.e., X = X (S, P) where

S: selling cost

P: price

X: output demanded

Let us assume S is fixed at level **So**. Then we can get different combinations of P and X for this level of S = So which satisfies the demand equation. Locus of all such points is the AR (average revenue) curve. Thus, for each level of selling cost, we will get an AR curve. This is shown in the following figure.

AB': AR curve when $S=S_o$

A'B': AR curve when $S=S_1$

The figure shows that for selling the same quantity (X_o), the firm can charge higher price (P_o to P^1) if it incurs higher selling costs (S_o to S_1).

The selling cost is a function of price and quantity. Symbiotically, S = S(X, P)

Therefore, profit (π) of a firm is

$\Pi = P.X - C(X) - S(P, X)$ [where C= C(X) is the cost function]

First order conditions of profit maximisation are

$$\frac{\partial \Pi}{\partial X} = P - C'(X) - \frac{\partial S}{\partial X} = 0 \qquad ...(1)$$

$$\frac{\partial \Pi}{\partial P} = X - \frac{\partial S}{\partial P} = 0 \qquad ...(2)$$

From (1) $P = C'(X) + \frac{\partial S}{\partial X}$ ...(3)

Total Revenue R= P.X

$$\frac{\partial R}{\partial X} = P \text{ or, } MR = P$$

From (3) $MR = C'(X) + \frac{\partial S}{\partial X}$

Thus, for profit maximisation marginal revenue with respect to output must be equal to marginal production cost plus the marginal selling cost.

From $X = \frac{\partial S}{\partial P}$

X may be called MR with respect to price. Thus, MR of a firm with respect to price must be equal to MSC (marginal selling cost).

The following diagram explains the equilibrium of a firm

$D_0 D_0$: Demand curve for selling cost $S = S_0$

D_1D_1: Demand curve for selling cost $S = S_1$

D_2D_2: Demand curve for selling cost $S = S_2$

MR_0, $MR_1$and MR_2 are the marginal revenues for selling cost S_0, S_1 and S_2 respectively. MC is the marginal cost curve.

The second order condition required that MR increases less rapidly than MC both with respect to output and price

If the firm behaves like a monopolist, its profit maximising output-price combination is (X_o, P_o), (X_1, P_1), (X_2, P_2) for selling cost S_o, S_1 and S_2, respectively (these are obtained by equating MR_o, MR_1 and MR_2 with MC).

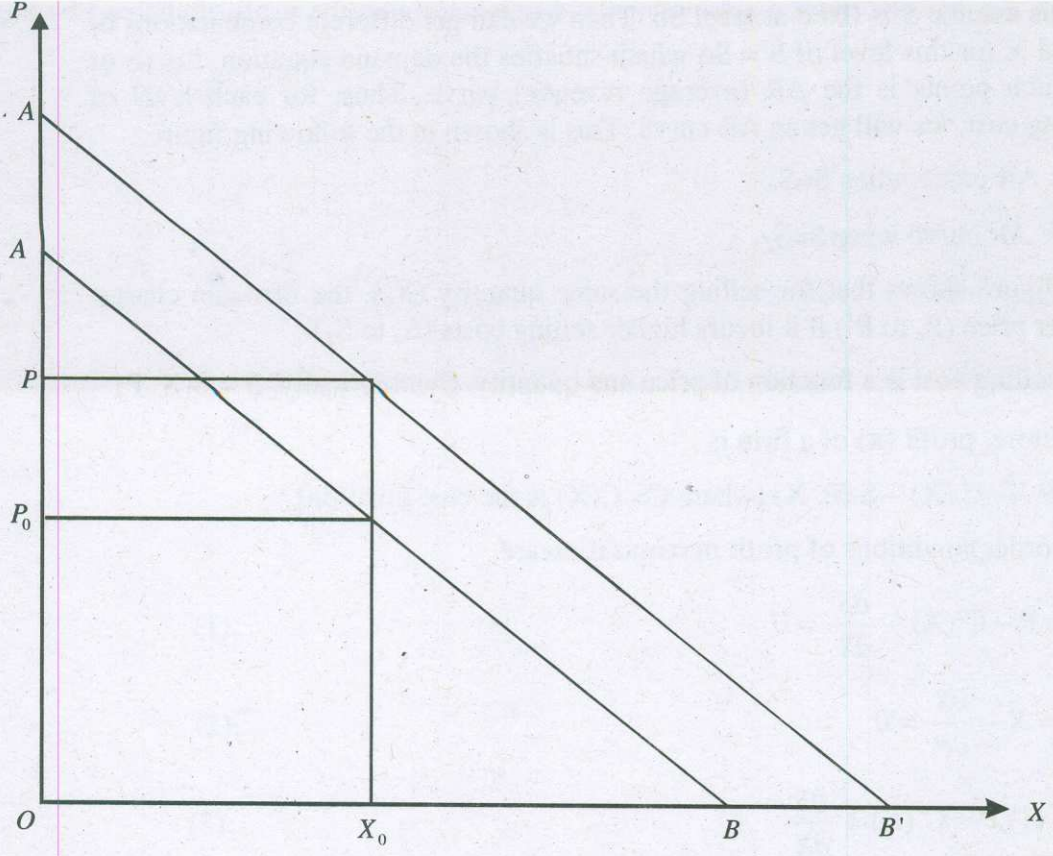

Fig. 9.10: Selling Cost and AR

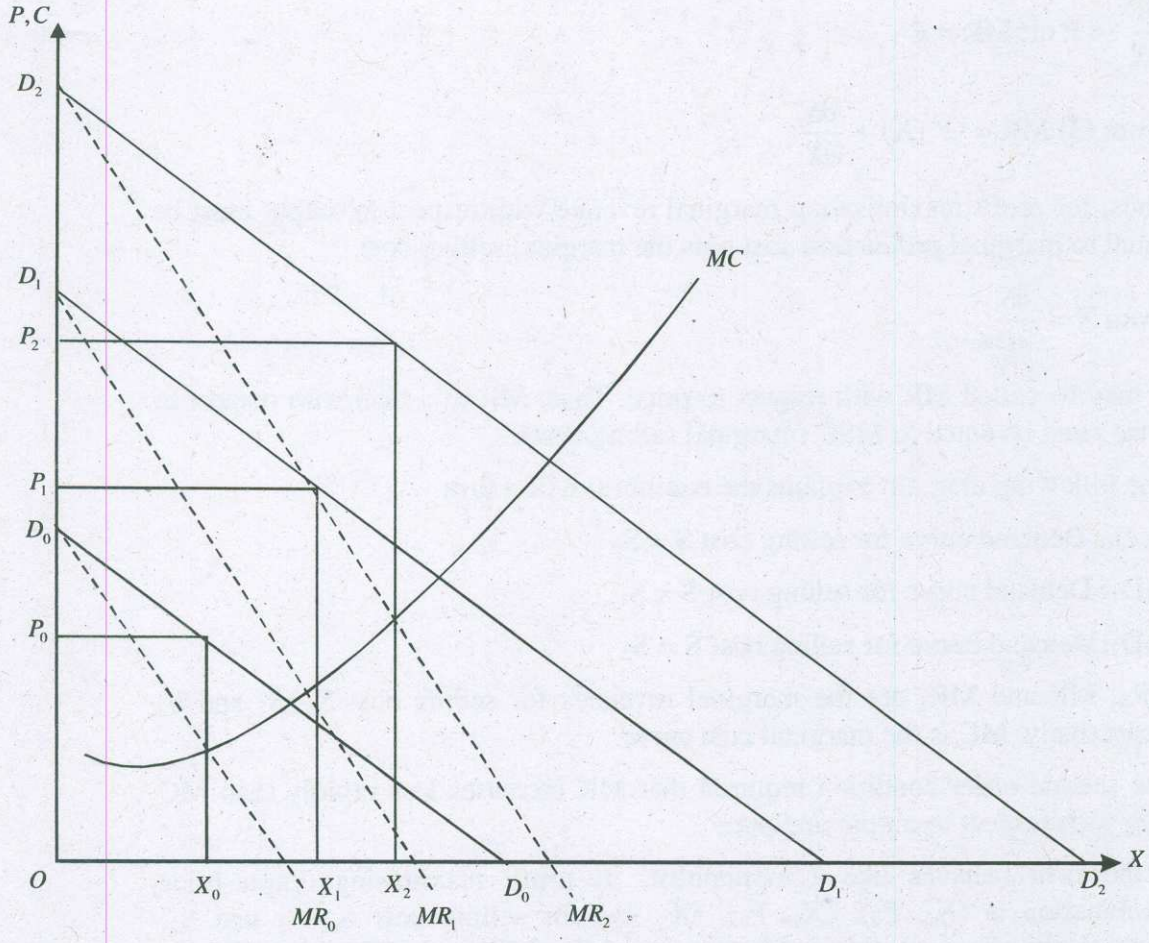

Fig. 9.11: Equilibrium in Monopolistic Competition with Selling Costs

For each of these combinations, we can determine the profit. Let these be π_o, π_1, π_2, respectively for $S = S_o$, S_1 and S_2

Thus, we can find a functional relationship between profit and selling costs, viz.,

$\pi = \pi (S)$

If we plot the profit on vertical axis and selling costs on horizontal axis, the curve will look like the curve given in Figure 9.12.

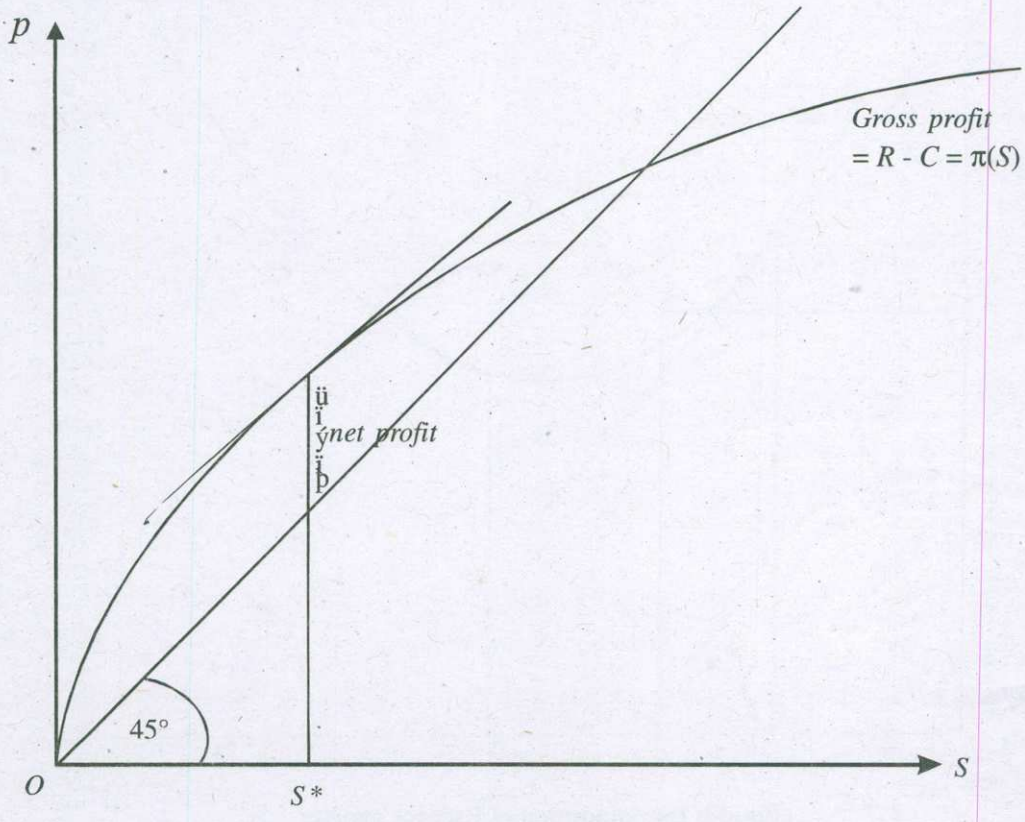

Fig. 9.12: Relationship between Profit and Selling Costs

Clearly, where the vertical difference between π (s) and the 45^0 line π (S) =S is maximum,

i.e., $\pi (S) - S$

or, $R - C (X) - S(X)$

or, $P.X - (X) - S(X)$

gives the optimum level of selling cost.

Thus, the optimum selling cost (S^*) is obtained when the slope of π (S) is equal to unity.

9.6 EXCESS CAPACITY UNDER MONOPOLISTIC COMPETITION

Consider the long-run equilibrium for the firm under monopolistic competition. At the equilibrium, the perceived demand curve is tangent to the LRAC curve. Since the demand curve is downward sloping, the LRAC is also downward sloping at this point. Unlike in perfect competition, the firm's equilibrium would never be at the minimum point of the LRAC curve. Hence, it is argued that the firm's output under monopolistic competition is not the ideal output and there exists excess capacity, which is a wasteful use of society's resources.

