5 INDEX NUMBERS

5.1 Introduction Often we want to know how certain variables like prices, production, etc. have changed over time and space. For example, we may like to compare the change in the average retail price of milk in 1975 with that in 1972 or we may like to compare the retail price of milk in Lahore with that in Rawalpindi or Karachi. We may also like to know the increase in the yield of wheat in Pakistan during 1975 as compared to 1972. We can easily compare such changes by expressing the price or quantity in a given period as percentage of the price or quantity in the base period, i.e. the period with which comparison is made. These percentages which compare changes in the prices of quantities at different periods of time with that of the base period (taken as 100) are very simple examples of what are known as *Index Numbers* as shown in the following table. More difficult problems arise when we want to compare changes in a complex phenomenon like the cost of living, total industrial production, wages, etc. This involves comparing changes in the prices or quantities of many commodities. Since the prices or quantities of different commodities are given in different units (e.g. wheat per maund, cloth per yard, and so on), they cannot be compared directly. To measure changes in such a situation, we combine the prices and quantities and find a single number. This single number which shows overall changes in a phenomenon is called an *index number* or simply an *index*. Thus an index number is a statistical measure which shows changes in a variable or group of related variables with respect to time, geographic location or other characteristics such as income, profession, etc.

Year	Price of Milk	Index Number
1972	1.00	100 (base)
1973	1.25	$\left(\frac{1.25}{1.00}\right)100 = 125$
1974	1.50	$\left(\frac{1.50}{1.00}\right)100 = 150$
1975	2.00	$\left(\frac{2.00}{1.00}\right)100 = 200$

5.1.1 Simple and Composite Index Numbers An index number that is computed for a single variable is called a *simple index number*. On the other hand, an index number that is computed from two or more variables is called a *composite index number*. Index numbers computed in the above table are simple index numbers because they have been computed for a single commodity (milk). Wholesale price index numbers and consumer price index numbers are composite index numbers because they are computed for two or more variables (commodities).

5.2 Types of Index Numbers Following types of index numbers are generally used.

(i) *Price Index Numbers* These index numbers show changes in the wholesale or retail prices of a particular commodity or a number of commodities.

(ii) *Quantity Index Numbers* These index numbers measure changes in the volume or quantity of goods produced or goods exported or imported.

(iii) *Aggregate or Aggregative Index Numbers* These index numbers are used to measure changes in a phenomenon like cost of living, total industrial production, etc. They involve both quantities and prices of items appropriate to a given situation.

5.3 Uses of Index Numbers An index number is a device for measuring changes in a variable or a group of related variables. This device can be used whenever we want to compare changes in one or more variables in one period with those in others or in one region with those in others. For example, the index numbers of prices show changes in the wholesale or retail prices of commodities. These index numbers can, therefore, be used to compare changes in the price of one commodity with those in others at different periods of time or the prices in one part of the country with those in others during the same period. The index number of industrial activity enables us to study the progress of industrialization in the country. The quantity index numbers show rise or fall in the volume of production, volume of exports and imports, etc. The most well-known is the *cost of living index* or *consumer price index*. These cost of living index numbers are, in fact, the retail price indices. They show changes in the prices of goods generally consumed by people. They can, therefore, help the government to formulate its price policies and take suitable economic measures to control prices. Moreover, these indices can be made a basis for regulation of wage rates and can be used by industrial and commercial organizations to grant dearness allowance and bonus to their employees in order to meet the increased cost of living. They are also used to evaluate the purchasing power of money. Index numbers are also used for forecasting business and economic activities and in discovering seasonal fluctuations and business cycles.

Although index numbers are mainly used in business and economic field, they can also be applied in many other fields. For example, index numbers can be used in education to compare the intelligence of a student with that of an average student of his age or class. They can also be used to measure the effectiveness of teaching system. In the field of health, index numbers can be used to show the general health conditions of the people and to indicate the adequacy of hospital facilities.

5.4 Steps in the Construction of Index Numbers of Prices Following steps are usually involved in the construction of index numbers of prices.

(i) Definition of the purpose and scope
(ii) Selection of commodities to be included
(iii) Collection of prices
(iv) Selection of the base period
(v) Choice of average to be used
(vi) Selection of suitable weights

5.4.1 Definition of the Purpose and Scope The purpose may be general or special. A *general purpose index* can be put to more than one use while a *special purpose index* can serve only some special purpose. An index number designed to measure changes in the general price level in a country would be a general-purpose index number. On the other hand, an index number aimed at comparing the prices of particular items, e.g. cigarettes would be a special purpose index number.

