Chapter 2

Theory of Consumer Behaviour

In this chapter, we will study the behaviour of an individual consumer in a market for final goods[1]. The consumer has to decide on how much of each of the different goods she would like to consume. Our objective here is to study this choice problem in some detail. As we see, the choice of the consumer depends on the alternatives that are available to her and on her tastes and preferences regarding those alternatives. To begin with, we will try to figure out a precise and convenient way of describing the available alternatives and also the tastes and preferences of the consumer. We will then use these descriptions to find out the consumer's choice in the market.

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] We will refer to the two goods as good 1 and good 2. 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 amount of good 1 and x_2 to denote the amount of good 2. x_1 and x_2 can be positive or zero. (x_1, x_2) would mean the bundle consisting of x_1 amount of good 1 and x_2 amount of good 2. 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 units of good 1 and 10 units of good 2; the bundle (10, 5) consists of 10 units of good 1 and 5 units of good 2.

2.1 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 which 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

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[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.

Spoilt for Choice

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.

2.1.1 Budget Set

Suppose the income of the consumer is M and the prices of the two goods are p_1 and p_2 respectively.[3] If the consumer wants to buy x_1 units of good 1, she will have to spend $p_1 x_1$ amount of money. Similarly, if the consumer wants to buy x_2 units of good 2, she will have to spend $p_2 x_2$ amount of money. Therefore, if the consumer wants to buy the bundle consisting of x_1 units of good 1 and x_2 units of good 2, she will have to spend $p_1 x_1 + p_2 x_2$ amount of money. She can buy this bundle only if she has at least $p_1 x_1 + p_2 x_2$ 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

$$p_1 x_1 + p_2 x_2 \leq M \tag{2.1}$$

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.

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[3]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 goods 1 being p_1 means the consumer has to pay p_1 rupees per kilograms of good 1 that she wants to buy.

2.1.2 Budget Line

If both the goods are perfectly divisible[4], 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 2.1.

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

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

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.

Good 2

M/p_2

$p_1x_1 + p_2x_2 = M$

O $\qquad M/p_1$ Good 1

Fig. 2.1

Budget Set. Quantity of good 1 is measured along the horizontal axis and quantity of good 2 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[5]

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

The budget line is a straight line with horizontal intercept $\dfrac{M}{p_1}$ and vertical intercept $\dfrac{M}{p_2}$. The horizontal intercept represents the bundle that the consumer can buy if she spends her entire income on good 1. Similarly, the vertical intercept represents the bundle that the consumer can buy if she spends her entire income on good 2. The slope of the budget line is $-\dfrac{p_1}{p_2}$.
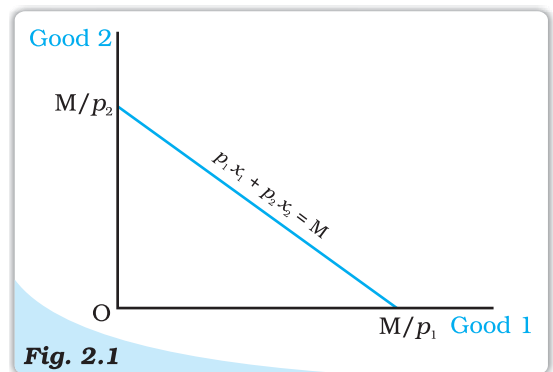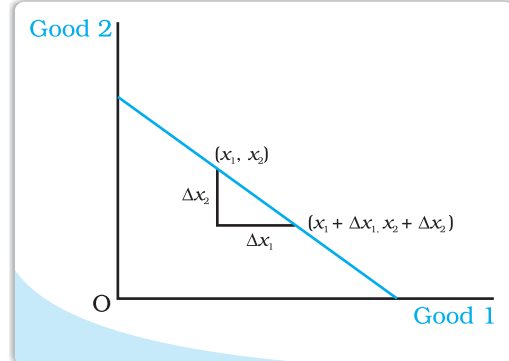

Derivation of the Slope of the Budget Line

The slope of the budget line measures the amount of change in good 2 required per unit of change in good 1 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

$$p_1x_1 + p_2x_2 = M \qquad (2.4) \text{ and}$$

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

Good 2

(x_1, x_2)

Δx_2

$(x_1 + \Delta x_1, x_2 + \Delta x_2)$

Δx_1

O $\qquad$ Good 1

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[4]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.

[5]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.

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

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

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[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.

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 unit of good 1. She can do it only if she gives up some amount of the other good. How much of good 2 does she have to give up if she wants to have an extra unit of good 1? It would depend on the prices of the two goods. A unit of good 1 costs p_1. Therefore, she will have to reduce her expenditure on good 2 by p_1 amount. With p_1, she could buy $\frac{p_1}{p_2}$ units of good 2. Therefore, if the consumer wants to have an extra unit of good 1 when she is spending all her money, she will have to give up $\frac{p_1}{p_2}$ units of good 2. In other words, in the given market conditions, the consumer can substitute good 1 for good 2 at the rate $\frac{p_1}{p_2}$. The absolute value[6] of the slope of the budget line measures the rate at which the consumer is able to substitute good 1 for good 2 when she spends her entire budget.

Points Below the Budget Line

Consider any point below the budget line. Such a point represents a bundle which costs less than the consumer's income. Thus, if the consumer buys such a bundle, she will have some money left over. In principle, the consumer could spend this extra money on either of the two goods, and thus, buy a bundle which consists of more of, at least, one of the goods, and no less of the other as compared to the bundle lying below the budget line. In other words, compared to a point below the budget line, there is always some bundle on the budget line which contains more of at least one of the goods and no less of the other. Figure 2.2 illustrates this fact. The point C lies below the budget line while points A and B lie on the budget line. Point A contains more of good 2 and the same amount of good
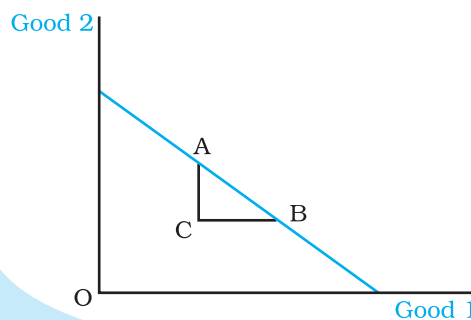
Fig. 2.2

A Point below the Budget Line. Compared to a point below the budget line, there is always some bundle on the budget line which contains more of at least one of the goods and no less of the other.

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

1 as compared to point C. Point B contains more of good 1 and the same amount of good 2 as compared to point C. Any other point on the line segment 'AB' represents a bundle which has more of both the goods compared to C.