Ideal output or the optimum output is associated with the minimum point of the LRAC curve. The excess capacity is the difference between the optimal output and the actual output attained by the firm in the long-run.

As Cassels argues, excess capacity in monopolistic competition could be divided into two components. This is shown in the following figure:

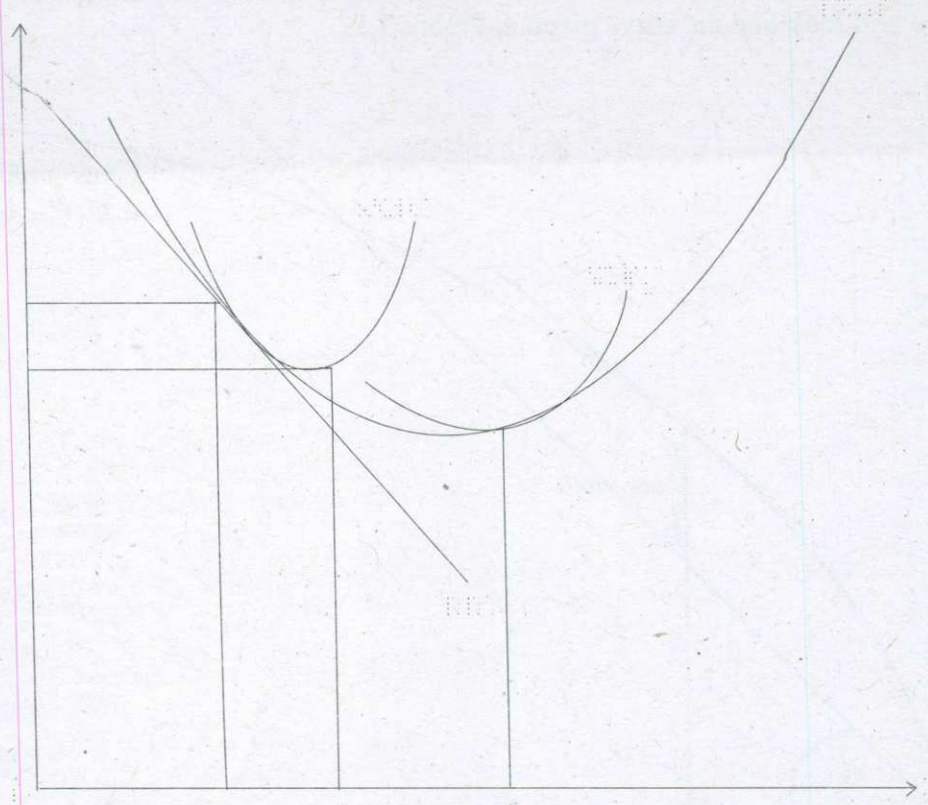

Fig. 13: Decomposition of Excess Capacity

OX_1: Ideal or optimal output as it corresponds to minimum point of LRAC curve

OX_E: Long-run equilibrium output in a monopolistic competitive market

$SRAC_1$: Short-run average cost curve corresponding to optimal plant for output OX_E

$SRAC_2$: Short-run average cost curve corresponding optimal plant for output OX_1

Excess capacity is $X_E X_1$, which could be decomposed as

i) $X_M X_1$: due to not building the technically optimal plant

ii) $X_E X_M$: due to not operating the plant at the minimum point of the average cost

Chamberlin, however, defended the high cost of output under monopolistic competition with the shield of the product differentiation. According to him, people may be willing to pay for the differentiation. Thus, the ideal output is not that one corresponding to the minimum point of the LRAC curve. Of course, excessive proliferation of products of different quality is a waste of society's resources, but the cost of monotonicity produced by having uniform products has to be taken into account as well.

Check Your Progress 2

1) What it an ideal output? Why it is ideal?

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2) What is excess capacity? In a monopolistic competitive market, could there be situation where firms are actually producing more than the ideal output? Explain.

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3) Is excess capacity socially desirable? How Chamberlin argued in favour of excess capacity?

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9.7 CRITICISM OF MONOPOLISTIC COMPETITION

The model of monopolistic competition was received very enthusiastically and many economists termed it as "Chamberlin revolution" but there were several serious attacks on this model

The downward sloping demand curves are derived from the assumption of product differentiation. This is inconsistent with the assumption that cost curves or demand conditions are the same for all the firms. If the output of two firms is genuinely different, then the cost per unit of output is not really comparable. Furthermore, the long-run equilibrium of a firm with only normal profit is logically incorrect. If the firm is providing a unique product and making supernormal profits as a consequence, other firms can compete away these profits only by providing the same product.

Another problem created by the introduction of product differentiation is the difficulty to define the industry or the product group, e.g., tea, coffee, soft drinks, beer, wine and liquor could form a product group according to somebody but some others may reject. Thus, in monopolistic competition it is not very clear where do we draw the line.

Finally, differentiated products are not produced by different firms. One single firm may produce several differentiated products, which are close substitutes of each other.

The monopolistic competition market structure is not useful for making any prediction. Unlike the theories of perfect competition and monopoly, it does not provide unambiguous predictions of the effect of changes in costs or demand on the price of the product, size of the plant and the number of firms operating in the industry.

All these discussions on monopolistic competition, however, do not mean that it has been useless. For, it did raise a lot of issues previously overlooked which prompted literature of selling costs, advertising, non-price competition etc.

9.8 LET US SUM UP

Monopoly and perfect competition are extreme forms of market and do not resemble with reality. Chamberlin clubbed these two market structures together and generated the concept of monopolistic competition.

The short-run and long-run equilibrium under monopolistic competition differ considerably from those of monopoly and perfect competition. In short run there is excess profit and in the long-run that is wiped out as new firms enter the market.

Most interestingly, under this market structure one could see that firms do not operate at optimal plant size. This has huge significance to optimal use of constrained resources.

9.9 KEY WORDS

Monopolistic Competition: A market structure characterised by many small independent sellers of a differentiated product without barriers to entry.

Product Differentiation: The case where consumers perceive similar products to have distinguished characteristics despite being substitutes of each other.

Product Group: A group of all the products, which are close substitutes of each other.

Proportional Demand Curve: It is the demand curve facing a particular firm in a product when all the firms charge the same price even though the particular firm changes its prices.

Optimal output or Ideal Output: Output corresponding to the minimum point of the LRAC curve.

Excess Capacity: The difference between optimal output and the output attained by the firm in the long run equilibrium.

Selling Costs: The cost incurred by a firm in order to increase the volume of sales. This cost is different from production cost.

9.10 SOME USEFUL BOOKS

Chamberlin, E.H (1933), *The Theory of Monopolistic Competition*, Cambridge, MA: Harvard University Press.

Ferguson and Gould (1989), *Microeconomic Theory*, Irwin publications in economics;; Homewood, IL: Irwin.

Koutsoyiannis, A. (1979), *Modern Microeconomics*, Second edition, London: Macmillian.

9.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) a) $\Pi_k = p_k.x_k - c_k\,(150 - x_k - 0.02 \sum_{\substack{i=1 \\ i\neq k}}^{k} x_k)\, x_k - 0.5x_k^3 + 20\, x_k^2 - 270\, x_k$

First order condition for profit maximisation requires

$$\frac{\partial \Pi_k}{\partial X_K} = 0$$

$$1.5x_k^2 - 38x_k + 120 + 0.02\sum_{\substack{i=1 \\ i\neq k}}^{k} x_k = 0$$

In eqm. $x_i = x_k\ \forall_I\ (1, 101)$

Therefore, the first order condition reduces to

$1.5x_k^2 - 38x_k + 120 + (100)\ (0.02)\ x_k = 0$

Solving this equation, we get $x_k = 4, 20$

Second order condition requires

$$\frac{\partial^2 \Pi}{\partial X_{K^2}} < 0$$

Check yourself that at x = 20, second order condition holds but not at x=4

$$\therefore P_k = 150 - x_k - 0.02 \sum_{\substack{i=1 \\ i\neq k}}^{k} x_k$$

Since at eqm. $x_i = x_k\ \forall_i$

$\therefore P_k = 150 - x_k - 0.02\ (100).\ X_k$

$= 150 - 3\ x_k$

$= 90$ [Therefore $x_k = 20$]

$\Pi_k = 400$

b) As in the short run $\Pi_K > 0$, new firms will enter the industry

$$\Pi_k = x_k\,(150 - x_k - 0.02\,\frac{n}{2} n_i) - 0.5x_k^2 + 20\, x_k^2 - 270\, x_k$$

(we sum over i =1 to n as the number of firms is unknown)

From first order condition

$$1.5\, x_k^2 - 38x_k + 120 + 0.02\,\frac{n}{2} x_i = 0$$

In eqm. $x_i = x_k$

$1.5\ X_k^2 - 38xk + 120 + 0.02\ (n\text{-}1)\ X_k = 0$ ...(1)

In the long-run p = LAC

$$\text{or, } (50 - X_k - 0.02) \sum_{\substack{i=1 \\ i\neq k}}^{k} x_k = 0.5\ X_k^2 - 20\ X_k + 1270$$

or, $0.5\ X_k^2 - 19\ X_k + 120 + 0.02\ (n-1)\ X_k = 0$ {Therefore, in eqn. $Q_i = q_k\ \forall_i$} ...(2)

$$X_k^2 - 19X_k = 0$$

or, $X_k = 0$ or, 19.

The second order condition requires

$$\frac{\partial^2 \Pi_K}{\partial X_K} = 38 - 3X_K < 0$$

which is satisfied for $X_k = 19$

Long-run equilibrium is obtained when $X_k = 19$

Now putting $X_k = 19$ in equation (2)

$$0.5\ (19)^2 - 19\ (19) + 120 + 120 + 0.02\ (n-1)\ 19 = 0$$

$$\text{or, } 0.5 \times 361 - 361 + 120 + 0.38\ (n-1) = 0$$

$$\text{or, } 0.38\ (n-1) = 60.5$$

$$\text{or, } n = \frac{6050}{38} + 1 = 160.2 \cong 161$$

Thus, there will be 161 firms in the long run

2) Do it yourself using Section 9.3.1.

3) Do it yourself using Section 9.2.

Check Your Progress 2

1) Do it yourself using Section 9.6 the output is ideal because the L AC is minimum at that point.

2) For the first part use Section 9.6

In monopolistic competition the demand curve is negatively sloped and the long-run equilibrium is achieved when perceived demand curve is tangent to LAC. Since the perceived demand curve is negatively slope, it would be tangent to LAC only at its falling portion. Therefore, a firm in the long-run would never produce more than the optimal output

3) Do it yourself using Section 9.6

9.12 EXERCISES

1) Illustrate a monopolistically competitive firm in short run suffering a loss. Describe the adjustment procedure in the long run.

2) Which one between perceived and proportional demand curve determines the firms choice of output and price? Why two must intersect at the equilibrium point?

3) Is the soft drink market in India an example of monopolistic competition? If not, give reasons.

UNIT 10 OLIGOPOLY

Structure

10.0 Objectives

10.1 Introduction

10.2 Oligopoly: Homogenous Product

- 10.2.1 Quasi-Competitive Solution
- 10.2.2 Collusion Solution
- 10.2.3 Cournot Solution
  - 10.2.3.1 Cournot Model with Conjectural Variations
  - 10.2.3.2 Isoprofit Curve and Counot Equilibrium
- 10.2.4 Stackelberg Solution
  - 10.2.4.1 Stackelberg Solution with Isoprofit Curves
- 10.2.5 Bertrand Competition

10.3 Oligopoly: Differential Products

- 10.3.1 Market-Shares Solution
- 10.3.2 Kinked-Demand-Curve Solution

10.4 Oligopsony

10.5 Let Us Sum Up

10.6 Key Words

10.7 Some Useful Books

10.8 Answer or Hints to Check Your Progress

10.9 Exercises and Answers

10.0 OBJECTIVES

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

- understand the oligopolistic market structure;
- appreciate the role of interdependence among the producers in deciding the output and price; and
- examine the important models developed for analysing oligopolistic behaviour.

10.1 INTRODUCTION

The distinguishing feature in oligopoly is strategic interdependence among the firms with regard to price and output decisions.

Oligopoly is a market system that is dominated by few big suppliers of homogeneous or differentiated products. Because there are few firms, oligopolists exercise control over prices. However, they take into account the reaction of rivals after they change price of goods, output quantity and amount of money spent on advertising.

Producers

By saying "few large producers" we essentially describe a market structure. Some example of oligopoly can be two or three zinc producers in Sweden, or five or six producers of auto parts in U.K. In general when you speak about big three/four/five firms producing a product, you are describing about an oligopoly market.

Homogeneous or Differentiated Products

Firms in oligopoly of market system produce a standardized or differentiated product. In case of oligopoly the standardized product is homogeneous. Many industrial goods such as aluminum, lead and cement are standardized products that are supplied in oligopolies. However, there is a set of other goods, like cigarettes, automobiles, breakfast cereals which are produced in differentiated oligopolies. In this product market producers are engaged in non-price competition by heavy advertising.

