Chapter 1

Introduction

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1.1 A Simple Economy

Think of any society. People in the society need many goods and services[1] in their everyday life including food, clothing, shelter, transport facilities like roads and railways, postal services and various other services like that of teachers and doctors. In fact, the list of goods and services that any individual[2] needs is so large that no individual in society, to begin with, has all the things she needs. Every individual has some amount of only a few of the goods and services that she would like to use. A family farm may own a plot of land, some grains, farming implements, maybe a pair of bullocks and also the labour services of the family members. A weaver may have some yarn, some cotton and other instruments required for weaving cloth. The teacher in the local school has the skills required to impart education to the students. Some others in society may not have any resource[3] excepting their own labour services. Each of these decision making units can produce some goods or services by using the resources that it has and use part of the produce to obtain the many other goods and services which it needs. For example, the family farm can produce corn, use part of the produce for consumption purposes and procure clothing, housing and various services in exchange for the rest of the produce. Similarly, the weaver can get the goods and services that she wants in exchange for the cloth she produces in her yarn. The teacher can earn some money by teaching students in the school and use the money for obtaining the goods and services that she wants. The labourer also can try to fulfill her needs by using whatever money she can earn by working for someone else. Each individual can thus use her resources to fulfill her needs. It goes without saying that no individual has unlimited resources compared to her needs. The amount of corn that the family farm can produce is limited by the amount of resources it has, and hence, the amount of different goods

[1] By goods we means physical, tangible objects used to satisfy people's wants and needs. The term 'goods' should be contrasted with the term 'services', which captures the intangible satisfaction of wants and needs. As compared to food items and clothes, which are examples of goods, we can think of the tasks that doctors and teachers perform for us as examples of services.

[2] By individual, we mean an individual decision making unit. A decision making unit can be a single person or a group like a household, a firm or any other organisation.

[3] By resource, we mean those goods and services which are used to produce other goods and services, e.g. land, labour, tools and machinery, etc.

and services that it can procure in exchange of corn is also limited. As a result, the family is forced to make a choice between the different goods and services that are available. It can have more of a good or service only by giving up some amounts of other goods or services. For example, if the family wants to have a bigger house, it may have to give up the idea of having a few more acres of arable land. If it wants more and better education for the children, it may have to give up some of the luxuries of life. The same is the case with all other individuals in society. Everyone faces scarcity of resources, and therefore, has to use the limited resources in the best possible way to fulfill her needs.

In general, every individual in society is engaged in the production of some goods or services and she wants a combination of many goods and services not all of which are produced by her. Needless to say that there has to be some compatibility between what people in society collectively want to have and what they produce[4]. For example, the total amount of corn produced by family farm along with other farming units in a society must match the total amount of corn that people in the society collectively want to consume. If people in the society do not want as much corn as the farming units are capable of producing collectively, a part of the resources of these units could have been used in the production of some other good or services which is in high demand. On the other hand, if people in the society want more corn compared to what the farming units are producing collectively, the resources used in the production of some other goods and services may be reallocated to the production of corn. Similar is the case with all other goods or services. Just as the resources of an individual are scarce, the resources of the society are also scarce in comparison to what the people in the society might collectively want to have. The scarce resources of the society have to be allocated properly in the production of different goods and services in keeping with the likes and dislikes of the people of the society.

Any allocation[5] of resources of the society would result in the production of a particular combination of different goods and services. The goods and services thus produced will have to be distributed among the individuals of the society. The allocation of the limited resources and the distribution of the final mix of goods and services are two of the basic economic problems faced by the society.

In reality, any economy is much more complex compared to the society discussed above. In the light of what we have learnt about the society, let us now discuss the fundamental concerns of the discipline of economics some of which we shall study throughout this book.

1.2 Central Problems of an Economy

Production, exchange and consumption of goods and services are among the basic economic activities of life. In the course of these basic economic activities, every society has to face **scarcity** of resources and it is the scarcity of resources that gives rise to the problem of **choice**. The scarce resources of an economy have competing usages. In other words, every society has to decide on how to use its scarce resources. The problems of an economy are very often summarised as follows:

[4]Here we assume that all the goods and services produced in a society are consumed by the people in the society and that there is no scope of getting anything from outside the society. In reality, this is not true. However, the general point that is being made here about the compatibility of production and consumption of goods and services holds for any country or even for the entire world.

[5]By an allocation of the resources, we mean how much of which resource is devoted to the production of each of the goods and services.

What is produced and in what quantities?

Every society must decide on how much of each of the many possible goods and services it will produce. Whether to produce more of food, clothing, housing or to have more of luxury goods. Whether to have more agricultural goods or to have industrial products and services. Whether to use more resources in education and health or to use more resources in building military services. Whether to have more of basic education or more of higher education. Whether to have more of consumption goods or to have investment goods (like machine) which will boost production and consumption tomorrow.

How are these goods produced?

Every society has to decide on how much of which of the resources to use in the production of each of the different goods and services. Whether to use more labour or more machines. Which of the available technologies to adopt in the production of each of the goods?

For whom are these goods produced?

Who gets how much of the goods that are produced in the economy? How should the produce of the economy be distributed among the individuals in the economy? Who gets more and who gets less? Whether or not to ensure a minimum amount of consumption for everyone in the economy. Whether or not elementary education and basic health services should be available freely for everyone in the economy.

Thus, every economy faces the problem of allocating the scarce resources to the production of different possible goods and services and of distributing the produced goods and services among the individuals within the economy. *The allocation of scarce resources and the distribution of the final goods and services are the central problems of any economy.*

Production Possibility Frontier

Just as individuals face scarcity of resources, the resources of an economy as a whole are always limited in comparison to what the people in the economy collectively want to have. The scarce resources have alternative usages and every society has to decide on how much of each of the resources to use in the production of different goods and services. In other words, every society has to determine how to allocate its scarce resources to different goods and services.

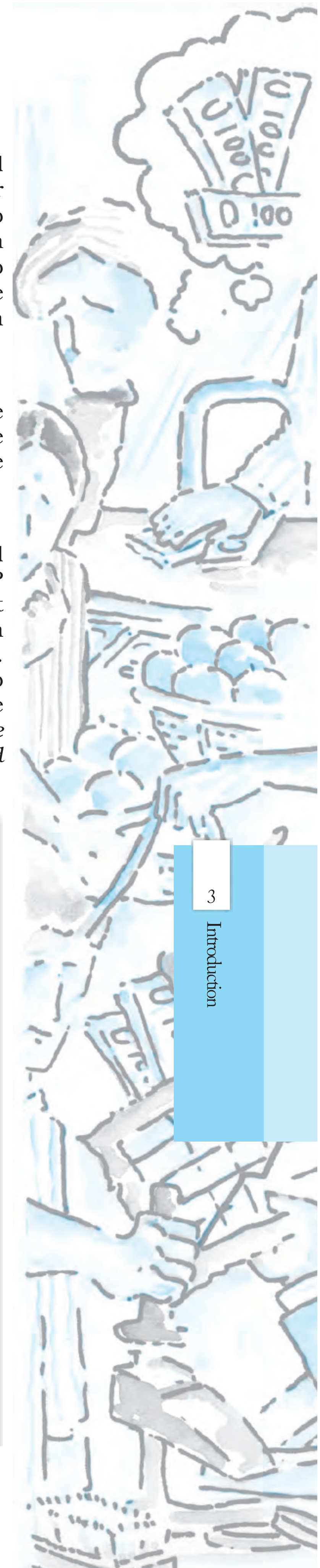
An allocation of the scarce resource of the economy gives rise to a particular combination of different goods and services. Given the total amount of resources, it is possible to allocate the resources in many different ways and, thereby achieving different mixes of all possible goods and services. The collection of all possible combinations of the goods and services that can be produced from a given amount of resources and a given stock of technological knowledge is called the **production possibility set** of the economy.

EXAMPLE 1

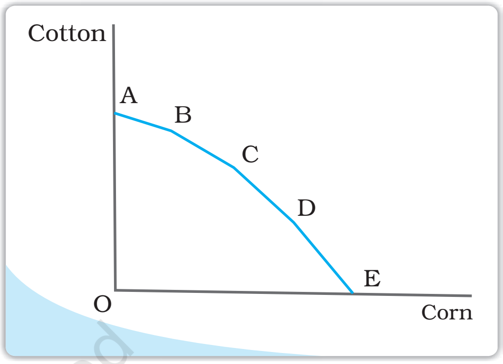
Consider an economy which can produce corn or cotton by using its resources. Table 1.1 gives some of the combinations of corn and cotton that the economy can produce. When its resources are fully utilised.

Table 1.1: Production Possibilities

Possibilities	*Corn*	*Cotton*
A	0	10
B	1	9
C	2	7
D	3	4
E	4	0



If all the resources are used in the production of corn, the maximum amount of corn that can be produced is 4 units and if all resources are used in the production of cotton, at the most, 10 units of cotton can be produced. The economy can also produce1 unit of corn and 9 units of cotton or 2 units of corn and 7 units of cotton or 3 units of corn and 4 units of cotton. There can be many other possibilities. The figure illustrates the production possibilities of the economy. Any point on or below the curve represents a combination of corn and cotton that can be produced with the economy's resources. The curve gives the maximum amount of corn that can be produced in the economy for any given amount of cotton and vice-versa. This curve is called the **production possibility frontier**.



The **production possibility frontier** gives the combinations of corn and cotton that can be produced when the resources of the economy are fully utilised. Note that a point lying strictly below the production possibility frontier represents a combination of corn and cotton that will be produced when all or some of the resources are either underemployed or are utilised in a wasteful fashion.

If more of the scarce resources are used in the production of corn, less resources are available for the production of cotton and vice versa. Therefore, if we want to have more of one of the goods, we will have less of the other good. Thus, there is always a cost of having a little more of one good in terms of the amount of the other good that has to be forgone. This is known as the **opportunity cost**[a] of an additional unit of the goods.

Every economy has to choose one of the many possibilities that it has. In other words, one of the central problems of the economy is to choose from one of the many production possibilities.

[a]Note that the concept of opportunity cost is applicable to the individual as well as the society. The concept is very important and is widely used in economics. Because of its importance in economics, sometimes, opportunity cost is also called the economic cost.

1.3 Organisation of Economic Activities

Basic problems can be solved either by the free interaction of the individuals pursuing their own objectives as is done in the market or in a planned manner by some central authority like the government.

1.3.1 The Centrally Planned Economy

In a centrally planned economy, the government or the central authority plans all the important activities in the economy. All important decisions regarding production, exchange and consumption of goods and services are made by the government. The central authority may try to achieve a particular allocation of resources and a consequent distribution of the final combination of goods and services which is thought to be desirable for society as a whole. For example, if it is found that a good or service which is very important for the prosperity and well-being of the economy as a whole, e.g. education or health service, is not produced in adequate amount by the individuals on their own, the government might try to induce the individuals to produce adequate amount of such a good or service or, alternatively, the government may itself decide to produce the good or service in question. In a different context, if some people in the economy get so little a share of the final mix of goods and services produced in the economy that their survival is at stake, then the central authority may intervene and try to achieve an equitable distribution of the final mix of goods and services.

1.3.2 The Market Economy

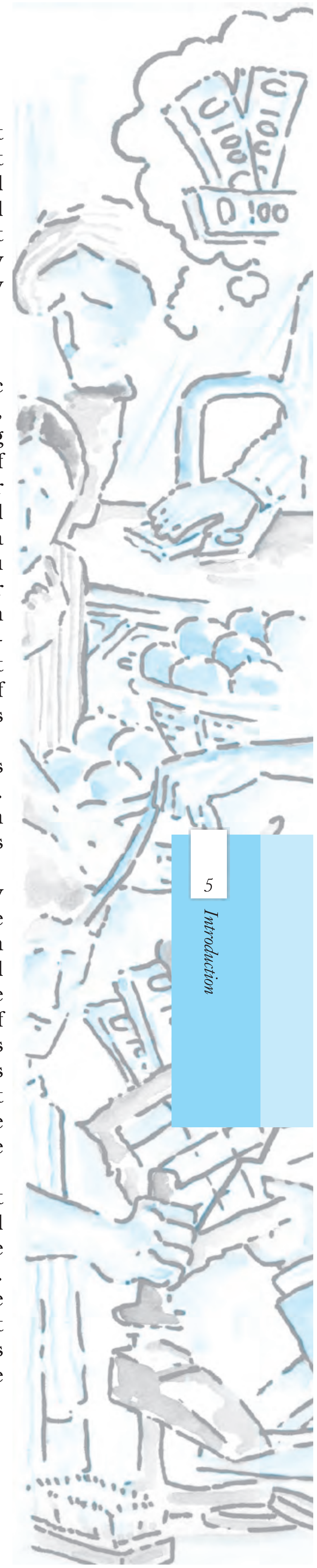
In contrast to a centrally planned economy, in a **market economy**, all economic activities are organised through the market. A **market**, as studied in economics, is an institution[6] which organises the free interaction of individuals pursuing their respective economic activities. In other words, a market is a set of arrangements where economic agents can freely exchange their endowments or products with each other. It is important to note that the term 'market' as used in economics is quite different from the common sense understanding of a market. In particular, it has nothing as such to do with the marketplace as you might tend to think of. For buying and selling commodities, individuals may or may not meet each other in an actual physical location. Interaction between buyers and sellers can take place in a variety of situations such as a village-chowk or a super bazaar in a city, or alternatively, buyers and sellers can interact with each other through telephone or internet and conduct the exchange of commodities. The arrangements which allow people to buy and sell commodities freely are the defining features of a market.

For the smooth functioning of any system, it is imperative that there is coordination in the activities of the different constituent parts of the system. Otherwise, there can be chaos. You may wonder as to what are the forces which bring the coordination between the activities of millions of isolated individuals in a market system.

In a market system, all goods or services come with a price (which is mutually agreed upon by the buyers and sellers) at which the exchanges take place. The price reflects, on an average, the society's valuation of the good or service in question. If the buyers demand more of a certain good, the price of that good will rise. This signals to the producers of that good that the society as a whole wants more of that good than is currently being produced and the producers of the good, in their turn, are likely to increase their production. In this way, prices of goods and services send important information to all the individuals across the market and help achieve coordination in a market system. Thus, in a market system, the central problems regarding how much and what to produce are solved through the coordination of economic activities brought about by the price signals.

In reality, all economies are mixed economies where some important decisions are taken by the government and the economic activities are by and large conducted through the market. The only difference is in terms of the extent of the role of the government in deciding the course of economic activities. In the United States of America, the role of the government is minimal. The closest example of a centrally planned economy is the China for the major part of the twentieth century. In India, since Independence, the government has played a major role in planning economic activities. However, the role of the

[6]An institution is usually defined as an organisation with some purpose.



government in the Indian economy has been reduced considerably in the last couple of decades.

1.4 Positive and Normative Economics

It was mentioned earlier that in principle there are more than one ways of solving the central problems of an economy. These different mechanisms in general are likely to give rise to different solutions to those problems, thereby resulting in different allocations of the resources and also different distributions of the final mix of goods and services produced in the economy. Therefore, it is important to understand which of these alternative mechanisms is more desirable for the economy as a whole. In economics, we try to analyse the different mechanisms and figure out the outcomes which are likely to result under each of these mechanisms. We also try to evaluate the mechanisms by studying how desirable the outcomes resulting from them are. Often a distinction is made between **positive economic analysis** and **normative economic analysis** depending on whether we are trying to figure out how a particular mechanism functions or we are trying to evaluate it. In positive economic analysis, we study how the different mechanisms function, and in normative economics, we try to understand whether these mechanisms are desirable or not. However, this distinction between positive and normative economic analysis is not a very sharp one. The positive and the normative issues involved in the study of the central economic problems are very closely related to each other and a proper understanding of one is not possible in isolation to the other.

1.5 Microeconomics and Macroeconomics

Traditionally, the subject matter of economics has been studied under two broad branches: **Microeconomics** and **Macroeconomics**. In microeconomics, we study the behaviour of individual economic agents in the markets for different goods and services and try to figure out how prices and quantities of goods and services are determined through the interaction of individuals in these markets. In macroeconomics, on the other hand, we try to get an understanding of the economy as a whole by focusing our attention on aggregate measures such as total output, employment and aggregate price level. Here, we are interested in finding out how the levels of these aggregate measures are determined and how the levels of these aggregate measures change over time. Some of the important questions that are studied in macroeconomics are as follows: What is the level of total output in the economy? How is the total output determined? How does the total output grow over time? Are the resources of the economy (eg labour) fully employed? What are the reasons behind the unemployment of resources? Why do prices rise? Thus, instead of studying the different markets as is done in microeconomics, in macroeconomics, we try to study the behaviour of aggregate or macro measures of the performance of the economy.

1.6 Plan of the Book

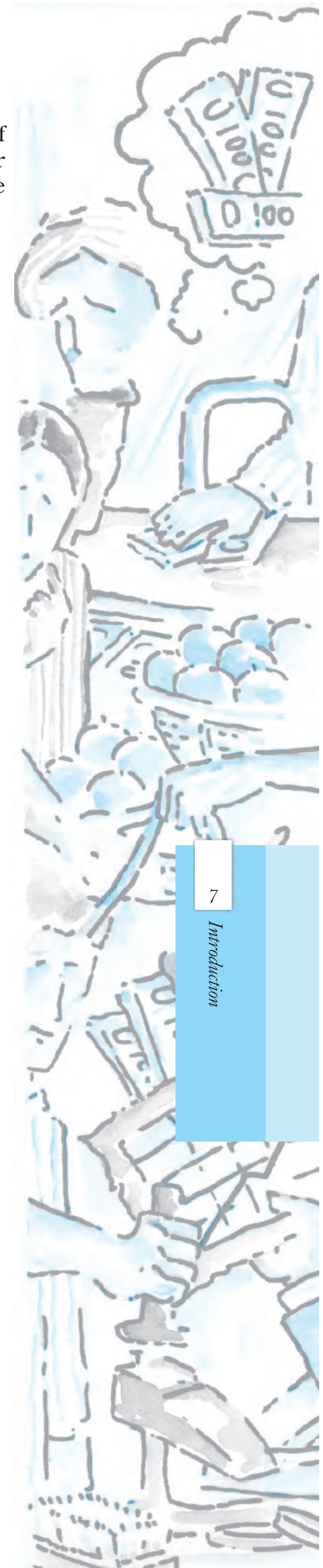
This book is meant to introduce you to the basic ideas in microeconomics. In this book, we will focus on the behaviour of the individual consumers and producers of a single commodity and try to analyse how the price and the quantity is determined in the market for a single commodity. In Chapter 2, we shall study the consumer's behaviour. Chapter 3 deals with basic ideas of production and cost. In Chapter 4, we study the producer's behaviour. In Chapter 5, we shall study how price and quantity is determined in a perfectly competitive market for a commodity. Chapter 6 studies some other forms of market.

Key Concepts

Consumption	Production	Exchange
Scarcity	Production possibilities	Opportunity cost
Market	Market economy	Centrally planned economy
Mixed economy	Positive analysis	Normative analysis
Microeconomics	Macroeconomics	

Exercises

1. Discuss the central problems of an economy.
2. What do you mean by the production possibilities of an economy?
3. What is a production possibility frontier?
4. Discuss the subject matter of economics.
5. Distinguish between a centrally planned economy and a market economy.
6. What do you understand by positive economic analysis?
7. What do you understand by normative economic analysis?
8. Distinguish between microeconomics and macroeconomics.



Chapter 2

Theory of Consumer Behaviour

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In this chapter, we will study the behaviour of an individual consumer. The consumer has to decide how to spend her income on different goods[1]. Economists call this the problem of choice. Most naturally, any consumer will want to get a combination of goods that gives her maximum satisfaction. What will be this 'best' combination? This depends on the likes of the consumer and what the consumer can afford to buy. The 'likes' of the consumer are also called 'preferences'. And what the consumer can afford to buy, depends on prices of the goods and the income of the consumer. This chapter presents two different approaches that explain consumer behaviour (i) Cardinal Utility Analysis and (ii) Ordinal Utility Analysis.

Preliminary Notations and Assumptions

A consumer, in general, consumes many goods; but for simplicity, we shall consider the consumer's choice problem in a situation where there are only two goods[2]: bananas and mangoes. Any combination of the amount of the two goods will be called a consumption bundle or, in short, a bundle. In general, we shall use the variable x_1 to denote the quantity of bananas and x_2 to denote the quantity of mangoes. x_1 and x_2 can be positive or zero. (x_1, x_2) would mean the bundle consisting of x_1 quantity of bananas and x_2 quantity of mangoes. For particular values of x_1 and x_2, (x_1, x_2), would give us a particular bundle. For example, the bundle (5,10) consists of 5 bananas and 10 mangoes; the bundle (10, 5) consists of 10 bananas and 5 mangoes.

2.1 Utility

A consumer usually decides his demand for a commodity on the basis of utility (or satisfaction) that he derives from it. What is utility? Utility of a commodity is its want-satisfying capacity. The more the need of a commodity or the stronger the desire to have it, the greater is the utility derived from the commodity.

Utility is subjective. Different individuals can get different levels of utility from the same commodity. For example, some one who

[1]We shall use the term goods to mean goods as well as services.
[2]The assumption that there are only two goods simplifies the analysis considerably and allows us to understand some important concepts by using simple diagrams.

likes chocolates will get much higher utility from a chocolate than some one who is not so fond of chocolates, Also, utility that one individual gets from the commodity can change with change in place and time. For example, utility from the use of a room heater will depend upon whether the individual is in Ladakh or Chennai (place) or whether it is summer or winter (time).

2.1.1 Cardinal Utility Analysis

Cardinal utility analysis assumes that level of utility can be expressed in numbers. For example, we can measure the utility derived from a shirt and say, this shirt gives me 50 units of utility. Before discussing further, it will be useful to have a look at two important measures of utility.

Measures of Utility

Total Utility: Total utility of a fixed quantity of a commodity (TU) is the total satisfaction derived from consuming the given amount of some commodity *x*. More of commodity *x* provides more satisfaction to the consumer. TU depends on the quantity of the commodity consumed. Therefore, TU_n refers to total utility derived from consuming *n* units of a commodity *x*.

Marginal Utility: Marginal utility (MU) is the change in total utility due to consumption of one additional unit of a commodity. For example, suppose 4 bananas give us 28 units of total utility and 5 bananas give us 30 units of total utility. Clearly, consumption of the 5^{th} banana has caused total utility to increase by 2 units (30 units minus 28 units). Therefore, marginal utility of the 5^{th} banana is 2 units.

$MU_5 = TU_5 - TU_4 = 30 - 28 = 2$

In general, $MU_n = TU_n - TU_{n-1}$, where subscript *n* refers to the n^{th} unit of the commodity

Total utility and marginal utility can also be related in the following way.

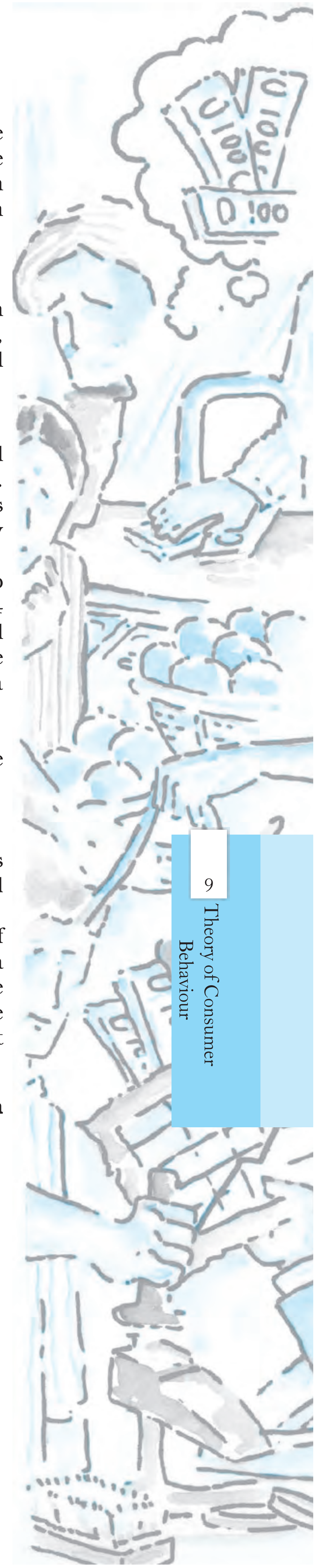
$TU_n = MU_1 + MU_2 + \ldots + MU_{n-1} + MU_n$

This simply means that TU derived from consuming *n* units of bananas is the sum total of marginal utility of first banana (MU_1), marginal utility of second banana (MU_2), and so on, till the marginal utility of the n^{th} unit.

Table No. 2.1 and Figure 2.1 show an imaginary example of the values of marginal and total utility derived from consumption of various amounts of a commodity. Usually, it is seen that the marginal utility diminishes with increase in consumption of the commodity. This happens because having obtained some amount of the commodity, the desire of the consumer to have still more of it becomes weaker. The same is also shown in the table and graph.

Table 2.1: Values of marginal and total utility derived from consumption of various amounts of a commodity

Units	Total Utility	Marginal Utility
1	12	12
2	18	6
3	22	4
4	24	2
5	24	0
6	22	-2



Notice that MU_3 is less than MU_2. You may also notice that total utility increases but at a diminishing rate: The rate of change in total utility due to change in quantity of commodity consumed is a measure of marginal utility. This marginal utility diminishes with increase in consumption of the commodity from 12 to 6, 6 to 4 and so on. This follows from the law of diminishing marginal utility. **Law of Diminishing Marginal Utility** states that marginal utility from consuming each additional unit of a commodity declines as its consumption increases, while keeping consumption of other commodities constant.

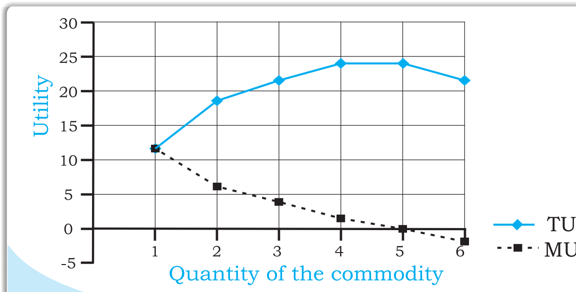


Fig. 2.1

The values of marginal and total utility derived from consumption of various amounts of a commodity. *The marginal utility diminishes with increase in consumption of the commodity.*

MU becomes zero at a level when TU remains constant. In the example, TU does not change at 5th unit of consumption and therefore $MU_5 = 0$. Thereafter, TU starts falling and MU becomes negative.

Derivation of Demand Curve in the Case of a Single Commodity (Law of Diminishing Marginal Utility)

Cardinal utility analysis can be used to derive demand curve for a commodity. What is demand and what is demand curve? The quantity of a commodity that a consumer is willing to buy and is able to afford, given prices of goods and income of the consumer, is called demand for that commodity. Demand for a commodity *x*, apart from the price of *x* itself, depends on factors such as prices of other commodities (see substitutes and complements 2.4.4), income of the consumer and tastes and preferences of the consumers. Demand curve is a graphic presentation of various quantities of a commodity that a consumer is willing to buy at different prices of the same commodity, while holding constant prices of other related commodities and income of the consumer.

Figure 2.2 presents hypothetical demand curve of an individual for commodity *x* at its different prices. Quantity is measured along the horizontal axis and price is measured along the vertical axis.

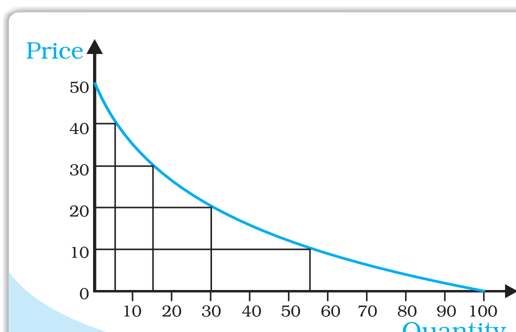


Fig. 2.2

Demand curve of an individual for commodity x

The downward sloping demand curve shows that at lower prices, the individual is willing to buy more of commodity *x*; at higher prices, she is willing to buy less of commodity *x*. Therefore, there is a negative relationship between price of a commodity and quantity demanded which is referred to as the **Law of Demand.**

An explaination for a downward sloping demand curve rests on the notion of diminishing marginal utility. The law of diminishing marginal utility states that each successive unit of a commodity provides lower marginal utility.

