Index Numbers and Moving Averages

INDEX NUMBERS

The value of money is going down, we hear everyday. This means that since prices of things are going up, we get lesser and lesser quantities of the same item for a rupee. The workers say the increases in wages are not keeping up with inflation, and so actual wages are going down — or that standard of living is going down. People in Delhi say that property prices have skyrocketed, compared to cities like Kolkata and Chennai, or even Hong Kong. Similarly, crime rate in Delhi is increasing, even outstripping increase in population. In all these cases, we are making comparisons, either in terms of time, or in terms of geographic locations. This leads us to define a very useful and widely used statistic—the index number. An index number is simply a ratio of two quantities, such as prices, values or other economic variables taken at two different periods of time. Thus, it helps to compare the change with similar data collected in the *base period* or *fixed period.*

Index number *is a specialised average designed to measure the change in the level of an activity or item, either with respect to time or geographic location or some other characteristic.* It is described either as a ratio or a percentage. For example, when we say that consumer price index for 2008 is 175 compared to 2001, it means that consumer prices have risen by 75% over these seven years.

Study of index numbers reveals long term trends also. By using suitable time frame to calculate index numbers, we can find seasonal variations, cyclical variation, irregular (or abnormal) changes and long term trends of any activity - whether it is sale of ice-cream, or absence from school, or literacy level in a district, or unemployment problem, or sale of Ambassador cars by Birlas, and so on.

Wholesale Price Index (WPI) and ***Consumer Price Index (CPI)*** are widely used terms. They indicate the inflation rates, and also changes in standard of living. Consumer price index is based on prices of five sets of items — Food, Housing (Rent), Household goods, Fuel and light, and Miscellaneous. Each item is based on study of a number of items — *e.g.* Food includes Rice, Wheat, Dal, Milk, and so on.

Thus, the **characteristics of index** numbers are :

— they are expressed as ratio or percentage.

— they are specialised averages.

— they measure the change in the level of a phenomenon.

— they measure the effect of change over a period of time.

— they measure changes not capable of direct measurement *i.e.* they measure relative changes in an economic activity by measuring those factors which affect that activity.

Uses of Index Numbers

Index numbers are important tools of business and economic activity. Their main uses are :

1. They are used to feel the pulse of the economy. Thus, the index numbers work as *barometers of economic activity.*
2. They help in framing suitable policies and take decisions relating to wages, prices, consumption etc.
3. They reveal trends and tendencies. They are used as indicators of inflationary or deflationary tendencies.
4. They are used to measure the purchasing power of money.
5. They help in forecasting future economic activity.

Classification of Index Numbers

According to the activity they measure, the index numbers are classified as

(*i*) Price indexes (*ii*) Quantity indexes

(*iii*) Value indexes (*iv*) Special purpose indexes.

Price indexes measure changes in some price characteristic. Wholesale price index and consumer price index are two examples of Price indexes.

Quantity indexes measure changes in some quantity (volume) characteristic, for example, index of Industrial production, or index of scooters sold.

Value indexes measure change in some criterion of value, while **Special Purpose indexes** are constructed from time to time to measure certain special characteristic.

Problems in the construction of Index Numbers

The following points should be kept in mind while constructing index numbers.

(*i*) *Defining the purpose of the Index clearly.* There is no all-purpose index. If you are constructing a consumer price index, then don't include wholesale prices, and so on.

(*ii*) *Selecting base year (or base period) carefully.* The period against which relative change is to be measured should be chosen carefully. It should not be too distant in the past. It should be normal period - free of abnormalities like wars, floods, epidemics etc. Sometimes, instead of a fixed base, the *chain base method* may be used, for example, where the prices of a year are linked to the previous year and not with the fixed year.

(*iii*) *Selecting the numbers of items to be included.* As every item cannot be included, only the relevant and representative items should be chosen. Also items should be standardised so that after a time lapse they can be easily identified.

(*iv*) *Selection of price quotations and choice of places.* Once the items and their number has been decided, the locations (markets, shops) should be selected carefully so that a representative sample of price quotations can be obtained.

(*v*) *Choice of an average.* Since index numbers are specialised averages, we have to decide which average (arithmetic mean, median, mode, geometric mean or harmonic mean) is to be used while constructing the index. Though geometric mean gives best results, usually arithmetic mean is used to save calculation work.

(*vi*) *Selection of appropriate weights.* Since different items are consumed in different quantities, suitable weights may be used to reflect the relative importance of different items.

Methods of construction of Index Numbers

If only one item is involved and its two different values are given at two different times (or places etc.), then index number is simply the ratio of two numbers, expressed as a percentage. For example, if in 1990, only 2 lac cars were registered, and in the year 2000, ten lac cars were registered, then the (quantity) index is $\frac{10 \text{ lac}}{2 \text{ lac}} \times 100 = 500$. Similarly, if in

Mumbai the commercial space rent is \$1 per sq. foot per month, while in New York it is \$2·50 per sq. foot per month, then index of rental of New York compared to Mumbai is $\frac{2 \cdot 50}{1 \cdot 00} \times 100 = 250$.