2.1.3 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 $p_1 x_1 + p_2 x_2 \leq M'$. Now the equation of the budget line is

$$p_1 x_1 + p_2 x_2 = M' \tag{2.8}$$

Equation (2.8) can also be written as

$$x_2 = \frac{M'}{p_2} - \frac{p_1}{p_2} x_1 \tag{2.9}$$

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 income, ie if $M' > M$, the vertical intercept increases, and hence, 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, ie if $M' < M$, the vertical intercept decreases, 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 2.3.
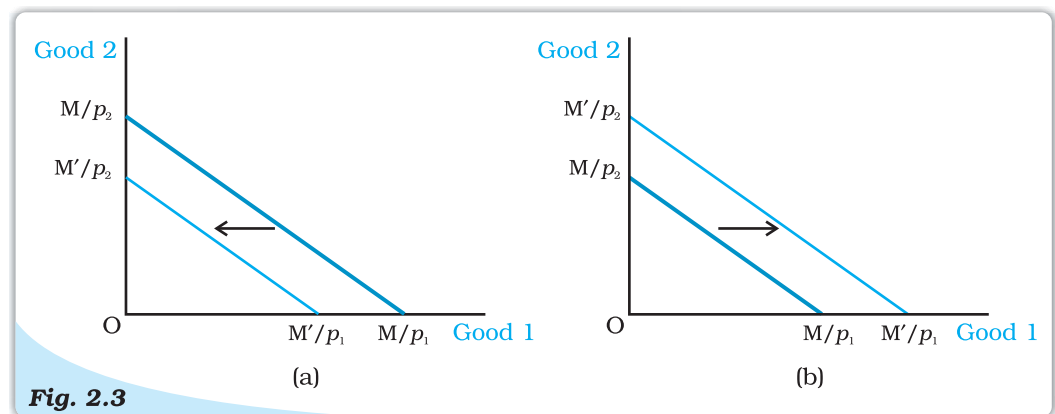

Fig. 2.3

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 good 1 changes from p_1 to p'_1 but the price of good 2 and the consumer's income remain unchanged. At the new price of good 1, the consumer can afford to buy all bundles (x_1, x_2) such that $p'_1 x_1 + p_2 x_2 \leq M$. The equation of the budget line is

$$p'_1 x_1 + p_2 x_2 = M \tag{2.10}$$

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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 good 1. However, the slope of the budget line has changed after the price change. If the price of good 1 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). If the price of good 1 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). Changes in the set of available bundles resulting from changes in the price of good 1 when the price of good 2 and the consumer's income remain unchanged are represented in Figure 2.4.
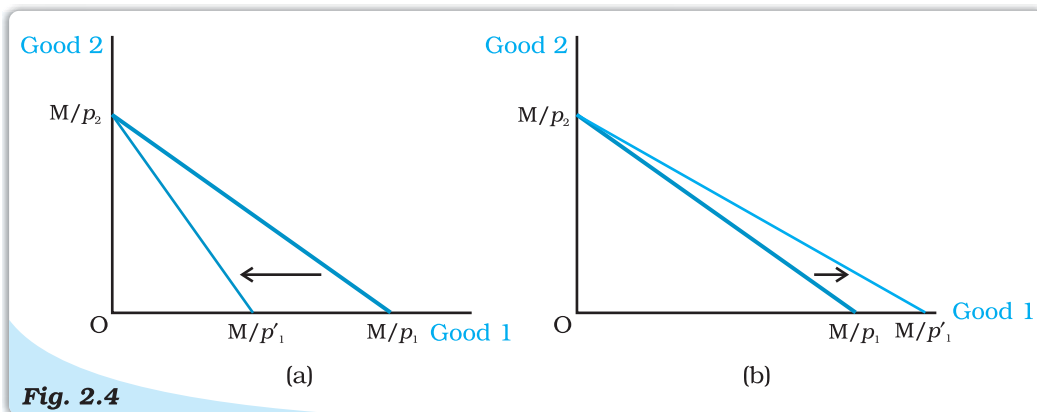

Fig. 2.4

Changes in the Set of Available Bundles of Goods Resulting from Changes in the Price of Good 1. An increase in the price of good 1 makes the budget line steeper as in panel (a). A decrease in the price of good 1 makes the budget line flatter as in panel (b).

A change in price of good 2, when price of good 1 and the consumer's income remain unchanged, will bring about similar changes in the budget set of the consumer.

2.2 PREFERENCES 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 tastes and preferences over the bundles in the budget set. It is generally assumed that the consumer has well-defined preferences to 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 to the two. Furthermore, it is assumed that the consumer can rank[7] the bundles in order of her preferences over them.

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[7]The simplest example of a ranking is the ranking of all students according to the marks obtained by each in the last annual examination.

EXAMPLE _____ **2.2**

Consider the consumer of Example 2.1. Suppose the preferences of the consumer over the set of bundles that are available to her are as follows:

   The consumer's most preferred bundle is (2, 2).

   She is indifferent to (1, 3) and (3, 1). She prefers both these bundles compared to any other bundle except (2, 2).

   She is indifferent to (1, 2) and (2, 1). She prefers both these bundles compared to any other bundle except (2, 2), (1, 3) and (3, 1).

   The consumer is indifferent to any bundle which has only one of the goods and the bundle (0, 0). A bundle having positive amounts of both goods is preferred to a bundle having only one of the goods.

   The bundles that are available to this consumer can be ranked from the best to the least preferred according to her preferences. Any two (or more) indifferent bundles obtain the same rank while the preferred bundles are ranked higher. The ranking is presented in the Table 2.1.

Table 2.1: **Ranking of the bundle available to the consumer in Example 2.1**

Bundle	Ranking
(2, 2)	First
(1, 3), (3, 1)	Second
(1, 2), (2, 1)	Third
(1, 1)	Fourth
(0, 0), (0, 1), (0, 2), (0, 3), (0, 4), (1, 0), (2, 0), (3, 0), (4, 0)	Fifth

2.2.1 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 as compared to (y_1, y_2), 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.

EXAMPLE _____ **2.3**

For example, consider the bundle (2, 2). This bundle has more of both goods compared to (1, 1); it has equal amount of good 1 but more of good 2 compared to the bundle (2, 1) and compared to (1, 2), it has more of good 1 and equal amount of good 2. If a consumer has monotonic preferences, she would prefer the bundle (2, 2) to all the three bundles (1, 1), (2, 1) and (1, 2).

2.2.2 Substitution between Goods

Consider two bundles such that one bundle has more of the first good as compared to the other bundle. If the consumer's preferences are monotonic, these two bundles can be indifferent only if the bundle having more of the first good has less of good 2 as compared to the other bundle. Suppose a

consumer is indifferent between two bundles (x_1, x_2) and $(x_1 + \Delta x_1, x_2 + \Delta x_2)$. Monotonicity of preferences implies that if $\Delta x_1 > 0$ then $\Delta x_2 < 0$, and if $\Delta x_1 < 0$ then $\Delta x_2 > 0$; the consumer can move from (x_1, x_2) to $(x_1 + \Delta x_1, x_2 + \Delta x_2)$ by substituting one good for the other. The **rate of substitution** between

good 2 and good 1 is given by the absolute value of $\dfrac{\Delta x_2}{\Delta x_1}$. The rate of substitution is the amount of good 2 that the consumer is willing to give up for an extra unit of good 1. It measures the consumer's willingness to pay for good 1 in terms of good 2. Thus, the rate of substitution between the two goods captures a very important aspect of the consumer's preference.

