UNIT 12 INDEX NUMBERS

STRUCTURE

12.0 OBJECTIVES

After studying this unit, you should be able to:

- explain the meaning and appreciate the uses of index numbers,
- identify and avoid various issues faced while developing index numbers for some special purposes,
- discuss the classification of index numbers,
- apply and calculate index numbers using different methods, and
- describe the limitations of index numbers to avoid errors in interpretation.

12.1 INTRODUCTION

In the previous Unit-11, we have discussed the analysis of time series. In this unit we shall discuss the methods of constructing various types of index numbers for different purposes. This device is an extension of the time series analysis because an index number combines two or more time series variables related to non-comparable units. You would have read in newspapers or heard on the television/the radio that the cost of living index has increased by so many points, hence for government employees another slab of Dearness Allowance has been declared. Probably you might have wondered what is this cost of living index?

Many of you must also be aware of the Stock Exchange Share Price Index – commonly referred to as BSE SENSEX or, more recently, NSE SENSEX. In fact, these various types of index series have come to be used in many activities such as industrial production, export, prices, etc. In this Unit, you will study and understand the meaning and uses of index numbers, various problems resulting from the incorrect use of index numbers, methods for construction of various index numbers, and their limitations.

12.2 MEANING AND CONCEPT OF INDEX NUMBERS

When we talk that the general level of industrial production has registered an increase of 4 per cent, it is obvious that we are referring to the production of all those items that are produced by the industrial sector. However, production of some of these items may be increasing while that of others may be decreasing or may remain constant. The rate of increase or decrease and the units in which these items are expressed may differ. For instance, cement may be quoted per kg, cloth may be per meters, cars may be per unit etc. In such a situation, when the purpose is to measure the changes in the average level of prices or production of industrial products for comparing over a time or with respect to geographic location, it is not appropriate to apply the technique of measure of central tendency because it is not useful when series are expressed in different units or/and in different items.

It is in these situations, that we need a specialised average, known as index numbers. These are often termed as 'economic barometers'.

An index number may be defined as a special average which helps in comparison of the level of magnitude of a group of related variables under two or more situations.

Index numbers are a series of numbers devised to measure changes over a specified time period (the time period may be daily, weekly, monthly, yearly, or any other regular time interval), or compare with reference to one variable or a group of related variables. Thus, each number in a series of specified index number is:

a) A pure number i.e., it does not have any unit.

b) Calculated according to a pre-determined formula.

c) Generated at regular time intervals, sometimes during the same time interval at different places.

d) The regular generation of numbers form a chronological series.

e) With reference to some specified period and number known as base period and base number, the latter is always 100. For example, if the consumer price index, with base year 1996 is calculated to be 180 for the year 2003, it means that consumer prices have increased by 80 per cent in 2003 as compared to the prices prevalent in 1996.

12.3 USES OF INDEX NUMBERS

Though originally the index number was developed for measuring the effect of change in prices, today they have become indispensable for analyzing the data related to business and economic activity. This statistical tool can be used in several ways as follows:

1) Decision makers use index numbers as part of intermediate computations to understand other information better. Nominal income can be transformed into real income. Similarly, nominal sales into real sales & so on …, through an appropriate index number. Consumer price index, also known as cost of living index, is arrived at for a specified group of consumers in respect of prices of specific commodities and services which they usually purchase. This index serves as an indicator of 'real' wages (or income) of the consumers. For

example, an individual earns Rs. 100/- in the year 1970 and his earnings increase to Rs. 300/- in the year 1980. If during this period, consumer price index increases from 100 to 400 then the consumer is not able to purchase the same quantity of different commodities with Rs. 300, which he was able to purchase in the year 1970 with his income of Rs. 100/-. This means the real income has declined. Thus real income can be calculated by dviding the actual income by dividing the consumer price index:

$$\text{Real income in } 1980 = \frac{\text{Actual income in } 1980}{\text{Consumer price index of } 1980}$$

$$= \frac{300}{400} = \text{Rs. } 75/- \text{ with respect to 1970 as base year.}$$

Therefore, the consumer's real income in the year 1980 is Rs. 75/- as compared to his income of Rs. 100/- in the year 1970. We can also say that because of price increase, even though his income has increased, his purchasing power has decreased.

2) Different types of price indices are used for wage and salary negotiations, for compensating in price rise in the form of DA (Dearness Allowance).

3) Various indices are useful to the Government in framing policies. Some of these include taxation policies, wage and salary policies, economic policies, custom and tariffs policies etc.

4) Index numbers can also be used to compare cost of living across different cities or regions for the purpose of making adjustments in house rent allowance, city compensatory allowance, or some other special allowance.

5) Indices of Industrial Production, Agricultural Production, Business Activity, Exports and Imports are useful for comparison across different places and are also useful in framing industrial policies, import/export policies etc.

