INDEX NUMBERS

Introduction

Index numbers are the indicators which reflect changes over a specified period of time in (i) prices of different commodities (ii) industrial production (iii) sales (iv) imports and exports (v) cost of living etc.

Definition

Index numbers are statistical devices designed to measure the relative change in the level of a phenomenon variable or a group of variables) with respect to time, geographical location or other characteristics such as income, profession etc.

That is the index numbers are some special averages of the value of the variable at any given data called the "given period" as the percentage of the value of the variable at some standard date called the "base period." The variable may be

(i) the price of a particular commodity example; silver, iron, etc. or a group of commodities like consumer goods, food stuffs, etc.

(ii) the volume of trade, exports and imports, agricultural or industrial production, sales in a departmental store, etc.

(iii) the national income of a country or cost of living of persons belonging to particular income group/ profession etc.

Construction of index numbers

The problems involved in the construction of index numbers deserves the careful study of the following problems.

1. Purpose of index numbers
2. Selection of items.
3. Data for index numbers.
4. Selection of base period.
5. Selection of the average and system of waiting.

1. The purpose of index numbers

The first and foremost problem in construction of index numbers is to define the purpose for which index number is going to construct. The precise definition of the purpose helps us to select the commodities, base year, weights, etc.

2. The Selection of items

The selection of item is made depending upon the nature and purpose of the index numbers. For example if we desired to construct a specific purpose index number such as the cost of living index numbers of special categories of people, eg: the industrial class or the middle class or the clerks of the government etc., then the selection of commodities requires a careful thought. However the following points must be noted in selecting any items for the construction of the index numbers.

- *The items should be strictly representative*. That is the item should be true indicator of the consumption habits of the people and that a change in their prices truly reflects the change in the price of the group under study.
- *The items should be standard quality*. That is the item selected should not vary in quality from time to time, or from place to place. For example suppose rice is an item which effect the general level of the price, we should select such a variety of rice which is in common demand.
- *Non-tangible items should not be included in the construction of index number*. Things for which the prices or values are difficult to ascertain are not included in the construction of the index number (e.g. goodwill, personal service).
- *The number of items should be small*. The number of items included must not be very large since this result in greater complication, delay and expense in construction of index numbers. Also the number of items must not be too small, because even a slight change in the price of one of the item will reflect in the index number. In short the number of items should be moderate. The best solution of the problem of selection of the items for any index number is to split the whole group of commodities into various homogeneous subgroups and to select an adequate number of representative items from each sub-group. Now the question is how many varieties of an items are to be selected from each of the sub-group, the first criteria is select all those varieties which are in common use and likely to effect the index number. Secondly, if it is desired to attach more importance to a commodity on account of its larger use or for any other reason, then more than one varieties of the commodity should be selected.

3. Data for index numbers

The data, usually the set of prices and of quantities consumed of the selected commodities for different periods, places etc., are either obtained from a secondary source like standard trade journals, official publications, periodical special reports from the producers, exporters etc. or through the primary data collection. If the data is adopted from the secondary source one must have to check for the accuracy, comparability, sample representative etc. On the other hand if the second method is used one has to collect the data relating to the items under consideration. This done by obtaining the price quotations. The following things must be considered while obtaining the price quotations.

1. The selection of the place from which quotations have to be obtained is an important consideration. The method is choose the important markets for various commodities and select from them a moderate number (Pre-determined) of markets by the method of random sample. It is not necessary to select the same market of centres for all the commodities.
2. The second step is to selection of the dealers from whom the price quotations are to be obtained. Again this is done by the method of random samples, if possible select those dealers who supply most of the required items before the random sample is taken.
3. After deciding the market and dealers, the next things to specify the volume of the quotations. There will not have any general rule for this. The frequency of the quotation is generally decided upon by the nature of the index number we are going to construct. For e.g. if we are going to construct a weekly index number one quotation a week would be all right. If it is a monthly index then at least one quotation per week should be obtained. It is therefore clear that in no case a quotation at intervals of more than one week should be obtained for one commodity. After obtaining all the quotations they are averaged out to form a single quotation.
4. The method of quoting prices should be clearly specified. There are two methods in practice, one is to quote the in terms of units or commodity (money price) as Rs. 5 per Kg. And the other in terms of unit of money (commodity prices), as 8 gms a rupee. The former one is more logical and is uniformly adopted.

5. The type of prices to be quoted, whether wholesale or retail, is another important consideration and must be decided with reference to the type of index number which we are going to construct. Wholesale prices are more uniform and sensitive to slightest changes in the movement of economic forces effecting supply and demand. Retail prices shows a certain time lag particularly in their downward movement. Therefore wholesale prices are better choice for the general purposes index numbers and retail prices may be used in specific cases like the construction of cost of living index number, because it is the retail price which effects cost of living.
6. Finally one must be vary careful in choosing the enumerators for the collection work. Since they form the primary reporting agency, great care should be taken in their appointment, because the quality of the index number would ultimately depend upon the quality of the work done by the enumerators. They should be persons free from bias of any kind and must approach their task with objectivity.

