

**ARBAMINCH UNIVERSITY COLLEGE OF
BUSINESS AND ECONOMICS
DEPARTMENT OF ECONOMICS**



**MODULE ON
*MICROECONOMICS I***

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Preface

*Dear Learner, as we are aspiring to ensure enabling and convenient learning for you, we have prepared this learning material for **Microeconomics II**. While preparing this Module, we have had the assumption that you have successfully completed Microeconomics I. With such assumption, we have tried to maintain the required level of this material, in terms of approach and content.*

All the Six chapters for the course are incorporated in this Module: Game Theory, Oligopoly, Factor Pricing and Income Distribution General Equilibrium Analysis and Information asymmetry.

Finally, as an input for our effort of facilitating your learning, we appreciate your constructive feedbacks concerning the material.

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CHAPTER ONE

Monopolistic competition

1.1. INTRODUCTION

Perfect competition and pure monopoly are the two extreme ends of the market structure, lying between which is a series of intermediate cases which differ from each other in relative strengths of monopoly and competitive elements, or in other words, in degree of imperfection. Perfect competition is rarely found in the real world and thus it does not represent the actual market situations appropriately. Besides, the conclusions which followed from the theories of perfect competition were found to be inapplicable to the behavior of firms in the real world.

This urge to develop the theory of price nearer to the actual world gave rise to the reformulation of alternative models which lies between the two extreme cases of market structure.

One of such alternative models was the theory of monopolistic competition, which was developed independently by Prof. E.H. Chamberlin and Joan Robinson (British Cambridge economist), simultaneously. The theories developed by Chamberlin and Robinson are similar in various ways; though differ in some important respects. There are elements of both monopoly and competition under monopolistic competition and hence named monopolistic competition.

Monopolistic competition is a market structure with many buyers and sellers in which product differentiation exists, and in which there are elements of both perfect competition and pure monopoly. It is a type of market structure which occurs when many firms serve a market with free entry and exit, but in which one firm's products are not perfect substitutes for the products of other firms.

Learning objectives

Up on completion of this chapter, you should be able to:

- State and explain the assumptions of monopolistic competition.
- Identify the demand curve a firm under monopolistic competition faces.
- Distinguish between the concept of industry and product group.
- Explain the short-run and long-run equilibrium of the firm and the product group.
- Discuss the welfare loss caused by monopolistic competition.

Chapter Outline

1.1 Monopolistic competition

1.2 Introduction

1.3 Assumptions of monopolistic competition

1.4 Product differentiation and demand curve

1.5 The concept of industry and product group

1.6 Short- run equilibrium of the firm

1.6.1 Equilibrium with new firms entering to the group

1.6.2 Equilibrium with price competition

1.6.3 Equilibrium through entry and price competition

1.7 Long-run equilibrium of the firm

1.8 Excess capacity and welfare loss

1.9 Criticism of chamberlain's large group model.

1.2 ASSUMPTION OF MONOPOLISTIC COMPETITION

Chamberlin's model of monopolistic competition works under many of the assumptions of perfect competition, though there are few assumptions which enable a firm to enjoy a certain degree of monopoly power. The following are the assumptions of Chamberlin's model of monopolistic competition.

1. There are large number of sellers and buyers.
2. The products of the sellers are differentiated, but are close substitutes of one another.
3. There is free entry and exit of firms in the market under monopolistic competitions. There may not be full freedom of entry. Entry can be fully free only if the new firms who chose to enter into the market could produce exactly identical products as those of existing firms. With product differentiation this is not possible under monopolistic competition.
4. The firm is assumed to have profit maximization goal. Though a firm can have different alternative objectives such as sales maximization, growth, mergers, and profit maximization, the only goal of the firm is assumed to be profit maximization.
5. The prices of factors of production and technology are assumed to be constant.
6. The firm is assumed to behave as if it knew its demand and cost curves with certainty.
7. The long-run is supposed to be a series of a number of identical short-run periods, which are assumed to be independent of one another, in the sense that decisions in one period do not affect future periods and will not be affected by past periods.
8. The *myopia* assumption: firms are assumed not to learn from their past experience.
9. Heroic assumption. Chamberlin assumed that both demand and cost curves for all the products of the firms in the same product group, under monopolistic competition can be taken to be identical or uniform. The identity of demand and

cost curves in a given product group across all firms is also called as the *uniformity assumption*. Thus, we can proceed under the uniformity assumption that both demand and cost curves of all products are uniform throughout the group.

The identity of demand and costs leads us to the conclusion that prices of the products of various firms are identical. This requires that consumer preference be evenly distributed among the different sellers, and the differences in costs. This assumption is made in order to be able to show the equilibrium of the firm and the group on the same diagram. Besides the assumption of identical costs and prices for all products in a group, it is also assumed that buyers have perfect knowledge.



Check your progress 1

Distinguish the basic differences in the assumptions of perfect competition and monopolistic competition.

1.3 PRODUCT DIFFERENTIATION AND DEMAND CURVE

The distinguishing feature of monopolistic competition which makes it as a blending of competition and monopoly is the differentiation of the products. Product differentiation does not mean that the products of various firms are not homogenous but different though they are closely related to each other. The products of firms are only slightly different so that they are quite similar and serve as close substitutes of each other.

When there is any degree of differentiation of products monopoly element enters into the market situation. The greater the differentiation of the products the greater will be the monopoly element involved. When there are a large number of firms producing differentiated products, each firm has a monopoly power over its own product, but is subjects to the competition of close substitutes. Since each is a monopolist and yet has competitors, the market structure is called as ‘Monopolistic competition’.

Product differentiation is any feature of a product of sellers that makes buyers to prefer one product or seller to that of another. It is done to make a firm product unique in the minds of buyers.

Product differentiation can be real or fancied (artificial). Real differentiation exists when the inherent characteristics of the products have slight differences (slight difference in quality, durability) in the specification of products (in terms of credit, guarantee, transportation, location of the firm) which determines the convenience with which a product is accessible to the customers.

Check your progress 2

When do we say two bathing soaps, Lux and Duru, are close substitutes?

1.4 COST OF A FIRM UNDER MONOPOLISTIC COMPETITION

Cost structure of the firm under monopolistic competition is similar with that of any other firm (perfectly competitive and monopoly firms). The average variable cost, average total cost and marginal cost curves are all U-shaped implying that there is only a unit of output which can be optimally produced.

Apart from the production cost a firm under monopolistic competition incurs selling costs. The rationale for selling costs arises from the differentiation of products. The total costs, in this case, include both the selling costs and the production costs. Costs of production include manufacturing costs, transportation costs, and costs of hauling, storing and delivering a product to the customers: costs on activities which add utilities to the product. On the other hand, selling costs include those costs which will be incurred to increase the demand or the market for the firm's product.

Selling costs include expenditure on advertising, salaries for salesmen and other expenses on selling activities. While increasing demand, effective selling costs, shifted the demand curve right ward making it less elastic.

Selling costs are subject to varying returns. Initially increments in selling costs results in more than proportionate increase in the quantity demanded of the product. This leads to a falling per unit cost of selling. Average selling cost curve does not fall continuously. Eventually a stage will reach where the average selling cost curve attains its minimum point. Increments in selling costs beyond this level brings about less than proportionate increase in the quantity demanded of the product. In other words, the average selling costs (ASC) will increase. The following figure illustrates the economies and diseconomies of selling costs as out put increase.

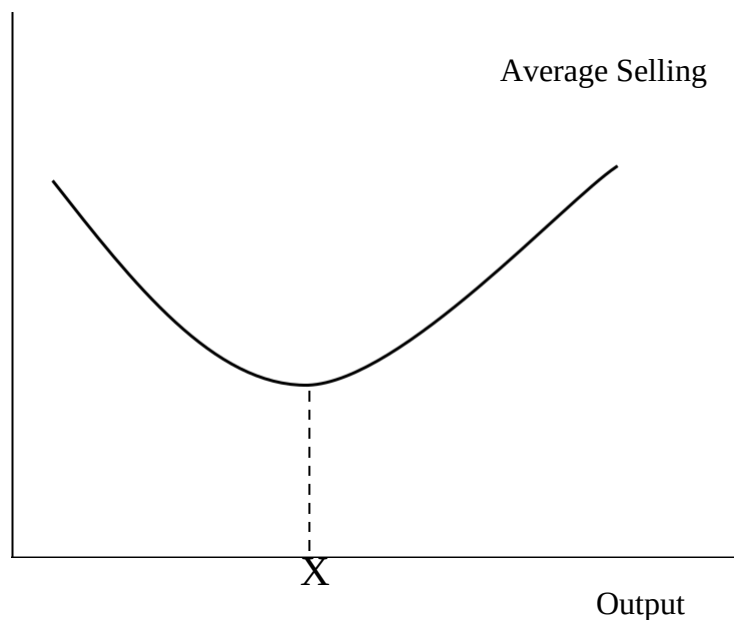


Fig 1.1 The U-shaped Average Selling Cost Curve

As depicted above the ASC curve is U-shape. Initially as output increases up to X units ASC falls (hence, ASC curve slopes downward) but further increases in output requires more than proportionate increase in total selling cost, and hence ASC rises. Together with the U-shaped average production cost, the U-shaped ASC curve yields a U-shaped average total cost curve.

Check Your Progress 3

What is the distinction between selling costs and production costs?

1.5 THE CONCEPT OF INDUSTRY AND PRODUCT GROUP

Strictly speaking, an industry is a collection of firms producing homogeneous product. The concept of an industry holds in a perfect competition where in there is product homogeneity. But product differentiation creates ambiguity in defining the concept of an industry and its precise boundaries in monopolistic competition. The urge to redefine this concept might have led Chamberlin to use the term *product group*. According to Chamberlin a product group (simply ‘group’ hence forward) is a collection of producers of fairly close substitutes. A group can also be defined as a collection of firms whose cross price elasticity of demand exceeds some pre-determined value.

The products should be close technological and economic substitutes. Technological substitutes are products which can technically cover the same want. For example, all bathing soaps are used for bathing; motor cars are all used for transpiration. On the other hand, economic substitutes are products which cover the same want and have similar prices. Products with different cost structure are not economic substitutes.

Product differentiation allows each firm to charge different prices and practically there will not be unique equilibrium price but an equilibrium cluster of prices, reflecting the preferences of customers for the products of the various firms in the group. When the market demand shifts or cost conditions change in a way affecting all firms, then the entire cluster of prices will rise or fall simultaneously. It is only after Chamberlin’s relaxation of the heroic assumption that the realistic market situation emerged.



Check Your Progress 4

What is the difference between a product group and an industry?

1.6 SHORT RUN EQUILIBRIUM OF THE FIRM

As noted earlier a firm under monopolistic competition faces a downward sloping demand curve for its product. The short-run cost curves, as usual, are U-shaped.

Given these demand and cost conditions, a firm will adjust its price and output in order to maximize its profit. The firm's economic profits are maximized when it produces that level of output at which marginal cost equals marginal revenue. This can be shown graphically as follows.

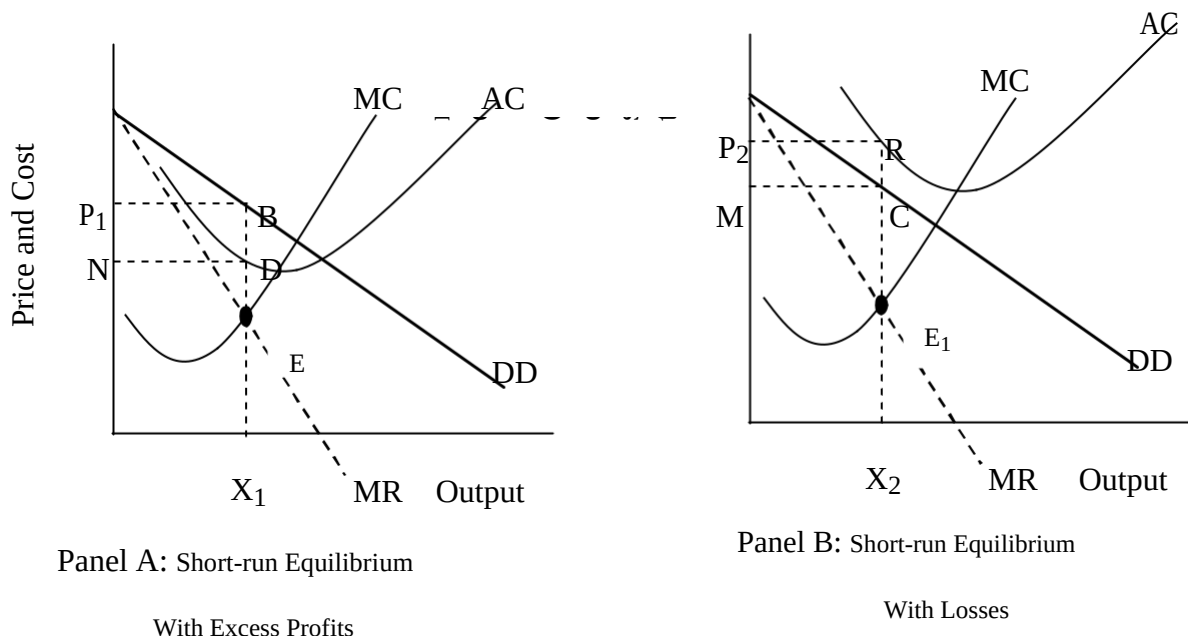


Fig 1.2 Short-Run Equilibrium of a Firm in Monopolistic Competition

At its short run equilibrium point, a firm may make excess profits or incur losses depending on the relative conditions of its costs and demand. The left hand panel of the above figure (Fig1.2) reveals the short-run equilibrium of a firm with excess profits in the short-run. The firm is in equilibrium at point E where $MR=MC$, producing X_1 unit of output, and selling it at P_1 per unit. At the optimal level of output (X_1), price (P_1) exceeds per unit cost (N), hence the firm earns a super normal profit equal to the area of the area P_1NDB if at P_1 . As shown on the right panel, the firm is in its short-run equilibrium at point E_1 (where $MC=MR$). At the equilibrium level of output (X_2), average cost (M) exceeds price (P_2), hence the firm incurs a loss equal to the area of MP_2RC .

Chamberlin developed another approach for the short-run equilibrium of a firm under monopolistic competition. Two demanded curves: perceived demand curve and proportionate demand curve, have been used in this approach.

Perceived demand curve is a demand curve for a firm's product drawn on the assumption that other firms in the product group will keep their prices constant when a firm changes the price of its product. The existence of large number of firms may tend the firm to think in such a way that the change in its product price will have negligible impact on each of its competitors, which will not be sufficient to induce the other firm to retaliate.

The proportionate demand curve, on the other hand, is a demand curve for a firm's product which shows the actual sales by each firm when the prices of all the firms changes equally and in the same direction, and therefore are identical. When one firm reduces its product price, facing identical cost and demand curves, all other firms in the group will have an incentive to reduce price by the same amount.

The same directional and equip- proportional change in prices of all firms results in no customer moving from one to another firm, which the proportionate demand curve conveys. If all other firms keep their price level constant, a decrease in a firm's product price increases its sales as it attracts customers from other firms. That is why the perceived demand curve is more elastic than the proportionate demand curve.

The demand facing any one firm will be more elastic if other firms hold prices constant than if all firms vary prices in unison.

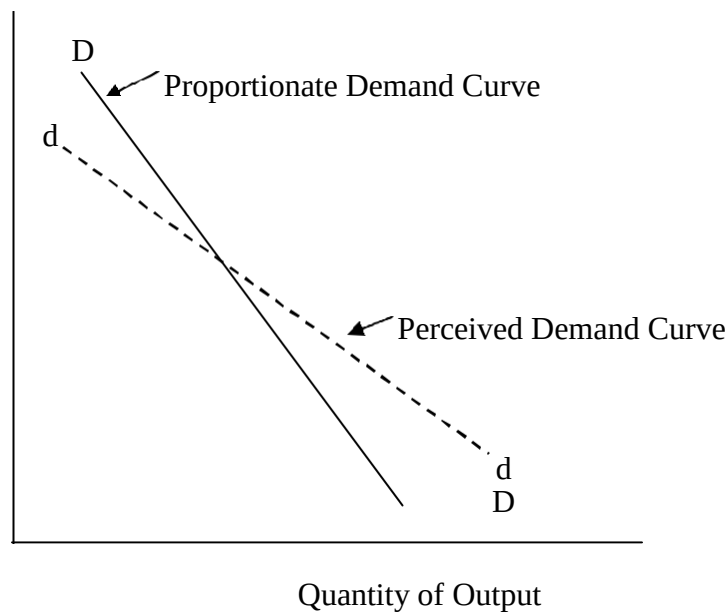


Fig 1.3 Chamberlin's Concept of Proportionate and Perceived Demand Curves

In order to analyze the equilibrium of the firm and of the industry on the same diagram the uniformity assumption (identical cost and demand curves by all firms in a group) was made. Below attempt will be made to discuss Chamberlain's models of equilibrium:

1.6.1. Equilibrium with New Firms Entering the Industry.

Each firm is assumed to make super normal profits in its short-run position. This is so because entry will be attractive when existing firms are earning excess profits. The following figure illustrates the short-run equilibrium of the firm under monopolistic competition.

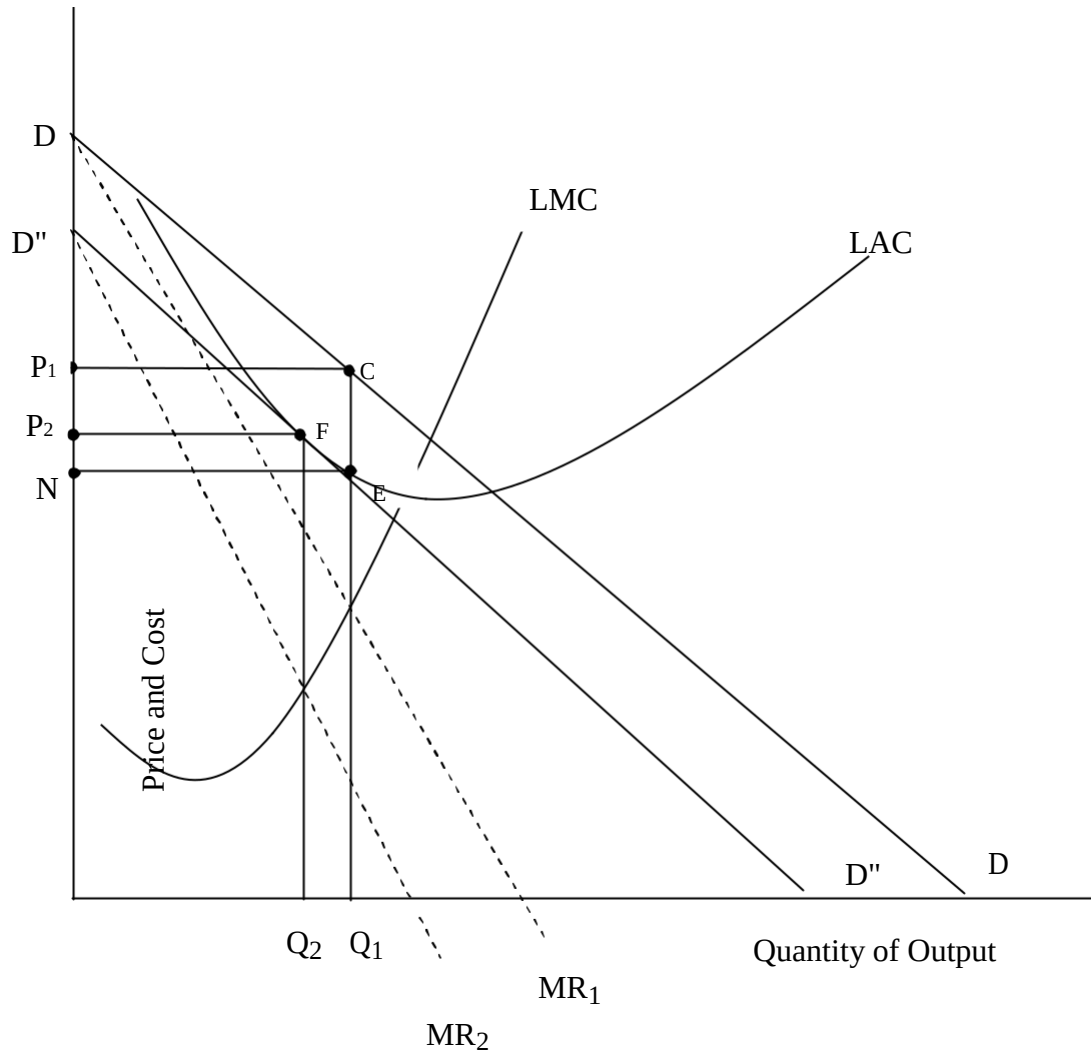


Fig 1.4 Equilibrium of a firm with new firms entering the industry

The firm is in its short-run equilibrium at point e where $MR_1 = MC$. At this short-run equilibrium the level of output to be produced is Q_1 and price to be charged being P_1 . Since P_1 exceeds per unit cost of production at equilibrium (N), the firm earns a supernormal profit equal to the area P_1CFN .

This positive profit earned by the exiting firms attracts new firms to enter in to the market. As entry of new firms proceeds the market share of each firm falls resulting in a downward shift in the demand curve from DD to $D''D''$. Entry proceeds until the inward

shifting demand curve is tangent to the LAC curve. When the demand curve is tangent to the LAC curve(at point F), excess profits will be wiped out, the price level will be P_2 and the firm will earn only a normal (zero) profit, which makes further entry unattractive.

1.6.2. Equilibrium with price competition

In this model, the number of firms in the industry is assumed to be compatible with long run equilibrium, so that neither entry nor exit will take place. But the ruling price in the short run is assumed to be higher than the equilibrium price.

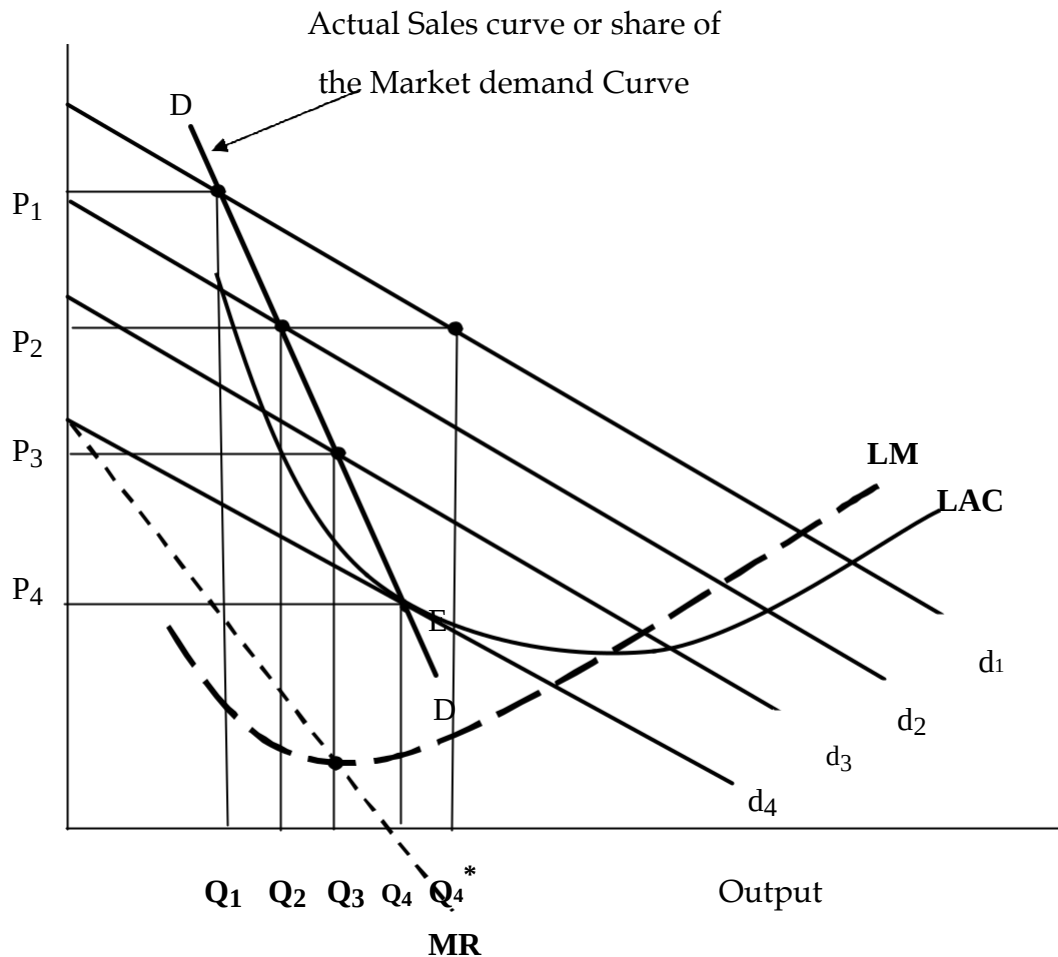


Fig 1.5 Equilibrium of a firm with price competition

Assume the firm is at a non-equilibrium position P_1 and Q_1 . The firm, in an attempt to maximize its profit, lowers the price to P_2 expecting to sell Q_4^* . This level of sales is not actually realized because all other firms faced by the same demand and cost condition have an incentive to act in the same way simultaneously. Thus, all firms acting independently reduce their price simultaneously to P_2 . As a result, the perceived demand (d_1) curve shifts downward (to d_2) and the firm instead of selling expected quantity Q_4^* sales actual quantity Q_2 (which is less than the expected quantity) on the shifted perceived demand curve d_2 along the share of the market demand curve DD .

According to Chamberlin, the firm suffers from myopia and does not learn from past experience and may further reduce price expecting that the others will not react. Thus the firm lowers its price to P_3 again in an attempt to reach equilibrium, but instead of the expected sales the firm achieves actual sales of Q_3 , because all other firms act identically, though independently. The process stops when the perceived demand curve has shifted so far to the left as to be tangent to the LAC curve. Equilibrium is determined by the tangency of perceived demand curve (d_4) and the LAC. At the point of tangency (at point E) the proportionate demand curve (DD) cuts the perceived demand curve (d_4). Obviously, it will pay no one firm to cut the price beyond that point, because the costs of producing the larger output would exceed the price at which this output could be sold in the market.

1.6.3. Equilibrium through Entry and Price Competition

Chamberlin suggests that in the real world adjustment towards long run equilibrium takes place through both entry and exit and price competition. Price adjustments are shown along the perceived demand curves while entry and exit cause shifts in the proportionate demand curve. Equilibrium is stable if the perceived demand curve is tangent to the LAC curve and expected sales are equal to actual sales, that is, proportionate demand curve cuts perceived demand curve at the point of tangency of the perceived demand curve and LAC.

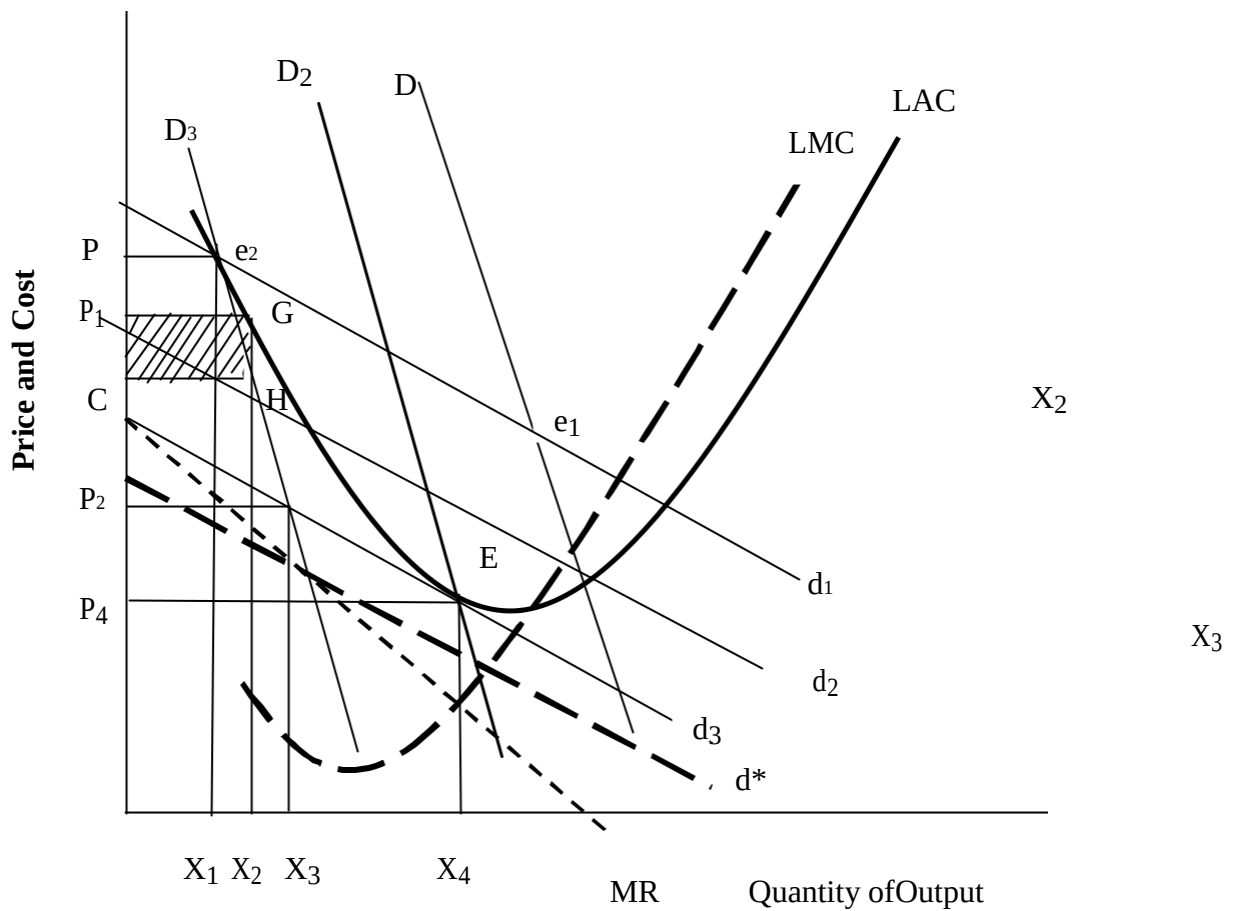


Fig1.6 Equilibrium of the Firm with Entry of New Firms and Active Price Competition

Let us start from e_1 where there is an abnormal profit. This excess profit attracts other firms to enter into the market. When they enter in to the market, the market will be shared by larger number of firms then share of the market demand curve keeps on shifting leftward until it becomes tangent to LAC.

Although, firms earn normal profit, e_2 does not constitute stable equilibrium, because the firm believes that d_1 is its demand curve. By taking d_1 as its sales planning curve the firm will feel that it can expand sales and earn excess profit by reducing price to P_1 . But all

the firms will be doing the same thing simultaneously. As price is reduced by all firms d_1 shifts down to d_2 and each firm realizes a loss of area P_1GHC instead of positive profit.

The firm is still in myopia assumption, now also it believes that it can obtain positive profit by cutting its price. However, all the firms do the same. One might think that the process would stop when perceived demand curve becomes tangent to the LAC (at point E where d_3 is tangent to LAC). This would be so if the firm could produce X_4 . However, there are so many firms and the share of the firm is only X_3 . The firm still on the myopia assumption believes that it can reach X_4 if it reduces to P_4 . However, all firms do the same and the perceived demand curve falls (to d^*) below the LAC with ever increasing losses. At this time, the financially weakest firms will leave the market. So that the surviving firms will have a higher market share then proportionate demand curve will move to the right with perceived demand curve. Exit will continue until the perceived demand curve becomes tangent to the LAC curve (at point E) and the market share curve (D_2) cuts the perceived demand curve (d_3) curve at the point of tangency(point E).

Equilibrium is then stable at point E with normal profits earned by all firms and no entry or exit taking place. The equilibrium price is P_4 , which is unique and each firm have a share equal to X_4 at E, expected share is equal to actual sale.

1.7 LONG RUN EQUILIBRIUM OF THE FIRM AND GROUP UNDER MONOPOLISTIC COMPETITION

A firm under monopolistic completion may earn supernormal profit or incur losses at its short run equilibrium point. But losses and excess profits are short run phenomenon, and the firm earns only a normal profit in the long run.

If a firm is making excess profits in the short run, attracted by this excess profit enjoyed by the existing firms, new firms will enter in to the market. Entry of new firms shifts the proportionate demand curve inward to the left as the market share of each firm decreases.

The perceived demand curve will also shift to the left. Entry will proceed until the inward shifting proportionate demand curve becomes tangent to the LAC curve.

Entry increases the availability of close substitutes leading to a more elastic perceived demand curve. At their long run equilibrium point where $P=LAC$, firms will earn a normal profit, which makes further entry unattractive.

The group will be at its long run equilibrium when:

- i. The perceived demand curve is tangent to the LAC curve.
- ii. The proportionate demand curve passes through the tangency point of LAC curve and the perceived demand curve.

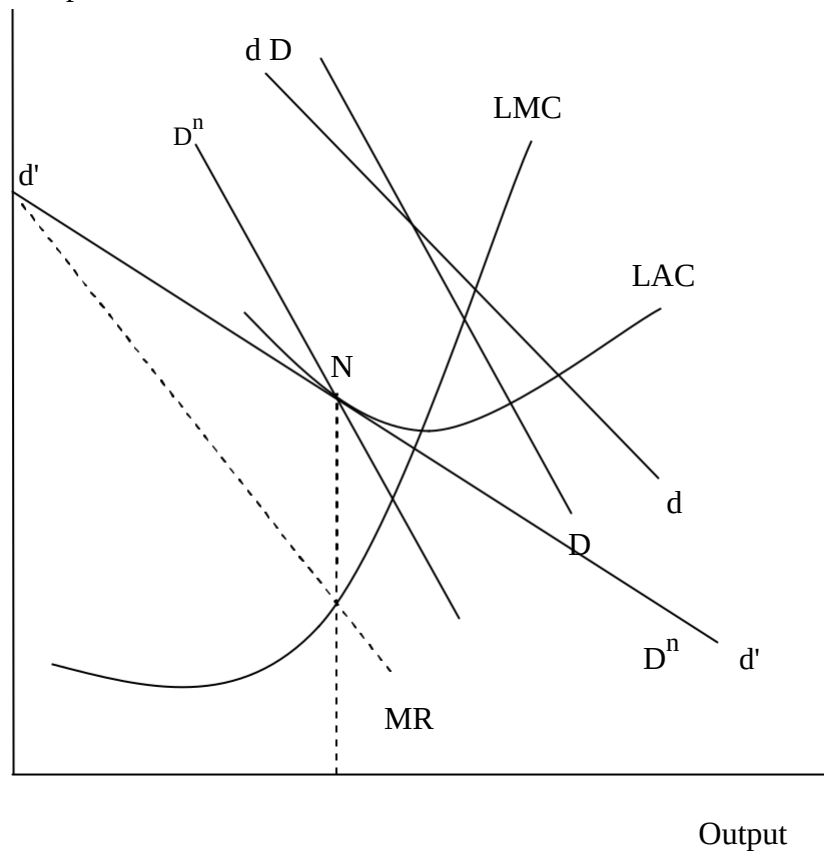


Fig 1.7 Long run equilibrium of a firm under Monopolistic Competition

The above figure illustrates the short run equilibrium of the firm under monopolistic competition. If the existing firms are earning supernormal profits, new firms enter into the market, and the market will be shared by a large number of firms. Each firm's share of the market demand will decrease resulting in a leftward shift in the proportionate demand curve from DD to $D^n D^n$, the perceived demand curve will also shift to the left from dd to d'd'. In the long run the firm will be at equilibrium at point N where the perceived demand curve (d'd') is tangent to the LAC curve and the proportionate demand curve passes through this point of tangency.

Example:

Suppose a proportionate demand curve DD facing a firm working under monopolistic competition is given by $P=36-2X$ and firm's $LAC=X^2-18X+100$. What is the long run equilibrium price and output level of an individual firm? Would the firm earn any profit in the long run?

Solution

A firm's long run equilibrium occurs at that point at which the LAC curve is tangent to the perceived demand curve, and the proportionate demand curve passes through the point of tangency. Therefore, $P=LAC$ in the long run equilibrium.

Given:

- Perceived demand curve $P=36-2X$
- $LAC=X^2-18X+100$

In the long run equilibrium

$$\Rightarrow 36 - 2X = X^2 - 18X + 100$$

$$\Rightarrow X^2 - 18X + 2X - 36 + 100 = 0$$

$$\Rightarrow X^2 - 16X + 64 = 0$$

$$\Rightarrow (X - 8)^2 = 0$$

$$PX = \pm 8$$

Since output cannot be negative, $X=8$ is the solution. Substituting the value $X=8$ in the demand function we have $P=20$. Thus, the long run equilibrium output and price are 8 units and 20 units, respectively.

To determine whether a firm earns positive profit in its long run equilibrium, let us substitute the equilibrium price and output in the total profit function. Thus,

$$\begin{aligned} p &= TR - TC \\ &= PX - (X^2 - 18X + 100) \\ &= 20(8) - 8^2 + 18(8) - 100 \\ &= 0 \end{aligned}$$



Check your progress 5

Do the same exercise as above for the following conditions.

The proportionate demand curve DD is given by $X = \frac{157}{3} - \frac{1}{3}P$, and the long run cost curve is $LAC = X^2 - 25X + 278$.

1.8 EXCESS CAPACITY AND WELFARE LOSS

The society's productive resources are said to be fully utilized when they are used to produce goods to the extent which minimizes the LAC. But as noted earlier, unlike a firm under perfect competition, the long-run equilibrium of a monopolistically competitive firm occurs at the falling segment (less than the minimum points) of the LAC curve. Under such circumstance, firms can reduce average cost (and hence price) by expanding output up to the minimum point of the LAC curve. But firms cannot do that as their profits are maximized (MR equals MC) at the level of output less than the minimum of LAC.

The long-run equilibrium of monopolistic competition also leads to excess capacity measured by the difference between the ideal output (long-run output of perfect competition corresponding to the minimum LAC) and the actual output produced in the long-run by a firm under monopolistic competition. That is, firms will typically operate to the left of output where LAC is minimized. This implies that there is misallocation of resources for price is greater than marginal cost.

If there is large number of firms, each could operate at a more efficient scale of operation, which could be better for customers. However, if there were fewer firms there would also be less product variety, and this would tend to make consumers worse off. Which of these effects dominates is a difficult question to answer. However, the extent of excess capacity depends on the conditions of entry and degree of price competition. If there is free entry and activate price competition, the size of excess capacity (restriction of output) will be small.

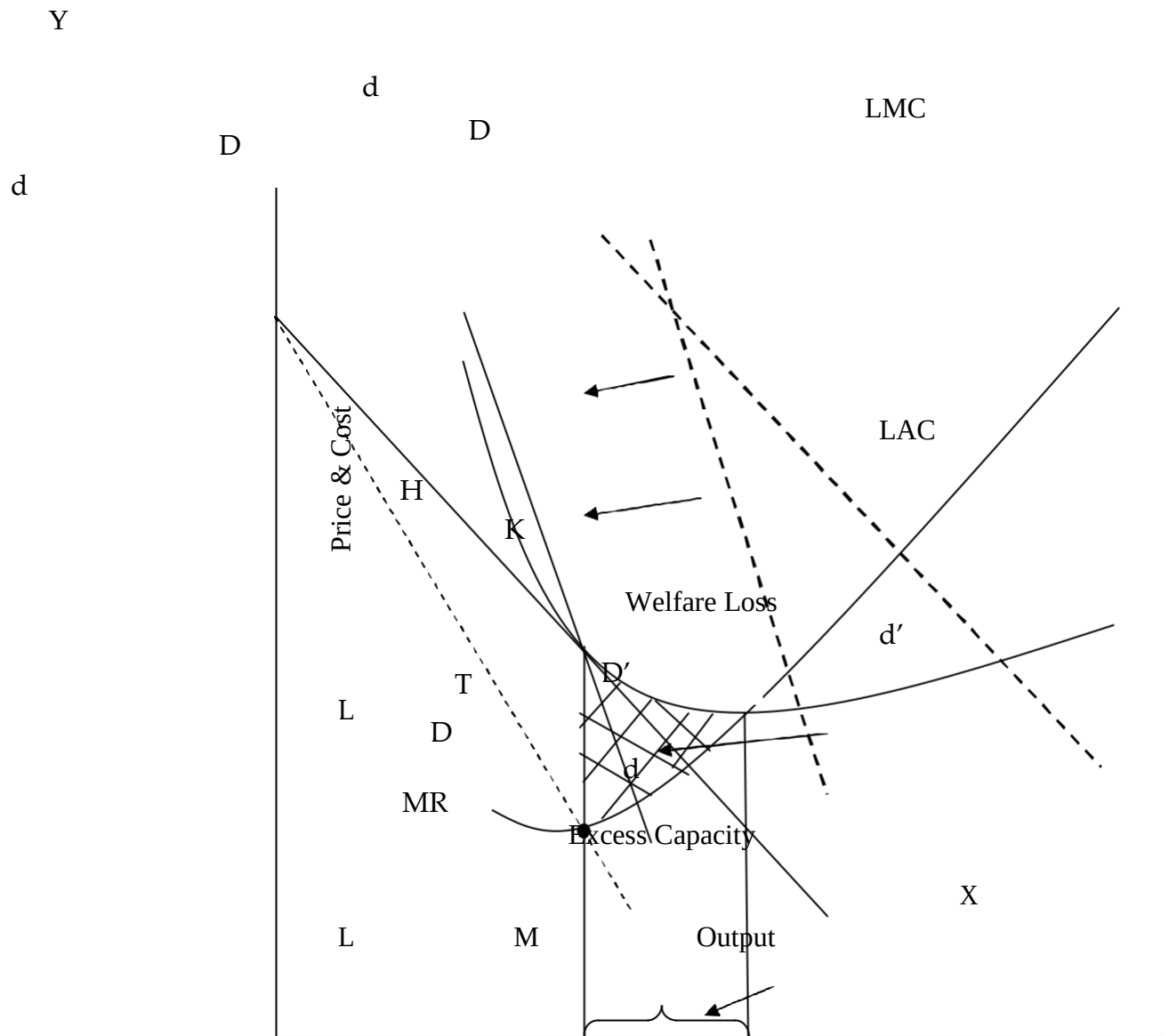


Fig 1.6 Long Run Equilibrium of the firm and Group under Monopolistic
Competition: Chamberlin's Alternative Approach

As shown in the above figure the ideal output (that minimizes the LAC) is M, and L is the long-run equilibrium level of output at which $MR=MC$ and the LAC is tangent to the demand curve. ML , the difference between the ideal output (M) and the long-run equilibrium output (L) is the excess capacity under monopolistic competition.

