DEPARTMENT OF STATISTICS,
GOVERNMENT ARTS COLLEGE, COIMBATORE – 641018

SUBJECT TITLE : TIME SERIES AND INDEX NUMBERS
SUBJECT CODE : 18 BST 23C
PREPARED BY : Dr. P. VASANTHAMANI
MOBILE NUMBER : 9994575462

UNIT III

INDEX NUMBERS

The first index was constructed in 1764 to compare the Italian price index in 1750 with the price level in 1500. Index numbers are used to feel the pulse of the economy and they have come to be used as indicators of inflationary or deflationary tendencies.

Definition: An index number is a statistical measure designed to show changes in a variable or a group of related variables or a group of related variables with respect to time, geographic location or other characteristics such as income, profession, etc. (Murray R.Spiegel).

Index number is a single ratio (usually in percentage) which measures the combined (that is, averaged) change of several variables between two different times, places or situations (A.M Tuttle).

The year for which index number is calculated is called the current year. The year with which the current year is compared is called the base year.

A price index number is the percentage of change, in the price of one commodity or one group of commodities in the current year compared with the base year. A similar calculation in quantity results in quantity index number.

Uses

1. Index numbers provide scope for comparisons. Price, production, value, etc. in two times are compared by index numbers.

2 Index numbers are Economic Barometers. The dictionary meaning of the word barometer is that it is an 'instrument measuring atmospheric pressure used for forecasting weather. Index numbers of whole sale prices, industrial production, agricultural production, etc. indicate the present condition of an economy compared with the past. Based on them, the direction in which the economy is likely to move is forecasted.

3. Index numbers serve as guides. Being economic barometers, the direction in which the economy is likely to move is foretold. Governments, Businessmen, Economists, etc. benefit by acting suitably.

4. Index numbers are the pulse of an economy. The condition of an economy is known from the index numbers of various economic activities.

5. Index numbers measure the purchasing power of money. for example, 20 mg. of gold may be available for Rs.100 on one occasion. If more than 20 mg. of gold is available for Rs. 100 subsequently, the purchasing power of money has increased. One the contrary, if less than 20 mg. of gold is available for Rs.100 subsequently, the purchasing power of money has [e]ased. Price and purchasing power move in opposite actions. Purchasing power is calculated as follows:

$$\text{Purchasing power of one rupee} = \frac{100}{Price\ Index}$$

6. Index numbers help to calculate real wages. When the real wage of a person increases, his standard of living increases. His standard of living decreases when his real wage decreases.

$$\text{Real Wage} = \frac{Money\ Wage}{Price\ Index\ or\ Cost\ of\ Living\ Index}\ X\ 100$$

7. Index numbers are deflators. Deflator is one which makes allowance for the change in the prices of commodities. Generally, the cost-of-living index numbers are used to revise the salaries, dearness allowance and other allowances so that wage - earners could maintain the same standard of living .

8. Index numbers are useful to formulate policies. Based on the relevant index numbers of suitable policies are framed by businessmen and economists. Governments and industrialists also use the prevailing conditions and benefit through planning.

TYPES OF INDEX NUMBERS

(i) Price Index Numbers

Price index is a 'Special type' of average which studies net relative change in the prices of commodities, expressed in different units. Here comparison is made in respect of prices. Price index numbers are wholesale price index numbers and retail price index numbers. Price index number are useful to comprehend and interpret varying economic and business conditions over time.

(ii) Quantity Index Numbers

This number measures changes in volume of goods produced, purchased or consumed. Here, the comparison is made in respect of quantity or volume. For example, the volume of agricultural goods produced, consumed, import, export etc.

(iii) Value Index

Value index numbers study the changes in the total value of a certain period with the total value of the base period. For example, the indices of stock-in-made, purchase, sales profit *etc.,* are analyzed here.

LIMITATIONS OF INDEX NUMBER OF PRICES:

The construction of index numbers creates some theoretical and practical problems. Since these problems cannot be accurately solved, the method of index numbers of prices loses its utility.