6) BSE SENSEX is an index of share prices for shares traded in the Bombay Stock Exchange. This helps the authorities in regulating the stock market. This index is also an indicator of general business activity and is used in framing various government policies. For example, if the share prices of most of the companies comprising any particular industry are continuously falling, the government may think of changes in its policies specific to that industry with a view to helping it.

7) Sometimes, it is useful to correlate index related to one industry to the index of another industry or activity so as to understand and predict changes in the first industry. For example, the cement industry can keep track of the index of construction activity. If the index of construction activity is rising, the cement industry can expect a rise in demand for cement.

12.4 ISSUES IN CONSTRUCTION OF INDEX NUMBERS

There are three major issues which may be faced in the construction of index numbers. They are: 1) Collection of Data; 2) Selection of Base Year and 3) Selection of Appropriate Index. Let us discuss them in detail:

1) Collection of Data

Data collection through a sample method is one of the issues in the construction of index numbers. The data has to be as reliable, adequate, accurate,

comparable, and representative, as possible. Here a large number of questions need to be answered. The answers ultimately depend on the purpose and individual judgement. For example, one needs to decide the following:

i) **Identification of Commodities to be Included:** How many and which category of commodities to include? A large number of items may be present. It is not possible to include all of them, only those items deserve to be included in the construction of an index number as would make it more representative. For example, if we are required to construct indices for shares on the Bombay Stock Exchange, there are several shares listed and traded, it is not possible to include all of them. Therefore, it has to be decided which sample number of shares (may be 30 or 40) should represent the general movement of share prices of the Bombay Stock Exchnage. Therefore, it is worthwhile to note that the selection of items must be deliberate and in keeping with the relevance and significance of each individual item to the purpose for which the index is constructed.

ii) **Sources of Data:** From where to collect data? It is an important and difficult issue. The source depends on the information requirement. For example, one may need to collect prices and quantities consumed related to certain commodities for a consumer price index. However, there may be a large number of retailers and wholesalers, selling the commodities, and quoting different prices. To get the details, only a few representative shops (which represent the typical purchasing points of the people under question) need to be selected. Thus, based on a representative sample survey, sources should be from where accurate, adequate, and timely data can be available.

iii) **Timings of Data Collection:** It is also equally important to collect the data at an appropriate time. Referring to the example of consumer price index, prices are likely to vary on different days of the month. For certain commodities prices may vary at different times of the same day. Take an example, vegetable prices are usually high in the morning when fresh vegetables arrive and are low in the late evening when sellers are closing for the day and wish to clear the perishable stock. For each commodity, individual judgement needs to be exercised to represent reality and to serve the purpose for which an index is to be used.

2) Selection of Base Year

A base period is the reference period for comparing and analysing the changes in prices or quantities in a given period. For many index number series, value of a particular time period, usually a year, is taken as reference period against which all subsequent index numbers in the series are calculated and compared.

In some other cases, especially when cost of living needs to be compared across the cities, the value of cost of living prevailing in a selected city is taken as a base against which cost of living in other cities is compared.

In yet other cases, we may be required to compare one index number series against another series. In such a context, a ‘base’ common to all series is more appropriate.

In the light of the above considerations, therefore, the period/year selected as base period/year must be a ‘normal’ period. **Normal period** is a period with price or quantity figures neither too low, nor too high. It should not have been affected by abnormal occurances, such as floods, (if interested in agricultural

production), wars, sudden recession etc. What is normal should also be decided keeping in view the purpose of constructing an index number, and the specific situation.

3) Selection of an Appropriate Index

Different methods of indices give different results, when applied to the same data. Utmost care must be taken in selection of a formula which is the most suitable for the purpose. Whether to use an unweighted or weighted index is a difficult question to answer. It depends on the purpose for which the index number is required to be used. For example, if we are interested in an index for the purpose of negotiating wages or compensating for price rise, only a weighted index would be worthwhile to use.

Which weights to be used? Whether base year quantities or current year quantities or some other weights are to be used is an important question to answer. Weights which realistically reflect the relative importance of items included in the construction of an index is perhaps the only answer. The purpose for which an index is needed will of course remain a vital factor to reckon with.

12.5 CLASSIFICATION OF INDEX NUMBERS

There are three principal types of indices: price indices, quantity indices, and value indices.

Price Indices: This type of indices is the most frequently used. Price indices consider prices of a commodity or a group of commodities and compare changes of prices from one period to another period and also compare the difference in price from one place to another. For example, the familiar Consumer Price Index measuring overall price changes of consumer commodities and services is used to define the cost of living.