Chamberlin argues that ideal under perfect competition cannot be regarded as ideals under monopolistic competition. In monopolistic competition, Product differentiation leads to a downward sloping demand curve, with which the equilibrium of the firm will occur at smaller than the minimum point of the LAC.

The difference between the ideal and actual long-run equilibrium output is the cost of product differentiation which consumers pay for the broader alternatives (choices) of differentiated products available to them.

Note

- Excess capacity is a long-run concept because any type of market structure can depart from the ideal, in the short run, reflecting incomplete adjustment to existing market conditions.
- It is the downward sloping demand curve that given rise to excess capacity under monopolistic competition. If demand curve is downward sloping the point of tangency of it with the U-shaped LAC curve occurs at the falling segment of the later.

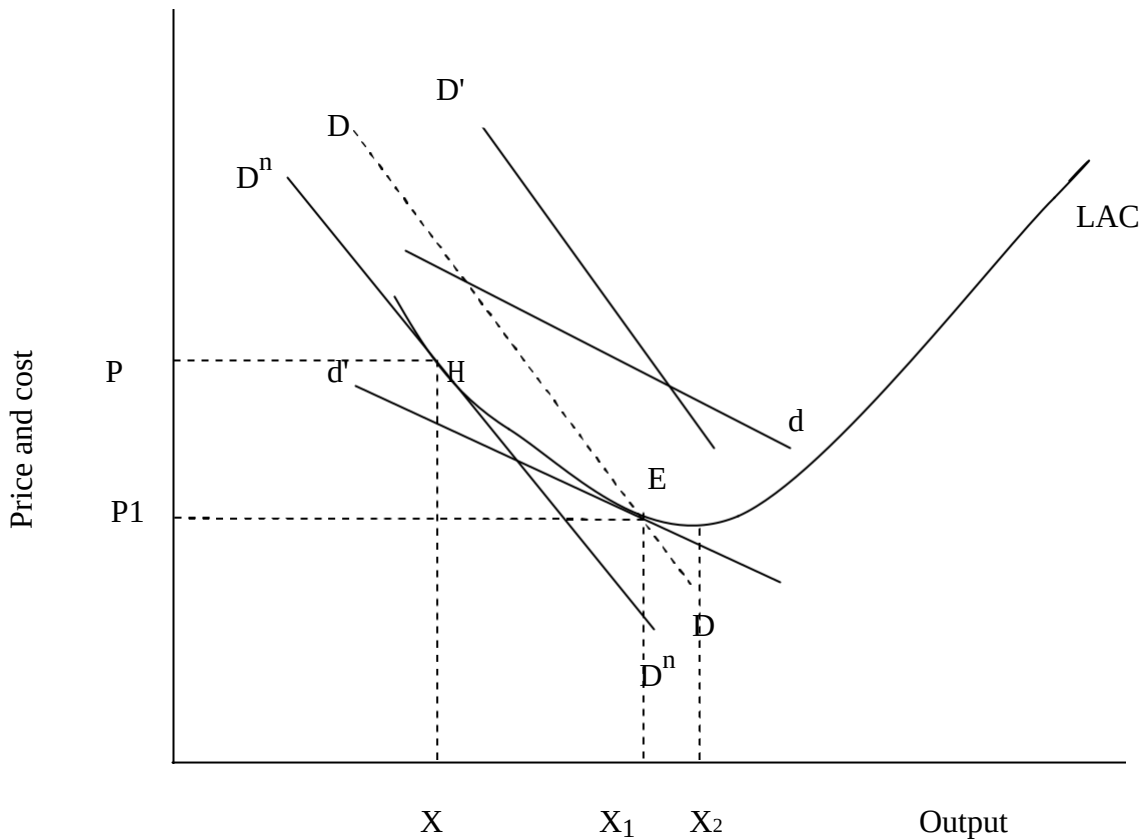


Fig1. 12 Chamberlin's concept of Monopolistic competition

If there is free entry (but not price competition) in the market, a firm's share from the market demand will fall shifting the actual sales curve from D' to D^nD^n . The long-run equilibrium will occur at point H where the LAC curve is tangent to the leftward shifted D^nD^n curve and the excess capacity being $X_2X (=X_2-X)$. But with free entry and active price competition the long-run equilibrium of the firm will occur at point E where the perceived demand curve (d' curve) is tangent to the LAC and the actual sales curve (DD) passing through the point of tangency.

According to Chamberlain X_1 is the social optimal level of output under monopolistic competition and excess capacity will occur as long as there is no active price

competition. Output level X_2X_1 can be regarded as excess capacity as it is the departure of the actual long-run equilibrium output without price competition from X_2 .

Another limitation of long-run equilibrium of a firm in monopolistic competition is that $P > LMC$ implying welfare loss. To maximize social welfare, output should be increased until $P = LMC$. However, this is not possible under monopolistic competition for the perceived demand curve is downward sloping and price is greater than the minimum of LAC.

The higher cost resulting from product differentiation would mean higher selling (advertising and promotion) cost and price than perfect competition. Society, however, may accept the higher price in order to have choice among the differentiated products.

Check your progress 6

Explain Chamberlin's argument against welfare loss due to excess capacity under monopolistic competition. What are the benefits of excess capacity under monopolistic competition?

1.9 CRITICISM OF CHAMBERLIN'S LARGE PRODUCT GROUP

Though Chamberlin introduced product differentiation and selling costs as additional decision variables in the theory of the firm, his model is not free from limitations.

1. Chamberlin's concept of industry is ambiguous, viewed from many perspectives. Firstly, differentiated (non-homogeneous) products cannot be taken altogether to form an industry. Secondly, Chamberlin defined the group to be a collection of firms the cross price elasticity of whose product is high, without specifying exactly how-high should the value of the elasticity be. So, Chamberlin left the precise boundary of a product group undefined.
2. He is also criticized on his assumption of identical cost and demand curves by all firms in a group. It is unrealistic to assume identical cost curves for differentiated products.

3. Product differentiation which is at the heart of Chamberlin's model is not compatible with his assumption of free entry. Free entry is said to occur if potential firms are left free to enter in to the market by producing identical products as the existing firms. Product differentiation brings an implicit barrier to entry.
4. The myopia assumption another area of Chamberlin's criticism. The myopia assumption which implies that firms will not learn from their past experience is inappropriate as there are firms, at least few, that can learn from their past bad experience.

Check your progress 7

Mention the points based on which Chamberlin's model of monopolistic competition is criticized.

1.10. SUMMARY

Monopolistic competition is a market structure with many buyers and sellers in which product differentiation exists, and in which there are elements of both perfect competition and pure monopoly. Monopolistic competition is characterized by the existence of many firms each producing differentiated products, free entry and exit, and uniformity assumption.

Product differentiation is any feature of a product of sellers that makes buyers to prefer one product or seller to that of another. It is done to make a firm product unique in the minds of buyers. It can be real or fancied. Apart from the production cost a firm under monopolistic competition incurs selling costs. Selling costs include those costs which will be incurred to increase the demand or the market for the firm's product.

A group is a collection of firms whose cross price elasticity of demand exceeds some pre-determined value. It is an analogous, but imprecise, concept to the term industry. Products produced by firms in the same group are economic and technological substitutes. A firm under monopolistic competition commands some degree of monopoly

power over its product price and quantity, because of product differentiation, but it is subject to competition as there are many firms producing closely related products. That is why monopolistic competition is called as a blend of perfect competition and monopoly.

Chamberlin used two demand curves to: perceived and proportionate, to explain the short run and long run equilibrium of the firm. At its short run equilibrium point a firm under monopolistic competition may incur a loss or earn super normal profits depending on its conditions of cost relative to demand. Product differentiation makes downward sloping demand curve inevitable. The a downward sloping demand curve the long run equilibrium of a firm under monopolistic competition occurs at less than the minimum point of the long run average cost curve. The extent by which the long run equilibrium output of a firm under monopolistic competition is less than that of perfect competition is taken as a measure of excess capacity in monopolistic competition. But Chamberlin argued that with free entry and active price competition the size of excess capacity would be small. Even this is not a loss in societal welfare, rather, according to Chamberlin, it is the price consumers pay for variety.

Chamberlin's large product model was not free from criticism. Some of the restrictive assumptions and are bases of criticism against his model.

Chapter Review Exercise

I. Answer the following questions

1. A firm in monopolistic competition is supposed to have some degree of monopoly power. Even after commanding this monopoly power, the firm is subject to competition. What is the source of this monopoly power? Why does the firm compete?
2. Write R against each of the following bases of product differentiation to indicate that it is a real base of product differentiation, and A if it is artificial.

Differentiation based on	Real/ Artificial
1. Durability	
2. Quality	
3. Color	
4. Design	
5. Credit facility	
6. Brand	
7. handling	
8. Packaging	

3. Differentiate between selling costs and production costs, give some examples for each.

4. What will the nature of average selling cost curve be if the total cost on selling activities is fixed?
5. Compare price and output equilibrium under monopolistic competition with that of perfect competition.

I. Choose the best answer from the given alternatives.

6. _____ is at the heart of Chamberlin's model of monopolistic competition.
A. Advertising
B. Product differentiation
C. Free entry
D. All can be answers
7. Advertising
A. Makes a firm's demand curve less elastic.
B. Is a fancied base of product differentiation.
C. Is one component of production costs.
D. All except C.
8. A firm expects a 10% increase in sales for a 1% fall in its product price. The firm's expectation is based on its assumption that all firms keep their prices constant following its action. Accompanying a 1% fall in a firm's product price, if all firms match the price reduction, each firm will move along its
A. Perceived demand curve.
B. Proportionate demand curve.
C. Marginal cost curve.
D. Average cost curve.

9. In the above case, what if all firms keep their prices inflexible following the price reduction by the first firm? The firm which reduced price will move along its
- A. Perceived demand curve.
 - B. Proportionate demand curve.
 - C. Marginal cost curve.
 - D. Average cost curve.
10. According to Chamberlin, the difference between long run equilibrium of monopolistic competition and that of pure competition is
- A. Excess capacity
 - B. Price consumers pay for product variety
 - C. Welfare loss
 - D. None.
11. According to Chamberlin, two products are close substitutes if
- A. They are sold at same price
 - B. They serve same purpose
 - C. Their color is the same
 - D. All except C.

Chapter two

OLIGOPOLY

2.1. INTRODUCTION

Oligopoly is another intermediate type of market structure lying between the extreme limiting cases of perfect competition and pure monopoly. Oligopoly is a market structure characterized by a small number of (few) firms and a great deal of interdependence among them. Since oligopoly contains small number of firms any change in firm's price or output influences the sales and profit of competitors.

In other words, because firms are few in this market, a firm controls a large share of the market and it is able to make a significant influence on the price and output of that market. Thus, oligopolists face a situation in which the optimal decision of one firm depends on what other firms decide to do.

Firms under oligopoly produce either homogenous or differentiated products. If the firms produce homogenous products, the industry is called pure oligopoly. If the firms produce differentiated products, the industry is called differentiated oligopoly.

Chapter Objectives

At the completion of this chapter, you should be able to

- Explain the characteristics of oligopoly and distinguish from other types of market structure.
- Distinguish between collusive and non-collusive oligopolies
- Explain Cournot's duopoly model and describe how the model verifies the establishment of oligopoly equilibrium.
- Elaborate the kinked demand curve hypothesis and explain price rigidities in oligopoly.
- Distinguish and explain the different types of cartels and their stability.
- Explain the different types of price leadership and describe how equilibrium can be flourished under each.

Chapter Contents

- 2.1.** Introduction
- 2.2.** Characteristics of oligopoly
- 2.3.** The Cournot's duopoly model
- 2.4.** Bertrand's duopoly model
- 2.5.** The kinked Demand Curve Hypothesis
- 2.6.** Collusive oligopoly
 - 2.6.1.** Cartels
 - 2.6.1.1. Cartel aiming at profit maximization
 - 2.6.1.2. Cartel aiming at market sharing
 - 2.6.2.** Price leadership
 - 2.6.2.1. The low cost price leadership
 - 2.6.2.2. The dominant firm price leadership

2.2. CHARACTERISTICS OF OLIGOPOLY

Oligopoly is a type of market structure which is characterized by the following features.

- The existence of very few sellers of the product. The number of firms in an oligopolistic market may range from two to ten.
- Firms are interdependent. Interdependence in decision making of the few firms that comprise the industry is the most important characteristic feature of oligopoly. Firms must consider not only the market demand for the industry's product but also possible reactions of other firms in the industry to any decision it may make.
- They may have monopoly power, when they collude and charge higher prices for their product.
- Existence of price rigidity – by fearing price war firms mostly stick to the prevailing market price.

- Excessive expenditure on Advertisement: If there is price rigidity and if firms have to stick to the prevailing price, the only way to increase the sales is through the advertisement or improvement of the design or quality of the product. Thus, the firm in order to make the demand less elastic has to advertise more. Advertising can be as a life and death matter for oligopolists. Advertising is more important in oligopoly than in any other market structure.
- They produce homogeneous or differentiated products.
- A demand curve for an oligopolist's product is indeterminate. Under oligopoly a firm cannot assume that its rivals will keep their price unchanged when it makes changes in its own price. As a result of this, the demand curve facing an oligopolist firm loses its definiteness and determinateness since it goes on constantly shifting as the rival's change their prices in reaction to price changes by a firm.
- Collusion is possible. Since there are few firms operating in the market they may come in to agreement with regard to price, output, etc.
- Entry is difficult. Entry barriers, legal and pricing strategies of firms, make entry of new firms difficult.

Reasons for the existence of oligopoly include barriers (cost or skill) that prohibit potential firms from entering the industry. The number of firms in an industry may decrease in response to the strategic price decrease made by large firms to drive out smaller firms, and it may give rise to the formation of oligopoly markets.

Activity

Compare and contrast the characteristic features of oligopoly and monopolistic competition.

2.3. THE COURNOT'S DUOPOLY MODEL

The Cournot model focuses on quantities. And in this model a firm is assumed to forecast its rivals output before it makes decisions about its optimal output. Given the

forecast it chooses the profit maximization level of output for itself. The original version of this model is limited that it makes the assumption that the duopolists have identical product and identical costs. Cournot assumed that there are two firms each owning similar resources and operating with zero cost.

They sell their output in a market with a straight line demand curve. Each firm treats the output level of its competitor as fixed and then decides how much to produce. Assume that Firm A is the first to start producing and selling mineral water. It will produce quantity A, at price P where profits are at a maximum, because at this point $MC=MR=0$. The elasticity of market demand at this level of output is equal to unity and the total revenue of the firm is a maximum. Because total cost is assumed to be zero, maximum total revenue implies maximum profit.

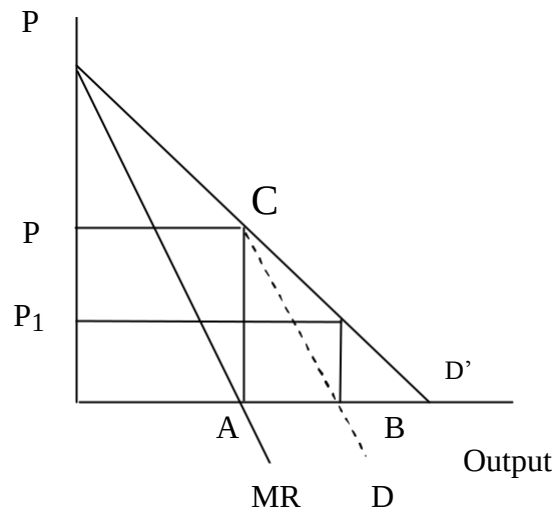


Fig 2.1. Cournot's Equilibrium

Now firm B assumes that A will keep its output fixed (at OA), and hence considers that its own demand curve is CD. Clearly firm B will produce half the quantity AD , because at output level B, its profit and revenue is maximum. B produces half of the market demand which has not been supplied by A, that is, B's output is $\frac{1}{4} = \frac{1}{2} \times \frac{1}{2}$ of the total market.

Firm A, faced with this situation, assumes that B will retain his quantity constant in the next period. So he will produce one half of the market demand which is not supplied by

B. Since B covers $\frac{1}{4}^{\text{th}}$ of the market, A will in the next period, produce $\frac{1}{2}[1-\frac{1}{4}] = \frac{3}{8}$ of the total market.

Firm B reacts on the Cournot assumption and will produce one-half of the unsupplied section of the market, i.e., $\frac{1}{2} [1-\frac{3}{8}] = \frac{5}{16}$. This action and reaction continues, since firms in this model are assumed not to learn from past patterns of reaction of their rival, however equilibrium will be reached in which each firm produces one third of the total market demand. In this case, each firm maximizes its profit in each period, but the industry profits are not maximized. That is the firms would have higher joint profits if they recognized their interdependence, after their failure in forecasting the correct reaction of their rival. Recognition of their interdependence (or open collusion) would lead them to act as a monopolist, producing one half of the total market output, selling at profit maximizing price, and sharing the market equally, that is each producing one quarter of the total market (instead of one-third). The equilibrium of the Cournot firms may be obtained as follows:

The product of firm A in successive periods will be as follows. In

$$\begin{aligned} \text{Period 1} &= \frac{1}{2} \\ \text{Period 2} &= \frac{1}{2} \left(1 - \frac{1}{4} \right) = \frac{3}{8} \\ \text{Period 3} &= \frac{1}{2} \left(1 - \frac{3}{8} \right) = \frac{5}{16} \\ \text{Period 4} &= \frac{1}{2} \left(1 - \frac{5}{16} \right) = \frac{7}{32} \end{aligned}$$

Firm A's output gradually declines. Its quantity of output at equilibrium is,

$$[\text{Product of A in equilibrium}] = \frac{1}{2} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64} + \dots$$

The expression in parenthesis is a declining geometric progression with ratio $r=1/4$.

Applying the summation formula for an infinite geometric series, $\sum = \frac{a}{1-r}$, where $\sum = 1-r$ sum, a = first term of series, r = ratio.

Product of A in equilibrium =

$$\frac{1}{2} - \frac{\frac{1}{8}}{1 - \frac{1}{4}} = \frac{1}{2} - \frac{\frac{1}{8}}{\frac{3}{4}} = \frac{1}{2} - \frac{4}{24} = \frac{8}{24} = \frac{1}{3}$$

The products of firm B in successive periods is can be calculated as below. In

$$\text{Period 2} = \frac{\frac{1}{2} - \frac{1}{8}}{1 - \frac{1}{4}} = \frac{\frac{3}{8}}{\frac{3}{4}} = \frac{1}{2}$$

$$\text{Period 3} = \frac{\frac{1}{2} - \frac{3}{8}}{1 - \frac{1}{4}} = \frac{\frac{1}{4}}{\frac{3}{4}} = \frac{1}{3}$$

$$\text{Period 4} = \frac{\frac{1}{2} - \frac{11}{16}}{1 - \frac{1}{4}} = \frac{\frac{5}{16}}{\frac{3}{4}} = \frac{5}{12}$$

$$\text{Period 5} = \frac{\frac{1}{2} - \frac{43}{128}}{1 - \frac{1}{4}} = \frac{\frac{31}{128}}{\frac{3}{4}} = \frac{31}{96}$$

Firm B's output gradually increases but at a declining rate.

$$\begin{aligned} & \frac{1}{4} + \frac{1}{16} + \frac{1}{64} + \frac{1}{256} + \dots \\ [\text{Product of B in Equilibrium}] &= \frac{1}{4} + \frac{1}{16} + \frac{1}{64} + \frac{1}{256} + \dots \end{aligned}$$

$$\Sigma = \frac{a}{1-r} = \frac{1/4}{1-\frac{1}{4}} = \frac{1/4}{3/4} = \frac{1}{3}$$

Thus the Cournot Solution is stable. If there are n firms in the industry, each firm will provide $\frac{1}{n+1}$ of the market and the industry output will be $\frac{n}{n+1}$. As more firms are assumed to exist in the industry, the higher the total quantity supplied and hence the lower the price. The larger the number of firms, the closer the output and price to the competitive level is.

Firm A chooses its output Q_A on the assumption that the output level of firm B is fixed at Q_B . Similarly, Q_B is chosen on the assumption that Q_A can be treated as fixed by firm B. Cournot's model can best be explained by using isoprofit curves and reaction curves. The reaction curves approach is more powerful method of analysis of oligopolists markets because it allows the relaxation of the assumption of identical costs and identical demand.

Suppose total market supply is Q , where $Q = Q_A + Q_B$ and $P = f(Q_A + Q_B)$. The profit maximization problem of firm A is maximizing its own profit for a given quantity of output by Firm B. This implies that given any belief about firm B's output, Q_B , there will be a specific optimal output for firm A. This means there is a functional relationship between Q_B and the optimal output of Firm A, Q_A .

$Q_A = f_A(Q_B)$ This is Firm A's reaction function. The function shows how Firm A reacts to its expectation about firm B's output. $Q_B = f_B(Q_A)$ This is Firm B's reaction function. The reaction function can be derived from isoprofit functions containing Q_A and Q_B . An isoprofit curve of firm A is the locus of points defined by the level of output of A and his rival B which yields to Firm A the same level of profit. Similarly, an isoprofit curve of Firm B is the locus of points of different levels of output of his competitor and his own, which yields to B the same level of profit. For substitute commodities, isoprofit curves are concave to the axis of the firm to which it relates. The level of profit declines as we move away from horizontal axis for Firm A and from the vertical axis for Firm B.

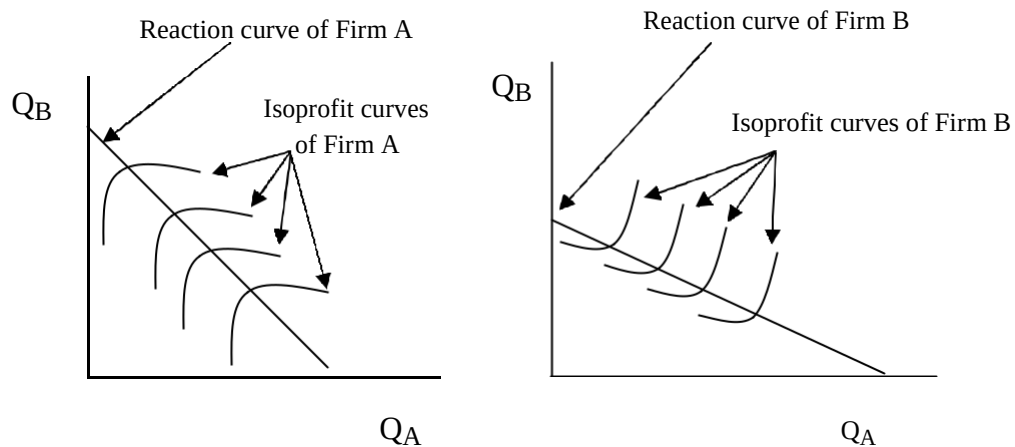


Fig2.2. Isoprofit and reaction curves for Cournot's duopolists

The shape of the isoprofit curve (concavity) shows how Firm A (or B) reacts to Firm B (or A). For Firm A the highest points of successive isoprofit curves lie to the left of each other and for Firm B the highest point of the isoprofit curves of Firm B lie to the right of

each other as we move to curves further away from the Q_B axis. If we join the highest point of isoprofit curves, we obtain firm's reaction curve.

The reaction curve of firm A (or B) is the locus of points of highest point that firm A (or B) can attain given the level of output of rival Firm B (or A). It is called reaction curve because it shows how Firm A (or B) will determine its output as a reaction to B's (or A's) decision to produce certain level of output.

In Cournot's model it is assumed that the firm expects the other firm to keep its output at the current level while making decisions regarding its own output. At the equilibrium each firm acts independently on the assumption that the other firm will not be acting under similar behavioral pattern. Given these assumptions, stable equilibrium in this model is attained at the intersection of the two reaction curves, provided that A's reaction curve is steeper than B's reaction curve.

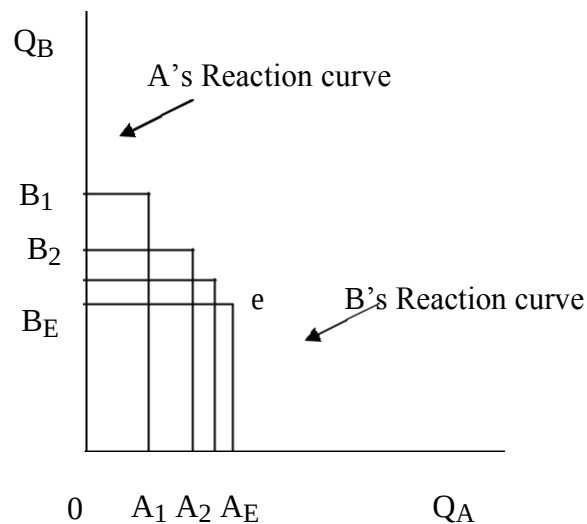


Fig 2.3. Cournot's equilibrium derivation from reaction curves

Let us examine the situation arising from Firm A's decision to produce quantity A_1 , lower than the equilibrium quantity A_E . Firm B will react by producing B_1 , by assuming that Firm A will keep its quantity fixed at A_1 . However, A reacts by producing a higher quantity of A_2 , on the assumption that B will stay at level B_1 . This adjustment will continue until point e is reached. Thus e is stable equilibrium at which each firm maximizes its own profit. But the industry profit or the joint profit is not maximized.

This can be seen by Edge worth contract curve which traces the point of tangencies of the two firms' isoprofit curves. Points on the contract curve are optimal in the sense that points out of this curve imply a lower profit for one or both firms, that is, less industry profit as compared to points on the contract curve.

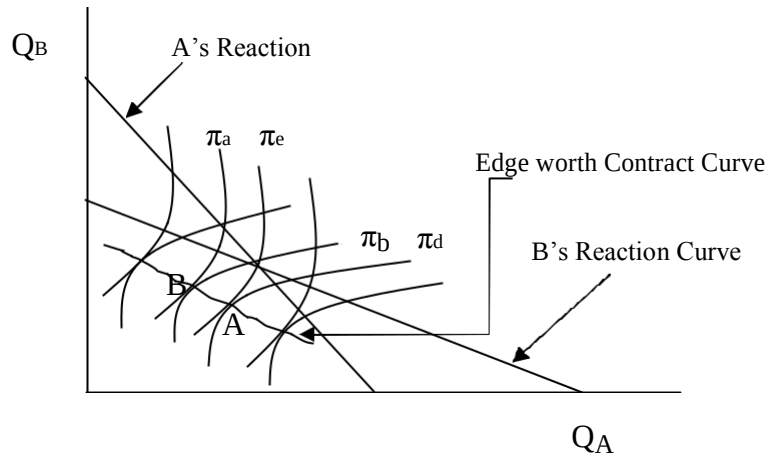


Fig2.4. Comparison between Edge worth Contract Curve and Cournot's equilibrium

The point at which the reaction curves intersect (Cournot equilibrium) is sub optimal and total industry profit will be higher if firms move away from it to any point between A and B on the contract curve.

For example if we move both firms from the Cournot's equilibrium to point A Firm A would continue having same profit (as it remains on the same isoprofit curve π_e) while Firm B would have a higher profit(because it moves on from isoprofit curve labeled as π_b to π_d). On the other hand at point B Firm B would continue having same profit as at the Cournot's equilibrium point (because it remains at π_b), while Firm A would have higher profit (as it moves from π_e to π_a). Finally, at any intermediate point between A and B, both firms would realize higher profits.

Example

The demand curve facing two Cournot's duopolists is $P = a - bQ$, where $a, b > 0$. If for $d > 0$, the total cost function of each firm is given as $C_i = dq_i$, where C_i and q_i are the total cost of production and quantity of output produced at the i^{th} firm, calculate the 37

equilibrium quantity of output each firm has to produced and the equilibrium price to be charged.

Answer

Given: $P = a - bQ$ as market demand curve,

$C_i = dq_i$, as cost function.

Solution

The cost functions of Firm 1 and Firm 2 can be rewritten as $C_1 = dq_1$ and $C_2 = dq_2$. First let us derive each firm's reaction function. To do so we have to write the isoprofit function first. The isoprofit function of Firm 1 can be written as below.

$$\pi_1 = Pq_1 - C_1 = (a - bQ)q_1 = [a - b(q_1 + q_2)]q_1 - dq_1$$

$$\Rightarrow \pi_1 = aq_1 - bq_1^2 - bq_1q_2 - dq_1$$

$\Rightarrow \pi_1 = (a - d)q_1 - bq_1^2 - bq_1q_2$. This equation represents Firm 1's isoprofit curve. To derive the reaction curve for Firm 1 set the first order partial derivative of Firm 1's isoprofit function equal to zero, so that, you will have the following.

$\frac{\partial \pi_1}{\partial q_1}$

$$= 0 \Rightarrow a - d - 2bq_1 - bq_2 = 0$$

$$\Rightarrow a - d - bq_2 = 2bq_1$$

$$\Rightarrow q_1 = \frac{a - d - bq_2}{2b} \dots \dots \dots \text{This is Firm 1's reaction function.}$$

Similarly, we can do the same thing for Firm 2 and get its isoprofit curve function and

$$\text{reaction function as } \pi_2 = (a - d)q_2 - bq_2^2 - bq_1q_2 \text{ and } q_2 = \frac{a - d - bq_1}{2b}.$$

Solving the two reaction functions simultaneously, we will have the following.

$$q_2 = \frac{a - d - b(a - d - bq_2)}{2b} \Rightarrow q_2 = \frac{a - d}{3b}. \text{ Substituting } q_2 = \frac{a - d}{3b} \text{ in Firm 1's reaction}$$

function we can get $q_1 = \frac{a - d}{3b}$.

Graphically this can be show as follows.

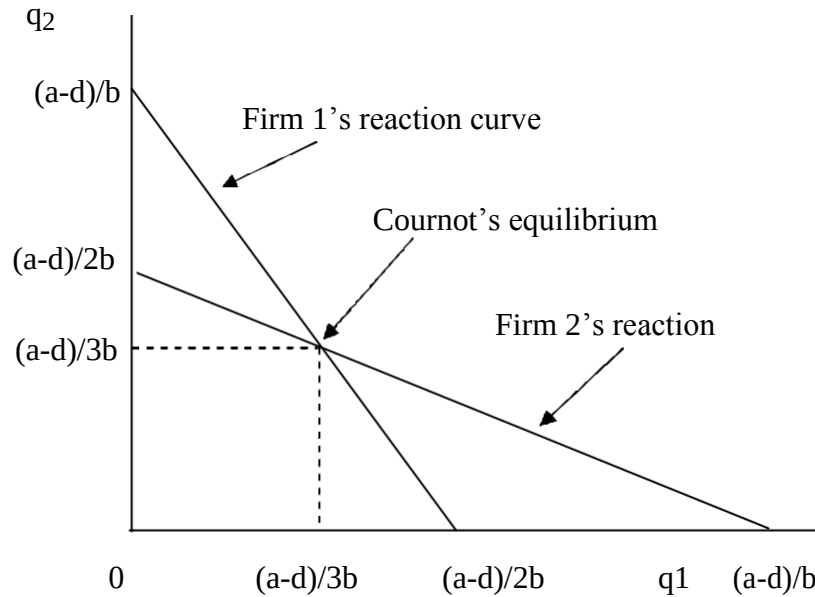


Fig2.5. Cournot solution

Therefore, Cournot's equilibrium is achieved when each firm produces $\frac{a - d}{3b}$ unit of output. This in turn, is the Nash equilibrium of the game.

Activity

If $P=100-0.5Q$ is the demand function that Cournot duopolists face and if the cost functions of Firm 1 and Firm 2 are given, respectively, as $C_1=5Q_1$ and $C_2=0.5Q_2^2$, calculate the quantity of output each firm has to produce and the price to be set.

2.4. BERTRAND'S DUOPOLY MODEL

Bertrand, who criticized Cournot's model, put forward a substitute model of duopoly. According to Bertrand, there is no limit to the fall in prices since each producer can always lower the price by underbidding the other and increasing his supply of output until the price becomes equal to his unit cost of production.

In Cournot's model, each producer adjusts his output believing that the rival will continue to produce the quantity of output as he is doing at present. Hence, in Cournot model the decision variable is the quantity of output to be produced. But in Bertrand model each producer believes that his rival will keep his price constant at the present level whatever price he might himself set. In both models the mutual interdependence of duopolists is ignored. Their difference lies in the variable which is assumed to constant. Whereas, in Cournot model each firm assumes its rival's output constant, in Bertrand model each firm assumes its rival's price to be constant.

To illustrate, suppose Firm 1 and Firm 2 are the two firms in Bertrand model. And assume that Firm 1 sets initial price $\$P$. Firm 2 faces essentially three choices:

- i. It can charge more than Firm 1, in which case it will sell nothing;
- ii. It can charge the same price as Firm 1; in which case the two firms will split the market demand at that price; or
- iii. It can sell at marginally lower price than Firm 1, in which case it will capture the entire market at that price. The third option is by far the most profitable.

In Bertrand model the option of selling at marginally lower price than the competitor will be the strategic choice for both firms. Needless to say, there can be no stable equilibrium in which each firm undersells the other. The back and forth process of price cutting will continue until it reaches its natural economic limit – namely, marginal cost, which in the mineral spring example is zero. Once each firm has cut its price to marginal cost, it will have no incentive to cut further. With each firm selling at marginal cost the duopolists will share the market equally.

Bertrand's model can be represented with the reaction functions of duopolists. The reaction curves are derived from the isoprofit curves which are convex to the axis, on which we measure the prices of the duopolists. Each isoprofit curve for firm A shows the same level of profit which would accrue to (A) from various levels of prices charged by this firm and the rival firm. The isoprofit curve for firm A is convex to its price axes (P_A). This is so because firm A must lower its price up to a certain limit to meet the

cutting of price of its competitor, in order to maintain the given level of its profits. The lower the isoprofit curve, the lower the level of profits it denotes.

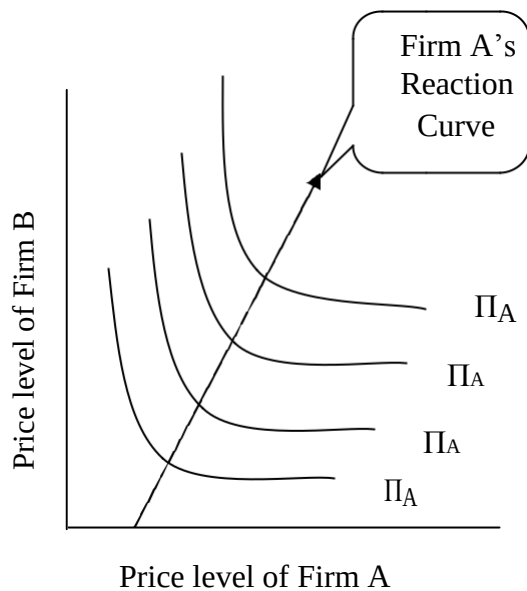


Fig2.6. A: Firm A's Isoprofit and Reaction Curves

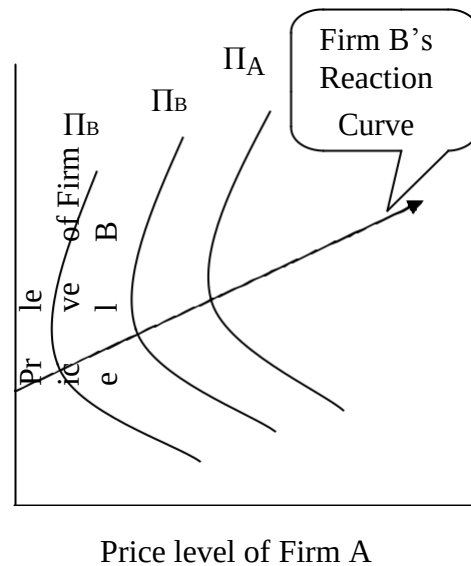


Fig2.6 B: Firm B's Isoprofit and Reaction Curves

For any price charged by Firm B there will be a unique price of Firm A which maximize the latter's profit. The unique profit maximizing price is determined at the lowest point on the highest attainable isoprofit curve of Firm A. Firm A's reaction curve is derived by joining successive lowest points on the highest attainable isoprofit curve. Firm A's reaction curves shows a locus of points of maximum profits that Firm A can attain by charging a certain price, given the price of its rival.

The reaction curves show how firms under Bertrand model react to each others price choices. Stable equilibrium will be established when the firms find their expectations about each others price correct. This occurs at the intersection of the reaction curves.

For example, if Firm A Charges price P_{A1} , firm B will change B_1 , because on the Bertrand assumption, this price will maximize B's profit (given P_{A1}). Firm A will react to this decision of its rival by charging a higher price P_{A2} . This action and reaction continues until point e is reached. The same equilibrium will be reached if firms started

by charging a price higher than P_{Be} or P_{Ae} . The 45° line shows a locus of points along which $P_A = P_B$.

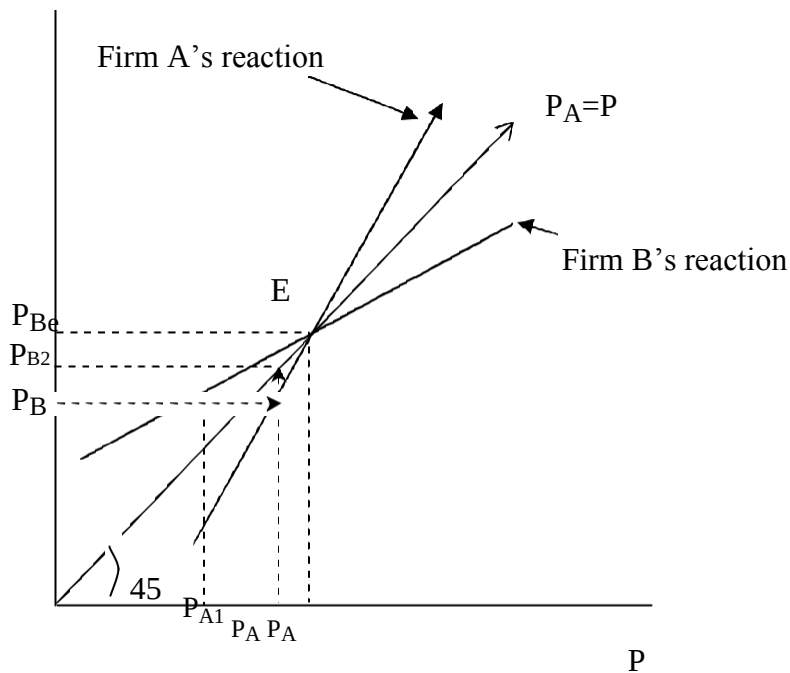


Fig 2.7 Equilibrium in Bertrand Model

Bertrand model leads to a stable equilibrium derived by the point of intersection of the two reaction curves. If their products are assumed to be homogeneous each firm must charge the same price in equilibrium. If they do not, the one offering the lower price would actually get the whole demand. Then, equilibrium is likely to be established where $P = MC$. This is so because if the equilibrium price is greater than MC , then each firm will have an incentive to under cut the price and take all the customers away. This incentive to cut prices is eliminated when the two firms charge an identical price equal to the MC , similar price to the competitive equilibrium, and the industry profit will be zero. The Bertrand model therefore leads us to the perfectly competitive solution despite the small number of firms in the industry.