The object of the index number also determines its *scope*. A general purpose index number has a wide scope because it can serve more than one purpose. On the other hand, a special purpose index number has limited scope because it can be put only to some special use.

5.4.2 **Selection of Commodities** In a special purpose index number, the commodities to be included in comparing prices are usually few. There is, therefore, no question as to what commodities are to be selected. In a general purpose index number, the number of commodities which can be included in comparing the prices is very large. It is not practicable either from the point of view of cost or time to measure changes in the prices of all relevant commodities. A selection has, therefore, to be made. The commodities selected must be (i) popular and important, (ii) representative of the tastes and habits of the people, and (iii) unlikely to vary in quality. Since each commodity has many brands/varieties, it is necessary to specify the variety, quality or grade of the commodity selected for inclusion. The number of commodities should also be large enough to represent the true picture of the phenomenon being compared.

5.4.3 **Collection of Prices** This problem requires consideration of two points: (i) the prices to be used and (ii) the sources of price data. The term *price* in itself is a vague term because it may mean "average price", "wholesale price", "retail price", etc. It is, therefore, necessary to specify the prices to be used. In a general purpose index number, *average wholesale prices* are generally used.

5.4.4 **Selection of the Base Period** The period with which prices in other periods are to be compared is called the *base period* or *reference period*. The base period is usually a year because a month or a quarter is too short a period to be used as base. There are two methods of selecting the base period: (a) *fixed base method* (b) *chain base method.*

(a) *Fixed Base Method* In this method, the average price of a particular year or the average of the prices of a number of years is used as base. If a particular year price is used as base, the base year should not be too far distant in the past. Further, the base year should be a *normal* year, i.e. a year which has economic stability and is free from crisis caused by wars, floods, famines, strikes, etc. It is, however, true that no one year is perfectly normal. For this reason, the average of the prices of a number of years should be used as base.

To compute index numbers by fixed base method, the value of the base year is taken as 100. Index numbers for other periods are computed by dividing the price of a given year by the base year price. Values so obtained are called *price relatives*. Price relatives are expressed as percentages by multiplying them by 100. An average of the price relatives of a year gives the index number for that year. Price relatives computed for a single commodity are called *simple price relatives.*

(b) *Chain Base Method* In the fixed base method, we compare changes in the prices of commodities in a number of years with that of the base year. As time passes, the tastes and habits of the people change. The relative importance of the commodities also changes due to a change in the quality of the commodities and discovery of some new commodities. For these reasons, it becomes necessary to shift the base year frequently. We may, therefore, use the chain base method in which price of the

preceding year is taken as base. Price relatives computed by chain base method are called *link relatives*. Link relatives are also expressed as percentages.

The link relatives cannot be directly used to make comparisons. To make comparisons of index numbers for a number of years, the link relatives are converted to a fixed base. Index numbers so obtained are called *chain indices*. The chain index for a year is obtained by multiplying the average of the link relatives of that year by the chain index of the preceding year and then dividing the resulting product by 100. Obviously the chain index for the base year is 100. However, if we are given the price relatives, then it is the average of the price relatives of the first year.

5.4.5 Choice of Average to be Used Any of the averages (arithmetic mean, median or geometric mean) can be used for index numbers. Arithmetic mean or median may be used because they are easy to calculate and simple to understand. Further, the median is not affected by extreme values. Geometric mean is specially suitable for averaging price relatives because it gives equal weight to equal ratios of change and that the geometric mean of relatives is reversible.

5.4.6 Selection of Suitable Weights We know that all the commodities which can be included in the construction of index numbers are not equally important. In order to give due regard to the importance of a commodity in the construction of index numbers, it is necessary to assign suitable weights to the commodities. Weights may be *implicit* or *explicit*. In implicit weighting, the price of the commodity whose importance is intended to be increased is quoted by a higher unit. For example, in the case of building material, the price of cement may be quoted per 100 bags instead of price per bag if the relative importance of cement is to be increased and wages of labour may be quoted per week or per month instead of per day if the relative importance of labour is to be increased. The importance of the price of a commodity in the overall picture described by an index number is generally determined by its *quantity produced, consumed, bought* or *sold*. We, therefore, use the quantities in the base year or given year or some other set of quantities as *weights*. Such a weighting is called *explicit weighting*. As we shall see in Section 5.6, different systems of weighting yield different results.

