## 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.

### 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

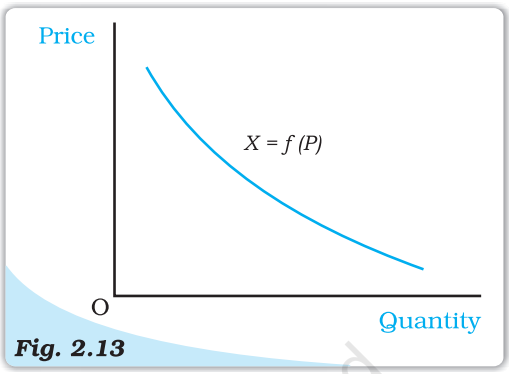



**Fig. 2.13**

***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.*

**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 $f(20) = 40$.

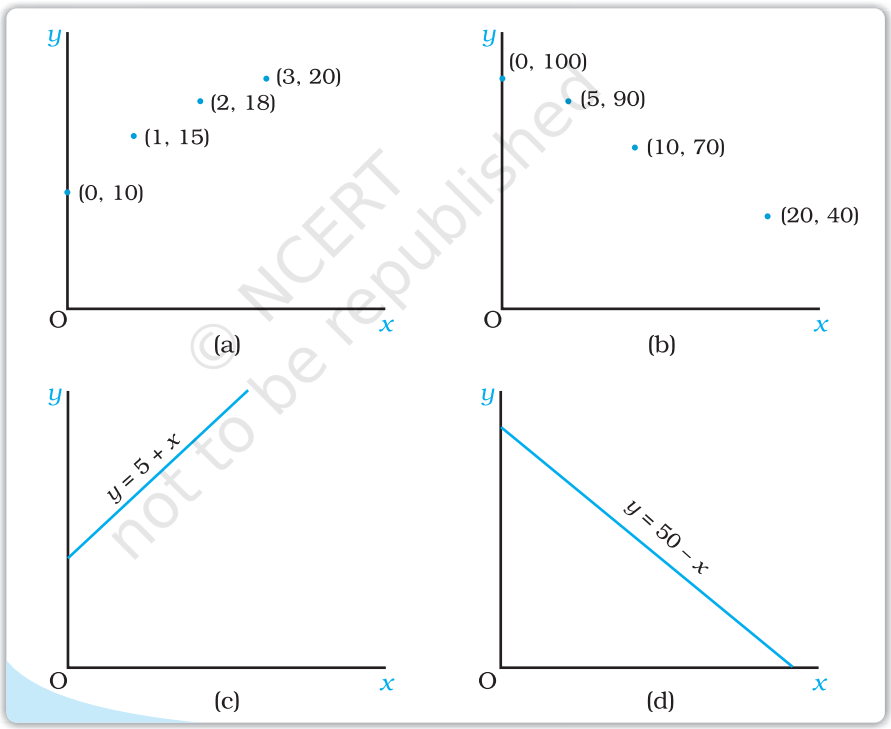
Very often a functional relation between the two variables can be expressed in algebraic form like

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

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 $X_1$.