Price and mutual interdependence

Since in oligopolies there are few firms, each one is a price-maker; like monopolists they may set the price and output level for their goods, so that these firms control the revenue. However, unlike monopolists (since there are no competitors), oligopolists have to consider the reaction of rivals to change price, output, product's characteristics and money spent on advertising. Thus oligopolists' decisions are affected by mutual interdependence: a situation in which firm's profits do not depend completely on its price and sales policy, but also on that of rivals. For example, before increasing the price of its drinks Pepsi has to consider the response of other major producers, like Coca-Cola.

Entry-Barriers

Entry barriers are created in oligopoly just like in pure monopoly. Economies of scale are a factor that serves as barrier to entry in some oligopolistic industries, such as aircraft, car-producing and cement industries. In type of industries three or four firms control the market supply, in order to exploit the economies of scale.

Ownership and control of raw materials are also pointed as explanations for the reasons to enter in oligopolistic market system. Oligopolists also prevent the entry of new competitors by preemptive pricing and advertising strategies.

Mergers

Oligopolies are often created by merging with other competing firms. Merging or combination of two or more firms may increase their revenues and economies of scale. The "urge to merge" is often viewed as a desire to exercise higher monopolistic power. Since a larger firm has greater control over market supply, it decides the price of its product. Also, because of higher economies of scale they get fewer costs on producing some goods and services than their rivals.

10.2 OLIGOPOLY: HOMOGENOUS PRODUCT

We have said above that an oligopolistic industry comprises number of firms small enough that the actions of one seller have an influence upon the rivals. Such a configuration results in interdependence of decisions among the sellers in the oligopoly market. We can say, if a seller's quantity decision influences the profit of another, the market is duopolistic or oligopolistic. In

such a market many products like zinc, copper, aluminum and lead are difficult to be distinguished by quality differences and are called homogenous products.

The price-quantity combinations and profit in such a market could be different from those in perfect completion or monopolistic competition. But optimal solution may not be unique as behavior of the producers differs.

In the following we rely on specific behavioural assumptions to generate price, quantity and profit in an oligopoly and compare these with solutions offered in case of perfect completion. It may be noted that we work with duopolistic market structure to arrive at the solutions. But these can be generalised for an oligopolistic market. The following discussion is based on the format of Henderson and Quandt(2003).

10.2.1 Quasi-Competitive Solution

We will assume that market is characterised by a relatively small number of identical firms who produce under symmetric cost conditions. There is perfect competition on the demand side in the sense that there are a large number of buyers. When we consider a small number of suppliers in the market we get the quasi-competitive situation. In such a model, it is easy to assume price-taking behaviour by all firms. Considering inverse demand function for the good, we have the price that buyers are willing to pay for any particular level of industry output. Now we ask in such a market, if prices could be set equal to marginal costs, as has been the case under perfect completion.

Let there be two firms producing a homogeneous product. The inverse demand function is set to be $p = F(q_1 + q_2)$ (10.1)

where q_1 and q_2 are the levels of duopolists' outputs. The total revenue of each duopolist depends upon this own output level and that of her rival. Therefore, we have

$R_1 = q_1F(q_1 + q_2) = R_1(q_1, q_2)$; and $R_2 = q_2F(q_1 + q_2) = R_2(q_1, q_2)$.

The profit of each is, $\pi_1 = R_1F(q_1, q_2) - C_1(q_1)$;

$$\pi_2 = R_2F(q_1, q_2) - C_2(q_2) \qquad (10.2)$$

See that the profit equals to total revenue less cost and the cost depends upon the output level of the concerned firm.

Recall that in a perfectly competitive market the equilibrium solution is obtained by equating price and MC. In the quasi-competitive set up, if each seller follows the competitive rule, then solution can be obtained by solving the equations

$$p = F(q_1 + q_2) - C_1'(q_1);\ p = F(q_1 + q_2) - C_2'(q_2) \qquad (10.3)$$

for $p, q_1,$ and q_2.

Example: Let the demand and cost functions be given by

$$p = 100 - 0.5(q_1 + q_2); \qquad C_1 = 5q_1; \qquad C_2 = 0.5\,q_2^2 \qquad (10.4)$$

Solving (10.3) and substituting in (10.2) gives the quasi-competitive solution as

$$q_1 = 185; \qquad q_2 = 5; \qquad p = 5; \qquad \pi_1 = 0; \quad \pi_2 = 12.5 \quad (10.5)$$

This is the solution of the quasi-competitive model. We compare it with the following duopolistic models.

10.2.2 Collusion Solution

We assume that each firm may recognize their mutual interdependence and agree to act in unison in order to maximize the total profit of the industry. In such an arrangement the industry looks like a multi-plant monopoly. Let

$$R(q_1 + q_2) = R_1(q_1, q_2) + R_2(q_1, q_2) = (q_1 + q_2)F(q_1 + q_2)$$

Aggregate profit is $\pi = \pi_1 + \pi_2 = R(q_1 + q_2) - C_1(q_1) - C_2(q_2)$

See that the profit function is for the two-plant monopolist. Thus, the first-order conditions require that the MC of each producer be equated to MR for output as a whole.

If we consider the example given by (10.4), the industry profit given by

$$\pi = \pi_1 + \pi_2 = 100(q_1 + q_2) - 0.5(q_1 + q_2)^2 - 5q_1 - 0.5q_2^2$$

Setting the partial derivatives of π equal to zero,

$$\frac{\partial \pi}{\partial q_1} = 95 - q_1 - q_2 = 0; \qquad \frac{\partial \pi}{\partial q_2} = 100 - q_1 - 2q_2 = 0\,.$$

Solving for q_1 and q_2 and substituting in the profit and demand equations,

$$q_1 = 90;\ \ q_2 = 5;\ p = 52.5;\ \pi_1 = 4275;\ \pi_2 = 250 \qquad (10.6)$$

Comparing the results of collusion model with the quasi-competitive solution given by (10.5), we find that the total output is much lower, price much higher, and profits much higher. The MCs of the two firms are equal in solutions. However, these are now equal to industry MR rather than price. The profit levels in the collusion model as given in (10.6) are those given by the individual profit functions.

10.2.3 Cournot Solution

Oligopolies commonly compete by trying to steal market share from one another. Thus, rather than compete by lowering price firms often compete on the other factor that directly affects profit — the quantity of the good they sell.

The classical solution of the duopoly problem is associated with the name of Augustin Cournot, an early-nineteenth-century French economist. The model is used when firms produce identical or standardized goods and don't collude. Each firm assumes that its rivals make decisions that maximise profit.

The model offers one view of firms competing through the quantity produced and assumes that the two firms move simultaneously, have the same view of market demand, have good knowledge of each other's cost functions, and choose their profit-maximising output with the belief that their rival chooses the same way. To see the solution of the model we take as before, the two firms. Each duopolist maximises her profit on the assumption that her rival's decision on quantity to be produced is invariant with respect to her decision. Thus, the first duopolist (I for short) maximizes π_1 with respect to q_1, treating q_2 as a parameter, and the second (II for short) maximizes π_2 with respect to q_2 treating q_1 as a parameter.

Set the concerned partial derivatives of (10.2) equal to zero to get,

$$\frac{\partial \pi_1}{\partial q_1} = \frac{\partial R_1}{\partial q_1} - \frac{\mathrm{d}C_1}{\mathrm{d}q_1} = 0; \qquad \frac{\partial R_1}{\partial q_1} - \frac{\mathrm{d}C_1}{\mathrm{d}q_1}; \text{ and}$$

$$\frac{\partial \pi_2}{\partial q_2} = \frac{\partial R_2}{\partial q_2} - \frac{dC_2}{dq_2} = 0; \qquad \frac{\partial R_2}{\partial q_2} - \frac{dC_2}{dq_2} \qquad (10.7)$$

Apply the first-order condition to have each duopolist MC = MR. Again, the second-order condition is

$$\frac{\partial^2 \pi_i}{\partial q_i^2} = \frac{\partial^2 R_i}{\partial q_i^2} - \frac{d^2 C_i}{dq_i^2} < 0 \quad i = 1,2 \quad \text{or,} \quad \frac{\partial^2 R_i}{\partial q_i^2} < \frac{d^2 C_i}{dq_i^2} \quad i = 1,2 \qquad (10.8)$$

From (10.8) it is seen that each duopolist's MR must be increasing less rapidly than her MC.

See that the maximisation process for the Cournot solution is not the same as in the case of the two-plant monopolist. In case of two-plant monopolist, a single firm controls the values of both output levels. Here each duopolist maximises her profit with respect to the single variable under her control. It therefore follows that the MRs of the duopolists are not necessarily equal.

Let $q = q_1 + q_2$ and $\frac{\partial q}{\partial q_1} = \frac{\partial q}{\partial q_2} = 1.$

The MRs of the duopolists are

$$\frac{\partial R_i}{\partial q} = p + q_i \frac{dp}{dq} \qquad i = 1,2$$

The duopolist with the greater output will have the smaller MR.

In equilibrium the values of q_1 and q_2 are such that each duopolist maximises her profit, given the output of the other, and neither desires to alter her output. Thus, the equilibrium is obtained by solving (10.7) for q_1 and q_2 if (10.8) is satisfied.

The underlying process of getting equilibrium solution in the market can be described by introducing an additional step. Reaction functions, which express the output of each duopolist as a function of her rival's output, are determined by solving the first equation of (10.7) for q_1 and the second for q_2. We write,

$$q_1 = \Psi(q_2) \text{ and } q_2 = \Psi(q_1) \qquad (10.9)$$

It may be useful to note that firm I's reaction function gives a relationship between q_1 and q_2 with the property that for any specified value of q_2, the corresponding value of q_1 maximises π_1. Similarly, II's reaction function gives the value of $q_2$which maximises π_2 for any specified value of q_1. In equilibrium, values for q_1 and q_2 satisfy both reaction functions. If the demand and cost functions are given as $p = A - B(q_1 + q_2)$; $C_1 = a_1 q_1 + b_1 q_1^2$; $C_2 = a_2 q_2 + b_2 q_2^2$

the profits of the duopolists are

$$\pi_1 = Aq_1 - B(q_1 + q_2)\, q_1 - a_1 q_1 - b_1 q_1^2$$

$$\pi_2 = Aq_2 - B(q_2 + q_2)\, q_2 - a_2 q_2 - b_2 q_2^2$$

Setting the partial derivatives equal to zero, we have

$$\frac{\partial \pi_1}{\partial q_1} = A - B(2q_1 + q_2) - a_1 - 2b_1 q_1 = 0; \text{ and}$$

$$\frac{\partial \pi_2}{\partial q_2} = A - B(q_1 + 2q_2) - a_2 - 2b_2 q_2 = 0$$

In this set up, the corresponding reaction functions are

$$q_1 = \frac{A - a_1}{2(B + b_1)} - \frac{B}{2(B + b_1)} q_2; \text{ and}$$

$$q_2 = \frac{A - a_2}{2(B + b_2)} - \frac{B}{2(B + b_2)} q_1 \qquad (10.10)$$

If B, b_1, and b_2 are all positive, a rise of either duopolist's output will cause a reduction of the other's optimum output. The reaction functions are linear as pictured in Fig. 10.1. An equilibrium is provided by a solution of (10.10), or equivalently, by an intersection point for the reaction curves, such as E in Fig. 10.1. The solution of (10.10) is

$$q_1 = \frac{2(B + b_2)(A - a_1) - B(A - a_2)}{4(B + b_1)(B + b_2) - B^2}; \text{ and}$$

$$q_2 = \frac{2(B + b_1)(A - a_2) - B(A - a_1)}{4(B + b_1)(B + b_2) - B^2}$$

Note that the second-order conditions are satisfied by the linear demand and quadratic cost functions since we have

$$\frac{\partial^2 \pi_1}{\partial q_1^2} = -2(B + b_1) < 0; \quad \frac{\partial^2 \pi_2}{\partial q_2^2} = -(B + b_2) < 0$$

Seen in terms of example of (10.4) above, you may verify that the reaction functions are

$$q_1 = 95 - 0.5q_2 \quad and \quad q_2 = 50 - 0.25q_1 \qquad (10.11)$$

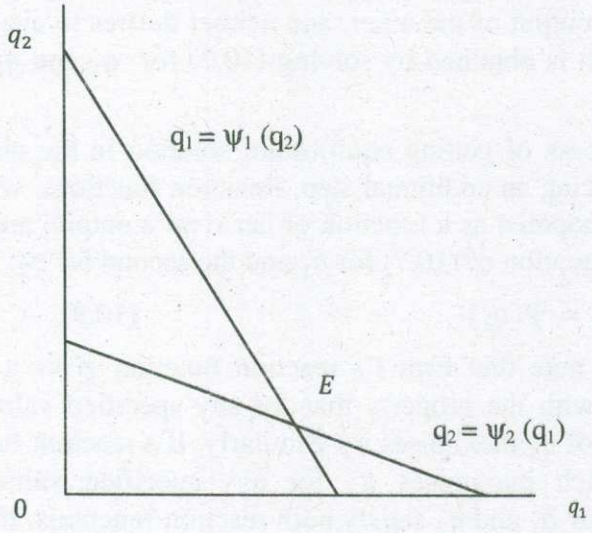

Fig. 10.1: Reaction Curve and Equilibrium

and that the equilibrium solution is

$$q_1 = 80; \quad q_2 = 30; \quad p = 45; \quad \pi_1 = 3200; \quad \pi_2 = 900$$

Let us now compare these solutions with the quasi-competitive solution (10.5). It can be seen that the Cournot duopolists produce a smaller total output, at a higher price and for larger profits. A comparison with the collusion solution (10.6) shows a larger total output at a lower price for a smaller total profit.

