Item	Weight W	Price (₹)		$I = \frac{p_1}{p_0} \times 100$	IW
		p_0	p_1		
A	40	160	200	$\frac{200}{160} \times 100 = 125$	5000
B	25	400	600	$\frac{600}{400} \times 100 = 150$	3750
C	5	50	70	$\frac{70}{50} \times 100 = 140$	700
D	20	10	18	$\frac{18}{10} \times 100 = 180$	3600
E	10	2	3	$\frac{3}{2} \times 100 = 150$	1500
Total	**100**				**14,550**

Index number of year 2016 $I = \frac{\Sigma IW}{\Sigma W}$

$= \frac{14550}{100}$

$= 145.50$

Thus, we say that there is an increase of (145.50 – 100) = 45.5 % in prices in the year 2016 as compared to the year 2011.

Illustration 12 : Find Laspeyre's, Paasche's and Fisher's index numbers for the year 2016 with base year 2015 from the data about price and consumption of food items given below.

Item	Unit	Year 2016		Year 2015	
		Price (₹)	Quantity	Price (₹)	Quantity
Rice	Kilogram	40	1.5 Kilogram	39	1 Kilogram
Milk	Litre	44	10 Litre	40	12 Litre
Bread	Kilogram	50	1.5 Kilogram	45	2 Kilogram
Banana	Dozen	36	1.5 Dozen	30	2 Dozen

We will take price p_0 and quantity q_0 for the base year, price p_1 and quantity q_1 for the current year.

Item	**Unit**	p_0	q_0	p_1	q_1	p_1q_0	p_0q_0	p_1q_1	p_0q_1
Rice	Kilogram	39	1	40	1.5	40	39	60	58.5
Milk	Litre	40	12	44	10	528	480	440	400
Bread	Kilogram	45	2	50	1.5	100	90	75	67.5
Banana	Dozen	30	2	36	1.5	72	60	54	45
Total						**740**	**669**	**629**	**571**

Laspeyre's index number $I_L = \frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times 100$

$= \frac{740}{669} \times 100$

$= 110.6128$

$\simeq 110.61$

Thus, there is a rise of $(110.61 - 100) = 10.61$ % in prices of the year 2016 as compared to the base year 2015.

Paasche's index number $I_P = \frac{\Sigma p_1q_1}{\Sigma p_0q_1} \times 100$

$= \frac{629}{571} \times 100$

$= 110.1576$

$\simeq 110.16$

Thus, there is a rise of $(110.16 - 100) = 10.16$ % in prices of the year 2016 as compared to the base year 2015.

Fisher's index number $I_F = \sqrt{I_L \times I_P}$

$= \sqrt{110.61 \times 110.16}$

$= 110.3847$

$\simeq 110.38$

Thus, there is a rise of (110.38 – 100) = 10.38 % in prices of the year 2016 as compared to the base year 2015.

Illustration 13 : Compute Laspeyre's, Paasche's and Fisher's index numbers for the year 2016 from the data given below by taking 2015 as the base year.

Item	Unit	Price (₹)		Quantity (Consumption)	
		Year 2015	Year 2016	Year 2015	Year 2016
A	20 Kilogram	300	440	5 Kilogram	8 Kilogram
B	Quintal	500	700	10 Kilogram	15 Kilogram
C	Kilogram	60	75	1200 Gram	2000 Gram
D	Meter	14.25	15	15 Meter	25 Meter
E	Litre	32	36	18 Litre	30 Litre
F	Dozen	30	36	8 Pieces	10 Pieces

The base year is 2015 and the current year is 2016. Hence, we will take price p_0 and quantity q_0 for the year 2015, price p_1 and quantity q_1 for the year 2016.

The price of item *A* is per 20 kg here whereas the unit for quantity is kg. The price of item *B* is per quintal but the unit for the quantity is kg. The price of item *C* is per kg whereas the unit for quantity is gram. The price for item *F* is per dozen whereas the unit for quantity is piece. The calculation of the price per item of these four items will be as follows :

The price of item *A* in the year 2015 is ₹ 300 per 20 kg. Hence, its price = $\frac{300}{20}$ = ₹ 15 per kg.

Similarly, the price of item *A* in 2016 is $\frac{440}{20}$ = ₹ 22 per kg.

It is convenient to express the price of item *B* per kg than quintal. Hence, the price for the year 2015 = $\frac{500}{100}$ = ₹ 5 per kg and the price for the year 2016 = $\frac{700}{100}$ = ₹ 7 per kg.

The price of item *C* is per kg. Hence, it is convenient to express its quantity in kg.

Thus, the quantity in the year 2015 = $\frac{1200}{1000}$ = 1.2 kg and the quantity for the year 2016 = $\frac{2000}{1000}$ = 2 kg.

The price of item *F* is per dozen which is convenient to express in per piece. Hence, the price of the year 2015 = $\frac{30}{12}$ = ₹ 2.5 per piece and the price for the year 2016 = $\frac{36}{12}$ = ₹ 3 per piece. Now, the index number will be calculated as follows :

Item	Unit	Year 2015		Year 2016		p_1q_0	p_0q_0	p_1q_1	p_0q_1
		p_0	q_0	p_1	q_1				
A	kg	15	5	22	8	110	75	176	120
B	kg	5	10	7	15	70	50	105	75
C	kg	60	1.2	75	2	90	72	150	120
D	Meter	14.25	15	15	25	225	213.75	375	356.25
E	Litre	32	18	36	30	648	576	1080	960
F	Piece	2.5	8	3	10	24	20	30	25
Total						**1167**	**1006.75**	**1916**	**1656.25**

Laspeyre's index number $I_L = \frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times 100$

$= \frac{1167}{1006.75} \times 100$

$= 115.9175$

$\simeq 115.92$

Thus, we can say that there is a rise of (115.92 – 100) = 15.92 % in the prices in the year 2016 as compared to the year 2015.