These problems are:

(a) Choice of a Base Year:

The first major problem is concerned with the choice of a base year. Two criteria for the selection of' base year are that it must show economic stability and it must not be too distant from the given year. The base period must not coincide with abnormally high or low prices. But it is very difficult to get a **'normal year'** free from any economic disturbances.

Further, if the base year is too distant from the current year, it is possible that the pattern of consumption may change considerably. New types of commodities may be introduced, and consumers may change over to these types of commodities which are not comparable with the similar types used in the base period.

(b) Problem of Averaging of Prices:

An index number is a summary measure. Thus, its usefulness decreases as it tries to describe a complex situation which is too wide in scope.

The arithmetic mean or any other form of averages becomes less and less representative. Such averaging is beset within certain technical difficulties. Some people recommend arithmetic mean while others recommend geometric mean. Proper method of averaging is, thus, not obtainable.

(c) Difficulty of Obtaining Correct Data:

Data or statistics collected are often unreliable and less accurate. As a result, estimates based on such data are bound to be unreliable.

(d) Difficulty in the Selection of Prices:

There are two prices—wholesale and retail. Should we select retail prices or wholesale prices? General Price index is based on the wholesale prices which are easy to collect. But as far as consumers are concerned, retail prices are more relevant.

While constructing index numbers of prices, retail prices should be taken into account. But it is difficult to collect reliable and accurate statistics relating to retail prices. Retail prices vary from market to market. Retail price index is, thus, difficult to construct.

(e) Difficulty in the Selection of Commodities and Choice of Weights:

The basket of goods and weights given to them are merely arbitrary. Basket of goods that are chosen is based on current spending habits and incomes of consumers. Different classes of people buy different kinds of goods. Therefore, it is difficult to choose all kinds of commodities.

However, to tackle this problem, we ought to construct a separate index number for the different groups of people. Even then, problem exists since most commodities are subject to frequent changes in quality. Where a price change suggests an

improvement in quality of the product one may face trouble in assessing the real nature of the price change.

Further, the compiler of the index number makes any arbitrary decision with regard to weighting. Now for two persons or households the assigned weight will be exactly the same. The chosen basket of goods is only applicable in the base year. But as incomes or tastes and fashions change, demand for goods changes. And weights assigned to these goods are likely to be arbitrary.

Despite its limitations, an index number is the most useful means of measurement of changes in the value of money—at least in the short run. It is merely an approximate indication of changes in the cost of living.

Even if a highly sophisticated statistical technique is employed to measure the changes in the value of money it will not be perfectly exact and accurate. Some sort of arbitrariness and inaccuracy will creep in. That is why it provides approximate indications.

General problems in the Construction of Index Numbers

The following aspects are to be carefully considered during the construction of an index number.

1. **The Purpose**. The purpose of the index number is to be clearly known. For whom it is meant, by whom it is to be used, etc. are to be spelt out. It is the purpose which will solve the other problems, such as choosing the suitable formula among the available formulae, deciding the reference or base period and the like. In short, it tells what are to be done and what are not to be done.

2. **The Base Period.** The period may be one year or a few years. The base

period is to be taken according to the purpose. If the impact of Five - Year Plan on the Indian economy is to be assessed, 1951 may be taken as the reference or the base year. Five - Year Plans were introduced in 1951. The condition of any subsequent year in relation with that shows how the country has progressed till that year from 1951. Generally, the base period should be as follows.

(i) It should be a normal period. There should not have been natural calamities such as famine, flood and earthquake, political upheavals, war, etc.

(ii) It should not be too short. In short periods, typical conditions might not be there. The price of a commodity, for example, might be very high during a very short time. The true condition is distorted if it is taken as the base period.

(iii) It should not be too distant in the past. This is to keep the index number useful.