2.5. THE KINKED DEMAND CURVE HYPOTHESIS

Price rigidity, as stated earlier, is one characteristic feature of oligopolistic markets. It means that firms will remain inflexible with the ongoing prices, though there may be changes in economic conditions. The kinked demand curve hypothesis is one and most

popular explanation for price rigidities in oligopoly. The kinked demand curve hypothesis was put forward by Paul M. Sweezy. The kinked demand curve hypothesis is used to explain price rigidities in differentiated oligopolies (oligopolies with differentiated product).

Unlike under pure competition, all customers may not leave the firm if it raises selling price. According to the kinked demand curve hypothesis, a firm's demand curve is assumed to have a kink at the ruling market price. The segment of a firm's demand curve above the kink is highly elastic and the segment of the demand curve which lies below the kink is less elastic.

The central idea in the kinked demand curve hypothesis is that each firm is supposed to expect its rivals to follow up if it cuts price below the prevailing one, and not to follow up if it raises price beyond what is prevailing in the market.

In other words, each oligopolist believes that though its rival firms will not match his increase in price above the prevailing level, they will indeed match its decision to cut price. There are two patterns of reactions by rival firms for a firm's decision to increase decrease price from the prevailing level. This can be elaborated by using the following figure.

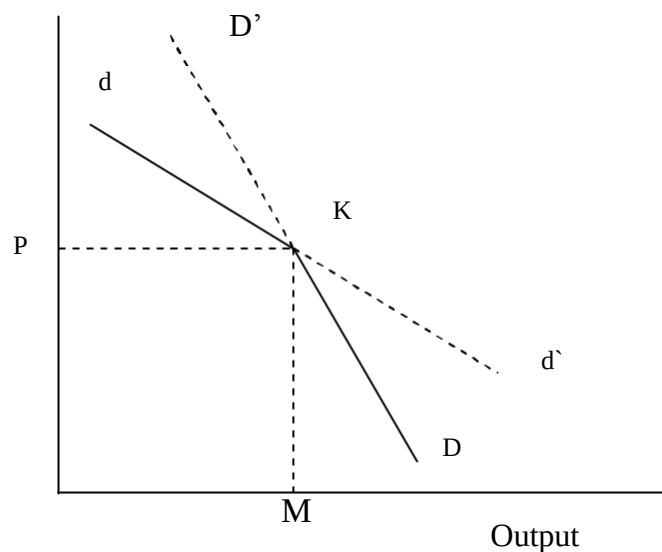


Fig 2.8. Kinked demand curve

In the figure above P is the prevailing market price, whereas dd' and DD' are perceived and proportionate demand curves, respectively.

If any one firm decreases prices below P , fear of loosing business will induce other firms to match the price cut. As its rivals match its price cut, a firm gains little from its action. This is so because price reduction by the rivals is so quick that the first firm cannot increase its sales at the expense of them. It follows from this that the segment of a firm's demand curve below the prevailing price is inelastic (KD). But if any one firm increases price beyond P , no one firm will follow its action. This increase in price by one firm has two effects. Firstly, some of the firm's customers will switch to substitute products producers. Secondly, even those customers who will stick to the firm may reduce their demand for the firm's product. So, a firm's demand curve above the prevailing price is more elastic. It follows from this that for price greater than P the relevant demand curve is dK .

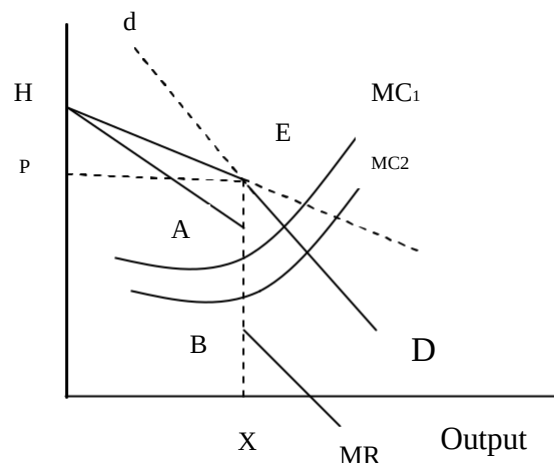


Fig 2.9. Equilibrium under the kinked demand curve hypothesis

The marginal revenue curve is discontinuous at E . The MR has two segments, segment HA corresponds to the upper part of the demand curve, while the segment from point B corresponds to the lower part of the kinked – demand curve. According to this theory marginal cost curve usually passes through the discontinuous part of the marginal revenue. The equilibrium of the firm is defined by the point of the kink because at any point to the left of the kink, MC is below the MR , while to the right of the kink MC is larger than the MR . Thus the total profit is maximized at the point of the kink.

Note that cost fluctuations that don't shift MC outside the discontinuity in the MR curve will not result in the firm to change either price or output.

This explains that firms keep the price and output same, even when there is change in cost. But if increase in cost is applied for all the firms in the industry, for example sales tax on the firms, then the firm expects all other firms to raise price and adjusts its equilibrium price and quantity accordingly. This model explains why price and quantity sometimes remain 'sticky' while costs (demand) are changing.

2.6. COLLUSIVE OLIGOPOLY

In oligopolistic markets, the existence of few firms and the recognition of their interdependence may tempt them into collusion. Fear of the disastrous price war is also another reason why oligopolistic firms may collude. Agreements in collusive oligopolies may be either formal or tacit (secret). A formal agreement is said to occur when oligopolists held formal discussion and consultation and agree to abide by certain rules with regard to output, price etc.

In some countries formal collusion is prohibited by laws (example antitrust laws in the US are against formal collusion). It is not uncommon to observe tacit (secret) agreements amongst oligopolistic firms. A tacit agreement occurs when, without formal discussion, firms come to have some understanding between them and pursue a uniform policy with regard to output, price etc. Whether agreements are tacit (secret) or formal, collusive oligopolies are of two types: cartel and price leadership. Below attempt will be made to discuss these two types of cartels.

2.6.1. Cartels

Cartel is a formal organization of producers within an industry that determines policies for all firms in the cartel with the view of increasing total profit of the cartel. A cartel is formed when oligopolistic firms work together to act like a monopolist that maximizes joint profit by reducing output and raising price. Firms must agree to fix price or reduce output. Factors that facilitate the formation of cartels include:

- Ability to raise price- facing an inelastic demand curve.
- Low expectation of severe punishment.

- Low Organization Costs (that is, existence of few concentrated firms producing homogeneous product).

There are two types of cartel aiming at joint profit maximization and cartel aiming at market sharing.

2.6.1.1. Cartel aiming at joint profit maximization

This is an extreme form of collusion wherein member firms agree to surrender completely their rights of output price determination to a Central Administration Agency (CAA). CAA passes decisions so as to secure maximum joint profits for the cartel members. Under a cartel aiming at joint profit maximization, the price and output determination of the whole industry as well as each member firm is determined by the CAA so as to achieve maximum joint profit for member firms. This type of cartel is also called as centralized cartel. In this case, the aim of the cartel is joint profit maximization which is similar to that of multi-plant monopolist.

We concentrate on pure oligopoly where all firms produce homogeneous product. Each member firm in the cartel surrenders its right on price and quantity of output to the CAA, and the CAA decides how much each member firm has to produce in such a way as to maximize total industry profit.

The CAA, in order to determine the optimal output and price level, has to assess the market. It should know the cost figures of each firm and the market demand curve with the corresponding marginal revenue curve. The CAA determines a separate output to be produced by member firms. Total cost will be minimized when the various firms in the cartel produce such separate outputs that their marginal costs are equal. This is because if the marginal costs of the member firms are not equal, the marginal units of output could be produced at a smaller cost by the firms with a lower marginal cost than by those with a higher marginal cost.

The CAA determines each firm to produce up to that level of output at which the marginal cost of production will be equalized across all member firms of the cartel. This

is so because, if there is difference in the marginal cost of production across member firms, then there will be a possibility of augmenting industry profits (joint cartel profits) when a firm with lower marginal cost of production is made to produce more.

The CAA allocates production among firms in such a way that $MR=MC_1=MC_2 = \dots MC_n$ where MR is marginal revenue, and MC_i is the marginal cost of production at the i^{th} firm. If we assume only two firms in the cartel, the figure below shows how the CAA passes decisions to maximize joint profits and the allocation of output across members of the cartel.

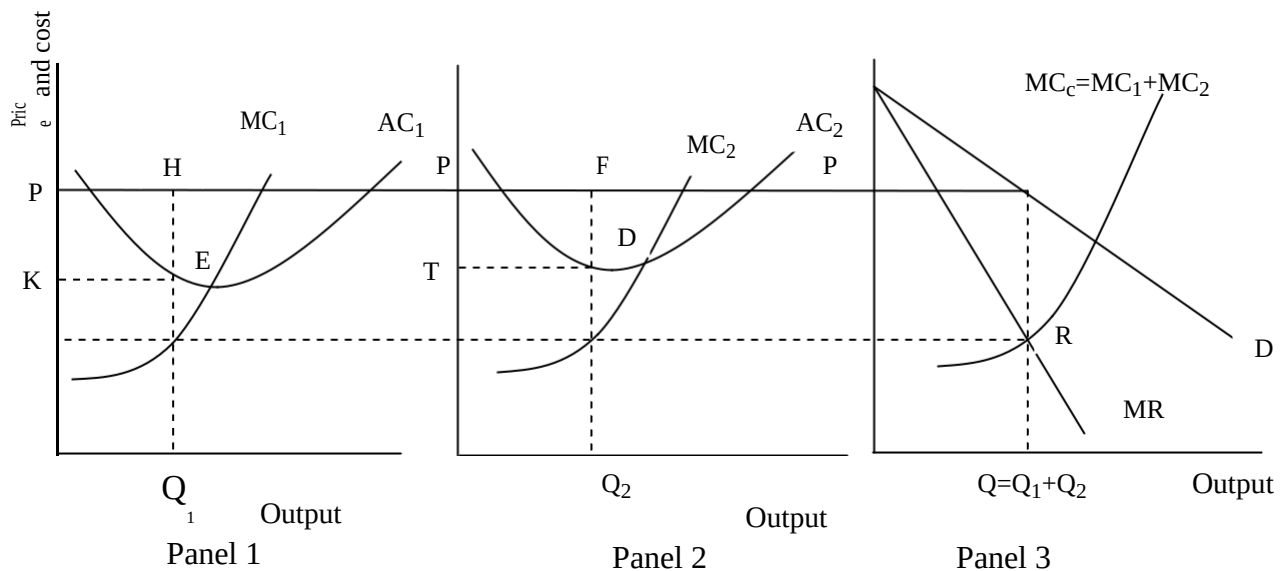


Fig 2.10. Price and Output Determination under Cartel aiming at Joint Profit

At point R (panel 3) the common marginal revenue MR crosses the marginal cost curve of all member firms' (MC_c), that is, $MR=MC_c$. Hence point R shows the optimal level of industry output to be produced (and price to be followed by each member firm being P). As shown on panel 3 the optimal industry output (at which joint profit will be maximized) is Q_c and price level being P .

The CAA then allocates the Q_c unit for the two member firms so as to maintain $MC_1 = MC_2$. The condition for joint profit maximization ($MC_1 = MC_2 = MR$) is maintained

when Firm 1 produces Q_1 and Firm 2 produces Q_2 (Such that $Q_1 + Q_2 = Q_C$) units of output.

The maximum joint profit will be the sum of Firm 1's profit (equal to the area PHEK) and Firm 2's profit (equal to the area PFDT). The sum of each firm's profits is the joint profits made by the cartel which will be the maximum under the given demand and cost conditions.

Example:-

Assume that there are two firms in the cartel market aiming at maximizing joint profit. If the market demand curve is given by the equation $p = 100 - 0.5X$, and total cost functions of firm 1 and firm 2 respectively are $C_1 = 5X_1$ and $C_2 = 0.5X_2^2$, calculate the quantity of output each firm has to produce, and the maximum joint profit of the cartel.

Answer:-

Given $P = 100 - 0.5X$

$$C_1 = 5X_1$$

$$C_2 = 0.5X_2^2$$

Required: - Optimal quantity of each member firm's output and the maximum joint profit.

Solution: - Let TR be total revenue

$$TR = PX$$

$$= (100 - 0.5X)X$$

$$= 100X - 0.5X^2$$

$$MR = \frac{dTR}{dX} = 100 - X$$

Since X is the total output produced by both firms, it cannot exceed the sum of each firm's output. That is, $X_1 + X_2 = X$

So, $MR = 100 - X = 100 - X_1 - X_2$

$$C_1 = 5X_1 \Rightarrow MC_1 = \frac{dC_1}{dX_1} = 5$$

$$C_2 = 0.5X_2^2 \Rightarrow MC_2 = \frac{dC_2}{dX_2} = X_2$$

The joint profit is maximized when the following condition is

fulfilled $MC_1 = MC_2 = MR$

$$MC_1 = MR \Rightarrow 100 - X = 5$$

$$\Rightarrow 100 - X_1 - X_2 = 5$$

$$\Rightarrow X_1 + X_2 = 95$$

$$\Rightarrow X_1 = 95 - X_2 \dots \dots \dots (1)$$

$$MC_2 = MR \Rightarrow 100 - X_1 - X_2 = X_2$$

$$\Rightarrow X_1 + 2X_2 = 100 \dots \dots \dots (2)$$

Substituting (1) in (2) we have

$$\Rightarrow X_2 = 5$$

If we substitute $X_2 = 5$ in (1) we can get $X_1 = 90$. The price set by the CAA will be

$$P = 100 - 0.5X \qquad X = X_1 + X_2 = 90 + 5 = 95$$

$$P = 100 - 0.5(95)$$

$$P = 100 - 47.5$$

$$P = 52.5$$

Substituting the values of X_1 , X_2 , X and P in the above demand and cost functions we can get joint profit being equal to 4525.

Hence, to maximize the joint industry profit the CAA determines Firm 1 to produce 90 units and Firm 2 to produce 5 units, and both to sell at a price $P = 52.5$. The maximum joint industry profit will be 4525.

Activity: - Do the same exercise as the above example but for the following

$$P = 50 - X$$

$$C_1 = 10X_1$$

$$C_2 = X_2^2$$

A cartel agreement can be enforced through

A. Detecting Cheating. This will be easier if,

- There are few firms in the cartel.
- Prices do not fluctuate independently.
- Prices are widely known.
- All members sell identical product at the same point in distribution.

B. Methods of enforcing cartels such as

- Fixing more than just price.
- Dividing the market.
- Fixing market shares.
- Meeting competition clauses.

Firms have strong incentive to break from the cartel and expand output and reduce price if all other firms keep the cartel. Incentive to collude is strong so as to maximize joint profits but so is the incentive to cheat. If any member can secretly violate the agreement, he will gain larger profits than by conforming to it. Therefore enforcement, i.e., detecting significant deviations from the agreed-upon prices, is paramount.

In practice cartel may not achieve the maximum profit because of the following reasons.

- They might make a mistake in estimation of the demand and marginal cost. If they under estimate the elasticity, price will be set higher. This benefits the high cost firm.
- Slow process of cartel negotiation: cartel agreements take a long time to negotiate due to the differences in size, costs and markets of the individual firms. During the negotiation period the actual market condition might be changed when they reach at agreement.

- Stickiness of negotiated price: they will take longer time until the prices are revised to the existing conditions. Because of this, profit may not be maximized all the time. There is always a time lag between the market condition and the price setting.
- Bluffing attitude of some members of the cartel during the negotiation process. Some members reduce price to expand their sale and attain larger market share before the final arrangement. This leads to miscalculations of the real monopoly equilibrium price and output.
- The existence of high cost firms: some firms might have very high cost so that they can not survive with low price. Due to this reason they may refuse to be a member of a cartel. And for the sake of these firms, price can be set higher that does not maximize cartels profit.
- Fear of entry. If cartel gets higher profit, new firms might enter into the industry and drive the market price lower.

2.6.1.2. Market sharing cartels

The formation of cartels is illegal and they are not common in the real world in this case the firms agree to have same price and share the market. They share the market in to two different ways- sharing by non price competition and quotas.

A. Market sharing by a non – price competition

They agree to charge same price and not to sell at a price below the cartel price but keep a considerable degree of freedom to vary the style of their products and selling activities. The price is negotiated by bargaining with low cost firms pressing for a lower price and the high cost firms for a higher price. The agree price must be such as to allow some profit to all members. In this case firms are allowed to compete on a non-price basis.

This form of Cartel is unstable or loose cartel. If firms have the same costs, it will be relatively easy to come to agreement on one particular price, such as monopoly price. However, if members have differential cost conditions, there exists strong incentive for low cost members to break away from the cartel openly and charge a lower price, or

through secret price discount to the buyers. When other members come to know their loss of customers, they may go out of the cartel, and a price war and instability may develop until only the fittest low cost firms survive. Huge cost differentiation leads to price war and the cartel becomes unstable.

B. Sharing the market by agreement on Quota:

Firms decide a fixed amount each member may sell on the agreed price. If they have similar costs a monopoly solution will be reached with the market being shared equally among member firms. However, if they have differential cost conditions quotas and shares of the market will differ. And it is determined through bargaining on

- Past levels of sales.
- Productive Capacity.
- Cost difference.
- Geographical differences.

Most of the decisions are easily violated and cartel agreements, in the case of cost differences, are highly unstable.

It should be obvious that the cartel models of collusive oligopoly are closed models. The instability of cartels is intensified if new firms can enter the market, because the new entrant may not want to join the cartel and compete the cartel members from outside by lowering the price level.

2.6.2. Price leadership

It is a coordinated behavior of oligopolists, where one firm sets the price and the other firms follow because it is an advantage for them or because they prefer to avoid uncertainty about their competitors' reaction even if it is a departure of the followers from their profit maximizing position.

There are various forms of price leadership

- i. Price leadership by low cost firm
- ii. Price leadership by a dominant (large) firm

2.6.2.1. The Low Cost Price Leadership

Assumption – there are two firms producing homogeneous product at different cost. In the case of cost differences the high cost firms may agree to adopt whatever price the lowest cost firm sets in the market, in order to avoid price war that will be to their disadvantage. The low cost firm sets price at $MR = MC$ level for it self and the high cost firm adopts it even if it doesn't maximize its profit.

For two firms, Firm 1 having lower cost than Firm 2, costs and market demand are given as $C_1 = 5Q_1$, $C_2 = 15Q_2$ and $P = 105 - 2.5Q$ where $Q = Q_1 + Q_2$.

Find the equilibrium output to be produced by each firm the under the assumption of the low cost price leadership.

Answer

Given: $C_1 = 5Q_1$

$$C_2 = 15Q_2$$

$$P = 105 - 2.5Q$$

Required: equilibrium output to be produced by each firm.

Solution:

$$P = 105 - 2.5(Q_1 + Q_2)$$

$$P = 105 - 2.5(Q_1 + Q_1) \quad \text{Because } Q_1 = Q_2$$

$$P = 105 - 5Q_1$$

$$\pi_1 = P \times Q_1 - C_1$$

$$= (105 - 5Q_1)Q_1 - 5Q_1$$

$$= 100Q_1 - 5Q_1^2$$

Applying the first order condition for maximization, that is; by setting the first order partial derivative of the total profit function with respect to Q_1 equal to zero, we have:

$$\frac{\partial \pi}{\partial Q_1} = 0 \Rightarrow \frac{\partial (100Q_1 - 5Q_1^2)}{\partial Q_1} = 100 - 10Q_1 = 0$$

$$\Rightarrow 100 = 10Q_1$$

$$\Rightarrow Q_1 = 10 \quad \text{Substituting } Q_1 = 10, \text{ in the above demand function, we can have:}$$

$$P = 105 - 5Q_1 = 105 - 5 \times 10 = 55$$

Firm 2 also produces 10 units and sets price at $P=55$, which is not profit maximizing level for itself.

Compare the profit of Firm 2 when it adopts the price of the leader and when it charges price which is determined by the equality of MR_2 & MC_2 .

Firm 2's demand function is $P = 105 - 5Q_2$ and its total revenue is;

$$TR_2 = PQ_2 = (105 - 5Q_2)Q_2 = 105Q_2 - 5Q_2^2$$

$$\text{Firm 2's marginal revenue is } MR_2 = \frac{dTR_2}{dQ_2} = 105 - 10Q_2. \quad MC_2 = \frac{dC_2}{dQ_2} = \frac{d(15Q_2)}{dQ_2} = 15$$

To calculate the profit maximizing level of output we have to equate MR_2 with that of MC_2 .

$MR_2 = MC_2 \Rightarrow 105 - 10Q_2 = 15 \Rightarrow Q_2 = 9$. Substituting $Q_2=9$ in Firm 2's demand function we can see that $P = 105 - 5(9) = 105 - 45 = 60$.

Let us substitute the quantities of output and the level of prices in the two different cases and compare the amount of profits accruing to Firm 2.

Firm 2's profit by adopting the leader's price is found by substituting $Q_2=10$ and $P=55$ in the firm's profit function. By doing so we have,

$$\pi(Q_2 = 10, P = 55) = 55(10) - 15(10) = 550 - 150 = 400.$$

Firm's profit when it sets price according to the marginalist rule ($MR=MC$) is given by;

$$\pi_2 = 60(9) - 15(9) = 540 - 135 = 405. \text{ The leader's price is, therefore, not an optimal price for Firm 2.}$$

2.6.2.2. The Dominant Firm Price Leader

The model is appropriate when there exists one large dominant firm with a considerable market share and some other firms with small market share. The small firms may feel that it is difficult to compete with the dominant firm and may simply adopt whatever price it is set in the market by the dominant firm and adjust their output levels to

maximize profit like perfectly competitive firms. The dominant firm is assumed to know the marginal cost curves of the smaller firms, which he can add horizontally and find the total supply by the small firms at each price.

Activity

Why do small firms let the dominant firm set price first and follow the price set by it?

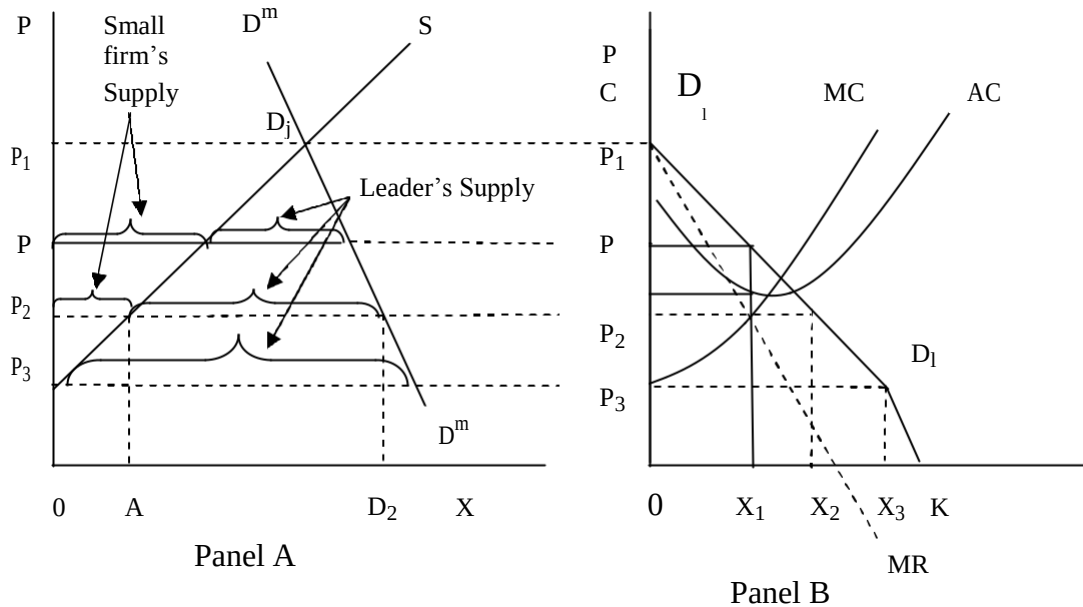


Fig 2.11. Price leadership by a dominant firm

In the above figure (on Panel A), D^m and S curves are market demand and supply by all small firms curves, respectively. The D_1D_1K downward sloping line is the demand curve for the dominant firm.

With this knowledge the leader can obtain his demand curve. At each price, the dominant firm can sell the part of the market demand that could not be satisfied by the small firms. The demand for dominant firm is the difference between market demand and supply of the smaller firms. For example, at price P_1 , the demand for the leader's product is zero, because the total quantity demanded (D_1) is supplied by the small firms. As price falls below P_1 the demand for the leader's product increases. At P_2 the total demand is D_2 ; the part $0A$ is supplied by the small firms and the remaining AD_2 is supplied by the leader. At P_3 total demand is D_3 and the total quantity is supplied by the leader since at that price

the small firms do not supply any quantity. Below P_3 the market demand coincides with the leader's demand curve.

The dominant firm maximizes its profit by equating its marginal cost to marginal revenue, while the smaller firms are price-takers, and may or may not maximize their profit, depending on their cost structure. However, for the leader to maximize profit, he has to be sure that the small firms follow his price and also they are supplying (producing) the right quantity.

Example:

Let D_m , D_L , S_f and C_L be the market demand, demand for the dominant firm, total supply of small firm and cost of the leader, respectively. So that $D_L = D - S_f$. Given the market demand function as $D_m = 50 - 0.3P$, the leader's cost function $C_L = 4Q_L$ and the supply by small firms as $S_f = 0.2P$, calculate the price level and the quantity of output to be produced by all small firms and the dominant firm.

Answer:

Given: $D_m = 50 - 0.3P$

$$S_f = 0.2P$$

$$C_L = 4Q_L$$

Required: the price level and the quantity of output to be produced by all small firms and the dominant firm.

Solution: let us first calculate the demand function for the dominant firm (D_L).

$$D_L = D_m - S_f = 50 - 0.5P$$

$$\Rightarrow 0.5P = 50 - Q_L$$

$$\Rightarrow P = 100 - 2Q_L$$

The leader's total revenue function is given by,

$$R = P \times Q_L = (100 - 2Q_L)Q_L = 100Q_L - 2Q_L^2$$

In order to maximize its profit, the dominant firm has to keep a balance between marginal revenue and marginal cost (maintain marginalist rule).

$$MR_L = \frac{dR}{dQ_L} = 100 - 4Q_L, \text{ and } MC_L = \frac{dC_L}{dQ_L} = 4$$

$MR_L = MC_L \Rightarrow 100 - 4Q_L = 4 \Rightarrow Q_L = 24$ By substituting $Q_L=24$ in the demand function we have $P=52$. To calculate the total market demand, substitute $P=52$ in the market demand function. You will have,

$$D_m = 50 - 0.3P = 50 - 0.3(52) = 34.4.$$

To calculate the quantity supplied by all the small firms, substitute $P=52$ in the function $S_f=0.3P$ and you will have $S_f=10.4$, or $S_f=D_m-Q_L=34.4-24=10.4$.

This model is called partial monopoly because the larger firm acts as a monopoly and the smaller firms are price takers and act like the firm in pure competition and hence the model is a combination of the theory of pure competition and the theory of monopoly.

2.7. SUMMARY

Oligopoly is a market structure wherein there are few firms which serves the market by producing differentiated or homogeneous products. The existence of high degree of mutual interdependence among oligopolistic firms is their major characteristics feature. Recognition of their mutual interdependence may lead the firms to collusion, in which case they can act as a monopoly. Accordingly, we have non collusive oligopolies (for example the Cournot's and Bertrand's model) and collusive oligopolies (cartels and price leadership).

In Cournot's model a firm is assumed to believe that the quantity of its rival constant while deciding how much to produce. The back and forth process of the firms' competition based on quantities proceeds until the point of intersection of the two firm's reaction curves. A zero cost of production assumption leads to a duopoly solution at which each firm supplies one third of the total market demand and all together supplying two third of the market demand. While maximizing their respective profits, Cournot firms

leave the industry profit at a suboptimal point which can be proved by comparing industry profits along the Edgeworth contract curve against the Cournot's equilibrium.

In Bertrand model the option of selling at marginally lower price than the competitor will be the strategic choice for both firms. The Bertrand model leads to a stable equilibrium implied by the point of intersection of the two reaction curves. Equilibrium is likely to be established at that point where $P = MC$. This is so because if the equilibrium price is greater than MC , then each firm will have an incentive to undercut the price and take all the customers away. Despite the existence of only two firms in the industry, Bertrand's model leads to competitive equilibrium.

The kinked demand curve hypothesis explains price rigidity in oligopoly. Accordingly, an oligopolist's demand curve is assumed to have a kink at the prevailing price based on the hypothesis that rivals match reduction in price by a firm but not increase in prices.

Recognition of their mutual interdependence and fear of possible price war are among the reasons for collusion in oligopolistic markets. Collusive oligopoly can be either in the form of cartel or price leadership. In a cartel aiming at joint profit maximization, each firm will surrender its power to the CAA which passes decisions concerning all member firms of the cartel. In order to maximize joint profits, each firm is made to produce that level of output which maintains the same MC across all the member firms.

In a cartel aiming at market sharing each firm may agree either to compete on a non price basis or to share the market based on some quota. In a non price competition cartel stability occurs only if there is no significant cost differential across member firms which induce the low cost firm to break the agreement by cutting prices. In a cartel aiming at market sharing based on quota, quota determination may depend on past level of sales, productive capacity, cost differentials and geographical location.

Fear for a possible price war by oligopolists may lead to a collusive oligopoly in which one firm sets price first and others follow up. This type of collusive oligopoly is called price leadership. In price leadership, the leader can either be a dominant firm or a low cost firm.

Chapter review exercise

I. Answer the following questions.

1. Fill in the following table about the summary characteristics of the four basic market models.

Characteristics	Market models			
	Pure competition	Pure Monopoly	Monopolistic competition	Oligopoly
Number of firms				
Type of product				
Control over price				
Conditions of entry				
Non-price competition				

2. In a two firm industry, Firm A and B, behave as Cournot duopolists. If each firm faces a constant marginal cost of \$10 and the market demand for the homogeneous product produced by them as $P=100-X$, what will be the equilibrium price and total industry output?
3. The market demand curve for mineral water is given by $P=15-X$. If there are two firms that produce mineral water, each with a constant marginal cost of \$3 per unit, fill in the entries for each of the two duopoly models indicated in the table.

Model	Q_1	Q_2	P	Π_1	Π_2	Π_3
A. Cournot						
B. Bertrand						

II. Choose the best answer.

4. In Cournot's model, the industry profit is higher on _____ than at _____.
 - A. The demand curve, the minimum MC curve.
 - B. The reaction curve, the kink.
 - C. The Edge worth contract curve, the Cournot equilibrium.
 - D. The isoprofit curve, the kink.
5. _____ is a locus of points which represent the combination of the level of output by two firms that are just sufficient to generate the same profit for either firm.
 - A. Reaction curves.
 - B. Edge worth contract curve.
 - C. Kinked demand curve.
 - D. Isoprofit curve.
6. Advertising and selling costs, in their strict sense, are very important in
 - A. Monopoly
 - B. Perfect competition
 - C. Monopolistic competition
 - D. Oligopoly
7. Identify the correctly matched pairs of concepts.
 - A. Perfect competition-falling demand curve
 - B. Monopoly-many sellers
 - C. Oligopoly-free entry
 - D. Monopolistic competition-product differentiation
8. As generalized from Cournot's model, if the number of firms in an oligopoly is 4, the industry is in equilibrium while each firm produces ____ of the market demand and all firms altogether produce _____ of the market demand respectively.

A. 80% and 20%	C. 50% and 50%
B. 20% and 80%	D. 75% and 25%
9. In the Cournot's duopoly model, while firms maximize their respective profits, they will leave
 - A. Their demand inelastic.
 - B. The industry profit at sub optimal point.
 - C. Their costs maximized.
 - D. The industry price lower.

Chapter 3

Game Theory and Oligopoly Behavior

3.1. INTRODUCTION

The game theory is concerned with the choice of the optimum strategy in conflict situations. The game theory can help an oligopoly firm choose the course of action. For example, the best price to charge, the optimum degree of product differentiation, or the best level of advertising) that maximizes its benefit or profit after considering all possible reactions of its competitors. For each strategy adopted by one player or firm there is usually a number of strategies (reactions) open to the other player or firm. The outcome of each combination of strategies adopted by the two players or firms is called the *Payoff*. The payoff of all the strategies is called the *payoff matrix*.

After the completion of this chapter you should be able to:

- Define what a game is and distinguish different types of games.
- Explain the behavior of oligopolists based on game theory concept.
- Define the concept of Nash equilibrium and determine Nash equilibrium outcomes of different games.
- Explain equilibrium concepts in mixed strategic games and sequential games.
- Explain the strategic interaction of economic issues in a game theoretic approach.
- Identify minimax and maximin strategies.

Chapter Outline

3. Game theory and oligopoly behavior

3.1. Introduction

3.2. Maximin and Minimax Strategies

3.3. Nash equilibrium

3.3.1. A game with no Nash equilibrium

3.3.2. A game with multiple Nash equilibrium

3.3.3. A game with one Nash equilibrium

3.4. Mixed strategies

3.5. The prisoners' dilemma

3.6. Repeated games

3.6.1. Tit-for-tat games

3.7. Sequential games

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- Explain equilibrium concepts in mixed strategic games and sequential games.
- Explain the strategic interaction of economic issues in a game theoretic approach.
- Identify minimax and maximin strategies.

3.2. GAME THEORY SET UP

The game theory is concerned with the choice of the optimum strategy in conflict situations. The game theory can help an oligopoly firm choose the course of action. For example, the best price to charge, the optimum degree of product differentiation, or the best level of advertising) that maximizes its benefit or profit after considering all possible reactions of its competitors. For each strategy adopted by one player or firm there is usually a number of strategies (reactions) open to the other player or firm. The outcome

of each combination of strategies adopted by the two players or firms is called the *Payoff*. The payoff of all the strategies is called the *payoff matrix*.

Game theory provides a different way of studying industries (with a small number of producers) with strategic interaction. It can be used to study different forms of competition including price, output, advertising, development of new products, entry to market, and so on. Games are of different types. They can be non-cooperative, simultaneous, pure strategic, mixed strategic, extensive, and so on. The following are the three basic elements of any game.

1. Players: are parties involved in the game. All the players are specified in advance
2. Strategies: all the actions each player can take. They are set of actions (alternatives) available to each player. Strategies include charging high or low price, introducing new product or selling the existing one, advertising. Strategy is a complete description of what the players can do, that is, the set of all actions.
3. Payoffs: are outcomes for each player resulting from all possible combination of strategies by players. The amount each player gets for every possible combination of the actions.
4. Rules :rules include whether
 - The game is cooperative or non-cooperative.
 - Players maximize individual gain or maximize their minimum return (risk averse).
 - The game is single play or repeated play.
 - The game is simultaneous or sequential.
 - Strategies are pure or mixed.

Why do Economists study games?

- Games are a convenient way in which to model the strategic interactions among economic agents.
- Many economic issues involve strategic interaction.
 - Behavior in imperfectly competitive markets, for example, Coca Cola versus Pepsi.

- Behavior in auctions, for example, Investment Banks, bidding on treasury bills.
- Behavior in economic negotiations, for example, trade.

The following table (table-3.1) gives the pay off for each of two course of action or strategies open to form A associated with each of three possible responses from Firm B. For example, strategy A_1 by firm A can be associated with strategy B_1 , B_2 or B_3 by Firm B. Specifically if Firm B responds with strategy B_1 to strategy A_1 by firm A, Firm A will gain 1 percent in market share from Firm B. If instead Firm B responds to A_1 with strategy B_2 , Firm A gains zero market shares. Finally, with strategies A_1 and B_3 , Firm A gains 2 percent of market share at the expense of Firm B. With strategies A_2 and B_1 Firm A loses 2 per cent of the market to Firm B, and so on.

Table-3.1: Pay off of Firm A Associated with the Response from Firm B

		Firm B		
		B_1	B_2	B_3
Firm A	A_1	1	0	2
	A_2	-2	-1	0

Assume that there are two firms serving the entire market by producing identical products. If we assume a constant industry profit, one firm can earn more profit only at the expense of the other form. Every time the total profit of both the firms is added up to the given industry profit. If the constant industry profit is \$6 million which is distributed equally by both the firms, one firm can earn \$1million more profit (A total of \$4 million profits) only at the expense of the other firm (By letting the other firm earn \$1million less profits than before). Games of this nature, where the gains of one firm equal the losses of the other (so that total gains plus total losses sumup to zero), are called *zero-sum games*.

A game in which one player could get only at the expense of the other, hence, the sum of payoffs from each pair of strategies by both the players is added up to a certain constant, is called a zero-sum-game.

😊 *Check your progress 1*

It has come to be customary that the solution in Cournot and Bertrand model are determined in game theoretic approach. In both duopoly models, identify the basic elements of a game?

3.3. MAXIMIN AND MINIMAX STRATEGIES

Let us suppose that three strategies: A_1, A_2, A_3 are open to A, and three strategies: B_1, B_2, B_3 , are open to B. The payoffs to each player as a result of various combinations of strategies open to them are given in the following payoffs.

Table-3.2: A's payoffs

		<u>B's strategies</u>			<u>Row minima</u>
		<u>B_1</u>	<u>B_2</u>	<u>B_3</u>	
A's strategies	A_1	2	8	1	3
	A_2	4	3	9	3
	A_3	5	6	7	5
Column maxima		5	8	9	

The above game represented in the payoff matrix is a constant sum game.(A's and B's profits always added up to \$10).

If A adopts strategy A_1 and B adopts strategy B_1 the profits to A will be \$2 and that of B will be \$8 (\$10-\$2). Suppose A has to choose his strategy first. A will choose his strategy keeping in mind that B will adopt the most unfavorable strategy for him, that is, B will play that strategy which will provide minimum possible share of profits to A.

If A decides to choose strategy A_1 , then B can either choose strategy B_1, B_2, B_3 . Given that A chooses strategy A_1 , B is better-off by choosing strategy B_3 , that is, strategy B_3 is that strategy which minimizes A's profits (hence, it is a strategy which minimizes B's profits). Likewise, if A chooses strategy A_2 , then B will choose strategy B_2 , and if A chooses to play A_3 , B will play B_1 , because these are strategies which maximize B's profits (minimize A's profit) given what A is doing.

If we suppose that B has to select his strategy first, in the same analysis we can see that, if B chooses strategy B_1 , then A will adopt strategy A_3 because A_3 is a strategy which maximizes A's profits (minimizes B's profit) given that B is playing B_1 . In the same way, A_1 and A_2 will be strategies played by A if B chooses to play B_2 and B_3 , respectively.

The best course of action for B will be to choose minimum of the column maxima, since by doing so he will ensure minimum possible profits to A and hence maximum possible profits to him. Thus, given this situation as depicted in the above payoff table, B will select strategy B_1 which provides \$5 to A which is minimum of the column maxima. It follows therefore that B will follow a minimax strategy. Similarly, A will look at the row minima of his payoff matrix and will select maximum of the row minima. Hence, A will follow a maximin strategy.

3.4. NASH EQUILIBRIUM

Dominant strategy equilibriums do not happen all the time. Sometimes the optimal choice of one player depends on what it thinks the other player does will do. A set of strategies is a Nash equilibrium if A's choice is optimal, given B's choice; and B's choice is optimal given A's choice. Note that neither party knows what the other will do when it has to make its own choice of strategy. But each player may have some expectation about what the other player's choice will be.

Nash Equilibrium (named after John Forbes Nash, who proposed it) is a set of strategies, one for each player, such that each player's strategy is a best response to others' strategy. The best strategy is that strategy which optimizes a player's payoff given others' strategies. There is no incentive to unilaterally change a strategy by a player as every player is playing a best strategy. The Nash Non-cooperative Equilibrium of a game is a set of actions for all players that, when played simultaneously, have the property that no player can improve his or her payoff by playing a different action. Each player maximizes his or her payoff under the assumption that all other players will do likewise.

The concept of Nash equilibrium relies heavily on individual rationality. Each player's choice of strategy depends not only on its own rationality, but also on that of its opponent, which is a limitation.

Stated simply, Beti and Belay are in Nash equilibrium if Beti is making the best decision she can, taking into account Belay's decision, and Belay is making the best decision he can, taking into account Beti's decision. Likewise, many players are in Nash equilibrium if each one is making the best decision that they can, taking into account the decisions of the others. However, Nash equilibrium does not necessarily mean the best cumulative payoff for all the players involved; in many cases all the players might improve their payoffs if they could somehow agree on strategies different from the Nash equilibrium (example, competing businessmen forming a cartel in order to increase their profits).