Paasche's index number $I_P = \frac{\Sigma p_1q_1}{\Sigma p_0q_1} \times 100$

$= \frac{1916}{1656.25} \times 100$

$= 115.6830$

$\simeq 115.68$

Thus, it can be said that there is (115.68 – 100) = 15.68 % rise in the prices in the year 2016 as compared to the year 2015.

Fisher's index number $I_F = \sqrt{I_L \times I_P}$

$= \sqrt{115.92 \times 115.68}$

$= 115.7999$

$\simeq 115.8$

Thus, it can be said that there is (115.8 – 100) = 15.8 % rise in the prices in the year 2016 as compared to the year 2015.

Illustration 14 : Find the ideal index number for the year 2015 from the following data.

Item	Base year 2014		Current year 2015	
	Price (₹)	Quantity	Price (₹)	Quantity
A	16	10	20	11
B	20	9	24	9
C	32	16	40	17

Fisher's index number is considered as an ideal index number. So, we will find Fisher's index number here. We will take price p_0 and quantity q_0 for base year, price p_1 and quantity q_1 for the current year.

Item	p_0	q_0	p_1	q_1	p_1q_0	p_0q_0	p_1q_1	p_0q_1
A	16	10	20	11	200	160	220	176
B	20	9	24	9	216	180	216	180
C	32	16	40	17	640	512	680	544
Total					**1056**	**852**	**1116**	**900**

Fisher's index number $I_F = \sqrt{\frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times \frac{\Sigma p_1q_1}{\Sigma p_0q_1}} \times 100$

$= \sqrt{\frac{1056}{852} \times \frac{1116}{900}} \times 100$

$= \sqrt{1{\cdot}5369} \times 100$

$= 1.2397 \times 100$

$I_F = 123.97$

Thus, it can be said that there is (123.97 – 100) = 23.97 % rise in the prices in the year 2015 as compared to the year 2014.

Illustration 15 : Find Fisher's index number for the year 2015 by taking the year 2014 as the base year from the data given below about consumption and total expenditure of five different items.

Item	Base Year 2014		Current Year 2015	
	Consumption	Total expenditure	Consumption	Total expenditure
A	50 kg	2500	60 kg	4200
B	120 kg	600	140 kg	700
C	30 litre	330	20 litre	200
D	20 kg	360	15 kg	300
E	5 kg	40	5 kg	50

The consumption and total expenditure for the items are given here.

Total expenditure of item = (Price of item per unit) × (Consumption of item)

$\therefore$ Price of item per unit = $\frac{\text{Total expenditure of item}}{\text{Consumption of item}}$

We will obtain the price per unit of each item using the above formula.

Item	Base year 2014		Current year 2015		p_1q_0	p_0q_0	p_1q_1	p_0q_1
	Quantity	$p_0 = \frac{\text{Expenditure}}{q_0}$	Quantity	$p_1 = \frac{\text{Expenditure}}{q_1}$				
	q_0	p_0	q_1	p_1				
A	50	$\frac{2500}{50} = 50$	60	$\frac{4200}{60} = 70$	3500	2500	4200	3000
B	120	$\frac{600}{120} = 5$	140	$\frac{700}{140} = 5$	600	600	700	700
C	30	$\frac{330}{30} = 11$	20	$\frac{200}{20} = 10$	300	330	200	220
D	20	$\frac{360}{20} = 18$	15	$\frac{300}{15} = 20$	400	360	300	270
E	5	$\frac{40}{5} = 8$	5	$\frac{50}{5} = 10$	50	40	50	40
Total					**4850**	**3830**	**5450**	**4230**

Fisher's index number $I_F = \sqrt{\frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times \frac{\Sigma p_1q_1}{\Sigma p_0q_1}} \times 100$

$= \sqrt{\frac{4850}{3830} \times \frac{5450}{4230}} \times 100$

$= \sqrt{1{\cdot}6315} \times 100$

$= 1.2773 \times 100$

$I_F \simeq 127.73$

Thus, it can be said that there is (127.73 – 100) = 27.73 % rise in the prices in the year 2015 as compared to the year 2014.

Illustration 16 : The health department has implemented a certain policy for the industrial units in the year 2003 to control the possibility of cancer due to the chemical process which is hazardous to the health of workers employed in the industrial units of a certain industrial area who are residing in the same area. To evaluate this policy, a survey was conducted about deaths due to cancer of persons in the different age groups. The following data are obtained for the years 2003 and 2008. Find the index number of deaths due to cancer using weighted average method by taking the population of this industrial area in the year 2003 as weight and interpret it.

Age-group (years)	Population in year 2003 (thousand)	Deaths in year 2003	Deaths in year 2008
< 5	10	200	65
5-15	8	145	100
15-40	48	610	480
40-60	38	350	225
> 60	14	550	465

We shall obtain the general index number by finding the relative percentages of cancer deaths for the year 2008 and taking the population in different age-groups in 2003 as weights.

Age-group (years)	Population in year 2003 (thousand) W	Deaths in year 2003 p_0	Deaths in year 2008 p_1	$I = \frac{p_1}{p_0} \times 100$	IW
< 5	10	200	65	$\frac{65}{200} \times 100 = 32.5$	325
5-15	8	145	100	$\frac{100}{145} \times 100 = 68.97$	551.76
15-40	48	610	480	$\frac{480}{610} \times 100 = 78.69$	3777.12
40-60	38	350	225	$\frac{225}{350} \times 100 = 64.29$	2443.02
> 60	14	550	465	$\frac{465}{550} \times 100 = 84.55$	1183.7
Total	**118**				**8280.6**

Index number for year 2008 $I = \frac{\Sigma IW}{\Sigma W}$

$= \frac{8280.6}{118}$

$= 70.1745$

$\simeq 70.17$

Thus, it can be said that there is a decrease of (100 – 70.17) = 29.83 % in the deaths due to cancer in the year 2008 as compared to the year 2003.