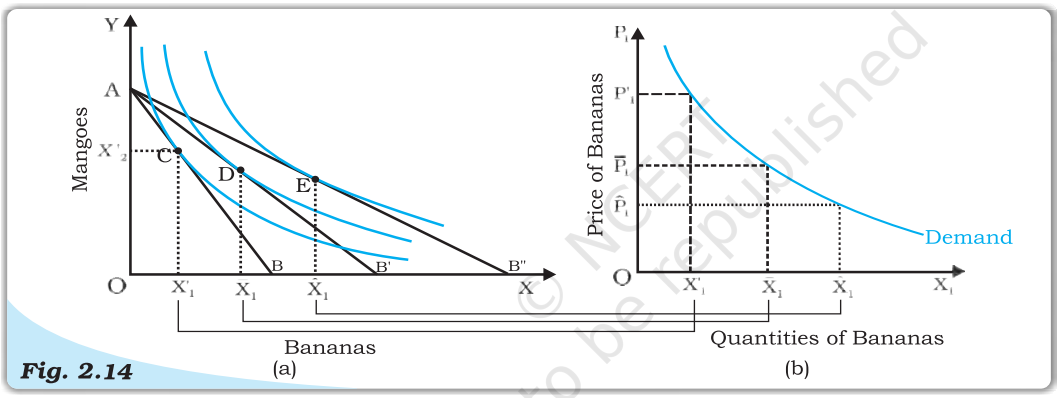



***Fig. 2.14***

***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.

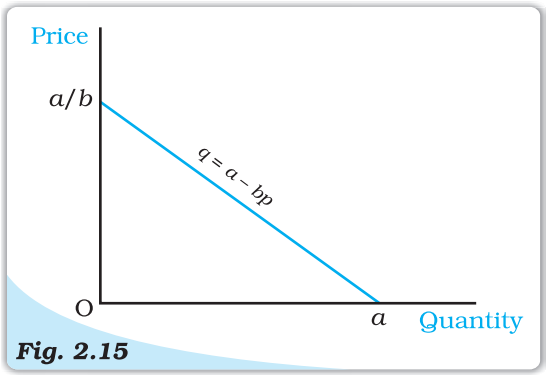



***Fig. 2.15***

***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.

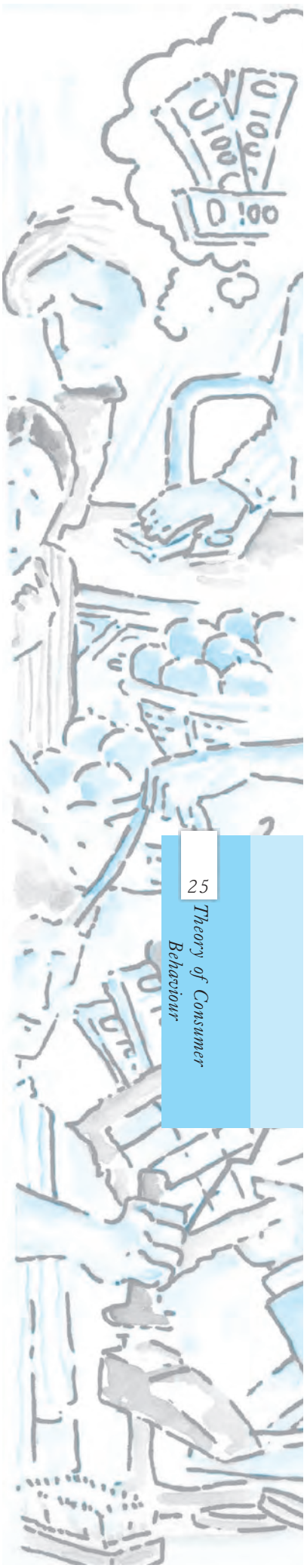



**Fig. 2.16**

***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.



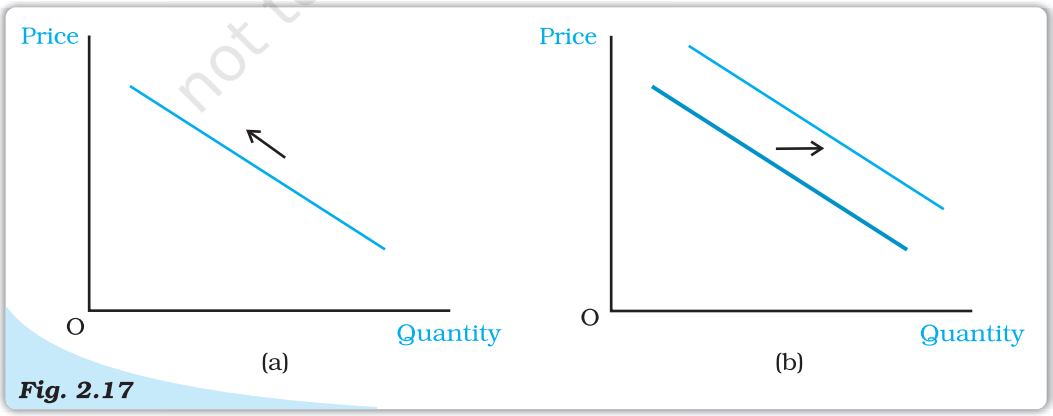



**Fig. 2.17**

***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

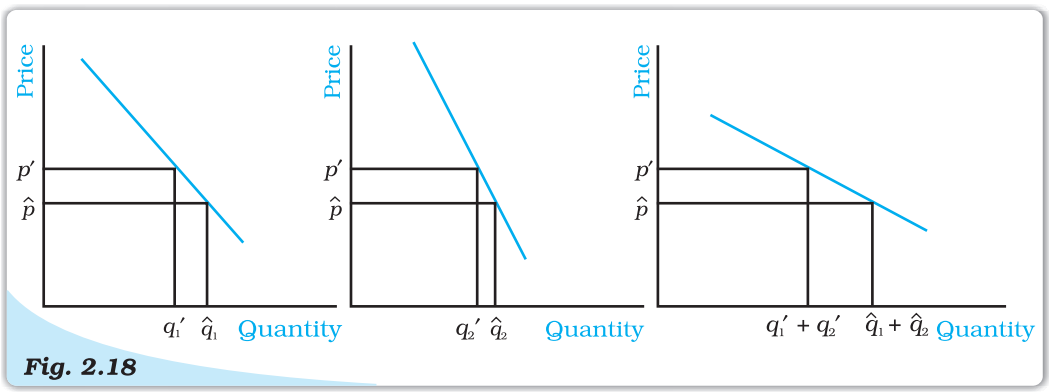



**Fig. 2.18**

***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, $\Delta P$ is the change in price of the good and $\Delta Q$ 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.

