LESSON 39: INTRODUCTION TO INDEX NUMBER & ITS CONSTRUCTION

Objective

After reading this chapter, you will be conversant with

1. The Concept of Index Numbers
2. Uses of Index Number
3. Different Types of Index Numbers
4. Aggregates Method of Constructing Index Numbers

Introduction

Index numbers are today one of the most widely used statistical indicators. Generally used to indicate the state of the economy, index numbers are aptly called 'barometers of economic activity'. Index numbers are used in comparing production, sales or changes exports or imports over a certain period of time. The role-played by index numbers in Indian trade and industry is impossible to ignore. It is a very well known fact that the wage contracts of workers in our country are tied to the cost of living index numbers.

What is an Index Number?

By definition, an index number is a statistical measure designed to show changes in a variable or a group or related variables with respect to time, geographic location or other characteristics such as income, profession, etc.

What are the characteristics of an Index Numbers?

1. These are expressed as a percentage: Index number is calculated as a ratio of the current value to a base value and expressed as a percentage. It must be clearly understood that the index number for the base year is always 100. An index number is commonly referred to as an index.

2. Index numbers are specialized averages: An index number is an average with a difference. An index number is used for purposes of comparison in cases where the series being compared could be expressed in different units i.e. a manufactured products index (a part of the whole sale price index) is constructed using items like Dairy Products, Sugar, Edible Oils, Tea and Coffee, etc. These items naturally are expressed in different units like sugar in kgs, milk in liters, etc. The index number is obtained as a result of an average of all these items, which are expressed in different units. On the other hand, average is a single figure representing a group expressed in the same units.

3. Index numbers measures changes that are not directly measurable: An index number is used for measuring the magnitude of changes in such phenomenon, which are not capable of direct measurement. Index numbers essentially capture the changes in the group of related variables over a period of time. For example, if the index of industrial production is 215.1 in 1992-93 (base year 1980-81) it means that the industrial production in that year was up by 2.15 times compared to 1980-81. But it does not, however, mean that the net increase in the index reflects an equivalent increase in industrial production in all sectors of the industry. Some sectors might have increased their production more than 2.15 times while other sectors may have increased their production only marginally.

What are the uses of Index Numbers?

Uses of index numbers

1. Establishes trends

Index numbers when analyzed reveal a general trend of the phenomenon under study. For eg. Index numbers of unemployment of the country not only reflects the trends in the phenomenon but are useful in determining factors leading to unemployment.

2. Helps in policy making

It is widely known that the dearness allowances paid to the employees is linked to the cost of living index, generally the consumer price index. From time to time it is the cost of living index, which forms the basis of many a wages agreement between the employees union and the employer. Thus index numbers guide policy making.

3. Determines purchasing power of the rupee

Usually index numbers are used to determine the purchasing power of the rupee. Suppose the consumers price index for urban non-manual employees increased from 100 in 1984 to 202 in 1992, the real purchasing power of the rupee can be found out as follows:

$$100/202=0.495$$

It indicates that if rupee was worth 100 paise in 1984 its purchasing power is 49.5 paise in 1992.

4. Deflates time series data

Index numbers play a vital role in adjusting the original data to reflect reality. For example, nominal income(income at current prices) can be transformed into real income(reflecting the actual purchasing power) by using income deflators. Similarly, assume that industrial production is represented in value terms as a product of volume of production and price. If the subsequent year's industrial production were to be higher by 20% in value, the increase may not be as a result of increase in the volume of production as one would have it but because of increase in the price. The inflation which has caused the increase in the series can be eliminated by the usage of an appropriate price index and thus making the series real.

What are the different types of Index Numbers?

Types of index numbers

Three are three types of principal indices. They are:

1. the price index,
2. the quantity index

3. the value index.

Let us discuss all three in details

1. Price Index

The most frequently used form of index numbers is the price index. A price index compares charges in price of edible oils. If an attempt is being made to compare the prices of edible oils this year to the prices of edible oils last year, it involves, firstly, a comparison of two price situations over time and secondly, the heterogeneity of the edible oils given the various varieties of oils. By constructing a price index number, we are summarizing the price movements of each type of oil in this group of edible oils into a single number called the price index. The Whole Price Index (WPI). Consumer Price Index (CPI) are some of the popularly used price indices.

2. Quantity Index

A quantity index measures the changes in quantity from one period to another. If in the above example, instead of the price of edible oils, we are interested in the quantum of production of edible oils in those years, then we are comparing quantities in two different years or over a period of time. It is the quantity index that needs to be constructed here. The popular quantity index used in this country and elsewhere is the index of industrial production (HP). The index of industrial production measures the increase or decrease in the level of industrial production in a given period compared to some base period.