EXERCISE 1.3

1. The information about six different items used in the production of an electronics item is as follows. Find the index number and interpret it.

Items	*A*	*B*	*C*	*D*	*E*	*F*
Weight	5	10	10	30	20	25
Percentage price relative	290	315	280	300	315	320

2. The information about six different items used in the furniture items is as follows. Find the index number for the year 2015 with the base year 2014 and interpret it.

Item	*A*	*B*	*C*	*D*	*E*	*F*
Weight	17	15	22	16	12	18
Price in year 2014 (₹)	30	20	50	32	40	16
Price in year 2015 (₹)	24	24	70	40	48	24

3. Find the Laspeyre's, Paasche's and Fisher's index numbers for the year 2015 with the base year 2014 using the following information.

Item		Wheat	Rice	Pulses	Oil	Cloth	Kerosene
	Unit	kg	kg	kg	kg	Meter	Litre
Year 2014	**Quantity**	20	10	10	6	15	18
	Price (₹)	15	20	26.50	24.80	21.25	21
Year 2015	**Quantity**	30	15	15	8	25	30
	Price (₹)	18	31.25	29.50	30	25	28.80

4. Find the Laspeyre's, Paasche's and Fisher's index numbers for the year 2015 with the base year 2014 using the following information.

Item	**Unit**	**Price (₹)**		**Quantity (Consumption)**	
		Year 2014	**Year 2015**	**Year 2014**	**Year 2015**
A	20 kg	80	120	5 kg	7 kg
B	kg	20	24	2400 gm	4000 gm
C	Quintal	2000	2800	10 kg	15 kg
D	Dozen	48	72	30 pieces	35 pieces

5. Find the ideal index number from the following data for the year 2015.

Item	Unit	Base year 2014		Base year 2015	
		Price (₹)	Quantity	Price (₹)	Quantity
A	20 kg	120	10 kg	280	15 kg
B	5 Dozen	120	3 Dozen	140	48 pieces
C	kg	4	5000 gm	8	4 kg
D	5 Litre	52	15 Litre	58	20 Litre

6. Find the Paasche's and Fisher's index numbers for the year 2015 with the base year 2014 using the data given below.

Item		*A*	*B*	*C*	*D*	*E*
Year 2014	Price (₹)	100	100	150	180	250
	Total expenditure	400	500	600	1080	1000
Year 2015	Price (₹)	120	120	160	200	300
	Total expenditure	720	600	800	1000	1200

*

1.7 Cost of Living Index Number

The cost of living index number is constructed to measure and study the changes in the cost of living of people from different sections of the society due to the fluctuations in prices. Thus, "The number showing the percentage of relative changes in the cost of living of the people of a certain section of the society in the current year (period) as compared to the base year (period) is called the **cost of living index number**."

The cost of living index number is prepared separately for the people of different sections of the society and regions.

For example, a family spends ₹ 15,000 per month for their living in the year 2012 and the same family spends ₹ 18,000 per month for their living in the year 2014 for the same lifestyle. Their cost of living index number can be obtained as follows :

$$\text{Cost of living index number} = \frac{\text{Current year (period) monthly expenditure}}{\text{Base year (period) monthly expenditure}} \times 100$$

$$= \frac{18000}{15000} \times 100$$

$$= \frac{600}{5}$$

$$= 120$$

Thus, it can be said that there is a rise of (120 – 100) = 20 % in the monthly expense in the year 2014 as compared to the year 2012.

1.7.1 Construction of Cost of Living Index Number

The following points should be considered while constructing the cost of living index number :

(1) Purpose : The purpose of every index number should be explained before constructing it. We should ascertain the class of people in the society for whom the cost of living index number is to be constructed. The requirements of the people of worker class and rich class are different. For example, the rise in price of grains does not affect much to the cost of living of the people from rich class whereas it affects a lot to the cost of living of the people from worker class. Thus, it is necessary to clarify the purpose of the construction of the cost of living index number.

(2) Family Budget Inquiry : A sample of some families is randomly selected from the families of that class of people for whom the cost of living index is to be prepared. The budget of the families selected in the sample is studied. The information is obtained about the list of different items consumed by them, their consumption, list of retail prices, the expenses incurred on them and place of purchase, etc. This type of inquiry is called sample family budget inquiry.

The data obtained from the inquiry of families included in the sample are generally divided into five sections : (a) food (b) clothing (c) house rent (d) fuel and electricity and (e) miscellaneous.

The importance of different items in the expenditure for living can be known from the sample inquiry of family budget. Hence, the importance of each item selected in the construction of the index number in its group and the importance of each group in the total expenditure can be determined.

(3) Availability of Prices of Items : The retail prices of items are collected from the areas of residence of the people from the class of families for whom the cost of living index number is to be obtained. As far as possible, these prices should be collected from the standard or government approved shops. The average price of items should be taken into consideration when the prices obtained from various shops at different times are different.

(4) Base Year : A normal year is selected as a base year. The price relatives are found as follows for each item by taking the retail prices of the normal year as the base year prices :

$$\text{Price relative} \quad I = \frac{p_1}{p_0} \times 100$$

Where, p_1 = retail price of item in current year

p_0 = retail price of item in base year

(5) Average : It is necessary to find a general price relative from the price relatives of different items. A proper average should be used for this purpose. Theoretically, the geometric mean is the ideal average for the construction of index number. But due to the difficulty of its computation, it is common to use the weighted mean for the construction of index number.