Nash equilibrium is a pair of expectations about each player's choice such that, when the other player's choice is revealed, neither individual player wants to change its behavior. It is a generalization of the Cournot equilibrium (chapter-2) where the choices were output levels, and each firm chose its output level taking the other firm's choice as being fixed. Each firm was supposed to do the best for itself, assuming that the other firm continued to produce the output levels it has chosen – that is, it continued to play the strategy it had chosen and a Cournot equilibrium occurs when each firm is maximizing profits given the other firm's output. A game may have no Nash equilibrium, may have one Nash equilibrium, or it can have multiple Nash equilibria.

3.4.1. A Game with No Nash Equilibrium

Let us assume that there are two firms; Firm A and Firm B, in the market producing and selling the same product. The strategy adopted by either firm will have an impact on the demand, hence on the profits of the other firm. Firm A has two strategic choices: Fight and Accommodate, and Firm B has two strategies: Advertise and don't advertise. The payoff for each firm from the pair of strategies by each firm is given in the following table.

Table- 3.3: Payoff Matrix for Firm A and Firm B.

		Firm B	
		Advertise	Do not advertise
Firm A	Fight	(5, 4)	(4, 1)
	Accommodate	(7, 3)	(3, 4)

If Firm A plays 'fight', Firm B is better off by playing 'advertise', but if Firm B is playing 'advertise', Firm A is better off by playing 'accommodate'. Hence, {advertise, accommodate} is not a Nash equilibrium. If Firm B is playing 'do not advertise', the best strategy for Firm A is to play 'fight', but 'do not advertise' is not the best response for Firm B if Firm A plays 'fight'. Hence, {fight, do not advertise} is not a Nash equilibrium.

A similar calculation of all the other payoffs of a pair of strategies reveals no Nash equilibrium. Generally in this game there is no Nash equilibrium, in the sense that there is no set of strategies by each firm which imply one firm is better off given what the other is doing and vice versa.

3.4.2. Game with One Nash Equilibrium

If we assume two firms: A and B, A with the strategies ‘advertise’ and ‘don’t advertise’ and B with the strategies ‘expand production’ and ‘cut production’. The payoffs for each player are given in the following table.

Tale-3.4: Payoff matrix for Firm A and Firm B

		Firm B	
		Expand Production	Cut Production
Firm A	Advertise	(2, 1)	(0, 0)
	Do not advertise	(0, 0)	(-1, 2)

In the above table, the strategy (Advertise, expand production) is a Nash equilibrium. If A chooses to advertise, then the best thing for B to do is expand production, since the payoff to B from choosing Expand production is 1 and from choosing to cut production is 0; and if B chooses to expand production then the optimal choice for a is to choose to advertise since then A will get a pay off of 2 rather than 0.

Thus if A chooses to advertise, the optimal choice for B is to expand production; and if B chooses to expand production, then the optimal choice for A is to advertise. So we have a Nash equilibrium, each firm is making the optimal choice given the other firm’s choice.

3.4.3. A GAME WITH MULTIPLE NASH EQUILIBRIA

Assume there are two cola companies, Pepsi and Coke, that each owns a vending machine. Each must decide how stock its machine. They can fill the machine with diet soda or regular soda. The payoffs are presented in the following table.

Table-3.5: Payoff matrix for Coke and Pepsi

		Coke	
		Diet	Regular
Pepsi	Diet	(25, 25)	(50, 30)
	Regular	(30, 50)	(15, 15)

There is no dominant strategy for either Pepsi or Coke. In this game you can use ‘best response’ to find that there are two Nash equilibria.

Playing ‘regular’ is the best response for Pepsi when Coke plays ‘diet’, and the best response for Coke is to play ‘diet’ if Pepsi plays ‘regular’. Hence, the set of strategies {diet, regular}, where Pepsi plays ‘diet’ and Coke plays ‘regular’ is the Nash equilibrium. In similar way we can also find that the set of strategies {regular, diet} where Pepsi plays ‘regular’ and Coke plays ‘diet’ is another Nash equilibrium for the same game.

In a net shell, there are two Nash equilibria in the above game. There are two features of the two Nash equilibria

- The total payoff is no greater for any other strategy pairs
- The total payoff is the same for both equilibria.

Without some coordination between the players, this game could end in a disaster. Suppose Coke decides that they will leave it to Pepsi to play ‘regular’ and chooses ‘diet’ for itself. It is reasonable for us to conjecture that Pepsi plays the same way. In which

case they both end up with playing ‘diet’ and the outcome is worse for both of them than either of the Nash equilibria.

Alternatively suppose that Coke is in a magnanimous mood and decides they will play ‘regular’, believing that greedy Pepsi will surely play ‘diet’ and the result will be a Nash equilibrium rather than one of the other less desirable outcomes. But, again, it is reasonable for us to think that Pepsi is going through the same reasoning process and chooses to play ‘regular’. Now they have earned the worst payoffs of the game.

Both players may end up with worse outcomes than the Nash equilibrium because of ‘coordination problem’. If we keep in our mind that it is illegal for them to collude, what mechanism can be used to coordinate the strategies of the two players? One way economists seek solutions for coordination problem is through restriction of the assumptions that would rule out the multiple equilibria. This can be done by looking at the number of times the game is to be played. (This is discussed later)

😊 *Check your progress 2*

Firm 1 and Firm 2 are automobile producers. Each firm has the option of producing either a big car or a small car. The payoffs to each firm as a result of all the possible combination of strategies is given in the following table.

Table-3.6: Payoff matrix for Firm 1 and firm 2

		Firm 2	
		Big car	Small car
Firm 1	Big car	$\pi_1=400$ $\pi_2=400$	$\pi_1=1000$ $\pi_2=800$
	Small car	$\pi_1=800$ $\pi_2=1000$	$\pi_1=500$ $\pi_2=500$

Note: Note: π_i stands for million dollar profit of the i^{th} firm.

- A. Does either firm have a dominant strategy?
- B. There are two Nash equilibria for this game, what are they?

3.5. MIXED STRATEGIES

In all the games that we examined so far, we considered pure strategies- strategies in which a player makes a specific choice or take a specific action (choosing a strategy once and for all). Some times players may randomize their strategies – to assign a probability to each choice and play according to these strategies. This kind of strategy is called mixed strategy. It is defines as a strategy in which a player makes a random choice among two or more possible actions, based on a set of chosen probabilities. Nash equilibrium in mixed strategies refers to an equilibrium in which each agent chooses the optimal frequency with which to play his strategies given the frequency choices of the other agent. A mixed strategy is one in which a player plays his available pure strategies with certain probabilities. Mixed strategies are best understood in the context of repeated games, where each player’s aim is to keep the other player (s) guessing. If each player in the game has a finite member of pure strategies then there exists at least one Nash equilibrium in (possibly) mixed strategies. However, it is possible for pure strategy and mixed strategy Nash equilibrium to coexist. Pure strategies can be understood as special cases of mixed strategies, where the probabilities with which each player plays to be chosen from $\{0, 1\}$.

Table-3.7: Payoff for Firm A and B in Mixed strategies

		Firm B	
		Advertise (25%)	Price incentive (75%)
Firm A	Sales promotion (50%)	(0, 0)	(0, -1)
	Deliver cargo via port (50%)	(1, 0)	(-1, 3)

If Firm A assigns a probability of 50% of the time to make sales promotion and B choose to advertise for 25% of the time. Therefore, their expected pay offs (in terms of customers attraction, in thousands) will be zero $[(0.25)(0.5)(0) + (0.5)(0.75)(0)]$ from making sales promotion and $-0.25 [(0.5)(0.25)(1) + (0.75)(0.5)(-1)]$ from delivering cargo transport for Firm A; and that of Firm B from advertising equals zero $[(0.25)(0.5)(0) + (0.25)(0.5)(0)]$ and $0.75 [(0.75)(0.5)(-1) + (0.75)(0.5)(3)]$ from offering price incentives to customers. This implies that the Nash equilibrium is for Firms A is to make sales promotion and Firm B to provide price incentives to customers. The mixed strategy Nash equilibrium is Sales promotion, Offer price incentive with expected payoff of 0, 0.75.

One reason to consider mixed strategies is that some games do not have any Nash equilibrium in pure strategies. It can be shown that once we allow for mixed strategies, every game has at least one Nash equilibrium.

😊 **Check your progress 3**

Let 0.5 be the probability that firm A chooses a strategy Advertise and 0.5 is the probability that firm A chooses is to cut price. If 0.4 and 0.6 are the probabilities that Firm B (firm A's rival firm) chooses to Advertise and Expand production, respectively, find the mixed strategy Nash equilibria. The payoff to each firm from all possible combination of strategies is given in the following payoff matrix.

Table-3.8: Payoff matrix of Firm A and Firm B in mixed strategies

		Firm B	
		Advertise (40%)	Expand Production (0.6)
Firm A	Advertise (50%)	(50, 50)	(50, 80)
	Cut price (50%)	(90, 10)	(20, 80)

3.6. THE PRISONERS' DILEMMA

The original discussion of the game considers a situation where two prisoners who were partner in a crime were being questioned in separate rooms. Each partner had a choice of confessing to the crime, and thereby implicating the other, or denying that he had participated in the crime. If any one prisoner confessed, then he would go free, and the authorities would throw the book at the other prisoner, requiring him to spend six months in prison. If both prisoners denied being involved, then both would be held for one month on a technicality; and if both prisoners confessed they will both be held for 3 months. Suppose the payoffs indicated in the matrix represent the utilities that the prisoners attached to the various prison terms.

Table-3.9: Payoff matrix of prisoners

		Player B	
		Confess	Deny
Player A	Confess	(-3, -3)	(0, -6)
	Deny	(-6, 0)	(-1, -1)

In the above table, put yourself in A's position, if B decides to deny committing the crime, then you are certainly better off confessing, since then you will get off free. Similarly, if B confesses, then you will be better off confessing, since then you get a sentence of 3 months rather than a sentence of 6 months. Thus, whatever B chooses A is better off confessing. The same thing goes for B, he is better off confessing. Thus the unique Nash equilibrium for this game is for both players to confess (It is also dominant strategy equilibrium).

The strategy (deny, deny) is efficient for there is no other strategy choice that makes both players better off, while the strategy (confess, confess) – the Nash equilibrium – is

inefficient. The problem is that there is no way for the two prisoners to co-ordinate their actions.

The prisoner's dilemma applies to a wide range of economic and political phenomena. The problem of cheating in a cartel agreement for market sharing is taken as an example of prisoners' game in economic phenomenon. If you think the other firm is going to stick to its share, it will pay you to produce more than your own share. And if you think that the other firm will over produce, then you might as well too!

The prisoner's dilemma has provoked a lot of controversy as to what is the 'correct' way to play the game – or more precisely, what is a reasonable way to play the game. The answer seems to depend on whether you are playing a one-shot game or whether the game is to be repeated an indefinite number of times. If the game is going to be played just one time, the strategy of defeating – in the above example confessing - seems to be a reasonable one. After all, what ever the other fellow does you are better off, and you have no way of influencing the other prisoner's behavior. What if the game is repeated?

Check your progress 4

1. The prisoners' dilemma game is also applicable in collusive oligopoly, especially for a cartel aiming at market sharing. Instead of the two prisoners, in this case, we have two firms, let Firm A and B, which have entered in to a cartel agreement fixed the price and output each has to produce and sell. The choice problem facing each member firm of the cartel is whether to cooperate and abide by the agreement and, thus, sharing the monopoly profits; or to cheat the other and try to make higher individual profits. If both firms cheat at the same time, price will fall to competitive level pushing profit down. The payoff matrix for two member firms of the cartel from all the possible combination of strategies is presented as below.

Table-3.10: Payoffs to Cartel members

		Firm B	
		Cheat	Cooperate
Firm A	Cheat	(5, 5)	(25, 2)
	Cooperate	(2, 25)	(15, 15)

- What outcome, if any is Nash equilibrium? Does the game either firm has a dominant strategy?
- Is the Nash equilibrium best outcome for the firms? If not, which strategic combination results in better outcome than the Nash equilibrium? Why do they fail to achieve the later outcome?
- Comment on the stability of the cartel.

3.7. REPEATED GAMES

In the above section the players met only once and played the prisoner's dilemma game a single time. However, the situation is different if the game is to be played repeatedly by the same player. In this case there are new strategic possibilities open to each player. If the other player chooses to defeat on one round, then you can choose to defeat on the next round. Thus, your opponent can be 'punished' for 'bad' behavior. In a repeated game, each player has the opportunity to establish a reputation for cooperation and thereby encourage the other player to do the same.

Whether this kind of strategy will be viable depends on whether the game is going to be played a fixed number of times or an indefinite number of times. That is, if the game is going to be played a fixed number of times or an indefinite number of times.

If a game has a known, fixed number of rounds (say 10) then each player will defeat on every round because if there is no way to enforce cooperation on the last round (10th round), there will be no way to enforce cooperation on the next to the last round (9th

round), and so on. Players cooperate because they hope that cooperation will induce further cooperation in the future. But this requires that there will always be the possibility of future play. In a repeated game with fixed number of rounds, since there is no possibility of future play in the last round, no one will cooperate then. But then why should any one cooperate on the next to the last round, or the one before that? And so it goes – the cooperative solution ‘unravels’ (collapse) from the end in a prisoner’s dilemma with a known, fixed number of rounds.

On the other hand, if a game is going to be repeated an indefinite number of times, a player has a way of influencing other player’s behavior. If the opponent refuses to cooperate this time, you can refuse to cooperate next time. As long as both players care enough about future pay offs, the threat of non-cooperation in the future may be sufficient to convince players to choose the optimal strategy. Therefore, the winning strategy – the one with the highest over all pay offs – is the ‘tit for that’, that is do whatever the other player did in the last round. This strategy does very well because it offers an immediate punishment for defection. It is also a forgiving strategy for it punishes the other player only once for each defection- that is, if the opponent falls into line and starts to cooperate, then the strategy will reward the other player with cooperation.

3.7.1. Tit-for-tat Game

Tit for tat is a highly effective strategy in game theory for the iterated prisoner's dilemma. Based on the English saying meaning "equivalent retaliation" ("tit for tat"), an agent using this strategy will initially cooperate, and then respond in kind to an opponent's previous action. If the opponent previously was cooperative, the agent is cooperative. If not, the agent is not.

This strategy is dependent on four conditions that have allowed it to become the most prevalent strategy for the prisoner's dilemma:

- Unless provoked, the agent will always cooperate
- If provoked, the agent will retaliate
- The agent is quick to forgive
- The agent must have a good chance of competing against the opponent more than once

If a game is to be played for a fixed number of times (rounds), there is no chance to retaliate a rival who defects on the last round of the game. When a prisoners' dilemma game confronts with parties who will interact only once, this game will turn out to be very difficult to achieve. But when the participants expect to interact repeatedly in the future, new possibilities emerge. When a game is to be played repeatedly there may be a chance to retaliate defectors by adopting a simple strategy that may prove to be remarkably effective at keeping potential defectors in check. The strategy is called tit-for-tat and works as follows.

The first time interact with someone, you cooperate. In each subsequent interaction you simply do what the person did in the previous interaction. Thus, if your partner defected on your first interaction you would then defect on your next interaction with him. If he then cooperates, your move next time will be to cooperate as well.

By tit-for-tat strategy, it is meant that 'do whatever your rival does on the last round.'

This strategy (tit-for-tat) holds in a game wherein players move simultaneously (or play strategies at the same time). Each player had to choose his strategy knowing only the incentives facing his opponent, not the actual choice of strategy.

3.8. SEQUENTIAL GAMES

In simultaneous move game, a player has to choose his strategies without knowing the actual strategic choice by his rival. But in many games, one player moves first, and the other is then be able to choose his strategy with full knowledge of the first player's choice. In a sequential game, the key is to think through the possible actions and rational reaction of each player. It is easier to visualize sequential games by representing the

possible moves in the form of decision tree - this representation is called the extensive form of a game. Table 3.11 shows the payoff matrix and its extensive form presentation for a sequential game. In sequential games follow the rule that “Look forward, reason back”

Table-3.11: Payoffs to the incumbent and entrant firms

		<u>Incumbent Firm</u>	
		<u>Fight</u>	<u>Do not fight</u>
Potential Entrant	Enter	(0, 0)	(2, 1)
	Stay out	(1, 9)	(1, 9)

When the game is presented in this form it has two Nash equilibria: (stay out, fight) and (enter, don't fight). However, we can see from the extensive form presentation in the following table that one of these equilibria is not really reasonable because the payoff matrix hides the fact that one player/ firm gets to know what the other player/ firm has chosen before it makes its choice. In this case, it is more useful to consider a diagram that illustrates the asymmetric nature of the game.

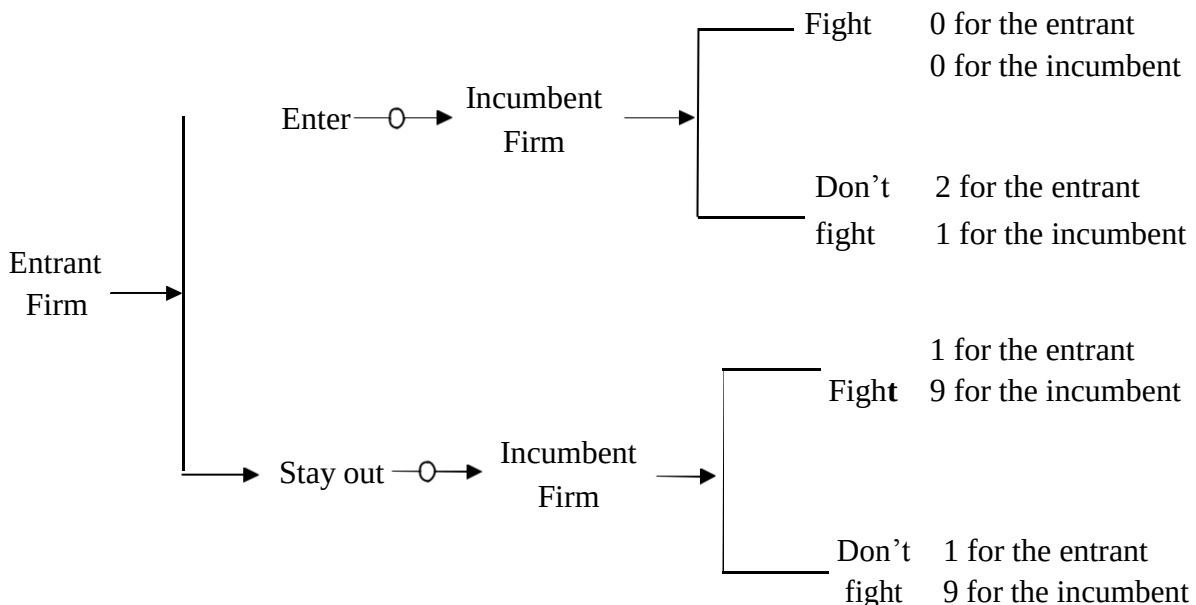


Fig 1: An Extensive Form Presentation of a Game – Game Tree Diagram

An extensive form of the game indicates the order in which the players move. Given this, the best way to analyze the game is to go to the end and work backward. Suppose that the entrant firm has already made his choice and we are sitting on one branch of the game tree. If the entrant firm chooses to stay out, then it doesn't matter what the incumbent firm does, and the payoff is (1, 9). If the entrant firm has chosen to enter, then the sensible thing for the incumbent firm to do is to choose not to fight and the pay off is (2, 1).

Now think about the entrant's initial choice. If it chooses to stay out, the outcome will be (1, 9) and thus it will get a pay off of 1. But, if it chooses to enter, it will get a pay off of 2. So the sensible thing for the entrant firm to do is to choose to enter. Thus, the equilibrium choice in the game will be (enter, don't fight), so that the pay offs to the entrant and incumbent firms will be 2 and 1, respectively.

Therefore the strategies (stay out, fight) are not a reasonable equilibrium in this sequential game, that is they are not an equilibrium given in which the firm actually get to make their choices. From the incumbent firm's point of view, however, this is unfortunate. What might it do about it?

The incumbent firm can threaten to play 'fight' if the entrant firm chooses 'enter' and force the entrant firm to choose to stay out and have pay off of 1 rather than 0 with the strategy (enter, fight). The question is the credibility of this threat.

3.9. SUMMARY

Game theory provides an important way of examining various issues (economic, political, social, etc.) which involve strategic interaction. A game theoretic approach is important to assess equilibrium in Bertrand and Cournot models. Any game has four components: players, rules, strategies and payoffs.

A player pursues a pure strategy if he always chooses the same strategic action out of all the strategic action choices available to him in every round. A mixed strategic game is

one in which a player randomizes the choice of strategies. In a pure strategy game, a player may have one optimal strategy to be adopted regardless of what the other player (s) is doing. This strategy is called a dominant strategy. If players in a game have no dominant strategy they may or may not have Nash equilibrium. In a pure strategy game there may be no or one or multiple Nash equilibria. But in mixed strategies a game will have at least one Nash equilibrium.

Nash equilibrium is a set of strategies in which each player is playing the strategy that is a best response to the strategy of the other players. No player has an incentive to change his strategy given the strategy choices of the others. Nash equilibrium does not necessarily result in the best possible outcome. Lack of coordination by players, sometimes, leads them to Nash equilibrium which results in a worse outcome than some other combination of strategies. Such a game prevails in collusive oligopolies where self interest rather than group (industry) interest leads each firm to experience worse outcome. Such a game is called prisoners' dilemma.

In some type of games players have the chance to see the strategic choices of other players before choosing their strategies. If a game is to be played for a fixed number of rounds, the last round game will be like a one shoot game. Since players expect no further cooperation they have no inducement to cooperate on the last round. But if a game is going to be repeated an indefinite number of times, a player has a way of influencing other player's behavior on further rounds, which might lead the players to cooperation.

A tit-for-tat strategy is meaning that do whatever your rival does on the last round.' It is used to explain the situation during the Cold War. In simultaneous move game, a player has to choose his strategies without knowing the actual strategic choice by his rival. But in a sequential game, one player moves first, and the other is then be able to choose his strategy with full knowledge of the first player's choice. There will be a first move advantage in sequential games. The determination of equilibrium strategy in a sequential game requires thinking forward and reasoning back.

CHAPTER REVIEW EXERCISE

1. The following table presents two firms: Firm 1 and Firm 2, and the payoffs for each from all possible combination of strategies.

Table-3.12: Payoffs to each firm from all the possible combination of strategies

		Firm 2	
		High research budget	Low research budget
Firm 1	High research budget	$\pi_1=200$ $\pi_2=40$	$\pi_1=0$ $\pi_2=30$
	Low research budget	$\pi_1=60$ $\pi_2=100$	$\pi_1=40$ $\pi_2=80$

Note: π_i stands for million dollar profit of the i^{th} firm.

- A. Does either firm have a dominant strategy?
- B. Does the game have Nash equilibrium?

2. Market Entry Game

Two firms, MD and BK must decide whether to put one of their restaurants in a shopping mall the strategies available for them are to enter or Don't Enter If either firm plays Don't Enter it earns profits. If one firm plays enter and the other plays Do not enter, the firm that plays enter earns 300,000 in profits (Don't Enter always yields 0 profits). If both firms choose to play enter both lose \$ 100,000 since there is no enough demand for two restaurants to make positive profits. If both firms choose to play enter with a probability of 0.50

- A. Draw the payoff matrix with all payoffs to each firm, determine and all the pure strategy Nash Equilibria.
- B. Calculate the expected payoffs, and find mixed strategy Nash equilibrium.

- C. If the payoff matrix is changed because MD earns a profit of \$400,000 if MD is the sole entrant rather than \$300,000, would there be a change in your answers under A and B?
3. Suppose the former USSR was considering whether to launch a nuclear strike against the US. The USSR has two alternatives: attacking or not attacking the US. The US, too, has the same two alternative strategic choices against USSR. The payoffs from the game accruing to each are given in the following payoff matrix.

Table 3.13: Payoff matrix of The US and USSR

		US	
		Launch Missiles	Do not launch
USSR	Launch missiles	(-500, -100)	(100, -50)
	Do not launch	(-50, -50)	(0, 0)

- A. Determine the Nash equilibrium and explain how it can be used to the Cold War.
- B. If USSR is the first to move (assuming the game to be sequential), explain, with the help of a game tree diagram, what the equilibrium strategy be?
4. Consider the following scenario. There are two firms (A and B). A decides whether or not to enter the market. B decides what price to set. The resulting payoffs are as follows:
- If B plays P1 and A Enters: B gets 2 units, A gets -1 unit.
- If B plays P1 and A Stays Out: B gets 3 units, A gets 0 units.
- If B plays P2 and A Enters: B gets 3 units, A gets 2 units.
- If B plays P2 and A Stays Out: B gets 6 units, A gets 0 units.
- A. Prepare a payoff matrix which can represent the game.
- B. Find all Nash Equilibria for this game.

5. Imagine a product choice problem – cereal manufacturer first, a simultaneous game.

Table-3.14: Payoffs to each firm

		Firm 2	
		Crispy	Sweet
Firm 1	Crispy	(-5, -5)	(10, 20)
	Sweet	(20, 10)	(-5, -5)

- A. What is the pure strategy Nash equilibrium of the game?
- B. Now, imagine a sequential game, with Firm 1 moving first. Using a game tree diagram determine Nash equilibrium. Why does one of the pure strategy Nash equilibrium not equilibrium in this case?

Chapter Four

FACTOR PRICING AND INCOME DISTRIBUTION

4.1 INTRODUCTION

What are the determinants of income distribution in an economy? Ownership of resources and their prices are major determinant of money income. They also determine allocation of resources to various uses and firms. In this chapter, we examine how prices of productive resources are determined. The economy's income is distributed in the markets for the factors of production. The four factors of production are labor, capital, land and entrepreneurship. These factors of production are, respectively, compensated with, wage, interest, and profit. Such income distribution between the factors of production is called functional income distribution; and the theory of factor prices is popularly known as the theory of distribution.

How much the factors receive depends on the demand for them, which is derived demand that comes from firms that use the factors to produce goods and services. Competitive, profit maximizing firms hire each factor up to point at which the value of the marginal product of the factor equals its price. The price paid to each factor adjusts to balance the supply and demand for the factor. Because factor demand reflects the value of the marginal product of that factor, in equilibrium each factor is compensated according to its marginal contribution to the production of goods and services and hence revenue.

In this chapter, we analyze factor demand by considering how a competitive, profit maximizing firm decides how much of any factor to buy. We begin our analysis by examining the demand for labor, which is the most important factor of production. In modern economies, workers receive most of the national income, which makes labor the most important factor of production. Later, we introduce the supply side and analyze the wage and employment determination under different market conditions. Once we assure comprehensive understanding of the principles governing labor, we will make applications of the lessons learnt therein to the market for other factors of production. Finally we analyze income distribution with emphasis on factor substitution and technical progress.

Chapter Objectives

At the end of this chapter, you should be able to:

- Analyze the labor demand under perfect and imperfect product and labor markets
- Learn why equilibrium wages equal the value of the marginal product of labor
- Derive and identify the short run and long run demand for labor
- Consider how the other factors of production-land and capital are compensated.
- Examine the determinants of distributive income share of factors

Chapter Outline

4.1 Introduction

4.2 Demand of a Firm For Factors of Production

4.2.1 Optimum Input Employment with One Variable Input

4.2.2 Optimum Input Employment with Two Variable Inputs

4.3 Competitive Industry Demand for Labor

4.4 Supply of Factors of Production

4.4.1 Short Run Individual labor Supply

4.4.2 Aggregate and Long Run Labor supply

4.5 Factor Pricing under Perfect Competitive and Imperfect Markets

4.6 Income Distribution, Elasticity of Factor Substitution and Technological Progress

4.6.1 Marginal Productivity Theory of Income Distribution

4.6.2 Elasticity of Factor Substitution

4.6.3 Technological Progress

4.7 Chapter Summary

4.8 Activities for Review

4.2 DEMAND OF A FIRM FOR FACTORS OF PRODUCTION

Although in many ways factor markets resemble the goods markets you have analyzed in parts of your previous Module and the present one, they are different in one important way. That is the demand for a factor of production is a derived demand. A firm's demand for a factor of production is derived from its decision to supply a good in another market.

For example, *ceteris paribus*

- The demand for brick layer is closely tied to the demand for houses.
- The demand for apple pickers is derived from the demand for apple.

- To add an example form service, the demand for tourist guide is derived from the demand for the service.

4.2.1 Optimum Input Use with One Variable Input

We begin by reviewing production theory which was discussed in your Module Two of Microeconomics I, and then bridge you to the main parts of the chapter. Suppose that a firm uses labor (L) and capital (K) inputs and the production function is $TP = f(L, K)$. If we are not able to vary both input in the short run, the change in TP occurs due to change in the variable factor only. For instance, if capital is kept constant the production function becomes $TP = f(L, \bar{K})$. It can be recalled that, among the stages of production, the technically feasible level of employment of a variable input is the range where its marginal productivity is positive and the average productivity is falling. Since information conferred by MP_L (along with relative prices of inputs) is crucial for profit maximizing firms, we give it equally important weight in deriving demand for labor. Now important questions come to be: can we get useful information from a production function in order to derive demand for labor? If so how? In order to answer this question we first mathematically present the relationship between demand for labor and MP_L . Then we depict the relationships with the use of graphs.

According to our marginal principle (which is clearly known so far) a profit maximizing firm optimizes at the equality of marginal revenue and marginal cost of an extra unit of product:

$$MC = MR$$

It can be recalled that MC is addition to total cost of a firm in producing a unit of extra output. Using an equation,

$$MC = \frac{TC}{Q}$$

Since dividing both the numerator and denominator in the right hand side by L does not change the equality, the above equation becomes:

$$MC = \frac{TC/L}{Q/L}$$

$TC/L = w$. This means, if the labor market is perfectly competitive and a firm employs labor at a given market wage, the change in total cost due to extra labor unit is just the wage rate.¹ The numerator of the above equation is clearly equal to marginal productivity of labor: $Q/L = MP_L$

Substituting and rearranging, we get:

$$MC = \frac{w}{MP_L}, \text{ meaning } \frac{w}{MP_L} \text{ gives the change in total cost per unit increase in output.}^2$$

Restating our initial points: to maximize profit, the firm must use the optimal or least-cost input combination to produce the best level of output. The best level of output for a perfectly competitive firm is the output at which, $MC = MR$

Thus it follows that to maximize profit,

$$\frac{w}{MP_L} = MC = MR.$$

By cross multiplication and rearranging the terms, we get:

$$w = MR \cdot MP_L \quad \text{Marginal Revenue Product of labor (MRP}_L\text{)}$$

if $P = MR$ (Perfectly competitive product market),

$$w = P \cdot MP_L \quad \text{Value of Marginal Product of labor (VMP}_L\text{)}$$

Therefore, MRP_L or VMP_L is the demand for labor.

¹ We will show later that marginal labor cost can be greater than the wage rate when the firm does have monopsony power in the labor market.

² Similarly, $\frac{r}{MP_K} = MC$

Dear Learner, we have just shown demand for labor is the **marginal revenue product in general**.

Give your own definition to marginal Revenue product of a resource in general.

(Hint: $MRP = MR' \quad MP = \frac{\Delta TR}{\Delta L}$)

.....

Answer: In general, **Marginal Revenue Product** of a resource is a measurement of the change in the firm's total revenue from selling the extra or marginal physical product that results from employing one additional unit of a resource together with other fixed resources

.

The profit maximizing rule is that

- The firm should hire until the marginal product of labor *times* the firm's marginal revenue or price of the commodity equals the wage rate.
- Similarly, the firm should rent capital until the marginal product of capital *times* the firm's marginal revenue or price of the product is equal to the rental price of capital.

To maximize profits, the same rule holds for all inputs that the firm uses.

Whereas the optimum is attained at the equality, the right hand side terms of the above equations represent the derived demand. Just focusing on labor, its demand is represented by *the change in the firm's total revenue from selling the extra or marginal physical product that results from employing one additional unit of labor together with other fixed resources*. This derived demand is commonly called *Marginal Revenue Product of labor* (MRP_L). In the case where the product market is perfectly competitive and $MR=P$, the demand for labor is called *Value of Marginal Product of labor* (VMP_L).

☺ **Check Your Progress 1**

A firm sells its product at a given price of \$10 per unit in a competitive market. In the first two columns of the table below, the short run technical relations between labor and output are given. Fill the remaining columns.

Labor (L)	Quantity Produced (Q)	MP_L	TR	VMP_L
0	0	-	-	-
1	100			
2	180			
3	240			
4	280			
5	300			

Alternatively way to derive Demand for Labor

Given capital, an the optimum level of labor is the level which maximizes profit, $\frac{\partial \pi}{\partial L} = 0$.

$$\pi = TR - TC$$

$$Q = Q(L, \bar{K})$$

$$TR = P(Q(L, \bar{K})) \cdot Q(L, \bar{K})$$

$$TC = wL + r\bar{K}$$

$$\pi = P(Q(L, \bar{K})) \cdot Q(L, \bar{K}) - [wL + r\bar{K}]$$

We initially begin with the assumption that w is function of L and P is function of Q . We will refine later where these are so or not.

The first order condition of the general function will be:

$$\frac{\partial \pi}{\partial L} = \frac{\partial}{\partial L} [P(Q(L, \bar{K})) \cdot Q(L, \bar{K})] - \frac{\partial}{\partial L} [w(L) \cdot L + r\bar{K}] = 0$$

$\frac{\partial TR}{\partial L} = MRP_L$
 $\frac{\partial TC}{\partial L} = MLC$

$$\frac{\partial \pi}{\partial L} = \frac{\partial P}{\partial Q} \frac{\partial Q}{\partial L} Q + P \frac{\partial Q}{\partial L} - \frac{\partial w}{\partial L} L - \frac{\partial}{\partial L} [wL] = 0$$

Rearranging and collecting identical terms,

$$\frac{\partial Q}{\partial P} = \frac{\partial Q}{\partial P} \cdot \frac{\partial P}{\partial W} + \frac{\partial Q}{\partial W} \quad \text{Notice that } \frac{\partial Q}{\partial P} \text{ is negative while } \frac{\partial Q}{\partial W} \text{ is positive}$$

$$\frac{\partial L}{\partial P} = \frac{\partial L}{\partial P} \cdot \frac{\partial P}{\partial W} + \frac{\partial L}{\partial W} \quad \frac{\partial Q}{\partial L} = \frac{\partial L}{\partial L} \quad \frac{\partial L}{\partial P}$$

(See Table 4.1 and 4.2 for more clarification).

From the equation, we do have

$$\frac{\partial Q}{\partial L} = MP_L \quad \text{and} \quad P - \left| \frac{\partial P}{\partial Q} \right| Q = MR$$

Generally, we will have equilibrium condition

$$\frac{\partial Q}{\partial L} = \frac{\partial Q}{\partial L} \cdot \frac{\partial P}{\partial W} + \frac{\partial Q}{\partial W} = \frac{\partial Q}{\partial L} \cdot \frac{\partial P}{\partial W} + \frac{\partial Q}{\partial W}$$

Marginal Revenue Product

Marginal Labor Cost

Demand for labor

The left hand side of the above equation represents demand for labor (Marginal Revenue Product). It can be written as:

$$MRP_L = p \left(1 - \frac{1}{e_p} \right) MP_L, \text{ where } e_p \text{ is price elasticity of the product demand.}$$

As $|e_p|$ rises, demand for labor becomes more elastic. At the extreme when $|e_p|$ is infinite (the firm's product demand is perfectly elastic), $\left(1 - \frac{1}{e_p} \right)$ becomes zero and the demand for labor becomes its Value of Marginal Product (VMP_L)

$$VMP_L = PMP_L$$

The interpretations of the foregoing mathematical treatments can be summarized in the table 4.1 and Figure 4.1. From our equations above do have also the marginal factor cost which stands for the supply side. However, for the sake of convenience in exposition, we will not treat the supply side until section 4.4 and 4.5. Therefore Table 4.1 and Figure 4.1 summarize only the demand side regardless of the equilibrium outcomes.

Short Run Demand for Labor

Fig 4.1. Derived Short Run Labor Demand Curves in with Perfect and Imperfect Product Market conditions.

On the vertical axis are VMP_L , MRP_L and w . As wage declines and more labor is demanded, the firm moves along the VMP_L or MRP_L .

Suppose that the market product demand for an industry of 100 identical, *perfectly*

$$\text{is}MP_L = 8 - 0.5L.$$

Determine the function of demand for labor of a perfectly competitive firm in this industry. (Graphical aid is useful)

4.2.2 Optimum Input Employment With Two Variable inputs

Suppose that a firm uses labor (L) and capital (K) inputs and the production function is $Q = f(L, K)$. The firm maximizes profit subject to a given outlay (B), $B = wL + rK$, where w is wage rate and r is rental price of capital. The least input combination of a firm will be

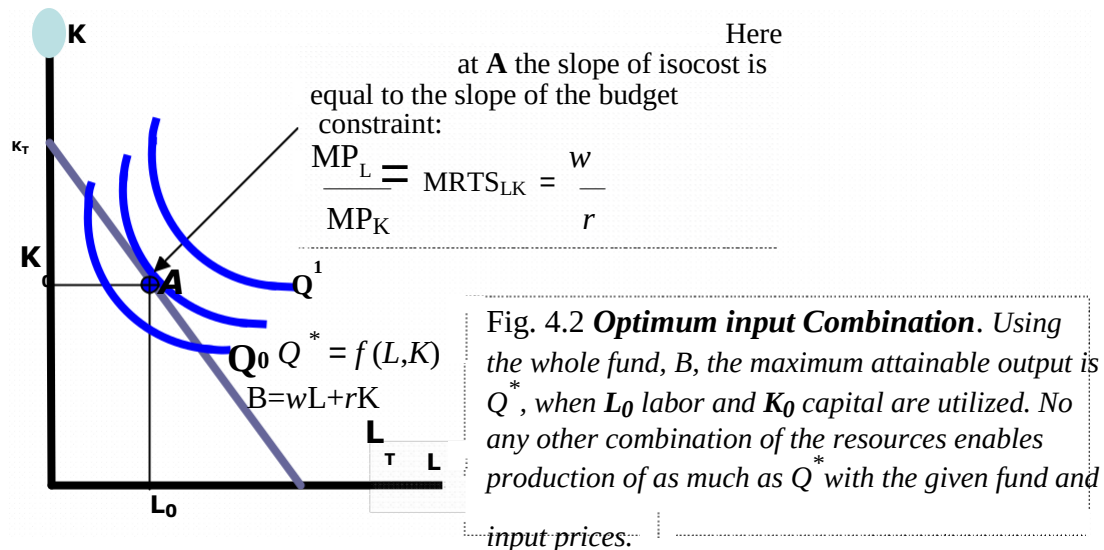
$$\frac{MP_L}{w} = \frac{MP_K}{r}$$

where MP refers to the marginal (physical) product.

The above equation indicates that to minimize production costs, the extra output or marginal product per dollar spent on labor must be equal to the marginal product per dollar spent on capital. Another way of expressing this is that at optimum resource utilization, the ratio of marginal productivities of the resources is equal to the ratio of their prices:

$$\frac{MP_L}{MP_K} = \frac{w}{r}$$

This is depicted in *Figure 4.2* by the use of isocost line and isocost curves.



Check Point ∞:

(i) If $MP_L=8$, $MP_K=10$ and wage rate and rental price of capital are equal, is it least cost combination? If not what could be done? |

The answer is clearly No! If $w=r$, the inequality becomes $\frac{MP_L (= 8)}{w} < \frac{MP_K (=10)}{r}$,

meaning the firm is getting more extra output for a dollar spent on capital than on labor. Remember that the factor prices are given. What the firm can do is changing the input combination. To minimize cost, therefore, the firm would have to hire more capital and less labor. As the firm does this, MP_K falls and MP_L increases (because of diminishing returns). The process would have to continue until equality is attained.

(ii) If $MP_L=8$, $MP_K=10$ and $w=4$ and $r=5$, is it least cost combination?

Now, the answer is **yes** it is least cost combination since $\frac{8}{4} = \frac{10}{5} = 2$. Meaning the firm is

getting equal extra output for a dollar spent on each factor.

©**Dear learner**, this exercise is meant to remind and reinforce what you have learnt in *Microeconomics I* and bridge you to the present.