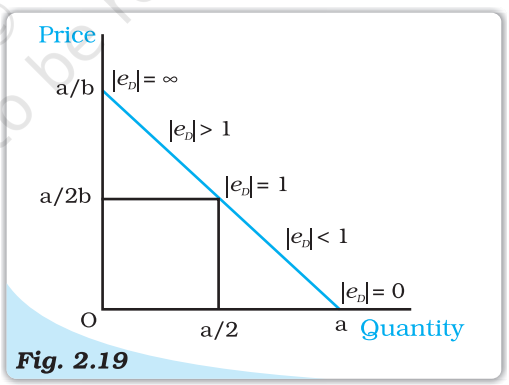
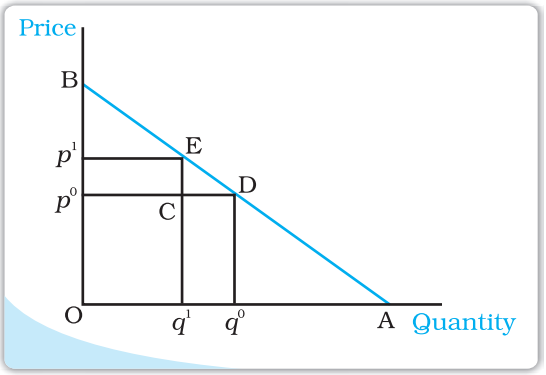



**Fig. 2.19**

***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 $\infty$ 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) depicts 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.

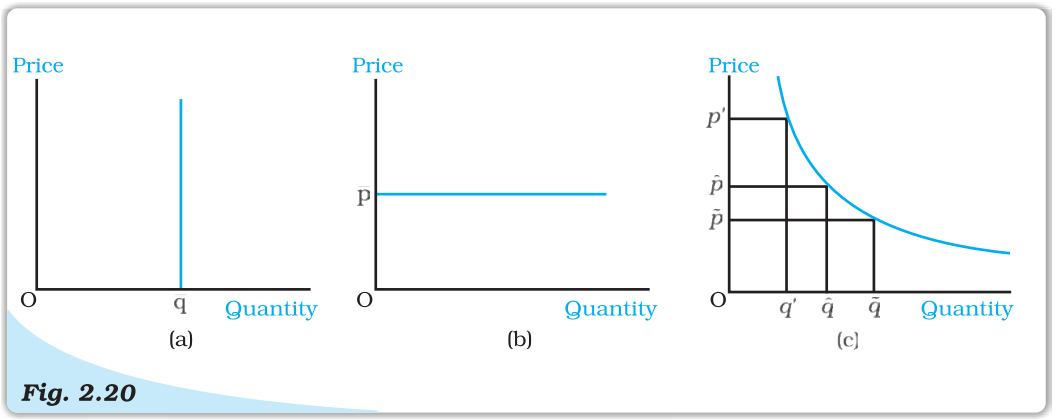



**Fig. 2.20**

***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 $\|e_d\|$ |
|---|---|---|---|---|---|---|
| 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 |

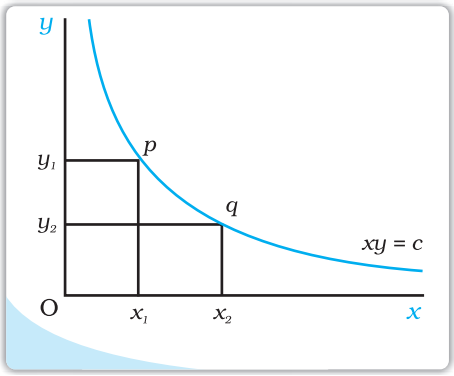


**Rectangular Hyperbola**

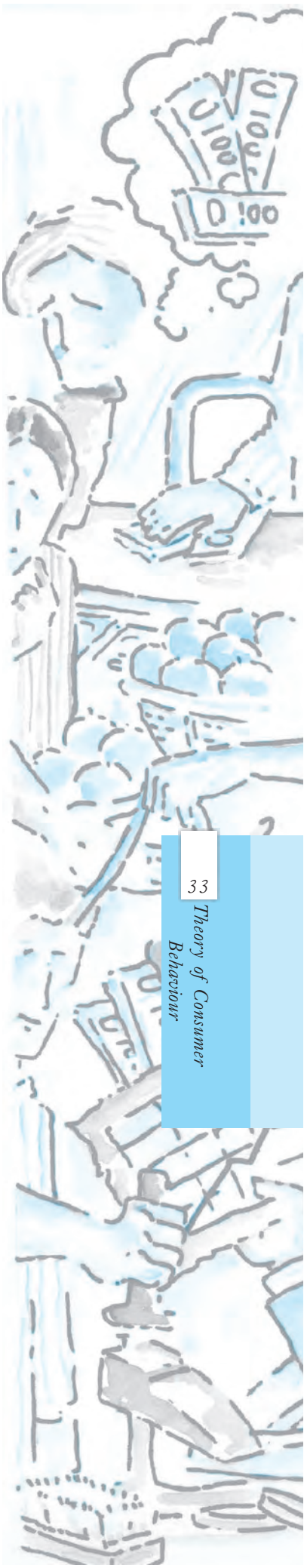
An equation of the form

$$xy = c$$

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 $\Delta p$ and $\Delta q$, 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, $\Delta E$ has the opposite sign as $\Delta p$,

if $e_D > -1$, then $q(1 + e_D) > 0$, and hence, $\Delta E$ has the same sign as $\Delta p$,

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?