4. Selection of Base Period

The period with which the comparisons of relative changes in the level of a phenomenon are made is termed as *base year* and the index for this period is always taken as 100. There are two type of base periods

1. Fixed base
2. Chain base

1. *Fixed base*: under this method a date is fixed as the base which is adhered to throughout in the construction of the index number. The following are basic criteria for the choice of the base period.
   (i) *The base period should be a normal period*. ie. A period free from all sorts of abnormalities or chance fluctuations such as economic boom or depression, labour strikes, wars, floods, earthquake etc.
   (ii) *The base period should not be too distant from the given period.*
2. *Chain base*: If comparison is desired from date to date a system of chain base is used. It simply consists in assuming the pervious date as the base and then calculate the indices on that basis.

5. Selection of Average and System of Weighting

The following are the averages commonly used for the construction of the index numbers

1. Arithmetic mean (A.M.): Simple and Weighted
2. Geometric Mean (G.M.): Simple and Weighted
3. Median

Use of Mean as an average. The arithmetic mean is widely used in the construction of index numbers. It is so simple that even a common man can easily understand it. But it has the following disadvantages

a. It is effected too much by the extreme items and gives larger weights to the bigger items. If one commodity increased or decreased too much in price the entire index is likely to be effected thereby.
b. It is an absolute measure and in index numbers we are concerned with relative changes. Hence, such a measure cannot be satisfactorily used in the construction of index numbers.

Use of Median as an average. The median though easiest to calculate and fairly easy to understand, completely ignores the extreme observations. Also it has the following disadvantages

a. If the number of items is small it is not a representative average. In index numbers the number of commodities is generally small, hence median is liable to be erratic.

b. Like arithmetic mean the median also is irreversible and hence does not reflect typical movements of prices or quantities.

Use of Geometric mean as average. From the theoretical consideration geometric mean is the most appropriate average to be used. The following are some merit of the G.M.

a. It makes the index number reversible so far as time is concerned.

b. The index constructed on G.M. posses circular property.

c. It enables the index number to give equal importance to equal ratio changes.

Weighting

Generally, various items or commodities included in the index are not of equal importance. So we attached weights to the items depending on their relative importance while calculating the index numbers. Thus we have two types of indices:

(i) *unweighted Indices*, in which no specific weights are attached to various commodities and

(ii) *Weighted Indices,* in which appropriate weights are assigned to various items. Weighting an index number makes it free from bias.

Basis of Weighting:- In scientific study we cannot assign weights arbitrary or by chance. That is we have to adopt some system of rational weighting based on some logic, which usually done on the basis of the purpose of the index numbers. The following are some of the quantities used as weights

1. The value (or quantity) produced or manufactured
2. The value (or quantity) sold or put for sale, or demanded
3. The value (or quantity) consumed.

Implicit or Explicit weights. Weights may be either (i) implicit weights or (ii) Explicit weights

(i) In implicit weighting the weights are not expressly laid, but they are implied by the nature of commodities selected. Under this system, a commodity which is to be given a greater weight is counted as many time as it is necessary to give the weight. Generally, the practice is that several varieties of that commodities are taken into account.

(ii) In explicit weighting, the weights are expressly laid down on the basis of some outward evidence of importance of items, e.g. the value of produce, or sale, or consumption, etc.

Fixed and Fluctuating Weights. The next problem now is whether weights should be fixed or fluctuating. If weights are allowed to vary from period to period, they give better measure of relative importance of items. That is an index number with fluctuating weight not only gives changes in the price but also of shifts in emphasis.

Method of Weighting

In the case of explicit weighting, where weights have to be laid down specifically, one of the following method is adopted.

(i) Weighted Average of Relatives Method or the Family Budget method

(ii) The Aggregate Expenditure Method.

(iii) Weighting by Fishers ideal Method.

Construction of Various Types of Index numbers

Let $X_1, X_2, \ldots, X_n$ be set of variables and let our interest be in studying the change in the values of these variables taken as whole at two point of time. Let $X_{10}, X_{20}, \ldots, X_{n0}$ be the value of $X_1, X_2, \ldots, X_n$ in the base period and $X_{1k}, X_{2k}, \ldots, X_{nk}$ be the values of the variable in the current period. Then the ratio $\frac{X_{ik}}{X_{jo}}, j = 1,2,...,n$ is called a *relative.* A weighted or unweighted average of this relative is called an Index Number.

Let p_0 denote the price of commodity in the base year and p_k that in the current year. Then $\frac{p_k}{p_0}$ is the relative. We also assume that q_0 and q_k as the quantities of goods in the current year and the base year.