Now, if relative price of the inputs changes and the firm varies both labor and capital, what will the demand for labor look like? In *section 4.2.1* we have assumed that as wage declines and more labor is demanded, the firm moves along the VMP_L or MRP_L . This assumption is valid in the short run because in drawing the demand curve of labor, the fixed cooperating factors in the production process such as capital are given and constant. Therefore, in searching answer for the preceding question, we build on the foregoing analysis of isocost-isoquant approach we have just made. Assume that both labor and capital are variable. Specifically speaking, we analyze how the optimum input combination changes. Then we trace these points of equilibria over various input relative prices. To do so, let us assume that the rental price of capital, r remains constant and

wage rate, w falls (and hence $\frac{w}{r}$ falls). Using Fig.4.3, the budget constraint rotates

outward with the center at K_T , the optimum being reached at higher isoquant where at least more of the cheaper input, labor will be employed.

Let's conceptualize the effect of relative input price change before we use our simple model. Intuitively, if wage falls while rental price of capital is kept constant, the firm can produce the previous level of output but by using more of the cheaper input-labor- and

less of the relatively expensive one-capital. In other words, less of the available fund can be used and the same level of output can be maintained, but with different combination of inputs. On the other hand, if the whole available fund is used, it is plausible to make further use of additional inputs (even including complementary capital input) and produce more. That is, in the long run a firm would make appropriate adjustment in the amount of capital employed when the amount of labor used changes in response to changes in wage rate. Considering that the two factors, labor and capital are complementary, the increase in the amount of labor used, when wage rate declines would lead the firm to adjust the quantity of capital (and other fixed factors) in the long run.

Let us make a long pause here and give you an activity.

Activity: Using your previous knowledge

In your *Microeconomics I, Theory of Consumer Demand* chapter, you were able to decompose the price effects into income and substitution effects. Recall of the case of two normal goods, X_1 and X_2 . Draw a graph where you have X_1 and X_2 , respectively, on the horizontal axis and vertical axis. Using well behaved indifference curves of a consumer and budget constraint, show an optimum combinations of the good. Later, assume price of X_1 falls while that of X_2 remains unchanged. Show the new equilibrium and decompose the price effects into substitution and income effects. Remember that you are doing this for two normal goods. (You can refer to Fig. 2.27 on page 64 of Module I of Microeconomics I).

Well, now use this analogy for complementary (also substitute to some degree) labor and capital inputs, where you now use **isocosts** instead of the consumer budget constraints, **isoquants** instead of indifference curves, and fall in price of labor instead of that of commodity X_1 .

If you have properly done this, the movement on the isoquant curve is, indeed analogously, the **substitution effect**. The other effect on both of these inputs is the **output effect**, which is positive alike the income effect in your previous example. What is left? There is even further effect which we will see together.

Switching to Fig. 4.3, Panel (a), the firm was initially at *point A*, producing Q_0 by employing L_0 and K_0 . Due the wage decline, the new equilibrium will be at *C*, where Q_2 is produced by optimum utilization of L_2 and K_2 units of the inputs. In decomposing this wage decline effect we will have the following components.

1. *Price effect: A to B*
 - *Substitution effect: A to B'*
 - *Output effect: B' to B*
2. *Profit maximization effect: B to C.*

1. Price effect. Consider 4.3 Panel (A), the fall in price of labor (w) results in flatter isocost, showing the decline in relative price. If we conceive, however, that the firm is made produce only the previous level, Q_0 , at the new input relative prices, the movement will be from *A* to *B*. this is ***Substitution effect***. That is, some of labor whose price has fallen substitutes capital. If so, unambiguously more of the former and less of the latter will be used to produce as much as what had been produced before.³ When the output is kept constant with the new prices, the total outlay will not be fully used. If the firm uses full of it, more of both inputs will be employed to produce more generating **Output Effect**, which is the movement from *B'* to *B* in the figure.

³ You are advised to analogously use the concept of compensated budget line in your Module One of Microeconomics I, section 2.6 page 64.

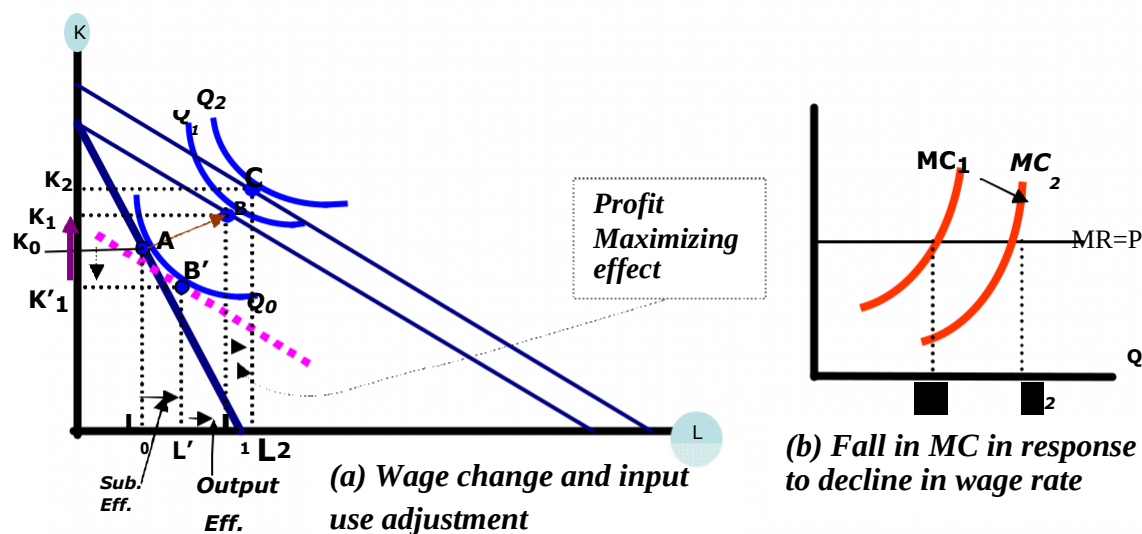


Fig.4.3 Price and Profit Maximization Effects (i) A to B' is Substitution effect. Relative input price change has resulted in input substitution. That is, labor whose price has fallen substitutes capital and movement is along the same isoquant (ii) B' to B is Output effect. where more of both inputs are employed to produce more by using the whole fund. (iii) B to C is Profit Maximizing effect, where even additional fund can be used to maximize profit by producing Q_2 in response to fall in MC (panel b)

2.Profit Maximizing effect. It can be recalled that the profit maximizing point for firm is the level of output where $MC=MR$. When wage declines, total cost and unit costs will be less at a given level of output. Hence, profit maximizing levels of output and employment will be greater (see Panel (B) in Fig. 4.3) If greater fund is used and profit is to be maximized, Q_2 will be produced instead of Q_1 . The effect on both factors will be positive.

So far we have discussed how adjustment of the inputs utilization is made in the long run in response to relative price change. The next step is deriving the demand for a factor (labor in our example). Considering labor, whose price is assumed to change and using the foregoing discussion, we will derive the firm's long run demand for labor.

The adjustments in capital, we have seen above, make it appealing that in the long run decline in wage will cause only movement on the short run demand curve depicted in Fig. 4.1. Rather, the demand curve becomes more elastic in the long run. Before we show this,

let us briefly revise the production theory of our previous Module I using Fig. 4.4.

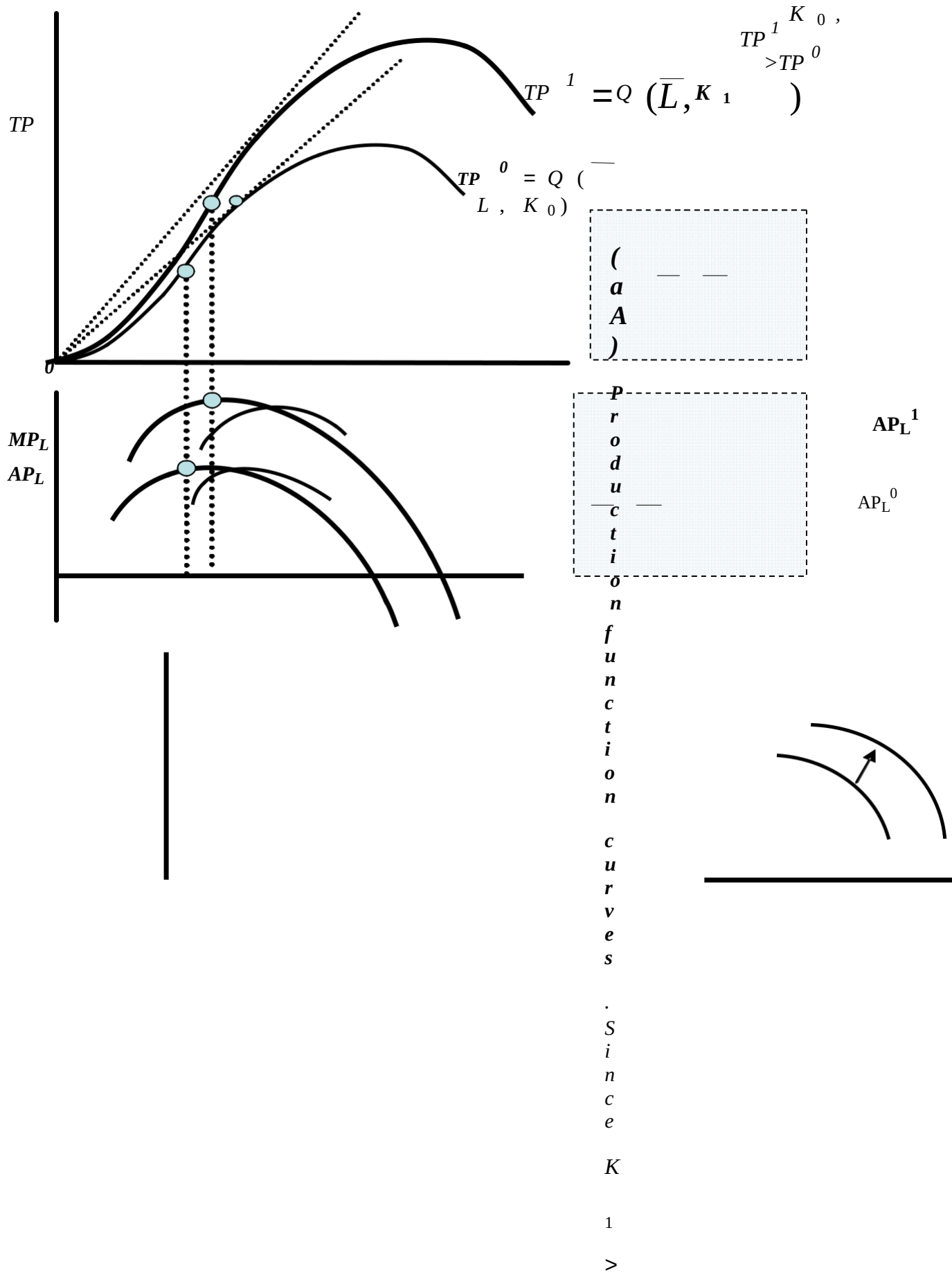


Fig. 4.4 Production Function, Change in Capital and Demand for Labor: MP_L of labor is the change in TP (Total Product) as a result of an extra unit of labor input. The relevant portion of MP_L is the positive range beyond the maximum of AP_L (that is technically feasible part of the production function). The product of MP_L over relevant portion and product price, P gives demand for labor (called Value of Marginal Product, VMP) curve. Given product demand, rise in labor productivity due to higher level of capital, leads to higher demand for labor. This is depicted in the figure where the shifts in TP in **Panel (a)** and unit product curves in **panel (b)** are followed by shift in the Value of Marginal Product curve in the same direction (**panel (c)**).

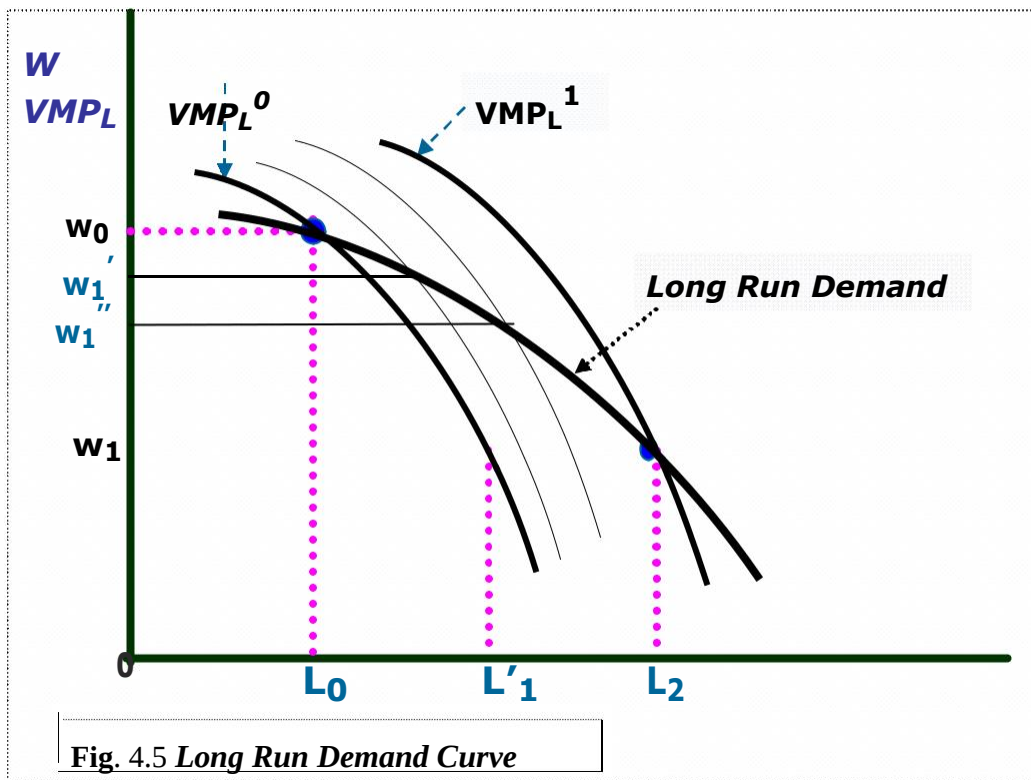
Consider the three panels in Fig. 4.4, in which we do have (a) total product curve and (b) unit products curves followed by (c) demand for labor curves. Initially, the firm was employing fixed capital, $\bar{K}_0$ and the total product curve corresponding to this level of capital with variable labor is TP^0 . However, if the firm gets appropriate adjustment time and raises capital to $\bar{K}_1$, the total product curve becomes TP^1 , which lies above the previous one at each level of labor input. Besides, the corresponding unit product curves in panel (b) shift upward and to the right. Of our main focus is MP_L which closely determines the demand for labor. When capital is raised from $\bar{K}_0$ to $\bar{K}_1$, marginal productivity of labor increases, as can be seen in panel (b) of Fig 4.4, where MP_L^0 shifts to MP_L^1 . As a consequence of increased productivity, the demand for labor increases, in turn, shown in panel (c). The reason is that the demand for labor is the product of marginal productivity and marginal revenue (or price for competitive firms), as we have seen in our previous short run treatments.

It can be learnt from the foregoing revision of production function, as labor is used with more capital its productivity increases and hence, VMP_L shifts up rightwards.

We have already been convinced that:

As wage declines, not only more of labor is used, but also output and profit maximization effects lead to utilization of more capital.

Now, we have come to the point of deriving long run demand for labor. Let's switch to Fig. 4.5 for illustration. If we begin from w_0 , the short run demand for labor is VMP_L^0 . Decline in wage leads to shift in VMP_L in the long run. The greater the wage decline, the greater will the shift in VMP_L be. If you assume various wage rates, like w_1' , w_1'' and w_1 and connect the intersections of various w 's and corresponding VMP_L 's with a curve, this curve will be the long run demand for labor, as can be seen in Fig. 4.5. The long run labor demand curve traces the locus of various wage rates and optimum units of labor when the firm makes adjustment for labor and other cooperating factors.



4.3 COMPETITIVE INDUSTRY'S DEMAND FOR LABOR

Wage and employment are determined by the interaction of aggregate demand and supply. So far, we have derived the individual firm demand for labor both when labor is the only variable input as well as when capital is also variable. In this section, we derive the aggregate demand for labor.

Dear student, suppose that the level of employment at w_0 in Figure 4.5 above is 100. After wage falls to w_1 , it becomes 200. Besides, suppose that there are 100 identical *perfectly competitive* firms producing homogeneous product. Given these, how do you find the employment level at w_1 at aggregate? Is it just 200 *per individual firm times 100 individual firms*? Or is there some other consideration?

The short run supply curve of an input (like the supply curve of a final commodity) is generally upward sloped, indicating that a greater quantity of the input is supplied per unit of time at higher input prices. However, while the other inputs are supplied by firms, and their supply curves are generally positively sloped, labor is supplied by individuals and their supply curve may be backward bending.

4.4.1 Short Run Individual Labor Supply

One of the most important decisions made by any individual is how to allocate time between activities in the market and all other activities. Time in the market yields income, perhaps also some intrinsic satisfaction. Call this “work”. Time at home also produces satisfaction. Call this “leisure”. This typically doesn’t yield income. But only a fixed amount of time is available.

How to allocate time between these uses? The answer to this question is thought of as “labor supply”.

The Work – Leisure Decision: Basic Model

Two set of information are necessary to determine the optimal distribution of an individual’s time between work and leisure.

1st. **Subjective (psychological) information** concerning the individual’s work-leisure preferences. This information is embodied in *indifference curves*.

2nd. **Objective (market) information**, which is reflected in *budget constraints*.

Order of Analysis

- (i) Short run individual labor supply
 - (a) Preferences
 - (b) Constraints
 - (c) Optimal Choices
 - (d) Effect of wage change on equilibrium individual labor hours
 - (e) Decomposing the effect of wage change on equilibrium individual labor hours into substitution and Income effects
- (ii) Long run and aggregate labor supply

Assumptions

- Utility of an individual depends on leisure time (l) and goods and services consumed (c):

$U = U(l, c)$; both MU_l and MU_c are positive, meaning that the utility is increasing function of l and c .

- Both l and c are normal goods: as income of an individual increases, *ceteris paribus*, more of them are consumed.
- The total available time (T) is allocated between non labor time (leisure, l) and labor (h) at free choice of an individual: $T=l+h$ $\Delta h=T-l$
- The individual uses his labor income and (possibly non-labor) income for goods and services (c)

$c = y = wh + y_u$; where y is total income; w is wage rate per hour; h is hours worked; y_u is non-labor (unearned) income.

Assuming that y_u zero and substituting h with $(T-l)$

$$\Delta c = w(T-l)$$

Preferences, budget constraints and optimal choice

When applied to the work leisure decision, an indifference curve shows the various combinations of real income and leisure time which will yield some specific level of utility or satisfaction to the individual.

In panel (a) and (b) of fig 4.7 the vertical axis represents consumption of goods and services, c in real terms. the horizontal axis represents leisure, l from left to right (0 to total time, T). Since h is T minus l , it increases from right to left. In panel (a) the indifference curves represent $U(l, c)$. As usual, higher indifference curve represents higher utility, whereas utility is constant on an indifference curve with different combinations of (l, c) . The indifference curves are downward sloped reflecting that if one of the variables is reduced, more of the other has to be consumed to maintain the same level of utility. For example, if c is foregone, the individual has to increase l in order to maintain the utility

level. In our usual way of expression, $\left| \frac{dc}{dl} \right|$ (which equals the absolute slope of indifference curve) stands for the maximum amount of c an individual willingly foregoes to consume *a unit* of l to remain neither worse off nor better off (that is to remain on the

same indifference curve)⁴. However, since the diminishing marginal utility commonly operates, the amount of c you are willing to forego to get a unit of l decreases as you have more of the former and less of the latter. Hence, $\frac{dc}{dl}$ become smaller and smaller as you move down to the bottom-right, resulting in convex indifference curve. It is worth mentioning that preferences vary from individual to individual; some are leisure lovers and have extremely steep indifference curves; others value the labor income and do have very flat indifference curve. The indifferences we use for exposition in this section are of intermediate ones.

Whereas panel (a) of Fig. 4.7 depicts the subjective information, panel (b) depicts the objective information. Labor time (h) is measured from right to left. If income, which is entirely used for consumption, c is gained from labor service one sells at given wage (w), $c=wh$ increases as more h is supplied. At the absence of non-labor income, the budget constraint line originates at $h=0$ and extends to c -intercept where $h=T$. Since w is given and constant, the change in c is entirely due to change in h (hours supplied).

$$\frac{\partial c}{\partial h} (= \frac{\partial y}{\partial h}) = w, \text{ meaning that the slope of the budget constraint line is a given constant wage rate, } w.$$

If wage increases the budget constraint line becomes steeper.

At this stage of discussion, it is appropriate to make theoretical prediction of the optimum (l^*, c^*) by bringing together preference and budget constraint of a typical individual. To do so, we make use of Fig. 4.8

On an indifference curve the total change in utility is zero : $dU(l, c) = \frac{\partial U}{\partial l} dl + \frac{\partial U}{\partial c} dc = 0$

$$\frac{\partial U}{\partial l} dl = - \frac{\partial U}{\partial c} dc \Rightarrow \frac{MU_l}{MU_c} = - \frac{dc}{dl}$$

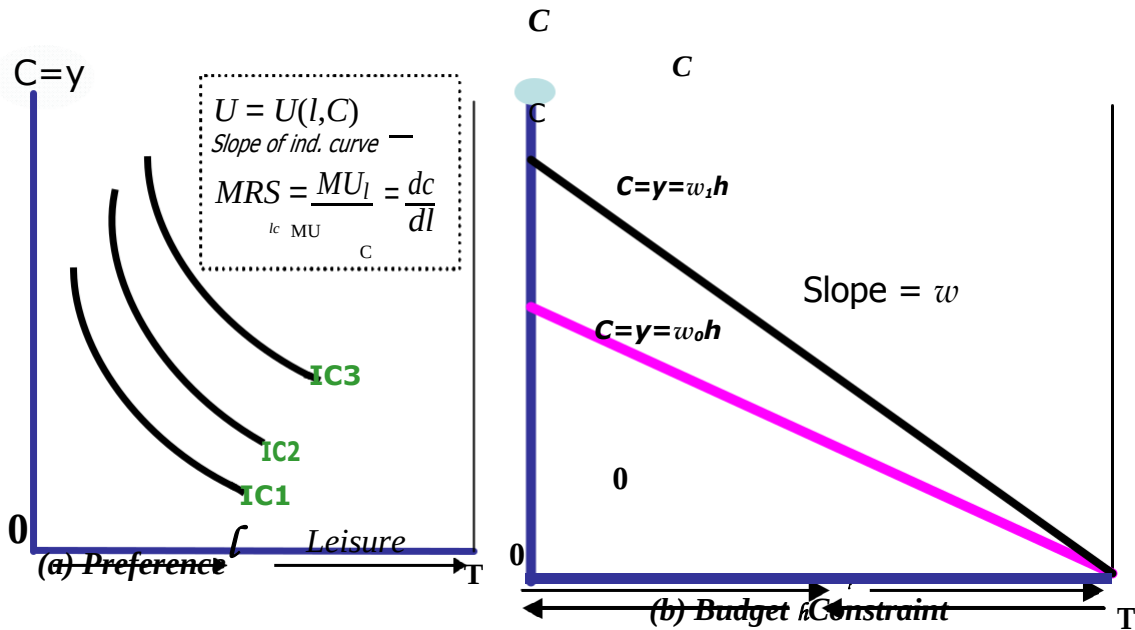


Fig. 4.7 l - c indifference map and Budget Constraint

It can be recalled that one of our assumptions was that individuals do have freedom of allocating the available time between work and leisure. Given this, the optimum time is determined by finding the l and c that maximize utility. Once l is determined, h is clearly $T-l$. Below, we will use graphical and mathematical treatments to determine the optimum choice.

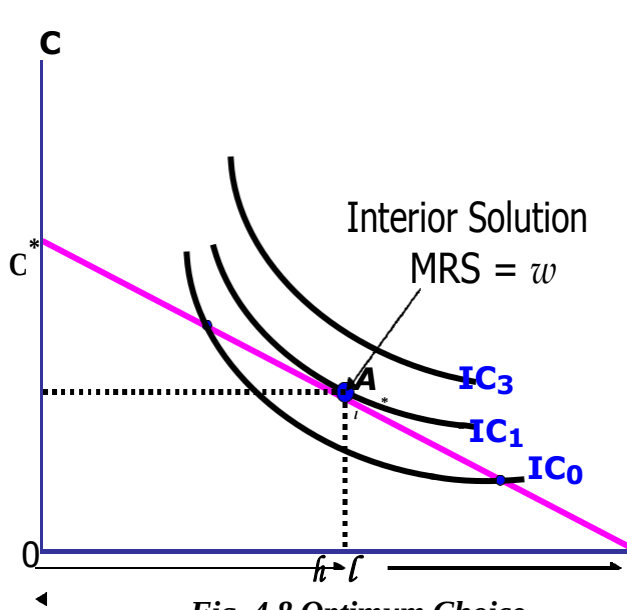


Fig. 4.8 Optimum Choice

$\max U(l, c)$ subject to $c = wT - wl$.

Changing into Lagrangean:

$\mathcal{L} = U(l, c) - \lambda(c - wT + wl)$ and finding FOC,

$$\frac{\partial \mathcal{L}}{\partial l} = \frac{\partial U}{\partial l} - \lambda w = 0 \quad \delta MU_l = \lambda w$$

$$\frac{\partial \mathcal{L}}{\partial c} = \frac{\partial U}{\partial c} - \lambda = 0 \quad \delta MU_c = \lambda$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = c - wT + wl = 0$$

Using the first two FOC equations, we get:

$$\frac{MU_l}{MU_c} = MRS_{lc} = \frac{w}{1}$$

Subjective rate

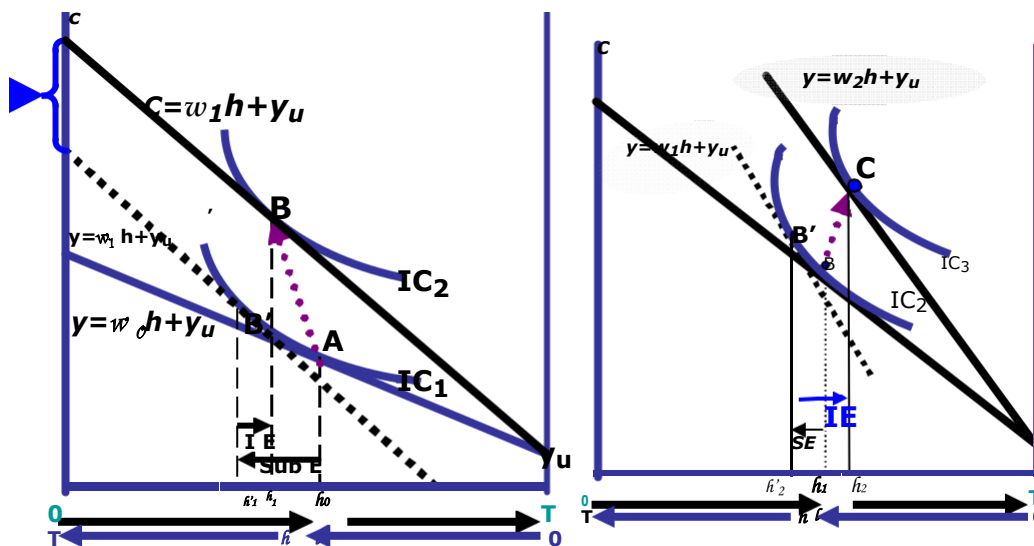
Meaning that the individual chooses l^* and c^* levels at which the subjective rate he/she is willing to exchange l for labor market

income (and hence c) is equal to the market wage rate.

Labor Supply Response to wage Change

What will the work-leisure decision of an individual be as the wage rate changes (say, increases)? Will the individual choose to work more or fewer hours as the wage rate increases? **It depends.** The effect of a wage rate change on labor supply (or hours of work) is decomposable into a *substitution* and *income* effects. When the wage rate changes, these two effects tend to alter one's utility-maximizing position.

Income effect: the income effect refers to the change in the desired hours of work resulting from a change in income. This effect is conceptually decomposed by keeping an individual on the previous satisfaction level when wage increases, such as, the imaginary position, B' in panel (a) of Fig. 4.9. In this Fig. when wage increases from w_0 to w_1 , the observable movement is from A to B . However, if you 'compensate' the individual (in negative sense here), you keep him/her on the old indifference curve. In other words, it is as if we "remove" some of the individual's real income until the new budget constraint is tangent to the old indifference curve at the new higher wage (eg. Keeping at imaginary position, B' instead of B in panel (a) of Fig 4.9).



(a) Greater Substitution Effect (b) Greater Income Effect
Fig.4.9 Substitution and Income Effects of Wage Change.

Notice that the broken line tangent to IC_1 at B' is parallel to the new budget line reflecting the same wage rate, w_1 and different y_u .

If you give back the conceptually ‘removed’ ($y_u - y_u'$), the individual moves from B' to B .

To further conceptualizing this effect, a rise in wage rate means that a larger money income is obtained from a given number of hours of work. We would expect an individual to use a part of this increased income to buy goods and service. But if we make a reasonable assumption that leisure is a normal good [a good of which more is consumed as income rises], then we can expect that part of ones expended income might be used to ‘purchase’ leisure. Consumers do not derive utility from goods alone, but from combination of goods and non market time (leisure).

How does one purchase leisure or non market time? In a unique way: *by working fewer hours*. This means that when wage rate rise and leisure is a normal good, the income effect results in a reduction in the desired number of hours.

Substitution effect: The substitution effect indicates the change in the desired hours of work resulting from a change in the wage rate, keeping utility constant. When wage rate increases the relative price of leisure is altered. Specifically, an increase in the wage rate raises the ‘price’ or opportunity cost of leisure. Because of higher wage rate, one must now forego more income for each hour of leisure consumed. The basic theory of economic choice implies that an individual will purchase less of any normal good when it becomes relatively more expensive. In brief, the higher price of leisure motivates one to consume less leisure (or to work in market).

The substitution effect merely tells us that when wage rates rise and leisure become more expensive, it is reasonable to substitute work for leisure. For a wage increase, the substitution effete results in the person desiring to work more hours. In panels (a) and (b) of Fig. 4.9, the substitution effects are, respectively, from B' to B and from B' to C .

Net effect: The over all effect of an increase in the wage rate on the number of hours an individual wants to work depend on the relative magnitudes of these two effects. Economic theory does not predict the net outcome unambiguously.⁵

⁵Net Effect = Sub Effect + Income Effect = $\left[\frac{\partial h}{\partial w} \right] = \underbrace{\left[\frac{\partial h}{\partial w} \right]}_{\substack{14243 \text{ } u=\text{const} \\ + \text{ve}}} + \underbrace{\left[\frac{\partial h}{\partial y} \right] h}_{\substack{14243 \text{ } w=\text{constant} \\ - \text{ve}}}$

The left hand side is the net change in hours of work. The first expression in the right hand side is pure substitution effect while the second is pure income effect. In other words, $[\frac{\partial h}{\partial w}]_{u=\text{cons}}$ is about the tangency point of the new wage rate with the previous indifference curve.

If the substitution effect dominates the income effect, the individual will choose to work more hours when the wage rate rises (as shown in panel (a) of Fig. 4.9). But if the income effect is larger than the substitution effect, a wage increase will induce the individual to work fewer hours (as shown in panel (b) of Fig. 4.9)

Table 4.2 Summary of the effect of the relative size of the substitution and income effect on the desired hours of work.

Relative Size of effect	Impact on hours of work		Slope of labor supply curve
	a)wage rate increase	b)wage rate decrease	
Substitution effect exceeds income effect	Increase	Decrease	Positive
Income effect equal substitution effect	No change	No change	Vertical
Income effect exceeds substitution	Decrease	Increase	Negative

The Backward Bending Labor supply curve

As the wage rate increases, the budget line rotates up along the vertical axis; i.e. the income that the individual earns increases and hence the *c intercept* increases & the budget constraint gets steeper. From the Fig. 4.10 below, we observe that for the wage rate increase the budget line gets steeper. Initially, we find that individual chooses fewer hours of leisure and more hours work. Later, wage increase causes a further reduction in hours of work.

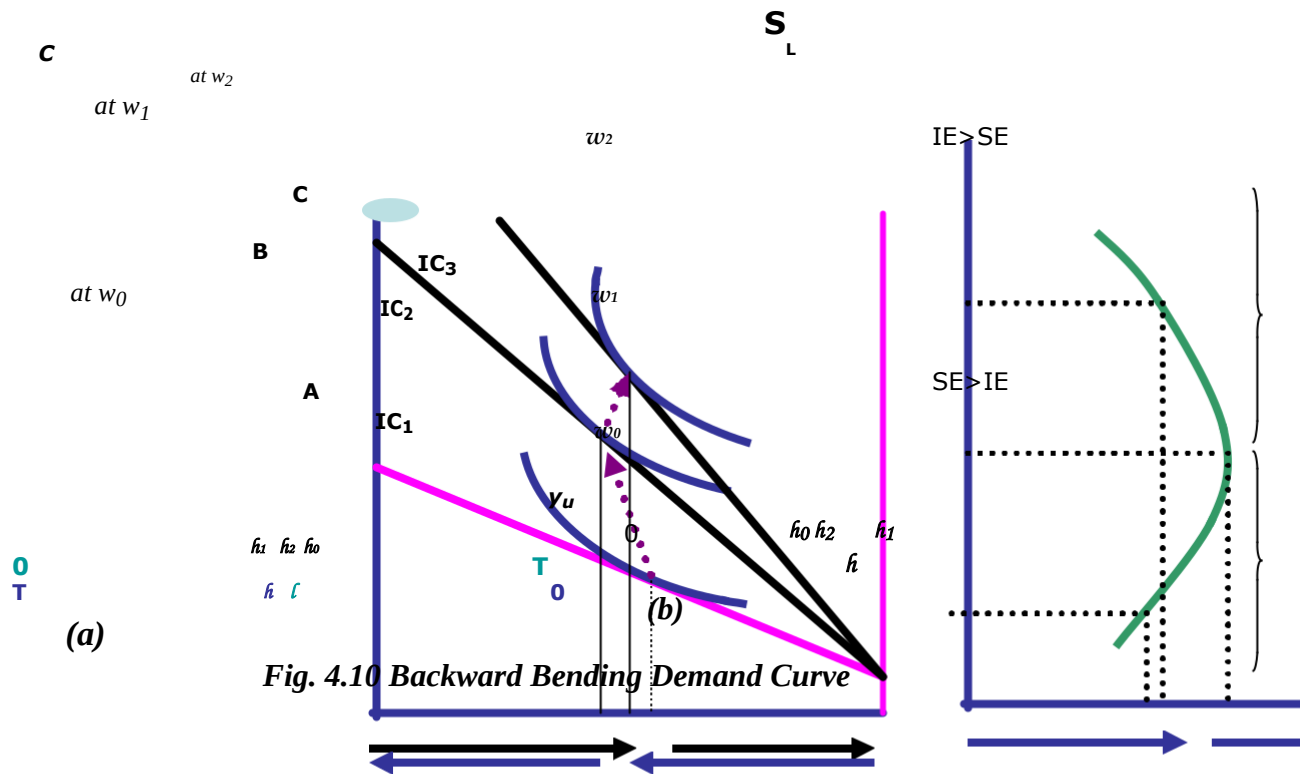


Fig. 4.10 Backward Bending Demand Curve

This analysis suggests that for specific person, hours of work may for a time increase as wage rate rise, but beyond some point, further wage increase may lead to fewer of labor being supplied.

The labor income- leisure figure can be transformed into a diagram which has traditional axis measuring wage rates on the vertical axis and hours of labor supplied left to right on the horizontal axis. In so doing, we find that this individual's labor supply curve is forward rising for a time and then backward bending.

This curve is known as a *backward bending supply curve*, the forward rising portion being expected or taken for granted. We can envision an individual labor supply curve for each person in the Economy. But keep in mind that each individual's preference for work versus leisure is unique and hence the exact location, shape, and point of the backward bend of the curve vary from person to person.

Finally, the backward bending supply curve we have seen above does not apply to every person. In other words, not all people reduce hours of work in response to higher wage.

4.4.2 Aggregate and Long Run Labor Supply

The supply curve of labor of a group of individuals or of the whole working force in the economy can be derived by summing up horizontally the supply curves of individuals. It is generally believed that when the wage rate rises from initially low level to a sufficiently good level, the total supply of labor to the economy as a whole increases.

In the case of supply of workers to a particular occupation, if wages go up, some persons from other similar occupations would be attracted to it and thus the supply of labor to that occupation will increase. Especially, the elasticity is higher for non-specialized labor.

Particularly in the long run, the labor supply curve is upward sloping even for specialized skills for which the short run individual labor supply may be backward bending. In the long run, besides occupational shifts in the in the present labor force, new entrants to the labor market can also adopt that occupation by getting training for it.

4.5 FACTOR PRICING IN PERFECT COMPETITIVE AND IMPERFECT MARKETS

So far, we have analyzed both the demand and supply sides of factors of production. The factor price and employment are determined by the interaction of demand and supply. In this section, we analyze the wage and employment determination under different market characteristics. For this purpose, the previously derived general FOC equation:

$$\frac{\partial P}{\partial Q} = \frac{\partial P}{\partial L} \frac{\partial L}{\partial Q} = \frac{\partial P}{\partial L} \frac{\partial L}{\partial Q} \quad \text{can be used. The equilibrium conditions are summarized}$$

under Table 4.3 below.

Table 4.3 Summary of the Firm's Demand for Labor and Equilibrium Conditions under Different Market Situations

Labor Market Characteristics Product Market Characteristics	Perfect: A single firm cannot affect the market wage. It employs as much as needed without raising wage rate. $\frac{\partial w}{\partial L}$ If so, $\frac{\partial L}{\partial w} = 0$. Hence, $\frac{\partial L}{\partial w}$ MC_L is equal to the wage rate (w).	Imperfect: A single firm does have the power to affect the market wage. At extreme, we do have a single buyer of labor service (monopsonist). In this case, it is required to raise wage to attract more labor. If so, $\frac{\partial w}{\partial L}$ $\frac{\partial L}{\partial w} > 0$. Hence, Marginal Labor Cost (MLC) is greater than wage rate (w) by $\frac{\partial L}{\partial w}$ $\frac{\partial L}{\partial w} L$. $\rightarrow$ The new higher wage applies to all.
Perfect: A firm sells as much as needed at a given price. Hence, MR is equal to price. $\frac{\partial P}{\partial Q} = 0$ $\frac{\partial P}{\partial Q}$ Value of Marginal Product (VMP_L) is Demand curve.	<u>Equilibrium Condition</u> $MP_L = w$ $\frac{MP_L}{VMP_L} = \frac{w}{MLC}$ 123_L Labor is paid value of its Marginal product	<u>Equilibrium Condition</u> $MP_L = w + \frac{\partial w}{\partial L} L$ $\frac{MP_L}{VMP_L} = \frac{w + \frac{\partial w}{\partial L} L}{MLC}$ 142_{L3} Labor is paid less than the value of its Marginal product due to Monopsonistic exploitation.
Imperfect: A firm with monopoly power sells more by reducing price. If so, $\frac{\partial P}{\partial Q} < 0$. Hence, $\frac{\partial P}{\partial Q}$ $MR < P$ Marginal Revenue Product (MRP_L) is Demand curve.	<u>Equilibrium Condition</u> $MP_L = w$ $\frac{MP_L}{L} = \frac{w}{L}$ Labor is paid less than the value of its Marginal product due to Monopolistic exploitation.	<u>Equilibrium Condition</u> $\frac{MP_L}{L} = \frac{w + \frac{\partial w}{\partial L} L}{L}$ $\frac{MP_L}{L} = \frac{w + LMP}{L}$ Labor is paid less than the value of its Marginal product due to both monopolistic and Monopsonistic exploitations.

It can be seen that employment of and reward for a factor of production is affected by imperfections both in the product and labor markets. This is shown in Fig. 4.11 which is closely related to the summary in Table 4.3.