3. Value Index

The value index is a combination index. It combines price and quantity changes to present a more spatial comparison. The value index as such measures changes in net monetary worth. Though the value index enables comparison of value of a commodity in a year to the value of that commodity in a base year, it has limited use. Usually value index is used in sales, inventories, foreign trade, etc. Its limited use is owing to the inability of the value index to distinguish the effects of price and quantity separately.

What are the methods of constructing Index Numbers?

Methods for constructing index numbers

The are two approaches for constructing an index number namely

1. The aggregates method
2. Average of relatives method.

Note: The index constructed in either of these methods could be

1. **An unweighted index**. An unweighted index is an index where equal weights are implicitly assigned.
2. **A weighted index.** A weighted index is an index where weighted are assigned to the various items constituting the index.

Let us discuss each method in detail.

Aggregates Method

Under the aggregates method of constructing an index number, we could have unweighted aggregates index and the weighted aggregates index.

Unweighted Aggregates Index

An unweighted aggregates index is calculated by totaling the current year/given year's elements and then dividing the result by the sum of the same elements during the base period. To construct a price index, the following mathematical formula may be used.

$$\text{Unweighted Aggregates Price Index} = \frac{SP_1}{SP_0} \times 100$$

where,

SP_1 = Sum of all elements in the composite for current year

SP_0 = Sum of all elements in the composite for base year

What are the merits and demerits of this method?

Merit

This is the simplest method of constructing index numbers.

Demerits

It does not consider the relative importance of the various commodities involved.

The unweighted index doesn't reflect the reality since the price changes are not linked to any usage/consumption levels.

The following example demonstrates the application of an unweighted index.

Construction of Unweighted Price Index

Elements in the composite	Prices (in Rs.) 1990 (P_0)	1992 (P_1)
Oranges (1 dozen)	20	28
Milk (1 liter)	5	8
LPG Cylinder	76	100
	101	136

$$\text{Unweighted aggregates price index} = \frac{\Sigma P_1}{\Sigma P_0} \times 100$$

$$= \frac{136}{101} \times 100 = 134.65$$

Above we measured changes in general price levels on the basis of changes in prices of a few items. While the year 1990 was taken as the base year, a comparison has been made between the prices of 1992 and that of the base year 1990.

Interpretation:

As evident, the price index was 134.65, which means that the prices rose by 34.65 percent from 1990 to 1992. By no means should this price index be interpreted as a reflection of the price changes of all goods and services, as this calculation is a rough estimate. On inclusion of other items/elements and varying weights in the composite, with 1990 as the base year and 1992 as the current year, there is every possibility that the calculated price index would be different from the price index calculated earlier. This factor can be cited as one of the drawbacks of the simple unweighted index. *The unweighted index doesn't reflect the reality since the price changes are not linked to any usage/consumption* *levels. On the other hand, a weighted index attaches weights according to their significance and hence is preferred to the unweighted index.*

To make this clear, let us calculate the price index with the same data provided above but by changing the milk consumption from 1 liter to 100 liters.

The following table provides the calculation of the price index.

Unweighted Price Index

Elements in the composite	1990 (P_0)	Prices (in Rs.) 1992 (P1)
Oranges (1 dozen)	20	28
Milk (100 liters)	500	800
LPG Cylinder	76	100
	596	928

Unweighted aggregates price index $= \Sigma P_1 / \Sigma P_0 * 100$

$= 928/596 * 100 = 155.70$

Merely by changing the milk consumption in the composite, the unweighted price index changed from 134.65 to 155.70. As a result of ensuring that equal importance is given to all items in the composite irrespective of the consumption, the unweighted aggregates never gained much acceptance.

An unweighted aggregates quantity index and, an unweighted aggregates value index can be calculated on similar lines as calculated for price index. A mere substitution of quantities or values for prices in the equation $(S\ P_1 / S\ P_0) * 100$ would suffice.

Weighted Aggregates Index

In a weighted aggregates index, weights are assigned according to their significance and consequently the weighted index improves the accuracy of the general price level estimate based on the calculated index. Generally, the level of consumption is taken as a measure of its importance in computing a weighted aggregates index.

There are various methods of assigning weights to an index. The more important ones are:

1. Laspeyres Method
2. Paasche Method
3. Fixed Weight Aggregates Method
4. Fisher's Ideal Method and
5. Marshall-Edgeworth Method

Let us discuss each of these methods in detail.