EXAMPLE _____ **2.4**

Suppose a consumer is indifferent to the bundles (1, 2) and (2, 1). At (1, 2), the consumer is willing to give up 1 unit of good 2 if she gets 1 extra unit of good 1. Thus, the rate of substitution between good 2 and good 1 is 1.

2.2.3 Diminishing Rate of Substitution

The consumer's preferences are assumed to be such that she has more of good 1 and less of good 2, the amount of good 2 that she would be willing to give up for an additional unit of good 1 would go down. The consumer's willingness to pay for good 1 in terms of good 2 would go on declining as she has more and more of good 1. In other words, as the amount of good 1 increases, the rate of substitution between good 2 and good 1 diminishes. Preferences of this kind are called convex preferences.

2.2.4 Indifference Curve

A consumer's preferences to 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 are considered indifferent by the consumer can generally be joined to obtain a curve like the one in Figure 2.5. Such a curve joining all points representing bundles among which the consumer is indifferent is called an **indifference curve**.
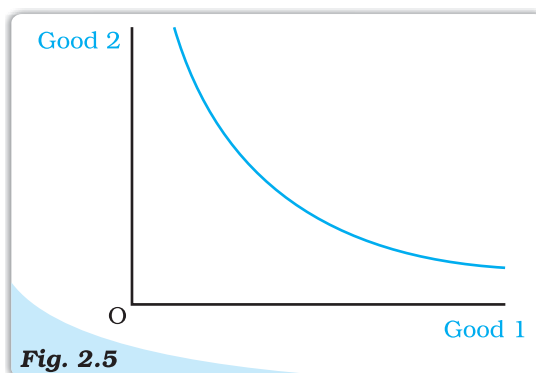
Fig. 2.5

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

Consider a point above the indifference curve. Such a point has more of at least one of the goods and no less of the other good as compared to at least one point on the indifference curve. Consider the Figure 2.6. The point C lies above the indifference curve while points A and B lie on the indifference curve. Point C contains more of good 1 and the same amount of good 2 as compared to A. Compared to point B, C contains more of good 2 and the same amount of good 1. And it has more of both the goods compared to any other point on the segment AB of the indifference curve. If preferences are monotonic, the bundle represented by the point C would be preferred to bundles represented by points

on the segment AB, and hence, it would be preferred to all bundles on the indifference curve. Therefore, monotonicity of preferences implies that any point above the indifference curve represents a bundle which is preferred to the bundles on the indifference curve. By a similar argument, it can be established that if the consumer's preferences are monotonic, any point below the indifference curve represents a bundle which is inferior to the bundles on the indifference curve. Figure 2.6 depicts the bundles that are preferred and the bundles that are inferior to the bundles on an indifference curve.
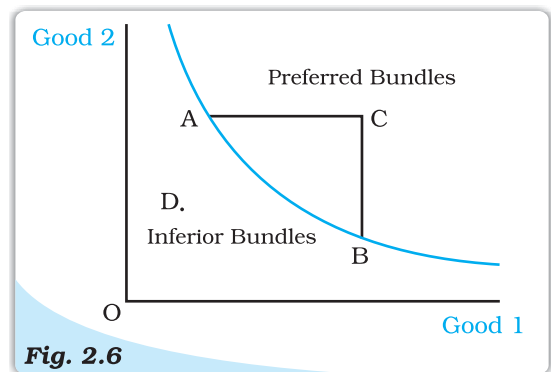

Fig. 2.6

Points Above and Points Below the Indifference Curve. Points above the indifference curve represent bundles which are preferred to bundles represented by points on the indifference curve. Bundles represented by points on the indifference curve are preferred to the bundles represented by points below the indifference curve.

2.2.5 Shape of the Indifference Curve

The Rate of Substitution and the Slope of the Indifference Curve

Think of any two points (x_1, x_2) and $(x_1 + \Delta x_1, x_2 + \Delta x_2)$ on the indifference curve. Consider a movement from (x_1, x_2) to $(x_1 + \Delta x_1, x_2 + \Delta x_2)$ along the indifference curve. The slope of the straight line joining these two points gives the change in the amount of good 2 corresponding to a unit change in good 1 along the indifference curve. Thus, the absolute value of the slope of the straight line joining these two points gives the rate of substitution between (x_1, x_2) and $(x_1 + \Delta x_1, x_2 + \Delta x_2)$. For very small changes, the slope of the line joining the two points (x_1, x_2) and $(x_1 + \Delta x_1, x_2 + \Delta x_2)$ reduces to the slope of the indifference curve at (x_1, x_2). Thus, for very small changes, the absolute value of the slope of the indifference curve at any point measures the rate of substitution of the consumer at that point. Usually, for small changes, the rate of substitution between good 2 and good 1 is called the **marginal rate of substitution (MRS)**.

If the preferences are monotonic, an increase in the amount of good 1 along the indifference is associated with a decrease in the amount of good 2. This implies that the slope of the indifference curve is negative. Thus, *monotonicity of preferences implies that the indifference curves are downward sloping.* Figure 2.7 illustrates the negative slope of an indifference curve.

Figure 2.8 illustrates an indifference curve with diminishing marginal rate of substitution. The indifference curve is convex towards the origin.
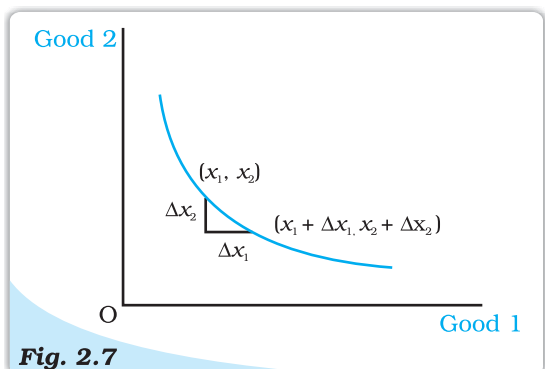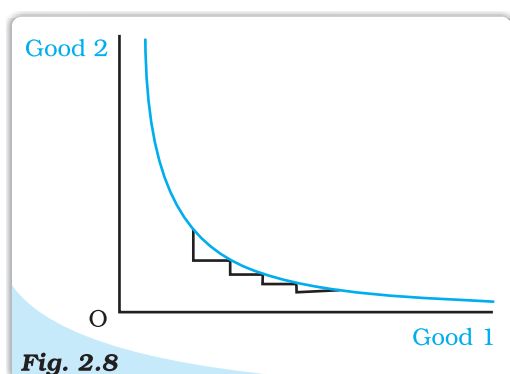

Fig. 2.7

Slope of the Indifference Curve. The indifference curve slopes downward. An increase in the amount of good 1 along the indifference curve is associated with a decrease in the amount of good 2. If $\Delta x_1 > 0$ then $\Delta x_2 < 0$.