Therefore the individual will not be willing to pay as much for each additional unit and this results in a downward sloping demand curve. At a price of Rs. 40 per unit *x*, individual's demand for *x* was 5 units. The 6th unit of commodity *x* will be worth less than the 5th unit. The individual will be willing to buy the 6th unit only when the price drops below Rs. 40 per unit. Hence, the law of diminishing marginal utility explains why demand curves have a negative slope.

2.1.2 Ordinal Utility Analysis

Cardinal utility analysis is simple to understand, but suffers from a major drawback in the form of quantification of utility in numbers. In real life, we never express utility in the form of numbers. At the most, we can rank various alternative combinations in terms of having more or less utility. In other words, the consumer does not measure utility in numbers, though she often ranks various consumption bundles. This forms the starting point of this topic – Ordinal Utility Analysis.

A consumer's preferences over the set of available bundles can often be represented diagrammatically. We have already seen that the bundles available to the consumer can be plotted as points in a two-dimensional diagram. The points representing bundles which give the consumer equal utility can generally be joined to obtain a curve like the one in Figure 2.3. The consumer is said to be indifferent on the different bundles because each point of the bundles give the consumer equal utility. Such a curve joining all points representing bundles among which the consumer is indifferent is called an **indifference curve**. All the points such as A, B, C and D lying on an indifference curve provide the consumer with the same level of satisfaction.

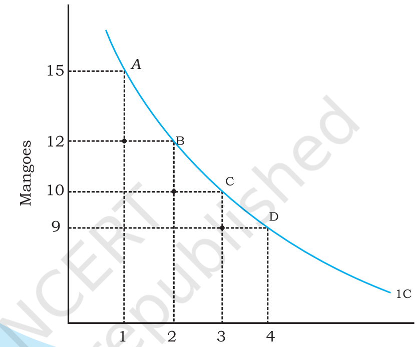


Fig. 2.3

Indifference curve. *An indifference curve joins all points representing bundles which are considered indifferent by the consumer.*

It is clear that when a consumer gets one more banana, he has to forego some mangoes, so that her total utility level remains the same and she remains on the same indifference curve. Therefore, indifference curve slopes downward. The amount of mangoes that the consumer has to forego, in order to get an additional banana, her total utility level being the same, is called **marginal rate of substitution (MRS)**. In other words, MRS is simply the rate at which the consumer will substitute bananas for mangoes, so that her total utility remains constant. So, $MRS = |\Delta Y / \Delta X|$[3].

One can notice that, in the table 2.2, as we increase the quantity of bananas, the quantity of mangoes sacrificed for each additional banana declines. In other words, MRS diminishes with increase in the number of bananas. As the number

[3] $|\Delta Y / \Delta X| = \Delta Y / \Delta X \ if \ (\Delta Y / \Delta X) \geq 0$

$= -\Delta Y / \Delta X \ if \ (\Delta Y / \Delta X) < 0$

$MRS = |\Delta Y / \Delta X|$ means that MRS equals only the magnitude of the expression $\Delta Y / \Delta X$. If $\Delta Y / \Delta X = -3/1$ it means MRS=3.

Table 2.2: Representation of Law of Diminishing Marginal Rate of Substitution

Combination	Quantity of bananas (Qx)	Quantity of Mangoes (Qy)	MRS
A	1	15	-
B	2	12	3:1
C	3	10	2:1
D	4	9	1:1

of bananas with the consumer increases, the MU derived from each additional banana falls. Similarly, with the fall in quantity of mangoes, the marginal utility derived from mangoes increases. So, with increase in the number of bananas, the consumer will feel the inclination to sacrifice small and smaller amounts of mangoes. This tendency for the MRS to fall with increase in quantity of bananas is known as **Law of Diminishing Marginal Rate of Substitution**. This can be seen from figure 2.3 also. Going from point A to point B, the consumer sacrifices 3 mangoes for 1 banana, going from point B to point C, the consumer sacrifices 2 mangoes for 1 banana, and going from point C to point D, the consumer sacrifices just 1 mango for 1 banana. Thus, it is clear that the consumer sacrifices smaller and smaller quantities of mangoes for each additional banana.

Shape of an Indifference Curve

It may be mentioned that the law of Diminishing Marginal Rate of Substitution causes an indifference curve to be convex to the origin. This is the most common shape of an indifference curve. But in case of goods being perfect substitutes[4], the marginal rate of substitution does not diminish. It remains the same. Let's take an example.

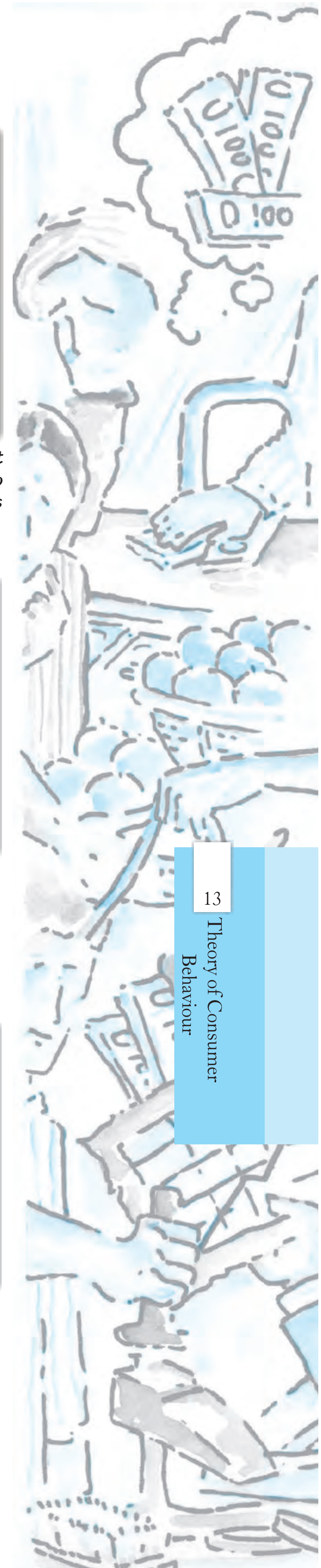
Table 2.3: Representation of Law of Diminishing Marginal Rate of Substitution

Combination	Quantity of five Rupees notes (Qx)	Quantity of five Rupees coins (Qy)	MRS
A	1	8	-
B	2	7	1:1
C	3	6	1:1
D	4	5	1:1

Here, the consumer is indifferent for all these combinations as long as the total of five rupee coins and five rupee notes remains the same. For the consumer, it hardly matters whether she gets a five rupee coin or a five rupee note. So, irrespective of how many five rupee notes she has, the consumer will sacrifice only one five rupee coin for a five rupee note. So these two commodities are perfect substitutes for the consumer and indifference curve depicting these will be a straight line.

In the figure.2.4, it can be seen that consumer sacrifices the same number of five-rupee coins each time he has an additional five-rupee note.

[4] Perfect Substitutes are the goods which can be used in place of each other, and provide exactly the same level of utility to the consumer.



> ### *Monotonic Preferences*
>
> Consumer's preferences are assumed to be such that between any two bundles (x_1, x_2) and (y_1, y_2), if (x_1, x_2) has more of at least one of the goods and no less of the other good compared to (y_1, y_2), then the consumer prefers (x_1, x_2) to (y_1, y_2). Preferences of this kind are called **monotonic preferences**. Thus, a consumer's preferences are monotonic if and only if between any two bundles, the consumer prefers the bundle which has more of at least one of the goods and no less of the other good as compared to the other bundle.

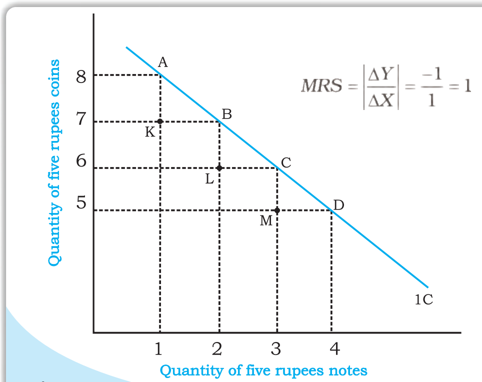


Fig. 2.4

Indifference Curve for perfect substitutes. *Indifference curve depicting two commodities which are perfect substitutes is a straight line.*

Indifference Map

The consumer's preferences over all the bundles can be represented by a family of indifference curves as shown in Figure 2.5. This is called an indifference map of the consumer. All points on an indifference curve represent bundles which are considered indifferent by the consumer. Monotonicity of preferences imply that between any two indifference curves, the bundles on the one which lies above are preferred to the bundles on the one which lies below.

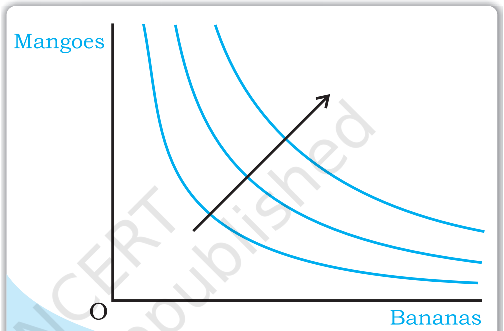


Fig. 2.5

Indifference Map. *A family of indifference curves. The arrow indicates that bundles on higher indifference curves are preferred by the consumer to the bundles on lower indifference curves.*

Features of Indifference Curve

1. Indifference curve slopes downwards from left to right: An indifference curve slopes downwards from left to right, which means that in order to have more of bananas, the consumer has to forego some mangoes. If the consumer does not forego some mangoes with an increase in number of bananas, it will mean consumer having more of bananas with same number of mangoes, taking her to a higher indifference curve. Thus, as long as the consumer is on the same indifference curve, an increase in bananas must be compensated by a fall in quantity of mangoes.

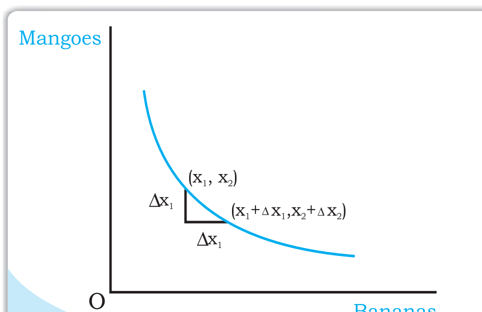


Fig. 2.6

Slope of the Indifference Curve. *The indifference curve slopes downward. An increase in the amount of bananas along the indifference curve is associated with a decrease in the amount of mangoes. If $\Delta x_1 > 0$ then $\Delta x_2 < 0$.*

2.Higher indifference curve gives greater level of utility:

As long as marginal utility of a commodity is positive, an individual will always prefer more of that commodity, as more of the commodity will increase the level of satisfaction.

Table 2.4: Representation of different level of utilities from different combination of goods

Combination	Quantity of bananas	Quantity of Mangoes
A	1	10
B	2	10
C	3	10

Consider the different combination of bananas and mangoes, A, B and C depicted in table 2.4 and figure 2.7. Combinations A, B and C consist of same quantity of mangoes but different quantities of bananas. Since combination B has more bananas than A, B will provide the individual a higher level of satisfaction than A. Therefore, B will lie on a higher indifference curve than A, depicting higher satisfaction. Likewise, C has more bananas than B (quantity of mangoes is the same in both B and C). Therefore, C will provide higher level of satisfaction than B, and also lie on a higher indifference curve than B.

A higher indifference curve consisting of combinations with more of mangoes, or more of bananas, or more of both, will represent combinations that give higher level of satisfaction.

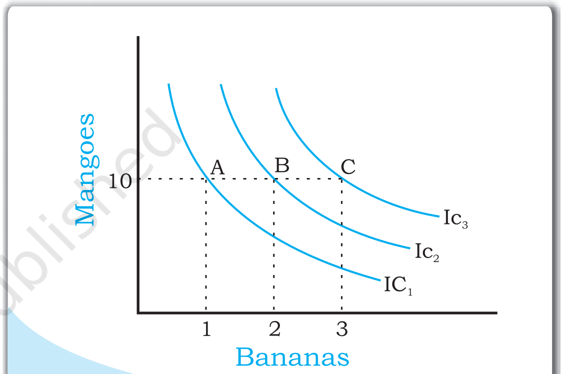


Fig. 2.7

Higher indifference curves give greater level of utility.

3.Two indifference curves never intersect each other:

Two indifference curves intersecting each other will lead to conflicting results. To explain this, let us allow two indifference curves to intersect each other as shown in the figure 2.8. As points A and B lie on the same indifference curve IC_1, utilities derived from combination A and combination B will give the same level of satisfaction. Similarly, as points A and C lie on the same indifference curve IC_2, utility derived from combination A and from combination C will give the same level of satisfaction.

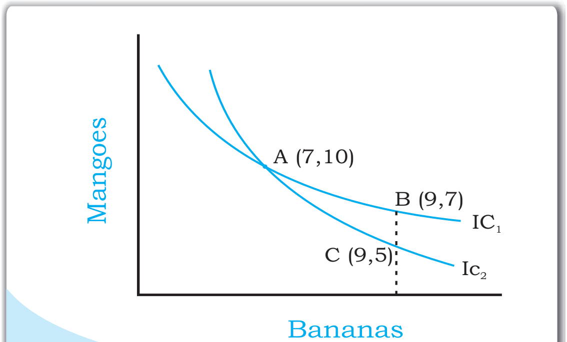


Fig. 2.8

Two indifference curves never intersect each other

From this, it follows that utility from point B and from point C will also be the same. But this is clearly an absurd result, as on point B, the consumer gets a greater number of mangoes with the same quantity of bananas. So consumer is better off at point B than at point C. Thus, it is clear that intersecting indifference curves will lead to conflicting results. Thus, two indifference curves cannot intersect each other.

2.2 The Consumer's Budget

Let us consider a consumer who has only a fixed amount of money (income) to spend on two goods. The prices of the goods are given in the market. The consumer cannot buy any and every combination of the two goods that she may want to consume. The consumption bundles that are available to the consumer depend on the prices of the two goods and the income of the consumer. Given her fixed income and the prices of the two goods, the consumer can afford to buy only those bundles which cost her less than or equal to her income.

2.2.1 Budget Set and Budget Line

Suppose the income of the consumer is M and the prices of bananas and mangoes are p_1 and p_2 respectively[5]. If the consumer wants to buy x_1 quantities of bananas, she will have to spend p_1x_1 amount of money. Similarly, if the consumer wants to buy x_2 quantities of mangoes, she will have to spend p_2x_2 amount of money. Therefore, if the consumer wants to buy the bundle consisting of x_1 quantities of bananas and x_2 quantities of mangoes, she will have to spend $p_1x_1 + p_2x_2$ amount of money. She can buy this bundle only if she has at least $p_1x_1 + p_2x_2$ amount of money. Given the prices of the goods and the income of a consumer, she can choose any bundle as long as it costs less than or equal to the income she has. In other words, the consumer can buy any bundle (x_1, x_2) such that

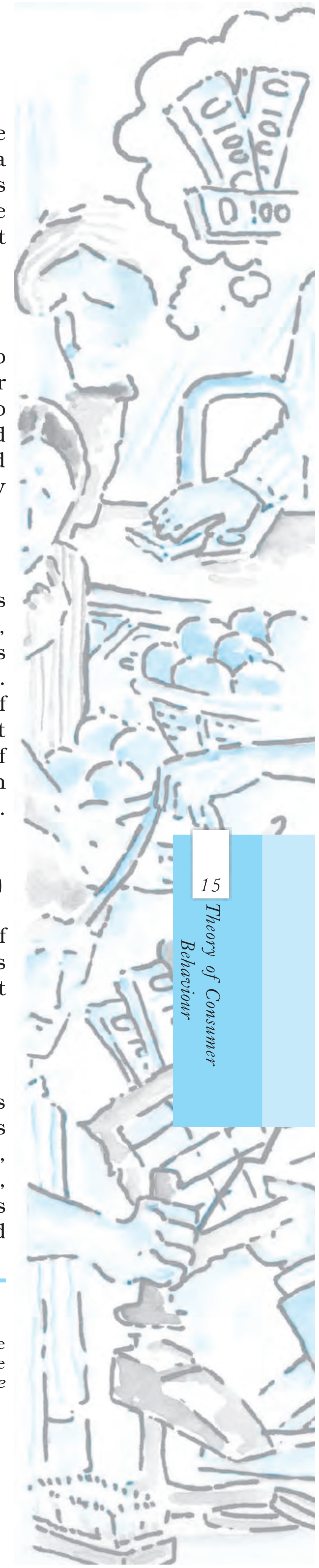
$$p_1x_1 + p_2x_2 \leq M \qquad (2.1)$$

The inequality (2.1) is called the consumer's **budget constraint**. The set of bundles available to the consumer is called the **budget set**. The budget set is thus the collection of all bundles that the consumer can buy with her income at the prevailing market prices.

EXAMPLE 2.1

Consider, for example, a consumer who has Rs 20, and suppose, both the goods are priced at Rs 5 and are available only in integral units. The bundles that this consumer can afford to buy are: (0, 0), (0, 1), (0, 2), (0, 3), (0, 4), (1, 0), (1, 1), (1, 2), (1, 3), (2, 0), (2, 1), (2, 2), (3, 0), (3, 1) and (4, 0). Among these bundles, (0, 4), (1,3), (2, 2), (3, 1) and (4, 0) cost exactly Rs 20 and all the other bundles cost less than Rs 20. The consumer cannot afford to buy bundles like (3, 3) and (4, 5) because they cost more than Rs 20 at the prevailing prices.

[5] Price of a good is the amount of money that the consumer has to pay per unit of the good she wants to buy. If rupee is the unit of money and quantity of the good is measured in kilograms, the price of banana being p_1 means the consumer has to pay p_1 *rupees per kilograms of banana that she wants to buy.*



If both the goods are perfectly divisible[6], the consumer's budget set would consist of all bundles (x_1, x_2) such that x_1 and x_2 are any numbers greater than or equal to 0 and $p_1x_1 + p_2x_2 \leq M$. The budget set can be represented in a diagram as in Figure 2.9.

All bundles in the positive quadrant which are on or below the line are included in the budget set. The equation of the line is

$$p_1x_1 + p_2x_2 = M \quad (2.2)$$

The line consists of all bundles which cost exactly equal to M. This line is called the budget line. Points below the budget line represent bundles which cost strictly less than M.

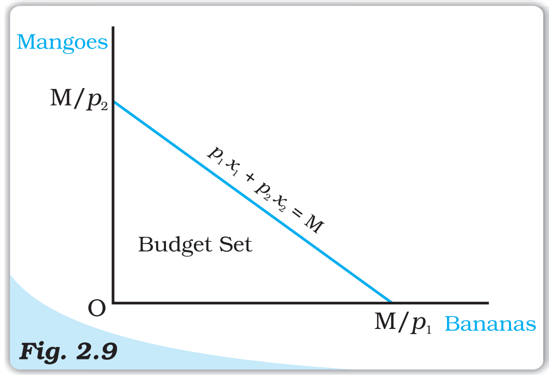


Fig. 2.9

Budget Set. *Quantity of bananas is measured along the horizontal axis and quantity of mangoes is measured along the vertical axis. Any point in the diagram represents a bundle of the two goods. The budget set consists of all points on or below the straight line having the equation* $p_1x_1 + p_2x_2 = M$.

The equation (2.2) can also be written as[7]

$$x_2 = \frac{M}{p_2} - \frac{p_1}{p_2}x_1 \quad (2.3)$$

The budget line is a straight line with horizontal intercept $\frac{M}{p_1}$ and vertical intercept $\frac{M}{p_2}$. The horizontal intercept represents the bundle that the consumer can buy if she spends her entire income on bananas. Similarly, the vertical intercept represents the bundle that the consumer can buy if she spends her entire income on mangoes. The slope of the budget line is $-\frac{p_1}{p_2}$.

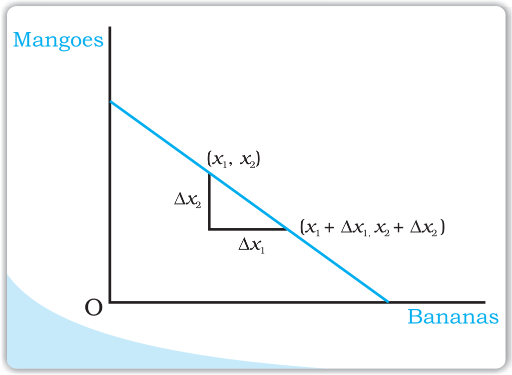
Price Ratio and the Slope of the Budget Line

Think of any point on the budget line. Such a point represents a bundle which costs the consumer her entire budget. Now suppose the consumer wants to have one more banana. She can do it only if she gives up some amount of the other good. How many mangoes does she have to give up if she wants to have an extra quantity of bananas? It would depend on the prices of the two goods. A quantity of banana costs p_1. Therefore, she will have to reduce her expenditure on mangoes by p_1 amount, if she wants one more quantity of banana. With p_1, she could buy $\frac{p_1}{p_2}$ quantities of mangoes. Therefore, if the consumer wants to have an extra quantity of bananas when she is spending all her money, she will have to give up $\frac{p_1}{p_2}$ quantities of mangoes. In other words, in the given market

[6]The goods considered in Example 2.1 were not divisible and were available only in integer units. There are many goods which are divisible in the sense that they are available in non-integer units also. It is not possible to buy half an orange or one-fourth of a banana, but it is certainly possible to buy half a kilogram of rice or one-fourth of a litre of milk.

[7]In school mathematics, you have learnt the equation of a straight line as $y = c + mx$ where c is the vertical intercept and m is the slope of the straight line. Note that equation (2.3) has the same form.

Derivation of the Slope of the Budget Line



The slope of the budget line measures the amount of change in mangoes required per unit of change in bananas along the budget line. Consider any two points (x_1, x_2) and $(x_1 + \Delta x_1, x_2 + \Delta x_2)$ on the budget line.[a]

It must be the case that

$$p_1x_1 + p_2x_2 = M \qquad (2.4)$$

and, $p_1(x_1 + \Delta x_1) + p_2(x_2 + \Delta x_2) = M$ (2.5)

Subtracting (2.4) from (2.5), we obtain

$$p_1\Delta x_1 + p_2\Delta x_2 = 0 \qquad (2.6)$$

By rearranging terms in (2.6), we obtain

$$\frac{\Delta x_2}{\Delta x_1} = -\frac{p_1}{p_2} \qquad (2.7)$$

[a]Δ (delta) is a Greek letter. In mathematics, Δ is sometimes used to denote 'a change'. Thus, Δx_1 stands for a change in x_1 and Δx_2 stands for a change in x_2.

conditions, the consumer can substitute bananas for mangoes at the rate $\frac{p_1}{p_2}$. The absolute value[8] of the slope of the budget line measures the rate at which the consumer is able to substitute bananas for mangoes when she spends her entire budget.

2.2.2 Changes in the Budget Set

The set of available bundles depends on the prices of the two goods and the income of the consumer. When the price of either of the goods or the consumer's income changes, the set of available bundles is also likely to change. Suppose the consumer's income changes from M to M' but the prices of the two goods remain unchanged. With the new income, the consumer can afford to buy all bundles (x_1, x_2) such that $p_1x_1 + p_2x_2 \le M'$. Now the equation of the budget line is

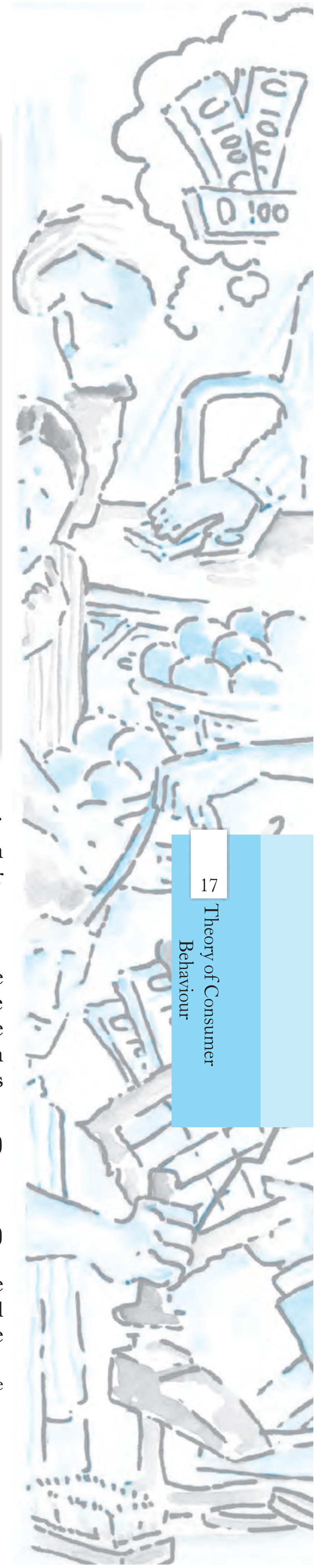
$$p_1x_1 + p_2x_2 = M' \qquad (2.8)$$

Equation (2.8) can also be written as

$$x_2 = \frac{M'}{p_2} - \frac{p_1}{p_2}x_1 \qquad (2.9)$$

Note that the slope of the new budget line is the same as the slope of the budget line prior to the change in the consumer's income. However, the vertical intercept has changed after the change in income. If there is an increase in the

[8]The absolute value of a number x is equal to x if $x \ge 0$ and is equal to $-x$ if $x < 0$. The absolute value of x is usually denoted by $|x|$.



income, i.e. if $M' > M$, the vertical as well as horizontal intercepts increase, there is a parallel outward shift of the budget line. If the income increases, the consumer can buy more of the goods at the prevailing market prices. Similarly, if the income goes down, i.e. if $M' < M$, both intercepts decrease, and hence, there is a parallel inward shift of the budget line. If income goes down, the availability of goods goes down. Changes in the set of available bundles resulting from changes in consumer's income when the prices of the two goods remain unchanged are shown in Figure 2.10.

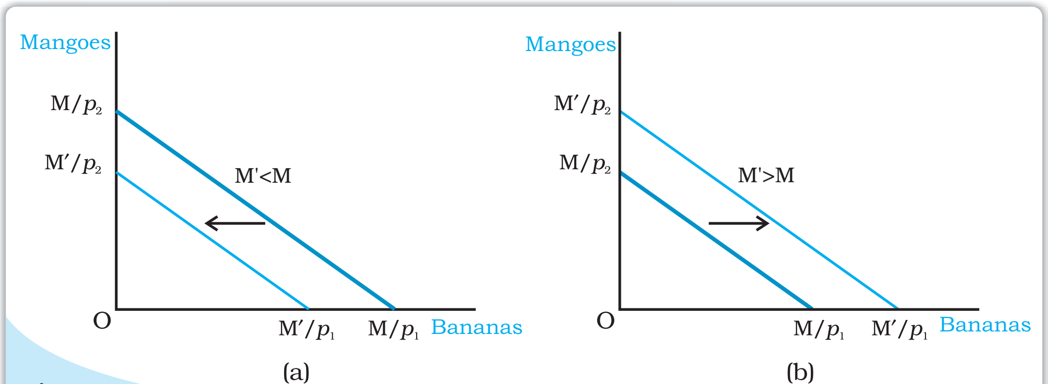


Fig. 2.10

Changes in the Set of Available Bundles of Goods Resulting from Changes in the Consumer's Income*. A decrease in income causes a parallel inward shift of the budget line as in panel (a). An increase in income causes a parallel outward shift of the budget line as in panel (b).*

Now suppose the price of bananas change from p_1 to p'_1 but the price of mangoes and the consumer's income remain unchanged. At the new price of bananas, the consumer can afford to buy all bundles (x_1,x_2) such that $p'_1x_1 + p_2x_2 \leq M$. The equation of the budget line is

$$p'_1x_1 + p_2x_2 = M \qquad (2.10)$$

Equation (2.10) can also be written as

$$x_2 = \frac{M}{p_2} - \frac{p'_1}{p_2}x_1 \qquad (2.11)$$

Note that the vertical intercept of the new budget line is the same as the vertical intercept of the budget line prior to the change in the price of bananas. However, the slope of the budget line and horizontal intercept have changed after the price change. If the price of bananas increases, ie if $p'_1 > p_1$, the absolute value of the slope of the budget line increases, and the budget line becomes steeper (it pivots inwards around the vertical intercept and horizontal intercept decreases). If the price of bananas decreases, i.e., $p'_1 < p_1$, the absolute value of the slope of the budget line decreases and hence, the budget line becomes flatter (it pivots outwards around the vertical intercept and horizontal intercept increases). Figure 2.11 shows change in the budget set when the price of only one commodity changes while the price of the other commodity as well as income of the consumer are constant.