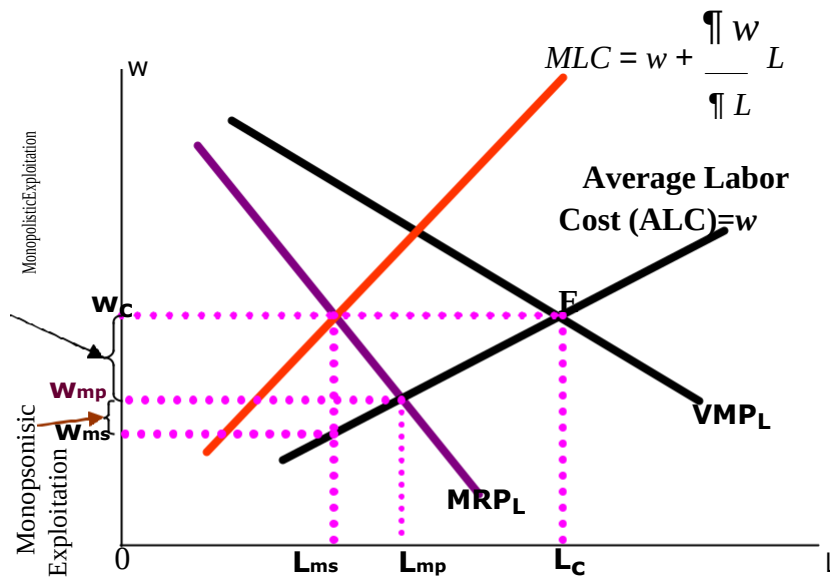


Fig 4.11 Wage and Employment Determination under Perfect and Imperfect Markets

When both the product market and the labor market are perfect, both employment (L_c) and wage (w_c) are the maximum. Wage rate less than w_c is considered an exploitation. Firstly, the portion, $w_c - w_{mp}$ in Fig. 4.11 is attributed to monopolistic power in the product market. It is known as monopolistic exploitation. Secondly, a firm may be a single buyer of labor service, called monopsony. The portion, $w_{mp} - w_{ms}$ is attributed to such monopsonistic power.

☺Check Your Progress 3

The Labor Demand of a monopolist is given by $MRP_L = 20 - L$, which could have been $VMP_L = 20 - 0.5L$ had it been a competitive industry. This firm is also a monopsonist (single buyer of labor service) and the Average Labor Cost (ALC) it faces is given by

$$w = 2L.$$

Required: Find out the following and Graphically show on a single Plane:

- The competitive level of employment and wage
- The monopolistic level of employment and wage, regardless of monopsonistic power.
- The monopsonistic level of employment and wage
- The monopolistic and monopsonistic exploitation

Bilateral Monopoly

In the previous section we have seen that wage rate is very small at the presence of both monopoly and monopsony power. Suppose that now there is organized labor union that bargains for higher wage by acting as a single seller. This results in bilateral monopoly. Bilateral monopoly, in our case, is a market from where a monopolist, a single seller of a labor service (labor union), sells to the monopsonist who is the single buyer of the labor service. Here under collective bargaining, we will not easily determine a particular wage rate. Rather, we determine the upper and the lower limits. The lower limit is the monopsonist wage rate (similar to w_{ms} in Fig. 4.11).

In order to settle the range of wage rates within the particular wage rate lies, we will use Fig. 4.12. Notice that MR_U in the figure is the union's marginal revenue which shows how much additional income or revenue the union will obtain when more labor is hired. In nutshell, it is marginal to MRP_L . At the absence of collective bargaining, the profit maximizing level of employment would be determined at the equality of MLC and MRP_L . At this point, L_{ms} units of labor are employed at w_{ms} wage rate.

• w_{ms} is the minimum limit below which wage rate cannot fall. It is the rate the monopsonist would wish to set if left free of collective bargaining.

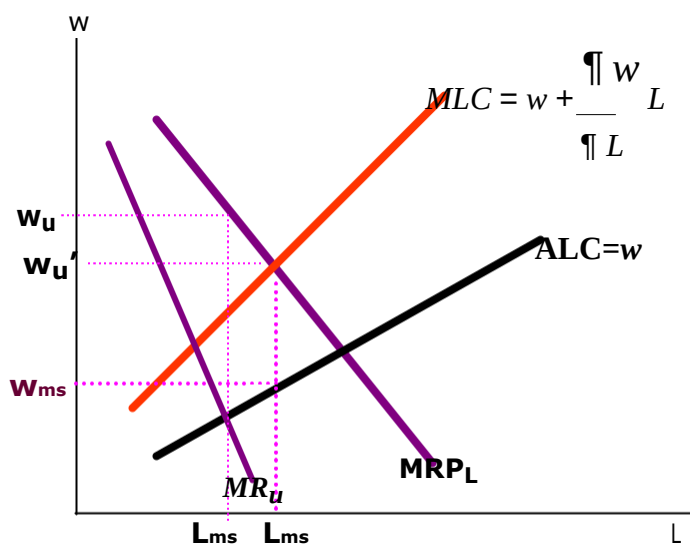


Fig. 4.12 Wage Determination under Bilateral Monopoly
MR is marginal to MRP_L .

On the other hand the labor union aims at maximizing its net revenue (i.e. revenue over and above opportunity costs of labor which is maximum at w_u).

$\bar{w}_u$ is the maximum limit above which wage rate cannot be raised. It is the rate the union would wish to set.

Finally, whereas the range of the wage lies between w_{ms} and w_u , a particular one depends on bargaining power of the two parties.

Economic Rent

In ordinary sense of the term, rent means a payment for hiring of any fixed asset such as house, machines, vehicles, etc. In economics, however, rent is the difference between the payment made to a factor of production and the minimum amount to keep the a factor of production in its present occupation in an industry under equilibrium state.

So far we have seen how wage is determined under different situations. If we take a further step, we will identify that part of labor income is an economic rent. For example, if the equilibrium wage is w in Fig. 4.11, part of the area of the rectangle, OL_cEw_c above the ALC curve (labor supply) is Economic Rent. Generally, the lower the elasticity of labor supply curve, the larger the economic rent will be. For example, land which is relatively of fixed supply, is highly inelastic and its economic rent is consequently high.

4.6 INCOME DISTRIBUTION, ELASTICITY OF FACTOR SUBSTITUTION AND TECHNOLOGICAL PROGRESS

4.6.1 Marginal Productivity Theory of Income Distribution

According to marginal productivity theory, *all factors* can be assumed to be variable and get the reward equal to their marginal product. Thus labor gets real wage rate equal to marginal product, capital gets rate of interest equal to its marginal product, land gets rent equal to its marginal product. The total *absolute* share of a factor is determined by its marginal product (i.e., remuneration in real terms) multiplied by the amount of the factor used. Thus, the absolute share of labor in the national income is determined by the amount of labor used (L) in production multiplied by its marginal product (or real wage rate), and so on.

$$\text{Absolute Share of Labor} = L' MP_L$$

$$\text{Absolute Share of Capital} = K' MP_K$$

The relative share of labor (a) in the national income is the absolute share divided by the total national product (Q).

$$\text{Relative Share of Labor} = a = \frac{L' MP_L}{Q}$$

Likewise, The relative share of capital (b) in the national income is the absolute share divided by the total national product (Q).

$$\text{Relative Share of Capital} = b = \frac{K' MP_K}{Q}$$

It should be noted that in neo-classical marginal productivity theory, all factors are regarded as substitutes of each other, though to varying degrees. With the given and fixed supplies of factors, the marginal products of the various factors are known from the production function. With the knowledge of these marginal products of factors (equal to which real rewards for factors are determined), the absolute and relative shares of the factors can be found out. A better understanding can be made by rewriting Equations of the relative shares above by substituting:

$$\begin{aligned} MP_L & \text{ with } \frac{Q}{L} \text{ and} \\ MP_K & \text{ with } \frac{Q}{K} \end{aligned}$$

and then rearranging, we will obtain a better expression.

$$\begin{aligned} a &= \frac{L' MP_L}{Q} = \frac{L' \frac{Q}{L}}{Q} = \frac{Q'}{L} \frac{L}{Q} = \frac{Q}{Q} \cdot \frac{L}{L} \\ \Delta a &= \underbrace{\frac{Q}{Q}}_{\substack{\text{Relative change} \\ \text{in production}}} \cdot \underbrace{\frac{L}{L}}_{\substack{\text{Relative change} \\ \text{in Labor}}} = \underbrace{\frac{Q}{Q}}_{\substack{14243 \\ \text{Labor Elasticity}}} \cdot \underbrace{\frac{L}{L}}_{\substack{\text{of production}}} \end{aligned}$$

This means that the relative share of labor in national income is equal to the elasticity of production with respect to labor input. In a numerical terms, if 2% change in the quantity

of labor brings about a 80% change in production, then labor's share in national product will be 40% ($a=0.4$).

In the same manner, relative share of capital (b) is

$$b = \frac{K' MP_K}{Q} = \frac{K' \frac{Q}{K}}{Q} = \frac{Q}{K} \frac{K'}{Q} = \frac{Q}{Q} \cdot \frac{K'}{K}$$

14243
capital Elasticity of production

Thus, the relative share of capital (b) is equal to the elasticity of production with respect to capital. In a numerical terms, if 1% change in the quantity of capital brings about a 60% change in production, then capital's share in national product will be 60% ($b=0.6$).

Activity: Given the Cobb-Douglas Production Function of an economy, $Q = AL^h K^m$, where $h+m=1$

Verify that the relative income share of labor is equal to h and that of capital is equal to m .

The change in Factor Share of Income depend on

- Elasticity of Factor Substitution
- Technological Progress

4.6.2 Elasticity of Factor Substitution

Elasticity of Factor Substitution shows proportional change in input ratio in response to proportionate change of the factor price ratio. As shown above, in neo-classical theory factor rewards are equal to their marginal products which are equal to their real prices:

$MP_L = \text{real wage, } w$

$MP_K = \text{real interest, } r$

From the previous relative share equations, can be rewritten as:

$$a = \frac{L' w}{Q} \text{ and } b = \frac{K' r}{Q}, \text{ respectively.}$$

The ratio of these relative shares is called distributive share which becomes:

$$\frac{\text{relative shares of labor}}{\text{relative share of capital}} = \frac{a}{b} = \frac{wL}{rK} = \frac{(L/K)}{(r/w)} = \frac{(K/L)}{(w/r)}.$$

Changing both the numerator and the denominator of the above into proportional changes, we get Elasticity of Factor Substitution.

$$\text{Elasticity of Factor Sub., } S = \frac{(K/L)}{(W/r)} \frac{d(K/L)}{d(W/r)}$$

If relative price of labor rises, that is $\frac{W}{r}$ increases, this will induce the substitution of r capital for labor and as a result capital-labor ratio (K/L) will increase. If the elasticity of substitution is less than one, say equal to 0.5, then 10% increase in wage-rental ratio $\frac{W}{r}$ will lead to the increase in capital-labor ratio by only 5%. Thus, given that the

elasticity of factor substitution is less than unity (inelastic), then a given percentage increase in $\frac{W}{r}$ ratio will not cause the substitution of capital for labor in the same

proportion. If the elasticity is unity, a given percentage increase in $\frac{W}{r}$ ratio will cause the

substitution of capital for labor in the same proportion. Whereas when it is greater than unity (elastic), greater percentage change in capital-labor ratio is caused by a given percentage change in $\frac{W}{r}$.

Dear learner, (i) does the information about elasticity of factor substitution tell us anything about the change in distributive income share of labor and capital in response to change in $\frac{W}{r}$? ____ Verify. _____

_____.

(ii) If the elasticity is already known to be greater than unity (elastic) and our objective is to increase the distributive share of labor, which policy should we support: policy that raises $\frac{W}{r}$ or reduces it? _____

Explain. _____

 —.

Well! For the first question, Yes, it does! One way of verifying this is as follows. From above we can rewrite as,

$$\frac{\text{relative shares of labor}}{\text{relative share of capital}} = \frac{(w / r)}{(K / L)} = \frac{wL}{rK}$$

Using this equation,

- (a) If the factor substitution is inelastic, a given percentage change in (w/r) is followed by smaller percentage change in (K/L) ratio and hence,

$$\frac{\delta (w / r)}{(K / L)} = \frac{wL}{rK} < 1, \text{ meaning that rise in } (w/r) \text{ favors the}$$

distribution share of labor.

- (b) If the factor substitution is unitary elastic, a given percentage change in (w/r) is followed by the same percentage change in (K/L) ratio and hence,

$$\frac{\delta (w / r)}{(K / L)} = \frac{wL}{rK} = 1, \text{ meaning that rise in } (w/r) \text{ does not cause}$$

distribution share.

- (c) If the factor substitution is elastic (greater than unity), a given percentage change in (w/r) is followed by greater percentage change in (K/L) ratio and hence,

$$\frac{\delta (w / r)}{(K / L)} = \frac{wL}{rK} > 1, \text{ meaning that rise in } (w/r) \text{ favors the}$$

distribution share of capital.

Briefly responding to the second question, if the factor substitution is elastic our objective of raising distributive share of labor is will be achieved when $\frac{w}{r}$ decreases (otherwise, its rise favors capital as shown in (c) above).

Note that the elasticity of factor substitution depends on production function of the economy, for which we will provide illustrative example next.

Illustrative Example: Cobb-Douglas production function and distributive share of labor and capital

Cobb-Douglas production function is a popular function. According to Ahuja (2005:867), Cobb-Douglas production function proved to be ideal for explaining the constancy of labor's share in the national income, which for long time economists believed to be empirically true.

$$Q = AL^a K^{1-a}$$

where L and K are, respectively, labor and capital. Q stands for production. A and a are constant. $a + (1 - a) = 1$ means that Cobb-Douglas production function represents constant returns to scale, that is increase in the scale of production has no effect on productivity. In an activity, you were asked to verify that the exponents of the factors in the Cobb-Douglas production function represent the relative income shares. Likewise, here a and (1 - a) represent relative shares of labor and capital, respectively, as can be verified along the way.⁶

$$\begin{aligned} \text{Given } Q &= AL^a K^{1-a} \\ MP_L &= aAL^{a-1}K^{1-a} = a \frac{AL^a K^{1-a}}{L} \\ \partial MP_L &= a \frac{Q}{L} \\ MP_K &= (1-a)AL^a K^{-a} = (1-a) \frac{AL^a K^{1-a}}{K} \\ \partial MP_K &= (1-a) \frac{Q}{K} \\ \text{Elasticity of Factor Sub., } S &= \frac{(K/L)_2 (K/L)_1}{(w/r)_2 (w/r)_1} \end{aligned}$$

$$\begin{aligned} \text{Rearranging } MP_L = a \frac{Q}{L}, \text{ we obtain } a &= \frac{MP_L \cdot L}{Q} = \text{relative share of labor. Similarly,} \\ \text{rearranging } MP_K = (1-a) \frac{Q}{K}, \text{ we obtain } (1-a) &= \frac{MP_K \cdot K}{Q} = \text{relative share of capital} \end{aligned}$$

$$a(Q/L)$$

substituting ————— for w/r ,

$$\begin{aligned} \text{Elasticity of Factor Sub., } S &= \frac{(K/L)_1 (K/L)_2}{\frac{\partial}{\partial \left(\frac{a(Q/L)}{(1-a)^{1-a} (1-a)^{-a}} \right)} \frac{a(Q/L)}{(1-a)^{1-a} (1-a)^{-a}}} \\ \text{Elasticity of Factor Sub., } S &= \frac{(K/L)_1 (K/L)_2}{\frac{a}{(1-a)} \frac{\partial K}{\partial L} \div \frac{a}{(1-a)} \frac{\partial K}{\partial L}} \\ \text{Elasticity of Factor Sub., } S &= 1 \end{aligned}$$

For an economy characterized by Cobb-Douglas production function, the elasticity of factor substitution is unity, and hence a given percentage of relative price change causes the same percentage response (change) in factor ratio. For example, if w/r increases by 10% K/L increases by 10% and ————— remains constant.

To briefly summarize the discussion of this sub section, firstly, according to the marginal productivity theory, all factors can be assumed to be variable and get the reward equal to their marginal product. Secondly, the distributive share of a factor is determined by both *how much of it is employed* and *how much it is paid*. Raising its price does not necessarily increase its relative distribution since there is possibility of high response in substituting it with relatively cheaper factors. In other words change in distributive share in response to relative price change depends on how responsive the economy is in substituting factors, which is measured by elasticity of factor substitution. This in turn depends on the production function of the economy.

4.6.3 Technological Progress

Being concerned with static analysis of factor shares we have so far assumed that production function remains constant over a period of time. However, in real life change in technology is continuously taking place which causes a shift in the production function and thereby brings about a change in marginal products of factors and therefore in marginal rate of technical substitution between labor and capital. Due to its effect on $MRTS_{LK}$ (or ratio of MP_L/MP_K) the technological change affects income distribution or relative shares of factors.

Technological changes has been classified by J. R. Hicks (cited in Ahuja, 2005) into the following categories:

- Capital using technological change
- Neutral and technological change
- Labor-using technological change

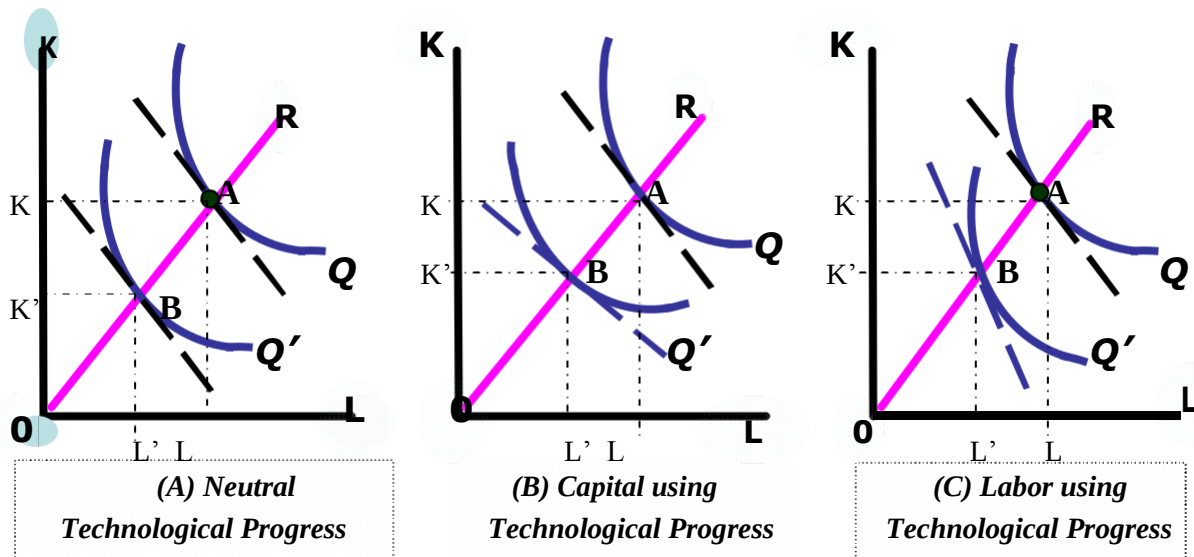


Fig.4.13 Different Types of Technological Progress. Initially the firm produces Q units of output by utilizing L and K units of labor and capital, respectively. Due technological progress, the same units of output, Q' can be produced by using less of the factors. OR is a linear ray from the origin representing constant capital-labor ratio equal to its slope.

It may be noted that technological advancement implies that a given level of output can be produced with smaller quantities of factors and therefore isoquants shift downward as a result of this. Technological change is said to be neutral if at a given and constant capital-labor ratio, marginal rate of technical substitution (MPL/MP_K) remains the same when, due to the progress in technology, isoquants representing production function shift downward. This is illustrated in *panel (a) of Fig. 4.13*. Initially the firm is at isoquant Q producing level of output Q . OR is a linear ray from the origin representing constant capital-labor ratio equal to its slope. Now, as a result of neutral technological progress isoquant representing level of output Q shifts downward to the new position Q' and along the ray of constant capital-labor ratio (K/L), the firm reaches at point B . It will be found

that the slope of the tangent drawn at point B on the new isoquant, indicating $MRTS_{LK}$ is the same as at point A of the ray OR on the initial isoquant Q . This occurs when the nature of technological change is such that it equally increases the marginal products of both labor and capital so that $MRTS_{LK}$ which is equal to the ratio of MP_L/MP_K remains the same.

Capital-Using Technological Progress. Technological progress is capital-using (or capital deepening) if it raises the marginal product of capital relative to labor. This means that with the shift of the isoquants representing production function due to capital biased technological change, the $MRTS_{LK}$ ($=MP_L/MP_K$) will decrease as can be seen in panel (b) of Fig. 4.13. Here, the linear ray OR from the origin depicting-a given constant capital-labor (K/L) ratio intersects the initial isoquant Q at point A and the new isoquant Q' at point B after its downward shift due to the technological advancement. A glance at panel (b) will reveal that the slope of the tangent depicting $MRTS_{LK}$, drawn at point B on the isoquant Q' is less than at point A on the initial isoquant Q . This implies that $MRTS_{LK}$ has declined as a result of technological change showing that this is the case of capital- deepening technological progress.

Labour-Using Technological Change. Lastly, labour-using technological change occurs when it leads to the increase in marginal product of labor relative to marginal product of capital so that $MRTS_{LK}$ at the constant capital labor (K/L) ratio increases, as can be seen in panel (c) of Fig 4.13. With the improvement of technology and consequent downward shift in isoquant representing a given level of output shifts from Q to Q' . It will be seen on the ray OR and at point B that the shope of the new isoquent Q' , is greater than at *point* A on the initial isoquant Q which means that $MRTS_{Lk}$ has increased with the change in technology, capital-labor ratio remaining constant. Thus, panel (c) represents the case of labor-using technological progress.

Technological Change and Relative Factor Shares

The nature of technological progress, whether it has capital-using or labor-using bias, has an important bearing on the income distribution between labor and owners of capital.

Consider the following three points to show the effect of each type of technical

progress on relative share:

(a) As we know at equilibrium, $\frac{MP_L}{MP_K} = MRTS_{LK} = \frac{w}{r}$.

(b) Technological progress that affects $\frac{MP_L}{MP_K}$ also affects $\frac{w}{r}$ in the same direction since factors are rewarded according to their marginal productivities.

(c) For technological progress to cause change in distributive share, $\frac{wL}{rK}$ should be affected.

(i) When technological progress is **neutral**, relative shares of labor and capital ($\frac{wL}{rK}$) will remain constant, as will be explained below.

- The isoquant shifts down and $MRTS_{LK}$ remains the same at constant K/L ratio.
- If so, the ratio of factor prices (w/r) which in equilibrium equals $MRTS_{LK}$ will remain the same.
- Thus, if w/r remains constant at constant K/L, $\frac{wL}{rK}$ remains constant, meaning that neutral technological progress does not cause change in distributive share.

(ii) When technological progress is **capital deepening**, relative shares of labor declines while that of capital increases ($\frac{wL}{rK} \uparrow$) as will be explained below.

- The isoquant shifts down and $MRTS_{LK}$ decrease at constant K/L ratio.
- If so, the ratio of factor prices (w/r) which in equilibrium equals $MRTS_{LK}$ will also decrease. Specifically, r increases relative to wage since MP_K increases.
- Thus, if w/r decreases at constant K/L, $\frac{wL}{rK}$ decreases, meaning that capital rK deepening technological progress causes change in distributive share in favor of capital.

It is desirable to mention here that the assumption of constant K/L ratio is not without criticism, since such technological progress can lead to rise in K/L ratio.

(iii) When technological progress is **Labor-using**, relative shares of labor rises while that of capital decreases ($\frac{wL}{rK} \downarrow$) as will be explained below.

- The isoquant shifts down and $MRTS_{LK}$ increases at constant K/L ratio.
- If so, the ratio of factor prices (w/r) which in equilibrium equals $MRTS_{LK}$ will also increase.
- Thus, if w/r increases at constant K/L, $\frac{wL}{rK}$ increases, meaning that labor- rK using technological progress causes change in distributive share in favor of labor.

4.7 CHAPTER SUMMARY

1. The demand for resources is derived from the demand for the commodities that require the resource in production. The greater the demand for the commodity and the more productive the resource, the greater the price that firms are willing to pay for the resource.
2. The marginal revenue product (MRP) measures the increase in the firm's total revenue from selling extra product that results from employing one additional unit of the resource. As additional units of the variable resource are used with fixed inputs, the extra unit, or marginal physical product (MPP), falls due to diminishing returns.
3. A firm that is perfect competitor in the resource market maximizes profit when its Value of marginal product from the variable resource equals the resource price. Thus, the firm's Value of marginal product schedule is the firm's demand schedule for the variable resource.
4. If the firm is an imperfect competitor in the commodity market, its marginal revenue product declines both because the marginal physical product from the

- variable input declines and because the firm must lower the commodity price in order to sell more units of the commodity.
5. A firm's demand for productive resource increases if the demand for the product increases, if productivity of the resource rises, if the price of a substitute resource rises, or price of the price of a complementary resource falls
 6. If the firm is an imperfect competitor in resource market, the firm maximizes total profits by hiring each resource until the value of marginal product from each resource equals the marginal resource cost. The marginal resource cost is equal to the increase in the firm's total cost for hiring each additional unit of the resource.
 7. According to the marginal productivity theory of distribution factors are rewarded according to their marginal productivity.
 8. Both product and factor market imperfections lead to both lower employment and factor prices.
 9. Distributive factor share of income is influenced by production function, elasticity of factor substitution, factor prices and technological progress.

4.8 QUESTIONS FOR REVIEW

- 1 What do we mean by derived demand for a factor?
- 2 What is the difference between Value of Marginal Product and Marginal Revenue product?
- 3 How does imperfection in the product market affect the demand for labor?
- 4 Explain how the following affect demand for a factor of production
 - Demand for the product
 - Marginal physical productivity of the product
 - Price of other factors
 - Adjustment period
- 5 Explain the relationship between income distribution, production function, factor substitution and technological progress

Chapter Five

GENERAL EQUILIBRIUM ANALYSIS

5.1 INTRODUCTION

Before we turn to the detailed study of general equilibrium analysis, it will be helpful for the proper understanding of the subject if we first make the distinction between *partial equilibrium* and *general equilibrium analyses*. So far, both in the first module and the previous chapters of this module of your Microeconomics, we have examined the behavior of individual decision making units and the workings of individual markets for commodities and inputs under various market structures. We have adopted a partial equilibrium approach, concentrating on decisions in a particular segment of the economy in isolation of what was happening in other segments, under *ceteris paribus assumption*.

How are the individual pieces-individuals as consumers of commodities and suppliers of inputs, and firms as employers of inputs and producers of commodities- are integrated? Such an examination of how the various individuals fit together to form an integrated economic system has generally been missing from our presentations. However, you are advised to appreciate the great importance of *ceteris paribus* assumption and partial equilibrium analyses so far. They have, indeed, created convenience in analysis by reducing complexities to manageable set of variables.

In this chapter, we take up the topic of interdependence or relationship among the various decision-making units and markets in the economy. This allows us to trace both the effect of a change in any part of the economic system on every other part of the system, and the repercussions from the latter on the former. We begin the chapter by distinguishing between partial equilibrium analysis and general equilibrium analysis and by examining the conditions under which each type of analysis is appropriate. Then, we discuss the conditions required for the economy to be in general equilibrium of exchange, production, and production and exchange simultaneously, and we examine their welfare implications.

Chapter objectives

At the end of this chapter, you should be able to:

- Distinguish between partial equilibrium and general equilibrium
- Describe the contract curve in Edgeworth exchange box diagram
- Determine the conditions for general equilibrium in consumption and production
- Show the points of general equilibrium in a competitive output market using Production Possibility Frontier (PPF) and Edgeworth exchange box diagram.
- Explain Pareto optimality in exchange, consumption and production
- Derive welfare implications of general equilibrium

Chapter Outline

5.1 Introduction

5.2 *Partial versus general equilibrium analysis*

5.3 *General equilibrium of exchange and production*

5.3.1 *General equilibrium of exchange*

5.3.2 *General equilibrium of production*

5.4 *General equilibrium of production and exchange and Pareto optimality*

5.4.1 *General equilibrium of production and exchange simultaneously*

5.4.2 *Marginal conditions for economic efficiency and Pareto optimality*

5.5 *Perfect competition, economic efficiency, and equity*

5.6 *Chapter summary*

5.7 *Activities for review*

5.2 PARTIAL VERSUS GENERAL EQUILIBRIUM ANALYSIS

While conducting partial equilibrium analysis, we studied the behavior of individual decision-making units and individual markets viewed in isolation. We examined how an individual maximizes satisfaction subject to his or her income constraint; how a firm efficiently allocates resources and maximizes profit under a certain market structure; how the price and employment of input is determined, etc. In doing so, we have abstracted from all the interconnections that exist between the market under study and the rest of the economy (the *ceteris paribus* assumption). In short, we have shown how demand and supply in each market determine the equilibrium price and quantity in that market independently of other markets.

However, a change in any market has spillover effects on other markets, and the change in these other markets will, in turn, have repercussions or feedback effects on the original market. These effects are studied by general equilibrium analysis. That is, general equilibrium analysis studies the interdependence or interconnections that exist among all markets and prices in the economy and attempts to give a complete, explicit, and simultaneous answer to the questions of what, how, and for whom to produce.

Suppose that a country domestically produces automobiles. The industry uses steel, glass, rubber and other inputs. Besides, a number of workers are employed here and they generate income for their living. Assume that these domestically produced automobiles are high-petroleum-consuming ones compared to imported automobiles. Now if oil price increases, demand for domestic automobiles will decrease, since consumers shift to oil efficient imported automobiles. This results in reduction in price of the domestic automobiles. Consequently, new equilibrium will be established at lower price and quantity.

We could have completed the analysis had we been studying partial equilibrium analysis!

On the other hand, the analysis goes on if we adopt general equilibrium analysis since there are further *spill over* and *feedback* effects of the initial oil price change. A change in the demand and price for domestically produced automobiles will immediately affect:

- The demand and price of steel, glass, and rubber (the intermediate inputs of automobiles),
- The demand, wages, and income of auto workers and of the workers in the related other industries.
- The demand and price of gasoline and of public transportation (as well as the wages and income of workers in these industries) are also negatively affected.

When does the effect end? These affected industries do have spillover effects on still other industries, until the entire economic system is more or less involved, and all prices and quantities are affected. This is like throwing a rock in a pond and examining the ripples emanating in every direction until the stability of the entire pond is affected. The size of the ripples declines as they move farther and farther away from the point of impact. Similarly, industries further removed or less related to the automobile industry are less affected than more closely related industries.

What is important is that the effect that a change in the automobile industry has on the rest of the economy will have repercussions (through changes in relative prices and incomes) on the automobile industry itself. This is like the return or feedback effect of the ripples in the pond after reaching the shores. These repercussions or feedback effects are likely to significantly modify the original partial equilibrium conclusions (price and output) reached by analyzing the automobile industry in isolation (see Fig. 5.1).

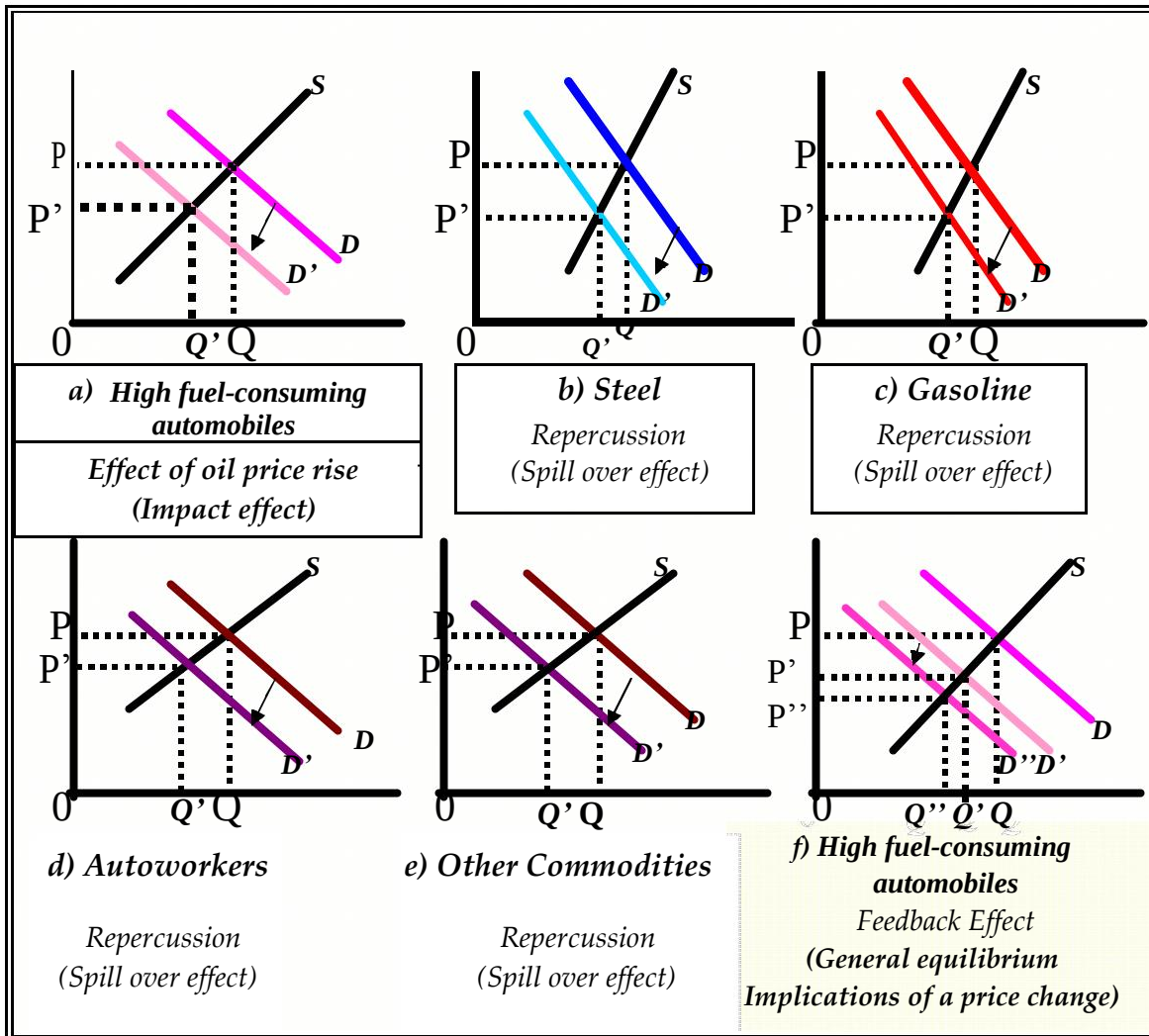


Fig.5.1 General Equilibrium Implications of a price change: USA example.

The impact or partial equilibrium effect of a reduction in the demand for new domestically produced automobiles is to reduce price from P to P' and quantity from Q to Q' [panel (a)] This reduces the demand for (and price and quantity of) steel [panel (b)] and gasoline [panel (c)] and the demand for (and wages and employment of) workers in the automobile [panel (d)] and other affected industries This, in turn, has spillover effects on the market for other commodities [panel (e)] and feedback effects on the domestic automobile industry itself [panel (f)]

Source: Adapted from USA example (1973-1980) in Salvatore (2003:p570).

The illustration in Fig. 5.1 is adapted from Salvatore (2003:p570). To have clear understanding of this example, start from panel (a), where the effect of oil price rise begins. Had it been just partial equilibrium analysis, the model would have predicted new equilibrium at (Q', P') in response to the shift in demand for high fuel-consuming automobiles. However, considering (b) to (e) show how this initial change in (a)

production of directly or indirectly related industries and income of individuals that can have feedback effect to (a) by further reducing the demand for these automobiles. As can be seen in (f), the feedback effect further reduces the equilibrium quantity and price to (Q'', P'') . This later consideration is made by general equilibrium analysis.

When (as in the automobile example) the repercussions or feedback effects from the other industries are significant, partial equilibrium analysis is inappropriate. By measuring only the impact effect on price and output, partial equilibrium analysis provides a misleading measure of the total.

On the other hand, if the industry in which the original change occurs is small and the industry has few direct links with the rest of the economy, then partial equilibrium analysis provides a good first approximation to the results sought.

The logical question is why not use general equilibrium analysis all the time and immediately obtain the total, direct, and indirect results of a change on the industry (in which the change originated) as well as on all the other industries and markets in the economy? The answer is that general equilibrium analysis, dealing with each and all industries in the economy at the same time, is by its very nature difficult, time consuming, and expensive. Happily for the practical economist, partial equilibrium analysis often suffices. In any event, partial equilibrium analysis represents the appropriate point of departure, both for the relaxation of more and more of the *ceteris paribus* or "other things equal" assumptions, and for the inclusion of more and more industries in the analysis, as required.

The first and simplest general equilibrium model was introduced in 1874 by the great French economist, Leon Walras. This model and subsequent general equilibrium models are necessarily mathematical in nature and include one equation for each commodity and input demanded and supplied in the economy, as well as market clearing equations. More recently, economists have extended and refined the general equilibrium model theoretically and proved that under perfect competition, a general equilibrium solution of the model usually exists with all markets simultaneously in equilibrium. Our analysis in this chapter is based on the assumption of perfect competition and follows a very simple model.

5.3 GENERAL EQUILIBRIUM OF EXCHANGE AND PRODUCTION

In this section, we examine separately general equilibrium of exchange and of production, and we derive the production-possibilities frontier. In the next section, we then examine how both equilibria are achieved simultaneously and the conditions for maximum economic efficiency.

5.3.1 General Equilibrium of Exchange

Let us begin by examining general equilibrium of exchange for a very simple economy composed of only

- Two individuals (A and B),
- Two commodities (X and Y),
- The tastes and welfare of individuals A and B are described by the following two utility functions.

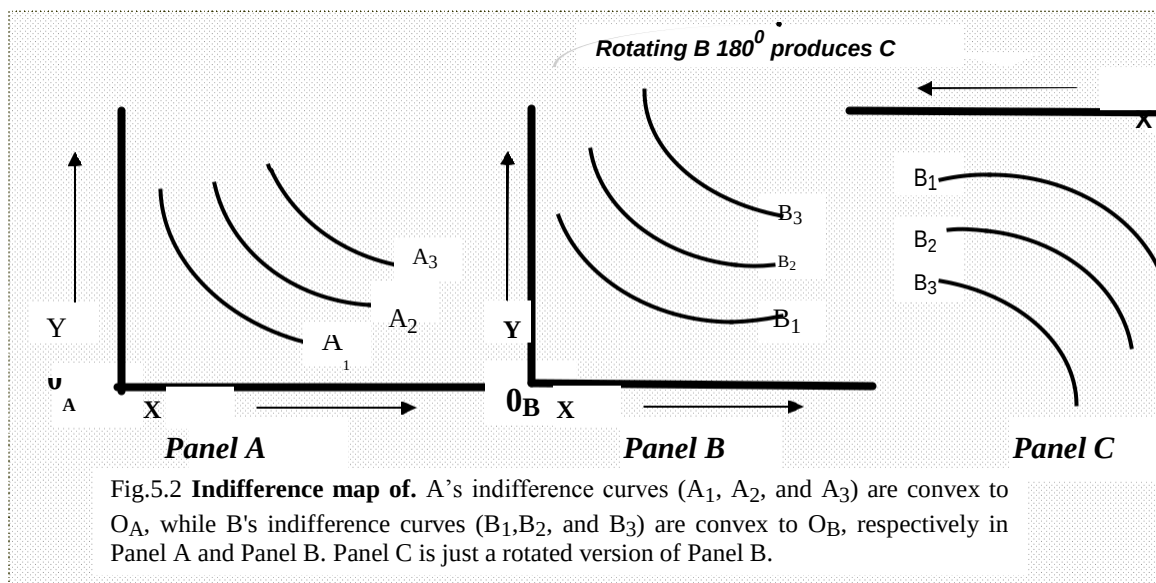
$$U_A = U(X_A, Y_A)$$

$$U_B = U(X_B, Y_B)$$

These functions are represented by the indifference curves in Fig 5.2 and 5.3.

- No production.

This allows us to present the general equilibrium of exchange graphically. Initially, let us present preferences of the individuals for the two commodities (Fig 5.2 (A) and (B)). It does not matter if we rotate Panel B 180°, to Panel C.



If you join Panels (A) and (B) of fig 5.2, you will get the Edgeworth box of figure 5.3. The *Edgeworth box diagram for exchange* shown in Figure 5.3 is obtained by rotating the indifference diagram for individual B by 180 degrees (so that origin O_B appears in the top right-hand corner) and superimposing it on the indifference diagram for individual B (with origin O_B) in such a way that the size of the box refers to the total amount of X and Y available to the two individuals (10X and 8Y).