Suppose that there is agreement between the duopolists to distribute industry profit. In that event both the duopolists would be better off if the collusion solution attained. For them such an agreed solution is better than that of the Cournot solution.

It can also be shown that the collusion solution is not the only one that dominates the Cournot solution. If, for example, firm I produced 79 units of q_1 and firm II produced 29 units of q_2 (each 1 unit less than in the Cournot solution), their respective profits would be $\pi_1 = 3229$ and $\pi_2 = 913.5$. Thus, although the Cournot solution is optimal for each duopolist on the assumption that the other produces her Cournot equilibrium output, the Cournot solution is not optimal with respect to joint and coordinated changes in output levels.

The Cournot solution assumes that a producer acts as if her rival's output were fixed. However, this needs be a realistic behaviour. The equilibrium can be reached through a sequence of finite adjustments: one duopolist sets an output; this induces the other to adjust her output, which in turn induces the first to adjust decisions. If done so, it will not affect her rival's quantity decision as each of her adjustments will immediately be followed by a reaction on the part of her rival. If equilibrium is thought to be reached simultaneously, the optimal quantity of duopolist I is not given by $q_1 = \Psi(q_2)$, but by $q_2 = \Psi[(q_1)]$, and similarly for firm II, since each knows the behaviour pattern of the other.

In some cases the Cournot solution coincides with the quasi-competitive solution in the limit as the number of firm's increases. As an example, assume that there are n firms with output levels $(q_1, q_2 \ldots\ldots, q_n)$ and let the inverse demand function be $p = aq^b$ where $q = q_1 + q_2 + \cdots \ldots + q_n, a > 0$, and -1< $b < 0$. Let all firms be identical and have total cost given by $C_i = cq_i (i = 1, \ldots\ldots, n)$. If there is a homogeneous product and the firms have identical costs, each will produce the output level $q_i = q/n$. To obtain the Cournot solution differentiate

$\pi_1 = aq^b q_i - cq_i, \quad i = 1,2, \ldots\ldots, n$ with respect to q_i and get, $\frac{\partial \pi_i}{\partial q_i} = aq^b + baq^{b-1}q_i - c = 0$

Substituting $q = nq_i, \quad q_i = \frac{c^{1/b}}{n^{(b-1)/b}(an+ab)^{1/b}}$ and $q = \frac{c^{1/b}}{(a+ab/n)^{1/b}}$

As $n \to \infty$, $q \to (c/a)^{1/b}$. This yields the quasi-competitive solution which can be confirmed by solving $aq^b = c$ ($p = \text{MC}$ in this case) for q.

10.2.3.1 Cournot Model with Conjectural Variations

In conjectural variation models each firm makes certain assumptions about what the rival firm's reaction will be to its own actions. For example, in the Cournot model each firm assumes there will be no reaction to its decision to change output on the part of the other firms. To understand the underlying idea let us take a market with two firms, X and Y, with outputs q_1 and q_2. The market price P is given by the linear demand curve $P = 1 - q_1 - q_2$. so that the total revenue of firm X is then $q_1 P = q_1(1 - q_1 - q_2) = q_1 - {q_1}^2 - q_1 q_2$ assuming that there are no production costs, profits $(\pi) = q_1 - {q_1}^2 - q_1 q_2$.

With conjectural variations, the first order condition for the firm becomes: $\frac{d\pi}{dq_1} = (1 - 2q_1 - q_2) - q_1 \frac{dq_2}{dq_1} = 0$ where $\frac{dq_2}{dq_1} = \emptyset$

is the firms conjecture about how the other firm will respond the conjectural variation or CV term. This first order optimisation condition defines the reaction function for the firm, which states, for a given CV, the optimal choice of output given the other firm's output, i.e., $q_1 = R(q_2, \emptyset) = \frac{1-q_2}{2+\emptyset}$.

Note that the Cournot Conjecture is $\emptyset = 0$, in which case we have the standard Cournot Reaction function. The CV term serves to shift the reaction function and most importantly later its slope. To solve for a symmetric equilibrium, where both firms have the same CV, we simply note that the reaction function will pass through the $q_1 = q_2$ line so that:

$q_1 = \frac{1-q_1}{2+\emptyset}$ so that in symmetric equilibrium $q_1^* = q_2^* = \frac{1}{3+\emptyset}$ and the equilibrium price is $P^* = \frac{1+\emptyset}{3+\emptyset}$. If we have the Cournot conjecture, then we have the standard Cournot equilibrium with $P^* = \frac{1}{3}$. However, if we have the Bertrand conjecture, i.e., $\emptyset = -1$, which we will see later on in this unit, then we obtain the perfectly competitive outcome with price equal to marginal cost.

10.2.3.2 Isoprofit Curve and Cournot Equilibrium

Another way of deriving reaction functions and of visualizing the Cournot equilibrium is with isoprofit equations. For firm 1, for example, this describes all combinations of q_1 and q_2 for a constant level of profit (π_1 = k). In other words, the isoprofit equation includes all $q_1 - q_2$ pairs of points that satisfy, $\pi_1 = k = aq_1 - bq_1^2 - bq_1q_2 - cq_1$.

We obtain the isoprofit equation by solving for q_2: $q_2 = (aq_1 - cq_1 - bq_1^2 - k)/(bq_1)$, which is much like an indifference curve in consumer theory and an isoquant in production theory. A series of isoprofits for firm 1 are graphed in **Figure 10.2** for different values of k. Notice that they are concave to the q_1 axis and that firm 1's profits rise as we move to lower isoprofits (i.e., $k_B > k_A$). The reason for this is that for a given value of q_1 (e.g., q_1'), firm 1's profits increase as q_2 falls (from q_2' to q_2''), as indicated by equation (9.8). The same can be done for firm 2; the only difference is that its isoprofit will be concave to the q_2 axis.

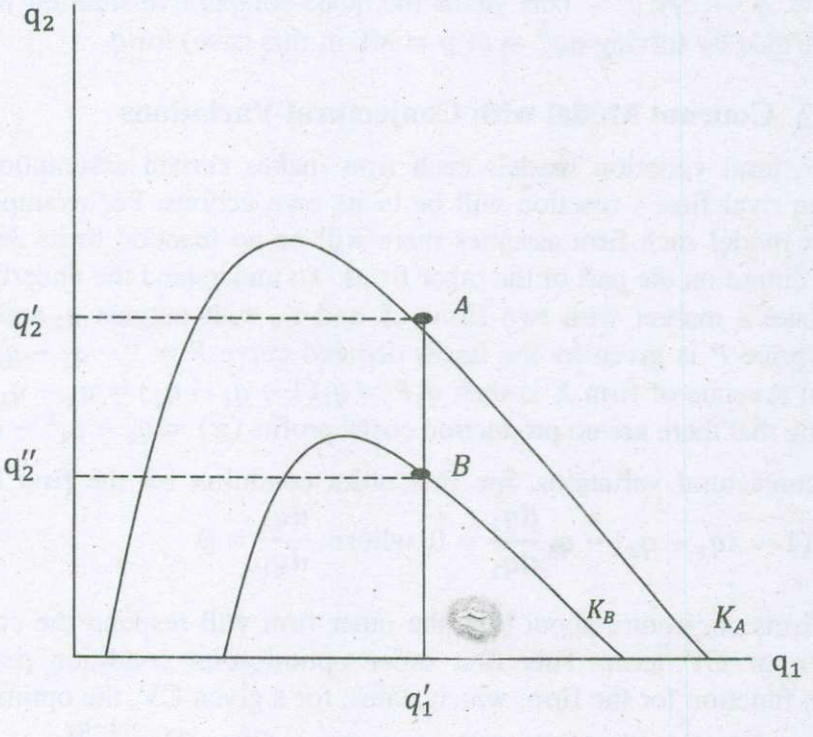

Fig. 10.2: Firm I's Isoprofit Curves

Isoprofits and the definition of a reaction function can be used to derive a firm's best-reply function. To illustrate, consider firm 1's problem when q_2=q_2', as described in **Figure 10.3**. To obtain firm 1's reaction function, firm 1 will chose the level of output that maximises its profits, given the constraint that $q_2 = q_2'$. That will put the firm on the lowest possible isoprofit curve, which occurs at the tangency point A. Notice that this is simply a constrained optimisation problem.

Similarly, when $q_2' = q_2''$, the tangency point is at B. The locus of these tangencies for all values of q_2 generates firm 1's reaction function. The same approach can be used to derive firm 2's reaction function.

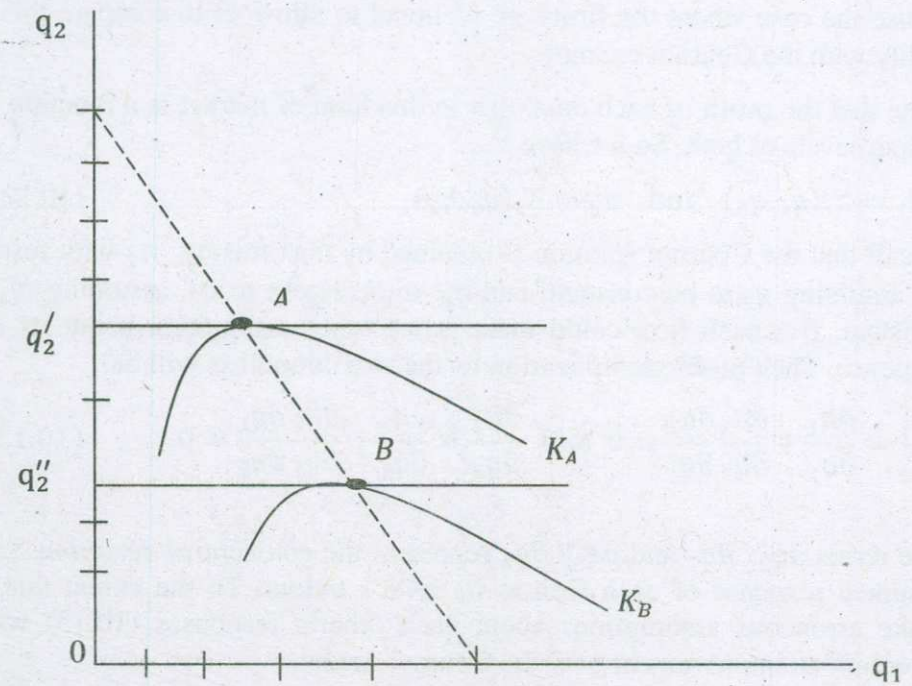

Fig. 10.3: Derivation of Firm 1's Best- Reply Function

Figure 10.4 describes the Cournot equilibrium with respect to best-reply functions and isoprofits. At the equilibrium, it is clear that each firm is maximising the profit given that its rival is producing at the equilibrium level of output. Thus, this is equilibrium because it is a mutual best reply and neither firm has an incentive to deviate. Notice, however, that each firm can earn higher profits if they both cut production and move into the shaded, lens-shaped region.

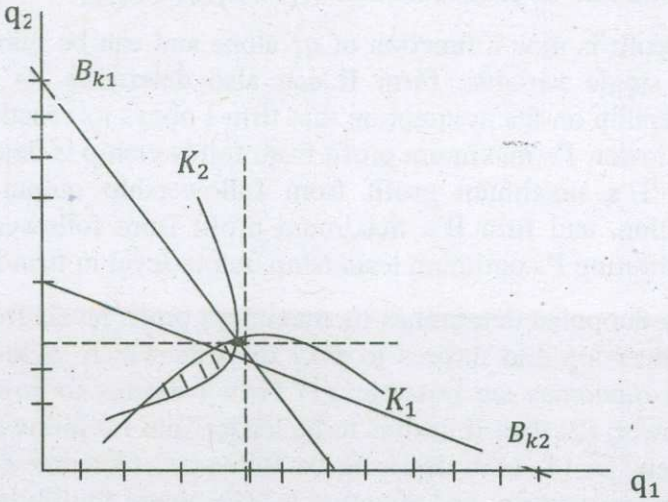

Fig. 10.4: Cournot Equlibrium with Best-reply Fucntion and Isoporfits

10.2.4 Stackelberg Solution

Consider the situation where the firms did not make their decisions simultaneously. One firm moves first and the other firm knew what output the first firm was producing, when it came to make its own decision. This gives the first firm an advantage, because now if the second firm is going to respond by choosing the appropriate point on its best response curve, it has no choice but to choose the output that corresponds to the output chosen by the first firm. This form of competition is called **Stackelberg competition** and the firm moving first is called the **Stackelberg leader**.