Quantity Indices: The major focus of consideration and comparison in these indices are the quantities either of a single commodity or a group of commodities. For example, the focus may be to understand the changes in the quantity of paddy production in India over different time periods. For this purpose, a single commodity's quantity index will have to be constructed. Alternatively, the focus may be to understand the changes in food grain production in India, in this case all commodities which are categorized under food grains will be considered while constructing the quantity index.

Value Indices: Value indices actually measure the combined effects of price and quantity changes. For many situations either a price index or quantity index may not be enough for the purpose of a comparison. For example, an index may be needed to compare cost of living for a specific group of persons in a city or a region. Here comparsion of expenditure of a typical family of the group is more relevant. Since this involves comparing expenditure, it is the value index which will have to be constructed. These indices are useful in production decisions, because it avoids the effects of inflation.

The formula, therefore is:

$$\text{Value indices} = \frac{\Sigma p_1 q_1}{\Sigma p_1 q_1} \times 100$$

Self Assessment Exercise A

1) State with reasons, whether the following statements are TRUE or FALSE.

   a) Index numbers are specialised averages.

   b) The index number for a base year is always zero.

   c) A value index measures either price or quantity changes.

   d) In times of inflation, a quantity index provides a better measure of actual output than a corresponding value index.

   e) Through appropriate indices, normal increase can be transformed into real income.

   f) Probability sampling is the most appropriate method for selecting commodities while constructing indices.

   g) A base period may be described as a "normal" period if it is the most recent period for which we have data.

2) In magazines and newspapers you might have come across many index numbers. Name four such index numbers and briefly state what does each one of them indicate?

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3) List out the problems that arise in connection with the construction of an index number.

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4) Try to cite one example each where (a) price index, (b) quantity index, and (c) value index is not appropriate.

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12.6 METHODS OF CONSTRUCTING INDEX NUMBERS

In the above section, we have discussed different types of indices, i.e., price indices, quantity indices, and value indices. We shall now focus on the construction of price and quantity indices and their limitations.

Different formulae have been introduced by statisticians for constructing composite index numbers. They may be categorized into two broad groups as given below:

I. Unweighted Indices; and

II. Weighted Indices

The formula and its use in constructing each category of indices, listed above, are discussed in the following sections. Let us first acquaint ourselves with the symbols used in construction of index numbers. They are as follows:

P_0 denotes price per unit of a commodity in the base period.

P_1 denotes price per unit of the same commodity in the current period (current period is one in which the index number is calculated with reference to the base period).

Similar measurements are assigned to Q_0, Q_1 and V_0, V_1.

Capital letters P, Q, and V are used for denoting price index, quantity index, and value index numbers, respectively.

Thus, P_{01} refers to price index for period 1. (P_1) with respect to base period (P_0). Similar meanings are assigned to quantity (Q_{01}) and value (V_{01}) indices. It may be noted that indices are expressed in per cent.

12.6.1 Unweighted Index Numbers

This type of indices are also referred to as simple index numbers. In this method of constructing indices, weights are not expressly assigned. These are further classified under two categories:

1) Simple Aggregative Index

2) Simple Average of Relatives Index

Let us study the construction of indices under these two heads:

1) **Simple Aggregative Index:** This is the simplest and least satisfactory method of constructing indices. In the case of price indices, through this method, the total of unit cost of each commodity in the current year is divided by the total of unit cost of the same commodity in the base year and the quotient is multiplied by 100. Symbolically,

$$P_{01} = \left(\frac{\Sigma P_1}{\Sigma P_0} \right) \times 100$$

Similarly, the quantity index may be expressed as:

$$Q_{01} = \left(\frac{\Sigma q_1}{\Sigma q_0} \right) \times 100$$

For example, consider the sample data given below for the year 1990 and 2000 for construction of price index and quantity index.

Illustration 1

Table 12.1 Computation of Index by Single Assergative Method

Item	Year 1990		Year 2000	
	Price (Rs.)	Quantity	Price (Rs.)	Quantity
Wheat	700	4 qts	950	3.5 qts
Clothing	200	30 mts	300	35 mts
Gas	150	4 cylinder	220	6 cylinders
Electricity	0.80	800 units	1.10	1,000 units
House Rent	400	1 dwelling	800	1 dwelling
	1450.80 ΣP_0	839 Σq_0	2271.1 Σp_1	1045.5 Σq_1

The price index for the year 2000 with reference to base year 1990 the simple aggregative method is

$$P_{01} = \left(\frac{\Sigma P_1}{\Sigma P_0}\right) \times 100 = \frac{2271.1}{1450.8} \times 100 = 156.54$$

Thus, the prices in respect of commodities considered in the index have shown an increase of 56.54 per cent in 2000 as compared to 1990.