A change in price of mangoes, when price of bananas and the consumer's income remain unchanged, will bring about similar changes in the budget set of the consumer.

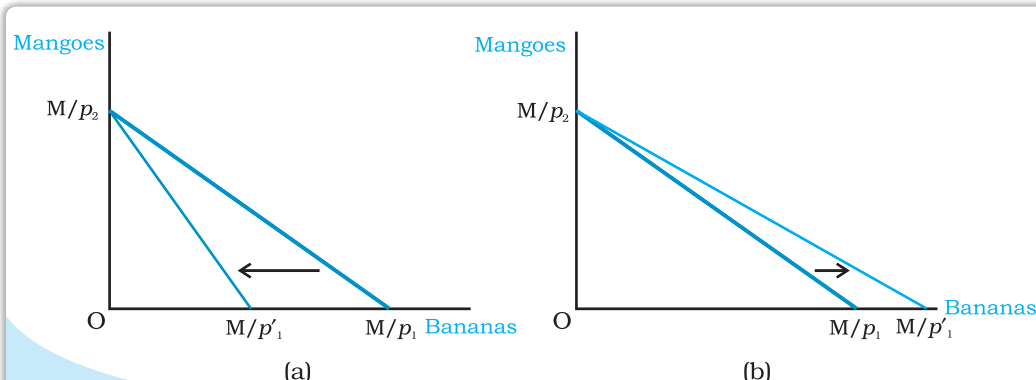


Fig. 2.11

***Changes in the Set of Available Bundles of Goods Resulting from Changes in the Price of bananas**. An increase in the price of bananas makes the budget line steeper as in panel (a). A decrease in the price of bananas makes the budget line flatter as in panel (b).*

2.3 Optimal Choice of the Consumer

The budget set consists of all bundles that are available to the consumer. The consumer can choose her consumption bundle from the budget set. But on what basis does she choose her consumption bundle from the ones that are available to her? In economics, it is assumed that the consumer chooses her consumption bundle on the basis of her tatse and preferences over the bundles in the budget set. It is generally assumed that the consumer has well defined preferences over the set of all possible bundles. She can compare any two bundles. In other words, between any two bundles, she either prefers one to the other or she is indifferent between the two.

Equality of the Marginal Rate of Substitution and the Ratio of the Prices

The optimum bundle of the consumer is located at the point where the budget line is tangent to one of the indifference curves. If the budget line is tangent to an indifference curve at a point, the absolute value of the slope of the indifference curve (MRS) and that of the budget line (price ratio) are same at that point. Recall from our earlier discussion that the slope of the indifference curve is the rate at which the consumer is willing to substitute one good for the other. The slope of the budget line is the rate at which the consumer is able to substitute one good for the other in the market. At the optimum, the two rates should be the same. To see why, consider a point where this is not so. Suppose the MRS at such a point is 2 and suppose the two goods have the same price. At this point, the consumer is willing to give up 2 mangoes if she is given an extra banana. But in the market, she can buy an extra banana if she gives up just 1 mango. Therefore, if she buys an extra banana, she can have more of both the goods compared to the bundle represented by the point, and hence, move to a preferred bundle. Thus, a point at which the MRS is greater, the price ratio cannot be the optimum. A similar argument holds for any point at which the MRS is less than the price ratio.

In economics, it is generally assumed that the consumer is a rational individual. A rational individual clearly knows what is good or what is bad for her, and in any given situation, she always tries to achieve the best for herself. Thus, not only does a consumer have well-defined preferences over the set of available bundles, she also acts according to her preferences. From the bundles which are available to her, a rational consumer always chooses the one which gives her maximum satisfaction.

In the earlier sections, it was observed that the budget set describes the bundles that are available to the consumer and her preferences over the available bundles can usually be represented by an indifference map. Therefore, the consumer's problem can also be stated as follows: The rational consumer's problem is to move to a point on the highest possible indifference curve given her budget set.

If such a point exists, where would it be located? *The optimum point would be located on the budget line.* A point below the budget line cannot be the optimum. Compared to a point below the budget line, there is always some point on the budget line which contains more of at least one of the goods and no less of the other, and is, therefore, preferred by a consumer whose preferences are monotonic. Therefore, if the consumer's preferences are monotonic, for any point below the budget line, there is some point on the budget line which is preferred by the consumer. Points above the budget line are not available to the consumer. Therefore, the optimum (most preferred) bundle of the consumer would be on the budget line.

Where on the budget line will the optimum bundle be located? *The point at which the budget line just touches (is tangent to), one of the indifference curves would be the optimum.*[9] To see why this is so, note that any point on the budget line other than the point at which it touches the indifference curve lies on a lower indifference curve and hence is inferior. Therefore, such a point cannot be the consumer's optimum. The optimum bundle is located on the budget line at the point where the budget line is tangent to an indifference curve.

Figure 2.12 illustrates the consumer's optimum. At (x_1^*, x_2^*), the budget line is tangent to the black coloured indifference curve. The first thing to note is that the indifference curve just touching the budget line is the highest possible indifference curve given the consumer's budget set. Bundles on the indifference curves above this, like the grey one, are not affordable. Points on the indifference curves below this, like the blue one, are certainly inferior to the points on the indifference curve, just touching the budget line. Any other point on the budget line lies on a lower indifference curve and hence, is inferior to (x_1^*, x_2^*). Therefore, (x_1^*, x_2^*) is the consumer's optimum bundle.

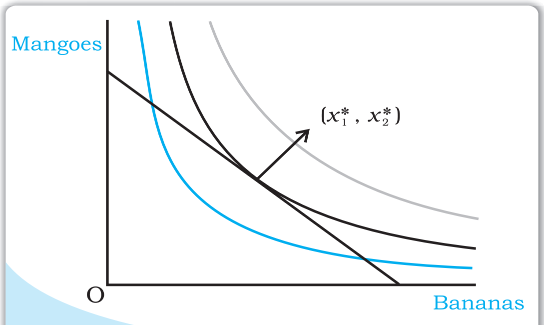


Fig. 2.12

Consumer's Optimum. *The point (x_1^*, x_2^*), at which the budget line is tangent to an indifference curve represents the consumers*

[9] To be more precise, if the situation is as depicted in Figure 2.12 then the optimum would be located at the point where the budget line is tangent to one of the indifference curves. However, there are other situations in which the optimum is at a point where the consumer spends her entire income on one of the goods only.

2.4 Demand

In the previous section, we studied the choice problem of the consumer and derived the consumer's optimum bundle given the prices of the goods, the consumer's income and her preferences. It was observed that the amount of a good that the consumer chooses optimally, depends on the price of the good itself, the prices of other goods, the consumer's income and her tastes and preferences. The quantity of a commodity that a consumer is willing to buy and is able to afford, given prices of goods and consumer's tastes and preferences is called **demand** for the commodity. Whenever one or more of these variables change, the quantity of the good chosen by the consumer is likely to change as well. Here we shall change one of these variables at a time and study how the amount of the good chosen by the consumer is related to that variable.

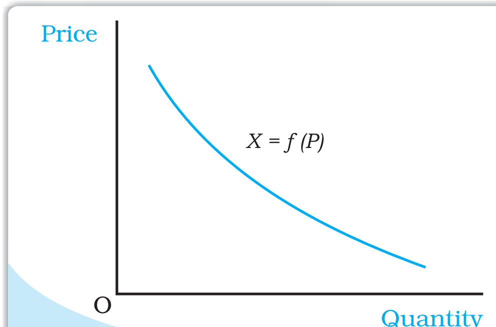


Fig. 2.13

Demand Curve. *The demand curve is a relation between the quantity of the good chosen by a consumer and the price of the good. The independent variable (price) is measured along the vertical axis and dependent variable (quantity) is measured along the horizontal axis. The demand curve gives the quantity demanded by the consumer at each price.*

2.4.1 Demand Curve and the Law of Demand

If the prices of other goods, the consumer's income and her tastes and preferences remain unchanged, the amount of a good that the consumer optimally chooses, becomes entirely dependent on its price. The relation between the consumer's optimal choice of the quantity of a good and its price is very important and this relation is called the **demand function**. Thus, the consumer's demand function for a good

Functions

Consider any two variables x and y. A function

$$y = f(x)$$

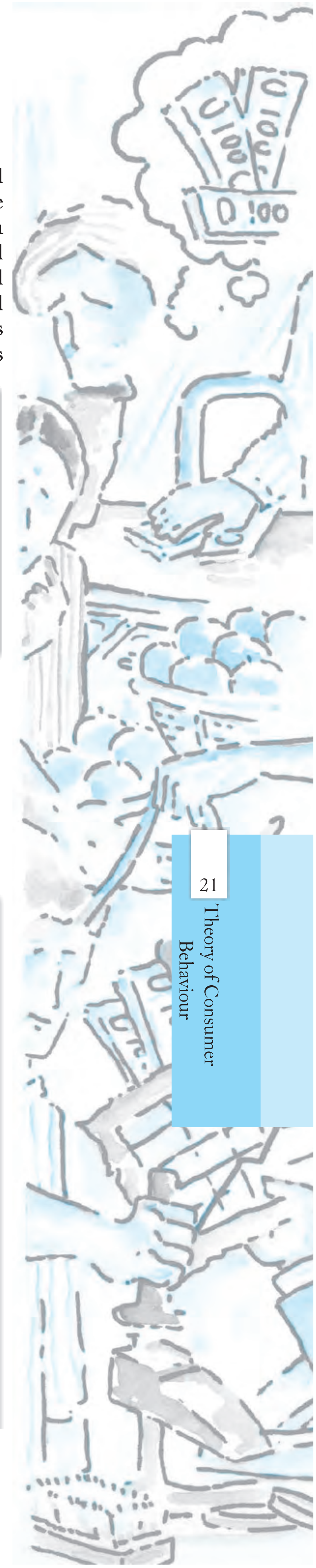
is a relation between the two variables x and y such that for each value of x, there is an unique value of the variable y. In other words, $f(x)$ is a rule which assigns an unique value y for each value of x. As the value of y depends on the value of x, y is called the dependent variable and x is called the independent variable.

EXAMPLE 1

Consider, for example, a situation where x can take the values 0, 1, 2, 3 and suppose corresponding values of y are 10, 15, 18 and 20, respectively. Here y and x are related by the function $y = f(x)$ which is defined as follows: $f(0) = 10$; $f(1) = 15$; $f(2) = 18$ and $f(3) = 20$.

EXAMPLE 2

Consider another situation where x can take the values 0, 5, 10 and 20. And suppose corresponding values of y are 100, 90, 70 and 40, respectively.



Here, y and x are related by the function $y = f(x)$ which is defined as follows: $f(0) = 100$; $f(10) = 90$; $f(15) = 70$ and $f(20) = 40$.

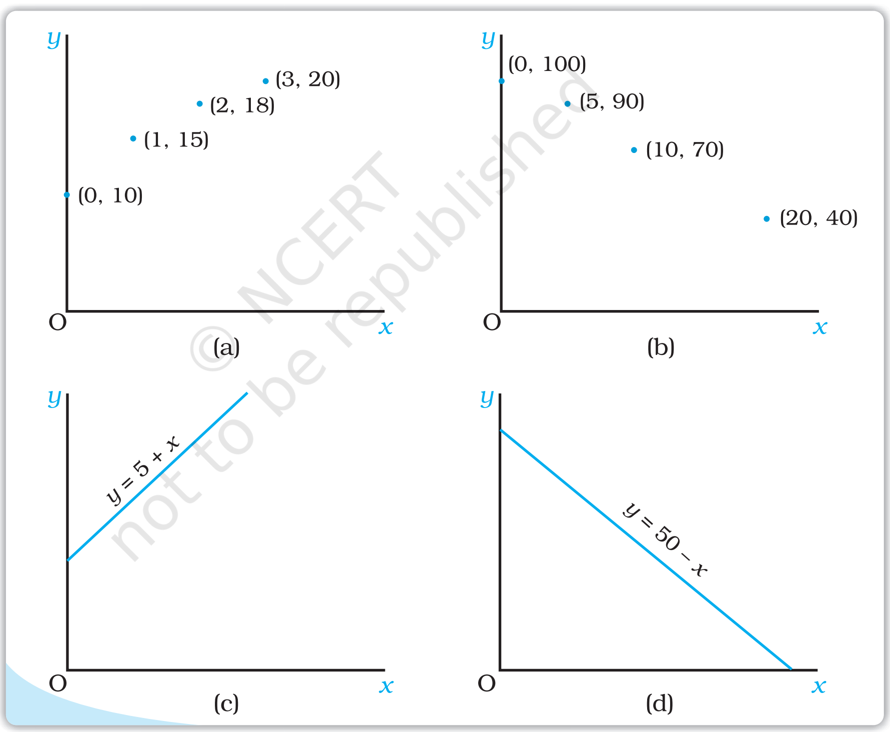
Very often a functional relation between the two variables can be expressed in algebraic form like

$$y = 5 + x \text{ and } y = 50 - x$$

A function $y = f(x)$ is an increasing function if the value of y does not decrease with increase in the value of x. It is a decreasing function if the value of y does not increase with increase in the value of x. The function in Example 1 is an increasing function. So is the function $y = x + 5$. The function in Example 2 is a decreasing function. The function $y = 50 - x$ is also decreasing.

Graphical Representation of a Function

A graph of a function $y = f(x)$ is a diagrammatic representation of the function. Following are the graphs of the functions in the examples given above.



Usually, in a graph, the independent variable is measured along the horizontal axis and the dependent variable is measured along the vertical axis. However, in economics, often the opposite is done. The demand curve, for example, is drawn by taking the independent variable (price) along the vertical axis and the dependent variable (quantity) along the horizontal axis. The graph of an increasing function is upward sloping or and the graph of a decreasing function is downward sloping. As we can see from the diagrams above, the graph of $y = 5 + x$ is upward sloping and that of $y = 50 - x$, is downward sloping.

gives the amount of the good that the consumer chooses at different levels of its price when the other things remain unchanged. The consumer's demand for a good as a function of its price can be written as

$$X = f(P) \qquad (2.12)$$

where X denotes the quantity and P denotes the price of the good.

The demand function can also be represented graphically as in Figure 2.13. The graphical representation of the demand function is called the **demand curve.** The relation between the consumer's demand for a good and the price of the good is likely to be negative in general. In other words, the amount of a good that a consumer would optimally choose is likely to increase when the price of the good falls and it is likely to decrease with a rise in the price of the good.

2.4.2 Deriving a Demand Curve from Indifference Curves and Budget Constraints

Consider an individual consuming bananas (X_1)and mangoes (X_2), whose income is M and market prices of X_1 and X_2 are P'_1 and P'_2 respectively. Figure (a) depicts her consumption equilibrium at point C, where she buys X'_1 and X'_2 quantities of bananas and mangoes respectively. In panel (b) of figure 2.14, we plot P'_1 against X'_1 which is the first point on the demand curve for X_1.

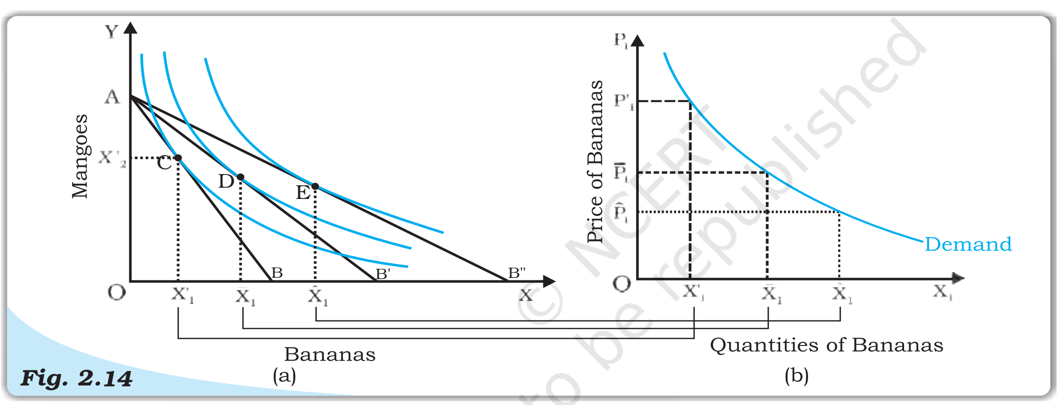
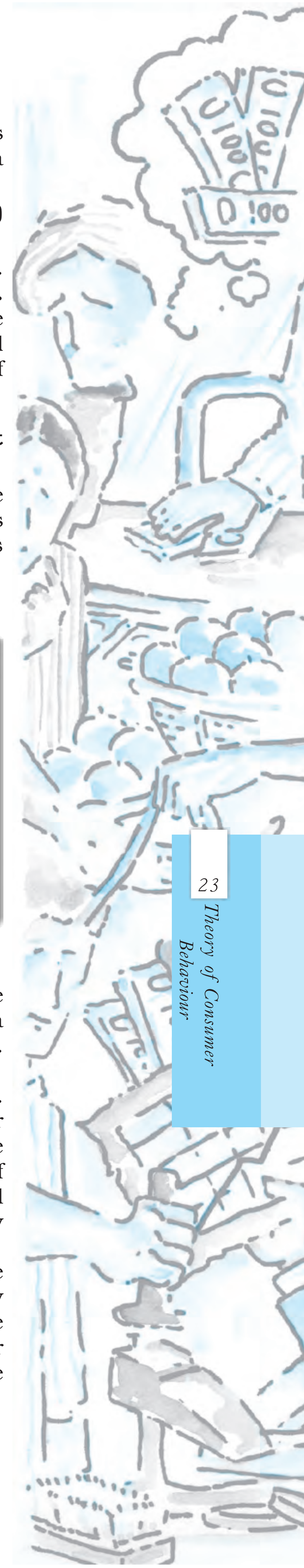


Fig. 2.14

Deriving a demand curve from indifference curves and budget constraints

Suppose the price of X_1 drops to $\bar{P}_1$ with P'_2 and M remaining constant. The budget set in panel (a), expands and new consumption equilibrium is on a higher indifference curve at point D, where she buys more of bananas ($\bar{X}_1 > X'_1$). Thus, demand for bananas increases as its price drops. We plot $\bar{P}_1$ against $\bar{X}_1$ in panel (b) of figure 2.14 to get the second point on the demand curve for X_1. Likewise the price of bananas can be dropped further to $\hat{P}_1$, resulting in further increase in consumption of bananas to $\hat{X}_1$. $\hat{P}_1$ plotted against $\hat{X}_1$ gives us the third point on the demand curve. Therefore, we observe that a drop in price of bananas results in an increase in quality of bananas purchased by an individual who maximises his utility. The demand curve for bananas is thus negatively sloped.

The negative slope of the demand curve can also be explained in terms of the two effects namely, **substitution effect** and **income effect** that come into play when price of a commodity changes. When bananas become cheaper, the consumer maximises his utility by substituting bananas for mangoes in order to derive the same level of satisfaction of a price change, resulting in an increase in demand for bananas.



Moreover, as price of bananas drops, consumer's purchasing power increases, which further increases demand for bananas (and mangoes). This is the income effect of a price change, resulting in further increase in demand for bananas.

Law of Demand: *Law of Demand states that other things being equal, there is a negative relation between demand for a commodity and its price. In other words, when price of the commodity increases, demand for it falls and when price of the commodity decreases, demand for it rises, other factors remaining the same.*

Linear Demand

A linear demand curve can be written as

$$d(p) = a - bp; \; 0 \leq p \leq \frac{a}{b}$$

$$= 0; \; p > \frac{a}{b} \qquad (2.13)$$

where a is the vertical intercept, $-b$ is the slope of the demand curve. At price 0, the demand is a, and at price equal to $\frac{a}{b}$, the demand is 0. The slope of the demand curve measures the rate at which demand changes with respect to its price. For a unit increase in the price of the good, the demand falls by b units. Figure 2.15 depicts a linear demand curve.

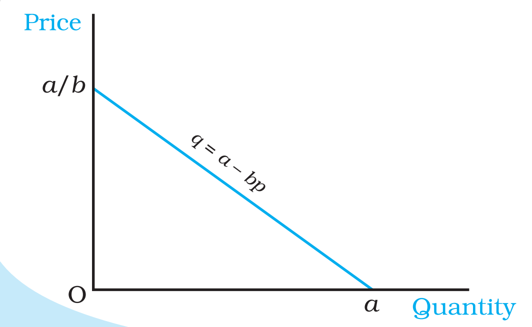


Fig. 2.15

Linear Demand Curve. *The diagram depicts the linear demand curve given by equation 2.13.*

2.4.3 Normal and Inferior Goods

The demand function is a relation between the consumer's demand for a good and its price when other things are given. Instead of studying the relation between the demand for a good and its price, we can also study the relation between the consumer's demand for the good and the income of the consumer. The quantity of a good that the consumer demands can increase or decrease with the rise in income depending on the nature of the good. For most goods, the quantity that a consumer chooses, increases as the consumer's income increases and decreases as the consumer's income decreases. Such goods are called **normal goods.** Thus, a consumer's demand for a normal good moves in the same direction as the income of the consumer. However, there are some goods the demands for which move in the opposite direction of the income of the consumer. Such goods are called **inferior goods.** As the income of the consumer increases, the demand for an inferior good falls, and as the income decreases, the demand for an inferior

A rise in the purchasing power (income) of the consumer can sometimes induce the consumer to reduce the consumption of a good. In such a case, the substitution effect and the income effect will work in opposite directions. The demand for such a good can be inversely or positively related to its price depending on the relative strengths of these two opposing effects. If the substitution effect is stronger than the income effect, the demand for the good and the price of the good would still be inversely related. However, if the income effect is stronger than the substitution effect, the demand for the good would be positively related to its price. Such a good is called a **Giffen good.**

good rises. Examples of inferior goods include low quality food items like coarse cereals.

A good can be a normal good for the consumer at some levels of income and an inferior good for her at other levels of income. At very low levels of income, a consumer's demand for low quality cereals can increase with income. But, beyond a level, any increase in income of the consumer is likely to reduce her consumption of such food items as she switches to better quality cereals.

2.4.4 Substitutes and Complements

We can also study the relation between the quantity of a good that a consumer chooses and the price of a related good. The quantity of a good that the consumer chooses can increase or decrease with the rise in the price of a related good depending on whether the two goods are **substitutes** or **complementary** to each other. Goods which are consumed together are called complementary goods. Examples of goods which are complement to each other include tea and sugar, shoes and socks, pen and ink, etc. Since tea and sugar are used together, an increase in the price of sugar is likely to decrease the demand for tea and a decrease in the price of sugar is likely to increase the demand for tea. Similar is the case with other complements. In general, the demand for a good moves in the opposite direction of the price of its complementary goods.

In contrast to complements, goods like tea and coffee are not consumed together. In fact, they are substitutes for each other. Since tea is a substitute for coffee, if the price of coffee increases, the consumers can shift to tea, and hence, the consumption of tea is likely to go up. On the other hand, if the price of coffee decreases, the consumption of tea is likely to go down. The demand for a good usually moves in the direction of the price of its substitutes.

2.4.5 Shifts in the Demand Curve

The demand curve was drawn under the assumption that the consumer's income, the prices of other goods and the preferences of the consumer are given. What happens to the demand curve when any of these things changes?

Given the prices of other goods and the preferences of a consumer, if the income increases, the demand for the good at each price changes, and hence, there is a shift in the demand curve. For normal goods, the demand curve shifts rightward and for inferior goods, the demand curve shifts leftward.

Given the consumer's income and her preferences, if the price of a related good changes, the demand for a good at each level of its price changes, and hence, there is a shift in the demand curve. If there is an increase in the price of a substitute good, the demand curve shifts rightward. On the other hand, if there is an increase in the price of a complementary good, the demand curve shifts leftward.

The demand curve can also shift due to a change in the tastes and preferences of the consumer. If the consumer's preferences change in favour of a good, the demand curve for such a good shifts rightward. On the other hand, the demand curve shifts leftward due to an unfavourable change in the preferences of the consumer. The demand curve for ice-creams, for example, is likely to shift rightward in the summer because of preference for ice-creams goes up in summer. Revelation of the fact that cold-drinks might be injurious to health can adversely affect preferences for cold-drinks. This is likely to result in a leftward shift in the demand curve for cold-drinks.

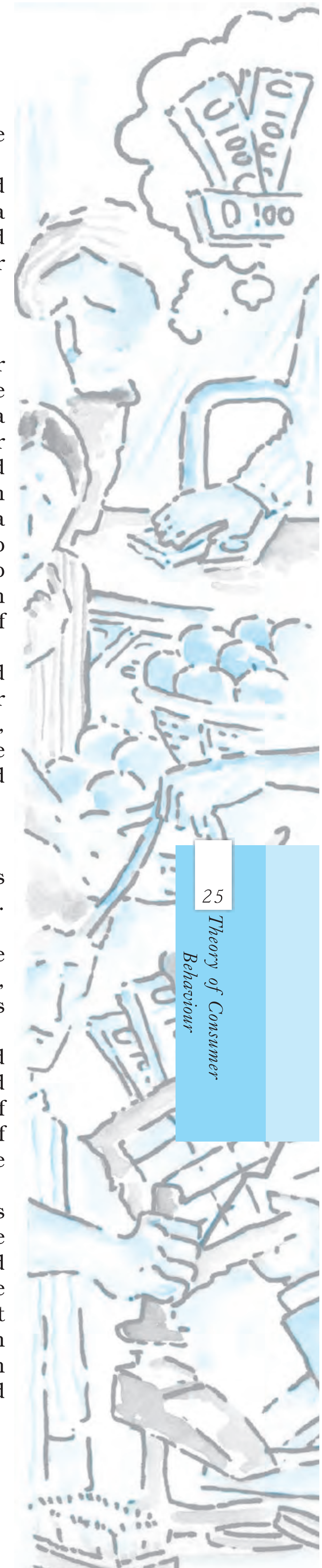


Fig. 2.16

Shifts in Demand. *The demand curve in panel (a) shifts leftward and that in panel (b) shifts rightward.*

Shifts in the demand curve are depicted in Figure 2.16. It may be mentioned that shift in demand curve takes place when there is a change in some factor, other than the price of the commodity.

2.4.6 Movements along the Demand Curve and Shifts in the Demand Curve

As it has been noted earlier, the amount of a good that the consumer chooses depends on the price of the good, the prices of other goods, income of the consumer and her tastes and preferences. The demand function is a relation between the amount of the good and its price when other things remain unchanged. The demand curve is a graphical representation of the demand function. At higher prices, the demand is less, and at lower prices, the demand is more. Thus, any change in the price leads to movements along the demand curve. On the other hand, changes in any of the other things lead to a shift in the demand curve. Figure 2.17 illustrates a movement along the demand curve and a shift in the demand curve.

