STA 3050: TIME SERIES AND FORECASTING

ESTIMATING SEASONAL INDICES

In a time-series, seasonal variation may exist if data are recorded quarterly, monthly, daily and so on. The main objective of the analysis of seasonal variations are

i. We analyze the seasonal variations to get an idea of the relative position of the phenomenon under study in each season and it helps us to identify the forces behind the seasonal variations so that we can plan for the season.
ii. The estimation of seasonal variations is also necessary to eliminate the seasonal effect from the time series data so we can see better patterns of the time series such as trends. This technique is called deseasonalised data.

Seasonal variation is measured in terms of an index, called a seasonal index. It is an average that can be used to compare an actual observation relative to what it would be if there were no seasonal variations. An index value is attached to each period of the time series within a year. This implies that if monthly data are considered there are 12 separate seasonal indices, one for each month.

There are various methods of estimating seasonal variations. We list some of the most popular methods as follows:

1. Simple average method
2. Ratio to trend method
3. Ratio to moving average method

We will discuss one at a time in the subsequent sections.

SIMPLE AVERAGE METHOD

When we discuss the methods of measuring seasonality, the method of simple average is the simplest of all. This method is based on the basic assumption that the data do not contain any trend and cyclic components and consists of eliminating irregular components by averaging the monthly (quarterly) values over the years. These assumptions may or may not be true since most of the economic or business time series exhibit trends.

This method consists of the following steps:

Step 1: If the time series data is given monthly or quarterly of different years, then we, first of all, arrange the data by months, quarters, etc. of different years in such a way that the months, quarters, etc. lie in rows and years in columns or vice-versa (see Example 1).

Step 2: After arranging the time series data, we compute the average $(\bar{y}_i)$ of each month or quarter in different years which eliminates the irregular fluctuations. These averages are known **season indices.** For example, if we have quarterly data for three years, say, 2020,2021 and 2022, then we compute the average of the ith quarter (Q_i) as

$$\bar{y}_i = \frac{Q_i(2020) + Q_i(2021) + Q_i(2022)}{3}$$

Step 3: Each seasonal index has a base index of 100. Therefore, the average of all seasonal indices will always be 100. In other wards, the sum of the seasonal indices will be 400 for quarterly data and 1200 for monthly data. So we calculate the grand average of these averages . For example, if we have quarterly data then we can compute the grand average as

$$\bar{y} = \frac{\bar{y}_1 + \bar{y}_2 + \bar{y}_3 + \bar{y}_4}{4}$$

where $\bar{y}_1, \bar{y}_2, \bar{y}_3$ and $\bar{y}_4$ are the averages of the first, second, third and fourth quarters, respectively. If we have monthly data, then we can compute the grand average as

$$\bar{y} = \frac{\bar{y}_1 + \bar{y}_2 + \ldots + \bar{y}_{12}}{12}$$

Step 4: If the average of all seasonal indices is not 100, then we normalise them so that their mean should be 100. For that, we find the adjusted seasonal indices by expressing each seasonal index as the percentage of the average of seasonal indices as

$$\text{Adjusted seasonal index} = \frac{\text{Seasonal index}}{\text{Average of seasonal index}} \times 100$$

That is, after calculating the grand average, we express each average as the percentage of the grand average $\bar{y}$. These percentages are known as **adjusted seasonal indices.** We can compute the ith seasonal index (Si) as

$$S_i = \frac{\bar{y}_i}{\bar{y}} \times 100$$

Interpretation of seasonal index

Each (adjusted) seasonal index measures the average magnitude of the seasonal influence on the actual values of the time series for a given period within the year and it measures how a particular season compares on average to the mean of the cycle. For example, if the seasonal index of the season (April-June) of the sales of AC of a particular company is 170.5. It means that the sale of AC in that season, on an average, is 70.5 (170.5-100) times higher than the average. If the seasonal index for the season (October-December) is 75 then it indicates that the sale of AC in that season, on an average, is 25 (100-75) times below the average and the company may be depressed by the presence of seasonal forces by approximately 25%. Alternatively, the AC sales would be about 25% higher if seasonal influences had not been present.

After understanding various steps of computing seasonal indices using the simple average method and how to interpret these, let us take an example to apply this method.

Example 1: The marketing manager of an electricity company recorded the following quarterly (seasonally) demand levels for electricity (in 1000 megawatts) in a city from 2019 to 2022.

Season	2019	2020	2021	2022
Summer	70	101	120	135
Monsoon	52	64	75	82
Winter	22	24	30	34
Spring	31	45	49	50

(i) Calculate the seasonal index for each season by assuming that there are no trend and cyclic effects.

(ii) Plot seasonal indices and original data on the same graph.

(iii) Also, interpret the seasonal indices.