Fig. 2.8

Diminishing Rate of Substitution.
The amount of good 2 the consumer is willing
to give up for an extra unit of good 1 declines
as the consumer has more and more of
good 1.

Fig. 2.9
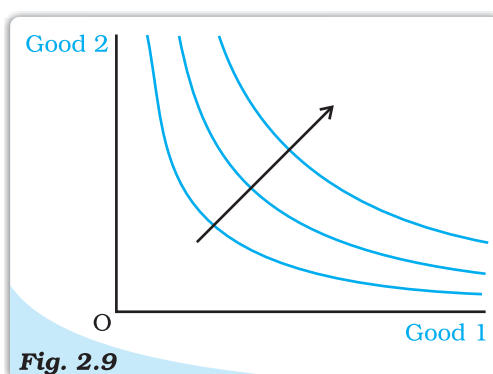
Indifference Map. A family of
indifference curves. The arrow indicates
that bundles on higher indifference curves
are preferred by the consumer to the
bundles on lower indifference curves.

2.2.6 Indifference Map

The consumer's preferences over all the bundles can be represented by a family of indifference curves as shown in Figure 2.9. 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.

2.2.7 Utility

Often it is possible to represent preferences by assigning numbers to bundles in a way such that the ranking of bundles is preserved. Preserving the ranking would require assigning the same number to indifferent bundles and higher numbers to preferred bundles. The numbers thus assigned to the bundles are called the utilities of the bundles; and the representation of preferences in terms of the **utility** numbers is called a utility function or a utility representation. Thus, a utility function assigns a number to each and every available bundle in a way such that between any two bundles if one is preferred to the other, the preferred bundle gets assigned a higher utility number, and if the two bundles are indifferent, they are assigned the same utility number.

It is important to note that the preferences are basic and utility numbers merely represent the preferences. The same preferences can have many different utility representations. Table 2.2 presents two different utility representations U_1 and U_2 of the preferences of Example 2.2.

Table 2.2: Utility Representation of Preferences

Bundles of the two goods	U_1	U_2
(2, 2)	5	40
(1, 3), (3, 1)	4	35
(1, 2), (2, 1)	3	28
(1, 1)	2	20
(0, 0), (0, 1), (0, 2), (0, 3), (0, 4), (1, 0), (2, 0), (3, 0), (4, 0)	1	10

2.3 Optimal Choice of the Consumer

In the last two sections, we discussed the set of bundles available to the consumer and also about her preferences to those bundles. Which bundle does she choose? 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 to 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 she prefers the most.

EXAMPLE ————————— **2.5**

Consider the consumer in Example 2.2. Among the bundles that are available to her, (2, 2) is her most preferred bundle. Therefore, as a rational consumer, she would choose the bundle (2, 2).

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.


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 units of good 2 if she is given an extra unit of good 1. But in the market, she can buy an extra unit of good 1 if she gives up just 1 unit of good 2. Therefore, if she buys an

extra unit of good 1, 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.

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.*[8] 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 2.10 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. 2.10
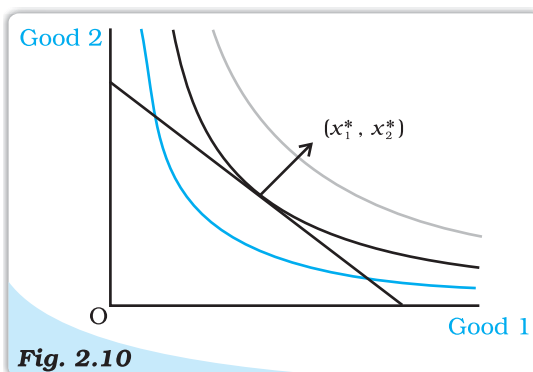
Consumer's Optimum. The point (x_1^*, x_2^*), at which the budget line is tangent to an indifference curve represents the consumers optimum bundle.

Problem of Choice

The problem of choice occurs in many different contexts in life. In any choice problem, there is a feasible set of alternatives. The feasible set consists of the alternatives which are available to the individual. The individual is assumed to have well-defined preferences to the set of feasible alternatives. In other words, the individual is clear in her mind about her likes and dislikes, and hence, can compare any two alternatives in the feasible set. Based on her preferences, the individual can rank the alternatives in the order of preferences starting from the best. The feasible set and the preference relation defined over the set of alternatives together constitute the basis of choice. Individuals are generally assumed to be rational. They have well-defined preferences. In any given situation, a rational individual tries to do the best for herself.

In the text we studied, the choice problem applied to the particular context of the consumer's choice. Here, the budget set is the feasible set

[8] To be more precise, if the situation is as depicted in Figure 2.10 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.

and the different bundles of the two goods which the consumer can buy at the prevailing market prices are the alternatives. The consumer is assumed to be rational. Her preference relation to the budget set is well-defined and she chooses her most preferred bundle from the budget set. The consumer's optimum bundle is the choice she makes in the given situation.

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. 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.

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 $f(20) = 40$.
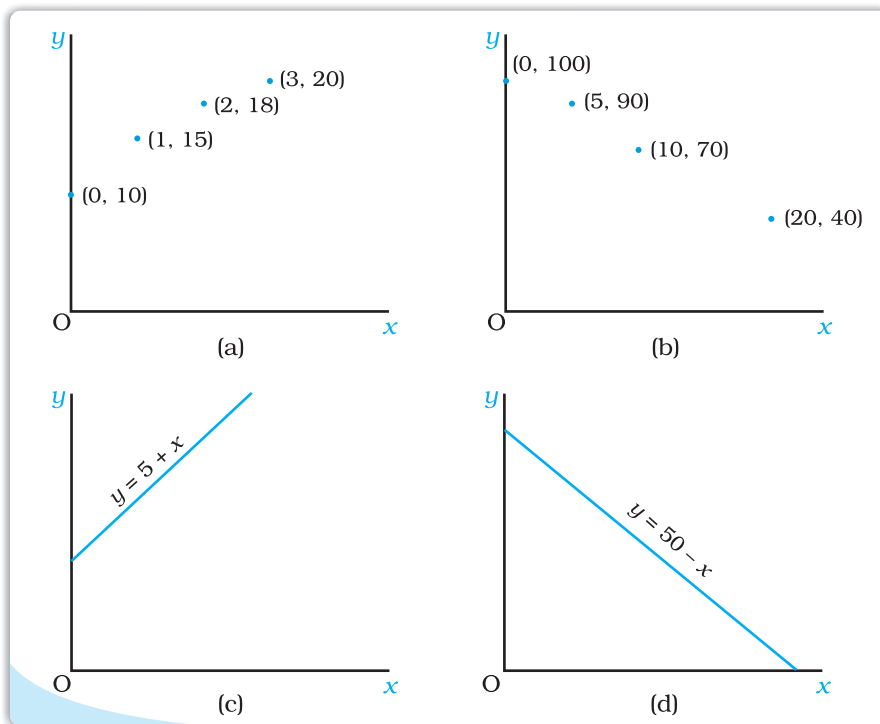
Very often a functional relation between the two variables can be expressed in algebraic form like

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

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.