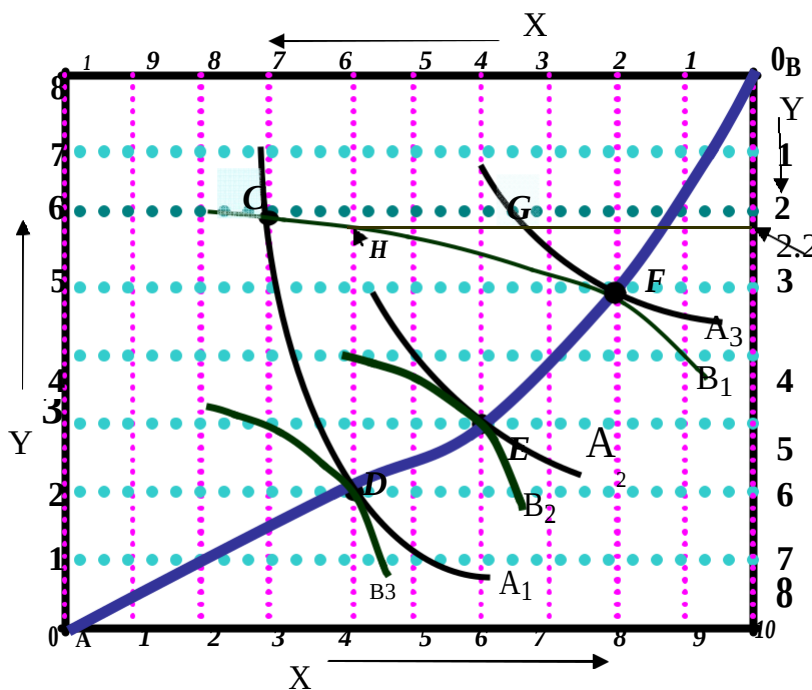


Fig.5.3 Edgeworth Box Diagram for Exchange.

Quick self check on
Edgeworth Box | **Q1. Can**
A achieve A_3 ?
By moving from C to G?
No, B is not willing to
exchange that way since it
puts him on lower
indifference curve than B_1 . |
Q2. Can A achieve A_3 by
moving from C to F? |
Possibly yes, since B is not
affected |
Q3. Can both benefit by
moving from C through
Exchange? | *Yes, if they*
move to some | *point*
between D and F. |

We can read from the edgeworth diagram that

- The economy does have 10X and 8y totally:
- $X = 10 = X_A + X_B$
 $Y = 8 = Y_A + Y_B$
 - Eg. A point such as **C** indicates that *individual A* has 3X and 6Y (viewed from origin O_A), while *individual B* has 7X and 2Y (viewed from origin O_B) out of the total of 10X and 8Y.

- Curve O_ADEFO_B is the **contract curve for exchange**. It is the locus of tangencies of the indifference curves (at which the MRS_{xy} are equal) for the two individuals where the economy is in general equilibrium of exchange.
- Starting from any point not on the contract curve, both individuals can gain from exchange by getting to a point on the contract curve.

Suppose that point C in Fig 5.3 represents the original distribution of commodities X and Y between individuals A and B. Since at point C, indifference curves A_1 and B_1 intersect, their slope or marginal rate of substitution of commodity X for Y (MRS_{xy}) differs. Starting at point C, individual A is willing to give up 4Y to get additional 1X (and move to point D on A_1), While individual B is willing to accept only 0.2Y in exchange for one unit of X (and move to point H on B_1). Because A is willing to give up much more Y than necessary to induce B to give up 1X, there is a basis for exchange that will benefit either or both individuals. This is true whenever, as at point C the MRS_{xy} for the two individuals differ. For example, starting from point C, if individual A exchanges 4Y for 1X with individual B, A moves from point C to point D along indifference curve A_1 , while B moves from point C on B_1 to point D on B_3 . Thus, individual B receives all of the gains from exchange while individual A gains or loses nothing (since A remains on A_1). At point D, A_1 and B_3 are tangent, so that their slopes (MRS_{xy}) are equal, and there is no further basis for exchange.

Alternatively, if individual A exchanged 1Y for 5X with individual B, individual A would move from point C on A_1 to point F on A_3 , while individual B would move from point C to point F along B_1 . Then, A would reap all of the benefits from exchange while B would neither gain nor lose. At point F, MRS_{xy} for A equals MRS_{xy} for B and there is no further basis for exchange. Finally, if A exchanges 3Y for 3X with B and gets to point E, both individuals gain from exchange since point E is on A_2 and B_2 . Thus, starting from point C, which is not on line DEF, both individuals can gain through exchange by getting to a point on line DEF between D and F. The greater A's bargaining strength, the closer the final equilibrium point of exchange will be to point F, and the greater will be the proportion of the total gains from exchange going to individual A (so that less will be left over for individual B).

Along the ***contract curve for exchange***, the marginal rate of substitution of commodity X for commodity Y is the same for individuals A and B, and the economy is in general equilibrium of exchange. Thus, for equilibrium,

$$MRS^A_{XY} = MRS^B_{XY}$$

Starting from any point not on the contract curve, both individuals can gain from exchange by getting to a point on the contract curve. Once on the contract curve, one of the two individuals cannot be made better off without making the other worse off. For example, a movement from point D (on A_1 and B_1) to point E (on A_1 and B_1) makes individual A better off but individual B worse off. Thus, the consumption contract curve is the locus of general equilibrium of exchange. For an economy composed of many consumers and many commodities, the general equilibrium of exchange occurs where the marginal rate of substitution between every pair of commodities is the same for all consumers consuming both commodities.

5.3.2 General Equilibrium of Production

In the preceding section we have examined general equilibrium in a pure exchange economy with no production. We turn to *general equilibrium of production* in a simple economy in which no exchange takes place.

To examine general equilibrium of production, we deal with a very simple economy that produces only two commodities (X and Y) with only two inputs, labor (L) and capital (K).

Suppose that the technological relationships in the economy are as follows:

$$X = X(L_X, K_X)$$

$$Y = Y(L_Y, K_Y)$$

These two functions are represented by the isoquants in Fig 5.4

Where, X and Y are the annual outputs. L and K are, respectively, labor and capital whose subscripts indicate the corresponding output for which they are used.

If $\bar{L}$ is the total (say, annual) available labor services and $\bar{K}$ is the (say, annual) available capital services, then this condition can be written as follows:

$$\bar{L} = L_X + L_Y$$

This is horizontal distance 5.4

$$\bar{K} = K_X + K_Y$$

This is vertical distance 5.4

L_X , L_Y , K_X , and K_Y are variables with values to be solved in the general equilibrium model. $\bar{L}$ and $\bar{K}$ are assumed to be in fixed supply.

Productive efficiency

Productive efficiency exists if it is not possible to reallocate inputs in to alternative uses in such a manner as to increase the output of anyone good without reducing the output of some alternative good.

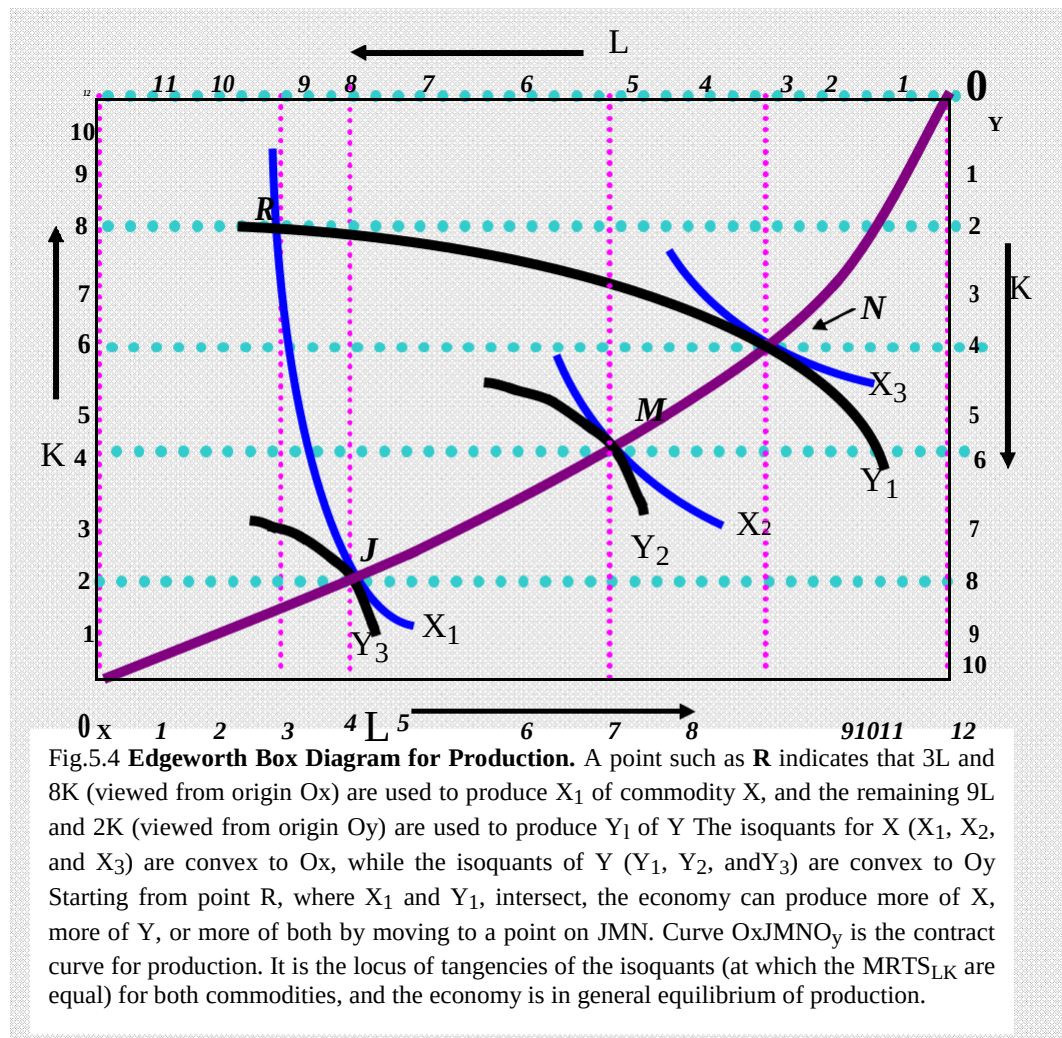
If productive resources are presumed to be always fully employed, then it must follow that:

$$L_X = \bar{L} - L_Y$$

$$K_X = \bar{K} - K_Y$$

Next, we construct an Edgeworth box diagram for production from the isoquants for commodities X and Y in a manner completely analogous to the Edgeworth box diagram for exchange of Figure 5.3. This is shown in Figure 5.4, accounting for the above equations.

The *Edgeworth box diagram for production* shown in Figure 5.4 is obtained by rotating the isoquant diagram for commodity Y by 180 degrees (so that origin 0_Y appears in the top right-hand corner) and superimposing it on the isoquant diagram for commodity X (with origin 0_X) in such a way that the size of the box refers to the total amount of L and K available to the economy (12L and 10K). Any point inside the box indicates how the total amount of the two inputs is utilized in the production of the two commodities. For example, Point R indicates that 3L and 8K are used in the production of X_1 of Commodity X and the remaining 9L and 2K are used to produce Y_1 of Y. Three of X's isoquants (convex to origin 0_X) are X_1 , X_2 and X_3 . Three of Y's isoquants (convex to origin 0_Y) are Y_1 , Y_2 and Y_3 .



If this economy was initially at point **R**, it would not be maximizing its output of commodities X and Y because, at point **R**, the marginal rate of technical substitution of labor for capital ($MRTS_{LK}$) in the production of X (the absolute slope of X_1) exceeds the $MRTS_{LK}$ in the production of Y (the absolute slope of Y_1). By simply transferring 6K from the production of X to the production of Y and 1L from the production of Y to the production of X, the economy can move from point **R** (on X_1 and Y_1) to point **J** (on X_1 and Y_3) and increase its output of Y without reducing its production of X.

Alternatively, this economy can move from point **R** to point **N** (and increase its output of X from X_1 to X_3 without reducing its output of Y_1) by transferring 2K from the production of X to the production of Y and 6L from Y to X. Or, by transferring 4K from the pro-

duction of X to the production of Y and 4L from Y to X, this economy can move from point R (on X_1 and Y_1) to point M (on X_2 and Y_2), and increase its output of both X and Y. At points J, M, and N, an X isoquant is tangent to a Y isoquant so that the $MRTS_{LK}$ in the production of X equals $MRTS_{LK}$ in the production of Y.

Curve 0xJMNOy is ***the contract curve for production***. It is the locus of tangency points of the isoquants for X and Y at which the marginal rate of technical substitution of labor for capital is the same in the production of X and Y. That is, the economy is in general equilibrium of production when

$$MRTS^X_{LK} = MRTS^Y_{LK}$$

Thus, by simply transferring some of the given and fixed amounts of available L and K between the production of X and Y, this economy can move from a point not on the contract curve for production to a point on the curve and increase its output of either or both commodities. Once on its production contract curve, the economy cannot increase the output of either commodity unless it reduces the output of the other. For example, by moving from point J (on X_1 and Y_3) to point M (on X_2 and Y_2), the economy increases its output of commodity X (by transferring 3L and 2K from the production of Y to the production of X), but its output of commodity Y falls. For an economy of many commodities and many inputs, the general equilibrium of production occurs where the marginal rate of technical substitution between any pair of inputs is the same for all commodities and producers using both inputs.

Derivation of Production Possibility frontier (PPF)

So far we have determined the conditions for equilibrium in exchange and production separately. Our general objective of this chapter is to determine the conditions for simultaneous equilibrium in both exchange and production. In order to do so we

- Derive the Production Possibility Frontier (PPF) from Edgeworth contract curve for production
- Bring the PPF and Edgeworth Box for exchange.

PPF shows the alternative combinations of commodities that the economy can produce by fully utilizing all of its resources with the best technology available to it. From the

production contract curve, we can derive the corresponding production-possibilities frontier or transformation curve by simply plotting the various combinations of outputs directly. For example, if isoquant X_1 in Figure 5.4 referred to an output of 4 units of commodity X and isoquant Y_3 referred to an output of 13 units of commodity Y, we can go from point J (X_1, Y_3) in Figure 5.4 to point J (4X, 13Y) in Figure 5.5. Similarly, if isoquant X_2 referred to an output of 10X and isoquant Y_2 to an output of 8Y, we can go from point M (X_2, Y_2) in Figure 5.4 to point M (10X, 8Y) in Figure 5.5.

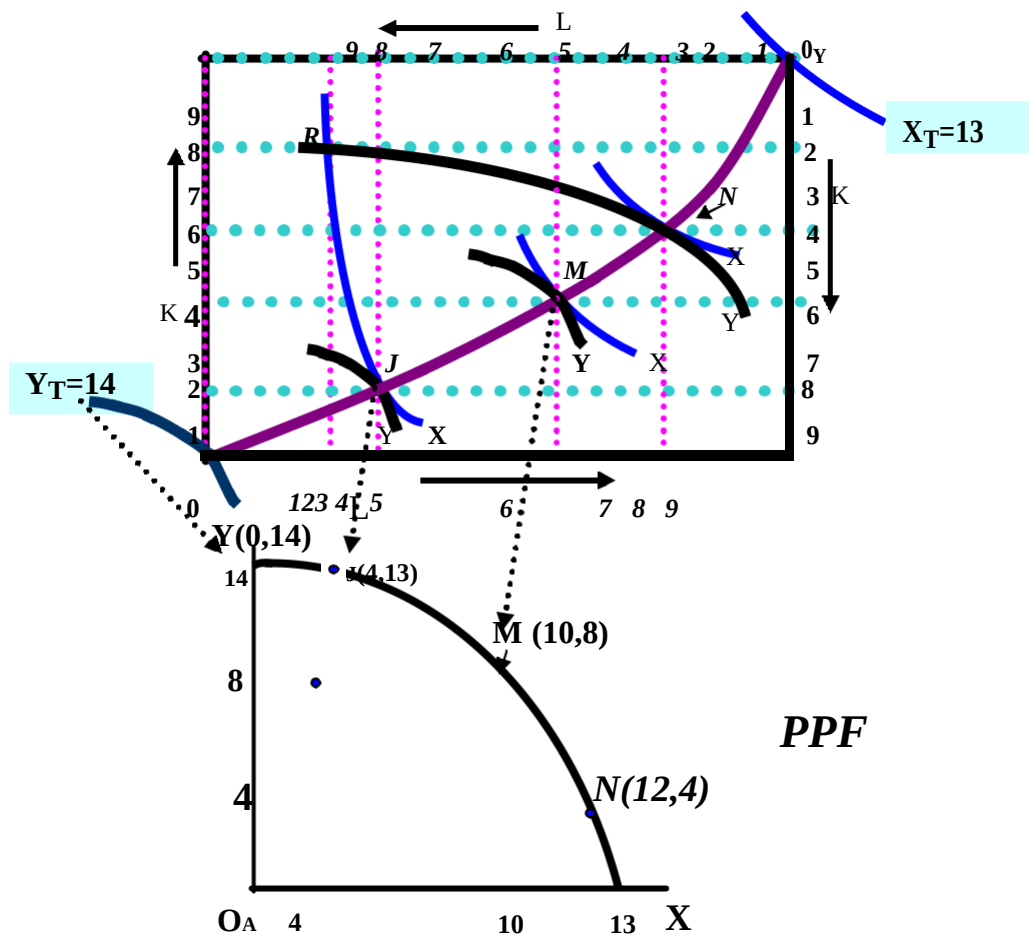


Fig. 5.5 Deriving PPF from Edgeworth Box for Production

Finally, if $X_3 = 12X$ and $Y_1 = 4Y$, we can plot point N (X_3, Y_1) from Figure 5.4 as point N ($12X, 4Y$) in Figure 5.5. By joining points JM N and other points similarly obtained, we derive the production possibilities frontier or transformation curve of X for Y as shown in Figure 5.5. *Thus, the production-possibilities frontier is obtained by simply mapping or transferring the production contract curve from input space to output space.*

The production-possibilities frontier or transformation curve shows the various combinations of commodities X and Y that the economy can produce by fully utilizing all of the fixed amounts of labor and capital with the best technology available. Since the production contract curve shows all points of general equilibrium of production, so does the production-possibilities frontier. That is, the production-possibilities frontier shows the maximum amount of either commodity that the economy can produce, given the amount of the other commodity that the economy is producing. Once on the production-possibilities frontier, the output of either commodity can be increased only by reducing the output of the other.

The absolute value of the slope of the PPF measures the amount of Y foregone in order to produce one extra unit of X. It is called the **marginal rate of transformation** of X for Y (MRT_{XY}). Clearly, transformation of X for Y is made by releasing enough amount resources from production of Y that enables production of an extra unit of X. In other words, marginal rate of transformation is equal to the ratio of marginal cost of X to

$$\text{marginal cost of Y: } MRT_{XY} = \frac{MC_X}{MC_Y}.$$

For example, at M if $MRT_{XY} = 1.5$,

or $\frac{MC_X}{MC_Y} = 1.5$, meaning that the economy gives up 1.5 amount of Y in order to produce an extra unit of X.

The more costly it becomes to produce an extra unit of X, the more resources are released from production of Y, meaning that more units of Y have to be given up. This is reflected in the shape of PPF that the absolute value of its slope increases as we move down the

curve. The reason for this is that, as the economy reduces its output of Y (in order to produce more of X), it releases labor and capital in combinations that become less and less suited for the production of more X . Thus, the economy incurs increasing MC_X in terms of Y . It is because of this imperfect input substitutability between the production of X and Y (and rising MC_X in terms of Y) that the production-possibilities frontier is concave to the origin.

5.4 GENERAL EQUILIBRIUM OF PRODUCTION AND EXCHANGE AND PARETO OPTIMALITY

In this section, we examine general equilibrium of production and exchange and define the concept of Pareto optimality, which summarizes the marginal conditions for economic efficiency.

5.4.1 General Equilibrium of Production and Exchange Simultaneously

We now can use the production-possibilities frontier and the contract curve for exchange to examine how our very simple economy composed of two individuals (A and B), two commodities (X and Y), and two inputs (L and K) can reach *simultaneously* general equilibrium of production and exchange. This equilibrium is shown in Figure 5.6. The production-possibilities frontier of Figure 5.6 is that of Figure 5.5, which was derived from the production contract curve of Figure 5.4. Thus, every point on production possibilities frontier is a point of general equilibrium of production. Suppose that this economy produces $10X$ and $8Y$, given by point M on production-possibilities frontier in Figure 5.6. By dropping perpendiculars from point M to both axes, we can construct in Figure 5.6 the Edgeworth box diagram for exchange between individuals A and B of Figure 5.3. Note that the top right-hand corner of the Edgeworth box diagram for exchange of Figure 5.3 coincides with point M on PPF in Figure 5.6. Given the indifference curves of individuals A and B and the output of $10X$ and $8Y$, we derived contract curve O_ADEFO_B for exchange in Figure 5.3. This curve is reproduced in Figure 5.6.

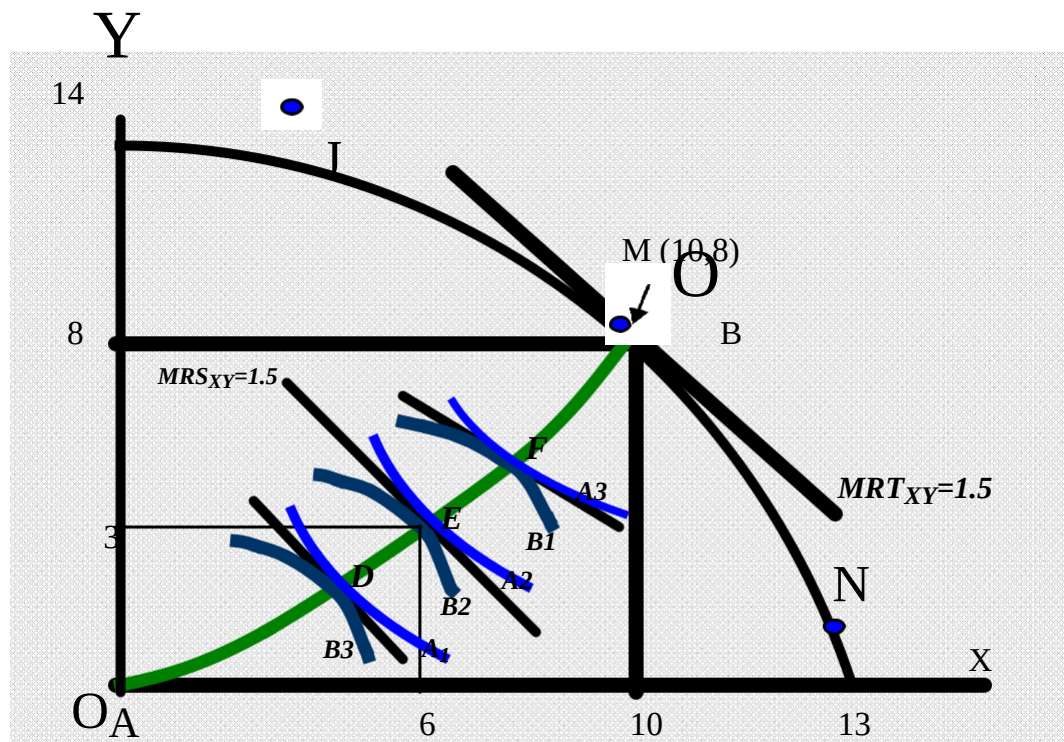


Fig.5.6 Derived PPF.

The PPF or transformation curve is derived by mapping the production contract curve of Figure 5.4 from input to output space. The absolute slope or $MRT_{xy} = 3/2$ at point M, means that 3/2 of Y must be given up to produce one additional unit of X. MRT_{xy} increases as we move down the frontier. For example, at point N, $MRT_{xy} = 3$.

Every point on the contract curve for exchange in Figure 5.6 is a point of general equilibrium of exchange.

Thus in Figure 5.6,

- Every point on PPF is a point of generalequilibrium of production, and
- Every point on the contract curve for exchange is a point of general equilibrium of exchange: $MRS^A_{xy} = MRS^B_{xy}$
- To be *simultaneously* in general equilibrium of production and exchange, the marginal rate of transformation of commodity X for commodity Y in production must be equal to the marginal rate of substitution of commodity X for commodity Y in consumption for individuals A and B. That is,

$$MRT_{XY} = MRS^A_{XY} = MRS^B_{XY}$$

Geometrically, this equation corresponds to the point on the contract curve for exchange at which the common slope of an indifference curve of individual A and individual B equals the slope of PPF at the point of production. In Figure 5.6, this occurs at point *E*, where

$$MRS^A_{XY} = MRS^B_{XY} = MRT_{XY} = 1.5$$

Thus, when producing 10X and 8Y (point *M* on PPF), this economy is simultaneously in general equilibrium of production and exchange when individual A consumes 6X and 3Y (point *E* on his/her indifference curve *A*₂) and individual B consumes the remaining 4X and 5Y (point *E* on his/her indifference curve *B*₂).

If the above condition did not hold, the economy would not be simultaneously in general equilibrium of production and exchange. For example, suppose that individuals A and B consumed at point *D* on the contract curve for exchange rather than at point *E* in Figure 5.6. At point *D*, the $MRS^A_{XY} MRS^B_{XY} = 3$. This means that individuals A and B are willing (indifferent) to give up 3 Y to obtain one additional unit of X. Since in production only 1.5 Y needs to be given up to produce an additional unit of X, society would have to produce more of X and less of Y to be simultaneously in general equilibrium of production and exchange. That is, if $MRS_{XY} = 3$, this society would not have chosen to produce at point *M*, but would have produced at point *N* (12X and 4Y), where

$$MRS_{XY} = MRT_{XY} = 3.$$

The opposite is true at point *F*. That is, at point *F*, $MRS_{XY} = 1/2$. Since $MRT_{XY} = 1.5$ at point *M*, more of Y needs to be given up in production to obtain one additional unit of X than individuals A and B are willing to give up in consumption. If this were the case, this society would have chosen to produce at point *J* (4X and 13Y) where $MRS_{XY} = MRT_{XY} = 1/2$, rather than at point *M*.

Only by consuming at point *E* will $MRT_{XY} = MRS_{XY}$ for both individuals, and society will be simultaneously in general equilibrium of production and exchange when it produces at point *M*'.

5.4.2 Marginal Conditions for Economic Efficiency and Pareto Optimality

With general equilibrium of production and exchange, economic efficiency is maximum and we have Pareto optimality. According to this concept, *a distribution of inputs among commodities and of commodities among consumers is Pareto optimal or efficient if no reorganization of production and consumption is possible by which some individuals are made better off (in their own judgment) without making someone else worse off.* Any change that improves the well-being of some individuals without reducing the well-being of others clearly improves the welfare of society as a whole and should be undertaken. This will move society from a Pareto nonoptimal position to Pareto optimum. Once at Pareto optimum, no reorganization of production and exchange is possible that makes someone better off without, at the same time, making someone else worse off. To evaluate such changes requires interpersonal comparisons of utility, which are subjective and controversial.

In a very simple economy of two individuals, two commodities (X and Y), and no production, the contract curve for exchange (along which the MRS_{xy} is the same for both individuals) is the locus of Pareto optimum in exchange and consumption. A movement from a point off the contract curve to a point on it improves the condition of either or both individuals, with the given quantities of the two commodities. Once on the contract curve, the economy is in general equilibrium or Pareto optimum in exchange, in the sense that either individual can be made better off only by making the other worse off. In an economy of many individuals and many commodities, Pareto optimum in exchange requires that the marginal rate of substitution between any pair of commodities be the same for all individuals consuming both commodities.

In a very simple economy of two commodities, two inputs (L and K), and no exchange, the production contract curve (along which the $MRTS_{LK}$ is the same for both commodities) is the locus of Pareto optimum in production. A movement from a point off the production contract curve to a point on it makes it possible for the economy to produce more of either or both commodities, with the given inputs and technology. Once on the production contract curve, the economy is in general equilibrium or Pareto op-

timum in production in the sense that the economy can increase the output of either commodity only by reducing the output of the other. In an economy of many commodities and many inputs, Pareto optimum in production requires that the marginal rate of technical substitution between any pair of inputs be the same for all commodities and producers using both inputs.

Finally, Pareto optimum in production and exchange simultaneously in an economy of many inputs, many commodities, and many individuals requires that the marginal rate of transformation in production equals the marginal rate of substitution in consumption for every pair of commodities and for every pair of individuals consuming both commodities. In the case of a very simple economy composed of only two commodities and two individuals (A and B), Pareto optimality in production and consumption requires that $MRT_{XY} = MRS^A_{XY} = MRS^B_{XY}$, where production and consumption are economically efficient and society maximizes welfare.

5.5 PERFECT COMPETITION, ECONOMIC EFFICIENCY, AND EQUITY

In this section we show why perfect competition leads to economic efficiency or Pareto optimum, but not necessarily to equity.

Perfect Competition and Economic Efficiency

With perfect competition in all input and commodity markets, the three marginal conditions for economic efficiency or- Pareto optimum in production and exchange are automatically satisfied. This is the basic argument for perfect competition. We can easily prove that perfect competition leads to economic efficiency.

Consumer maximizes utility or satisfaction when he or she reaches the highest indifference curve possible with his or her budget line. This occurs where an indifference curve is tangent to the budget line. At the tangency point, the slope of the indifference curve (the MRS_{xy}) is equal to the slope of the budget line (P_x/P_y). Since P_x and P_y , and thus P_x/P_y , are the same for all consumers under perfect competition, the MRS_{xy} is also the same for all consumers consuming both commodities. This is the ***first marginal condition for economic efficiency*** or ***Pareto optimum*** in exchange. In the foregoing analysis we do have assumed equilibrium to be at $MRS_{XY} = P_x/P_y = 1.5$

It can be recalled from your previous lessons that efficiency in production requires that the $MRTS_{LK} = w/r$ (the ratio of the input prices given by the absolute value of the slope of the isocost line). Since w and r , and thus w/r , are the same for all producers under perfect competition, the $MRTS_{LK}$ is also the same for all producers using both inputs. This is **the second marginal condition for economic efficiency** or **Pareto optimum** in production. In the foregoing analysis we do have assumed equilibrium to be at $MRTS_{LK}=w/r=1.5$

At Equilibrium

§ Perfectly competitive firms produce where $MC_x = P_x$ and $MC_y = P_y$.

$$\text{§ } MC_x/MC_y = P_x/P_y$$

§ $MRT_{xy}=MC_x/MC_y$, (Section 5.3.2)

$$\text{§ Therefore, } \underline{MC_x/MC_y = P_x/P_y = MRT_{xy}.}$$

Since we have also seen above that under perfect competition $MRT_{xy} = P_x/P_y$ for all consumers consuming both commodities, we conclude that $MRT_{xy} = MRS_{xy}$ for all consumers consuming both commodities. This is **the third marginal condition for economic efficiency** and Pareto optimum in production and exchange.

The output of 10X and 8 Y at point M in Figure 5.6 is based on a particular distribution of inputs (income) between individuals A and B and on their tastes. A different distribution of income and/or tastes for individuals A and B would lead to a different combination of goods X and Y demanded. This would result in a different P_x/P_y , different quantities of X and Y produced, and different levels of satisfaction for A and B. For example, suppose that individuals A and B demanded 12X and 4Y (point N in Figure 5.6). Then, general equilibrium of production and exchange or Pareto optimality requires that

$$MRT_{xy} = P_x/P_y = MRS^A_{xy} = MRS^B_{xy} = 3.$$

This involves constructing an Edgeworth box diagram from point N. In a purely exchange economy (i.e., one in which there is no production), the equilibrium P_x/P_y is the one that exactly matches the desired quantity of X and Y that each individual wants to exchange. If B wants more of X for a given amount of Y than A is willing to exchange, then P_x/P_y will rise until the demand for the quantities of X and Y to be

exchanged match. Similarly, if B wants less of X for a given amount of Y than A is willing to exchange, P_X/P_Y will fall until equilibrium is reached.

Efficiency and Equity

According to the **first theorem of welfare economics**, an equilibrium produced by competitive markets exhausts all possible gains from exchange, or that equilibrium in competitive markets is Pareto optimal.

There is also a **second theorem of welfare economics**, which postulates that when indifference curves are convex to their origin, every efficient allocation (every point on the contract curve for exchange) is a competitive equilibrium for some initial allocation of goods or distribution of inputs (income).

Activity: by now, you must have clearly understood that any point on the contract curve for exchange is efficient, regardless of the position of individual A or B. Now, the question is: is any point on the contract curve for exchange equitable as well? Why?

Efficient outcomes are not necessarily equitable. The significance of the second welfare theorem is that the issue of equity in distribution is logically separable from the issue of efficiency in allocation. This means that whatever the redistribution of income that society wants would lead to the exhaustion of all possible gains from exchange under perfect competition. Pareto optimality does not, therefore, imply equity: Society can use taxes and subsidies to achieve what it considers to be a more equitable distribution of income. These may discourage work, however, and show that there is usually a trade-off between efficiency and equity.

For economic efficiency and Pareto optimum to be reached, there should be no market failure.

To show that imperfect competition in the product market leads to economic inefficiency and Pareto nonoptimality, remember that a profit-maximizing firm always produces where marginal revenue (MR) equals marginal cost (MC). If commodity Y is produced in

a perfectly competitive market,

$$P_Y = MR_Y = MC_Y.$$

On the other hand, if commodity X is produced by a firm with monopoly power,

$$P_X > MR_X \text{ and } P_X > MC_X.$$

$$\text{Then, } MRT_{XY} = \frac{MC_X}{MC_Y} = \frac{MR_X}{MR_Y} < \frac{P_X}{P_Y}$$

$$\text{But } \frac{P_X}{P_Y} = MRS_{XY}. \text{ If so, } MRT_{XY} < MRS_{XY},$$

Therefore, the third condition for Pareto optimum and economic efficiency is violated.

To show that imperfect competition in the input market leads to economic inefficiency and Pareto nonoptimality, remember that in Chapter Four of this Module it was shown that a profit maximizing firm always produces where the Value of Marginal product (VMP) of each input equals the marginal resource cost (MRC) for the input. If P_I is the price of the input, and the input market is perfectly competitive, $VMP = MRC = P_I$. Otherwise, $VMP = MRC > P_I$.

Now suppose that all markets in the economy are perfectly competitive, except that the firm producing commodity X is a monopsonist in its labor market (i.e., it is the sole employer of labor in its labor market).

Therefore, $VMP = MRC > P_I$ in the production of X, while

$$VMP = MRC = P_I \text{ in the production of Y. (Notice our assumption that the only producer of X does have monopsony power).}$$

That is, $MRTS_{LK}^X > MRTS_{LK}^Y$ so that the first of the conditions for Pareto optimum and economic efficiency is violated. In other words, the maximizing behavior of producers and consumers no longer acts to achieve efficiency automatically. For this reason, monopoly (and monopsony) power is considered undesirable by normative economists.

Finally, note that perfect competition leads to efficiency and Pareto optimum in production and exchange *at a particular point in time*. Over time, tastes, the supply of

inputs, and technology change; what is most efficient at one point in time may not be most efficient over time. In short, perfect competition leads to *static, but not necessarily to dynamic, efficiency*.

5.6 CHAPTERSUMMARY

1. This chapter has been devoted to general equilibrium analysis by assuming perfect competition for which the general equilibrium exists.
2. With its advantage of convenience, partial equilibrium analysis studies the behavior of individual decision-making units and individual markets, viewed in isolation. General equilibrium analysis studies the interdependence that exists among all markets in the economy. Only when an industry is small and has few direct links with the rest of the economy is partial equilibrium analysis appropriate.
3. A simple economy of two individuals (A and B), two commodities (X and Y), and two inputs (L and K) is in general equilibrium of exchange when the economy is on its contract curve for exchange. This is the locus of tangency points of the indifference curves (at which the MRS_{XY} are equal) for the two individuals. The economy is in general equilibrium of production when it is on its production contract curve. This is the locus of the tangency points of the isoquants (at which $MRTS_{LK}$ are equal) for the two commodities. By mapping or transferring the production contract curve from input to output space, we derive the corresponding productionpossibilities frontier.
4. For the economy to be simultaneously in general equilibrium of production and exchange, the marginal rate of transformation of X for Y in production must be equal to the marginal rate of substitution of X for Y in consumption for individuals A and B. That is, $MRT_{XY} = MRS^A_{XY} = MRS^B_{XY}$. Geometrically, this corresponds to the point on the contract curve for exchange at which the common slope of the indifference curve of the two individuals equals the slope of the production-possibilities frontier at the point of production. A distribution

of inputs among commodities and of commodities among consumers is Pareto optimal or efficient if no reorganization of production and consumption is possible by which some individuals are made better off without making someone else worse off. Thus, the conditions for Pareto optimality are the conditions for general equilibrium of production and exchange.

5. Under perfect competition in all input and output markets. All the conditions for Pareto optimum are automatically satisfied. This is the basic argument in favor of perfect competition and proof of Adam Smith's law of the invisible hand. The first theorem of welfare economics postulates that equilibrium in competitive markets is Pareto optimal. The second theorem of welfare economics postulates that equity in distribution is logically separable from efficiency in allocation. Perfect competition leads to maximum economic efficiency only in the absence of market failures.

Chapter Six

INFORMATION ASYMMETRY:INTRODUCTION

Information imperfections are pervasive in the economy: indeed, it is hard to imagine what a world with perfect information would be like. ...different people know different things [asymmetries of information]: workers know more about their ability than does the firm; the person buying insurance knows more about his health, whether he smokes and drinks immoderately, than the insurance firm; the owner of a car knows more about the car than potential buyers; the owner of a firm knows more about the firm than a potential investor; the borrower knows more about his risk and risk taking than the lender.

JOSEPH E. STIGLITZ, “Information and the Paradigm in
Economics” Prize Lecture, December 8, 2001, PP: 17

6.1 INTRODUCTION

Information is a valuable economic resource. It makes difference if you know where to buy high-quality goods, if you know how much effort your employees are exerting, if you know how careless a driver your customer is. Most economic analysis assumes that buyers and sellers are both perfectly informed about the quality of the goods being sold in the market. If it is not costly to tell which goods are high-quality goods and which are low-quality goods, then the prices of the goods will simply adjust to reflect the quality difference. On the other hand if information about quality is costly to obtain, then it is no longer plausible that buyers and sellers have the same information about goods involved in transactions. In the real world, in many markets it may be very costly or even impossible to gain accurate information about the quality of the goods being sold. Such difference in access to relevant knowledge is called *information asymmetry*.

While analyzing choice under uncertainty in Chapter III of your Microeconomics I, we have assumed that individuals know the probability distributions over outcomes and on what outcomes would be observed in each state of the world. In reality, these assumptions are likely to be violated. First, individuals may have private information about their true probabilities of suffering losses. Second, they may be able to take unobservable actions which can either affect the probability of a loss or affect the size of any loss that might occur.

Although information asymmetry is applicable to wider areas, this introductory chapter delimits itself to the use of the famous, ‘market of the lemon’.

Chapter Objectives

At the end of this chapter, you should be able to:

- Define information Asymmetry
- Explain how lower quality products drive high quality goods in the presence of asymmetric Information
- Measure the loss to society due to Information Asymmetry

Chapter Outline

- 6.1 Introduction
- 6.2 Properties of Information
- 6.3 The Mixed Markets for Used Cars
- 6.4 Ignorant Consumers and Knowledgeable Sellers
- 6.5 Equilibrium in the mixed market
- 6.6 Measuring loss of information asymmetry

6.2 PROPERTIES OF INFORMATION

Why, do you think, is market mechanism may fail to perfectly allocate resources to information provision and acquisition? The answer to this question becomes clear once we look at the following properties of information.

Properties of information:

- Information is not a homogeneous good.
- It is hard to quantify the amount of information obtainable from various actions.
- Information is a durable good.
- Information is a pure public good. It is non-rival (others may use at zero cost) and non-excludable (no individual can prevent others from using the information).
- The cost of acquisition of information varies significantly among individuals. Some individuals may possess specific skills relevant to information acquisition.

Thus, the level of information may differ among the participants in market transactions.

Sortly, these properties of information imply that market mechanism may often operate imperfectly in allocating resources to information provision and acquisition.

We will further see how information asymmetry causes market failure. We will start by discussing two types of problems raised by differences in information. *Adverse selection* refers to situation where one side of the market cannot observe the type of quality of goods on the other side of the market. For his reason, it is sometimes called hidden information problem. In contrast, moral hazard refers to situation where one side of the market cannot observe the actions of the other. For this reason, it is sometimes called *hidden action* problem.

6.3 THE MIXED MARKETS FOR USED CARS

The common example of a market with imperfect information is the market for used cars. Suppose that prospective buyers cannot distinguish between low quality cars (lemons) and high quality cars (plums). Although a buyer can get some information about a particular car by looking at the car and taking it for a test drive, this information is not sufficient to indicate whether the car is a lemon or a plum. There is *asymmetric information* in a market if one side of the market has better information than the other. In other words, information asymmetry refers to the fact that the buyer and the seller of a product may have different amounts of information about that product's attributes.

For example, the sellers of used cars know more than the buyers. Because buyers cannot distinguish between lemons and plums, there will be a single market for the two types of used cars. Lemons and plums will be sold together in a mixed market for the same price. We start our discussion of the used car market with an extreme case, a market in which all the cars on the market will be lemons. This extreme case is unrealistic, but it provides a useful starting point for a discussion of the implications of asymmetric information. It shows that one possibility is the disappearance of the market for high quality good. As we will see later, the more realistic case is a situation in which most-but not all-the used cars are lemons, so there is a small chance that a buyer will get high-quality good.