Laspeyres Method

Laspeyres method uses the quantities consumed during the base period in computing the index number. This method is also the most commonly used method which incidentally requires quantity measures for only one period. Laspeyres index can be calculated using the following formula:

$$\text{Laspeyres Price Index} = \frac{\sum P_1 Q_0}{\sum P_0 Q_0} \times 100$$

here,

P_1 = Prices in the current year

P_0 = Prices in the base year

Q_0 = Quantities in the base year

Let us understand it with the help of an example.

Laspeyres Index

Commodities	Production (in quintals) Q_0 1985	Q_1 1990	Prices per quintal (in Rs.) P_0 1985	P_1 1990	P_0Q_0	P_1Q_0	P_0Q_1
Rice	46.60	58.00	700	910	32,620.00	42,406.00	40,600.00
Sugar	14.57	17.92	620	950	9,033.40	13,841.50	11,110.40
Jowar	69.46	85.10	205	300	14,239.30	20,838.00	17,445.50
Wheat	33.84	40.30	330	470	11,167.20	15,904.80	13,299.00

$$\text{Laspeyres price index} = \frac{\sum P_1 Q_0}{\sum P_0 Q_0} \times 100 = \frac{92990.30}{67059.90} \times 100$$

$$= 138.67$$

In general, Laspeyres price index calculates the changes in the aggregate value of the base year's list of goods when valued at current year prices. In other words, Laspeyres index measures the difference between the theoretical cost in a given year and the actual cost in the base year of maintaining a standard of living as in the base year.

Also, Laspeyres quantity index can be calculated by using the formula,

$$\text{Laspeyres quantity index} = \frac{\sum P_0 Q_1}{\sum P_0 Q_0} \times 100$$

Where,

Q_1 = Quantities in the current year

and Q_0, P_0 are as defined earlier

Using the same data as provided in the above table, Laspeyres quantity is

$$= \frac{82454.90}{67059.90} \times 100 = 122.96$$

What are the merit and demerits of Laspeyres method?

Merits

1.A laspeyres index is simpler in calculation and can be computed once the current year prices are known, as the weight are base year quantities in a price index.

This enables us an easy comparability of one index with another.

Demerits

Laspeyres tends to overestimate the rise in prices or has an upward bias.

Let us see how it overestimates the rise in prices or has an upward bias.

There is usually a decrease in the consumption of those items for which there has been a considerable price hike and the usage of base year quantities will result in assigning too much weight to prices that have increased the most and the net result is that the numerator of the Laspeyres index will be too large.

Similarly, when the prices go down, consumers tend to demand more of those items that have declined the most and hence the usage of base period quantities will result in too low weight to prices that have decreased the most and the net result is that the numerator of the Laspeyres index will again be too large.

This is a major disadvantage of the Laspeyres index. However, the Laspeyres index remains most popular for reason of its practicability. In most countries, index numbers are constructed by using Laspeyres formula.

Paasche's Method

Paasche index is similar to that of computing a Laspeyres index. The difference is that the Paasche method uses quantity measures for the current period rather than for the base period. The Paasche index can be calculated using the following formula.

Paasche Price Index = $\frac{\sum P_1 Q_1}{\sum P_0 Q_1} \times 100$

Where,

P_1 = Prices in the current year

P_0 = Prices in the base year

Q_1 = Quantities in the current year

What are the merits and demerits of Paasche's Index?

Merits and Demerits of Paasche's Index

Merit

Paasche's index attaches weights according to their significance.

Demerits

1. Paasche index is not frequently used in practice when the number of commodities is large. This is because for Paasche index, revised weights or quantities must be computed for each year examined. Such information is either unavailable or hard to gather adding to the data collection expense, which makes the index unpopular.

2. Paasche index tends to underestimate the rise in prices or has a downward bias.

Let us understand the Paasche's method with the help of an example.

The table below represents the calculation of Paasche index. In general Paasche index reflects the change in the aggregate value of the current year's (given period's) list of goods when valued at base period prices.

Paasche Index

	1992		1993					
Commodities	Price (P_0)	Quantity (Q_0)	Price (P_1)	Quantity (Q_1)	$P_0 Q_0$	$P_0 Q_1$	$P_1 Q_0$	$P_1 Q_1$
A	3	18	4	15	54	45	72	60
B	5	6	5	9	30	45	30	45
C	4	20	6	26	80	104	120	156
D	1	14	3	15	14	15	42	45
					178	209	264	306

Paasche price index $= \frac{\sum P_1 Q_1}{\sum P_0 Q_1} \times 100$ = 146.41

Paasche quantity index = $\frac{\sum P_1 Q_1}{\sum P_1 Q_0} \times 100$ = 115.91

Paasche price index is calculated as 146.41. Let us calculate the price index by the Laspeyres method using the same data.