(a)

Points: (0, 10), (1, 15), (2, 18), (3, 20)

(b)

Points: (0, 100), (5, 90), (10, 70), (20, 40)

(c)

$y = 5 + x$

(d)

$y = 50 - x$

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.

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 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

$$q = d(p) \qquad (2.12)$$

where q denotes the quantity and p denotes the price of the good.

The demand function can also be represented graphically as in Figure 2.11. 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.

To see why this is the case, consider a consumer whose income is M and let the prices of the two goods be p_1 and p_2. Suppose, in this situation, the optimum bundle of the consumer is (x_1^*, x_2^*). Now, consider a fall in the price of good 1 by the amount Δp_1. The new price of good 1 is $(p_1 - \Delta p_1)$. Note that the price change has two effects

Price

$q = d(p)$

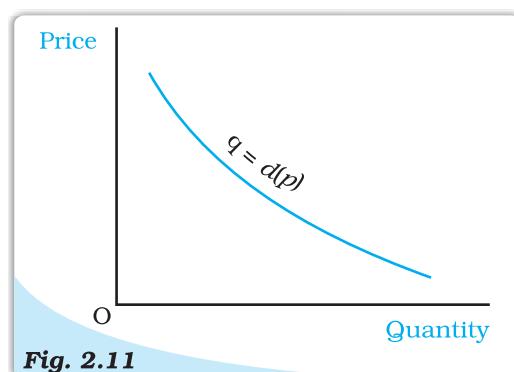O   Quantity

Fig. 2.11

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.

 (i) Good 1 becomes relatively cheaper than good 2 as compared to what it was before.

(ii) The purchasing power of the consumer increases. The price change, in general, allows the consumer to buy more goods with the same amount of money as before. In particular, she can buy the bundle which she was buying before by spending less than M.

Both these effects of the price change, the change in the purchasing power and the change in the relative price, are likely to influence the consumer's optimal choice. In order to find out how the consumer would react to the change in the relative price, let us suppose that her purchasing power is adjusted in a way such that she can just afford to buy the bundle (x_1^*, x_2^*).

At the prices $(p_1 - \Delta p_1)$ and p_2, the bundle (x_1^*, x_2^*) costs $(p_1 - \Delta p_1)\ x_1^* + p_2 x_2^*$

$$= p_1 x_1^* + p_2 x_2^* - \Delta p_1 x_1^*$$
$$= M - \Delta p_1 x_1^*.$$

Therefore, if the consumer's income is reduced by the amount $\Delta p_1 x_1^*$ after the fall in the price of good 1, her purchasing power is adjusted to the initial level.[9] Suppose, at prices $(p_1 - \Delta p_1)$, p_2 and income $(M - \Delta p_1 x_1^*)$, the consumer's optimum bundle is (x_1^{**}, x_2^{**}). x_1^{**} must be greater than or equal to x_1^*. To see why, consider the Figure 2.12.

The grey line in the diagram represents the budget line of the consumer when her income is M and the prices of the two goods are p_1 and p_2. All points

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[9]Consider, for example, a consumer whose income is Rs 30. Suppose the price of good 1 is Rs 4 and that of good 2 is Rs 5, and at these prices, the consumer's optimum bundle is (5,2). Now suppose price of good 1 falls to Rs 3. After the fall in price, if the consumer's income is reduced by Rs 5, she can just buy the bundle (5, 2). Note that the change in the price of good 1 (Rs 1) times, the amount of good 1 that she was buying prior to the price change (5 units) is equal to the adjustment required in her income (Rs 5).
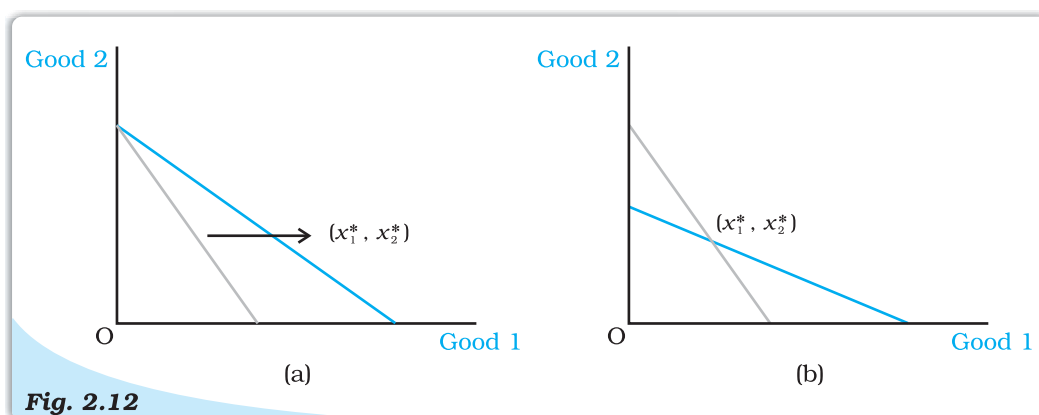
Fig. 2.12

Substitution Effect. The grey line represents the consumer's budget line prior to the price change. The blue line in panel (a) represents the consumer's budget line after the fall in price of Good 1. The blue line in panel (b) represents the budget line when the consumer's income is adjusted.

on or below the budget line are available to the consumer. As the consumer's preferences are monotonic, the optimum bundle (x_1^*, x_2^*) lies on the budget line. The blue line represents the budget line after the fall in the price of Good 1. If the consumer's income is reduced by an amount $\Delta p_1 x_1^*$, there would be a parallel leftward shift of blue budget line. Note that the shifted budget line passes through (x_1^*, x_2^*). This is because the income is adjusted in a way such that the consumer has just enough money to buy the bundle (x_1^*, x_2^*).