(6) Weight : The importance of different items selected in the construction of index number is not same. The number associated with items in propotion to their importance is called weight. These weights can be of two types : (i) Implicit Weight and (ii) Explicit Weight.

(i) Implict Weight : This is an indirect method of assigning weights. According to this method, the weights are determined as per the number of varieties of different items selected in the construction of index number. This method is called implicit method as the weights can not be accurately quantified.

(ii) Explicit Weight : This is a direct method of assigning weights. The weights of items are expressed numerically in proportion to their importance. In this method, the weights of items are determined according to the consumption, sale, production or the expenditure for that item. Thus, the weights given in accordance with the importance of the items are called explicit weights.

The two methods of assigning explicit weight are as follows :

(1) Method of total expenditure (2) Method of family budget

(1) Method of Total Expenditure : In this method, the expenditure for every item in the base year and current year is found using the consumption of these items and further the total expenditure of all the items is obtained for both the years. The percentage ratio of the total expenditure of the current year with the total expenditure of the base year is called the index number by the method of total expenditure.

Suppose p_0 = price of base year, q_0 = quantity of base year

p_1 = price of current year, q_1 = quantity of current year

If the quantity of the base year is used for finding the total expenditure of the current and base year,

Σp_1q_0 = total expenditure of current year and Σp_0q_0 = total expenditure of base year.

Index number $I = \frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times 100$. This formula is the formula of Laspeyre's index number.

If the quantity of the current year is used for finding the total expenditure of the current and base year,

Σp_1q_1 = total expenditure of current year and Σp_0q_1 = total expenditure of base year

Index number $I = \frac{\Sigma p_1q_1}{\Sigma p_0q_1} \times 100$. This formula is the formula of Paasche's index number.

(1) Method of Family Budget : In this method, the percentage price relative I is found first for every item. Here, $I = \frac{p_1}{p_0} \times 100$ where, p_1 = price of current year and p_0 = price of base year. Then, the expenditure of every item p_0q_0 in the base year is found and it is taken as the weight W for the percentage price relative I. The formula for index number by the method of family budget using the weighted average with weight $W = p_0q_0$ is as follows :

$$\text{Index number } I = \frac{\Sigma IW}{\Sigma W}$$

$$= \frac{\Sigma\left[\frac{p_1}{p_0} \times 100 \times p_0q_0\right]}{\Sigma p_0q_0}$$

$$= \frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times 100$$

Thus, the index number obtained by the method of family budget is the Laspeyre's index number.

Illustration 17 : Find the cost of living index number by the family budget method from the following information about index numbers of different groups of items for living and their weights.

Group	Food items	Clothing	Electricity-fuel	House rent	Miscellaneous
Index number	281	177	178	210	242
Weight	46	10	7	12	25

The index numbers of different groups and their weights are given here. Hence, we will use family budget method which is a method of weighted average.

Group	**Index number I**	**Weight W**	IW
Food Items	281	46	12,926
Clothing	177	10	1770
Electricity-fuel	178	7	1246
House Rent	210	12	2520
Miscellaneous	242	25	6050
Total		**100**	**24,512**

$$\text{Index number } I = \frac{\Sigma IW}{\Sigma W}$$

$$= \frac{24512}{100}$$

$$= 245.12$$

Thus, it can be said that there is a rise of (245.12 – 100) = 145.12 % in the total expenditure in the current year as compared to the base year.

Illustration 18 : Calculate the cost of living index number by the total expenditure method and the family budget method for the year 2015 with the base year 2014 using the following data.

Item	Wheat	Rice	Tuver Dal	Oil	Cloth	Kerosene
Unit	Quintal	kg	kg	litre	meter	litre
Quantity of year 2014	35 kg	25 kg	20 kg	10 litre	20 meter	15 litre
Price of year 2014 (₹)	1600	40	60	80	30	28
Price of year 2015 (₹)	1800	45	120	90	45	35

The base year is 2014. We will take p_0 = price of 2014, q_0 = quantity of 2014 and p_1 = price of 2015. We shall make uniform units for the price and quanity of each item.

Method of Total Expenditure

Item	Unit	Year 2014		Year 2015	p_1q_0	p_0q_0
		q_0	p_0	p_1		
Wheat	kg	35	16	18	630	560
Rice	kg	25	40	45	1125	1000
Tuver Dal	kg	20	60	120	2400	1200
Oil	litre	10	80	90	900	800
Cloth	meter	20	30	45	900	600
Kerosene	litre	15	28	35	525	420
Total					**6480**	**4580**

Index number by total expenditure method $= \frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times 100$

$= \frac{6480}{4580} \times 100$

$= 141.4847$

$\simeq 141.48$

Thus, there is a rise of (141.48 – 100) = 41.48 % in the total expenditure in the year 2015 as compared to the base year 2014.

Method of Family Budget

Item	Unit	Year 2014		Year 2015	$I = \frac{p_1}{p_0} \times 100$	$W = p_0q_0$	IW
		q_0	p_0	p_1			
Wheat	kg	35	16	18	$\frac{18}{16} \times 100 = 112.5$	560	63,000
Rice	kg	25	40	45	$\frac{45}{40} \times 100 = 112.5$	1000	1,12,500
Tuver dal	kg	20	60	120	$\frac{120}{60} \times 100 = 200$	1200	2,40,000
Oil	litre	10	80	90	$\frac{90}{80} \times 100 = 112.5$	800	90,000
Cloth	meter	20	30	45	$\frac{45}{30} \times 100 = 150$	600	90,000
Kerosene	litre	15	28	35	$\frac{35}{28} \times 100 = 125$	420	52,500
Total						**4580**	**6,48,000**

Index number by family budget method $= \frac{\Sigma IW}{\Sigma W}$

$= \frac{648000}{4580}$

$= 141.4847$

$\simeq 141.48$

Note : We can see here that the index numbers obtained by total expenditure method and family budget method are same.