Generally instead of one item, rates of a number of items are given, for current year as well as for base year. Sometimes different weights, or quantities are also given for those items. There are a number of ways to calculate index numbers in such cases.

Index number

- **Unweighted**
  - **Simple Aggregative**
  - **Simple Average of price relatives**
- **Weighted (or Arithmetic Mean method)**
  - **Weighted Aggregate**
  - **Weighted average of price relatives**

(*i*) **Simple aggregative method**

If Σp_1 is the sum total of current prices of commodities under consideration, and Σp_0 is the sum total of prices of these commodities in the base year, then the price index number for the current year is

$$P_{01} = \frac{\Sigma p_1}{\Sigma p_0} \times 100$$

(*ii*) **Simple average of price relatives method**

Price Relative means the ratio of price of a certain item in current year to the price of that item in base year, expressed as a percentage *i.e.* Price Relative $= \frac{p_1}{p_0} \times 100$.

For example, if a colour TV cost ₹ 12000 in 1995 and ₹ 18000 in 2008, the price relative is $\frac{18000}{12000} \times 100 = 150$.

When a number of items are involved, we first calculate the price relative of each item and then simply take their average to calculate the index number. Thus, the formula for computing price index using this method is

$$P_{01} = \frac{\Sigma\left(\frac{p_1}{p_0} \times 100\right)}{N},$$ where N is the number of items.

Sometimes, to simplify calculations, the following form is used :

$$P_{01} = \left(\Sigma \frac{p_1}{p_0}\right) \times \frac{100}{N} \quad \text{or} \quad \frac{1}{N} \; \Sigma\left(\frac{p_1}{p_0} \times 100\right)$$

(*iii*) **Weighted aggregate method**

If along with base prices, and current prices of a number of items, the weights or quantities of each are given, then index number based on weighted aggregates is given by

$$P_{01} = \frac{\Sigma\, p_1 w}{\Sigma\, p_0 w} \times 100$$

(*iv*) **Weighted average of price relatives method**

This is the commonly used method to construct consumer or wholesale price index when base and current prices of a number of items, along with weights or quantities are given. Weighted average of price relatives is given by

$$P_{01} = \frac{\Sigma\left(\frac{p_1}{p_0} \times 100\right) \times w}{\Sigma w}, \text{ or}$$

$$P_{01} = \frac{\Sigma I w}{\Sigma w}, \text{ where } I = \frac{p_1}{p_0} \times 100, \text{ the price relative.}$$

MOVING AVERAGES

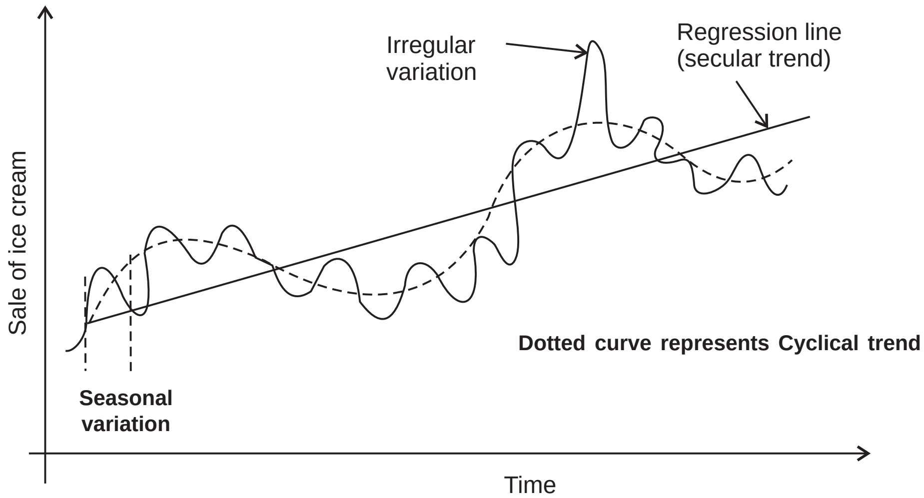
Consider the following data : monthly sale of ice cream in last one year ; annual rainfall in last 20 years ; weekly price index for last 52 weeks. This type of data, where observations are taken at specified times is called **time series.** Usually, equal intervals are used. Many times, long term or short term analysis of time series is required. Long term trend, called *secular trend,* is usually calculated by finding regression line,

$$y - \bar{y} = b_{yx} (x - \bar{x}).$$

There are three other kinds of variations which are important:

1. **Seasonal variation.** For example, sale of soft drinks and ice creams is higher in summer than in winter ; crockery sales are higher in festival season (diwali, christmas etc.) than at other times, and so on.
2. **Cyclical variation.** You must have heard about rise and fall of Roman empire. In fashion magazines, you read about rise and fall of hemlines. Share markets rise, fall, rise, fall like a yoyo. Only thing is we are not sure about the duration of the cycle (otherwise we would be millionaires!), but such cyclical trends are found in many time series.
3. **Irregular variations.** With sudden ban on mustard oil, Soya oil shows a marked, irregular upward sales. With announcement of elections, there is unusual rise in income of printing presses. With floods, there is irregular fall in crop yield. Such *spikes* in data can be attributed to some unusual phenomenon.