It may be fixed period for all the different period under consideration. Or, under chain base method, link relatives which for every year the preceding year is the base year may be calculated first and then may be chained together to a Common base year. Link relatives may prove their use in **business** and industry when any year is to be compared with the year just preceding it. Whenever different years are to be compared among themselves (with a common base year), fixed base as well as chain base index numbers are useful.

3. **The items.** Including all the items in a study is neither feasible nor useful. Only those items which concern the people for whom the index number is intended are to be included. For considering the living conditions of people in hill stations, woolen clothes should be included. For people who live in hot places throughout the year woolen clothes are not at all necessary. For students pen and paper may be necessary. For Keralites umbrella may be necessary. Only items essential for the people concerned should be included.

4. **The Price Quotations.** The prices are to be properly gathered. For consumer price index number, retail prices are necessary. For whole-sale price indices, whole-sale prices are needed. The places from where the people concerned buy are to be considered. Even among them the typical ones might be selected. The difficulty is all the greater when the prices vary from locality to locality in the same town, from shop to shop in the same locality and from customer to customer in the same shop.

5. **The Average.** For arriving at the average value of a group of items, the suitable average is to be decided. In other contexts, A.M. may be more useful. It may be simple to understand and easy to calculate. Nowadays calculators may be available to show the A.M. Median and Mode may be obtained by mere inspection. But Geometric mean is the Preferable average due to the following reasons:

(i) G.M. is the appropriate average to measure relative changes. Hence, index numbers where in the relative changes are expressed as percentages, give scope for G.M.

(ii) It gives more weightage to smaller items and lesser weight to grater items. it is not as unduly affected as A.M by extreme items.

(iii) It facilitates the change of the base period. Base cannot be kept the same for a long time because the purpose and all-around changes may warrant a change in the base period .

6. Weighting. By unweighted method, equal weightage of unity is given to all the items. It may not be desirable because the items may not be equally important. The quantity purchased, the amount spent, etc. show the relative importance of the different items. Weighting may be explicit as follows-

(i) Base year quantity as in Laspeyre's method or current year quantity as in

Paasche's method for price index number.

(ii) Base year value (price **x** quantity) as in consumer price index number by Family Budget Method.

(iii) Some fixed weight based on neither base year quantity nor current year quantity but on some other consideration as in Kelly's method.

The decision on suitable method of weighting depends on the purpose and convention.

7. The Formula. As seen in the following pages, many formulae are available. Each one has its own advantages. If for a certain situation only one formula is suitable, there is no difficulty in using the formula. For certain other situations more than one formula may be found suitable. In such cases the purpose and the opinion of the experts in the field are the guides in choosing a formula.

Proper decision under each of those headings is bound to lead to a good index number.

METHODS OF CONSTRUCTING INDEX NUMBERS

Period is referred to as year hereafter and the following notations are used.

p_0 - price of a commodity in the base year.

p_1 - price of a commodity in the current year.

q_0 - quantity of a commodity in the base year.

q_1 - quantity of a commodity in the current year

p - price of a commodity,

q - quantity of a commodity.

V or W - weight of a commodity.