Solution: Since there is no trend effect so we can apply simple average method to obtain seasonal indices. Since the electricity demand is recorded quarterly, therefore, we compute the average $\overline{y}_i$ of each season/quarter as follows:

$$\overline{y}_1 = \frac{70+101+120+135}{4} = 106.5,\ \overline{y}_2 = \frac{52+64+75+82}{4} = 68.25$$

$$\overline{y}_3 = \frac{22+24+30+34}{4} = 27.5,\ \overline{y}_4 = \frac{31+45+49+50}{4} = 43.75$$

After calculating the quarterly averages, we calculate the grand averages of all quarterly averages as

$$\overline{y} = \frac{\overline{y}_1+\overline{y}_2+\overline{y}_3+\overline{y}_4}{4} = \frac{106.5+68.25+27.5+43.75}{4} = 61.5$$

We now calculate the adjusted seasonal indices by expressing each average as the percentage of the grand average one by one for all i = 1, 2, 3, 4. i.e.

Seasonal index for summer $= \frac{106.5}{61.5} \times 100 = 173.17$

Seasonal index for monsoon $= \frac{68.25}{61.5} \times 100 = 110.98$

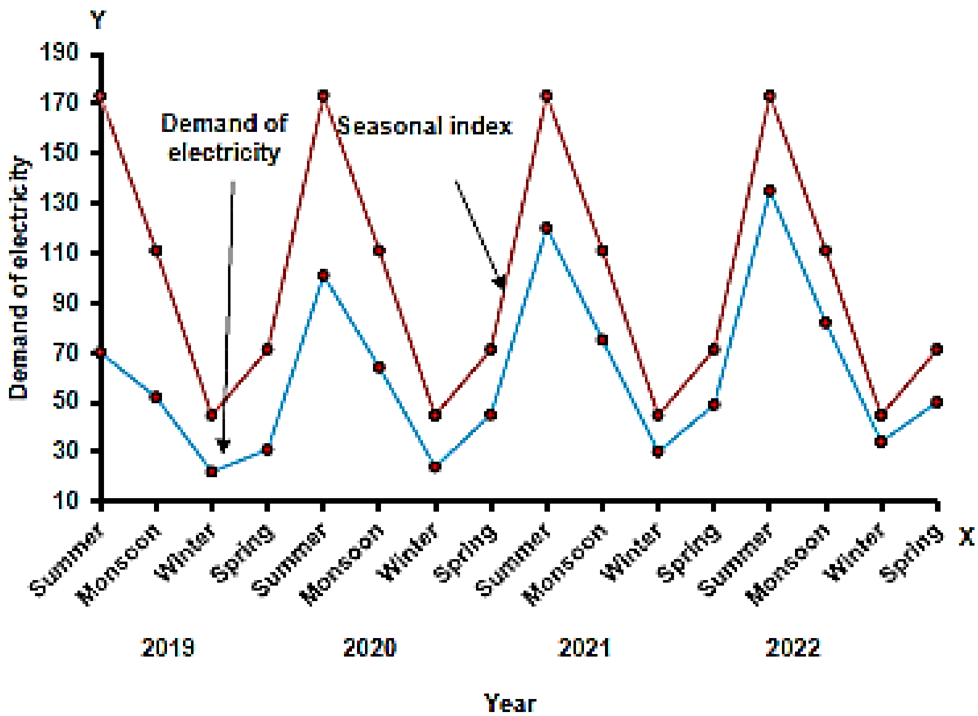
Seasonal index for winter $= \frac{27.5}{61.5} \times 100 = 44.72$

Seasonal index for spring $= \frac{43.75}{61.5} \times 100 = 71.14$

We can arrange these in a table as follows:

Season	2019	2020	2021	2022	Seasonal Index	Adjusted Seasonal Iindex
Summer	70	101	120	135	106.5	173.17
Monsoon	52	64	75	82	68.25	110.98
Winter	22	24	30	34	27.5	44.72
Spring	31	45	49	50	43.75	71.4
Average					61.5	100

We now plot the demand of electricity and seasonal indices on the graph paper as shown below:



Interpretation

The adjusted seasonal indices for summer and monsoon seasons are 173.17 and 110.98, respectively. They indicate that the demand of electricity in these seasons on an average are 173 (173.17 – 100) and 11 (110.98 – 100) times higher than the average, respectively. Similarly, the seasonal indices for the winter and spring seasons are 44.72 and 71.4, respectively. They indicate that the demand of electricity on an average are 55.28(100 – 44.72) and 28.6 (100 – 71.4) times below the average, respectively. We can say that the demand of electricity would be about 55.28% and 28.6% higher in both seasons if seasonal influences had not been present.

After understanding the simple average method and how to calculate seasonal indices, we now discuss the merits and demerits of this method.

Merits and Demerits

- It is a simplest method of measuring seasonal variations.
- This method is based on the unrealistic assumption that the trend and cyclical variations are not present in the time series data. These assumptions are not met in most of the economic or business time series because they generally exhibit trends.

EXERCISE 1

The sales manager of a company recorded the monthly sales (in thousands) of a product for the years 2020, 2021 and 2022 and are given as follows:

Months	Sales		
	2010	2011	2012
January	120	150	160
February	110	140	150
March	100	130	140
April	140	160	160
May	150	160	150
June	150	150	170
July	160	170	160
August	130	120	130
September	110	1360	100
October	100	120	100
November	120	130	110
December	150	140	150

Obtain the monthly seasonal indices assuming that there is no trend and cyclic effects.