Above analysis shows that for analysis of data or for prediction, regression lines may not always be useful.



Basically analysis/prediction requires "smoothening of curve".

Purpose of moving averages

Moving averages are used in cyclical variations to eliminate fluctuations due to cyclical changes in time series. The cyclical variations are smoothened by averaging the values for the variate for a specified number of successive years (months or weeks etc.). The number of years (months or weeks etc.) over which the values are averaged depends upon the length of the cycles found in the time series. The time-interval over which the averages are taken is called the **period** of the cycle.

Method for finding moving averages

The average value for a number of years (months or weeks etc.) is taken and placed against the middle of the period. If the period taken is equal to the length of one cycle (or two cycles, or more cycles), then this results in elimination of cycles.

If $x_1, x_2, x_3, \ldots, x_n$ is the given annual time series, then

(*i*) 3-yearly moving averages are

$$\frac{x_1+x_2+x_3}{3}, \frac{x_2+x_3+x_4}{3}, \frac{x_3+x_4+x_5}{3}, \ldots \text{ which are placed}$$

against years 2, 3, 4, … respectively.

(*ii*) 5-yearly moving averages are

$$\frac{x_1+x_2+x_3+x_4+x_5}{5}, \frac{x_2+x_3+x_4+x_5+x_6}{5}, \ldots \text{ which are placed}$$

against years 3, 4, … respectively.

(*iii*) 4-yearly moving averages are

$$\frac{x_1+x_2+x_3+x_4}{4}, \frac{x_2+x_3+x_4+x_5}{4}, \ldots \text{ which are placed}$$

against years 2·5, 3·5, … respectively. Further, to synchronise time frame for moving averages and original data, we have to average every two moving averages; average of first and second moving average in this case would be placed against $\frac{2\cdot5+3\cdot5}{2}$ = 3rd year; average of second and third moving average would be placed against $\frac{3\cdot5+4\cdot5}{2}$ = 4th year, and so on.

This is called **4-yearly centred moving average.**

Note. If the period is even, then the centred moving average is to be found out.

Following examples will make the above concept very clear.

ILLUSTRATIVE EXAMPLES

Example 1. *(i) Obtain the three year moving averages for the following series of observations.*

Year	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*
Annual Sales (In 0000 ₹)	*3·6*	*4·3*	*4·3*	*3·4*	*4·4*	*5·4*	*3·4*	*2·4*

(ii) Obtain the five year moving average.

(iii) Construct also the 4-year centred moving average.

Solution. (*i*) First 3-year moving average is $\frac{3 \cdot 6 + 4 \cdot 3 + 4 \cdot 3}{3} = \frac{12 \cdot 2}{3} = 4 \cdot 067$, and is placed against 2nd year *i.e.* 1996; second 3-year moving average is $\frac{4 \cdot 3 + 4 \cdot 3 + 3 \cdot 4}{3} = \frac{12 \cdot 0}{3} = 4 \cdot 0$, and is placed against 3rd year *i.e.* 1997, and so on. Thus, we have :

Calculation of 3-year moving averages :

Year	*Annual sale*	*3-year moving total*		*3-year moving average*
1995	3·6	–	1/3	–
1996	4·3	12·2	⟶	4·067
1997	4·3	12·0	⟶	4·00
1998	3·4	12·1	⟶	4·03
1999	4·4	13·2	⟶	4·40
2000	5·4	13·2	⟶	4·40
2001	3·4	11·2	⟶	3·73
2002	2·4	–		–

(*ii*) First 5-yearly moving average is $\frac{3 \cdot 6 + 4 \cdot 3 + 4 \cdot 3 + 3 \cdot 4 + 4 \cdot 4}{5} = \frac{20 \cdot 0}{5} = 4 \cdot 00$, and is placed against 3rd year *i.e.* 1997. Second 5-yearly moving average is $\frac{4 \cdot 3 + 4 \cdot 3 + 3 \cdot 4 + 4 \cdot 4 + 5 \cdot 4}{5} = \frac{21 \cdot 8}{5} = 4 \cdot 36$, and is placed against 4th year *i.e.* 1998, and so on. Thus, we have :

Calculation of 5-year moving averages :

Year	*Annual sale*	*5-year moving total*		*5-year moving average*
1995	3·6	–		–
1996	4·3	–	1/5	–
1997	4·3	20·0	⟶	4·00
1998	3·4	21·8		4·36
1999	4·4	20·9		4·18
2000	5·4	19·0		3·80
2001	3·4	–		–
2002	2·4	–		–

(*iii*) In the 4-year moving averages, the first step of averaging of 4 values each results in placing these in between years — so we take averages of each two successive moving averages to synchronise them with given time frame. Thus, we have the following table :