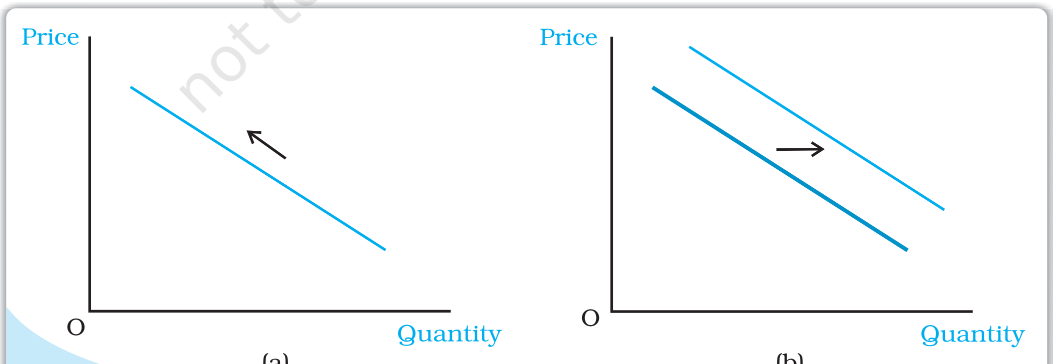


Fig. 2.17

Movement along a Demand Curve and Shift of a Demand Curve. *Panel (a) depicts a movement along the demand curve and panel (b) depicts a shift of the demand curve.*

2.5 Market Demand

In the last section, we studied the choice problem of the individual consumer and derived the demand curve of the consumer. However, in the market for a good, there are many consumers. It is important to find out the market demand for the good. The market demand for a good at a particular price is the total demand of all consumers taken together. The market demand for a good can be derived from the individual demand curves. Suppose there are only two

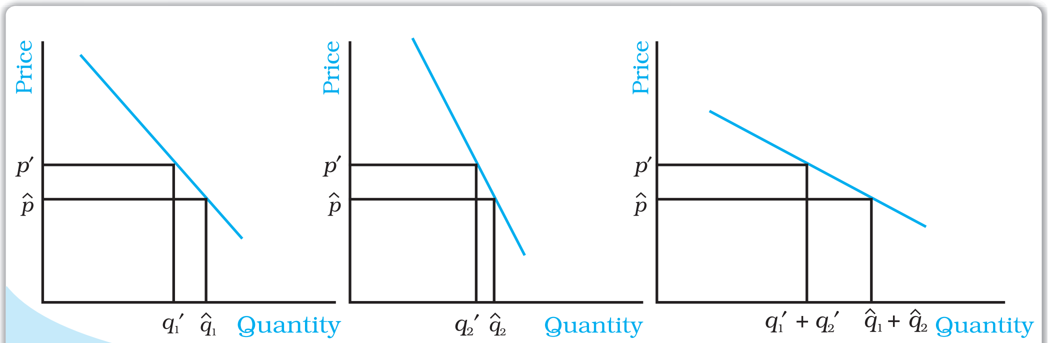


Fig. 2.18

Derivation of the Market Demand Curve. *The market demand curve can be derived as a horizontal summation of the individual demand curves.*

consumers in the market for a good. Suppose at price p', the demand of consumer 1 is q_1' and that of consumer 2 is q_2'. Then, the market demand of the good at p' is $q_1' + q_2'$. Similarly, at price $\hat{p}$, if the demand of consumer 1 is $\hat{q}_1$ and that of consumer 2 is $\hat{q}_2$, the market demand of the good at $\hat{p}$ is $\hat{q}_1 + \hat{q}_2$. Thus, the market demand for the good at each price can be derived by adding up the demands of the two consumers at that price. If there are more than two consumers in the market for a good, the market demand can be derived similarly.

The market demand curve of a good can also be derived from the individual demand curves graphically by adding up the individual demand curves horizontally as shown in Figure 2.18. This method of adding two curves is called horizontal summation.

Adding up Two Linear Demand Curves

Consider, for example, a market where there are two consumers and the demand curves of the two consumers are given as

$$d_1(p) = 10 - p \qquad (2.14)$$

$$\text{and} \quad d_2(p) = 15 - p \qquad (2.15)$$

Furthermore, at any price greater than 10, the consumer 1 demands 0 unit of the good, and similarly, at any price greater than 15, the consumer 2 demands 0 unit of the good. The market demand can be derived by adding equations (2.14) and (2.15). At any price less than or equal to 10, the market demand is given by 25 – 2p, for any price greater than 10, and less than or equal to 15, market demand is 15 – p, and at any price greater than 15, the market demand is 0.

2.6 Elasticity of Demand

The demand for a good moves in the opposite direction of its price. But the impact of the price change is always not the same. Sometimes, the demand for a good changes considerably even for small price changes. On the other hand, there are some goods for which the demand is not affected much by price changes.

Demands for some goods are very responsive to price changes while demands for certain others are not so responsive to price changes. Price elasticity of demand is a measure of the responsiveness of the demand for a good to changes in its price. Price elasticity of demand for a good is defined as the percentage change in demand for the good divided by the percentage change in its price. Price-elasticity of demand for a good

$$e_D = \frac{\text{percentage change in demand for the good}}{\text{percentage change in the price of the good}} \quad (2.16a)$$

$$= \frac{\frac{\Delta Q}{Q} \times 100}{\frac{\Delta P}{P} \times 100}$$

$$= \left(\frac{\Delta Q}{Q}\right) \times \left(\frac{P}{\Delta P}\right) \quad (2.16b)$$

Where, ΔP is the change in price of the good and ΔQ is the change in quantity of the good.

EXAMPLE 2.2

Suppose an individual buy 15 bananas when its price is Rs. 5 per banana. when the price increases to Rs. 7 per banana, she reduces his demand to 12 bananas.

Price Per banana (Rs.) : P	Quantity of bananas demanded : Q
Old Price : $P_1 = 5$	Old quantity : $Q_1 = 15$
New Price : $P_2 = 7$	New quantity: $Q_2 = 12$

In order to find her elasticity demand for bananas, we find the percentage change in quantity demanded and its price, using the information summarized in table.

Note that the price elasticity of demand is a negative number since the demand for a good is negatively related to the price of a good. However, for simplicity, we will always refer to the absolute value of the elasticity.

Percentage change in quantity demanded $= \frac{\Delta Q}{Q_1} \times 100$

$$= \left(\frac{Q_2 - Q_1}{Q_1}\right) \times 100$$

$$= \frac{12-15}{15} \times 100 = -20$$

Percentage change in Market price $= \frac{\Delta P}{P_1} \times 100$

$$= \left(\frac{P_2 - P_1}{P_1}\right) \times 100$$

$$= \frac{7-5}{5} \times 100 = 40$$

Therefore, in our example, as price of bananas increases by 40 percent, demand for bananas drops by 20 percent. Price elasticity of demand $|e_D| = \frac{20}{40} = 0.5$. Clearly, the demand for bananas is not very responsive to a change in price of bananas. When the percentage change in quantity demanded is less than the percentage change in market price, $|e_D|$ is estimated to be less than one and the demand for the good is said to be inelastic at that price. Demand for essential goods is often found to be inelastic.

When the percentage change in quantity demanded is more than the percentage change in market price, the demand is said to be highly responsive to changes in market price and the estimated $|e_D|$ is more than one. The demand for the good is said to be elastic at that price. Demand for luxury goods is seen to be highly responsive to changes in their market prices and $|e_D| > 1$.

When the percentage change in quantity demanded equals the percentage change in its market price, $|e_D|$ is estimated to be equal to one and the demand for the good is said to be Unitary-elastic at that price. Note that the demand for certain goods may be elastic, unitary elastic and inelastic at different prices. In fact, in the next section, elasticity along a linear demand curve is estimated at different prices and shown to vary at each point on a downward sloping demand curve.

2.6.1 Elasticity along a Linear Demand Curve

Let us consider a linear demand curve $q = a - bp$. Note that at any point on the demand curve, the change in demand per unit change in the price $\frac{\Delta q}{\Delta p} = -b$.

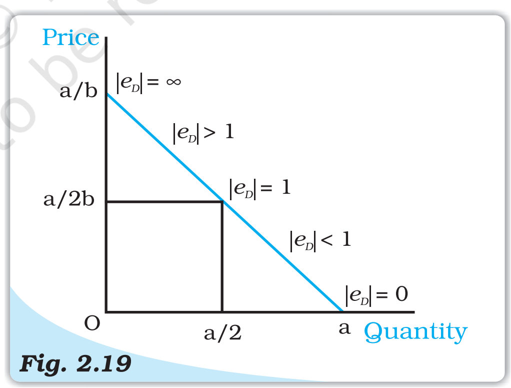
Substituting the value of $\frac{\Delta q}{\Delta p}$ in (2.16b),

we obtain, $e_D = -b\frac{p}{q}$

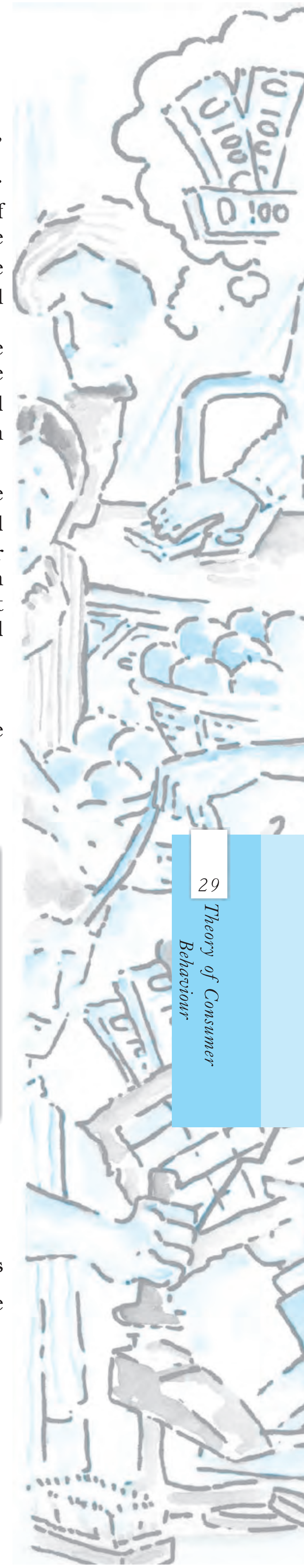
puting the value of q,

$$e_D = -\frac{bp}{a - bp} \qquad (2.17)$$

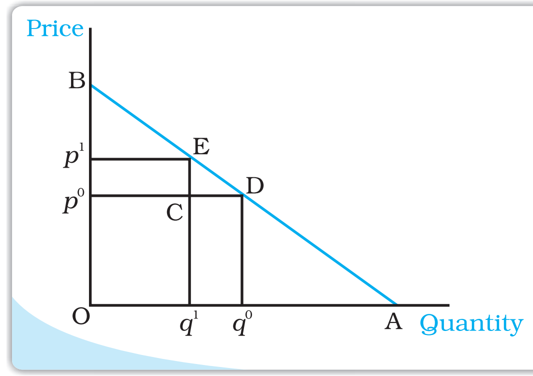
From (2.17), it is clear that the elasticity of demand is different at different points on a linear demand curve. At $p = 0$, the elasticity is 0, at $q = 0$, elasticity is ∞. At $p = \frac{a}{2b}$, the elasticity is 1, at any price greater than 0 and less than $\frac{a}{2b}$, elasticity is less than 1, and at any price greater than $\frac{a}{2b}$, elasticity is greater than 1. The price elasticities of demand along the linear demand curve given by equation (2.17) are depicted in Figure 2.19.



Elasticity along a Linear Demand Curve. *Price elasticity of demand is different at different points on the linear demand curve.*



Geometric Measure of Elasticity along a Linear Demand Curve



The elasticity of a linear demand curve can easily be measured geometrically. The elasticity of demand at any point on a straight line demand curve is given by the ratio of the lower segment and the upper segment of the demand curve at that point. To see why this is the case, consider the following figure which depicts a straight line demand curve, $q = a - bp$.

Suppose at price p^0, the demand for the good is q^0. Now consider a small change in the price. The new price is p^1, and at that price, demand for the good is q^1.

$\Delta q = q^1q^0 = CD$ and $\Delta p = p^1p^0 = CE$.

Therefore, $e_D = \dfrac{\Delta q / q^0}{\Delta p / p^0} = \dfrac{\Delta q}{\Delta p} \times \dfrac{p^0}{q^0} = \dfrac{q^1q^0}{p^1p^0} \times \dfrac{Op^0}{Oq^0} = \dfrac{CD}{CE} \times \dfrac{Op^0}{Oq^0}$

Since ECD and Bp^0D are similar triangles, $\dfrac{CD}{CE} = \dfrac{p^0D}{p^0B}$. But $\dfrac{p^0D}{p^0B} = \dfrac{Oq^o}{p^oB}$

$e_D = \dfrac{op^0}{P^0B} = \dfrac{q^0D}{P^0B}$.

Since, Bp^0D and BOA are similar triangles, $\dfrac{q^0D}{p^0B} = \dfrac{DA}{DB}$

Thus, $e_D = \dfrac{DA}{DB}$.

The elasticity of demand at different points on a straight line demand curve can be derived by this method. Elasticity is 0 at the point where the demand curve meets the horizontal axis and it is $\propto$ at the point where the demand curve meets the vertical axis. At the midpoint of the demand curve, the elasticity is 1, at any point to the left of the midpoint, it is greater than 1 and at any point to the right, it is less than 1.

Note that along the horizontal axis $p = 0$, along the vertical axis $q = 0$ and at the midpoint of the demand curve $p = \dfrac{a}{2b}$.

Constant Elasticity Demand Curve

The elasticity of demand on different points on a linear demand curve is different varying from 0 to ∞. But sometimes, the demand curves can be such that the elasticity of demand remains constant throughout. Consider, for example, a vertical demand curve as the one depicted in Figure 2.20(a). Whatever be the price, the demand is given at the level $\bar{q}$. A price never leads to a change in the demand for such a demand curve and $|e_D|$ is always 0. Therefore, a vertical demand curve is perfectly inelastic.

Figure 2.20 (b) depics a horizontal demand curve, where market price remains constant at $\bar{P}$, whatever be the level of demand for the commodity. At any other price, quantity demanded drops to zero and therefore $|e_d| = \infty$. A horizontal demand curve is perfectly elastic.

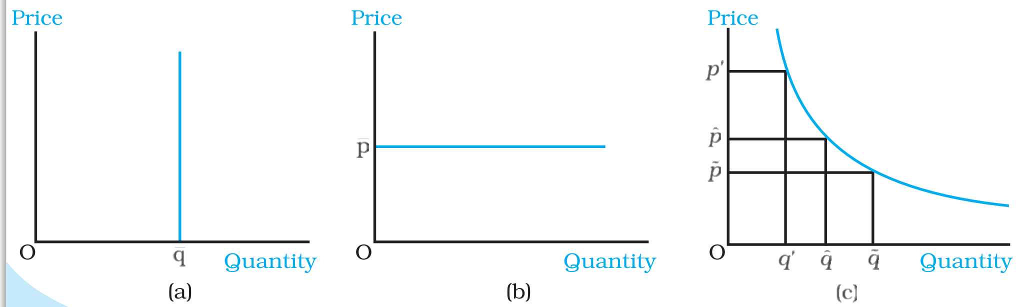


Fig. 2.20

Constant Elasticity Demand Curves. *Elasticity of demand at all points along the vertical demand curve, as shown in panel (a), is 0. Elasticity of demand at all point along the horizontal demand curve, as shown in panel (b) is ∞. Elasticity at all points on the demand curve in panel (c) is 1.*

Figure 2.20(c) depicts a demand curve which has the shape of a rectangular hyperbola. This demand curve has a property that a percentage change in price along the demand curve always leads to equal percentage change in quantity. Therefore, $|e_D| = 1$ at every point on this demand curve. This demand curve is called the unitary elastic demand curve.

2.6.2 Factors Determining Price Elasticity of Demand for a Good

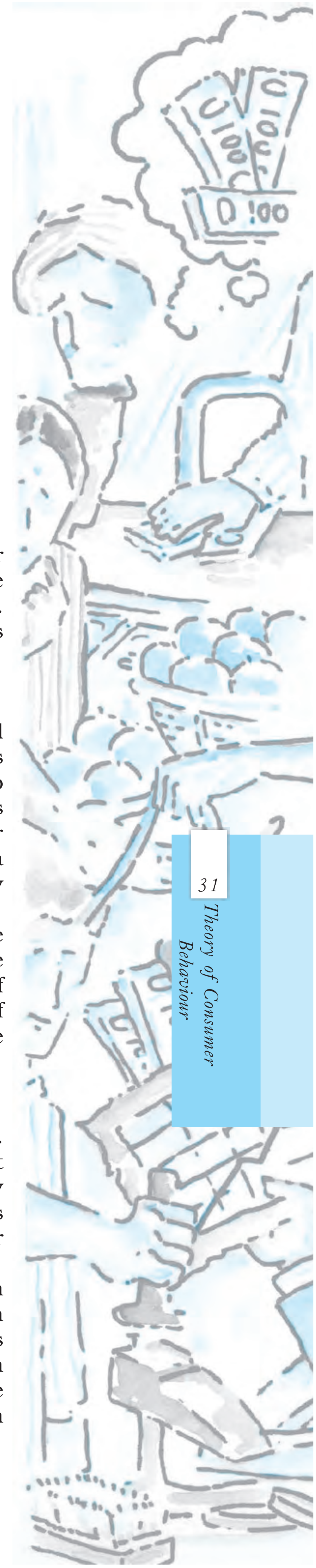
The price elasticity of demand for a good depends on the nature of the good and the availability of close substitutes of the good. Consider, for example, necessities like food. Such goods are essential for life and the demands for such goods do not change much in response to changes in their prices. Demand for food does not change much even if food prices go up. On the other hand, demand for luxuries can be very responsive to price changes. In general, demand for a necessity is likely to be price inelastic while demand for a luxury good is likely to be price elastic.

Though demand for food is inelastic, the demands for specific food items are likely to be more elastic. For example, think of a particular variety of pulses. If the price of this variety of pulses goes up, people can shift to some other variety of pulses which is a close substitute. The demand for a good is likely to be elastic if close substitutes are easily available. On the other hand, if close substitutes are not available easily, the demand for a good is likely to be inelastic.

2.6.3 Elasticity and Expenditure

The expenditure on a good is equal to the demand for the good times its price. Often it is important to know how the expenditure on a good changes as a result of a price change. The price of a good and the demand for the good are inversely related to each other. Whether the expenditure on the good goes up or down as a result of an increase in its price depends on how responsive the demand for the good is to the price change.

Consider an increase in the price of a good. If the percentage decline in quantity is greater than the percentage increase in the price, the expenditure on the good will go down. For example, see row 2 in table 2.5 which shows that as price of a commodity increases by 10%, its demand drops by 12%, resulting in a decline in expenditure on the good. On the other hand, if the percentage decline in quantity is less than the percentage increase in the price, the expenditure on



the good will go up (See row 1 in table 2.5). And if the percentage decline in quantity is equal to the percentage increase in the price, the expenditure on the good will remain unchanged (see row 3 in table 2.5).

Now consider a decline in the price of the good. If the percentage increase in quantity is greater than the percentage decline in the price, the expenditure on the good will go up(see row 4 in table 2.5). On the other hand, if the percentage increase in quantity is less than the percentage decline in the price, the expenditure on the good will go down(see row 5 in table 2.5). And if the percentage increase in quantity is equal to the percentage decline in the price, the expenditure on the good will remain unchanged (see row 6 in table 2.5).

The expenditure on the good would change in the opposite direction as the price change if and only if the percentage change in quantity is greater than the percentage change in price, ie if the good is price-elastic (see rows 2 and 4 in table 2.5). The expenditure on the good would change in the same direction as the price change if and only if the percentage change in quantity is less than the percentage change in price, i.e., if the good is price inelastic (see rows 1 and 5 in table 2.5). The expenditure on the good would remain unchanged if and only if the percentage change in quantity is equal to the percentage change in price, i.e., if the good is unit-elastic (see rows 3 and 6 in table 2.5).

Table 2.5: For hypothetic cases of price rise and drop, the following table summarises the relationship between elasticity and change in expenditure of a commodity

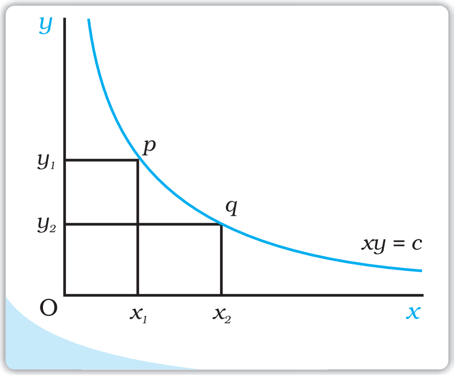
	Change in Price (P)	Change in Quantity demand (Q)	% Change in price demand	% Change in quantity	Impact on Expenditure = P×Q	Nature of price Elasticity of demand $\lvert e_d \rvert$
1	↑	↓	+10	-8	↑	Price Inelastic
2	↑	↓	+10	-12	↓	Price Elastic
3	↑	↓	+10	-10	No Change	Unit Elastic
4	↓	↑	-10	+15	↑	Price Elastic
5	↓	↑	-10	+7	↓	Price Inelastic
6	↓	↑	-10	+10	No Change	Unit Elastic

Rectangular Hyperbola

An equation of the form

$$xy = c$$

where x and y are two variables and c is a constant, giving us a curve called rectangular hyperbola. It is a downward sloping curve in the x-y plane as shown in the diagram. For any two points p and q on the curve, the areas of the two rectangles Oy_1px_1 and Oy_2qx_2 are same and equal to c.



If the equation of a demand curve takes the form $pq = e$, where e is a constant, it will be a rectangular hyperbola, where price (p) times quantity (q) is a constant. With such a demand curve, no matter at what point the consumer consumes, her expenditures are always the same and equal to e.

Relationship between Elasticity and change in Expenditure on a Good

Suppose at price p, the demand for a good is q, and at price $p + \Delta p$, the demand for the good is $q + \Delta q$.

At price p, the total expenditure on the good is pq, and at price $p + \Delta p$, the total expenditure on the good is $(p + \Delta p)(q + \Delta q)$.

If price changes from p to $(p + \Delta p)$, the change in the expenditure on the good is, $(p + \Delta p)(q + \Delta q) - pq = q\Delta p + p\Delta q + \Delta p\Delta q$.

For small values of Δp and Δq, the value of the term $\Delta p\Delta q$ is negligible, and in that case, the change in the expenditure on the good is approximately given by $q\Delta p + p\Delta q$.

Approximate change in expenditure $= \Delta E = q\Delta p + p\Delta q = \Delta p(q + p\frac{\Delta q}{\Delta p})$

$= \Delta p[q(1 + \frac{\Delta q}{\Delta p}\frac{p}{q})] = \Delta p[q(1 + e_D)]$.

Note that

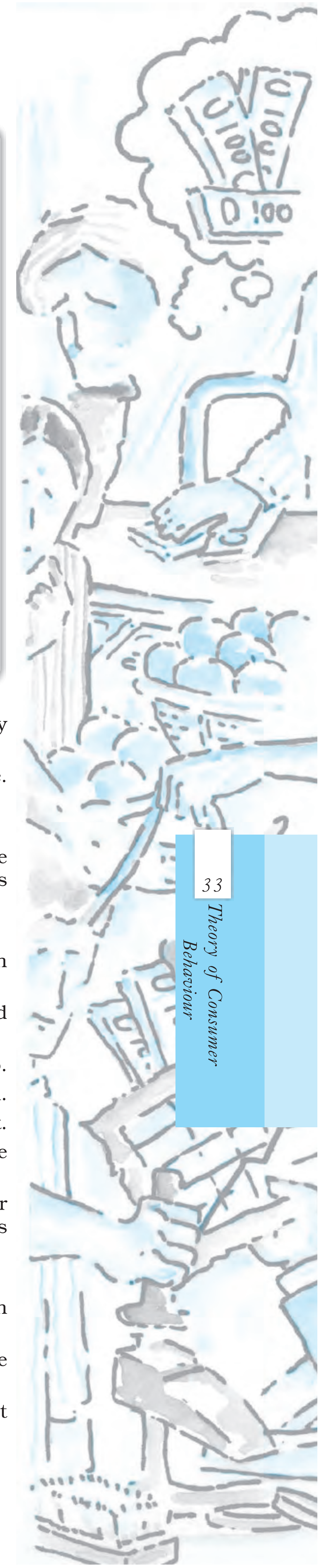
if $e_D < -1$, then $q(1 + e_D) < 0$, and hence, ΔE has the opposite sign as Δp,

if $e_D > -1$, then $q(1 + e_D) > 0$, and hence, ΔE has the same sign as Δp,

if $e_D = -1$, then $q(1 + e_D) = 0$, and hence, $\Delta E = 0$.

Summary

- The budget set is the collection of all bundles of goods that a consumer can buy with her income at the prevailing market prices.
- The budget line represents all bundles which cost the consumer her entire income. The budget line is negatively sloping.
- The budget set changes if either of the two prices or the income changes.
- The consumer has well-defined preferences over the collection of all possible bundles. She can rank the available bundles according to her preferences over them.
- The consumer's preferences are assumed to be monotonic.
- An indifference curve is a locus of all points representing bundles among which the consumer is indifferent.
- Monotonicity of preferences implies that the indifference curve is downward sloping.
- A consumer's preferences, in general, can be represented by an indifference map.
- A consumer's preferences, in general, can also be represented by a utility function.
- A rational consumer always chooses her most preferred bundle from the budget set.
- The consumer's optimum bundle is located at the point of tangency between the budget line and an indifference curve.
- The consumer's demand curve gives the amount of the good that a consumer chooses at different levels of its price when the price of other goods, the consumer's income and her tastes and preferences remain unchanged.
- The demand curve is generally downward sloping.
- The demand for a normal good increases (decreases) with increase (decrease) in the consumer's income.
- The demand for an inferior good decreases (increases) as the income of the consumer increases (decreases).
- The market demand curve represents the demand of all consumers in the market



taken together at different levels of the price of the good.

- The price elasticity of demand for a good is defined as the percentage change in demand for the good divided by the percentage change in its price.
- The elasticity of demand is a pure number.
- Elasticity of demand for a good and total expenditure on the good are closely related.

Key Concepts

Budget set	Budget line
Preference	Indifference
Indifference curve	Marginal Rate of substitution
Monotonic preferences	Diminishing rate of substitution
Indifference map,Utility function	Consumer's optimum
Demand	Law of demand
Demand curve	Substitution effect
Income effect	Normal good
Inferior good	Substitute
Complement	Price elasticity of demand

Exercises

1. What do you mean by the budget set of a consumer?

2. What is budget line?

3. Explain why the budget line is downward sloping.

4. A consumer wants to consume two goods. The prices of the two goods are Rs 4 and Rs 5 respectively. The consumer's income is Rs 20.
   (i) Write down the equation of the budget line.
   (ii) How much of good 1 can the consumer consume if she spends her entire income on that good?
   (iii) How much of good 2 can she consume if she spends her entire income on that good?
   (iv) What is the slope of the budget line?

Questions 5, 6 and 7 are related to question 4.

5. How does the budget line change if the consumer's income increases to Rs 40 but the prices remain unchanged?

6. How does the budget line change if the price of good 2 decreases by a rupee but the price of good 1 and the consumer's income remain unchanged?

7. What happens to the budget set if both the prices as well as the income double?

8. Suppose a consumer can afford to buy 6 units of good 1 and 8 units of good 2 if she spends her entire income. The prices of the two goods are Rs 6 and Rs 8 respectively. How much is the consumer's income?

9. Suppose a consumer wants to consume two goods which are available only in integer units. The two goods are equally priced at Rs 10 and the consumer's income is Rs 40.
   (i) Write down all the bundles that are available to the consumer.
   (ii) Among the bundles that are available to the consumer, identify those which cost her exactly Rs 40.

10. What do you mean by 'monotonic preferences'?

11. If a consumer has monotonic preferences, can she be indifferent between the bundles (10, 8) and (8, 6)?

12. Suppose a consumer's preferences are monotonic. What can you say about her preference ranking over the bundles (10, 10), (10, 9) and (9, 9)?

13. Suppose your friend is indifferent to the bundles (5, 6) and (6, 6). Are the preferences of your friend monotonic?

14. Suppose there are two consumers in the market for a good and their demand functions are as follows:

$d_1(p) = 20 - p$ for any price less than or equal to 20, and $d_1(p) = 0$ at any price greater than 20.

$d_2(p) = 30 - 2p$ for any price less than or equal to 15 and $d_1(p) = 0$ at any price greater than 15.

Find out the market demand function.

15. Suppose there are 20 consumers for a good and they have identical demand functions:

$d(p) = 10 - 3p$ for any price less than or equal to $\frac{10}{3}$ and $d_1(p) = 0$ at any price greater than $\frac{10}{3}$.

What is the market demand function?

16. Consider a market where there are just two consumers and suppose their demands for the good are given as follows:

Calculate the market demand for the good.

p	d_1	d_2
1	9	24
2	8	20
3	7	18
4	6	16
5	5	14
6	4	12

17. What do you mean by a normal good?

18. What do you mean by an 'inferior good'? Give some examples.

19. What do you mean by substitutes? Give examples of two goods which are substitutes of each other.

20. What do you mean by complements? Give examples of two goods which are complements of each other.

21. Explain price elasticity of demand.

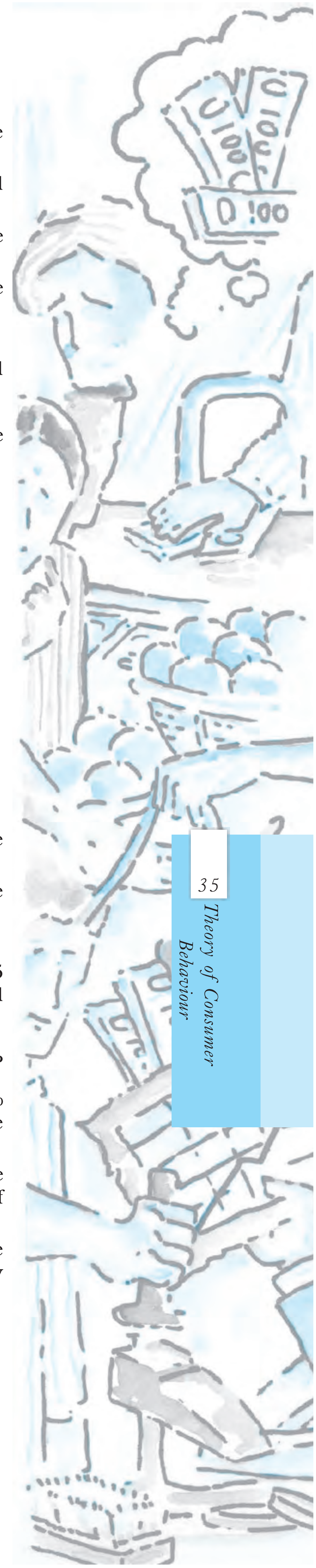
22. Consider the demand for a good. At price Rs 4, the demand for the good is 25 units. Suppose price of the good increases to Rs 5, and as a result, the demand for the good falls to 20 units. Calculate the price elasticity .