Again we assume that the firms are producing identical goods and are competing with each other based on their quantity decisions. We will continue to use the case where the firms are identical to allow us to compare this more easily with the Cournot example.

Note that the profit of each duopolist in this kind of market is a function of the output levels of both. So we have

$$\pi_1 = h_1(q_1, q_2) \quad \text{and} \quad \pi_2 = h_2(q_1, q_2) \tag{10.12}$$

Recall that the Cournot solution is obtained by maximising π_1 with respect to q_1, assuming q_2 to be constant, and π_2 with respect to q_2, assuming q_1 to be constant. But each firm could make some other assumption about its rival's response. Then profit maximization by the two duopolists will be

$$\frac{\partial \pi_1}{\partial q_1} = \frac{\partial h_1}{\partial q_1} + \frac{\partial h_1}{\partial q_2}\frac{\partial q_2}{\partial q_1} = 0 \text{ and } \frac{\partial \pi_2}{\partial q_2} = \frac{\partial h_2}{\partial q_2} + \frac{\partial h_2}{\partial q_1}\frac{\partial q_1}{\partial q_2} = 0 \tag{10.13}$$

The terms $\partial q_2 / \partial q_1$ and $\partial q_1 / \partial q_2$ represent the *conjectural variation,* i.e., the assumed response of each firm to its rival's output. To the extent that firms make erroneous assumptions about each other's responses (10.13) will not represent an improvement over the Cournot model.

The conjectural variation formulated by Stackelberg through an analysis of leadership and followership generates interesting set of results as a solution in an oligopoly market. A *follower would* obey her reaction function (10.9) and adjusts her output level to maximize her profit, given the quantity decision of her rival, whom she assumes to be a leader. A *leader* does not obey her reaction function. She assumes that her rival acts as a follower, and maximizes her profit, given her rival's reaction function. If firm I desires to play the role of leader, it assumes that firm II's reaction function is valid and substitutes this relation into its profit function: $\pi_1 = h_1[q_1 \Psi(q_1)]$.

I's profit is now a function of q_1 alone and can be maximised with respect to this single variable. Firm II can also determine its maximum profit from leadership on the assumption that firm I obeys its reaction function and acts as a follower. I's maximum profit from followership is determined by substituting firm II's maximum profit from followership output level in I's reaction function, and firm II's maximum profit from followership is determined by substituting I's optimum leadership output level in firm II's reaction function.

Each duopolist determines its maximum profit levels from both leadership and followership and desires to play the role which yields the larger maximum. Four outcomes are possible: (1) Firm I desires to be a leader, and firm II a follower; (2) firm II desires to be leader, and I a follower; (3) both desire to be leaders; or (4) both desire to be followers. Outcome (1) results in consistent behaviour patterns and therefore a determinate equilibrium. Assume that firm II will act as a follower, their expectations are not realised, since each assumes

that the other will act as a leader. The duopolists must revise their expectations. Under the Stackelberg assumptions, the Cournot solution is achieved if each desires to act as a follower, knowing that the other will also act as a follower. Otherwise, one must change its behaviour pattern and act as a leader before equilibrium can be achieved.

If both the firms desire to be leaders, each assumes that the other's behaviour is governed by its reaction function. However, neither of the reaction functions is obeyed, nor a *Stackelberg disequilibrium* is encountered. Hence Stackelberg believed that this disequilibrium is the most frequent outcome. The final result of a Stackelberg disequilibrium cannot be predicted a priori. If Stackelberg was correct, such a situation will result in economic warfare, and equilibrium will not be achieved until one has succumbed to the leadership of the other or a collusive agreement has been reached.

We return again to the example given by (10.4). The maximum leadership profit of firm I is obtained by substituting firm II's reaction function (10.11) into firm I's profit equation:

$\pi_1 = 100q_1 - 0.5q_1^2 - 0.5q_1(50 - 0.25q_1) - 5q_1 = 70q_1 - 0.375q_1^2$

Maximizing with respect to q_1,

$\frac{d\pi_1}{d\partial q_1} = 70 - 0.75q_1 = 0; \quad q_1 = 93\frac{1}{3}; \quad \pi_1 = 3266\frac{2}{3}.$

Likewise for firm II, $\pi_2 = 100q_2 - 0.5q_2^2 - 0.5q_2(95 - 0.5q_2) - 0.5q_2^2$ $= 52.5q_2 - 0.75q_2^2$ and

$$\frac{d\pi_2}{dq_2} = 52.5 - 1.5q_2 = 0; \quad q_2 = 35; \pi_2 = 918.75$$

The determine I's maximum followership profit; first determine her output by substituting the leadership output of firm II (35 units) into her reaction function (10.11), and then compute her profit: $q_1 = 95 - -0.5q_2 = 77.5; \quad \pi_1 =$ 3003.125

Likewise substitute $93\frac{1}{3}$ into firm II's reaction function and then compute her profit:

$$q_1 = 50 - 0.25; \; q_1 = 26\frac{2}{3}; \quad \pi_2 = 711\frac{1}{9}$$

Each duopolist receives a greater profit form leadership, and both desire to act as leaders. An example in which the Cournot solution is easily determined has become a Stackelberg disequilibrium as the result of an alteration of the basic behaviour assumptions.

10.2.4.1 Stackelberg Solution with Isoprofit Curves

Let us take firm 1 to be the leader and firm 2 the follower. Given that the leader has chosen q1, firm 2's problem is the same as in the Cournot duopoly case:

$\pi_2 = (q_1, q_2) = P(q_1 + q_2)q_2 - c(q_2)$. First order condition for profit maximisation requires

$\frac{d\pi}{dq_2} = P'q_2 + P - c = 0$. Firm 1's problem taking firm 2's best response into account is $\pi_1 = (q_1, q_2(q_1)) = P(q_1 + q_2(q_1))q_1 - c(q_1)$. The first order condition for firm 1 is $\frac{d\pi}{dq_1} = P'(1 + q_2'(q_1))q_1 + P - c = 0$, or $q_2'(q_1) = -\left[\frac{P-c'}{P'q_1}\right] - 1 = \frac{dq_2}{dq_1}$. That is firm2's best response function is equal to the slope

of the isoprofit function of firm 1. Now firm 1 chooses output so that one of its isoprofit functions is tangent to best response function of firm 2. The graph of such a formulation is given below:

It can be seen that relative to Cournot equilibrium, output is higher for firm 1 and lower for firm 2. Profit of firm 1 is higher while it is lower for firm 2. The aggregate output in stackelberg equilibrium is higher than that of Cournot's.

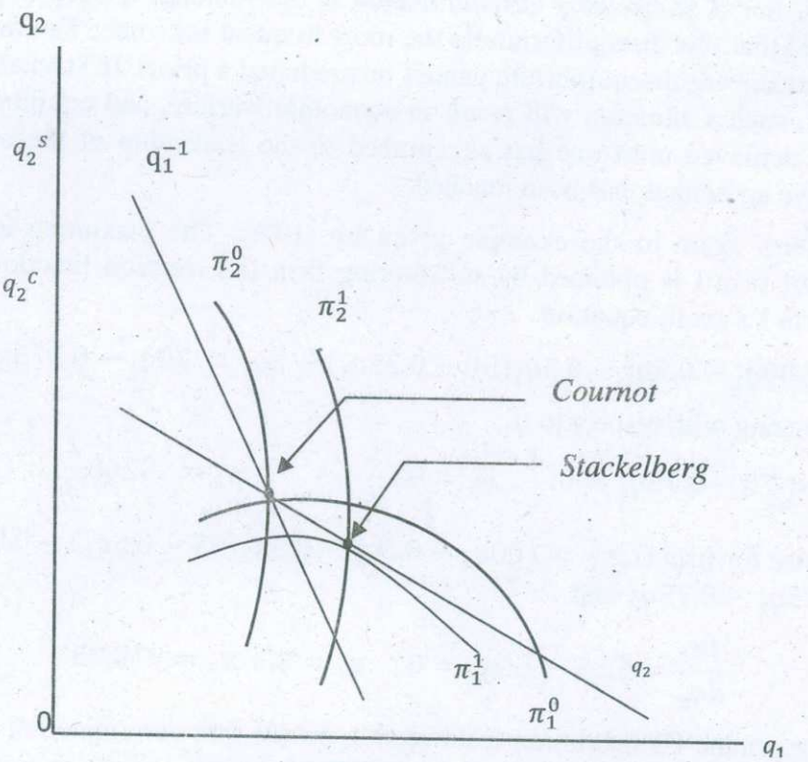

Fig. 10.5: Stackelberg Solution with Isoprofit Curves

10.2.5 Bertrand Competition

Bertrand competition describes interactions among firms that lead competition by a selection of price as the strategic variable. For example, Coca-Cola and Pepsi behave like Bertrand duopolists. Recall that in Cournot argument firms choose quantities. The equilibrium outcome involves firms pricing above marginal cost. Hence such a price is greater than that of the competitive price. However, if firms chose prices rather than quantities as pointed out by Bertrand, then the competitive outcome would occur with price equal to marginal cost.

The Bertrand model is developed by considering at least two firms producing a homogeneous product. Firms compete by setting prices simultaneously and consumers want to buy from a firm with a lower price. If two firms charge the same price, consumers demand is split evenly between them.

A crucial assumption about the technology is that both firms have the same constant unit cost of production. As a result the marginal and average costs are the same and equal to the competitive price. That means as long as the price it sets is above unit cost, the firm is willing to supply any amount that is demanded. If price is set equal to unit cost, then it is indifferent to how much it sells as profit is no longer earned. Moreover, the firm will never want to set a price below unit cost, since it would lose money on each unit sold.

To understand model's equilibrium, take a case where one firm sets price equal to marginal cost, while the other raises its price above unit cost. The high-priced firm earns nothing as all consumers will buy from its rival which charges lower price for the product. If both firms set the same price above unit cost and share the market, then each firm has an incentive to undercut the other by an arbitrarily small amount and capture the whole market and almost double its profits. Hence setting the competitive price yields an equilibrium position for the firms.

The Bertrand model rests on some very extreme assumptions. For example, it assumes that consumers want to buy from the lowest priced firm. There are various reasons why this may not hold in many markets: non-price competition and product differentiation transport and search costs. For example, would someone travel twice as far to save 1% on the price of their vegetables? The Bertrand model can be extended to include product or location differentiation but then the main result – that price is driven down to marginal cost – no longer holds.

The model also ignores capacity constraints. If a single firm does not have the capacity to supply the whole market then the "price equals marginal cost" result may not hold.

There is a big incentive to cooperate in the Bertrand model: colluding to charge the monopoly price and sharing the market each is the best that the firms could do in this set up.

It is difficult to make choice between Bertrand competition and Cournot competition. If capacity and output can be easily changed, Bertrand is generally a better model of duopoly competition. On the contrary, if output and capacity are difficult to adjust, then Cournot is generally a better model.

Example: Let the quantity demanded for firm A and firm B demand functions:

$$A: q_A = 400 - 4P_A + 2P_B$$

$$B: q_B = 240 - 3P_B + 1.5P_A$$

Assume that both firms have zero marginal cost for their products. Compute the Bertrand reaction functions for each proceed as follows:

Firm A's total revenue equals price times quantity, so

$TR_A = P_A \times q_A = P_A(400 - 4P_A + 2P_B) = 400 - 4P_A^2 + 2P_AP_B$. Taking the derivative of firm A's total revenue with respect to the price it charges we get,

$\frac{dTR_A}{dP_A} = 400 - 8P_A + 2P_B$. Setting the equation in Step 2 equal to zero and solving it for P_A yields firm A's reaction function setting the derivative of total revenue equal to zero so that

$\frac{dTR_A}{dP_A} = 400 - 8P_A + 2P_B = 0$; or, $400 + 2P_B = 8P_A$; or, $P_A = 50 + 0.25P_B$.

We firm B to derive its reaction function the same way as above to get $P_B = 40 + 0.25P_A$.

Substituting firm B's reaction function into firm A's, gives,

$P_A = 50 + 0.25P_B = 50 + 0.25(40 + 0.25P_A) = 50 + 10 + 0.0625P_A$, or, $P_A = 60 + 0.0625P_A$, or, $P_A = 64$. Again substituting $P_A$in firmB's reaction function we get $P_B = 56$.