This method suffers from the following two **limitations:**

1) The unit size affects the index number. For instance, in the above illustration if the price of wheat was quoted in terms of per kg. Rs. 7/- in 1990 and Rs. 9.5 in 2000) the index might be very different.
2) Relative importance of different commodities is not reflected in the index. For example, in the above illustration a total of Rs. 2,800/- is spent on wheat, which is the most important item of expenditure. This is not reflected in this method.

Analogously, the Quantity Index by the simple aggregate method is:

$$Q_{01} = \left(\frac{\Sigma q_1}{\Sigma q_0}\right) \times 100$$

Consider the illustration 1 for quantity index

$$Q_{01} = \frac{1045.5}{839} \times 100 = 124.61$$

Here, you should note that the 'P' in the formulae of price index will be replaced by 'q' in constructing index. This expression is applicable to the formulae of different methods.

Limitation: The units of quantities being different cannot be added and the quantities do not represent appropriate variables for the purpose of comparing expenditure.

2) Simple Average of Relatives Index

In this method of constructing price index, first of all price relatives have to be computed for the different items included in the index then the average of these is calculated simbolically,

$$P_{01} = \frac{\Sigma\left(\frac{P_1}{P_0} \times 100\right)}{N} \text{ or } \frac{\text{Sum of the Price Relatives}}{\text{No. of items}}$$

Using the same data by considering only prices given in the illustration-1, the computation of price index as simple average of price relatives is as follows:

Illustration-2

Table 12.2: Computation of Index by Simple Average of Relatives Method

Items	Units	Year 1990 Prices (Rs.)	Year 2000 Prices (Rs.)	Price relatives $\frac{P_1}{P_0} \times 100$
Wheat	qts	700	950	(950/700) × 100 = 135.7
Clothing	mts	200	300	(300/200) × 100 = 150.0
Gas	cylinder	150	220	(220/150) × 100 = 140.7
Electricity	units	0.80	1.10	(1.10/0.8) × 100 = 137.5
Housing	dwelling	400	800	(800/400) × 100 = 200
	N = 5			$\Sigma\left(\frac{P_1}{P_0} \times 100\right) = 763.9$

$$P_{01} = \frac{\Sigma\left(\frac{P_1}{P_0} \times 100\right)}{N} = \frac{763.9}{5} = 152.78$$

Thus, the index of simple average of price relatives shows 52.78 per cent increase in price.

For construction of Quantity Index, quantity relatives should be obtained and averaged. The formula for quantity index in this method is :

$$Q_{01} = \frac{\Sigma\left(\frac{q_1}{q_0} \times 100\right)}{N}$$

Which you may compute on your own by using the data given in Illustration-1.

This method also has its limitations. First, each price/quantity relative is given equal importance, which is not realistic. Secondly, the arithematic mean is not the right type of average for ratios, and percentages.

Self Assessment Exercise B

Calculate i) the price index number by the simple aggregative and average of relatives methods from the following data (price per kg).

ii) What are the limitations of both the methods?

Commodities	Price in 1996 (Rs.)	Price in 2000 (Rs.)
Apple	35	60
Mango	30	45
Watermelon	5	10

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12.6.2 Weighted Index Numbers

In the earlier two methods each item received equal weight/importance in the construction of an index, whereas in the weighted index methods, weights are expressly assigned to each item which is included in an index construction. This weighting allows us to consider more information than just the change in price/ quantity over time. The problem only is to decide how much weight (importance) to consider for each of the items included in the sample. This is further divided into two methods.

1) Weighted Aggregates Index, and

2) Weighted Average of Relatives Index.

Let us discuss these two methods one after another.

1) Weighted Aggregates Index

In this group, we shall study three specific methods commonly used in business research. They are: (a) Laspeyre's index, (b) Paasche's index, and (c) Fisher's index. After understanding the concepts of the three indices we will take up an illustration for construction of these indices.

a) **Laspeyre's Index:** In this method, weights assigned to each commodity are the quantities consumed in the base year for price indices. For quantity index weights used are the prices of commodities in the base year. Thus, according to Laspeyre:

$$\text{Price Index } (P_{01}^{La}) = \left(\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0}\right) \times 100, \quad \text{and}$$

$$\text{Quantity Index} = (Q_{01}^{La}) = \left(\frac{\Sigma q_1 P_0}{\Sigma q_0 P_0}\right) \times 100$$

It is to be noted that this method is most popular for constructing "Consumer Price Index". It is, therefore, considered as aggregate expenditure method which is one of the methods for constructing Consumer Price Index.