If the consumer's income is thus adjusted after the price change, which bundle is she going to choose? Certainly, the optimum bundle would lie on the shifted budget line. But can she choose any bundle to the left of the point (x_1^*, x_2^*)? Certainly not. Note that all points on this budget line which are to the left of (x_1^*, x_2^*) lie below the grey budget line, and therefore, were available prior to the price change. Compared to any of these points, there is at least one point on the grey budget line which is preferred by the consumer. Also note that since (x_1^*, x_2^*) was the optimum bundle prior to the price change, the consumer must consider (x_1^*, x_2^*) to be at least as good as any other bundle on the grey budget line. Therefore, it follows that all points on the shifted budget line which are to the left of (x_1^*, x_2^*) must be inferior to (x_1^*, x_2^*). It does not make sense for the rational consumer to choose an inferior bundle when the bundle (x_1^*, x_2^*) is still available. Bundles on the shifted budget line which are to the right of the point (x_1^*, x_2^*) were not available before the price change. If any of these bundles is preferred to (x_1^*, x_2^*) by the consumer, she can choose such a bundle, or else, she will continue to choose the bundle (x_1^*, x_2^*). Note that all those bundles on the shifted budget line which are to the right of (x_1^*, x_2^*), contain more than x_1^* units of good 1. Thus, if price of good 1 falls and the income of the consumer is adjusted to the previous level of her purchasing power, the rational consumer will not reduce her consumption of good 1. The change in the optimal quantity of a good when its price changes and the consumer's income is adjusted so that she can just buy the bundle that she was buying before the price change is called the **substitution effect**.

However, if the income of the consumer does not change due to the fall in the price of good 1, the consumer would experience a rise in the purchasing power as well. In general, a rise in the purchasing power of the consumer induces the consumer to consume more of a good. The change in the optimal quantity of a good when the purchasing power changes consequent upon a change in the price of the good is called the income effect. Thus, the two effects of a fall in the price of good 1 work together and there is a rise in the consumer's demand for good 1.[10] Thus, given the price of other goods, the consumer's income and her tastes and preferences, the amount of a good that the consumer optimally chooses, is inversely related to the price of the good. Hence, the demand curve for a good is, in general, downward sloping as represented in Figure 2.11. The inverse relationship between the consumer's demand for a good and the price of the good is often called the Law of Demand.

Law of Demand: *If a consumer's demand for a good moves in the same direction as the consumer's income, the consumer's demand for that good must be inversely related to the price of the good.*

Linear Demand

A linear demand curve can be written as

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

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

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 2.13 depicts a linear demand curve.
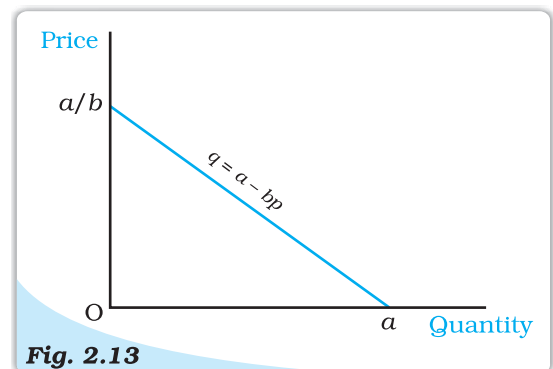

Fig. 2.13

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

2.4.2 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

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[10] As we shall shortly discuss, 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.*

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 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.

2.4.3 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.
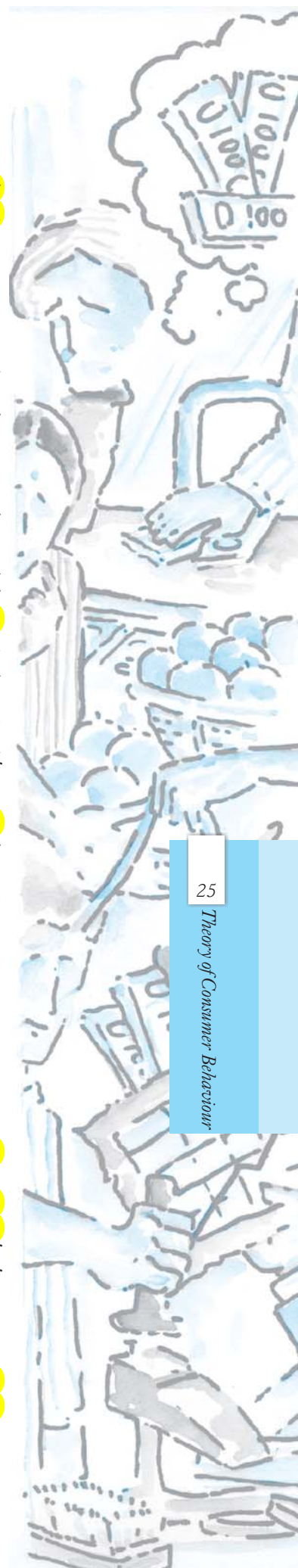
2.4.4 Shifts in the Demand Curve

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

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 lead to a change in preferences to cold-drinks. This is likely to result in a leftward shift in the demand curve for cold-drinks.

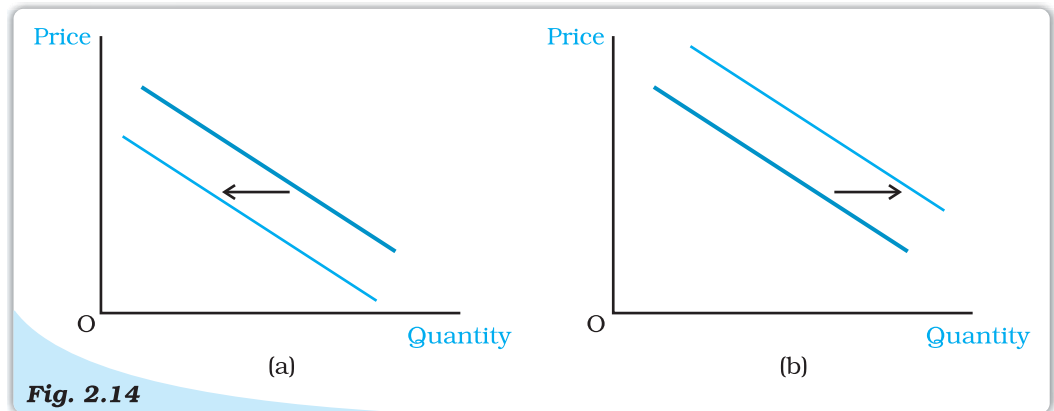Shifts in the demand curve are depicted in Figure 2.14.