6.4 IGNORANT CONSUMERS AND KNOWLEDGEABLE SELLERS

How much is a consumer willing to pay for a used car that could turn out to be either a lemon or plum? To determine price in mixed market, we must answer three questions:

- i. How much is a consumer willing to pay for a plum (a high-quality car)?
- ii. How much is a consumer willing to pay for a lemon (a low-quality car)?
- iii. What is the chance that a used car purchased in the mixed market will turn out to be a lemon?

Suppose that a typical buyer is willing to pay \$14,000 for a plum and \$10,000 for a lemon. In addition, suppose that a consumer has neutral expectations about the used car market: he assumes that half the used cars are lemon and the other half are plums, so there is a 50% chance of being a lemon. How much is he willing to pay for a car that has a 50% chance of being a lemon? A reasonable assumption is that he is willing to pay the average value of the two types of cars, that is, \$12,000.

In contrast to buyers, the sellers of the used cars are knowledgeable. The current owner of the used car knows from experience whether his car is a lemon or a plum. Given a single market price for all used cars- lemons and plums alike-each current owner must decide whether or not to sell his car. We can use the supply curve for lemon and plums to show how many plums and lemons will be supplied at a particular price.

Figure 6.1 shows two hypothetical supply curves: one for plums and another for lemons. The minimum price for plums is \$10800, below which no plum will be supplied. As shown by the plum supply curve, as price increases, the number of plums supplied increases. For example, five plums will be supplied at price of \$12000 (*point n*). The minimum price for lemons is \$4000, below which no lemon will be supplied. Lemons do have a lower minimum price because they are worth less to their current owners. As shown by the lemon supply curve the number of lemons supplied also increases as price increases. For example, 20 lemons will be supplied at price of \$12000 (*point m*).

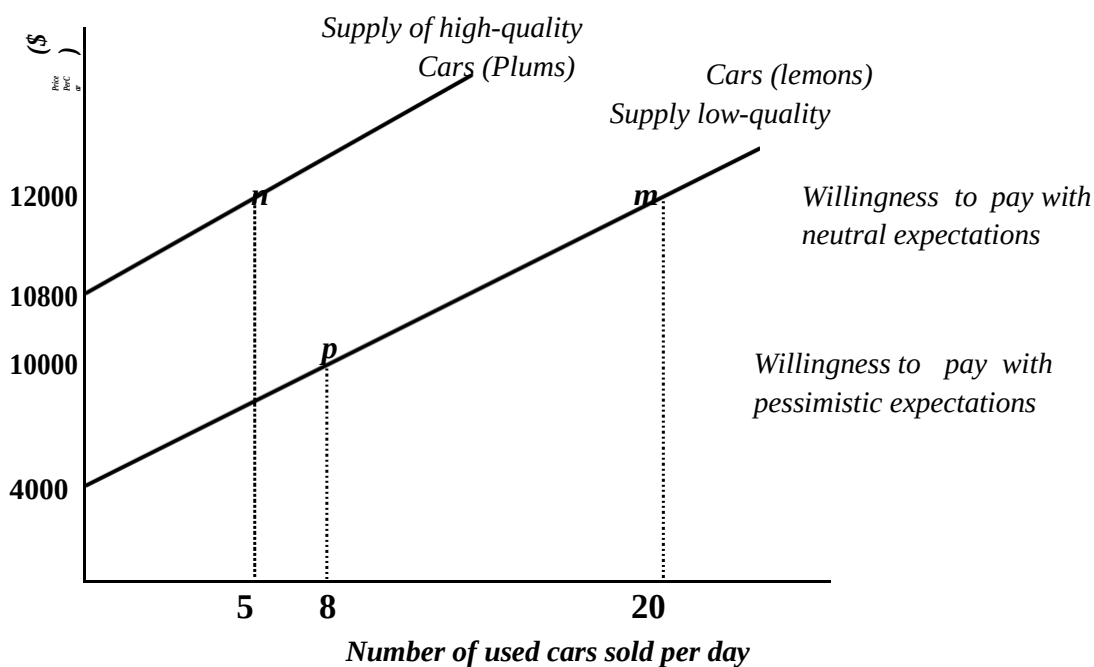


Fig. 6.1 Mixed Market and Information Asymmetry

6.5 EQUILIBRIUM IN THE MIXED MARKET

We do have two scenarios for our hypothetical used car markets: with neutral expectations and pessimistic expectations. These are summarized in Table 6.1. If consumers assume that half the used cars on the market are lemons and half are plums, the typical buyer will be willing to pay \$12,000 for a used car. At this price, 5 plums and 20 lemons will be supplied. So, 80% of the used cars (20 of 25) are lemons. In this case, consumers underestimate the chance of getting a lemon.

What will consumers do when they realize that they have underestimated the chance of getting a lemon? They certainly won't be willing to pay \$12,000 for a used car. In general, the greater the chance of getting a lemon, the smaller the amount that consumers are willing to pay. As a result, the price of used cars will decrease. Consequently, the market is not in equilibrium since there is pressure to change the price. Therefore, *the neutral expectations scenario is not equilibrium.*

Suppose that after observing the outcome in the first scenario, buyers become very pessimistic and assume that all the used cars on the market are lemons (chance of 100%).

Table 6.1 Equilibria in the Mixed Mixed Market

	<i>Neutral expectations</i>	<i>Pessimistic expectations</i>
<i>Assumed chance of lemon</i>	<i>50%</i>	<i>100%</i>
Willingness to pay for lemon	\$10,000	\$10,000
Willingness to pay for plums	\$14,000	\$14,000
Willingness to pay for used car (average)	\$12,000	\$10,000
Number of lemon supplied	20	8
Number of plum supplied	5	0
Total number of used cars	25	8
<i>Actual chance of lemon</i>	<i>80%</i>	<i>100%</i>

Under this assumption, the typical consumer will be willing to pay only \$10,000 (the value of a lemon) for a used car (average). This price is less than the minimum price for plum (10,800), so *plums will disappear from the used car market*. This is shown in figure 6.1: at price of 10,000, the quantity of plums supplied is zero, but the quantity of lemons is eight (*point p*). In other words, all the used cars will be lemons, and consumers' pessimism is justified. Because consumers' expectations are consistent with their actual experiences in the market, equilibrium prices of used cars is \$10,000 where eight lemons and zero plums are sold per day. No plums are sold and bought! Every buyer will get a lemon.

The above analysis has clearly shown the domination of the used car markets by the lemons. Such domination is an example of ***adverse selection problem***. The uninformed side of the market (buyer in this case) must choose from an undesirable or adverse selection of goods (used cars).

The asymmetric information in the market generates a ***downward spiral of price and quantity***:

A decrease in price decreases the quantity of high-quality cars supplied, depressing the price even further when buyers realize the lower average quality of cars on the market, which leads to even fewer high-quality cars on the market.

On the extreme case, this downward spiral continues until all the cars on the market are lemons where every buyer gets a lemon.

6.6 MEASURING LOSS DUE TO INFORMATION ASYMMETRY

When an individual decides to try to sell a bad car, he affects the *purchasers' perceptions* of the quality of the average car on the market. This lowers the price that people are willing to pay, and hurts those who want to sell good cars. This externality creates the market failure. As Akerlof points out, in some cases, buyers will only purchase lemons because they will not be willing to pay a premium for goods (cars in Akerlof's example) which are represents as high-quality, but which might be lemons. *If buyers express demand only for lemons, only lemons will be sold, even though both buyers and sellers of good quality cars would be better off if high-quality goods could be identified and sold for high price.* This is market failure.

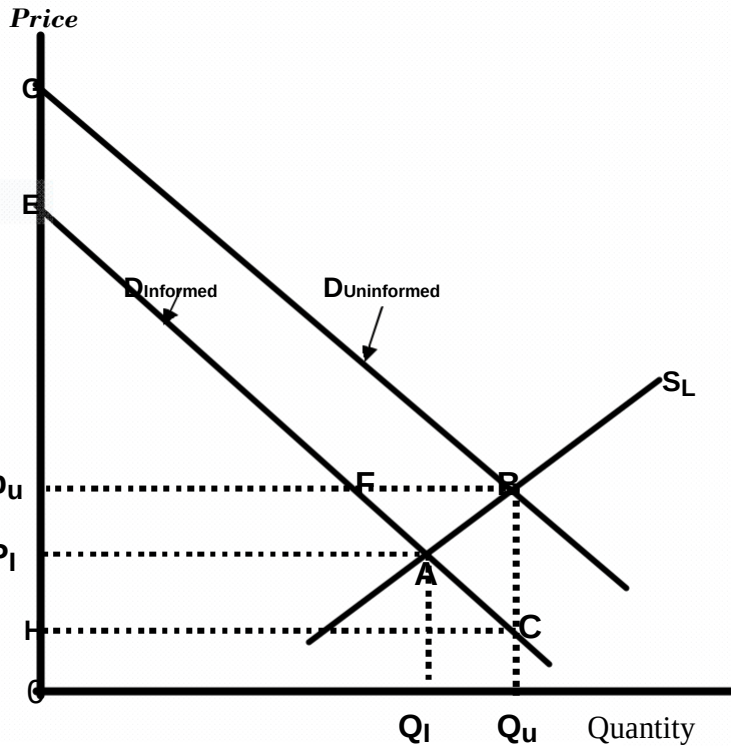


Fig. 6.2. Lemon Market and Loss due to Information Asymmetry

In Fig. 6.2 D_U and D_I represent the consumer's demand schedule in, respectively, the absence and presence of perfect information about its quality: they are, respectively, the consumer's 'uninformed' and 'informed' demands. The quantity actually purchased is Q_U and this is greater than Q_I , the quantity the consumer would have bought had he been fully informed. The gain in producer's surplus from 'over-consumption' is $P_U B A P_I$. The loss in consumer's surplus from over-consumption is:

$$A P_I E - (O E C Q_U - O P_U B Q_U) = A P_I E - (P_U E F - F B C) = A P_I P_U F + F B C.$$

So, the **net loss to society** from 'overconsumption' is loss in consumer's surplus less gain in producer's surplus $= A P_I P_U F + (A F B + A B C) - (A P_I P_U F + A F B)$

$$= A B C.$$

☺Check Your Progress 1

Suppose that due to asymmetric information, consumers in a town are not able to exactly distinguish between *original, high quality* (plum), MP3 song collections and the *duplicated, low quality* (lemon) MP3. The consumers do perceive the average quality. Indeed, through time the lemons have driven out the plums out of markets. As a result, only the former exist and the town is served with the lemon market, where the supply function is

$$N = 20 + p ; N \text{ is the number of MP3 per week.}$$

Had the consumers been informed, the demand in the town could have been

$$N_{Inf} = 38 - 2p$$

However, the existing demand is uninformed one given by:

$$N_{un\ inf} = 50 - 2p .$$

Required: With the use of graphical aid (mandatory),

- i. Find the equilibrium numbers MP3 CDs sold per week and corresponding prices.
 - a. With uninformed demand
 - b. Had demand been informed
 - ii. Show your results on your graphs. (**Hint: Use graphs similar to Fig 6.2**)
 - iii. Due to the information asymmetry, how much is:
 - a. gain in producer surplus?
 - b. consumer surplus loss?
 - c. net loss to the society?
-

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Answer to Self Check and Review Questions

Chapter one

Check your progress 1

Some of the difference in the assumptions of the two market structures lies in

- A. Number of firms. (very large in perfect competition, many in monopolistic competition)
- B. Nature of the product (homogeneous in perfect competition and differentiated in monopolistic competition)
- C. Firms under monopolistic competition commands a certain degree of monopoly power over their product price and quantity, while firms under perfect competition are price takers.
- D. Entry is fully free in perfect competition but there is implicit entry barrier in monopolistic competition.
- E. Selling costs and advertising are important in monopolistic competition, and they are causes of resource wastage. As every firm under perfect competition can sell whatever level of output produced, selling costs and advertising are irrelevant.

Check your progress 2

- When both are used for the same purpose and are sold at the same price.

Check your progress 3

- While selling costs are incurred to increase the demand for a firm's product, production costs are incurred to create utility, hence satisfy a given demand.

Check your progress 4

An industry is a collection of firms producing homogeneous product (a concept in perfect competition). But a product group is a collection of firms producing closely related products. The cross price elasticity of demand for products produced by firms in the same group has to exceed some pre-assigned value.

Check your progress 5

- Solution

$$\text{Given } LAC = X^2 - 25X + 278$$

$$X = 157 - \frac{1}{3}P$$

Required: long run equilibrium output and price.

Solution: the long run equilibrium of the firm will occur at point of tangency of the proportion demand curve and LAC curve. Thus, $P = LAC$. But the LAC is given in terms of X , so we have to change the proportionate demand curve in such a way that price will be a function of X . so that $P = 157 - 3X$

$$P = LAC \Rightarrow 157 - 3X = X^2 - 25X + 278$$

$$\Rightarrow X^2 - 25X + 3X + 278 - 157 = 0$$

$$\Rightarrow X^2 - 22X + 121 = 0$$

$$\Rightarrow (X - 11)^2 = 0$$

$$\Rightarrow X = \pm 11$$

Since output cannot be negative, $X=11$ is the solution. Substituting $X=11$ in the demand function, we have $P = 157 - 3X = 157 - 3(11) = 157 - 33 = 124$. Substituting $X=11$ and $P=124$ in the firm's profit function, we have,

$$\begin{aligned} \pi &= 11(124) - (11^2 - 25(11) + 278) \\ &= 1364 - 124 \\ &= 1240 \end{aligned}$$

Check your progress 6

- ▶ Product homogeneity in perfect competition leads to a horizontal demand curve, on the other hand, under monopolistic competition, product differentiation leads to a downward sloping demand curve. So, according to Chamberlin, 'competitive ideal' cannot be regarded as 'ideal' under monopolistic competition. Even so, when there is active price competition with free entry the size of excess capacity under monopolistic competition should be any departure from 'ideal' output and price in monopolistic competition under monopolistic competition, determined with free entry and active price competition, and not a departure from 'competitive ideal'.
- ▶ Excess capacity under monopolistic competition provides some benefits to the society. The excess capacity comes in to existence mainly due to the product differentiation under monopolistic competition which leads to product variety which is greatly beneficial to the consumers. The ability to choose among a wide variety of clothes, restaurant meals, and other types and styles of product designs add greatly to the satisfaction or welfare of the society. In short, the higher price under monopolistic competition shows the price consumers pay for a wide range of variety.

Check your progress 5

The main points of Chamberlin's criticism focused on

- ▶ His uniformity assumption.
- ▶ His concept of product differentiation.
- ▶ Degree of freedom to entry.
- ▶ Imprecise boundary of the market model.

Answers to Chapter Review exercises

1. The source of monopoly power is product differentiation. The firm even after commanding some degree of monopoly power over its product, because of many number of firms producing closely related products.

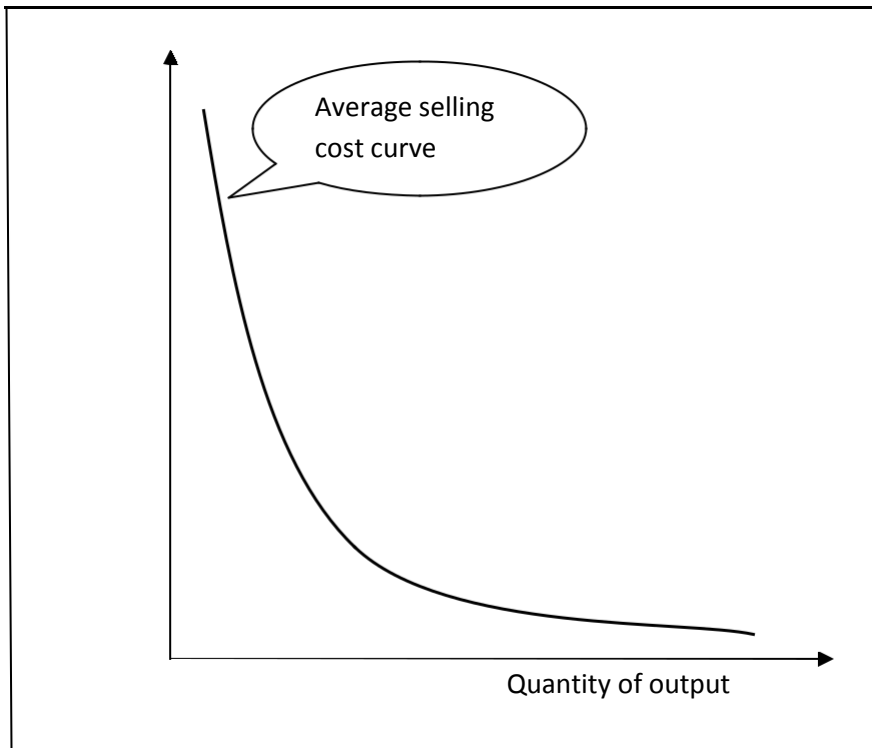
2.

Differentiation based on	Real/ Artificial
1. Durability	R
2. Quality	R
3. Color	A
4. Design	A
5. Credit facility	R
6. Brand	A
7. handling	A
8. Packaging	A

3. Production costs are incurred to create utility whereas selling costs are incurred to increase demand for a firm's product one's the product is produced. The costs of transporting a product from a factory to a market place, cost on factors of production, salaries of workers in production department, are among production costs. Selling costs include salaries of salesmen, expenditures on advertising, and so on.

4. If the total outlay on selling activities is constant, average selling cost continuously falls as quantity of output produced increases. The average selling cost curve will have a rectangular hyperbolic shape. The curve can be drawn as follows. Mathematically,

$$\text{ASC} = \frac{\text{SC}}{X} \quad \div \text{ and as } X \text{ increases ASC will continuously fall because SC is constant.}$$



5.

- Price is greater than MC under monopolistic and price equals MC under perfect competition.
- The long run equilibrium under perfect competition occurs at the minimum point of LAC (the optimal plant size). But the long run equilibrium under monopolistic competition is established at less than optimum size.
- Due to the monopoly element involved in monopolistic competition, price under monopolistic competition is greater than competitive price.
- There are wastes of competition, costs which are incurred for production under monopolistic competition.

6. B

9. A

7. D

10. B

8. B

11. D

CHAPTER TWO OLIGOPOLY

1.

Characteristics	Market model			
	Pure competition	Pure monopoly	Monopolistic competition	Oligopoly
Number of firms	A very large number	One	Many	Few
Type of product	Homogeneous or standardized	Unique (no close substitutes)	Differentiated	Standardized or differentiated
Control over price	None	Considerable	Some, but within rather narrow limits	Limited by mutual interdependence considerable with collusion
Conditions of entry	Very easy, no obstacles	Blocked	Relatively easy	Significant obstacles
Non-price competition	None	Mostly public relations advertising	Considerable emphasis on advertising, brand names, trade marks	Typically a great deal, particularly with product differentiation

2. Given: $P=100-X$

$$MC_a = MC_b = 10$$

The total revenue for Firm A and B are given as

$$R_a = P \times X_a \quad \text{and} \quad R_b = (100 - X)X_b. \text{ But } X_a + X_b = X,$$

hence, $R_a = 100X_a - X_a^2 - X_a X_b$. Firm A's marginal revenue is $MR_a = 100 - 2X_a - X_b$.

Setting $MR=MC$ to maximize profit, we have Firm A's reaction function as

$$X_a = 45 - 0.5X_b.$$

By the same calculation we can get Firm B's reaction function.

Solving the reaction functions simultaneously, we have $X_a = X_b = 30$ and $P = 45$.

2.

Model	Q_1	Q_2	P	Π_1	Π_2	$\Pi_1 + \Pi_2$	
A. Cournot				4	4	4	7
B. Bertrand				6	6	6	3

Given $P = 15 - X$, $X = X_1 + X_2$ and $MC = 3$. To derive the isoprofit curves (in Cournot's model)

$$P_1 = PX_1 - C_1 = (15 - X_1 - X_2)X_1 - 3X_1$$

$\Rightarrow P_1 = 12X_1 - X_1^2 - X_1X_2$ Firm 1's isoprofit curve. Similarly you can see that Firm 2's isoprofit function is given by:

$$P_2 = 15 - X_2^2 - X_1X_2 - 3X_2 = 12X_2 - X_2^2 - X_1X_2.$$

To find the reaction functions of each firm set the partial derivatives of each firm's profit function with respect to its output equal to zero.

$$\frac{\partial P_1}{\partial X_1} = 0 \Rightarrow X_1 = 6 - 0.5X_2 \dots \dots \text{Firm 1's reaction function, and}$$

$$\frac{\partial P_2}{\partial X_2} = 0 \Rightarrow X_2 = 6 - 0.5X_1 \dots \dots \text{Firm 2's reaction function. Solving the reaction functions}$$

of simultaneously we find $X_1 = X_2 = 4$ and $P = 7$. By substituting these values in the demand, cost and profit functions, you will find all entries of the table. Likewise derive the isoprofit curves and reaction functions of each firm and solve the reaction functions simultaneously.

4. C

6. D

7. D

8. B

5. D

9. B

CHAPTER THREE-GAME THEORY

Check your progress 1

The basic elements in any game are the players, the strategies, payoffs, and rules, which are indicated as follows for the above two duopoly models.

Models	Players	Strategies	Payoffs	Rules
1. Cournot	The two firms	Increasing or decreasing quantity of output	The set of profits to each firm	Non-cooperative
2. Bertrand	The two firms	Increasing or decreasing price	The set of profits to each firm	Non-cooperative

Check your progress 2

- A. Neither firm has a dominant strategy.
- B. Yes there are two. The two Nash equilibria of the given game are the set of strategies by Firm 1 and Firm 2: {Small car, Big car} and {Big car, Small car}.

Check your progress 3

To determine the mixed strategy Nash equilibrium we have to calculate the expected payoffs to each firm as a result of either strategic choice available to them.

Firma A's expected payoffs from adopting strategy

1. Advertise is $(0.5 \times 0.4 \times 50) + (0.5 \times 0.6 \times 80) = 34$

2. Cut Price is $(0.5 \times 0.4 \times 90) + (0.5 \times 0.6 \times 20) = 24$

The expected payoff from adopting Advertising strategy is higher for firm A. Thus, Advertise is a mixed strategic Nash equilibrium for Firm A.

Firm B's expected payoffs from adopting strategy

1. Advertise is $(0.4 \times 0.5 \times 50) + (0.4 \times 0.5 \times 80) = 12$
2. Expand production is $(0.6 \times 0.5 \times 20) + (0.6 \times 0.5 \times 80) = 30$

Adopting 'Expand production' strategy has higher expected payoff for Firm B than that of Advertise. Thus, expand production is a mixed strategy Nash equilibrium for Firm B. In general the mixed strategy Nash equilibrium is Advertise, Expand production with expected payoff of 34, 30.

Check your progress 4

- A. By assessing the best response strategy of each firm we can see that the pure strategy Nash equilibrium is {Cheat, Cheat}. Yes. Cheat is each firm's best response whatever the other is doing, thus, it is the dominant strategy for both firms.
- B. Not. If each firm cooperates and abide by the agreement, they will be better off than are with the Nash equilibrium outcome. Firms fail to achieve the later outcome because of coordination failure.
- C. The pursuit for self interest rather than group interest induces firms to cheat each other. Thus, both firms will cheat; and this will bring about the breakdown of the cartel.

Answers to Chapter Review exercises

1. Regardless of Firm 1's strategy, Firm 2 does best with a big research budget. The choice of a big research budget is, thus, a dominant strategy for Firm 2. Firm 1 has no dominant strategy. If Firm 2 does a lower research budget, then Firm 1 does best by choosing a lower research budget. But if Firm 2 chooses a high research budget, then Firm 1 does best by choosing a high research budget. Since Firm 1 can predict that Firm 2 will choose a high research budget, Firm 1's best strategy is to choose a high research budget. The combination of strategies {High research budget, High research budget} is Nash equilibrium.

2.

A. The pay off matrix is as follows

		BK	
		Enter	Do not enter
MD	Enter	(-1, -1)	(3, 0)
	Do not enter	(0, 3)	(0, 0)

Note: payoffs are in \$ 100,000

The pure strategy Nash Equilibrium Don't Enter, Enter With a payoff of 0.3 and Enter Don't Enter with a payoff of 3.0

B. The Expected payoff for MD is (the same for BK)

$$(0.5 \times 0.5 \times -1) + (0.5 \times 0.5 \times 3) = 0.5, \text{ from playing Enter and;}$$

$$(0.5 \times 0.5 \times 0) + (0.5 \times 0.5 \times 0) = 0, \text{ from playing Do not Enter.}$$

Hence, the mixed strategy Nash equilibrium is Enter, Enter with expected payoff of 0.5, 0.5.

The payoff matrix will be changed, a change by only one payoff to MD.

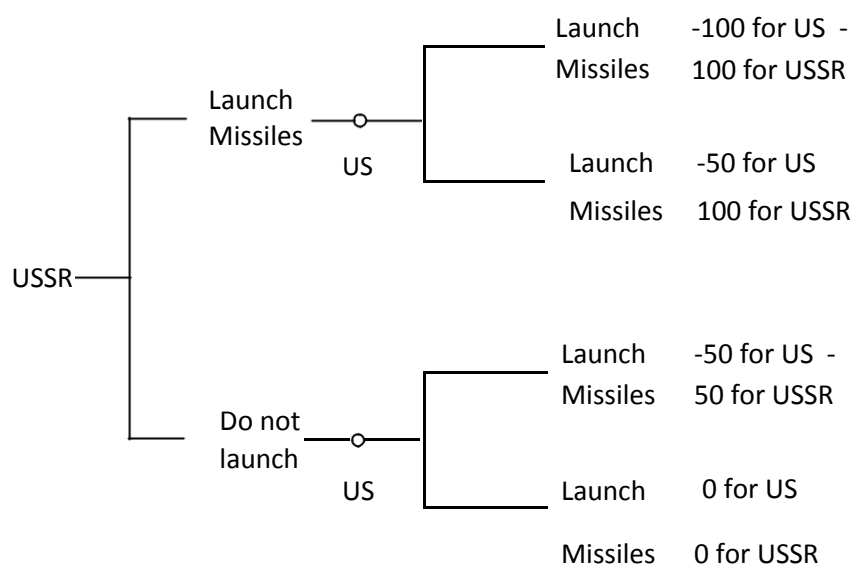
		BK	
		Enter	Do not enter
MD	Enter	(-1, -1)	(4, 0)
	Do not enter	(0, 3)	(0, 0)

The pure strategy Nash equilibrium remains the same Enter, Do not enter and Do not enter, Enter. Though the calculated expected payoffs differ the mixed strategic Nash equilibrium remains the same.

3.

A. The Nash equilibrium of the game is {Do not launch, Do not launch}, which can be calculated by assessing the best response strategy choice. During the Cold War there has been no actual battle, as the Nash equilibrium shows, while each waits for the other to launch the missile first, both did not go to actual war. This can be best explained by a tit-for-tat strategy. The US did what the USSR did in the last round, and USSR did what the US has done in the last round.

B. The game tree diagram can be draw as follows.



If the first move is USSR's, and if it attacks, the game is played on the upper branch of the game tree diagram. USSR puts itself on US's place and it considers whether to counter attack , hence, US gets a payoff of -100 and it gets a payoff -100, or not to retaliate , hence, US earns a payoff of -50 and it earns a payoff of 100. USSR assumes US to be rationale, and to choose not to retaliate.

In the same way USSR considers that if it does not launch missiles, so does the US. In this case USSR's if it plays the lower branch of the game tree diagram is 0. USSR has to choose whether to attack the US and get a payoff of -100, or not to attack and get a payoff of 0. Assuming the

USSR to be rational, it chooses to earn zero payoff (hence, play not to attack) than a negative payoff (hence, to attack).

4.

A.

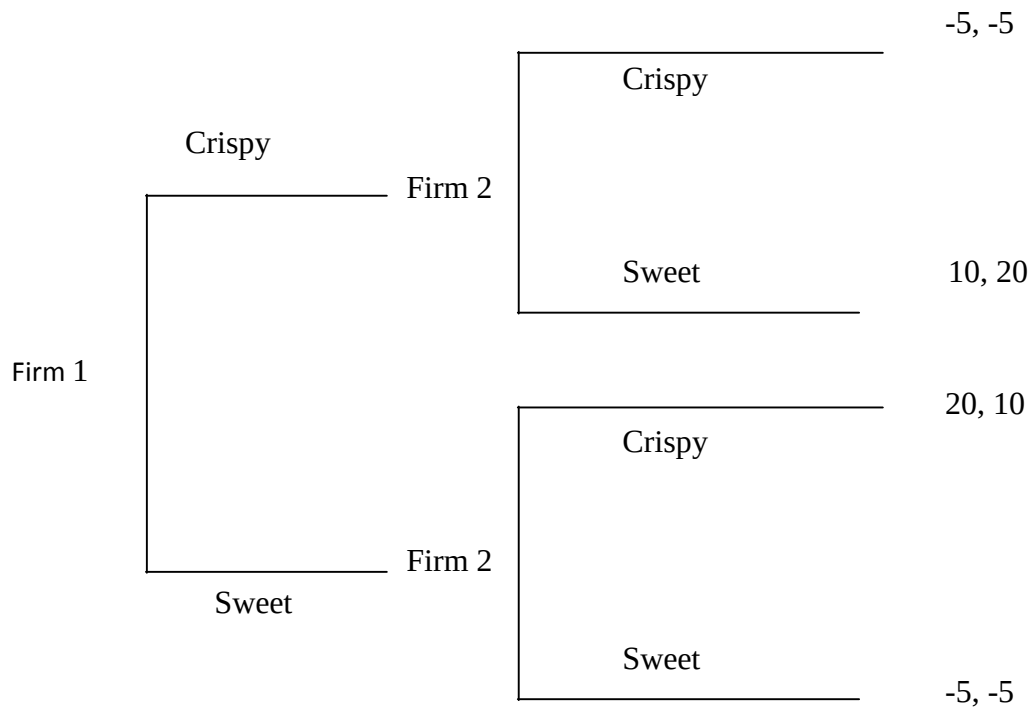
		A	
		Enter	Stay out
B	P ₁	(1, -1)	(3, 0)
	P ₂	(3, 2)	(6, 0)

B. The pure strategy Nash equilibrium of the game is {Enter, P₁}.

5.

A. The pure strategy Nash equilibria of the game are {Crispy, Sweet} and {Sweet, Crispy}.

B. The extensive form of the game can be drawn as below.



Through thinking forward and reasoning back we can see that the sequential game Nash equilibrium is {Sweet, Crispy}. Since Firm 1 has a first move advantage, it can make a credible commitment to one product.

Chapter Four: Factor Pricing and Income Distribution

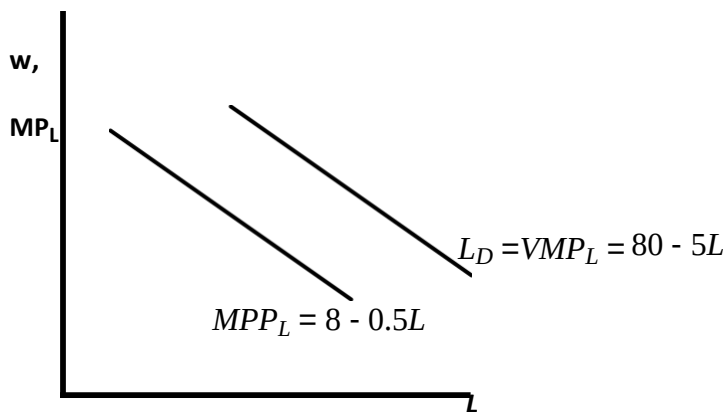
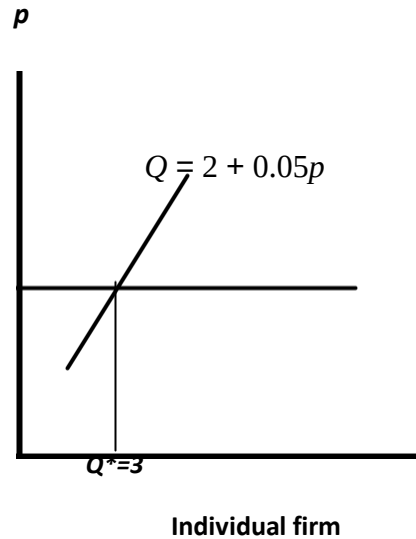
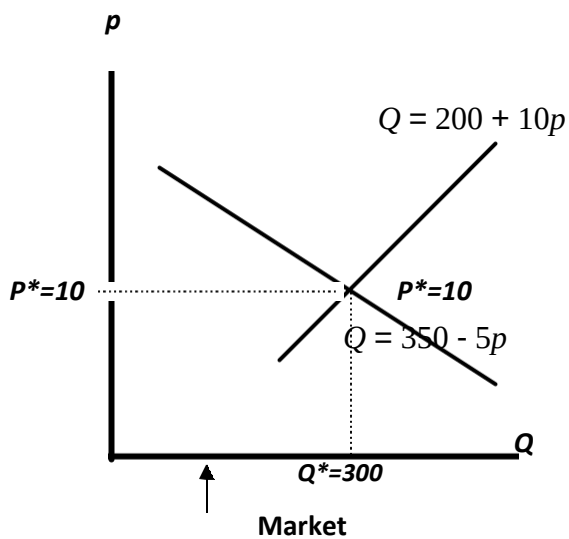
Check your progress 1

<i>Labor (L)</i>	<i>Quantity Produced (Q)</i>	<i>MP_L ($\frac{Q}{L}$)</i>	<i>TR (P*Q)</i>	<i>VMP_L Demand for Labor (P*MP_L)</i>
0	0	-	-	-
1	100	100	1000	1000
2	180	80	1800	800
3	240	60	2400	600
4	280	40	2800	400
5	300	20	3000	200

Check your progress 2

The demand for labor that produces product to be sold in competitive market is its value of marginal product, which is the product of product price and marginal physical product of labor. Now the product price is unknown, which can be solved by equating the aggregate demand and aggregate supply. However aggregate supply is also not directly given. To find it is an easy task of horizontal summation of the supply of the 100 individual firms. To do so, since they are identical, we just multiply the individual supply function by 100. Then we get $Q = 200 + 10p$.

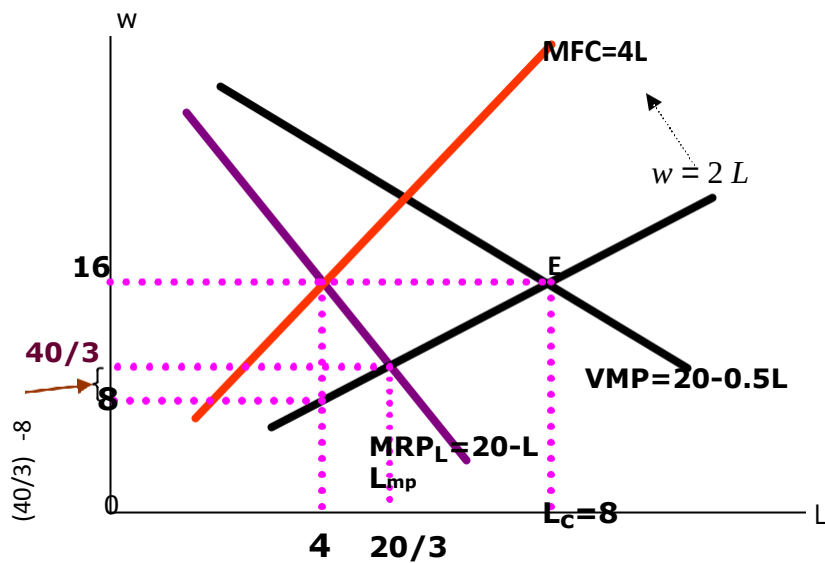
Equating the aggregate demand and supply and solving for p , we get the market $p=10$. Finally, $VMP_L = P \times MP_L = 80 - 5L$.



Check your progress 3

(answers only)

- (a) The competitive level of employment and wage: $L_C = 8$, $w_C = 16$
- (b) The monopolistic level of employment and wage, regardless of monopsonistic power. $L_{mp} = 20/3$, $w_{mp} = 40/3$
- (c) The monopsonistic level of employment and wage: $L_{ms} = 4$, $w_{ms} = 8$
- (d) The monopolistic = $16 - (40/3)$
and monopsonistic exploitation = $(40/3) - 8$



Chapter Six: INFORMATION ASYMMETRY

Check your progress 1

- (i) (a) When demand is informed, the equilibrium will be at
 $38 - 2p = 20 + p$

Solving for p , we get $p = 6$

The equilibrium number on MP3 in this case is 26 per week

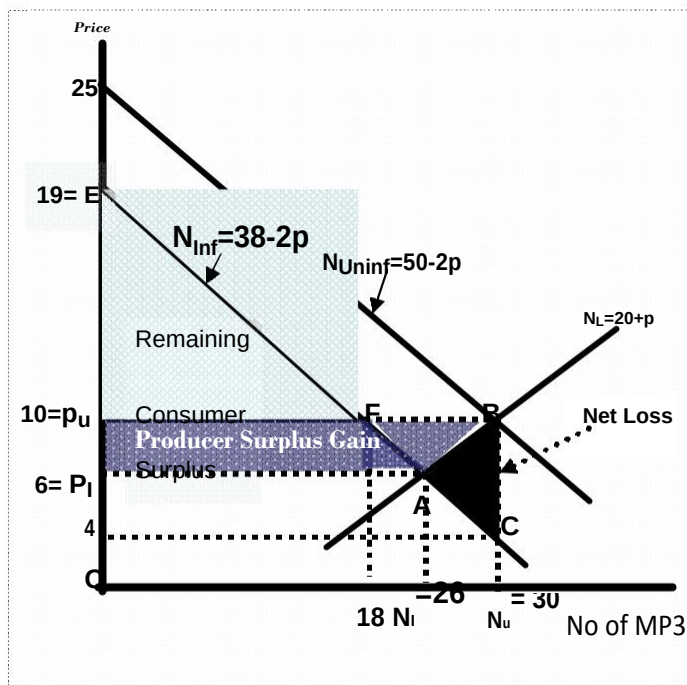
- (b) When demand is uninformed one, the equilibrium will be at

$$50 - 2p = 20 + p$$

Solving for p , we get $p = 10$

The equilibrium number on MP3 in this case is 30 per week

- (ii) The above results, along with the given conditions, are shown in the following figure



(iii) Here, we make use of the figure to the left hand side

(a) Gain in producer surplus (PS)

With informed demand, the producer surplus would have been the area between the supply curve and $P_I=6$ up to $N_I=26$. Now due to uninformed demand, it rises by the area:

$$ABPP = \frac{AFP}{UI} + \frac{ABF}{UI} = \frac{1}{2}(P_I + P_U)(A + F) + \frac{1}{2}(P_U - P_I)(B - A)$$

Therefore, the PS gain is:

$$PS \text{ gain} = \frac{1}{2}(26+18) \times 4 + \frac{1}{2}(10-6) \times (30-26) = 88 + 24 = 112$$

$$PS \text{ gain} = 88 + 24 = 112$$

(b) Consumer surplus (CS) loss

Consumer surplus (CS) is the net of Total value of consuming a commodity (the area under demand curve) and the Total Expenditure on it by the consumers.

$$\text{Change in CS} = [\text{The New CS}] - [\text{The Old CS}]$$

$$\text{Change in CS} = [OECN_U] - [OP_U BN_U] - [OEAN_I - OP_I AN_I]$$

$$\text{Change in CS} = [EFP_U - (ABF + ABC)] - [AEP_I]$$

By rearranging, we get

$$\text{Change in CS} = EFP - AEP - (ABF + ABC) = \frac{1}{2}(P_U - P_I)(N_U - N_I) - (ABF + ABC)$$

$$\text{Change in CS} = - [AFP_U P_I + ABF + ABC]$$

The negative sign shows loss in consumer surplus.

$$\text{Hence, Loss in CS} = AFP_U P_I + ABF + ABC$$

$$= \underline{\underline{ABP_U P_I + ABC}}$$

$$\begin{aligned}
 &= \frac{1}{2}(4' - 6) \times 2(26 + 30) + \frac{1}{2}(4' - 6) \times 2 \\
 &= 112 + 12 \\
 &= \underline{\underline{124 \text{ Birr}}}
 \end{aligned}$$

(c) **Net loss to the society**

From the figure and (a) and (b) above, part of lost CS is gained by the producer. That is, the area, $AFP_U P_I + ABF$ is lost by the consumer and gained by the producer. Therefore, the area, ABC is Net loss. Numerically,

$$\text{Net Loss} = \frac{1}{2}(4' - 6) = 12 \text{ Birr per week}$$

is the amount of consumer surplus loss due to information asymmetry.