Thus, Bertrand duopoly model indicates that firm A maximises profit by charging 64, and firm B by charging 56. Note that both the reaction functions

are derived by taking price and not quantity as in the Cournot and Stackelberg models.

Check Your Progress 1

1) What is a reaction function?

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2) In Cournot model why reaction functions are often downward sloping?

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3) In an oligopoly market with two firms, industry demand is given as $Q = 100 - 2p$ and marginal cost $(MC) = 5$, where $Q = q_1 + q_2$. Find the reaction functions of the firms.

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4) What is an isoprofit curve?

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5) Two firms compete in a market for a homogeneous product, respectively producing q_1 and q_2 units. Cost of producing each unit is c. Inverse demand curve is given by $p = a - b(q_1 + q_2)$. To trace out an iso-profit curve consider firm-1's profit for a given combination of (q_1, q_2).

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6) Name the non-collusive oligopoly models.

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10.3 OLIGOPOLY: DIFFERENTIAL PRODUCTS

Similar products may be produced by a few manufacturers within an industry. Each makes her product slightly different in order to charge consumers higher prices. See, for example, markets of cigarette and beer companies. Such Product differentiation occurs with duopoly and oligopoly as well as with monopolistic competition.

Product Differentiation

A differentiated product in an oligopolistic market gives the individual producer an advantage of her own distinct demand curve. She can sell the quantity which depends upon the price decisions of all members of the industry:

$$q_i = f_i(p_1, p_2, \ldots\ldots, p_n) \qquad i = 1, \ldots\ldots, n \qquad (10.14)$$

where $\partial q_i / \partial p_i < 0$ and $\partial q_i / \partial p_i > 0$ for all $i \neq j$. In such a market, an increase of price by the *i*th seller, with all other prices remaining unchanged, results in a reduction of her output level. Because, some of her customers will turn to her competitors. If some other seller whould increase her price, the *i*th seller can sell a larger quantity at a fixed price. Some of her competitor's customers are turning to her. Under monopolistic competition the effects of one producer's actions are spread imperceptibly among a large number of competitors. Under duopoly and oligopoly they are spread perceptibly among a small number.

Individual producers can set either price or quantity. Demand functions may be expressed in inverse form with output levels as independent variables:

$$p_i = F_i(q_1, q_2, \ldots\ldots, q_n) \qquad i = 1, \ldots\ldots, n \qquad (10.15)$$

All partial derivatives of (10.15) are negative. If the *i*th seller increases her output level, with all other output levels constant, p_i will decline, since a larger quantity brings a lower price. If some other seller increases her output level, her price will decline, and the price of the *ith* firm must also decline in order to maintain q_1 at a constant level. Otherwise some of her customers would turn to the firm with lowered price.

The Cournot, collusion, and Stackelberg Solutions are easily modified for product differentiation by replacing $p = F(q_1 + q_2)$ with individual demand functions:

$$p_1 = F_1(q_1, q_2); \; p_2 = F_2(q_1, q_2)$$

The analysis can also be extended to cases in which prices are the independent variables:

$$q_1 = f_1(p_1, p_2); \; q_2 = f_2(p_1, p_2)$$

Profits were expressed as functions of quantities:

$$\pi_1 = h_1(q_1, q_2); \quad \pi_2 = h_2(q_1, q_2)$$

By substitution, $\pi_1 = h_1[f_1(p_1, p_2), f_2(p_1, p_2)] = H_1(p_1, p_2)$; $\pi_2 = h_2[f_1(p_1, p_2), f_2(p_1, p_2)] = H_2(p_1, p_2)$. The profit of each duopolist is a function of both prices, and maximisation may proceed with respect to prices.

In the case of differentiated products the duopolists' profits may also depend upon the amount of their advertising expenditures. If advertising is effective, it allows a firm to sell a larger quantity at a higher price. The demand curves are

$p_1 = F_1(q_1, q_2, A_1, A_2)$; $p_2 = F_2(q_1, q_2, A_1, A_2)$

where A_1 and A_2 are the amounts of advertising expenditure by firm I and firm II respectively. The profit functions become

$\pi_1 = q_1 F_1(q_1, q_2, A_1, A_2) - C_2(q_1) - A_1$;

$\pi_2 = q_2 F_2(q_1, q_2, A_1, A_2) - C_2(q_2) - A_2$

Each duopolist must now maximise her profit with respect to her advertising expenditure as well as her output level.

10.3.1 Market-Shares Solution

There is another form of conjectural variation which assumes that firm II has to maintain a fixed share of the total sales of a differentiated product, regardless of the effects of its actions on the short-run profits. Its major concern is with the long-run advantages that are derived from maintaining a given market share. A quantity change by firm I will be immediately followed by a proportionate change by firm II. Thus, the relation

$$\frac{q_2}{q_1 + q_2} = k; \quad q_2 \quad \frac{kq_1}{1-k} \qquad (10.16)$$

where k is firm II's desired market share, will always hold. Firm I is a market leader in the sense that its actions will always be followed by firm II in a predetermined manner.

If we take firm I's inverse demand function as $p_1 = F_1(q_1, q_2)$, and its profit function is

$\pi_1 = q_1 F_1(q_1, q_2) - C_1(q_1)$ substituting from (10.16) for q_2,

$\pi_1 = q_1 F_1 \left(q_1, \frac{kq_1}{1-k}\right) - C_1(q_1)$.

See that firm I's profit is a function of q_1 alone and may be maximised with respect to this single variable as long as firm II reacts to maintain its market share.

Let firm I's demand and cost functions be $p_1 = 100 - 2q_1 - q_2$; $C_1 - 2.5q_1^2$. Let $k = \frac{1}{3}$, and therefore $q_2 = 0.5q_1$. Firm I's profit is $\pi_1 = q_1(100 - 2q_1 - 0.5q_1) - 2.5q_1^2 = 100q_1 - 5q_1^2$.

Setting the first derivative of π_1 equal to zero, solving for q_1, and substituting in the above relations, $\frac{d\pi_1}{dq_1} = 100 - 10q_1 = 0$; $q_1 = 10$, $q_2 = 5$, $p_1 = 75$ and $\pi_1 = 500$

Firm I maximise its profit at an output of 10 units, and firm II reacts by producing 5 units.

10.3.2 Kinked-Demand-Curve Solution

Some oligopolistic markets are characterised by infrequent price changes. Firms in such markets usually do not change their price quantity combinations in response to small shifts of their cost curves as the foregoing market analyses would suggest. The kinked-demand-curve solution presents a theoretical analysis which is consistent with this observed behavior. Starting from predetermined price-quantity combinations, if one of the duipolists lowers her price (increases her quantity), the other is assumed to react by lowering her price (increasing her quantity) in order to maintain her market share. If one of

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the duopolists raises its price, its rival is assumed to leave its own price unchanged and thereby increase market share. Price decreases will be followed, but price increases will not.

Assume that the demand and cost functions of the duopolists are:

$p_1 = 100 - 2q_1 - q_2;\ C_1 - 2.5$ and

$p_2 = 95 - q_1 - 3q_2;\ C_1 - 2.5q_2$ (10.17)

and that the currently established prices and quantities are $q_1 = 70$, $q_1 = 10, q_2 = 55,$ and $q_2 = 10$. If increased its price, firm II would leave its own price unchanged at 55 rupees. Substituting $q_2 = 55$ into firm II's demand function (10.17) and solving for q_2,

$$q_2 = \frac{40 - q_1}{3} \qquad (10.18)$$

Firm II's output level and market share will increase as firm I increases its price and thereby decreases its output level. Substituting the value for q_2 given by (10.18) into firm I's demand function (10.17),

$$p_1 = \frac{260 - 5q_1}{3} \qquad (10.19)$$

FIRM I's price is a function of q_1 alone given the assumption that firm II maintains its price at 55 rupees. Starting from the initial position, (10.19) is only valid for $p_1 > 70$ and $q_1 < 10$. firm I's MR function for price increases can be derived by forming its total revenue function from (10.19):

$$R_1 = q_1\left(\frac{260 - 5q_1}{3}\right);\ \frac{dR_1}{dq_1} = \frac{260 - 10q_1}{3} \qquad (10.20)$$

and at q_1 =10, firm I's MR for a price increase is $53\frac{1}{3}$ rupees.

The demand and MR functions given by (10.19) and (10.20) are not valid if firm I reduce its price. In this case, firm II will follow by lowering its price by an amount sufficient to allow its to retain half the total volume of sales. Firm II must increase its output level by the same amount as firm I in order to maintain its market share: $q_1 = q_1$. Substituting $q_1 = q_1$ into firm I's demand function (10.17), $p_1 = 100 - 3q_1$ (10.21)

Firm I's price is a function of q_1 alone given the fact that firm II maintains its market share. The demand function given by (10.21) is valid for $p_1 < 70$ and $q_1 > 10$. Firm I's MR function for price decreases can be derived by forming a total revenue function form (10.21):

$R_1 = 1\ q_1(100 - 3q_1)$. and $\frac{dR_1}{dq_1} = 100 - 6q_1$. At $q_1 = 10$, firm I's MR for a price decrease is 40 rupees.

The initial position represents a maximum-profit point for firm I. Its MC for an output of 10 units is 50 rupees. She cannot increase its profit by increasing its price (reducing its output level), since MR exceeds MC $53(\frac{1}{3}>50)$ and this difference would be increased by a price increase. She cannot increase its profit by reducing its price (increasing its output level), since MR is less than MC(40<50) and this difference would be increased by a price reduction. Its initial price-quantity combination is optimal for any value of MC form $53\frac{1}{3}$ to 40 rupees. A reduction of its MC by an amount not greater than 10 rupees would not induce it to lower its price and expand its sales. Likewise, an

increase of MC by an amount not greater than $3\frac{1}{3}$ rupees would not induce it to increase its price and contract its sales.

Graphically, firm I's effective demand curve is "kinked" and the effective MR curve discontinuous at the initial output level. Its demand curve is *D' D'*(see Fig. 10.6) if firm II reacts by maintaining its market share and *DD* if firm II reacts by maintaining its price. DD is valid for price increases, and *D'D'* for price decreases. The effective MR curve follows the MR curve corresponding to *DD* to the left of the initial output level and the MR curve corresponding to *DD* to the right of the initial output level. Firm I is unable to equate MR and MC.

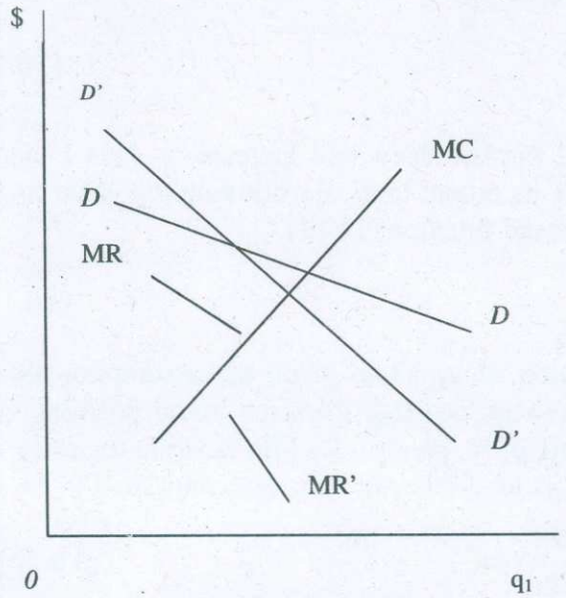

Fig.10.6

Check Your Progress 2

1) What is the difference between a homogenous and a differentiated oligopoly?

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2) If one oligopolist attempts to increase its market share by lowering price, then what would be the reaction of rival firms.

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3) a) How is the kinked demand curve different from the demand curve for a monopolist?

b) Suppose a kinked demand curve has a kink when P = P*. Then which of the following is true? P > P* or P < P*.

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10.4 OLIGOPSONY

In some input markets the number of buyers is greater than one, but still small enough so that the assumption of competitive buying at constant prices cannot be maintained. Such markets are considered in this section. A market with two buyers is a *duopsony,* and a market with a small number greater than two is an *oligopsony.*

A market situation with a small number of buyers is similar to one with small number of sellers. There are no generally accepted behavior assumptions. Each buyer can control the level of her purchases, but each is noticeably affected by the actions of the other buyers. Most theories of duopoly and oligopoly covering undifferentiated products can be modified to cover duopsony and oligopsony. For illustration, a modified version of the Cournot solution is considered here.

Consider a local labor market in which two firms buy from many competitive sellers. As before, the price of labor is an increasing function of quantity: $r = g(x_1 + x_2)$

where x_1 *and* x_2 are the amounts purchased by the two firms. Each buyer is assumed to use labor alone to produce a commodity which she sells in a competitive national market at a fixed price. Their production functions are $q_1 = h_1(x_1) + q_2 = h_2(x_2)$

And their profits are $\pi_1 = p_1 h_1(x_1) - g(x_1 + x_2)\, x_1;$

$$\pi_2 = p_2 h_2(x_2) - g(x_1 + x_2)\, x_2 \qquad (10.22)$$

The basic Cournot behaviour assumption is invoked. Each duopsonist maximises her profit on the assumption that the other is unaffected by her actions.