Since each index number depends upon price and quantity of the same base year, the researcher can compare the index of one period directly with the

index of another period. For instance, assume that the cement price index is 115 in 1995 and 143 in 2001, taking 1991 as base year. The firm concludes that the price level of cement has increased by 15 per cent from 1991 to 1995 and has increased 43% from 1991 to 2000.

b) **Paasche's Index:** In this method, quantities consumed in the current year are used as weights in construction of price indices, where as in construction of quantity index, weights used are the prices of items in the current year. Thus according to Paasche:

$$\text{Price Index } (P_{01}^{Pa}) = \left(\frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}\right) \times 100$$

$$\text{Quantity Index } (Q_{01}^{Pa}) = \left(\frac{\Sigma q_1 P_1}{\Sigma q_0 P_1}\right) \times 100$$

Comparison of Laspeyre's and Paasche's Indices

From the practical point of view, Laspeyre's index is usually preferred over Paasche's index. This is because as long as base period is fixed, the weights assigned will remain unchanged. Therefore, calculations and comparisons are easier. On the other hand, weights in Paasche's formula continue to change with the change in the current year so that the price index for every year has to be computed using fresh/different weights.

Another interesting property of Laspeyre's index is that it tends to overestimate the value of indices. It is argued that when prices increase, the consumers reduce the consumption of commodities (which are price elastic) for which price rise has been highest. Thus the use of base year quantities increases the value of the numerator, thus increasing the value of index number. The same is true when prices are falling. The Paasche's index, on the other hand, has a tendency to underestimate. This is because when prices are rising, reduced current quantities are used as weights which reduces the value of the index. When price changes are not very rapid, there is not much difference between the index values given by the two methods.

c) **Fisher's Ideal Index:** Irving Fisher used geometric mean of the Laspeyre's and Paache's indices to overcome the shortcomings of both. Thus,

$$\text{Fisher's Price Index } (P_{01}^{F}) = \sqrt{\left(\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0}\right)\left(\frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}\right)} \times 100$$

Analogously, Fisher's quantity index is:

$$Q^{F}_{01} = \sqrt{\left(\frac{\Sigma q_1 P_0}{\Sigma q_0 P_0}\right)\left(\frac{\Sigma q_1 P_1}{\Sigma q_0 P_1}\right)} \times 100$$

Fisher's index is superior because it uses geometric mean (which is best applicable for average of ratios and percentages) of Laspeyre's and Paache's indices. Also, because it is comparatively free from bias of over estimation and under estimation. Fisher's index satisfies the requirement of time reversal test and factor reversal test. This index is, therefore, called ideal index. So far we have discussed the three different indices of weighted aggregates method. For

illustration, let us observe the following data of 1995 and 2000, and also required computation for construction of (i) Laspeyre's, (ii) Paasche's, and (iii) Fisher's indices made in the table.

Illustration-3

Table 12.3: Computation of Weighted Aggregates Index

Commodities	Year 1995 (base year)		Year 2000 (current year)		P_0q_0	P_1q_0	P_0q_1	P_1q_1
	Prices (P_0)	Qty. (q_0)	Prices (P_1)	Qty. (q_1)				
Wheat	800	6	950	8	4800	5700	6400	7600
Rice	600	3	800	4	1800	2400	2400	3200
Oilseeds	400	5	425	4	2000	2125	1600	1700
Sugar	250	2	300	2	500	600	500	600
					ΣP_0q_0 =9100	ΣP_1q_0 =10824	ΣP_0q_1 =10900	ΣP_1q_1 =13100

i) **Laspeyre's Price Index or** $P_{01}^{La} = \frac{\Sigma P_1 q_0}{\Sigma P_o q_0} \times 100$

$$= \frac{10824}{9100} \times 100 = 118.94$$

This shows that prices for the group (sample commodities) have increased by 18.94 per cent in 2000 as compared to those prevailing in 1995.

The quantity index according to Laspeyre's formula is computed as shown below:

$$Q_{01} = \frac{\Sigma q_1 P_0}{\Sigma q_0 P_0} \times 100$$

The sum of q_1, P_0, and q_0 P_0 may be taken from the Table 12.3 as $\Sigma p_0 q_1 = \Sigma q_1 p_0$, and $\Sigma P_0 q_0 = \Sigma q_0 P_0$.

$$Q_{01}^{La} = \frac{10900}{9100} \times 100 = 119.78$$

This shows a 19.78 per cent increase in aggregate quantity consumption for this group in 2000 as compared to 1995.

ii) **Paache's Price Index or** $P_{01}^{La} = \frac{\Sigma P_1 q_1}{\Sigma P_0 q_1} \times 100$

$$= \frac{13100}{10900} \times 100 = 120.18$$

Thus, according to the Paache's Index the price index reveals an increase of 20.18 per cent in prices in 2000 as against 1995.