Illustration 19 : The data referring to worker class of a city are as follows. Find the general index numbers for the years 2014 and 2015. If the wages of these workers in 2014 are increased by 5 % in the year 2015, is this rise in wages sufficient to maintain their standard of living ?

Group	Food	Clothing	Fuel and Electricity	House Rent	Miscellaneous
Weight	48	18	8	12	14
Group index number of 2014	210	220	210	200	210
Group index number of 2015	230	225	220	200	235

Group	**Weight** W	**Group index number of year 2014** I_1	**Group index number of year 2015** I_2	I_1W	I_2W
Food	48	210	230	10,080	11,040
Clothing	18	220	225	3960	4050
Fuel and Electricity	8	210	220	1680	1760
House Rent	12	200	200	2400	2400
Miscellaneous	14	210	235	2940	3290
Total	**100**			**21,060**	**22,540**

Index number for year 2014 $= \frac{\Sigma I_1W}{\Sigma W} = \frac{21060}{100} = 210.60$

Index number for year 2015 $= \frac{\Sigma I_2W}{\Sigma W} = \frac{22540}{100} = 225.40$

There is a rise of $(225.4 - 210.6) = 14.8$ % in the cost of living of workers in the year 2015 than in the year 2014 with reference to the base year.

Thus, the percentage increase in the cost of living index number in the year 2015 is $\frac{14.8}{210.6} \times 100 = 7.03$ as compared to the year 2014. Hence, the rise of 5% in the wages of the year 2014 is not sufficient to maintain the same standard of living of the workers in the year 2015.

Illustration 20 : The following data are obtained from the budget inquiry of middle class families. State the change in the cost of living in the current year 2015 with respect to the base year 2014 by finding the index number. If the average monthly disposable income of a family is ₹ 30,000 during the year 2014 and their average monthly disposable income during the year 2015 is ₹ 35,000 then according to family budget index number, what should be the rise in the average monthly disposable income of the family to maintain the same standard of living of the base year ?

Group	Food	Clothing	Rent	Fuel	Miscellaneous
Weight	45	20	15	10	10
Percentage price relative of the group in year 2015	130	150	120	160	120

The weights W and the percentage price relatives I of the groups for the year 2015 are given here. Hence, we shall calculate the index number by family budget method.

Group	Food	Clothing	Rent	Fuel	Miscellaneous	**Total**
Percentage price relative *I*	130	150	120	160	120	
Weight *W*	45	20	15	10	10	**100**
IW	5850	3000	1800	1600	1200	**13,450**

Index number by family budget method $I = \frac{\Sigma IW}{\Sigma W}$

$= \frac{13450}{100}$

$= 134.5$

Thus, it can be said that there is a rise of (134.5 – 100) = 34.5 % in the cost of living in the year 2015 as compared to the year 2014.

According to the family budget method index number of the year 2015, the average monthly disposable income to maintain the same standard of living as the base year

$= \frac{\text{Index number of current year}}{\text{Index number of base year}} \times \text{income of base year}$

$= \frac{134.50}{100} \times 30,000$

$= ₹\ 40,350$

The required increase in the average monthly disposable income to maintain the standard of living of the family = ₹ 40,350 – ₹ 35,000 = ₹ 5350

1.7.2 Uses and limitations of cost of living index number

This index number is prepared by studying the changes in the cost of living of the people of different classes. Thus, the cost of living index number is used for different objectives as follows :

(1) The changes in the purchasing power of money of a class of people can be measured using the corresponding cost of living index number. If the increase in the price of item is higher than the increase in the income, there is a decrease in the real income of the earning members and subsequently their purchasing power decreases. Thus, the cost of living index number is useful to find the actual purchasing power of money and the real income. The purchasing power of money and real income can be obtained by the following formulae.

(i) Purchasing power of money $= \frac{1}{\text{Cost of living index number}} \times 100$

(ii) Real income $= \frac{\text{Income}}{\text{Cost of living index number}} \times 100$

(2) The cost of living index number for each class shows the real economic condition of the respective class. Hence, this measure is used to suggest the changes in the wage, dearness allowance, bonus, etc. paid to the people of that class.

(3) This index number measures the effect of retail prices on the cost of living of people. Hence, this index number guides the government regarding the items to be controlled under special acts and the items to be kept for free trade.

(4) The cost of living index number helps the government as an indicator to frame the tax policies, policies regarding issues like price-regulation and fare-regulation. Moreover, it is possible to know how the living of people of different classes gets affected by imposing tax on certain items and the tax policy can be planned accordingly.

(5) The government agencies and public institutions use it as a base to determine the necessity of special facilities to elevate the standard of living of people of different classes.

Limitations of cost of living index number :

(1) It is not possible to construct one common cost of living index number for all sections of the society.

(2) The cost of living index number obtained for a certain class of people in a certain region cannot be used for some other region even for the same class of people.

(3) The cost of living index number shows the average percentage changes in the cost of living of a certain class. Thus, it is not possible to measure the changes in the cost of living of an individual.

(4) It is necessary to construct separate index numbers for different classes of people as well as different regions.

(5) The expenditure of the people of any class depends upon the size of the family, life style, liking, habits, etc. There is no uniformity in the expenditure of all the families of the same class.

(6) Its calculation is based on the assumption that the life style of the families does not change in the current year as compared to the base year. In reality, the liking, habits and choices of people change with time. Thus, it is necessary to conduct family budget inquiry at regular intervals of time and change the items and their weights.