Laspeyres price index = $\frac{\sum P_1 Q_0}{\sum P_0 Q_0} \times 100$ S P_1 Q_0/ S P_0 Q_0*100

= 264/178*100

= 148.31

The difference between the purchase index and Laspeyres index reflects the change in consumption patterns of the commodities A, B, C and D used in that table. As the weighted aggregates price index for the set of prices was 148 .31 using the Laspeyres method and 146.41 using the Paasche method for the same set, it indicates a trend towards less expensive goods.

Generally, Laspeyres and Paasche methods tend to produce opposite extremes in index values computed from the same data. The use of Paasche index requires the continuous use of new quantity weights for each period considered. As opposed to the Laspeyres index, Paasche index generally tends to underestimate the prices or has a downward bias.

Because people tend to spend less on goods when their prices are rising, the use of the Paasche which bases on current weighting, produces an index which does not estimate the raise in prices rightly showing a downward bias. Since all prices or all quantities do not move in the same order, the goods which have risen in price more than others at a time when prices in general are rising, will tend to have current quantities and they will thus have less weight in the Paasche index.

Fixed Weight Aggregates Method

In fixed weight aggregates method, the current used are neither from base period nor from current period but from a representative period. These weights are generally referred to as representative weights or as fixed weights. These fixed weights are unaffected by the selection of the base period. This is the advantage under this method. The user of the method will be able to select a base year that is convenient to him enabling him to change the price base yet retaining the fixed weights.

The students may refer to the weights assigned to various industry groups constituting the Index of Industrial Production presented in the annexure.

Fisher ideal Index

Prof. Irving Fisher has proposed a formula for constructing index numbers, which is called the 'Fisher's Ideal Index'. The Ideal index is given by the following formula:

Fisher Ideal Index =

$$\frac{\sqrt{\Sigma P_1 Q_0 X}\ \Sigma P_1 Q_1 X\ 100}{\sqrt{\Sigma P_0 Q_0}\ \Sigma P_0 Q_1}$$

As, evident from the above formula,

Fisher's Ideal Index is the geometric mean of the Laspeyres and Paasche indices.

The following advantages can be cited in favor of Fisher's Ideal Index:

1. Theoretically, geometric mean is considered the best average for the construction of index numbers and Fisher's index uses geometric mean.
2. As already noted, Laspeyres index and Paasche index indicate opposing characteristics and Fisher's index reduces their respective biases. In fact, Fisher's ideal index is free from any bias. This has been amply demonstrated by the time reversal and factor reversal tests.
3. Both the current year and base year prices and quantities are taken into account by this index.

The Index is not widely used owing to the practical limitations of collecting data. Fisher's Ideal Quantity Index can be found out by the formula.

$$\frac{\sqrt{\Sigma P_1 Q_0 \, X \, \Sigma P_1 Q_1}}{\sqrt{\Sigma P_0 Q_0 \, \Sigma P_0 Q_1}} \text{ X } 100$$

Marshall- Edgeworth Method

Marshall-Edgeworth Method uses both the current year as well as the base year prices and quantities. Marshall-Edgeworth Index can be computed using the following formula,

$$\text{Marshall-Edgeworth Index} = \frac{\Sigma (Q_0 + Q_1) P_1}{\Sigma (Q_0 + Q_1) P_0} \text{ X } 100$$

where Q_0, Q_1, P_0 and P_1 follow the usual notations.

Marshall- Edgeworth Index is simple to construct but suffers from the problems in data collection. However, the Marshall-Edgeworth Index is closely approximates the results obtained by Fisher's Ideal Index.

Value Index Numbers

The value index number as described earlier is a combination index which combines price and quantity changes. Because of the difficulties experienced in price and quantity indices, the usage of the value index has been suggested. The value index number can be calculated by the following formula,

$$= \frac{\Sigma P_1 Q_1}{S P_0 Q_0} \text{ X } 100$$

where Q_0, Q_1, P_0 and P_1 follow the usual notations.

Interestingly, in value indices, weights need not be used as they are inherent in these indices. The value index, an aggregate of all values, measures the changes in values in the base year and the values in the given year. The value index can also be obtained by the product of price and quantity indices.