Fig. 2.14

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

2.4.5 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 2.15 illustrates a movement along the demand curve and a shift in the demand curve.
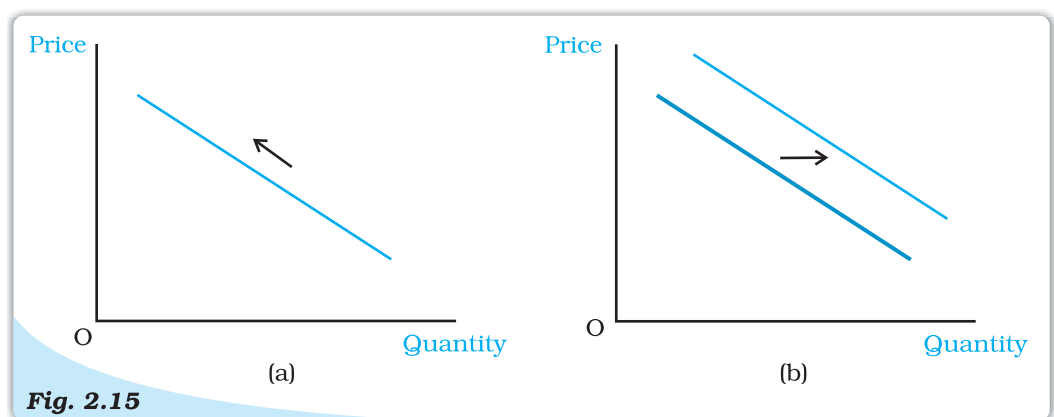

Fig. 2.15

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. <mark>The market demand for a good at a particular price is the total demand of all consumers taken together.</mark> The market demand for a good can be derived from the individual demand curves. Suppose there are only two 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 2.16. This method of adding two curves is called horizontal summation.
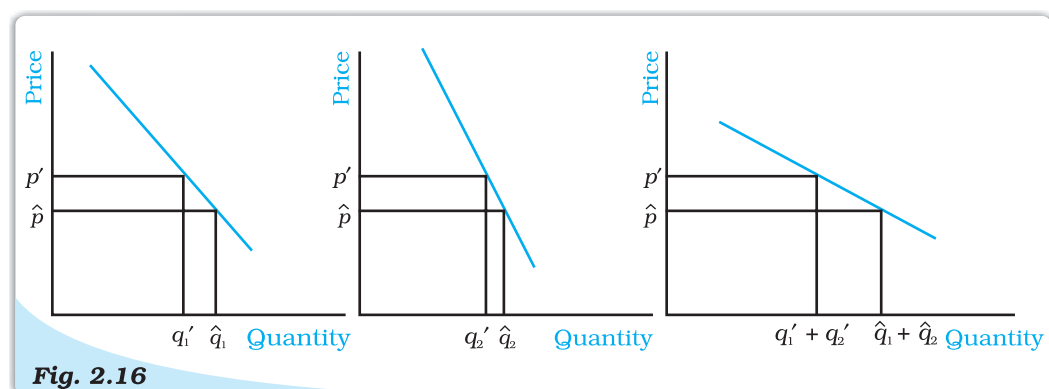

Fig. 2.16

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

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

$$d_1(p) = 10 - p \tag{2.14}$$
$$\text{and} \quad d_2(p) = 15 - p \tag{2.15}$$

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 (2.12) and (2.13). 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

$$e_D = \frac{\text{percentage change in demand for the good}}{\text{percentage change in the price of the good}}$$

Consider the demand curve of a good. Suppose at price p^0, the demand for the good is q^0 and at price p^1, the demand for the good is q^1. If price changes from p^0 to p^1, the change in the price of the good is, $\Delta p = p^1 - p^0$, and the change in the quantity of the good is, $\Delta q = q^1 - q^0$. The percentage change in price is,

$\frac{\Delta p}{p^0}$ $100 = \frac{p^1 - p^0}{p^0}$ 100, and the percentage change in quantity,

$\frac{\Delta q}{q^0} \times 100 = \frac{q^1 - q^0}{q^0} \times 100$

Thus

$$e_D = \frac{(\Delta q / q^0) \times 100}{(\Delta p / p^0) \times 100} = \frac{\Delta q / q^0}{\Delta p / p^0} = \frac{(q^1 - q^0)/q^0}{(p^1 - p^0)/p^0} \qquad (2.16)$$

It is important to note that elasticity of demand is a number and it does not depend on the units in which the price of the good and the quantity of the good are measured.

Also 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.

The more responsive the demand for a good is to its price, the higher is the price- elasticity of demand for the good. If at some price, the percentage change in demand for a good is less than the percentage change in the price, then $|e_D| < 1$ and demand for the good is said to be inelastic at that price. If at some price, the percentage change in demand for a good is equal to the percentage change in the price, ==$|e_D| = 1$, and demand for the good is said to be unitary-elastic at that price.== If at some price, the percentage change in demand for a good is greater than the percentage change in the price, ==then $|e_D| > 1$, and demand for the good is said to be elastic at that price.==

Price elasticity of demand is a pure number and does not depend on the units in which price and quantity are measured

Suppose the unit of money is rupee and the quantity is measured in kilograms. At price p^0, let the demand be q^0, and at price p^1, let the demand be q^1. Consider a price change from p^0 to p^1.
The change in price = p^1 rupees per kilogram − p^0 rupees per kilogram = $(p^1 - p^0)$ rupees per kilogram.

Percentage change in price of the good = $\dfrac{\text{change in the price}}{\text{initial price of the good}}$ 100

$$= \frac{(p^1 - p^0)\ rupees\ per\ kilogram}{p^0\ rupees\ per\ kilogram}\quad 100 = \frac{(p^1 - p^0)}{p^0}\quad 100.$$

Change in quantity of the good = q^1 kilograms $- q^0$ kilograms = $(q^1 - q^0)$ kilograms.

Percentage change in quantity of the good = $\dfrac{(q^1 - q^0)\ kilogram}{q^0\ kilogram}\quad 100$

$$= \frac{q^1 - q^0}{q^0}\quad 100.$$

$$e_D = \frac{(q^1 - q^0)}{q^0}\quad 100 \Big/ \frac{(p^1 - p^0)}{p^0}\quad 100 = \frac{(q^1 - q^0)}{q^0} \Big/ \frac{(p^1 - p^0)}{p^0}$$

If the unit of money used in the measurement of price is paisa and the quantity is measured in grams, the initial price of the good would be $100p^0$ paisa per 1,000 grams = $\dfrac{100p^0}{1,000}$ paisa per gram = $\dfrac{p^0}{10}$ paisa per gram. After the change, price would be $100p^1$ paisa per 1,000 grams = $\dfrac{100p^1}{1,000}$ paisa per gram = $\dfrac{p^1}{10}$ paisa per gram.

Change in price = $\dfrac{p^1}{10}$ paisa per gram $- \dfrac{p^0}{10}$ paisa per gram

$$= \frac{(p^1 - p^0)}{10}\ \text{paisa per gram.}$$

Percentage change in price = $\dfrac{p^1 - p^0}{10}$ paisa per gram $\Big/ \dfrac{p^0}{10}$ paisa per gram

$$= \frac{p^1 - p^0}{p^0}.$$

Change in quantity of the good = $1,000q^1$ grams $- 1,000q^0$ grams
$= 1,000(q^1 - q^0)$ grams.