Setting the appropriate partial derivatives of (10.22) equal to zero,

$$\frac{\partial \pi_1}{\partial x_1} = p_1 h_1'(x_1) - r - x_1 g'(x_1 + x_2) = 0;$$

$$\frac{\partial \pi_2}{\partial x_2} = p_1 h_2'(x_2) - r - x_2 g'(x_1 + x_2) = 0 \quad \text{and}$$

$$p_1 h_1'(x_1) = r + x_1 g'(x_1 + x_2);$$

$$p_2 h_2'(x_2) = r + x_2 g'(x_1 + x_2) \qquad (10.23)$$

Each duopsonist equates the value of her marginal product to her marginal cost for the input. The duosonists will not have the same marginal cost in equilibrium unless $x_1 = x_2$. The duopsonist with the higher purchase level will

have the higher marginal cost. The second-order conditions are a straight forward generalization: the value of the marginal product of each duopsonist must increase less rapidly than her marginal cost.

Input reaction functions which express the purchases of each duopsonist as a function of the other's purchases are determined by solving the first equation of (10.23) for x_1 and the second for:

x_2: $x_1 = {}_1(\ x_2)$; $\ x_2 = {}_2(\ x_1)$

The range of possible solutions is similar to that in the duopoly case and can accommodate conjectural variation and Stackelberg-type leadership or followership.

Check Your Progress 3

1) Define the following terms: monopsony and oligopsony.

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2) Is it true that monopsony labour markets usually have higher wages and higher employment levels than competitive labour markets.

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3) Why the value of the marginal product of each duopsonist must increase less rapidly than her marginal cost?

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10.5 LET US SUM UP

In this unit we have discussed the price and quantity determination in oligopoly market. In the process outcome due to homogenous and differentiated products along with collusive and non-collusive oligopolistic models are covered. A major feature of the market is that there is interdependence and rivalry among the firms. Depending on the conjectures made by the firms, we get different models.

The Cournot model deals with the case when the firms make conjecture that the rival would stick to the previous level of output. Here the firms deal with output changes. In the Stackelberg model one firm acts as the leader and the

other follower. A firm is a leader in the sense that it knows the reaction function of the follower. The leader maximises profit after incorporating the reaction function of the follower. In the Bertrand model, the case is similar to that of Cournot except that the firms compete in terms of price. Here they end up producing the competitive level of output.

We have seen that if a firm's desire to maintain a fixed share of the total sales of a differentiated product, its major concern is with the long-run advantages that are derived from maintaining a given market share. On the other hand within the context of differentiated products we have explained price rigidity in oligopoly encountered through a kinked demand curve. The two segments in it are: (1) a relatively more elastic segment for price increases and (2) a relatively less elastic segment for price decreases. The relative elasticity of these two segments is directly based on the interdependent decision-making of oligopolistic firms.

In the last section of the unit, we have seen the market situations with two buyers, *duopsony,* and a small number, greater than two, of buyers, *oligopsony.* It is assessed that each buyer can control the level of her purchases, but each is noticeably affected by the actions of the other buyers.

10.6 KEY WORDS

Sticky Price Model: Model where the price and also output remain unchanged within a certain range.

Conjectural Variation: CV of an i^{th} firm is defined as the reaction of the j^{th} firm, corresponding to a marginal adjustment in the i^{th} firm's strategy variable as perceived by the i^{th} firm.

Mutual Interdependence: The action of one firm in the market affecting that of the other.

Price Competition: When firms compete in terms of price i.e., price is the strategic variable.

Cartel: An agreement whereby oligopolists (competing firms) decide to collude and produce.

Merger: A consolidation of two or more independent firms into a single firm

Price Leadership: A particular firm from among the colluding members acting as a price setter.

Isoprofit Curve: Combinations of two or more variables that generate the same level of profit for a firm.

Reaction Function (best response function): Locus of optimal, that is, profit-maximizing, actions $R_i(a_j)$ that a firm i may undertake for any given action a_j chosen by a rival firm j.

Kinked Demand Curve: A bend in a standard demand curve that is a result of competitors decreasing their prices to match each others, but not raising them to achieve the same effect.

10.7 SOME USEFUL BOOKS

Koutsoyiannis, A. (1979), *Modern Microeconomics*, Second edition, London: Macmillian.

G.S. Maddala and E. Miller (1989), *Microeconomics: Theory and Applications*, McGrow-Hill, New Delhi.

J. Henderson & Richard E. Quandt (2003), *Microeconomic Theory: Mathematical Approach*, Tata McGraw-Hill Publishing Company Limited, New Delhi.

10.8 ANSWER OR HINTS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) The reaction function (also known as *best response function*) shows the optimal (i.e., profit-maximising) output q_1 as a function of q_2. It is implicitly defined by the first order condition for firm 1: $P'(q_1 + q_2)q_1 + P(q_1 + q_2) - C_1'(q_1) = 0$.

2) Because an increase in other firms' output will *tend to* reduce the incentive for each firm to increase output (i.e., $d/dq_j(dy_i/dq_i)$ tends to be negative.)

3) Since, $Q = 100 - 2p$ write it in inverse demand function as $p = 100 - 2(q_1 + q_2)$. So $TR_1 = pq_1 = q_1\{100 - 2(q_1 + q_2)\}$ or $MR_1 = 50 - q_1 - \frac{1}{2}q_2$. Equating MR and MC we get $50 - q_1 - \frac{1}{2}q_2 = 5$. So reaction function of $q_1 = 45 - \frac{1}{2}q_2$. Similarly, reaction function for$q_2 = 45 - \frac{1}{2}q_1$.

4) An isoprofit curve traces out the combinations of (q_1, q_2) at which all combinations along the curve yield an identical profit $\bar{\pi}$

5) Do yourself

6) Cournot's model; Stacklberg's Model; and Kinked Demand curve

Check Your Progress 2

1) In a homogeneous oligopoly the major firms produce identical products, such as steel bars or aluminum ingots. Prices tend to be uniform in homogeneous oligopolies. In a differentiated oligopoly, similar but not identical products are produced. Examples include the automobile industry, the cigarette industry, and the soft drink industry. In differentiated oligopolies companies attempt to differentiate their products from those of their competitors. To the extent that they are able to establish differentiated products, companies may be able to maintain price differences.

2) Cutting price.

3) a) A demand curve for a monopolist is downward sloping and not kinked. It is usually inelastic. A demand curve for an oligopolist is kinked.

   b) When $P > P^*$, the demand curve is more inelastic.

Check Your Progress 3

1) Oligopsony: market with only few buyers whereas in monopsony there is only a single buyer.

2) False

3) Higher purchase level will have the higher marginal cost for duopolist.

10.9 EXERCISES AND ANSWERS

1) Bob and Art live next door to each other and share a driveway between their houses. Both men are botanists and love flowers. Each has decided to plant pansies on his side of the driveway. On one Saturday morning, each announces to the other that he is going to his own favorite gardening shop to purchase pansies. Since each man will plant the flowers so close to each other, both will get enjoyment from his own and his neighbor's pansies. Art's preferences for how many pansies to purchase depend on how many Bob has bought and can be described by the best-response function

$$A = 20 - \frac{1}{2}B$$

where B is the number of pansies bought by Bob. Bob's preferences can be described by his best-response function

$$B = 24 - \frac{1}{4}A$$

here A is the number of pansies Art buys.

a) If Bob finds out that Art is going to buy 12 pansies, how many should he buy?

b) What is the equilibrium amount of pansies the men should buy if neither knows how many the other is going to purchase?

Answer: a) If Art buys 12 pansies, Bob's best response is

$$B = 24 - \frac{1}{4}(12) = 21$$

Thus, Bob should buy 21 pansies.

b) The equilibrium is found by solving the two best-response functions simultaneously that is, solving the following two equations:

$$A = 20 - \frac{1}{2}B;\ B = 24 - \frac{1}{4}A$$

This can easily be done by substituting Bob's function into Art's function and solving,

$$A = 20 - \frac{1}{2}\left(24 - \frac{1}{4}A\right) = 8 + \frac{1}{8}A \quad or, A = \frac{64}{7}$$

and substituting back into Bob's best-response function

$$B = 24 - \frac{1}{4}\left(20 - \frac{1}{2}B\right) \quad \text{or, } B = \frac{152}{7}.$$

2) Assume that there are two firms, each producing with a constant marginal cost function of MC=2. Assume that the demand function for the product is defined as follows:

$p = 100 - .5(q_1 + q_2)$. If firm 2 sets a quantity of $q_2 = 100$, what is the best response quantity for firm 1?

Answer

If firm 2 sets a quantity of $q_2 = 100$, then the residual demand curve facing firm 1 is

$$p = 100 - 0.5(q_1 + 100) = 100 - 0.5(100) - .5q_1 = 50 - 0.5q_1.$$

If the marginal cost of production is constant at 2, then the firm should set a quantity at which the marginal revenue associated with the residual demand curve is equal to the constant marginal cost. We know that the marginal revenue curve associated with this demand curve has the form $MR = 50 - q_1$, since it has a slope twice the steepness of the demand curve. Setting $R = MC$, $50 - q_1 = 2$. Solving, we see that $q_1 = 48$, and this is the best response.

3) Assume that you have two firms competing in a market and that these firms have the following reaction functions:

$$q_1 = 50 - \frac{1}{2}q_2;\ q_2 = 50 - \frac{1}{2}q_1$$

a) For what quantity produced by firm 2 would firm 1 prefer to shut down and produce nothing?

b) What quantity would firm 1 produce if firm 2 never existed?

c) Verify that q_1=33.3 and q_2=33.3 is an equilibrium.

Answers

a) If firm 2 set a quantity of 100, then, $q_1 = 50 - \frac{1}{2}(100) = 0$ and firm 1would shut down.

b) If firm 2 never existed, then q_2=0 and the best output for $q_1$would be 50.

c) We can verify that 33.3 for each firm is an equilibrium by seeing if those quantities constitute a best response for each firm. Plugging 33.3 into each reaction function we see that 33.33 =50–1/2(33.33); thus, if firm 1 is choosing 33.33, firm 2 will also want to choose 33.33, and vice-versa. That is the definition of equilibrium.

4) a) The town of Dehradun has only one chicken farmer to supply eggs. Assume that the marginal cost of egg production is zero and that in Dehradun the inverse demand for eggs (measured in cents) is p=100–2q. At what price and quantity will the chicken farmer sell eggs?

b) Now assume that a second chicken farmer moves to Dehradun who also has zero marginal cost. Taking demand into consideration, this means that chicken farmer 1 has a reaction function $q_1 = 25 - \frac{1}{2}q_2$; where q1and q_2 are the quantities of eggs supplied by chicken farmers 1 and 2, respectively. Chicken farmer 2, likewise, has a reaction function $q_2 = 25 - \frac{1}{2}q_1$.

c) What will the quantities supplied and price for eggs be now?

Answer

a) The chicken farmer will set the quantity that equates marginal revenue to marginal cost. Since demand is linear, marginal revenue will be MR(q)=100 –4q. Thus, to find the optimal quantity putting the quantity back into the demand curve, we find that the price of eggs is $100 - 2(25) = 50$

b) To find the quantities, simultaneously solve the two reaction functions.

$q_1 = 25 - \frac{1}{2}25 - \frac{1}{2}q_1$; or $0.75q_1 = 12.5$; or, $q_1 = 16\frac{2}{3}$. Substituting back into farmer 2's reaction function, we find that q2 is also equal to 16. This is a result of the fact that the two chicken farmers are symmetric; they face identical demands and marginal costs. Whenever this occurs, both firms in the Cournot duopoly game will produce identical amounts. The price of eggs is, then, $p = 100 - .5\left(16\frac{2}{3} + 16\frac{2}{3}\right)$.

Notice that the price has gone down and the total quantity supplied of eggs has gone up as compared to the case when there was only one chicken farmer. In the case when there was only one chicken farmer, consumer surplus was 6.25. When the second chicken farmer entered the market, consumer surplus increased to 11.11. This shows that increased competition lowers the price for the consumer.

5) An industry consists of two firms, each of which has variable costs of 10 per unit but no fixed costs. The industry demand curve is $P = 70 - Q$.

a) Solve for the Cournot equilibrium. Derive the reaction function of each firm if Q_1 and Q_2 are the output of each firm. Solve for each firm's output, the market price, and each firm's profits.

b) Graph the reaction functions of each firm.

c) Now suppose that firm 1 is a Stackelberg leader while firm 2 is a follower.