Analogously, Paasche's quantity index is

$$Q_{01}^{Pa} = \frac{\Sigma q_1 P_1}{\Sigma q_0 P_1} \times 100$$

The values of $\Sigma q_1 P_1$ and $\Sigma q_0 P_1$ in the Table 12.3, as they are equivalent to $\Sigma P_1 q_1$ and $\Sigma P_1 q_0$, respectively. Thus,

$$Q_{01}^{Pa} = \frac{13100}{10824} \times 100 = 121.03$$

It shows a 21.03 per cent increase in quantity consumption for this group in 2000 as compared to 1995.

iii) **Fisher's Index or** $P_{01}^{F} = \sqrt{\left(\frac{\Sigma P_1 q_0}{\Sigma P_0 q_0}\right)\left(\frac{\Sigma P_1 q_1}{\Sigma P_0 q_1}\right)}\ 100$

$$P_{01}^{F} = \sqrt{\left(\frac{10824}{9100}\right)\left(\frac{13100}{10900}\right)}\ 100$$

$$= \sqrt{1.43} \times 100 = 119.55$$

Therefore, Fisher index value is comparatively free from bias of underestimation and overestimation as in Laspeyre's and Paachre's indices. However, it is more complicated to construct.

Fisher's Quantity Index or $Q_{01}^{F} = \sqrt{\left(\frac{\Sigma q_1 P_0}{\Sigma q_0 P_0}\right)\left(\frac{\Sigma q_1 P_1}{\Sigma q_0 P_1}\right)}\ 100$

which you may compute and interpret on your own using the data in the Table 12.3.

2) Weighted Average of Relatives Index

In this method, the construction of the index number is similar to the simple average of relatives method, in respect of computation of price relatives, as discussed in Section 12.6.1. However, to overcome the limitation of simple average of relatives method, the weights used are the values of consumption for each commodity either in the base period, or in the current period.

This method is also called as Family Budget method, which is considered as one of the methods to construct consumer price index. It can be defined symbolically as:

$$P_{01} = \frac{\Sigma\left[\left(\frac{P_1}{P_0} \times 100\right) P_0 q_0\right]}{\Sigma P_0 q_0}, \text{ in simple } \frac{\Sigma PV}{\Sigma V}$$

As an illustration let us consider the data given in Table 12.4 which also contains required computations for constructing index number through weighted average of relatives method.

Illustration-4

Table 12.4: Computation of Index Number through Weighted Average of Relatives Method

Items	Year 1990 (base year)		Year 2000 (base year)		V (P_0q_0)	P $\left(\frac{P_1}{P_0}\times 100\right)$	PV
	Price P_0	Qty. q_0	Price P_1	Qty. q_1		Price Relatives	
A	7	25	12	21	175	171.43	30000.25
B	2	12	2.5	12	24	125.00	3000.00
C	3	4	5	3	12	166.67	2000.04
					ΣV = 211		ΣPV = 35000.29

Then, the price index $(P_{01}) = \frac{\Sigma PV}{\Sigma V} = \frac{35000.29}{211} = 165.88$

This means that according to this method, the rise in prices in 2000 as compared to the base year 1990 is 65.88 per cent. In this method, the index of quantity relatives is expressed as:

$$Q_{01} = \frac{\Sigma\left[\left(\frac{q_1}{q_0}\times 100\right) q_0P_0\right]}{\Sigma q_0P_0} = \frac{\Sigma qV}{\Sigma V}$$

which you may compute and interpret on your own by using the data in Table 12.4.

Self Assessment Exercise C

Compute price index number by Weighted Aggregates method (Laspeyre's, Paache's and Fisher's) and weighted Average of Relatives method, from the following data (Price quoted in Rs. per kg. and production in qtls).

Commodity	1990		2000	
	Price	Production	Price	Production
Wheat	8	700	12	900
Rice	7	900	16	1,400
Sugar	12	300	19	500

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12.7 SPLICING AND DEFLATING OF INDEX NUMBERS

Splicing

Sometimes, a specific situation may arise for shifting the base period of an index number series to some recent period. For instance, in course of time a few commodities which are being considered for constructing indices may get replaced with new commodities, as a result their relative weightage may also change. In some cases, the weights may have become outdated and we may take into account the revised weights. Consequently, whatever be the reasons, index number series loses continuity and now we have two different index number series with different base periods which are not directly comparable. It is, therefore, essential to connect these two different series of indices into one continuous series. The statistical procedure involved in connecting these two series of indices to make continuity is termed as 'Splicing'. Thus, splicing means reducing two overlapping series of indices with different base periods into a continuous index number series. In equation form, we can say,

$$\text{Spliced Index Numbers} = \text{New Index No. of current period} \times \frac{\text{Old index No. of new base period}}{100}$$

The following example would illustrate the procedure of splicing:

Illustration 5

Table 12.5: Splicing the New Series of Indices with the Old Series of Indices

Year	Consumer Price Index (1990 = base) (Old Index No. series)	Consumer Price Index (1994 =base) (New Index No. series)	Spliced Consumer Index [New index (114/100)]
1990	100		100
1991	110		110
1992	108		108
1993	114	100	100 (114/100) = 114
1994		108	108 (114/100) = 123
1995		116	116 (114/100) = 132
1996		112	112 (114/100) = 128

In the above illustration, old series was discontinued in 1993 and in that year new series was started. As shown in Column No. 4, splicing took place at the base year 1993 of the new series.