Simple Index Number

The following are some simple index numbers in common use

1) **Simple Arithmetic Index Number**

The simple A.M. of the price relative expressed as a percentage is called simple A.M. Index number

$$\text{Simple A.M. Index Number} = \frac{1}{n}\sum \frac{p_k}{p_0} \times 100$$

2) **Simple Geometric Index Number**

The simple G.M. of the price relative expressed as a percentage is called simple G.M. Index number

$$\text{Simple G.M. Index Number} = \sqrt[n]{\prod \frac{p_k}{p_0}} \times 100$$

3) **Simple Aggregate Index Number**

This is defined as the ratio of the sum of the prices in the current year and base year expressed as a percentage.

$$\text{Simple aggregate index number} = \frac{\sum P_k}{\sum P_0} \times 100.$$

Weighted Index Numbers

Weighted index numbers are obtained by taking weighted. The following are some of the commonly used weighted index numbers.

1) Laspeyre's Index number

In this case we find the weighted A.M. of the price relatives taking p_0q_0 as the weight.

Laspeyre's Index number = $\frac{\sum p_k q_0}{\sum p_0 q_0}$ x 100.

2) Paasche's Index number

In this case we find the weighted A.M. of the price relatives taking p_0q_k as the weight.

Paasche's Index number = $\frac{\sum p_k q_k}{\sum p_0 q_k}$ x 100

3) Marshall and Edgeworth Index number

In this case we find the weighted A.M. of the price relatives taking the average of p_0q_0 and p_0q_k as the weight.

Marshall and Edgeworth Index number = $\frac{\sum p_k (q_0 + q_k)}{\sum p_0 (q_0 + q_k)}$ x 100

4) Fisher's Ideal Index number

The geometric mean of Laspeyre's and Paasche's Index number is called the Fisher's Ideal Index number.

Fisher's Ideal Index number = $\sqrt{\frac{\sum p_k q_0}{\sum p_0 q_0} x \frac{\sum p_k q_k}{\sum p_0 q_k}}$ x 100

Test to be Satisfied by a good Index Number

We have observed that there are many Index Numbers. Now the question is which one is better. To judge this we check weather the index numbers satisfies the following mathematical tests.

1. The Commodity reversal test
2. Unit test
3. Time reversal test
4. Circular test
5. Factor reversal test

1. The Commodity reversal test

An index number is said to satisfy this test if it remains unchanged even if the order in which the commodities are considered is changed. All the index numbers satisfies this test.

2. Unit test

If the index number is independent of the units in which the prices and quantities are expressed it is said to satisfy the unit test. All index numbers considered so far satisfies this test.

3. Time reversal test

Let I_{ok} denote the index number calculated with the period denoted by '0' as the base period and the period denoted by 'k' as the current and I_{k0} the index number calculated with the periods interchanged. The index number is said to satisfy the time reversal test if I_{0k} x I_{k0} = 1. Only the simple G.M. index number and Fishers Ideal Index number satisfies this test.

4. Circular test

This is another test for the adequacy of an index number. This test is based on the shiftability of the base and is an extension of the time reversal test. Let 0, 1 and 2 are three years and $I_{01,}$ I_{12} and I_{02} are the indices for year 1 with 0 as base year, year 2 with 1 as base year and year 2 with 0 as base respectively. The circular test is said to be satisfied if, $I_{01} \times I_{12} = I_{02}$ or $I_{01} \times I_{12} \times I_{02} = 1$. The index number considered so far only simple G.M. index number, aggregate index number and Fishers ideal number satisfies this test.

5. Factor reversal test

This test is applicable only to weighted index number. Let I_{pq} be the index number calculated with p denoting the price and q denoting the quantity and I_{qp} denote the index number obtained by interchanging p and q. The index number is said to satisfy this test if $I_{pq} \times I_{qp} = \frac{\sum p_k q_k}{\sum p_0 q_0}$. Only Fisher's ideal index number satisfies this test.

Classification of Index Numbers

1. *Price index numbers* which measure the general changes in the retail or wholesale price level of a particular commodity or group of commodities.
2. *Cost of living index numbers* are intended to study the effect of change in the price level on the cost of living of different classes of people.
3. *Quantity index numbers* which are indices to measure the changes in the quantity of goods manufactured in a factory, e.g. the indices of *industrial production* or *agriculture production.*

Limitations of Index Number

The following are some of the limitations of the index numbers

1. Since index numbers are constructed taking into account only a representative set of variates and also based on a set of values of the variates collected by sampling index numbers are subject to sampling errors.
2. Only quantitative characteristics can be considered in the construction of index numbers. So qualitative changes in the items are not reflected by index numbers.
3. There are different index numbers and the choice in any particular case is arbitrary. So errors can happen due to wrong choice.
4. Interested parties can misuse the index numbers and may manipulate so as to support their personal interests.
5. Errors may enter the collection of data.