EXERCISE 1.4

1. The following data are obtained from the family budget inquiry of middle class people. State the change in the cost of living in the year 2015 with respect to the year 2013 by finding the index number. If the average monthly disposable income of a family in the year 2013 is ₹ 15,000 then obtain the estimate of the necessary average monthly disposable income in the year 2015.

Group	Food	Fuel-Electricity	Rent	Clothing	Miscellaneous
Weight	45	15	10	20	10
Expenditure in 2013 (₹)	3000	1450	1500	600	1600
Expenditure in 2015 (₹)	3900	1850	2400	900	1920

2. Find the index number for the year 2014 by the method of family budget from the following data about prices and consumption of food items and interpret it.

Item	**Year 2010**		**Year 2014**
	Quantity	**Price (₹)**	**Price (₹)**
Wheat	60	15	18
Rice	40	32	40
Bajri	15	12	14
Tuver Dal	25	50	70

3. Compute the cost of living index number by the method of total expenditure from the following data.

Item	*A*	*B*	*C*	*D*	*E*
Unit	Quintal	20 kg	10 litre	dozen	meter
Quantity of year 2014	50 kg	18 kg	12 litre	20 pieces	14 meter
Price of year 2014 (₹)	1200	340	30	15	12
Price of year 2015 (₹)	1700	380	40	24	16

4. Compute the general index number for the production using the following data.

Item	Cotton Cloth	Grains	Sugar	Steel	Copper	Cement
Weight	15	23	15	25	10	12
Index number of production	220	225	190	215	198	220

5. The details of expenditure on clothing for the worker class of a region are as follows. Find the index number for clothing by the total expenditure and family budget method.

Item	Saree	Dhoti	Shirting	Other
Unit	Piece	Piece	Meter	Meter
Quantity in year 2010	5	8	20	15
Price in year 2010 (₹)	300	70	32.40	20.90
Price in year 2014 (₹)	400	100	38	23.80

*

Typical examples :

Illustration 21 : The prices of three items *A*, *B* and *C* among five items have increased in the year 2015 by 90 %, 120 % and 70 % respectively with respect to the year 2010, whereas the prices of two items *D* and *E* have decreased by 2 % and 5 % respectively. Item *A* is four times important than item *B* and item *C* is six times important than item *A*. The importance of items *D* and *E* is two and half times the importance of item *B*. Compute the general price index number of the year 2015 for all the five items.

The percentage increase and decrease in the prices of items is given here. Similarly, the weight W of the items are the numbers showing their relative importance.

Suppose the relative importance of item B is 1.

Then the importance of item A will be 4, importance of C will be 24 and that of D and E will be 2.5 each.

The general price index number will be calculated as follows :

Item	**Percentage increase (+) decrease (–)**	**Index number** I **= (100 + increase) = (100 – decrease)**	**Weight** W	IW
A	+ 90	100 + 90 = 190	4	760
B	+ 120	100 + 120 = 220	1	220
C	+ 70	100 + 70 = 170	24	4080
D	– 2	100 – 2 = 98	2.5	245
E	– 5	100 – 5 = 95	2.5	237.5
Total			**34**	**5542.5**

$$\text{General price index number} = \frac{\Sigma IW}{\Sigma W}$$

$$= \frac{5542.5}{34}$$

$$= 163.0147$$

$$\simeq 163.01$$

Thus, it can be said that there is a rise of (163.01 – 100) = 63.01 % in the prices in the current year 2015 as compared to the base year 2014.

Illustration 22 : The details of expenses on fuel for a group of workers of a region are as follows.

Item	Base year 2012		Year 2014
	Quantity	Price per unit (₹)	Price per unit (₹)
Coal	5 Kilogram	25	30
Kerosene	20 Litre	40	45
Wood	5 Kilogram	22	25
Match-box	10 Boxes	0.90	1

Prepare the index number of the group of fuel expenditure from these data. If the expenditure for food, clothing, house rent and miscellaneous groups in the year 2015 are 3, 2.5, 4.5 and 3.25 times respectively that of the year 2012, and if the expenditures on these groups are 42 %, 15 %, 10 % and 12 % respectively of the total expenditure then prepare the cost of living index number for the workers.

First of all, we shall prepare the group index number for fuel-expenditure from its details. We will take the base year 2012 and obtain the index number by total expenditure method.

Note : The method of family budget can also be used here for calculation.

Item	Year 2012		Year 2014	p_1q_0	p_0q_0
	q_0	p_0	p_1		
Coal	5	25	30	150	125
Kerosene	20	40	45	900	800
Wood	5	22	25	125	110
Match box	10	0.90	1	10	9
Total				**1185**	**1044**

Index number for fuel expenditure $= \frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times 100$

$= \frac{1185}{1044} \times 100$

$= 113.5057$

$\simeq 113.51$

The expenditure for the groups of food, clothing, house rent and miscellaneous are 3, 2.5, 4.5 and 3.25 times respectively than the base year. Hence, the index numbers of these four groups are (3 × 100) = 300; (2.5 × 100) = 250; (4.5 × 100) = 450 and (3.25 × 100) = 325 respectively. The index number of fuel category is obtained as 113.51. We will take the percentage expenditure for all the five groups as the weights for their corresponding index numbers to find the cost of living index number.

The expenditures for the groups of food, clothing, house rent and miscellaneous are given here as 42 %, 15 %, 10 % and 12 % respectively. These will be taken as their respective weights W. Total expenditure is 100 %. Hence, the weight for fuel expenditure index number will be 100 – (42 + 15 + 10 + 12) = 21 %.

The calculation of cost of living index number is as follows.