Alternatively, splicing may be done to the old index number series with new index number series. It means instead of carrying old series forward, new series may be brought backwards. To do this, the formula looks like this:

$$\text{Old Index No. of current period} \times \frac{100}{\text{Old index No. of new base period}}$$

Under this approach (Splicing the old series with the new series) the spliced indices are as follows:

Year	1990	1991	1992	193	1994	1995	1996	1997	1998
Spliced Index	88	96	97	95	100	108	116	112	120

Self Assessment Exercise D

The index A was started in 1995 and continued upto 1998 in which year another index B was started. Splice the index B to index A so that a continuous series of index number from 1995 upto date may be available.

Year	1995	1996	1997	1998	1999	2000	2001
Index A	100	128	115	135	-	-	-
Index B	-	-	-	100	125	138	130

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Deflating

As we know that the price of goods and series gradually increases, as a result the purchasing power of money (value of money) decreases. Consequently, the real wages become less than the money wage. In such a situation the real wage may be obtained by reducing the money wage to the extent the price level has risen. Thus, the process of finding out the real wage by applying appropriate price indices to the money wages so as to allow for the changes in the price level is called ‘deflating’. We may express this process by the following formulae:

$$\text{Real wage} = \frac{\text{Money wage}}{\text{Price index}} \times 100, \text{ and}$$

$$\text{Real wage index number} = \frac{\text{Current period's real wage}}{\text{base period's real wage}} \times 100$$

Let us take an example consisting of the following data related to wages and price index of different years. It would illustrate the procedure of constructing real wage index numbers.

Illustration 6

Table 12.6: Construction of Real Wage Index

Year	Wages (Rs.)	Price index	Real wage (Rs.) (deflated income)	Real wage index (1995=100)
1995	200	100	(200/100) 100=200	(200/200) 100 = 100
1996	280	130	(280/130) 100 = 215	(215/200) 100 = 107.5
1997	280	190	(280/190) 100 = 147	(147/200) 100 = 73.5
1998	360	240	(360/240) 100 = 150	(150/200) 100 = 75
1999	390	280	(390/280) 100 = 139	(139/200) 100 = 69.5
2000	420	280	(420/280) 100 = 150	(150/200) 100 = 75

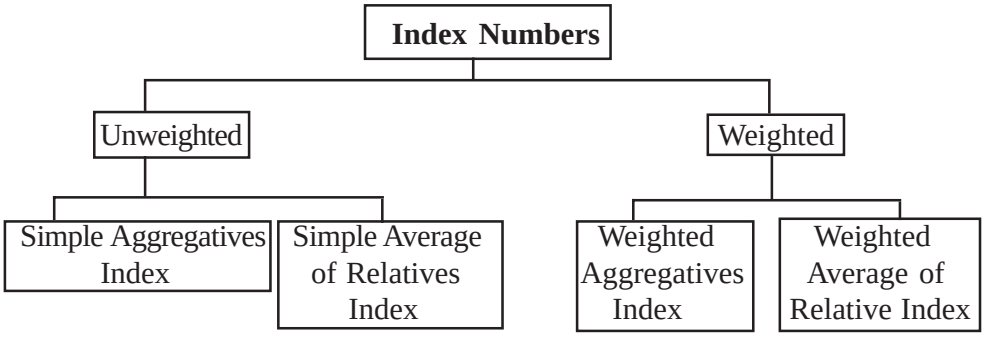
12.8 LET US SUM UP

An index number is a specialised average which helps in comparison of the level of magnitude of a group of related variables with respect to time, geographical location or other characteristics such as production, income, employment, etc. It combines two or more time series variables related to non-comparable units.

Index numbers can be used in several ways, such as study trends and tendencies of business activities, provide guidelines in framing suitable policies, measure real purchasing power of money, help in transforming nominal wage into real wage and so on. The researcher may face various problems in the construction of different types of indices. They may be selection of the base period, collection of data, selection of commodities, choice of averages and weights, selection of an appropriate index. These issues must be clarified before constructing indices.

There are three principal types of indices (i) price indices, (ii) quality indices, and (iii) value indices. Among these three, price indices is the most common in analysing the data.

There are different methods of constructing index numbers which is illustrated through the following chart:



Choice of an appropriate method depends upon the purpose of constructing indices.