5.5 Notations The following notations will be used in the construction of index numbers.

p_o Price in the base year

p_n Price in the current or given year. (p_1 will stand for the price in the year next to base year, p_2 for the price in the year second next to the base year and so on)

q_o Quantity in the base year

q_n Quantity in the current or given year. (q_1 will stand for the quantity in the year next to base year, q_2 for the quantity in the year second next to the base year and so on)

P_{on} Price index for the current or given year. (P_{01} will stand for the price index for the year next to the base year, P_{02} for the price index for the year second next to the base year and so on)

Q_{on} Quantity index for the current or given year. (Q_{01} will stand for the quantity index for the year next to base year, Q_{02} for the quantity index for the year second next to the base year and so on)

5.6 Construction of Price Index Numbers The methods for construction of different types of price index numbers are discussed below.

5.6.1 Simple Relatives or Simple Index Numbers Two types of relatives fall under this category: (i) price relatives and (ii) link relatives.

(i) *Price Relatives* A *price relative* is obtained by dividing the price in a given year (p_n) by the base year price (p_o) and is generally expressed as a percentage by multiplying by 100.

$$\text{Price relative} = \frac{p_n}{p_o} \times 100 \tag{5.1}$$

(ii) *Link Relatives* A *link relative* is obtained by dividing the price in a given year (p_n) by the price in the preceding year (p_{n-1}). It is also expressed as a percentage.

$$\text{Link relative} = \frac{p_n}{p_{n-1}} \times 100 \tag{5.2}$$

Example 5.1 The price of wheat (per maund) is given for the years 1964 to 1973. Calculate simple index numbers using (i) 1964 as base (ii) average of the prices for the first five years as base (iii) average of the prices of all the 10 years as base.

Year	Price (Rs.)	Year	Price (Rs.)
1964	20	1969	27
1965	18	1970	28
1966	23	1971	30
1967	24	1972	32
1968	25	1973	33

Solution (i) The price relative for the base year (1964) is 100. Price relatives for the years 1965 to 1973 are computed in the third column of Table 5.1.

(ii) The average of the prices for the first five years is (20 + 18 + 23 + 24 + 25)/5 = 110/5 = 22. Price relatives with this base for the years 1965 to 1973 are given in the fourth column of Table 5.1.

(iii) The average of the prices for the ten years is (20 + 18 + ... + 32 + 33)/10 = 260/10 = 26. Price relatives with this base are given in the fifth column of Table 5.1.

Table 5.1

Year	Price (Rs.)	(i) Index Number	(ii) Index Number	(iii) Index Number
1964	20	100	$\left(\frac{20}{22}\right)100 = 90.9$	$\left(\frac{20}{26}\right)100 = 76.9$
1965	18	$\left(\frac{18}{20}\right)100 = 90$	$\left(\frac{18}{22}\right)100 = 81.8$	$\left(\frac{18}{26}\right)100 = 69.2$
1966	23	$\left(\frac{23}{20}\right)100 = 115$	$\left(\frac{23}{22}\right)100 = 104.5$	$\left(\frac{23}{26}\right)100 = 88.5$
1967	24	$\left(\frac{24}{20}\right)100 = 120$	$\left(\frac{24}{22}\right)100 = 109.1$	$\left(\frac{24}{26}\right)100 = 92.3$
1968	25	$\left(\frac{25}{20}\right)100 = 125$	$\left(\frac{25}{22}\right)100 = 113.6$	$\left(\frac{25}{26}\right)100 = 96.2$
1969	27	$\left(\frac{27}{20}\right)100 = 135$	$\left(\frac{27}{22}\right)100 = 122.7$	$\left(\frac{27}{26}\right)100 = 103.8$
1970	28	$\left(\frac{28}{20}\right)100 = 140$	$\left(\frac{28}{22}\right)100 = 127.3$	$\left(\frac{28}{26}\right)100 = 107.7$
1971	30	$\left(\frac{30}{20}\right)100 = 150$	$\left(\frac{30}{22}\right)100 = 136.4$	$\left(\frac{30}{26}\right)100 = 115.4$
1972	32	$\left(\frac{32}{20}\right)100 = 160$	$\left(\frac{32}{22}\right)100 = 145.5$	$\left(\frac{32}{26}\right)100 = 123.1$
1973	33	$\left(\frac{33}{20}\right)100 = 165$	$\left(\frac{33}{22}\right)100 = 150$	$\left(\frac{33}{26}\right)100 = 126.9$

Example 5.2 (a) The prices of rice (per maund) for the years 1960 to 1967 are given