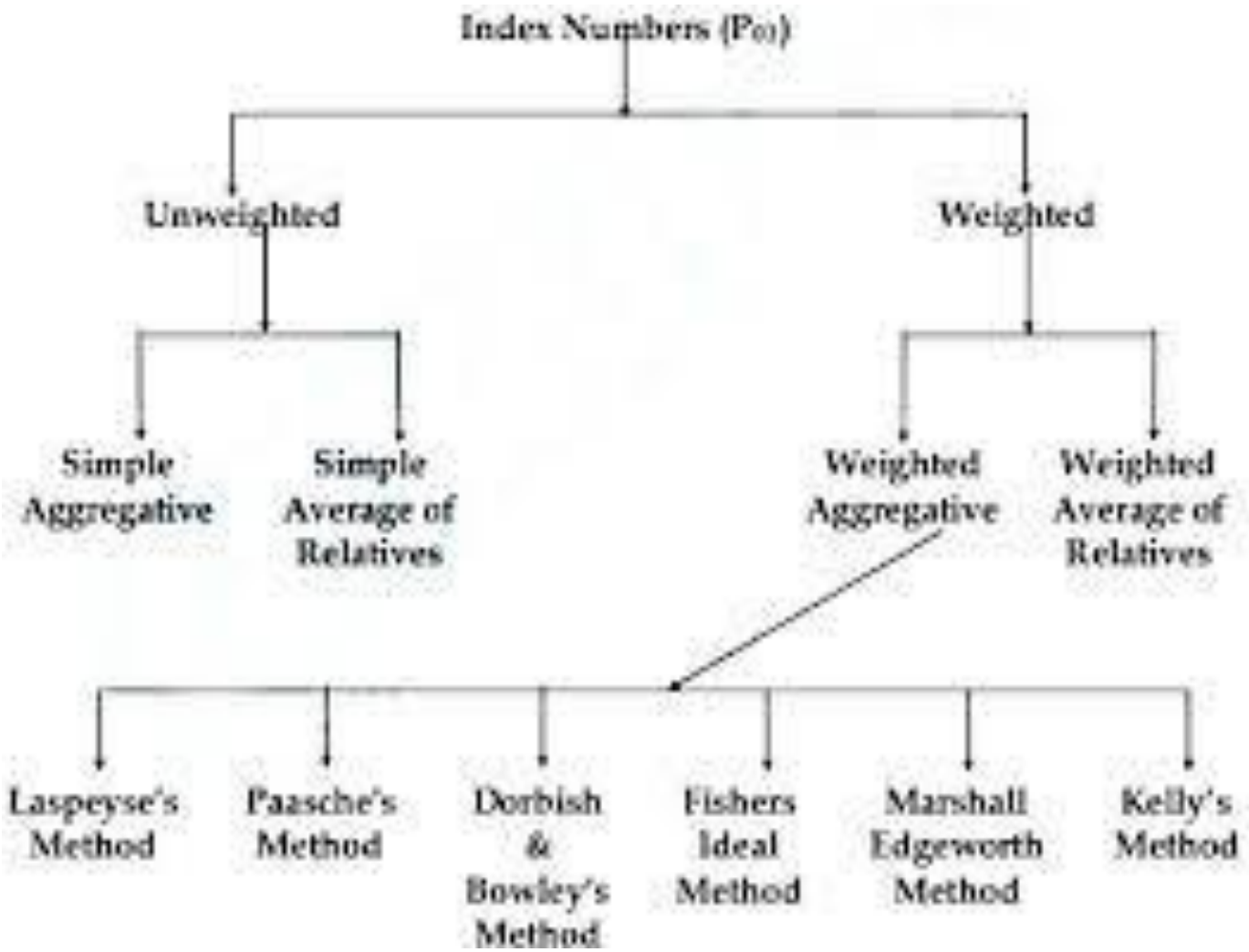
I or P - price relative or price index number of a commodity.

Q - quantity relative or quantity index number of a commodity.

$$P = \frac{P_1}{P_0} X\ 100 \qquad Q = \frac{q_1}{q_0} X\ 100$$

P_{01} - price index number of the current year compared with the base year.

Q_{01} - quantity index number of the current year spared with the base year.



UNWEIGHTED INDEX NUMBERS

1- Simple or Unweighted Aggregative Method.

This is the simplest method of constructing index numbers.

It is based on the aggregates or the totals as shown below

$$P_{01} = \frac{\sum P_1}{\sum p_0} X\ 100$$

It may be noted that the current year figure is in the numerator while the base year figure is in the denominator as in the other methods when the index number of the current year as compared to the base year is calculated.

When quantity index number is required $Q_{01} = \frac{\sum q_1}{\sum q_0} X\ 100$

The calculation is illustrated together with the simple average of relatives method.