Percentage change in quantity of the good

$$= \frac{1,000(q^1 - q^0)\ grams}{1,000q^0\ grams}\quad 100$$

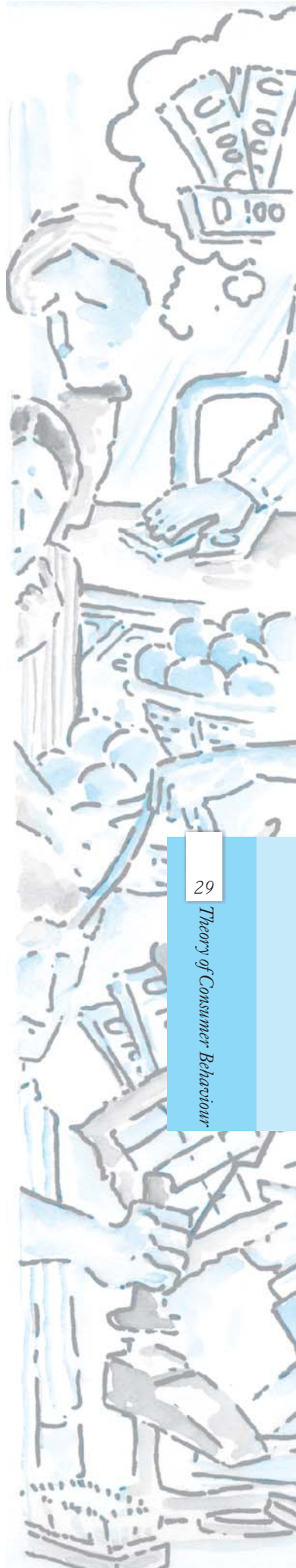$$= \frac{(q^1 - q^0)}{q^0}\quad 100.$$

$$e_D = \frac{q^1 - q^0}{q^0} \Big/ \frac{(p^1 - p^0)}{p^0}$$

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 $\dfrac{\Delta q}{\Delta p} = -b$.

Substituting the value of $\dfrac{\Delta q}{\Delta p}$ in (2.16), we obtain

$$e_D = -b\frac{p}{q} = -\frac{bp}{a - bp} \tag{2.17}$$

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 $p = \dfrac{a}{2b}$, the elasticity is 1, at any price greater than 0 and less than $\dfrac{a}{2b}$, elasticity is less than 1, and at any price greater than $\dfrac{a}{2b}$, elasticity is greater than 1. The price elasticities of demand along the linear demand curve given by equation (2.17) are depicted in Figure 2.17.
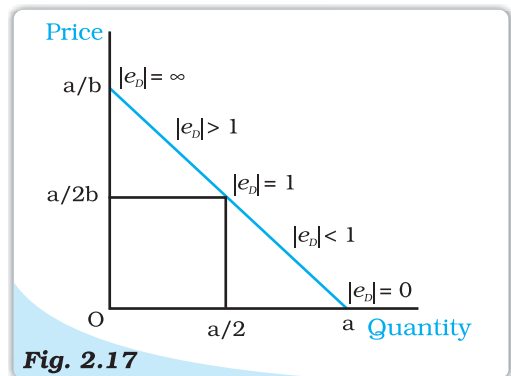

Fig. 2.17

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

Constant Elasticity Demand Curves

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 2.18 (a). Whatever be the price, the demand is given at the level $\bar{q}$. A price change 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.

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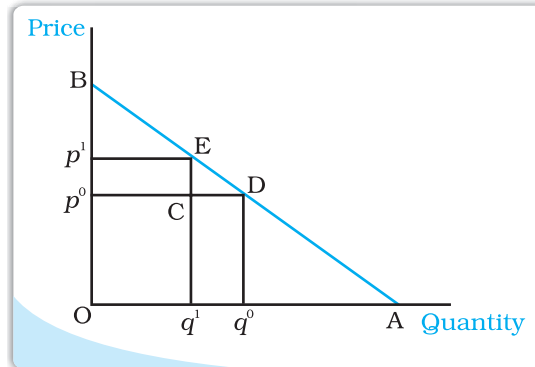
Suppose at price p^0, the demand for the good is q^0. Now consider a small change in the price. The new price is p^1, and at that price, demand for the good is q^1.

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

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

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

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

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 $p = \dfrac{a}{2b}$.

Figure 2.18(b) depicts a demand curve which has the shape of a rectangular hyperbola. This demand curve has the nice 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.
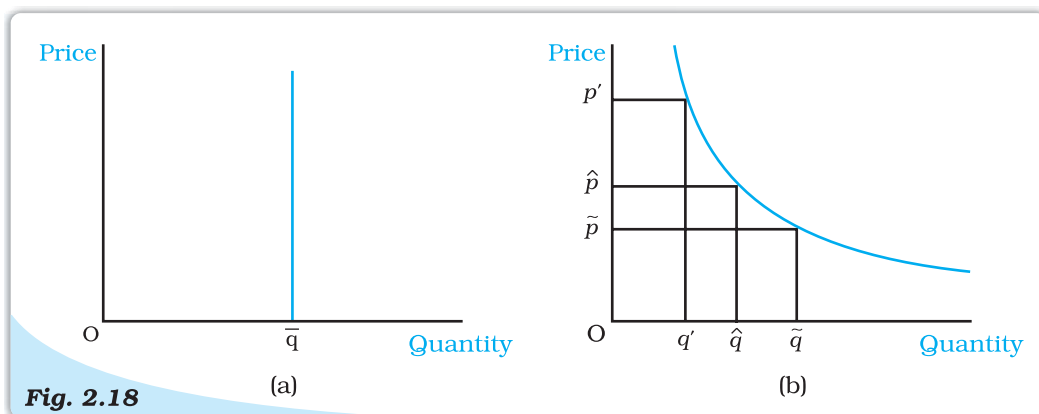

Fig. 2.18

(a)   (b)

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

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. 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. And if the percentage decline in quantity is equal to the percentage increase in the price, the expenditure on the good will remain unchanged.

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 = $\Delta E = q\Delta p + p\Delta q = \Delta p(q + p\dfrac{\Delta q}{\Delta p})$

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

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, $\Delta E = 0$.

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. 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. And if the percentage increase in quantity is equal to the percentage decline in the price, the expenditure on the good will remain unchanged.

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. 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. 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.

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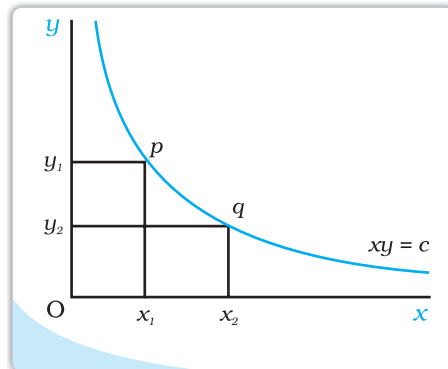
If the equation of a demand curve takes the form $pq = e$, where e is a constant, it will be a rectangular hyperbola, where price (p) times quantity (q) is a constant. With such a demand curve, no matter at what point the consumer consumes, her expenditures are always the same and equal to e.

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	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 15, and $d_1(p) = 0$ at any price greater than 15.

$d_2(p) = 30 - 2p$ 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?