23. Consider the demand curve $D(p) = 10 - 3p$. What is the elasticity at price $\frac{5}{3}$?

24. Suppose the price elasticity of demand for a good is –0.2. If there is a 5 % increase in the price of the good, by what percentage will the demand for the good go down?

25. Suppose the price elasticity of demand for a good is –0.2. How will the expenditure on the good be affected if there is a 10 % increase in the price of the good?

27. Suppose there was a 4 % decrease in the price of a good, and as a result, the expenditure on the good increased by 2 %. What can you say about the elasticity of demand?



Chapter 3

Production and Costs

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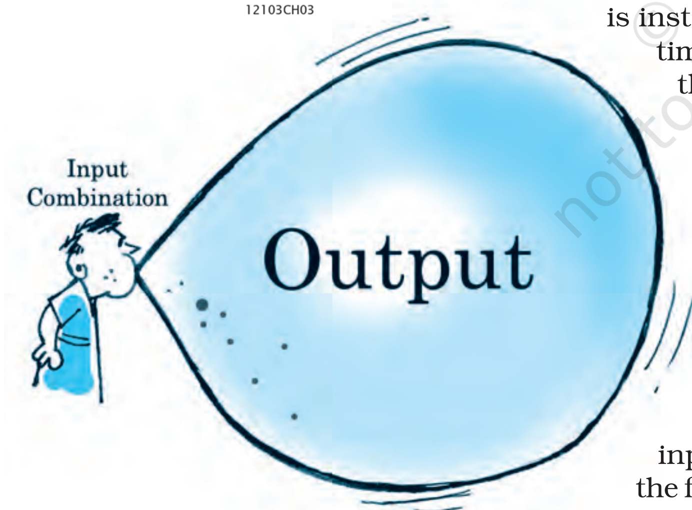
In the previous chapter, we have discussed the behaviour of the consumers. In this chapter as well as in the next, we shall examine the behaviour of a producer. Production is the process by which inputs are transformed into 'output'. Production is carried out by producers or **firms**. A firm acquires different inputs like labour, machines, land, raw materials etc. It uses these inputs to produce output. This output can be consumed by consumers, or used by other firms for further production. For example, a tailor uses a sewing machine, cloth, thread and his own labour to 'produce' shirts. A farmer uses his land, labour, a tractor, seed, fertilizer, water etc to produce wheat. A car manufacturer uses land for a factory, machinery, labour, and various other inputs (steel, aluminium, rubber etc) to produce cars. A rickshaw puller uses a rickshaw and his own labour to 'produce' rickshaw rides. A domestic helper uses her labour to produce 'cleaning services'.

We make certain simplifying assumptions to start with. Production is instantaneous: in our very simple model of production no time elapses between the combination of the inputs and the production of the output. We also tend to use the terms production and supply synonymously and often interchangeably.

In order to acquire inputs a firm has to pay for them. This is called the **cost of production**. Once output has been produced, the firm sell it in the market and earns **revenue**. The difference between the revenue and cost is called the firm's **profit**. We assume that the objective of a firm is to earn the maximum profit that it can.

In this chapter, we discuss the relationship between inputs and output. Then we look at the cost structure of the firm. We do this to be able to identifiy the output at which firms profits are maximum.



A Firm Effort

3.1 Production Function

The production function of a firm is a relationship between inputs used and output produced by the firm. For various quantities of inputs used, it gives the maximum quantity of output that can be produced.

Consider the farmer we mentioned above. For simplicity, we assume that the farmer uses only two inputs to produce wheat: land and labour. A production function tells us the maximum amount of wheat he can produce for a given amount of land that he uses, and a given number of hours of labour that he performs. Suppose that he uses 2 hours of labour/ day and 1 hectare of land to produce a maximum of 2 tonnes of wheat. Then, a function that describes this relation is called a production function.

One possible example of the form this could take is:

$q = K \times L$,

Where, q is the amount of wheat produced, K is the area of land in hectares, L is the number of hours of work done in a day.

Describing a production function in this manner tells us the exact relation between inputs and output. If either K or L increase, q will also increase. For any L and any K, there will be only one q. Since by definition we are taking the maximum output for any level of inputs, a production function deals only with the efficient use of inputs. Efficiency implies that it is not possible to get any more output from the same level of inputs.

A production function is defined for a given technology. It is the technological knowledge that determines the maximum levels of output that can be produced using different combinations of inputs. If the technology improves, the maximum levels of output obtainable for different input combinations increase. We then have a new production function.

The inputs that a firm uses in the production process are called factors of production. In order to produce output, a firm may require any number of different inputs. However, for the time being, here we consider a firm that produces output using only two factors of production – labour and capital. Our production function, therefore, tells us the maximum quantity of output (q) that can be produced by using different combinations of these two factors of productions- Labour (L) and Capital (K).

We may write the production function as

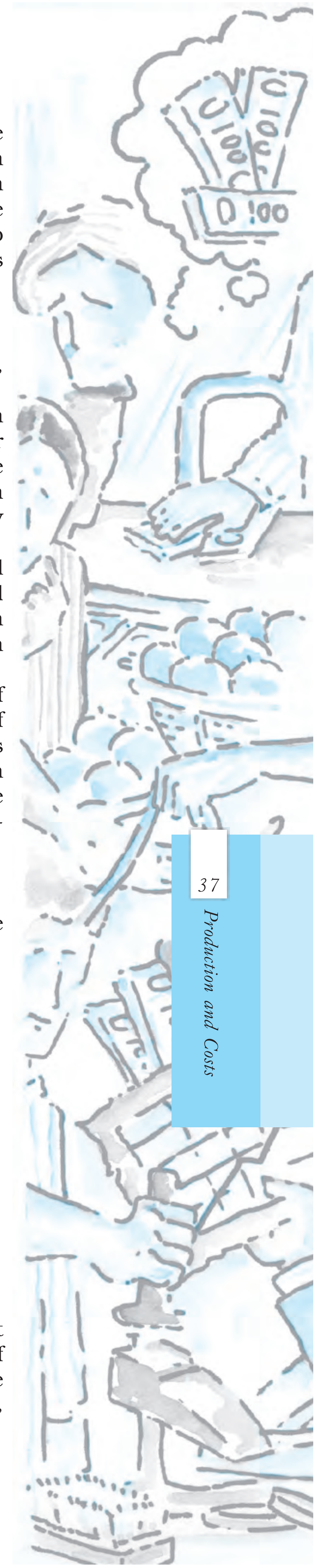
$$q = f(L,K) \tag{3.1}$$

where, L is labour and K is capital and q is the maximum output that can be produced.

Table 3.1: Production Function

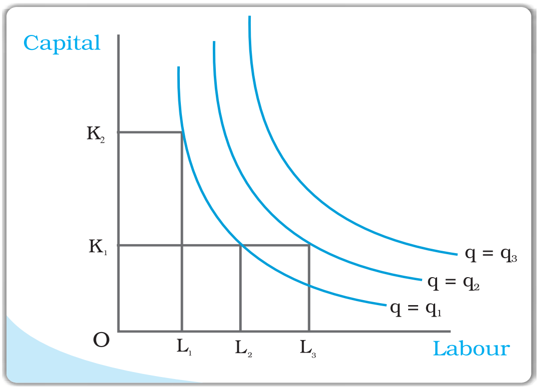
Factor		*Capital*						
		0	1	2	3	4	5	6
Labour	0	0	0	0	0	0	0	0
	1	0	1	3	7	10	12	13
	2	0	3	10	18	24	29	33
	3	0	7	18	30	40	46	50
	4	0	10	24	40	50	56	57
	5	0	12	29	46	56	58	59
	6	0	13	33	50	57	59	60

A numerical example of production function is given in Table 3.1. The left column shows the amount of labour and the top row shows the amount of capital. As we move to the right along any row, capital increases and as we move down along any column, labour increases. For different values of the two factors,



Isoquant

In Chapter 2, we have learnt about indifference curves. Here, we introduce a similar concept known as isoquant. It is just an alternative way of representing the production function. Consider a production function with two inputs labour and capital. An isoquant is the set of all possible combinations of the two inputs that yield the same maximum possible level of output. Each isoquant represents a particular level of output and is labelled with that amount of output.



Let us return to table 3.1 notice that the output of 10 units can be produced in 3 ways (4L, 1K), (2L, 2K), (1L, 4K). All these combination of L, K lie on the same isoquant, which represents the level of output 10. Can you identify the sets of inputs that will lie on the isoquant q = 50?

The diagram here generalizes this concept. We place L on the X axis and K on the Y axis. We have three isoquants for the three output levels, namely $q = q_1$, $q = q_2$ and $q = q_3$. Two input combinations (L_1, K_2) and (L_2, K_1) give us the same level of output q_1. If we fix capital at K_1 and increase labour to L_3, output increases and we reach a higher isoquant, $q = q_2$. When marginal products are positive, with greater amount of one input, the same level of output can be produced only using lesser amount of the other. Therefore, isoquants are negatively sloped.

the table shows the corresponding output levels. For example, with 1 unit of labour and 1 unit of capital, the firm can produce at most 1 unit of output; with 2 units of labour and 2 units of capital, it can produce at most 10 units of output; with 3 units of labour and 2 units of capital, it can produce at most 18 units of output and so on.

In our example, both the inputs are necessary for the production. If any of the inputs becomes zero, there will be no production. With both inputs positive, output will be positive. As we increase the amount of any input, output increases.

3.2 The Short Run and the Long Run

Before we begin with any further analysis, it is important to discuss two concepts– the **short run** and the **long run**.

In the **short run**, at least one of the factor – labour or capital – cannot be varied, and therefore, remains fixed. In order to vary the output level, the firm can vary only the other factor. The factor that remains fixed is called the **fixed factor** whereas the other factor which the firm can vary is called the **variable factor**.

Consider the example represented through Table 3.1. Suppose, in the short run, capital remains fixed at 4 units. Then the corresponding column shows the different levels of output that the firm may produce using different quantities of labour in the short run.

In the **long run**, all factors of production can be varied. A firm in order to produce different levels of output in the long run may vary both the inputs simultaneously. So, in the long run, there is no fixed factor.

For any particular production process, long run generally refers to a longer time period than the short run. For different production processes, the long run periods may be different. It is not advisable to define short run and long run in terms of say, days, months or years. We define a period as long run or short run simply by looking at whether all the inputs can be varied or not.

3.3 Total Product, Average Product and Marginal Product

3.3.1 Total Product

Suppose we vary a single input and keep all other inputs constant. Then for different levels of that input, we get different levels of output. This relationship between the variable input and output, keeping all other inputs constant, is often referred to as **Total Product** (**TP**) of the variable input.

Let us again look at Table 3.1. Suppose capital is fixed at 4 units. Now in the Table 3.1, we look at the column where capital takes the value 4. As we move down along the column, we get the output values for different values of labour. This is the total product of labour schedule with $K_2 = 4$. This is also sometimes called **total return** to or **total physical product** of the variable input. This is shown again in the second column of table in 3.2

Once we have defined total product, it will be useful to define the concepts of average product (AP) and marginal product (MP). They are useful in order to describe the contribution of the variable input to the production process.

3.3.2 Average Product

Average product is defined as the output per unit of variable input. We calculate it as

$$AP_L = \frac{TP_L}{L} \qquad (3.2)$$

The last column of table 3.2 gives us a numerical example of average product of labour (with capital fixed at 4) for the production function described in table 3.1. Values in this column are obtained by dividing TP (column 2) by L (Column 1).

3.3.3 Marginal Product

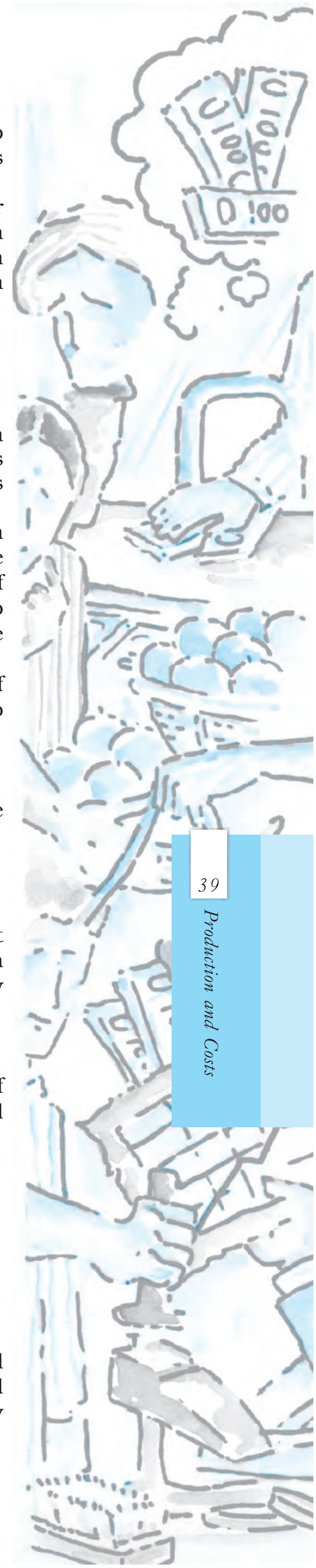
Marginal product of an input is defined as the change in output per unit of change in the input when all other inputs are held constant. When capital is held constant, the marginal product of labour is

$$MP_L = \frac{Change\ in\ output}{Change\ in\ input}$$

$$= \frac{\Delta TP_L}{\Delta L} \qquad (3.3)$$

where Δ represents the change of the variable.

The third column of table 3.2 gives us a numerical example of Marginal Product of labour (with capital fixed at 4) for the production function described in table 3.1. Values in this column are obtained by dividing change in TP by



change in L. For example, when L changes from 1 to 2, TP changes from 10 to 24.

$$MP_L = (\text{TP at } L \text{ units}) - (\text{TP at } L - 1 \text{ unit}) \qquad (3.4)$$

Here, Change in TP = 24 -10 = 14
Change in L = 1
Marginal product of the 2nd unit of labour = 14/1 = 14

Since inputs cannot take negative values, marginal product is undefined at zero level of input employment. For any level of an input, the sum of marginal products of every preceeding unit of that input gives the total product. So total product is the sum of marginal products.

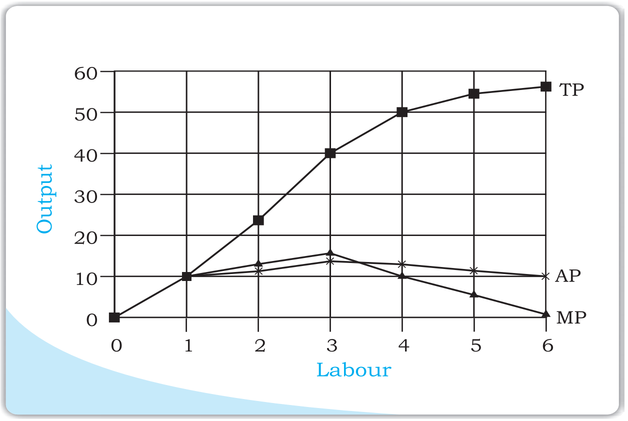
Table 3.2: Total Product, Marginal product and Average product

Labour	*TP*	MP_L	AP_L
0	0	-	-
1	10	10	10
2	24	14	12
3	40	16	13.33
4	50	10	12.5
5	56	6	11.2
6	57	1	9.5

Average product of an input at any level of employment is the average of all marginal products up to that level. Average and marginal products are often referred to as average and marginal returns, respectively, to the variable input.

3.4 The Law of Diminishing Marginal Product and the Law of Variable Proportions

If we plot the data in table 3.2 on graph paper, placing labour on the X-axis and output on the Y-axis, we get the curves shown in the diagram below. Let us examine what is happening to TP. Notice that TP increases as labour input increases. But the rate at which it increases is not constant. An increase in labour from 1 to 2 increases TP by 10 units. An increase in labour from 2 to 3 increases TP by 12. The rate at which TP increases, as explained above, is shown by the MP. Notice that the MP first increases (upto 3 units of labour) and then begins to



fall. This tendency of the MP to first increase and then fall is called the **law of variable proportions** or the **law of diminishing marginal product. Law of variable proportions** say that the marginal product of a factor input initially rises with its employment level. But after reaching a certain level of employment, it starts falling.

Why does this happen? In order to understand this, we first define the concept of factor proportions. Factor proportions represent the ratio in which the two inputs are combined to produce output.

As we hold one factor fixed and keep increasing the other, the factor proportions change. Initially, as we increase the amount of the variable input, the factor proportions become more and more suitable for the production and marginal product increases. But after a certain level of employment, the production process becomes too crowded with the variable input.

Suppose table 3.2 describes the output of a farmer who has 4 hectares of land, and can choose how much labour he wants to use. If he uses only 1 worker, he has too much land for the worker to cultivate alone. As he increases the number of workers, the amount of labour per unit land increases, and each worker adds proportionally more and more to the total output. Marginal product increases in this phase. When the fourth worker is hired, the land begins to get 'crowded'. Each worker now has insufficient land to work efficiently. So the output added by each additional worker is now proportionally less. The marginal product begins to fall.

We can use these observations to describe the general shapes of the TP, MP and AP curves as below.

3.5 Shapes of Total Product, Marginal Product and Average Product Curves

An increase in the amount of one of the inputs keeping all other inputs constant results in an increase in output. Table 3.2 shows how the total product changes as the amount of labour increases. The total product curve in the input-output plane is a positively sloped curve. Figure 3.1 shows the shape of the total product curve for a typical firm.

We measure units of labour along the horizontal axis and output along the vertical axis. With L units of labour, the firm can at most produce q_1 units of output.

According to the law of variable proportions, the marginal product of an input initially rises and then after a certain level of employment, it starts falling. The MP curve therefore, looks like an inverse 'U'-shaped curve as in figure 3.2.

Let us now see what the AP curve looks like. For the first unit of the variable input, one can easily check that the MP and the

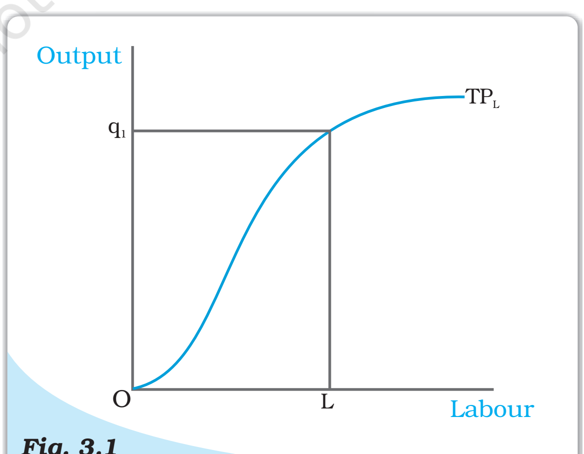


Fig. 3.1

Total Product*. This is a total product curve for labour. When all other inputs are held constant, it shows the different output levels obtainable from different units of labour.*

AP are same. Now as we increase the amount of input, the MP rises. AP being the average of marginal products, also rises, but rises less than MP. Then, after a point, the MP starts falling. However, as long as the value of MP remains higher than the value of the AP, the AP continues to rise. Once MP has fallen sufficiently, its value becomes less than the AP and the AP also starts falling. So AP curve is also inverse 'U'-shaped.

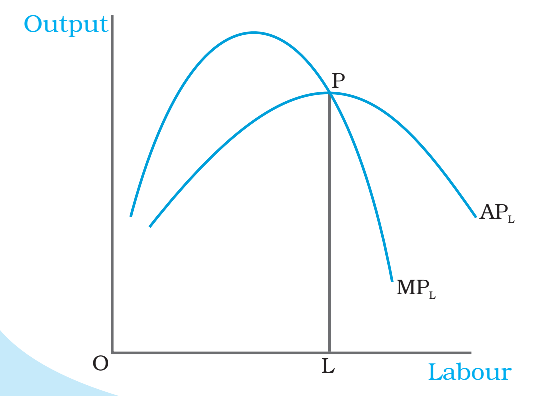


Fig. 3.2

Average and Marginal Product. *These are average and marginal product curves of labour.*

As long as the AP increases, it must be the case that MP is greater than AP. Otherwise, AP cannot rise. Similarly, when AP falls, MP has to be less than AP. It follows that MP curve cuts AP curve from above at its maximum.

Figure 3.2 shows the shapes of AP and MP curves for a typical firm.

The AP of factor 1 is maximum at *L*. To the left of *L*, AP is rising and MP is greater than AP. To the right of *L*, AP is falling and MP is less than AP.

3.6 Returns to Scale

The law of variable proportions arises because factor proportions change as long as one factor is held constant and the other is increased. What if both factors can change? Remember that this can happen only in the long run. One special case in the long run occurs when both factors are increased by the *same proportion*, or factors are scaled up.

When a proportional increase in all inputs results in an increase in output by the same proportion, the production function is said to display **Constant returns to scale** (CRS).

When a proportional increase in all inputs results in an increase in output by a larger proportion, the production function is said to display **Increasing Returns to Scale** (IRS)

Decreasing Returns to Scale (DRS) holds when a proportional increase in all inputs results in an increase in output by a smaller proportion.

For example, suppose in a production process, all inputs get doubled. As a result, if the output gets doubled, the production function exhibits CRS. If output is less than doubled, then DRS holds, and if it is more than doubled, then IRS holds.

Returns to Scale

Consider a production function

$$q = f(x_1, x_2)$$

where the firm produces q amount of output using x_1 amount of factor 1 and x_2 amount of factor 2. Now suppose the firm decides to increase the employment level of both the factors t ($t > 1$) times. Mathematically, we can say that the production function exhibits constant returns to scale if we have,

$$f(tx_1, tx_2) = t.f(x_1, x_2)$$

ie the new output level $f(tx_1, tx_2)$ is exactly t times the previous output level $f(x_1, x_2)$.

Similarly, the production function exhibits increasing returns to scale if,

$$f(tx_1, tx_2) > t.f(x_1, x_2).$$

It exhibits decreasing returns to scale if,

$$f(tx_1, tx_2) < t.f(x_1, x_2).$$

3.7 Costs

In order to produce output, the firm needs to employ inputs. But a given level of output, typically, can be produced in many ways. There can be more than one input combinations with which a firm can produce a desired level of output. In Table 3.1, we can see that 50 units of output can be produced by three different input combinations ($L = 6$, $K = 3$), ($L = 4$, $K = 4$) and ($L = 3$, $K = 6$). The question is which input combination will the firm choose? With the input prices given, it will choose that combination of inputs which is least expensive. So, for every level of output, the firm chooses the least cost input combination. Thus the cost function describes the least cost of producing each level of output given prices of factors of production and technology.

Cobb-Douglas Production Function

Consider a production function

$$q = x_1^{\alpha} x_2^{\beta}$$

where α and β are constants. The firm produces q amount of output using x_1 amount of factor 1 and x_2 amount of factor 2. This is called a **Cobb-Douglas production function**. Suppose with $x_1 = \bar{x}_1$ and $x_2 = \bar{x}_2$, we have q_0 units of output, i.e.

$$q_0 = \bar{x}_1^{\alpha} \bar{x}_2^{\beta}$$

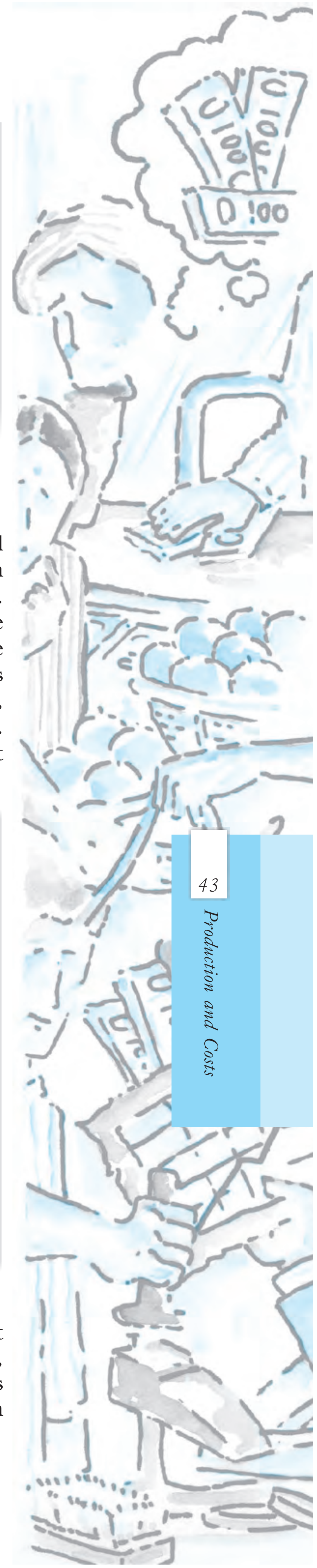
If we increase both the inputs t ($t > 1$) times, we get the new output

$$q_1 = (t\bar{x}_1)^{\alpha}(t\bar{x}_2)^{\beta}$$
$$= t^{\alpha+\beta} \bar{x}_1^{\alpha} \bar{x}_2^{\beta}$$

When $\alpha + \beta = 1$, we have $q_1 = tq_0$. That is, the output increases t times. So the production function exhibits CRS. Similarly, when $\alpha + \beta > 1$, the production function exhibits IRS. When $\alpha + \beta < 1$ the production function exhibits DRS.

3.7.1 Short Run Costs

We have previously discussed the short run and the long run. In the short run, some of the factors of production cannot be varied, and therefore, remain fixed. The cost that a firm incurs to employ these fixed inputs is called the total fixed cost (TFC). Whatever amount of output the firm



produces, this cost remains fixed for the firm. To produce any required level of output, the firm, in the short run, can adjust only variable inputs. Accordingly, the cost that a firm incurs to employ these variable inputs is called the total variable cost (TVC). Adding the fixed and the variable costs, we get the total cost (TC) of a firm

$$TC = TVC + TFC \tag{3.6}$$

In order to increase the production of output, the firm must employ more of the variable inputs. As a result, total variable cost and total cost will increase. Therefore, as output increases, total variable cost and total cost increase.

In Table 3.3, we have an example of cost function of a typical firm. The first column shows different levels of output. For all levels of output, the total fixed cost is Rs 20. Total variable cost increases as output increases. With output zero, TVC is zero. For 1 unit of output, TVC is Rs 10; for 2 units of output, TVC is Rs 18 and so on. In the fourth column, we obtain the total cost (TC) as the sum of the corresponding values in second column (TFC) and third column (TVC). At zero level of output, TC is just the fixed cost, and hence, equal to Rs 20. For 1 unit of output, total cost is Rs 30; for 2 units of output, the TC is Rs 38 and so on.

The **short run average cost (SAC)** incurred by the firm is defined as the total cost per unit of output. We calculate it as

$$SAC = \frac{TC}{q} \tag{3.7}$$

In Table 3.3, we get the SAC-column by dividing the values of the fourth column by the corresponding values of the first column. At zero output, SAC is undefined. For the first unit, SAC is Rs 30; for 2 units of output, SAC is Rs 19 and so on.