The drawbacks of this method are :

(i) It does not satisfy even unit test which is explained later. The defect is due to the fact that the unit prices are added as such even though the units of measurements are different such as kg, meter, liter, etc.

(ii) It does not distinguish between the commodities with regard to their relative importance.

2. Simple or Unweighted Averages of Relatives Method. The price relatives, P, for price index number and the quantity relatives, Q, for quantity index number are calculated and their A.M. or G.M. is found.

Price Index (P_{01})

(i) Using A.M., $P_{01} = \frac{\sum P}{N}$

(ii) Using G.M., P_{01} = Antilog $\frac{\sum \log P}{N}$

Both these formulae can be found to satisfy unit test.

Example 1 : From the following data construct an index for 1995 taking 1994 as base.

Commodities	A	B	C	D	E
Price in 1994 (Rs.)	50	40	80	110	20
Price in 1995 (Rs.)	70	60	90	120	20

Solution

Commodities	Price		$P=\frac{P_1}{P_0} X\ 100$	log P
	1994 (P0)	1995(P1)		
A	50	70	140.00	2.1461
B	40	60	150.00	2.1761
C	80	90	112.50	2.0512
D	110	120	109.09	2.0378
E	20	20	100.00	2.0000
Total	$\Sigma P_0=300$	$\Sigma P_1=360$	$\Sigma P=611.59$	$\Sigma(\log P)=10.4112$

By Aggregative Method,

$P_{01} = \frac{\sum P_1}{\sum P_0} \times 100 = \frac{360}{300} \times 100 = 120$

By simple weighted averages method

$P_{01} = \frac{\sum P}{N} = \frac{611.59}{5} = 122.32$ USING A.M.,

$P_{01} =$ Antilog $\left(\frac{\sum \log P}{N}\right) =$ Antilog $\left(\frac{10.4112}{5}\right) = 120.84$ USING G.M.

Note : Although any one of them is sufficient, all the three possible indices have been calculated for the sake of illustration. When the index number is required by only one method as in this problem, the preferable method is simple A.M. and the answer is **$P_{01} = 122.32$**

P_{01} = 122.32 indicates that the prices, on the average, have increased 22.32% in the current year compared with the base year.

Whenever the price index number is less than 100, it indicates that the prices, on the average, have decreased in the current year compared with the base **year.**

Compute price index based on the simple average of price relatives by using arithmetic mean.

Commodity	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Price in 1997 (in Rs.)	40	120	140	130	60	70	65	75
Price in 1998 (in Rs.)	60	140	170	135	100	80	75	80

Solution

Com.	**Price in Rs.**		**Price Relatives** $\left(\mathbf{P} = \frac{P_1}{P_0} X\ \mathbf{100}\right)$
	1997 (P_0)	**1998 (P_1)**	
A	40	60	150.00
B	120	140	116.67
C	140	170	121.43
D	130	135	103.85
E	60	100	166.67
F	70	80	114.29
G	65	75	115.38
H	75	80	106.67

Price Index Number by Simple Average of Price Relatives Method.

$$P_{01} = \frac{\sum P}{N} = \frac{994.96}{8} = 124.3$$

From the following data, construct an index for 1999 taking 1998 as base.

Commodities	Price in 1998 (Rs.)	Price in 1999 (Rs.)
A	50	70
B	40	60
C	80	90
D	110	120
E	20	20

Solution

Comm.	Price (Rs.)		Price Relative ($P = \frac{P_1}{P_0} \times 100$)	Price Index Number
	1998 (P_0)	1999(P_1)		
A	50	70	140.00	$P = \frac{\sum P}{N}$ $\frac{611.59}{5}$ =122.32
B	40	60	150.00	
C	80	90	12.50	
D	110	120	109.09	
E	20	20	100.00	

Note ; Method has not been specified. Hence, simple average method gas been used.

If the method had been specified as simple aggregative method

$$P = \frac{\sum P_1}{\sum P_0} X\ 100 = \frac{360}{300} \times 100 = 120$$