Assume that the follower behaves like a Cournot duopolist (that is, assumes that the leader's output is fixed). How will each firm behave when seen in terms of reaction functions? What will each firm produce, what will the price be, and what profits will each firm earn?

d) What will happen if this market is "contestable"(i.e., potential competitors can enter and exit without incurring sunk (irretrievable) costs)? What conditions are necessary for contestability to be a real possibility?

e) Compare the Cournot and Stackelberg outcomes with the outcomes if the firms collude and split the market, and with the outcome if the firms compete as price takers and split the market. Compare the four outcomes in terms of price, output, and each firm's profits. On a graph of the demand curve, show price and output for each outcome. Draw the industry's marginal cost curve. Compute the efficiency loss relative to competition for the other three outcomes.

Answers

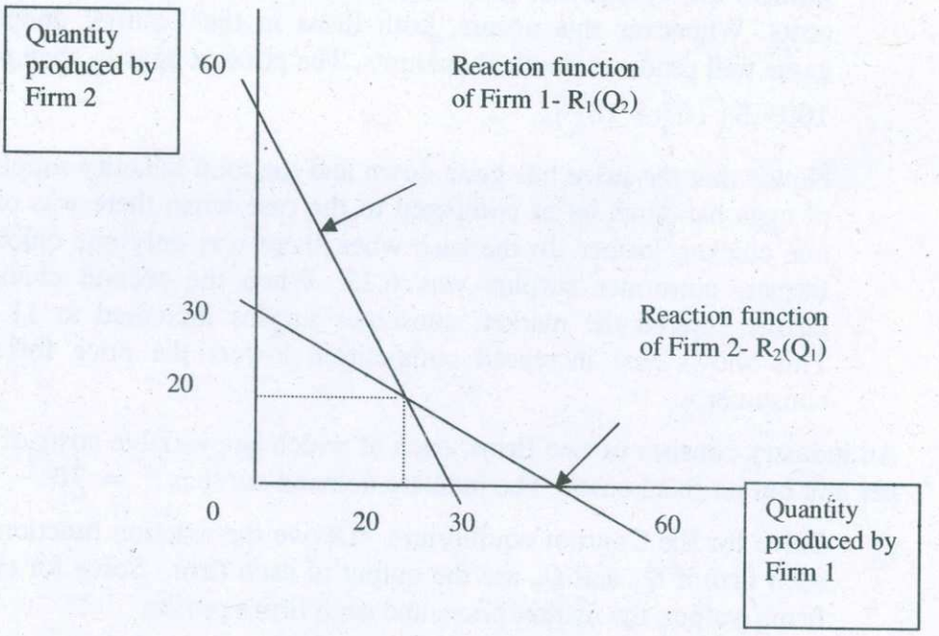
6) a) $P = 70 - Q_1 - Q2$

Thus for the first firm, $MR1 = (70 - Q2) - 2Q_1 = MC = 10$ so the first firm's reaction function is Q_1

Similarly, for the second firm, $MR2 = (70 - Q_1) - 2Q2 = MC = 10$ so the second firm's reaction function is $Q2 = 30 - 0.5Q1$. Solving the two reaction functions simultaneously, $Q1 = 30 - .5(30 - .5Q1)$; or, $Q1 = 15 + .25Q1$ or, $0.75Q1 = 15$; or, $Q1 = 20$

From the second firm's reaction function, $Q2 = 20$. From demand, $P = 30$. Each firm's profits are $\pi 1 = \pi 2 = Qi(P - AC) = 20(30 - 10) = 400$.

b)



c) Firm 2 continues to react according to $Q2 = 30 - 0.5Q1$.

Firm 1, the Stackelberg leader, takes this reaction function as a given.

Thus, firm 1 knows that if he produces $Q1$, firm 2 will react accordingly and the price will be $P = 70 - Q1 - (30 - .5Q1) = 40 - 0.5Q1$. This is, therefore, the demand function for the output of the Stackelberg leader.

Thus, $MR1 = 40 - Q1 = MC = 10$, so $Q1 = 30$ and, from #2's reaction function, $Q2 = 15$. Since output is 45 units, $P = 70 - 45 = 25, \pi 1 = Q1(P - AC) = 30(15) = 450$, $\pi 2 = Q2(P - AC) = 225$

d) A market is contestable if potential competitors can enter and exit without incurring sunk (irretrievable) costs. If the market is contestable, then any potential competitor will be willing to enter if there are positive profits. Thus, the price of incumbent firms is driven down to AC, so $P = 10, QT = 60$.

e) Under collusion, $MRT = 70 - 2QT$, $MR = MC = 10$, so $QT = 30, P = 40$, Thus, $Q1 = Q2 = 15$, $\pi 1 = \pi 2 = 450$.

i) Competition has $P = 10, Q = 60$,

$CS = 1800, DWL = 0$.

ii) Cournot has $P = 30, Q = 40, CS = 800$, since $\pi T = 800$, $DWL = 200$

iii) Stackelberg has $P = 25, Q = 45, CS = 1012.5$. Since $\pi T = 675$, $DWL = 112.5$

iv) Collusion has $P = 40$, $Q = 30$, CS = 450, since $\pi T = 900$, $DWL = 450$

6) The market demand curve faced by Cournot duopolies is: $p = 120 - 0.5Q_D$, where Q_D is the market quantity demanded and P is the market price in rupees. Assuming firm A has a constant marginal cost of Rs. 20 and firm B has a constant marginal cost of Rs. 34, derive the reaction function for each firm.

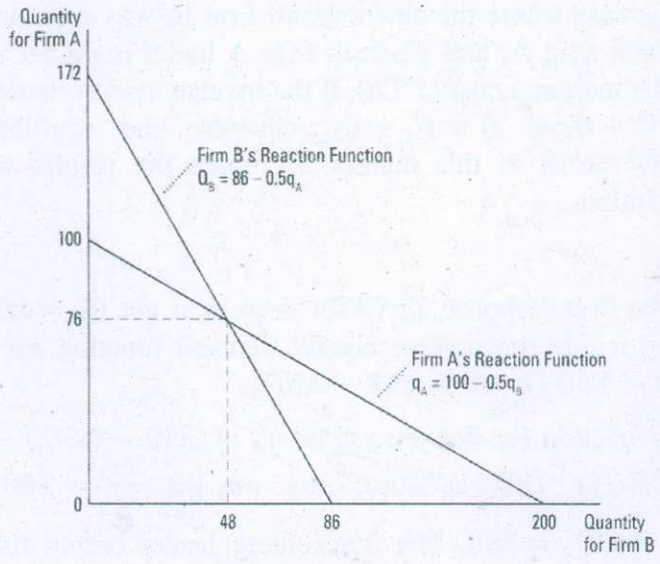
Answers

Note that the market quantity demand, Q_D, must be jointly satisfied by firms A and B. Thus, $Q_D = q_A + q_B$. Substituting the equation in Step 1 for Q_D in the market demand curve yields $P = 120 - 0.5(q_A + q_B) = 120 - 0.5q_A - 0.5q_B$. For firm A, total revenue equals price multiplied by quantity, i.e., $TR_A = P \times q_A = (120 - 0.5q_A - 0.5q_B) \times q_A = 120q_A - 0.5q^2{}_A - 0.5q_Bq_A$Firm A's marginal revenue is determined by taking the derivative of total revenue, TR_A, with respect to q_A. Treat q_B as a constant because firm A can't change the quantity of output produced by firm B. So $MR_A = \frac{dTR_A}{dq_A} = 120 - q_A - 0.5q_B$. If firm A maximises profit by setting its marginal revenue equal to marginal cost, its and marginal cost equals Rs.20 we get $MR_A = \frac{dTR_A}{dq_A} = 120 - q_A - 0.5q_B = 20 = MC_A$.Rearranging the equation to solve for q_A gives firm A's reaction function as $120 - 20 - 0.5q_B = 100 - 0.5q_B = q_A$.Repeating the above procedure we determine firm B's reaction function.

Since firm B's marginal cost equals Rs.34, we have,

$TR_B = P \times q_B = (120 - 0.5q_A - 0.5q_B) \times q_B = 120q_B - 0.5q_Bq_A - 0.5q^2{}_B$;

$MR_B = \frac{dTR_B}{dq_B} = 120 - q_A - 0.5q_B$, or, $MR_B = \frac{dTR_B}{dq_B} = 120 - 0.5q_A - q_B = 34 = MC_B$or, $120 - 34 - 0.5q_A = 86 - 0.5q_A = q_B$. Substituting firm B's reaction function for q_B in firm A's reaction function enables us to solve for q_A. That is, $100 - 0.5q_B = 100 - 0.5(86 - 0.5q_A) = q_B$ or, $100 - 43 + 0.25q_A = q_A$ or, $57 = 0.75q_A$, or $q_A = 76$. Substituting $q_A = 76$ in firm B's reaction function enables to solve for q_B. That is $86 - 0.5q_A = 86 - 0.5(76) = 48 = q_B$. Thus, in the profit maximising Cournot duopolist, firm A, produces 76 units of output while firm B produces 48 units of output.



In the Cournot duopoly model, both firms determine the profit-maximising quantity simultaneously.

In the above example, firms A and B had different marginal costs. If the firms have the same marginal costs ($MC_A = MC_B$), each firm produces half the market output.

7) Suppose two firms, A and B have marginal costs of 150. Assume firm A is the first mover, so firm B is entering the market but has to respond to the output level firm A is producing. If A knows B is entering then it can take advantage of being first mover by choosing to produce the Stackelberg leader output. If the inverse market demand function is $P = 500 - Q$and $= Q_1 + Q_2$, compute the equilibrium price, quantity and profit in this market. Compare the results with that of Cournot solution.

Answers

Because firm A, the Stackelberg leader, chooses its output first, then firm B has to respond by choosing its output based on the decision of A. The best response function for firm B is $Q_B = 175 - Q_A$. So we know how B's output will relate to A's output. Substituting this into the inverse market demand function gives $P = 500 - (175 + Q_A - 0.5Q_A) \Rightarrow P = 325 - 0.5Q_A$.

Next consider the profit function for firm A. This will be $\pi_A = TR_A - TC_A = (P - MC_A)Q_A$. As we have an expression for the market price, and we know the marginal cost is 150, the profit function for firm A becomes $\pi_A = (325 - 0.5Q_A - 150)Q_A \Rightarrow \pi_A = 175Q_A - 0.5Q_A^2)$.

To optimise the profits of firm A we differentiate the function with respect to the output of firm A and set that equal to 0, $\frac{d\pi_A}{dQ_A} = 175 - Q_A$. So Q_A=175 at equilibrium. That means the Stackelberg leader output for firm A is 175.

If A produces 175, then B will produce $Q_B = 175 - 0.5(175) = 87.5$.

With A producing 175 and B producing 87.5, market output is 262.5 and market price is 500-262.5=237.5. Firm A will get profits of 237.5(175) – 150(175) = 15312.5, and firm B will have profits of 237.5(87.5) – 150(87.5) = 7656.25. Both firms have a Lerner index of 0.368.

8) Consider a case of two firms, A and B, with different marginal costs. First consider the case where the new entrant, firm B, was more efficient than the incumbent firm A, and whereas firm A had a marginal cost of 150, firm B had a marginal cost of 120. If the inverse market demand function is $P = 500 - Q$and $Q = Q_1 + Q_2$, compute the equilibrium price, quantity and profit in this market. Compare the results with that of Cournot solution.

Answers

Compute the best response curve for firm B to get $Q_B = 190 - 0.5Q_A$. Substituting it into the inverse market demand function get $P = 500 - (Q_A + 190 - 0.5Q_A) \Rightarrow P = 310 - 0.5Q_A$.

The profit function for firm A will be $\pi_A = (310 - 0.5Q_A - 150)Q_A = 160Q_A - 0.5Q_A^2)$. Differentiating this we get $\frac{d\pi_A}{dQ_A} = 160 - Q_A$ so when $\frac{d\pi_A}{dQ_A} = 0, Q_A = 160$. The Stackelberg leader output for firm A is

160. If A produces 160, then B will produce $Q_B = 190 - 0.5Q_A = 110$. The total market output will be 270 so the market price will be 230.

9) Consider two Cournot oligopolists, Firm 1 and Firm 2, in a homogenous product market. The market demand is $P = 300 - Q$ and each firm has a constant marginal cost $MC = 30$. Derive the reaction functions for each firm indicating the quantity each firm will produce given some arbitrary level of output for the other firm.

Answers

To derive the reaction function for Firm 1, begin by identifying Firm 1's residual demand given an arbitrary level of output by Firm 2, Q_2. This is $P = (300 - Q_2) - Q_1$. The marginal revenue curve is then $MR = (300 - Q_2) - 2Q_1$. To find Firm 1's reaction function, set $MR = MC$ to maximize profit.

$(300 - Q_2) - 2Q_1 = 30$; or, $270 - Q_2 = 2Q_1$ or, $Q_1 = 135 - 0.5Q_2$

Since the problem is symmetric, Firm 2's reaction function will be $Q_2 = 135 - 0.5Q_1$.

NOTES

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