Similarly, the **average variable cost (AVC)** is defined as the total variable cost per unit of output. We calculate it as

$$AVC = \frac{TVC}{q} \tag{3.8}$$

Also, **average fixed cost (AFC)** is

$$AFC = \frac{TFC}{q} \tag{3.9}$$

Clearly,

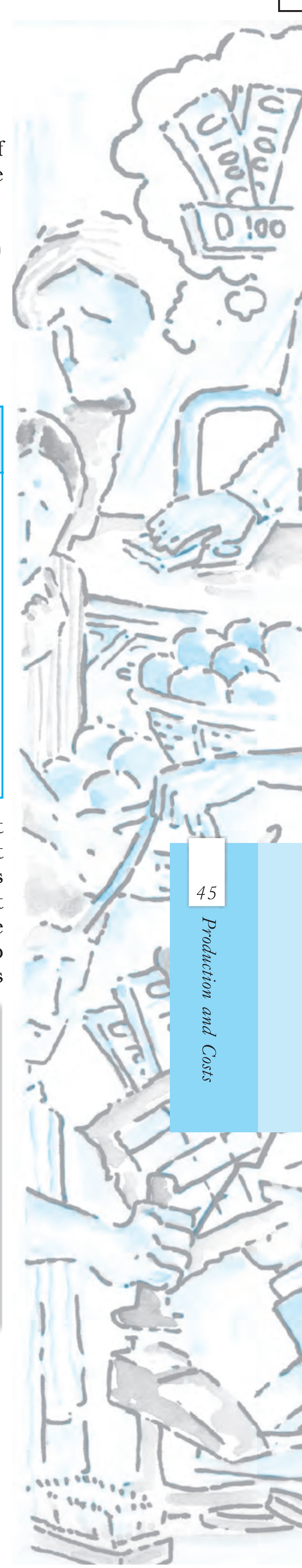
$$SAC = AVC + AFC \tag{3.10}$$

In Table 3.3, we get the AFC-column by dividing the values of the second column by the corresponding values of the first column. Similarly, we get the AVC-column by dividing the values of the third column by the corresponding values of the first column. At zero level of output, both AFC and AVC are undefined. For the first unit of output, AFC is Rs 20 and AVC is Rs 10. Adding them, we get the SAC equal to Rs 30.

The **short run marginal cost (SMC)** is defined as the change in total cost per unit of change in output

$$SMC = \frac{\textit{change in total cost}}{\textit{change in output}} = \frac{\Delta TC}{\Delta q} \tag{3.11}$$

where Δ represents the change in the value of the variable.



The last column in table 3.3 gives a numerical example for the calculation of SMC. Values in this column are obtained by dividing the change in TC by the change in output, at each level of output.

Thus at q=5,

Change in TC = (TC at q=5) - (TC at q=4) (3.12)

= (53) – (49)

= 4

Change in q = 1

SMC = 4/1 = 4

Table 3.3: Various Concepts of Costs

Output (units) (q)	*TFC (Rs)*	*TVC (Rs)*	*TC (Rs)*	*AFC (Rs)*	*AVC (Rs)*	*SAC (Rs)*	*SMC (Rs)*
0	20	0	20	–	–	–	–
1	20	10	30	20	10	30	10
2	20	18	38	10	9	19	8
3	20	24	44	6.67	8	14.67	6
4	20	29	49	5	7.25	12.25	5
5	20	33	53	4	6.6	10.6	4
6	20	39	59	3.33	6.5	9.83	6
7	20	47	67	2.86	6.7	9.57	8
8	20	60	80	2.5	7.5	10	13
9	20	75	95	2.22	8.33	10.55	15
10	20	95	115	2	9.5	11.5	20

Just like the case of marginal product, marginal cost also is undefined at zero level of output. It is important to note here that in the short run, fixed cost cannot be changed. When we change the level of output, whatever change occurs to total cost is entirely due to the change in total variable cost. So in the short run, marginal cost is the increase in TVC due to increase in production of one extra unit of output. For any level of output, the sum of marginal costs up to that level gives us the total variable cost at that level. One may wish to check this from the example represented through Table 3.3. Average variable cost at some level of output is therefore, the average of all marginal costs up to that level. In Table 3.3, we see that when the output is zero, SMC is undefined. For the first unit of output, SMC is Rs 10; for the second unit, the SMC is Rs 8 and so on.

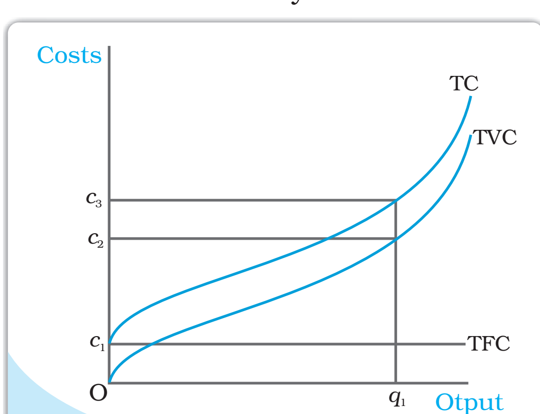


Fig. 3.3

***Costs**. These are total fixed cost (TFC), total variable cost (TVC) and total cost (TC) curves for a firm. Total cost is the vertical sum of total fixed cost and total variable cost.*

Shapes of the Short Run Cost Curves

Now let us see what these short run cost curves look like. You could plot the data from in table 3.3 by placing output on the x-axis and costs on the y-axis.

Previously, we have discussed that in order to increase the production of output the firm needs to employ more of the variable inputs. This results in an increase in total variable cost, and hence, an increase in total cost. Therefore, as output increases, total variable cost and total cost increase. Total fixed cost, however, is independent of the amount of output produced and remains constant for all levels of production.

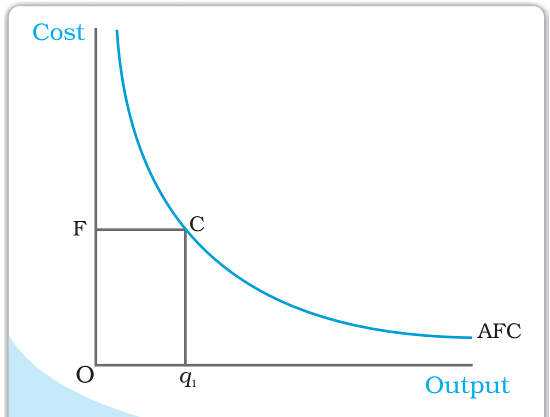


Fig. 3.4

Average Fixed Cost. *The average fixed cost curve is a rectangular hyperbola. The area of the rectangle* OFCq_1 *gives us the total fixed cost.*

Figure 3.3 illustrates the shapes of total fixed cost, total variable cost and total cost curves for a typical firm. We place output on the x-axis and costs on the y-axis. TFC is a constant which takes the value c_1 and does not change with the change in output. It is, therefore, a horizontal straight line cutting the cost axis at the point c_1. At q_1, TVC is c_2 and TC is c_3.

AFC is the ratio of TFC to q. TFC is a constant. Therefore, as q increases, AFC decreases. When output is very close to zero, AFC is arbitrarily large, and as output moves towards infinity, AFC moves towards zero. AFC curve is, in fact, a rectangular hyperbola. If we multiply any value q of output with its corresponding AFC, we always get a constant, namely TFC.

Figure 3.4 shows the shape of average fixed cost curve for a typical firm. We measure output along the horizontal axis and AFC along the vertical axis. At q_1 level of output, we get the corresponding average fixed cost at F. The TFC can be calculated as

$$\begin{aligned} TFC &= AFC \times \text{quantity} \\ &= OF \times Oq_1 \\ &= \text{the area of the rectangle } OFCq_1 \end{aligned}$$

We can also calculate AFC from TFC curve. In Figure 3.5, the horizontal straight line cutting the vertical axis at F is the TFC curve. At q_0 level of output, total fixed cost is equal to OF. At q_0, the corresponding point on the TFC curve is A. Let the angle $\angle AOq_0$ be θ. The AFC at q_0 is

$$AFC = \frac{TFC}{quantity}$$

$$= \frac{Aq_0}{Oq_0} = \tan\theta$$

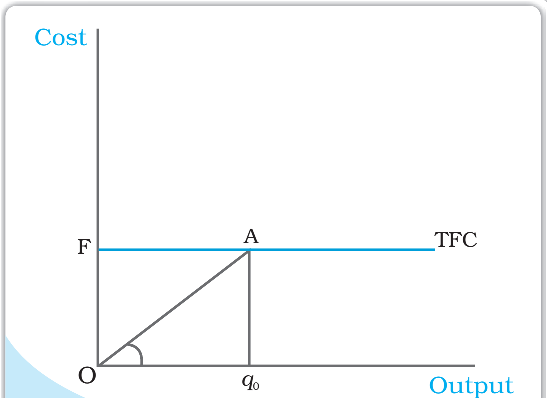


Fig. 3.5

The Total Fixed Cost Curve. *The slope of the angle* $\angle$AOq_0 *gives us the average fixed cost at* q_0.

Let us now look at the SMC curve. Marginal cost is the additional cost that a firm incurs to produce one extra unit of output. According to the law of variable proportions, initially, the marginal product of a factor increases as employment increases, and then after a certain point, it decreases. This means initially to produce every extra unit of output, the requirement of the factor becomes less and less, and then after a certain point, it becomes greater and greater. As a result, with the factor price given, initially the SMC falls, and then after a certain point, it rises. SMC curve is, therefore, 'U'-shaped.

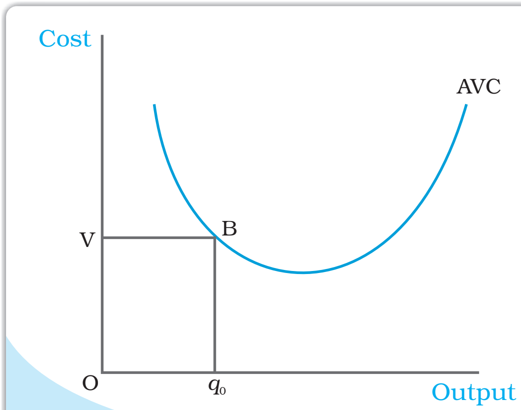


Fig. 3.6

The Average Variable Cost Curve. *The area of the rectangle OVBq_0 gives us the total variable cost at q_0.*

At zero level of output, SMC is undefined. The TVC at a particular level of output is given by the area under the SMC curve up to that level.

Now, what does the AVC curve look like? For the first unit of output, it is easy to check that SMC and AVC are the same. So both SMC and AVC curves start from the same point. Then, as output increases, SMC falls. AVC being the average of marginal costs, also falls, but falls less than SMC. Then, after a point, SMC starts rising. AVC, however, continues to fall as long as the value of SMC remains less than the prevailing value of AVC. Once the SMC has risen sufficiently, its value becomes greater than the value of AVC. The AVC then starts rising. The AVC curve is therefore 'U'-shaped.

As long as AVC is falling, SMC must be less than the AVC. As AVC rises, SMC must be greater than the AVC. So the SMC curve cuts the AVC curve from below at the minimum point of AVC.

In Figure 3.7, we measure output along the horizontal axis and TVC along the vertical axis. At q_0 level of output, OV is the total variable cost. Let the angle $\angle E0q_0$ be equal to θ. Then, at q_0, the AVC can be calculated as

$$AVC = \frac{TVC}{output}$$

$$= \frac{Eq_0}{Oq_0} = \tan\theta$$

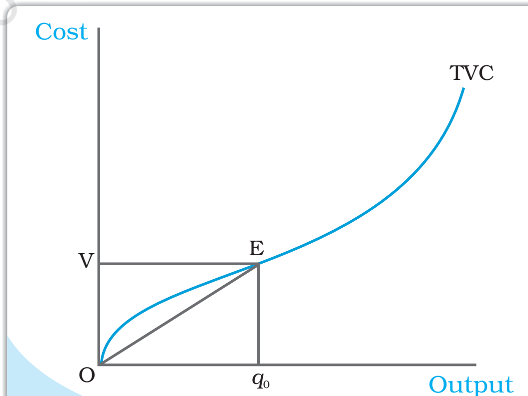
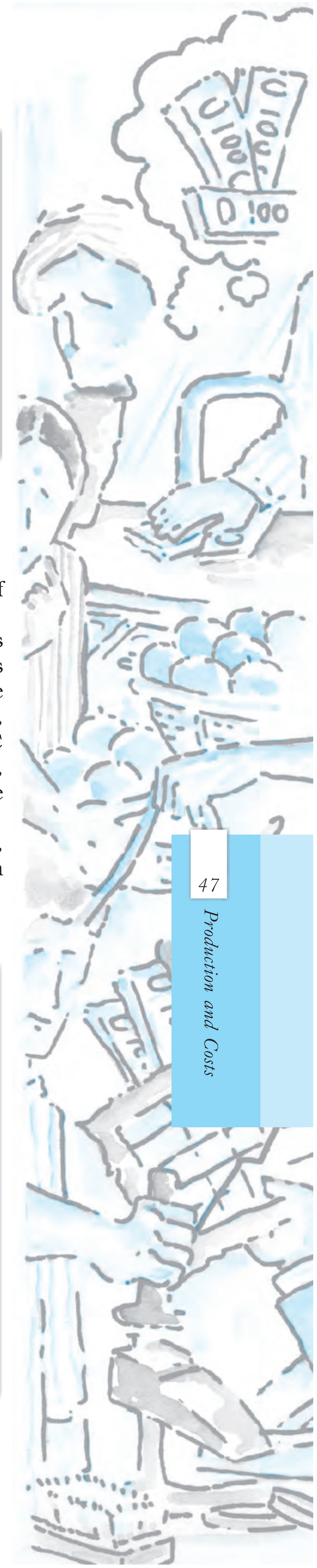


Fig. 3.7

The Total Variable Cost Curve. *The slope of the angle ∠EOqo gives us the average variable cost at qo.*



In Figure 3.6 we measure output along the horizontal axis and AVC along the vertical axis. At q_0 level of output, AVC is equal to OV. The total variable cost at q_0 is

$$TVC = AVC \times \text{quantity}$$
$$= OV \times Oq_0$$
$$= \text{the area of the rectangle } OVBq_0.$$

Let us now look at SAC. SAC is the sum of AVC and AFC. Initially, both AVC and AFC decrease as output increases. Therefore, SAC initially falls. After a certain level of output production, AVC starts rising, but AFC continuous to fall. Initially the fall in AFC is greater than the rise in AVC and SAC is still falling. But, after a certain level of production, rise in AVC becomes larger than the fall in AFC. From this point onwards, SAC is rising. SAC curve is therefore 'U'-shaped.

It lies above the AVC curve with the vertical difference being equal to the value of AFC. The minimum point of SAC curve lies to the right of the minimum point of AVC curve.

Similar to the case of AVC and SMC, as long as SAC is falling, SMC is less than the SAC. When SAC is rising, SMC is greater than the SAC. SMC curve cuts the SAC curve from below at the minimum point of SAC.

Figure 3.8 shows the shapes of short run marginal cost, average variable cost and short run average cost curves for a typical firm. AVC reaches its minimum at q_1 units of output. To the left of q_1, AVC is falling and SMC is less than AVC. To the right of q_1, AVC is rising and SMC is greater than AVC. SMC curve cuts the AVC curve at 'P' which is the minimum point of AVC curve. The minimum point of SAC curve is 'S' which corresponds to the output q_2. It is the intersection point between SMC and SAC curves. To the left of q_2, SAC is falling and SMC is less than SAC. To the right of q_2, SAC is rising and SMC is greater than SAC.

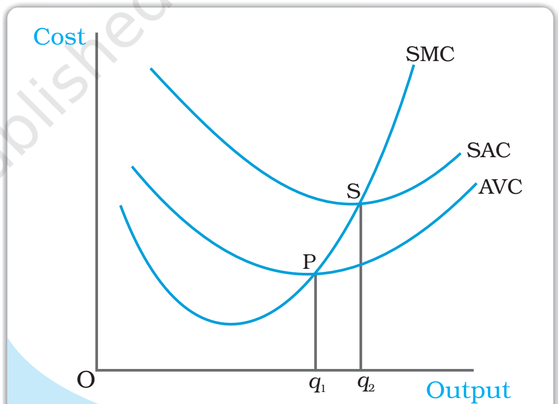


Fig. 3.8

Short Run Costs. *Short run marginal cost, average variable cost and average cost curves.*

3.7.2 Long Run Costs

In the long run, all inputs are variable. There are no fixed costs. The total cost and the total variable cost therefore, coincide in the long run. **Long run average cost** (LRAC) is defined as cost per unit of output, i.e.

$$LRAC = \frac{TC}{q} \tag{3.13}$$

Long run marginal cost (LRMC) is the change in total cost per unit of change in output. When output changes in discrete units, then, if we increase production from q_1–1 to q_1 units of output, the marginal cost of producing q_1th unit will be measured as

$$LRMC = (\text{TC at } q_1 \text{ units}) - (\text{TC at } q_1 - 1 \text{ units}) \tag{3.14}$$

Just like the short run, in the long run, the sum of all marginal costs up to some output level gives us the total cost at that level.

Shapes of the Long Run Cost Curves

We have previously discussed the returns to scales. Now let us see their implications for the shape of LRAC.

IRS implies that if we increase all the inputs by a certain proportion, output increases by more than that proportion. In other words, to increase output by a certain proportion, inputs need to be increased by less than that proportion. With the input prices given, cost also increases by a lesser proportion. For example, suppose we want to double the output. To do that, inputs need to be increased, but less than double. The cost that the firm incurs to hire those inputs therefore also need to be increased by less than double. What is happening to the average cost here? It must be the case that as long as IRS operates, average cost falls as the firm increases output.

DRS implies that if we want to increase the output by a certain proportion, inputs need to be increased by more than that proportion. As a result, cost also increases by more than that proportion. So, as long as DRS operates, the average cost must be rising as the firm increases output.

CRS implies a proportional increase in inputs resulting in a proportional increase in output. So the average cost remains constant as long as CRS operates.

It is argued that in a typical firm IRS is observed at the initial level of production. This is then followed by the CRS and then by the DRS. Accordingly, the LRAC curve is a 'U'-shaped curve. Its downward sloping part corresponds to IRS and upward rising part corresponds to DRS. At the minimum point of the LRAC curve, CRS is observed.

Let us check how the LRMC curve looks like. For the first unit of output, both LRMC and LRAC are the same. Then, as output increases, LRAC initially falls, and then, after a certain point, it rises. As long as average cost is falling, marginal cost must be less than the average cost. When the average cost is rising, marginal cost must be greater than the average cost. LRMC curve is therefore a 'U'-shaped curve. It cuts the LRAC curve from below at the minimum point of the LRAC. Figure 3.9 shows the shapes of the long run marginal cost and the long run average cost curves for a typical firm.

LRAC reaches its minimum at q_1. To the left of q_1, LRAC is falling and LRMC is less than the LRAC curve. To the right of q_1, LRAC is rising and LRMC is higher than LRAC.

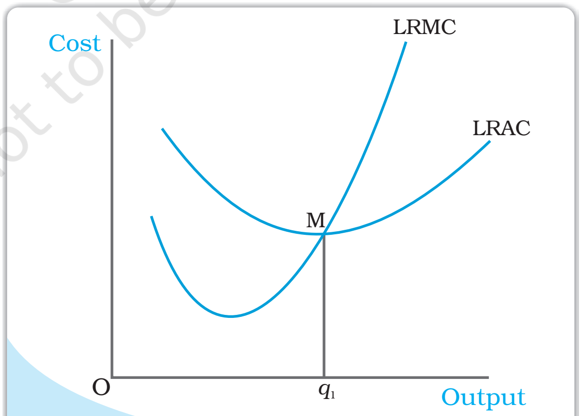


Fig. 3.9

***Long Run Costs**. Long run marginal cost and average cost curves.*

Summary

- For different combinations of inputs, the production function shows the maximum quantity of output that can be produced.
- In the short run, some inputs cannot be varied. In the long run, all inputs can be varied.
- Total product is the relationship between a variable input and output when all other inputs are held constant.
- For any level of employment of an input, the sum of marginal products of every unit of that input up to that level gives the total product of that input at that employment level.
- Both the marginal product and the average product curves are inverse 'U'-shaped. The marginal product curve cuts the average product curve from above at the maximum point of average product curve.
- In order to produce output, the firm chooses least cost input combinations.
- Total cost is the sum of total variable cost and the total fixed cost.
- Average cost is the sum of average variable cost and average fixed cost.
- Average fixed cost curve is downward sloping.
- Short run marginal cost, average variable cost and short run average cost curves are 'U'-shaped.
- SMC curve cuts the AVC curve from below at the minimum point of AVC.
- SMC curve cuts the SAC curve from below at the minimum point of SAC.
- In the short run, for any level of output, sum of marginal costs up to that level gives us the total variable cost. The area under the SMC curve up to any level of output gives us the total variable cost up to that level.
- Both LRAC and LRMC curves are 'U' shaped.
- LRMC curve cuts the LRAC curve from below at the minimum point of LRAC.

Key Concepts

Production function	Short run
Long run	Total product
Marginal product	Average product
Law of diminishing marginal product	Law of variable proportions
	Returns to scale
Cost function	Marginal cost, Average cost

Exercises

1. Explain the concept of a production function.
2. What is the total product of an input?
3. What is the average product of an input?
4. What is the marginal product of an input?
5. Explain the relationship between the marginal products and the total product of an input.
6. Explain the concepts of the short run and the long run.
7. What is the law of diminishing marginal product?
8. What is the law of variable proportions?
9. When does a production function satisfy constant returns to scale?
10. When does a production function satisfy increasing returns to scale?

11. When does a production function satisfy decreasing returns to scale?
12. Briefly explain the concept of the cost function.
13. What are the total fixed cost, total variable cost and total cost of a firm? How are they related?
14. What are the average fixed cost, average variable cost and average cost of a firm? How are they related?
15. Can there be some fixed cost in the long run? If not, why?
16. What does the average fixed cost curve look like? Why does it look so?
17. What do the short run marginal cost, average variable cost and short run average cost curves look like?
18. Why does the SMC curve cut the AVC curve at the minimum point of the AVC curve?
19. At which point does the SMC curve cut the SAC curve? Give reason in support of your answer.
20. Why is the short run marginal cost curve 'U'-shaped?
21. What do the long run marginal cost and the average cost curves look like?
22. The following table gives the total product schedule of labour. Find the corresponding average product and marginal product schedules of labour.

L	TP_L
0	0
1	15
2	35
3	50
4	40
5	48

23. The following table gives the average product schedule of labour. Find the total product and marginal product schedules. It is given that the total product is zero at zero level of labour employment.

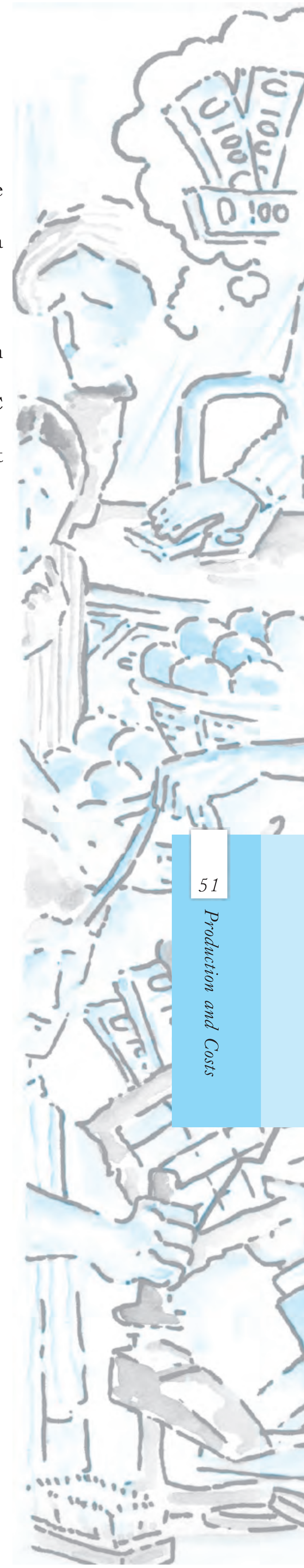
L	AP_L
1	2
2	3
3	4
4	4.25
5	4
6	3.5

24. The following table gives the marginal product schedule of labour. It is also given that total product of labour is zero at zero level of employment. Calculate the total and average product schedules of labour.

L	MP_L
1	3
2	5
3	7
4	5
5	3
6	1

25. The following table shows the total cost schedule of a firm. What is the total fixed cost schedule of this firm? Calculate the TVC, AFC, AVC, SAC and SMC schedules of the firm.

Q	TC
0	10
1	30
2	45
3	55
4	70
5	90
6	120



26. The following table gives the total cost schedule of a firm. It is also given that the average fixed cost at 4 units of output is Rs 5. Find the TVC, TFC, AVC, AFC, SAC and SMC schedules of the firm for the corresponding values of output.

Q	TC
1	50
2	65
3	75
4	95
5	130
6	185

27. A firm's SMC schedule is shown in the following table. The total fixed cost of the firm is Rs 100. Find the TVC, TC, AVC and SAC schedules of the firm.

Q	TC
0	-
1	500
2	300
3	200
4	300
5	500
6	800

28. Let the production function of a firm be

$$Q = 5L^{\frac{1}{2}}K^{\frac{1}{2}}$$

Find out the maximum possible output that the firm can produce with 100 units of L and 100 units of K.

29. Let the production function of a firm be

$$Q = 2L^2K^2$$

Find out the maximum possible output that the firm can produce with 5 units of L and 2 units of K. What is the maximum possible output that the firm can produce with zero unit of L and 10 units of K?

30. Find out the maximum possible output for a firm with zero unit of L and 10 units of K when its production function is

$$Q = 5L + 2K$$

Chapter 4

The Theory of the Firm under Perfect Competition

In the previous chapter, we studied concepts related to a firm's production function and cost curves. The focus of this chapter is different. Here we ask : how does a firm decide how much to produce? Our answer to this question is by no means simple or uncontroversial. We base our answer on a *critical*, if somewhat unreasonable, assumption about firm behaviour – a firm, we maintain, is a ruthless **profit maximiser**. So, the amount that a firm produces and sells in the market is that which maximises its profit. Here, we also assume that the firm sells whatever it produces so that 'output' and quantity sold are often used interchangebly.

The structure of this chapter is as follows. We first set up and examine in detail the profit maximisation problem of a firm. Then,0 we derive a firm's **supply curve**. The supply curve shows the levels of output that a firm chooses to produce at different market prices. Finally, we study how to aggregate the supply curves of individual firms and obtain the **market supply curve**.

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4.1 Perfect Competition: Defining Features

In order to analyse a firm's profit maximisation problem, we must first specify the market environment in which the firm functions. In this chapter, we study a market environment called **perfect competition**. A perfectly competitive market has the following defining features:

1. The market consists of a large number of buyers and sellers
2. Each firm produces and sells a homogenous product. i.e., the product of one firm cannot be differentiated from the product of any other firm.
3. Entry into the market as well as exit from the market are free for firms.
4. Information is perfect.

The existence of a large number of buyers and sellers means that each individual buyer and seller is very small compared to the size of the market. This means that no individual buyer or seller can influence the market by their size. Homogenous products further mean that the product of each firm is identical. So a buyer can choose to buy from any firm in the market, and she gets the same product. Free entry and exit mean that it is easy for firms to enter the market, as well as to leave it. This condition is essential for the large numbers of firms to exist. If entry was difficult, or restricted, then the number of firms in the market could be small. Perfect information implies that all buyers and all sellers are completely informed about the price, quality and other relevant details about the product, as well as the market.

These features result in the single most distinguishing characteristic of perfect competition: **price taking behaviour.** From the viewpoint of a firm, what does price-taking entail? A price-taking firm believes that if it sets a price above the market price, it will be unable to sell any quantity of the good that it produces. On the other hand, should the set price be less than or equal to the market price, the firm can sell as many units of the good as it wants to sell. From the viewpoint of a buyer, what does price-taking entail? A buyer would obviously like to buy the good at the lowest possible price. However, a price-taking buyer believes that if she asks for a price below the market price, no firm will be willing to sell to her. On the other hand, should the price asked be greater than or equal to the market price, the buyer can obtain as many units of the good as she desires to buy.

Price-taking is often thought to be a reasonable assumption when the market has many firms and buyers have perfect information about the price prevailing in the market. Why? Let us start with a situation where each firm in the market charges the same (market) price. Suppose, now, that a certain firm raises its price above the market price. Observe that since all firms produce the same good and all buyers are aware of the market price, the firm in question loses all its buyers. Furthermore, as these buyers switch their purchases to other firms, no "adjustment" problems arise; their demand is readily accommodated when there are so many other firms in the market. Recall, now, that an individual firm's inability to sell any amount of the good at a price exceeding the market price is precisely what the price-taking assumption stipulates.

4.2 Revenue

We have indicated that in a perfectly competitive market, a firm believes that it can sell as many units of the good as *it* wants by setting a price less than or equal to the market price. But, if this is the case, surely there is no reason to set a price lower than the market price. In other words, should the firm desire to sell some amount of the good, the price that it sets is exactly equal to the market price.