Group	Food	Clothing	House rent	Miscellaneous	Fuel	Total
Index number I	300	250	450	325	113.5	
Weight W	42	15	10	12	21	**100**
IW	12,600	3750	4500	3900	2383.71	**27,133.71**

$$\text{Cost of living index number} = \frac{\Sigma IW}{\Sigma W}$$

$$= \frac{27133.71}{100}$$

$$= 271.3371$$

$$\simeq 271.34$$

Thus, it can be said that there is a rise of (271.34 – 100) = 171.34 % in the cost of living in the current year as compared to the base year.

Illustration 23 : Find the real wages for the worker class of a city from the following data about their average monthly wage and the cost of living index number (base year 2001). Find the purchasing power of money in the year 2015 by taking the base year 2001 and state the importance of this answer.

Year	2010	2011	2012	2013	2014	2015
Average monthly wage (₹)	15,000	15,600	16,200	17,000	18, 000	20,000
Cost of living index number	192	203	228	268	270	287

The calculation of real wage using the wages and cost of living index numbers will be as follows.

$$\text{Real wage} = \frac{\text{Average monthly wage}}{\text{Cost of living index number}} \times 100$$

Year	Average monthly wage (₹)	Cost of living index number	Real wage (₹)
2010	15,000	192	$\frac{15000}{192} \times 100 = 7812.5$
2011	15,600	203	$\frac{15600}{203} \times 100 = 7684.73$
2012	16,200	228	$\frac{16200}{228} \times 100 = 7105.26$
2013	17,000	268	$\frac{17000}{268} \times 100 = 6343.28$
2014	18,000	270	$\frac{18000}{270} \times 100 = 6666.67$
2015	20,000	287	$\frac{20000}{287} \times 100 = 6968.64$

The purchasing power of money is the reciprocal of the cost of living index number of the current year with the respective base year.

$\therefore$ We can say that the purchasing power of money in the year 2015 with the base year 2001 $= \frac{100}{287} = 0.3484 \simeq 0.35$. Hence, it can be said that if the unit of money is rupee then the value of rupee in the year 2005 is 35 paise with respect to the base year 2001.

Thus, although the actual average monthly wage of the workers of this class in the year 2015 is more than the base year 2001, the real disposable wage in the year 2015 is only ₹ 6968.64 with respect to the base year.

Illustration 24 : Answer the following questions :

(1) The price of wheat was ₹ 1600 per quintal in the year 2014 and it was ₹ 1800 per quintal in the year 2015. Find the price index number of wheat for the year 2015 with the base year 2014 and interpret it.

Price index number of wheat for year 2015 $I = \frac{p_1}{p_0} \times 100$

$= \frac{1800}{1600} \times 100$

$= 112.5$

Thus, it can be said that there is a rise of (112.5 – 100) = 12.5 % in the price of wheat per quintal in the year 2015 as compared to the year 2014.

(2) The Laspeyre's index number is $\frac{8}{9}$ times the Fisher's index number. If the Fisher's index number is 180, find the Paasche's index number.

The Laspeyre's index number is $\frac{8}{9}$ times the Fisher's index number.

$\therefore \quad I_L = \frac{8}{9} \times I_F$

$$\therefore \quad I_L = \frac{8}{9} \times 180$$

$$I_L = 160$$

Now, $I_F = \sqrt{I_L \times I_P}$

$$180 = \sqrt{160 \times I_P}$$

$$(180)^2 = 160 \times I_P$$

$$\therefore \quad I_P = \frac{180 \times 180}{160} = 202.5$$

(3) The production of an item in the year 2015 has increased by 3 times the production in the base year. Find the index number of production for the year 2015.

Consider the index number of the base year as 100. The production has increased by 3 times in the year 2015.

Production index number of year 2015 = index number of base year + increase in index number in current year

$= 100 + (3 \times 100)$

$= 100 + 300 = 400$

(4) If $\Sigma p_1q_0 : \Sigma p_0q_0 = 3:2$ and $\Sigma p_1q_1 : \Sigma p_0q_1 = 5:3$, find I_L, I_P and I_F.

$$\frac{\Sigma p_1q_0}{\Sigma p_0q_0} = \frac{3}{2}$$

$$I_L = \frac{\Sigma p_1q_0}{\Sigma p_0q_0} \times 100$$

$$= \frac{3}{2} \times 100 = 150$$

$$\frac{\Sigma p_1q_1}{\Sigma p_0q_1} = \frac{5}{3}$$

$$I_P = \frac{\Sigma p_1q_1}{\Sigma p_0q_1} \times 100$$

$$= \frac{5}{3} \times 100 = 166.67$$

$$I_F = \sqrt{I_L \times I_P} = \sqrt{150 \times 166.67} = \sqrt{25000.5} = 158.12$$

(5) If the average monthly disposable income of middle class families in the year 2014 is ₹ 14,400 and if the cost of living index number for the year 2015 with the base year 2014 is 115 then estimate the average monthly disposable income of these families in the year 2015.

The cost of living index number of the middle class families for the year 2015 is 115 with the base year 2014. Hence, the index number has increased by $(115 - 100) = 15$ % as compared to the base year. Thus, there should be a 15 % rise in the average disposable income of the middle class families.

$\therefore$ Average monthly disposable income of the families $= 14400 + (14400 \times \frac{15}{100})$

$= 14400 + 2160 = 16560$

Hence, the average monthly disposable income of these families in the year 2015 should be ₹ 16,560.

(6) If the cost of living index number of the current year has increased to 180 from the base year index number 100 and if the average income of workers has increased from ₹ 6000 to ₹ 9000, is there an increase or decrease in the purchasing power of the workers ? How much is it ?