The process of connecting the series of index numbers of old base period with the series of index numbers of new base period is called splicing. Splicing may be done in two ways: one is splicing the new series of indices with old series of indices. Another is splicing the old series of indices with new series of indices. Deflating means the process of finding out the real wage by applying appropriate price indices to the money wage so as to allow for the changes in the price level.

12.9 KEY WORDS

Index Number: A ratio for measuring differences in the magnitude of a group of related variables over time.

Cost of Living Index: Numbers represent the average change in the prices paid by the consumer on specified goods and services over a period of time, popularly known as "Consumer Price Index Number".

Base period: It is the reference period against which comparisons are made.

Price Index: A measure of how much the price variables change over a period of time.

Quality Index: A measure which studies the quantity of a variable changes from one period to another period.

Value Index: A measure for changes in total monetary worth over a time.

Splicing: It is a process of connecting two different index series of different base periods into a continuous series.

Deflating: is a statistical technique of making allowances for the effect of changing price levels.

12.10 ANSWERS TO SELF ASSESSMENT EXERCISES

A) 1) a) True, b) False, c) False, d) True, e) True, f) False, g) False.

B) Simple aggregative P_{01} = 164.3

Average of Relatives P_{01} = 173.8

C) Weighted Aggregates index number:

P_{01}^{La} = 183.9; P_{01}^{Pa} = 180.4; P_{01}^{F} = 181.9

Weighted Average of Relatives Index (P_{01}) = 183.9

D)

Year :	1995	1996	1997	1998	1999	2000	2001
Spliced Index :	100	128	115	135	168.7	186.3	175.5

12.11 TERMINAL QUESTIONS/EXERCISES

1) What do you mean by an index number? Explain the uses of index numbers for analysing the data.
2) Discuss various issues that arise in connection with the construction of an index number.
3) Briefly explain different methods for construction of indices and their limitations.
4) Why do we consider Fisher's index as an ideal index?
5) Write short notes on:
   a) Price Index
   b) Quantity Index
   c) Splicing of Indices
   d) Deflating of Indices.

6) A drug processing plant utilized four different materials in the manufacturing of a medicine. The following data indicates the final inventory levels (in tons) and prices (per kg). for these materials for the years 2000 and 2004.

Material	2000		2004	
	Inventory	Price (Rs.)	Inventory	Price (Rs.)
A	96	45	108	41
B	495	26	523	32
C	1,425	5	1,608	8
D	208	12	196	9

Find the price indices and quantity indices by using the methods of unweighted index numbers and comment on the results.

7) A department of Statistics has collected the following data describing the prices and quantities of harvested crops for the years 1990, 2000 and 2004 (Price in Qtls. and Production in tons).

Item	1990		2000		2004	
	Price	Production	Price	Production	Price	Production
Paddy	200	1,050	500	1,300	600	1,450
Wheat	250	940	550	1,220	700	1,450
Groundnut	350	400	800	500	1,000	480

Construct the price and quantity indices of Laspeyre's Index, Paache's Index and Fisher's Index in 2000 and 2004, using 1990 as the base period. Give your comments on the results.

8) From the given data in Problem No. 7, find out the following:
   i) Weighted average of relative price index numbers for 2004, using 1990 and 2000 as the base.
   ii) Weighted average of relative quantity index for 2004, using 2000 as the base.
   iii) Give your comments on the price indices.

9. Two price index series of cement are given below. Splice the old series with the new series. By what per cent did the price of cement rise between 1995 and 2000.

Year	Old series Base (1990)	New series Base (1998)
1995	156.6	-
1996	174.8	-
1997	162.3	-
1998	160.0	100.0
1999	-	106.4
2000	-	114.1
2001	-	112.2

10) Given below is the annual income of an Engineer and the general index number of prices during 1997–2004. Construct the index number to show the change in the real income of the Engineer.

Year:	1997	1998	1999	2000	2001	2002	2003	2004
Income: (in 000' Rs.)	255	265	286	312	336	380	405	420
Price Index No.:	100	108	116	153	140	192	248	235

Note:

Note: These questions/exercises will help you to understand the unit better. Try to write answers for them. But do not submit your answers to the university for assessment. These are for your practice only.

12.12 FURTHER READING

A number of good text books are available for the topics dealt with in this unit. The following books may be used for more indepth study.

Hooda, R.P, 2001. *Statistics for Business and Economics*, Macmillan India Ltd.

Richard I. Levin and David S. Rubin, 1996, *Statistics for Management*, Prentice Hall of India Pvt. Ltd.

Gupta, S.P., *Statistical Methods*, 2000, Sultan Chand and Sons.

Gupta, C.B. and Vijay Gupta, 2001. *An Introduction to Statistical Methods*, Vikas Publishing House Pvt. Ltd., New Delhi.