A firm earns revenue by selling the good that it produces in the market. Let the market price of a unit of the good be p. Let q be the quantity of the good produced, and therefore sold, by the firm at price p. Then, **total revenue** (TR) of the firm is defined as the market price of the good (p) multiplied by the firm's output (q). Hence,

$$TR = p \times q$$

To make matters concrete, consider the following numerical example. Let the market for candles be perfectly competitive and let the market price of a box of candles be Rs 10. For a candle manufacturer, Table 4.1 shows how total revenue is related to output. Notice that when no box is sold, TR is equal to zero; if one box of candles is sold, TR is equal to 1×Rs 10= Rs 10; if two boxes of candles are produced, TR is equal to 2 × Rs 10 = Rs 20; and so on.

Table 4.1: Total Revenue

Boxes sold	*TR (in Rs)*
0	0
1	10
2	20
3	30
4	40
5	50

We can depict how the total revenue changes as the quantity sold changes through a **Total Revenue Curve.** A total revenue curve plots the quantity sold or output on the X-axis and the Revenue earned on the Y-axis. Figure 4.1 shows the total revenue curve of a firm. Three observations are relevant here. First, when the output is zero, the total revenue of the firm is also zero. Therefore, the TR curve passes through point *O*. Second, the total revenue increases as the output goes up. Moreover, the equation '$TR = p \times q$' is that of a straight line because p is constant. This means that the TR curve is an upward rising straight line. Third, consider the slope of this straight line. When the output is one unit (horizontal distance Oq_1 in Figure 4.1), the total revenue (vertical height Aq_1 in Figure 4.1) is $p \times 1 = p$. Therefore, the slope of the straight line is $Aq_1/Oq_1 = p$.

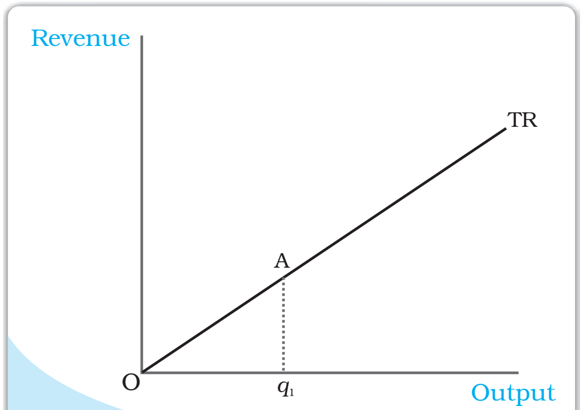


Fig. 4.1

Total Revenue curve*. The total revenue curve of a firm shows the relationship between the total revenue that the firm earns and the output level of the firm. The slope of the curve, Aq_1/Oq_1, is the market price.*

The **average revenue** (AR) of a firm is defined as total revenue per unit of output. Recall that if a firm's output is q and the market price is p, then TR equals $p \times q$. Hence

$$AR = \frac{TR}{q} = \frac{p \times q}{q} = p$$

In other words, for a price-taking firm, average revenue equals the market price.

Now consider Figure 4.2. Here, we plot the average revenue or market price (y-axis) for different values of a firm's output (x-axis). Since the market price is fixed at p, we obtain a horizontal straight line that cuts the y-axis at a height equal to p. This horizontal straight line is called the **price line**. It is also the firm's AR curve under perfect competition The price line also depicts the demand curve facing a firm. Observe that the demand curve is perfectly elastic. This means that a firm can sell as many units of the good as it wants to sell at price p.

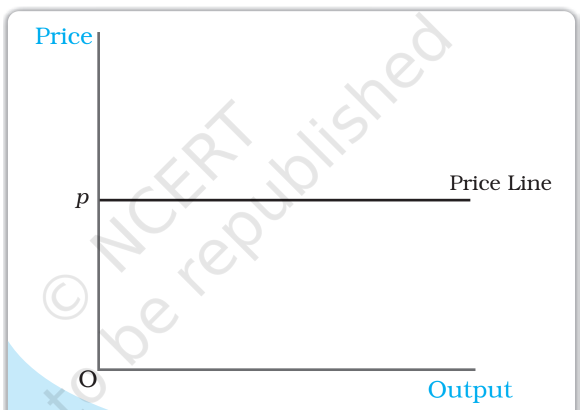
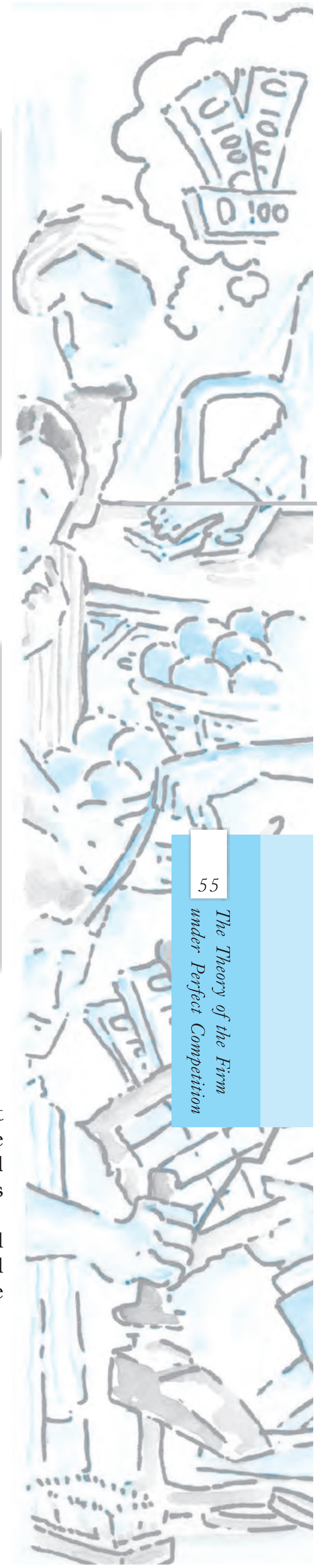


Fig. 4.2

Price Line. *The price line shows the relationship between the market price and a firm's output level. The vertical height of the price line is equal to the market price, p.*

The **marginal revenue** (MR) of a firm is defined as the increase in total revenue for a unit increase in the firm's output. Consider table 4.1 again. Total revenue from the sale of 2 boxes of candles is Rs.20. Total revenue from the sale of 3 boxes of candles is Rs.30.

$$\text{Marginal Revenue (MR)} = \frac{\text{Change in total revenue}}{\text{Change in quantity}} = \frac{30 - 20}{3 - 2} = 10$$



Is it a coincidence that this is the same as the price? Actually it is not. Consider the situation when the firm's output changes from q_1 to q_2. Given the market price p,

$$MR = (pq_2 - pq_1) / (q_2 - q_1)$$
$$= [p\,(q_2 - q_1)] / (q_2 - q_1)$$
$$= p$$

Thus, for the perfectly competitive firm, MR=AR=p

In other words, for a price-taking firm, marginal revenue equals the market price.

Setting the algebra aside, the intuition for this result is quite simple. When a firm increases its output by one unit, this extra unit is sold at the market price. Hence, the firm's increase in total revenue from the one-unit output expansion – that is, MR – is precisely the market price.

4.3 Profit Maximisation

A firm produces and sells a certain amount of a good. The firm's profit, denoted by π[1], is defined to be the difference between its total revenue (TR) and its total cost of production (TC). In other words

$$\pi = TR - TC$$

Clearly, the gap between TR and TC is the firm's earnings net of costs.

A firm wishes to maximise its profit. The firm would like to identify the quantity q_0 at which its profits are maximum. By definition, then, at any quantity other than q_0, the firm's profits are less than at q_0. The critical question is: how do we identify q_0?

For profits to be maximum, three conditions must hold at q_0:

1. The price, p, must equal MC
2. Marginal cost must be non-decreasing at q_0
3. For the firm to continue to produce, in the short run, price must be greater than the average variable cost (p > AVC); in the long run, price must be greater than the average cost (p > AC).

4.3.1 Condition 1

Profits are the difference between total revenue and total cost. Both total revenue and total cost increase as output increases. Notice that as long as the change in total revenue is greater than the change in total cost, profits will continue to increase. Recall that change in total revenue per unit increase in output is the marginal revenue; and the change in total cost per unit increase in output is the marginal cost. Therefore, we can conclude that as long as marginal revenue is greater than marginal cost, profits are increasing. By the same logic, as long as marginal revenue is less than marginal cost, profits will fall. It follows that for profits to be maximum, marginal revenue should equal marginal cost.

In other words, profits are maximum at the level of output (which we have called q_0) for which MR = MC

For the perfectly competitive firm, we have established that the MR = P. So the firm's profit maximizing output becomes the level of output at which P=MC.

4.3.2 Condition 2

Consider the second condition that must hold when the profit-maximising output level is positive. Why is it the case that the marginal cost curve cannot slope

[1]It is a convention in economics to denote profit with the Greek letter π.

downwards at the profit-maximising output level? To answer this question, refer once again to Figure 4.3. Note that at output levels q_1 and q_4, the market price is equal to the marginal cost. However, at the output level q_1, the marginal cost curve is downward sloping. We claim that q_1 cannot be a profit-maximising output level. Why?

Observe that for *all* output levels slightly to the left of q_1, the market price is lower than the marginal cost. But, the argument outlined in section 4.3.1 immediately implies that the firm's profit at an output level slightly smaller than q_1 exceeds that corresponding to the output level q_1. This being the case, q_1 cannot be a profit-maximising output level.

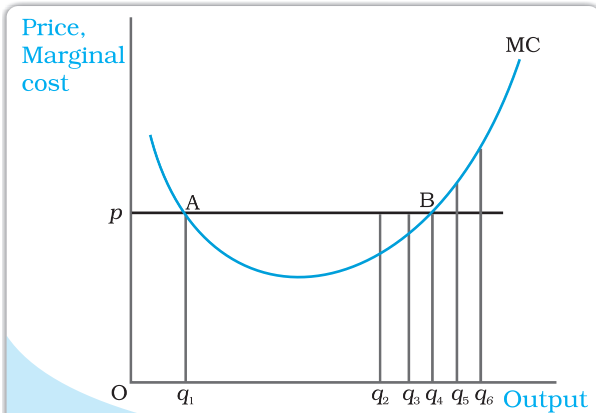


Fig. 4.3

Conditions 1 and 2 for profit maximisation. *The figure is used to demonstrate that when the market price is p, the output level of a profit-maximising firm cannot be q_1 (marginal cost curve, MC, is downward sloping), q_2 and q_3 (market price exceeds marginal cost), or q_5 and q_6 (marginal cost exceeds market price).*

4.3.3 Condition 3

Consider the third condition that must hold when the profit-maximising output level is positive. Notice that the third condition has two parts: one part applies in the short run while the other applies in the long run.

Case 1: Price must be greater than or equal to AVC in the short run

We will show that the statement of Case 1 (see above) is true by arguing that a profit-maximising firm, in the short run, will *not* produce at an output level wherein the market price is lower than the AVC.

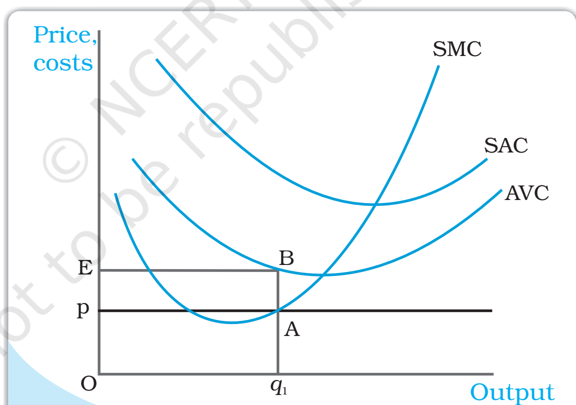


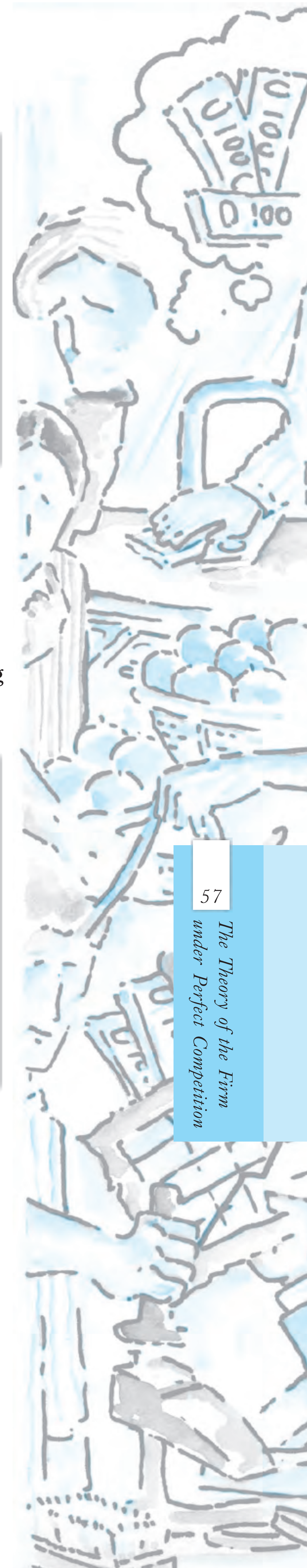
Fig. 4.4

Price-AVC Relationship with Profit Maximisation (Short Run). *The figure is used to demonstrate that a profit-maximising firm produces zero output in the short run when the market price, p, is less than the minimum of its average variable cost (AVC). If the firm's output level is q_1, the firm's total variable cost exceeds its revenue by an amount equal to the area of rectangle pEBA.*

Let us turn to Figure 4.4. Observe that at the output level q_1, the market price p is lower than the AVC. We claim that q_1 cannot be a profit-maximising output level. Why?

Notice that the firm's total revenue at q_1 is as follows

$$\begin{aligned} TR &= \text{Price} \times \text{Quantity} \\ &= \text{Vertical height } Op \times \text{width } Oq_1 \\ &= \text{The area of rectangle } OpAq_1 \end{aligned}$$



Similarly, the firm's total variable cost at q_1 is as follows

$$\begin{aligned} TVC &= \text{Average variable cost} \times \text{Quantity} \\ &= \text{Vertical height } OE \times \text{Width } Oq_1 \\ &= \text{The area of rectangle } OEBq_1 \end{aligned}$$

Now recall that the firm's profit at q_1 is TR – (TVC + TFC); that is, [the area of rectangle $OpAq_1$] – [the area of rectangle $OEBq_1$] – TFC. What happens if the firm produces zero output? Since output is zero, TR and TVC are zero as well. Hence, the firm's profit at zero output is equal to – TFC. But, the area of rectangle $OpAq_1$ is strictly less than the area of rectangle $OEBq_1$. Hence, the firm's profit at q_1 is [(area EBAp)-TFC], which is strictly less than what it obtains by not producing at all. So, the firm will choose not to produce at all, and exit from the market.

Case 2: Price must be greater than or equal to AC in the long run

We will show that the statement of Case 2 (see above) is true by arguing that a profit-maximising firm, in the long run, will *not* produce at an output level wherein the market price is lower than the AC.

Let us turn to Figure 4.5. Observe that at the output level q_1, the market price p is lower than the (long run) AC. We claim that q_1 cannot be a profit-maximising output level. Why?

Notice that the firm's total revenue, TR, at q_1 is the area of the rectangle $OpAq_1$ (the product of price and quantity) while the firm's total cost, TC , is the area of the rectangle $OEBq_1$ (the product of average cost and quantity). Since the area of rectangle $OEBq_1$ is larger than the area of rectangle $OpAq_1$, the firm incurs a loss at the output level q_1. But, in the long run set-up, a firm that shuts down production has a profit of zero. Again, the firm chooses to exit in this case.

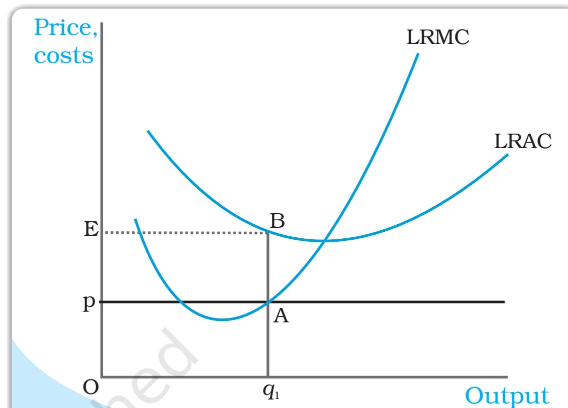


Fig. 4.5

***Price-AC Relationship with Profit Maximisation (Long Run)**. The figure is used to demonstrate that a profit-maximising firm produces zero output in the long run when the market price, p, is less than the minimum of its long run average cost (LRAC). If the firm's output level is q_1, the firm's total cost exceeds its revenue by an amount equal to the area of rectangle* pEBA.

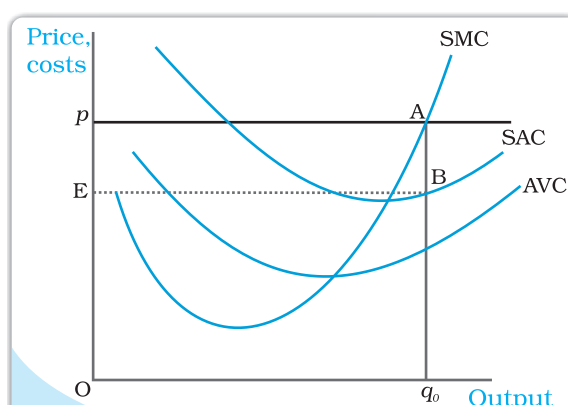


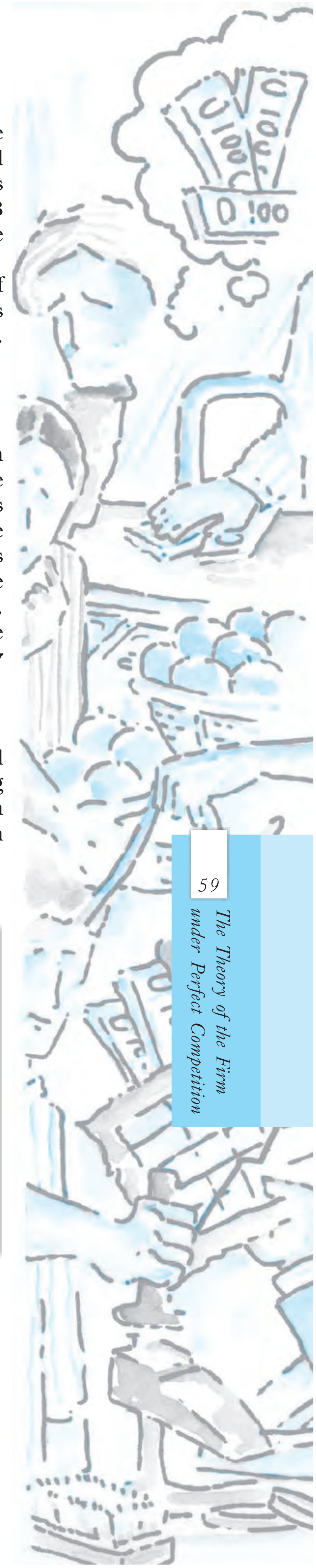
Fig. 4.6

***Geometric Representation of Profit Maximisation (Short Run).** Given market price* p*, the output level of a profit-maximising firm is q_0. At q_0, the firm's profit is equal to the area of rectangle* EpAB.

4.3.4 The Profit Maximisation Problem: Graphical Representation

Using the material in sections 3.1, 3.2 and 3.3, let us graphically represent a firm's profit maximisation problem in the short run. Consider Figure 4.6. Notice that the market price is p. Equating the market price with the (short run) marginal cost, we obtain the output level q_0. At q_0, observe that SMC slopes upwards and p exceeds AVC. Since the three conditions discussed in sections 3.1-3.3 are satisfied at q_0, we maintain that the profit-maximising output level of the firm is q_0.

What happens at q_0? The total revenue of the firm at q_0 is the area of rectangle $OpAq_0$ (the product of price and quantity) while the total cost at q_0 is the area of rectangle $OEBq_0$ (the product of short run average cost and quantity). So, at q_0, the firm earns a profit equal to the area of the rectangle *EpAB*.



4.4 Supply Curve of a Firm

A firm's '**supply**' is the quantity that it chooses to sell at a given price, given technology, and given the prices of factors of production. A table describing the quantities sold by a firm at various prices, technology and prices of factors remaining unchanged, is called a **supply schedule**. We may also represent the information as a graph, called a supply curve. The **supply curve** of a firm shows the levels of output (plotted on the x-axis) that the firm chooses to produce corresponding to different values of the market price (plotted on the y-axis), again keeping technology and prices of factors of production unchanged. We distinguish between the **short run supply curve** and the **long run supply curve**.

4.4.1 Short Run Supply Curve of a Firm

Let us turn to Figure 4.7 and derive a firm's short run supply curve. We shall split this derivation into two parts. We first determine a firm's profit-maximising output level when the market price is greater than or equal to the minimum AVC. This done, we determine the firm's profit-maximising output level when the market price is less than the minimum AVC.

Case 1: Price is greater than or equal to the minimum AVC

Suppose the market price is p_1, which exceeds the minimum AVC. We start out by equating p_1 with SMC on the rising part of the SMC curve; this leads to the output level q_1. Note also that the AVC at q_1 does not exceed the market price, p_1. Thus, all three conditions highlighted in section 3 are satisfied at q_1. Hence, when the market price is p_1, the firm's output level in the short run is equal to q_1.

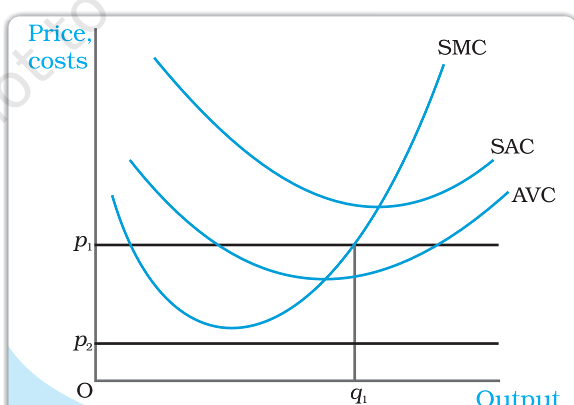


Fig. 4.7

Market Price Values. *The figure shows the output levels chosen by a profit-maximising firm in the short run for two values of the market price: p_1 and p_2. When the market price is p_1, the output level of the firm is q_1; when the market price is p_2, the firm produces zero output.*

Case 2: Price is less than the minimum AVC

Suppose the market price is p_2, which is less than the minimum AVC. We have argued (see condition 3 in section 3) that if a profit-maximising firm produces a positive output in the short run, then the market price, p_2, *must* be greater than or equal to the AVC at that output level. But notice from Figure 4.7 that for *all* positive output levels, AVC strictly exceeds p_2. In other words, it cannot be the case that the firm supplies a positive output. So, if the market price is p_2, the firm produces zero output.

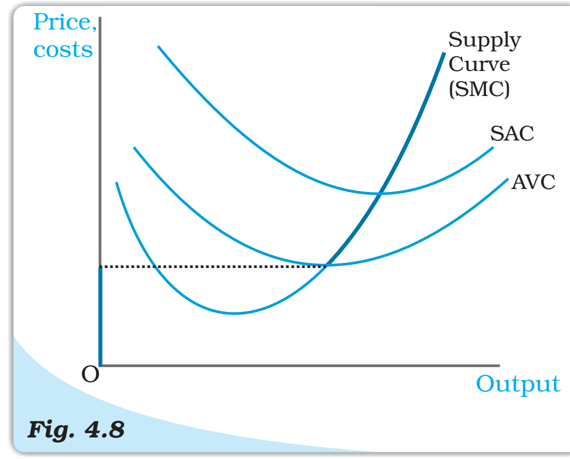


Fig. 4.8

The Short Run Supply Curve of a Firm. *The short run supply curve of a firm, which is based on its short run marginal cost curve (SMC) and average variable cost curve (AVC), is represented by the bold line.*

Combining cases 1 and 2, we reach an important conclusion. A firm's short run supply curve is the rising part of the SMC curve from and above the minimum AVC together with zero output for all prices strictly less than the minimum AVC. In figure 4.8, the bold line represents the short run supply curve of the firm.

4.4.2 Long Run Supply Curve of a Firm

Let us turn to Figure 4.9 and derive the firm's long run supply curve. As in the short run case, we split the derivation into two parts. We first determine the firm's profit-maximising output level when the market price is greater than or equal to the minimum (long run) AC. This done, we determine the firm's profit-maximising output level when the market price is less than the minimum (long run) AC.

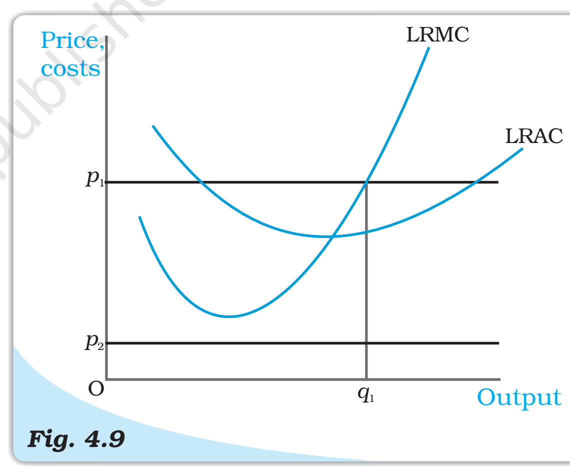


Fig. 4.9

Profit maximisation in the Long Run for Different Market Price Values. *The figure shows the output levels chosen by a profit-maximising firm in the long run for two values of the market price: p_1 and p_2. When the market price is p_1, the output level of the firm is q_1; when the market price is p_2, the firm produces zero output.*

Case 1: Price greater than or equal to the minimum LRAC

Suppose the market price is p_1, which exceeds the minimum LRAC. Upon equating p_1 with LRMC on the rising part of the LRMC curve, we obtain output level q_1. Note also that the LRAC at q_1 does not exceed the market price, p_1. Thus, all three conditions highlighted in section 3 are satisfied at q_1. Hence, when the market price is p_1, the firm's supplies in the long run become an output equal to q_1.

Case 2: Price less than the minimum LRAC

Suppose the market price is p_2, which is less than the minimum LRAC. We have argued (see condition 3 in section 3) that if a profit-maximising firm produces a positive output in the long run, the market price, p_2, *must* be greater than or equal to the LRAC at that output level. But notice from Figure 4.9 that for *all* positive output levels, LRAC strictly exceeds p_2. In other words, it cannot be the case that the firm supplies a positive output. So, when the market price is p_2, the firm produces zero output.

Combining cases 1 and 2, we reach an important conclusion. A firm's long run supply curve is the rising part of the LRMC curve from and above the minimum LRAC together with zero output for all prices less than the minimum LRAC. In Figure 4.10, the bold line represents the long run supply curve of the firm.