The index number has increased to 180 from 100 here which means that there is an increase of 80 %. Hence, the income should also increase by 80 %.

Average income $= 6000 + (6000 \times \frac{80}{100})$

$= 6000 + 4800 = ₹\ 10{,}800$

Hence, the average income of workers should be ₹ 10,800. But the average income of workers has increased to ₹ 9000. Thus, there is a decrease of (10800 – 9000) = ₹ 1800 in the average income with reference to the index number. Hence, it can be said that there is a decrease in their purchasing power.

(7) The wholesale price index numbers of the year 2015 and 2016 are found to be 150.2 and 165.7 respectively. Find the rate of inflation using index numbers of both the years.

The index number of the year 2015 is 150.2 and the index number of current year 2016 is 165.7.

We will use the following formula of the rate of inflation.

$$\text{Rate of inflation} = \frac{\left(\begin{matrix}\text{Wholesale price index}\\ \text{number of current year}\end{matrix}\right) - \left(\begin{matrix}\text{Wholesale price index}\\ \text{number of previous year}\end{matrix}\right)}{\text{Wholesale price index number of previous year}} \times 100$$

$$= \frac{165.7 - 150.2}{150.2} \times 100$$

$$= \frac{15.5}{150.2} \times 100$$

$$= 10.3196$$

$$\simeq 10.32$$

Thus, rate of inflation is 10.32 %.

(8) If the increase in the price relatives of three items are 250 %, 265 % and 300 % respectively and if the ratio of the importance of these items is 8 : 7 : 5, find the general price index number.

The percentage increase in the index numbers (price relatives) I and the relative importance W are given here.

We will calculate the index number.

Item	**Index Number (I)** **(Index Number of base year + increase)**	**Weight** W	IW
A	100 + 250 = 350	8	2800
B	100 + 265 = 365	7	2555
C	100 + 300 = 400	5	2000
Total		**20**	**7355**

General index number $= \frac{\Sigma IW}{\Sigma W} = \frac{7355}{20} = 367.75$

General index number = 367.75

Thus, there is a rise of (367.75 – 100) = 267.75 % in the prices in the current year as compared to the base year.

Summary

- The price, production, demand, supply, quantity, etc. of an item are called the variable for that item.
- The changes taking place in the values of the variable at two different time periods are compared by two methods : (1) Method of absolute measure (difference) and (2) Method of relative measure (ratio)
- The ratio of changes in the values of the variable at two different time periods is called relative change.
- The measure showing the percentage relative change in the prices of an item at different time periods is called price index number.
- The measure showing the percentage relative change in the quantities of an item at different time periods is called quantity index number.
- The average of the percentage change in the values of a variable associated with one or more items for the given period compared to its value in the fixed (base) period is called general index number for the group.
- When the price of an item is compared with the price of the same item in some specific (fixed) year of the past, then that specific year is called the base year.
- The year for which the price of an item is to be compared with the price of the base year is called the current year.
- Two methods of selecting base year : (1) Fixed base method (2) Chain base method.
- The expenditure p_0q_0 is assigned as weight to the price relative $\frac{p_1}{p_0}$ of the items. The formula of weighted average obtained by this method is called the formula of Laspeyre's index number.
- The expenditure p_0q_1 is assigned as weight to the price relative $\frac{p_1}{p_0}$ of the items. The formula of weighted average obtained by this method is called the formula of Paasche's index number.
- The geometric mean of Laspeyre's and Paasche's index numbers is called the Fisher's index number.
- The number showing the percentage of relative changes in the cost of living of the people of a certain section of the society in the current year (period) as compared to the base year (period) is called the cost of living index number.
- The points for the construction of index numbers : purpose, family budget inquiry, availability of prices of items, choice of base year, choice of average and choice of weight.
- In the construction of index number, the number associated with the selected items in proportion to their importance is called weight of that item.
- There are two types of weights : (i) Implicit weights (ii) Explicit weights
- Implicit weights : The weights are included in the selection of items and they cannot be expressed numerically. This indirect method of assigning weight is called implicit weight.
- Explicit weights : The weight to be assigned are determined in proportion to the importance of the item and can be expressed numerically. Such a weight is called explicit weight.
- There are two popular methods of assigning explicit weight : (i) Method of total expenditure (ii) Method of family budget.

List of Formulae

(1) Price relative $= \dfrac{\text{Price of current year (period)}}{\text{Price of base year (period)}}$

$= \dfrac{p_1}{p_0}$

(2) Quantity relative $= \dfrac{\text{Quantity of current year (period)}}{\text{Quantity of base year (period)}}$

$= \dfrac{q_1}{q_0}$

(3) Index number $I = \dfrac{\text{Value of variable in current year (period)}}{\text{Value of variable in base year (period)}} \times 100$

$I = \dfrac{p_1}{p_0} \times 100$

(4) Index number based on price relatives of n items $= \dfrac{\Sigma\left[\dfrac{p_1}{p_0}\right]}{n} \times 100$

(5) Fixed base index number $= \dfrac{\text{Value of variable in current year (period)}}{\text{Value of variable in base year (period)}} \times 100$

$I = \dfrac{p_1}{p_0} \times 100$

(6) Chain base index number $= \dfrac{\text{Value of variable in current year (period)}}{\text{Value of variable in preceding year (period)}} \times 100$

$I = \dfrac{p_1}{p_0} \times 100$

(7) Conversion of fixed base index number into chain base index number :

Chain base index number $= \dfrac{\text{Fixed base index number of current year}}{\text{Fixed base index number of preceding year}} \times 100$

(8) Conversion of chain base index number into fixed base index number :

Fixed base index number $= \dfrac{\text{(Chain base index number of current year)} \times \text{(Fixed base index number of preceding year)}}{100}$