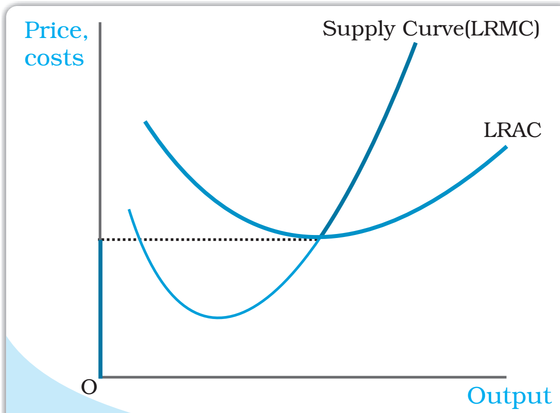


Fig. 4.10

The Long Run Supply Curve of a Firm*. The long run supply curve of a firm, which is based on its long run marginal cost curve (LRMC) and long run average cost curve (LRAC), is represented by the bold line.*

4.4.3 The Shut Down Point

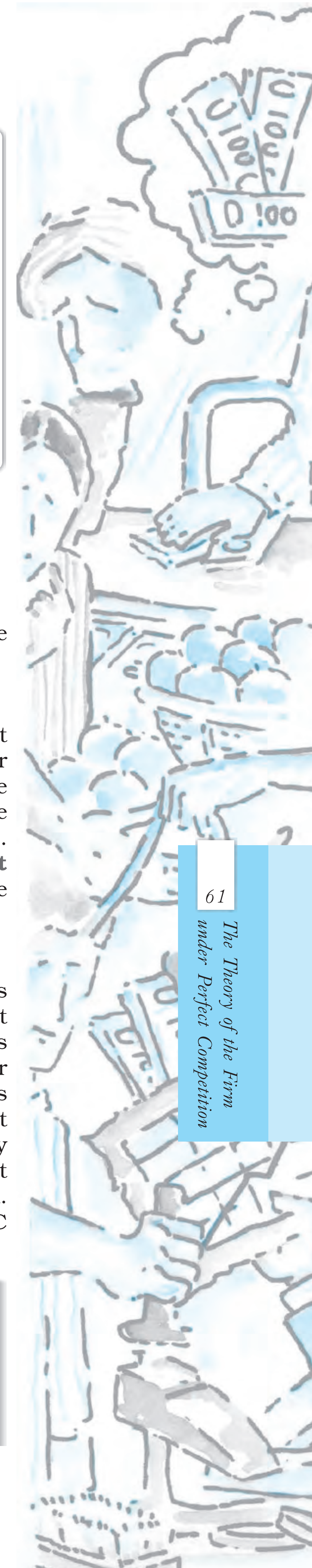
Previously, while deriving the supply curve, we have discussed that in the short run the firm continues to produce as long as the price remains greater than or equal to the minimum of AVC. Therefore, along the supply curve as we move down, the last price-output combination at which the firm produces positive output is the point of minimum AVC where the SMC curve cuts the AVC curve. Below this, there will be no production. This point is called the short run **shut down point** of the firm. In the long run, however, the shut down point is the minimum of LRAC curve.

4.4.4 The Normal Profit and Break-even Point

The minimum level of profit that is needed to keep a firm in the existing business is defined as **normal profit.** A firm that does not make normal profits is not going to continue in business. Normal profits are therefore a part of the firm's total costs. It may be useful to think of them as an opportunity cost for entrepreneurship. Profit that a firm earns over and above the normal profit is called the **super-normal profit**. In the long run, a firm does not produce if it earns anything less than the normal profit. In the short run, however, it may produce even if the profit is less than this level. The point on the supply curve at which a firm earns only normal profit is called the **break-even point** of the firm. The point of minimum average cost at which the supply curve cuts the LRAC curve (in short run, SAC curve) is therefore the break-even point of a firm.

Opportunity cost

In economics, one often encounters the concept of opportunity cost. Opportunity cost of some activity is the gain foregone from the second best activity. Suppose you have Rs 1,000 which you decide to invest in your family business. What is the opportunity cost of your action? If you do not invest



this money, you can either keep it in the house-safe which will give you zero return or you can deposit it in either bank-1 or bank-2 in which case you get an interest at the rate of 10 per cent or 5 per cent respectively. So the maximum benefit that you may get from other alternative activities is the interest from the bank-1. But this opportunity will no longer be there once you invest the money in your family business. The opportunity cost of investing the money in your family business is therefore the amount of forgone interest from the bank-1.

4.5 Determinants of a Firm's Supply Curve

In the previous section, we have seen that a firm's supply curve is a part of its marginal cost curve. Thus, *any* factor that affects a firm's marginal cost curve is of course a **determinant of its supply curve**. In this section, we discuss two such factors.

4.5.1 Technological Progress

Suppose a firm uses two factors of production – say, capital and labour – to produce a certain good. Subsequent to an organisational innovation by the firm, the same levels of capital and labour now produce more units of output. Put differently, to produce a given level of output, the organisational innovation allows the firm to use fewer units of inputs. It is expected that this will lower the firm's marginal cost at any level of output; that is, there is a rightward (or downward) shift of the MC curve. As the firm's supply curve is essentially a segment of the MC curve, technological progress shifts the supply curve of the firm to the right. At any given market price, the firm now supplies more units of output.

4.5.2 Input Prices

A change in input prices also affects a firm's supply curve. If the price of an input (say, the wage rate of labour) increases, the cost of production rises. The consequent increase in the firm's average cost at any level of output is usually accompanied by an increase in the firm's marginal cost at any level of output; that is, there is a leftward (or upward) shift of the MC curve. This means that the firm's supply curve shifts to the left: at any given market price, the firm now supplies fewer units of output.

Impact of a unit tax on supply

A unit tax is a tax that the government imposes per unit sale of output. For example, suppose that the unit tax imposed by the government is Rs 2. Then, if the firm produces and sells 10 units of the good, the total tax that the firm must pay to the government is 10 × Rs 2 = Rs 20.

How does the long run supply curve of a firm change when a unit tax is imposed? Let us turn to figure 4.11. Before the unit tax is imposed, $LRMC^0$ and $LRAC^0$ are, respectively, the long run marginal cost curve and the long run average cost curve of the firm. Now, suppose the government puts in place a unit tax of Rs t. Since the firm must pay an extra Rs t for each unit of the good produced, the firm's long run average cost and long run marginal cost at any level of output increases by Rs t. In Figure 4.11, $LRMC^1$ and $LRAC^1$ are, respectively, the long run marginal cost curve and the long run average cost curve of the firm upon imposition of the unit tax.

Recall that the long run supply curve of a firm is the rising part of the LRMC curve from and above the minimum LRAC together with zero output for all prices less than the minimum LRAC. Using this observation in Figure 4.12, it is immediate that S^0 and S^1 are, respectively, the long run supply curve of the firm before and after the imposition of the unit tax. Notice that the unit tax shifts the firm's long run supply curve to the left: at any given market price, the firm now supplies fewer units of output.

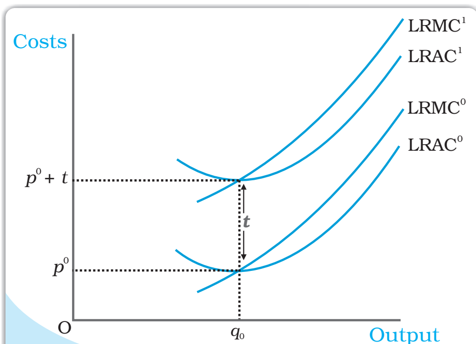


Fig. 4.11

Cost Curves and the Unit Tax. *$LRAC^0$ and $LRMC^0$ are, respectively, the long run average cost curve and the long run marginal cost curve of a firm before a unit tax is imposed. $LRAC^1$ and $LRMC^1$ are, respectively, the long run average cost curve and the long run marginal cost curve of a firm after a unit tax of Rs t is imposed.*

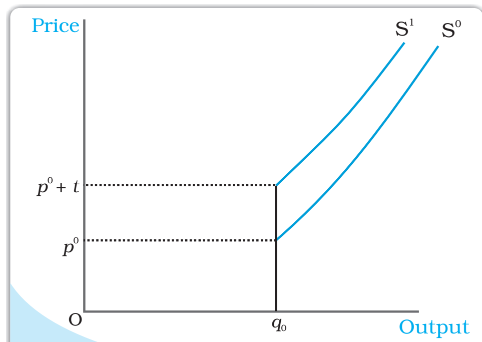


Fig. 4.12

Supply Curves and Unit Tax. *S^0 is the supply curve of a firm before a unit tax is imposed. After a unit tax of Rs t is imposed, S^1 represents the supply curve of the firm.*

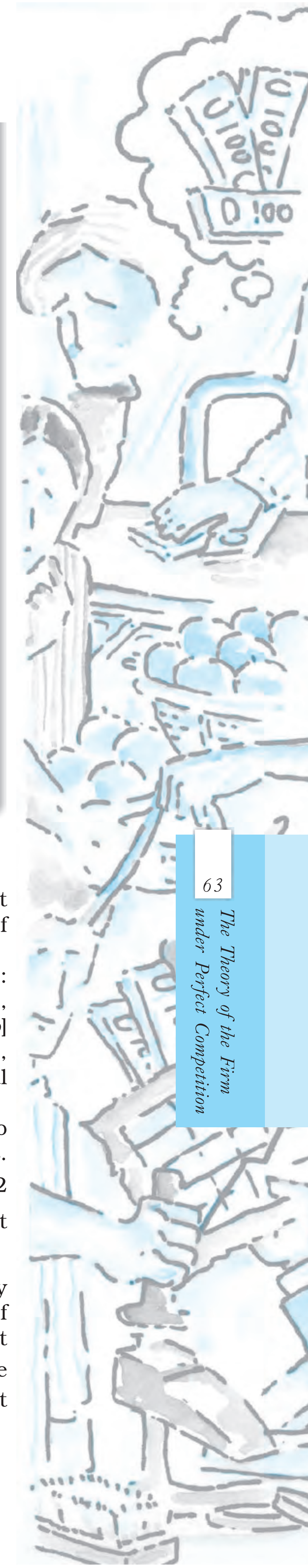
4.6 Market Supply Curve

The market supply curve shows the output levels (plotted on the x-axis) that firms in the market produce in aggregate corresponding to different values of the market price (plotted on the y-axis).

How is the market supply curve derived? Consider a market with n firms: firm 1, firm 2, firm 3, and so on. Suppose the market price is fixed at p. Then, the output produced by the n firms in aggregate is [supply of firm 1 at price p] + [supply of firm 2 at price p] + ... + [supply of firm n at price p]. In other words, the market supply at price p is the summation of the supplies of individual firms at that price.

Let us now construct the market supply curve geometrically with just two firms in the market: firm 1 and firm 2. The two firms have different cost structures. Firm 1 will not produce anything if the market price is less than $\bar{p}_1$ while firm 2 will not produce anything if the market price is less than $\bar{p}_2$. Assume also that $\bar{p}_2$ is greater than $\bar{p}_1$.

In panel (a) of Figure 4.13 we have the supply curve of firm 1, denoted by S_1; in panel (b), we have the supply curve of firm 2, denoted by S_2. Panel (c) of Figure 4.13 shows the market supply curve, denoted by Sm. When the market price is strictly below $\bar{p}_1$, both firms choose not to produce any amount of the good; hence, market supply will also be zero for all such prices. For a market



price greater than or equal to $\bar{p}_1$ but strictly less than $\bar{p}_2$, only firm 1 will produce a positive amount of the good. Therefore, in this range, the market supply curve coincides with the supply curve of firm 1. For a market price greater than or equal to $\bar{p}_2$, both firms will have positive output levels. For example, consider a situation wherein the market price assumes the value p_3 (observe that p_3 exceeds $\bar{p}_2$). Given p_3, firm 1 supplies q_3 units of output while firm 2 supplies q_4 units of output. So, the market supply at price p_3 is q_5, where $q_5 = q_3 + q_4$. Notice how the market supply curve, S_m, in panel (c) is being constructed: we obtain S_m by taking a horizontal summation of the supply curves of the two firms in the market, S_1 and S_2.

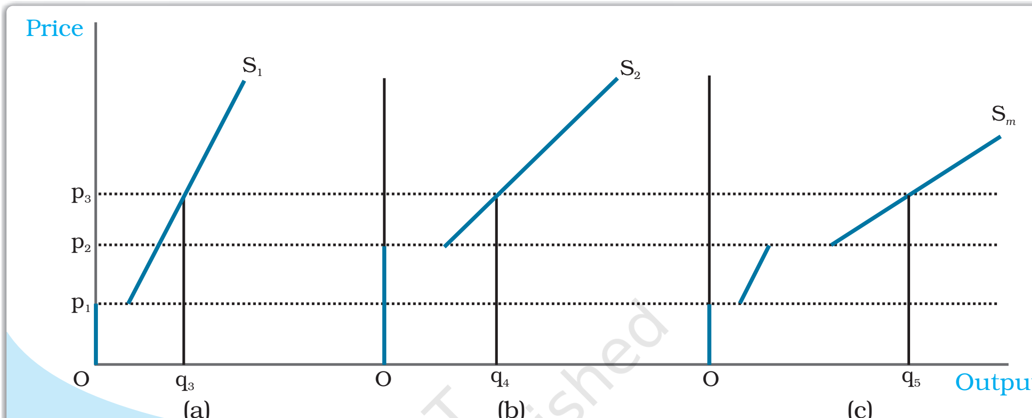


Fig. 4.13

The Market Supply Curve Panel. *(a) shows the supply curve of firm 1. Panel (b) shows the supply curve of firm 2. Panel (c) shows the market supply curve, which is obtained by taking a horizontal summation of the supply curves of the two firms.*

It should be noted that the market supply curve has been derived for a fixed number of firms in the market. As the number of firms changes, the market supply curve shifts as well. Specifically, if the number of firms in the market increases (decreases), the market supply curve shifts to the right (left).

We now supplement the graphical analysis given above with a related numerical example. Consider a market with two firms: firm 1 and firm 2. Let the supply curve of firm 1 be as follows

$$S_1(p) = \begin{cases} 0 & : p < 10 \\ p - 10 & : p \geq 10 \end{cases}$$

Notice that $S_1(p)$ indicates that (1) firm 1 produces an output of 0 if the market price, p, is strictly less than 10, and (2) firm 1 produces an output of $(p - 10)$ if the market price, p, is greater than or equal to 10. Let the supply curve of firm 2 be as follows

$$S_2(p) = \begin{cases} 0 & : p < 15 \\ p - 15 & : p \geq 15 \end{cases}$$

The interpretation of $S_2(p)$ is identical to that of $S_1(p)$, and is, hence, omitted. Now, the market supply curve, $S_m(p)$, simply sums up the supply curves of the two firms; in other words

$$S_m(p) = S_1(p) + S_2(p)$$

But, this means that $S_m(p)$ is as follows

$$S_m(p) = \begin{cases} 0 & : p < 10 \\ p - 10 & : p \geq 10 \text{ and } p < 15 \\ (p - 10) + (p - 15) = 2p - 25 & : p \geq 15 \end{cases}$$

4.7 Price Elasticity of Supply

The price elasticity of supply of a good measures the responsiveness of quantity supplied to changes in the price of the good. More specifically, the price elasticity of supply, denoted by e_S, is defined as follows

$$\text{Price elasticity of supply, } e_S = \frac{\text{Percentage change in quantity supplied}}{\text{Percentage change in price}}$$

$$= \frac{\frac{\Delta Q}{Q} \times 100}{\frac{\Delta P}{P} \times 100} = \frac{\Delta Q}{Q} \times \frac{P}{\Delta P}$$

Where ΔQ is the change in quantity of the good supplied to the market as market price changes by ΔP.

To make matters concrete, consider the following numerical example. Suppose the market for cricket balls is perfectly competitive. When the price of a cricket ball is Rs 10, let us assume that 200 cricket balls are produced in aggregate by the firms in the market. When the price of a cricket ball rises to Rs 30, let us assume that 1,000 cricket balls are produced in aggregate by the firms in the market.

The percentage change in quantity supplied and market price can be estimated using the information summarised in the table below:

Price of Cricket balls (P)	Quantity of Cricket balls produced and sold (Q)
Old price : $P_1 = 10$	Old quantity : $Q_1 = 200$
New price : $P_2 = 30$	New quantity: $Q_2 = 1000$

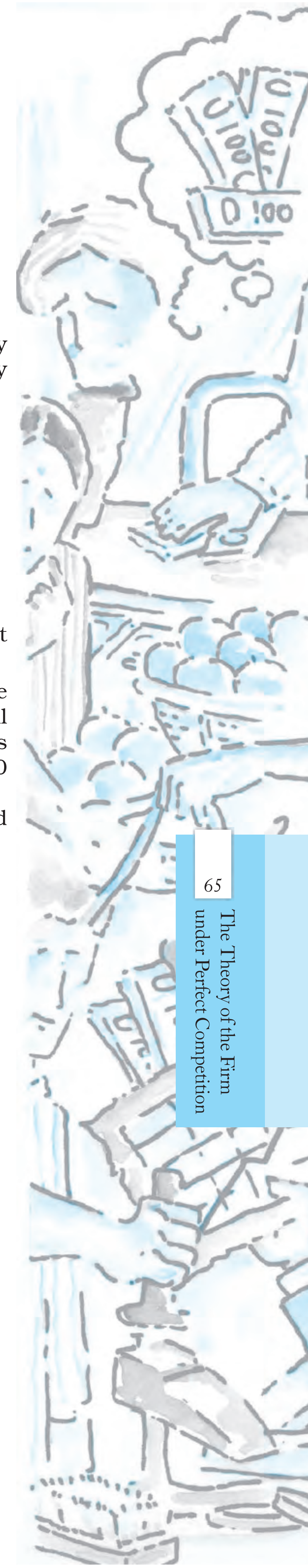
$$\text{Percentage change in quantity supplied} = \frac{\Delta Q}{Q_1} \times 100$$

$$= \frac{Q_2 - Q_1}{Q_1} \times 100$$

$$= \frac{1000 - 200}{200} \times 100$$

$$= 400$$

$$\text{Percentage change in market price} = \frac{\Delta P}{P_1} \times 100$$



$$= \frac{P_2 - P_1}{P_1} \times 100$$

$$= \frac{30 - 10}{10} \times 100$$

$$= 200$$

Therefore, price elasticity of supply, $e_S = \frac{400}{200} = 2$

When the supply curve is vertical, supply is completely insensitive to price and the elasticity of supply is zero. In other cases, when supply curve is positively sloped, with a rise in price, supply rises and hence, the elasticity of supply is positive. Like the price elasticity of demand, the price elasticity of supply is also independent of units.

The Geometric Method

Consider the Figure 4.14. Panel (a) shows a straight line supply curve. *S* is a point on the supply curve. It cuts the price-axis at its positive range and as we extend the straight line, it cuts the quantity-axis at *M* which is at its negative range. The price elasticity of this supply curve at the point *S* is given by the ratio, Mq_0/Oq_0. For any point *S* on such a supply curve, we see that $Mq_0 > Oq_0$. The elasticity at any point on such a supply curve, therefore, will be greater than 1.

In panel (c) we consider a straight line supply curve and *S* is a point on it. It cuts the quantity-axis at *M* which is at its positive range. Again the price elasticity of this supply curve at the point *S* is given by the ratio, Mq_0/Oq_0. Now, $Mq_0 < Oq_0$ and hence, $e_S < 1$. *S* can be any point on the supply curve, and therefore at all points on such a supply curve $e_S < 1$.

Now we come to panel (b). Here the supply curve goes through the origin. One can imagine that the point *M* has coincided with the origin here, i.e., Mq_0 has become equal to Oq_0. The price elasticity of this supply curve at the point *S* is given by the ratio, Oq_0/Oq_0 which is equal to 1. At any point on a straight line, supply curve going through the origin price elasticity will be one.

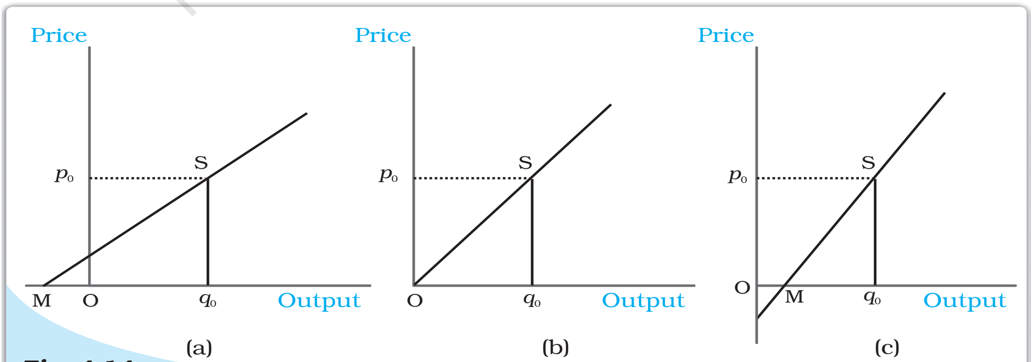


Fig. 4.14

Price Elasticity Associated with Straight Line Supply Curves. *In panel (a), price elasticity (e_S) at S is greater than 1. In panel (b), price elasticity (e_S) at S is equal to 1. In panel (c), price elasticity (e_S) at S is less than 1.*

Summary

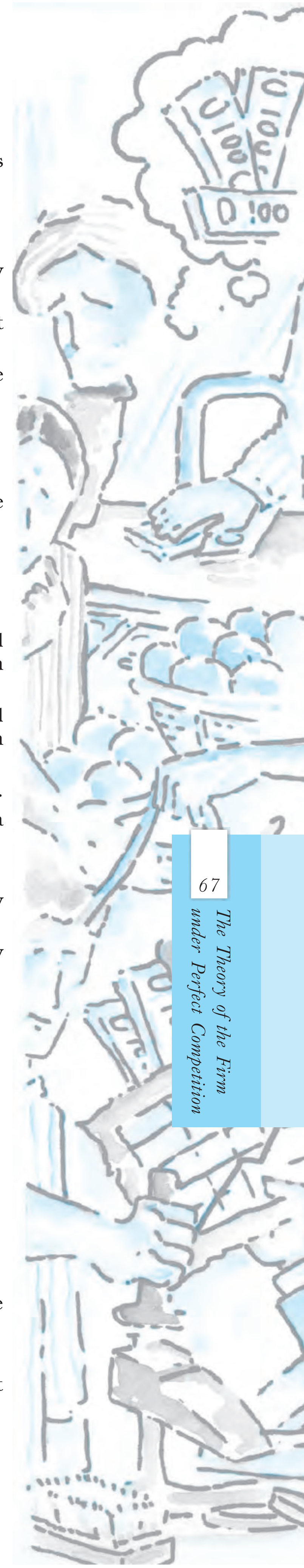
- In a perfectly competitive market, firms are price-takers.
- The total revenue of a firm is the market price of the good multiplied by the firm's output of the good.
- For a price-taking firm, average revenue is equal to market price.
- For a price-taking firm, marginal revenue is equal to market price.
- The demand curve that a firm faces in a perfectly competitive market is perfectly elastic; it is a horizontal straight line at the market price.
- The profit of a firm is the difference between total revenue earned and total cost incurred.
- If there is a positive level of output at which a firm's profit is maximised in the short run, three conditions must hold at that output level
  - (i) $p = SMC$
  - (ii) SMC is non-decreasing
  - (iii) $p \geq AVC$.
- If there is a positive level of output at which a firm's profit is maximised in the long run, three conditions must hold at that output level
  - (i) $p = LRMC$
  - (ii) $LRMC$ is non-decreasing
  - (iii) $p \geq LRAC$.
- The short run supply curve of a firm is the rising part of the *SMC* curve from and above minimum *AVC* together with 0 output for all prices less than the minimum *AVC*.
- The long run supply curve of a firm is the rising part of the *LRMC* curve from and above minimum *LRAC* together with 0 output for all prices less than the minimum *LRAC*.
- Technological progress is expected to shift the supply curve of a firm to the right.
- An increase (decrease) in input prices is expected to shift the supply curve of a firm to the left (right).
- The imposition of a unit tax shifts the supply curve of a firm to the left.
- The market supply curve is obtained by the horizontal summation of the supply curves of individual firms.
- The price elasticity of supply of a good is the percentage change in quantity supplied due to one per cent change in the market price of the good.

Key Concepts

Perfect competition	Revenue, Profit
Profit maximisation	Firms supply curve
Market supply curve	Price elasticity of supply

Exercises

1. What are the characteristics of a perfectly competitive market?
2. How are the total revenue of a firm, market price, and the quantity sold by the firm related to each other?
3. What is the 'price line'?
4. Why is the total revenue curve of a price-taking firm an upward-sloping straight line? Why does the curve pass through the origin?



5. What is the relation between market price and average revenue of a price-taking firm?
6. What is the relation between market price and marginal revenue of a price-taking firm?
7. What conditions must hold if a profit-maximising firm produces positive output in a competitive market?
8. Can there be a positive level of output that a profit-maximising firm produces in a competitive market at which market price is not equal to marginal cost? Give an explanation.
9. Will a profit-maximising firm in a competitive market ever produce a positive level of output in the range where the marginal cost is falling? Give an explanation.
10. Will a profit-maximising firm in a competitive market produce a positive level of output in the short run if the market price is less than the minimum of *AVC*? Give an explanation.
11. Will a profit-maximising firm in a competitive market produce a positive level of output in the long run if the market price is less than the minimum of *AC*? Give an explanation.
12. What is the supply curve of a firm in the short run?
13. What is the supply curve of a firm in the long run?
14. How does technological progress affect the supply curve of a firm?
15. How does the imposition of a unit tax affect the supply curve of a firm?
16. How does an increase in the price of an input affect the supply curve of a firm?
17. How does an increase in the number of firms in a market affect the market supply curve?
18. What does the price elasticity of supply mean? How do we measure it?
19. Compute the total revenue, marginal revenue and average revenue schedules in the following table. Market price of each unit of the good is Rs 10.

Quantity Sold	*TR*	*MR*	*AR*
0			
1			
2			
3			
4			
5			
6			

20. The following table shows the total revenue and total cost schedules of a competitive firm. Calculate the profit at each output level. Determine also the market price of the good.

Quantity Sold	*TR (Rs)*	*TC (Rs)*	*Profit*
0	0	5	
1	5	7	
2	10	10	
3	15	12	
4	20	15	
5	25	23	
6	30	33	
7	35	40	

21. The following table shows the total cost schedule of a competitive firm. It is given that the price of the good is Rs 10. Calculate the profit at each output level. Find the profit maximising level of output.

Output	TC (Rs)
0	5
1	15
2	22
3	27
4	31
5	38
6	49
7	63
8	81
9	101
10	123

22. Consider a market with two firms. The following table shows the supply schedules of the two firms: the SS_1 column gives the supply schedule of firm 1 and the SS_2 column gives the supply schedule of firm 2. Compute the market supply schedule.

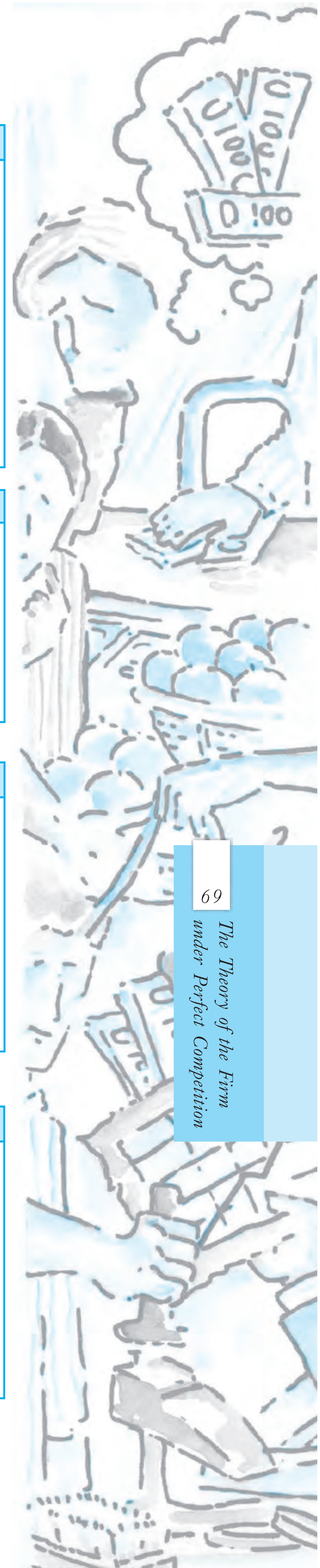
Price (Rs)	SS_1 (units)	SS_2 (units)
0	0	0
1	0	0
2	0	0
3	1	1
4	2	2
5	3	3
6	4	4

23. Consider a market with two firms. In the following table, columns labelled as SS_1 and SS_2 give the supply schedules of firm 1 and firm 2 respectively. Compute the market supply schedule.

Price (Rs)	SS_1 (kg)	SS_2 (kg)
0	0	0
1	0	0
2	0	0
3	1	0
4	2	0.5
5	3	1
6	4	1.5
7	5	2
8	6	2.5

24. There are three identical firms in a market. The following table shows the supply schedule of firm 1. Compute the market supply schedule.

Price (Rs)	SS_1 (units)
0	0
1	0
2	2
3	4
4	6
5	8
6	10
7	12
8	14



25. A firm earns a revenue of Rs 50 when the market price of a good is Rs 10. The market price increases to Rs 15 and the firm now earns a revenue of Rs 150. What is the price elasticity of the firm's supply curve?

26. The market price of a good changes from Rs 5 to Rs 20. As a result, the quantity supplied by a firm increases by 15 units. The price elasticity of the firm's supply curve is 0.5. Find the initial and final output levels of the firm.

27. At the market price of Rs 10, a firm supplies 4 units of output. The market price increases to Rs 30. The price elasticity of the firm's supply is 1.25. What quantity will the firm supply at the new price?