

Times Series Analysis

Forecasting: involves predicting the future. Forecasting can be made by examining what has happened in the past with the population and assuming that the pattern of behaviour observed in the past will be repeated in the future e.g. use regression analysis.

Time Series Analysis: involves the analysis of data, which is arranged in order on the basis of time. Time series analysis involves the following methods, which can be used to make predictions (forecasts).

1. Moving Averages

This time series method makes predictions by calculating a set of averages based on the given data.

Example (n = 3)

Suppose data was collected on the sales of a business for the first six months of a year. If $n = 3$ where n = the number of previous months used for calculating the average.

Sales predictions will be based on the average of the previous 3 months sales.

$$\text{July prediction} = \frac{\text{AprilSales} + \text{MaySales} + \text{JuneSales}}{3}$$

Example (n = 4)

Suppose data was collected on the sales of a business for the first eight months of a year. If $n = 4$ where n = the number of previous months used for calculating the average.

Sales predictions will be based on the average of the previous 4 months sales.

$$\text{Sept prediction} = \frac{\text{MaySales} + \text{JuneSales} + \text{JulySales} + \text{AugSales}}{4}$$

The table below shows sales figures over a 12 month period and also shows moving average forecasts for various values of n .

Month	Sales	Moving Average Forecasts (n = 1)	Moving Average Forecasts (n = 2)	Moving Average Forecasts (n = 3)	Moving Average Forecasts (n = 4)
Jan	49	X	X	X	X
Feb	46		X	X	X
Mar	45			X	X
Apr	42				X
May	38				
Jun	40				
Jul	45				
Aug	40				
Sept	38				
Oct	28				
Nov	30				
Dec	32				

Note:

1. For a given value of n, predictions will start for the (n+1) month.

Limitations of Moving Average Method: Look at the table above when n = 4

1. Some data is unused in the forecasts, e.g. the forecast for December makes no use of the data from January to July.
2. All data is weighted the same – the sales value for June is treated the same way as the sales figure for January. This can have the effect of hiding seasonal factors such as the importance of the time of the year when sales figures can be extremely HIGH (LOW) during particular months.

2. Exponential Smoothing

This time series method is used to make predictions in unpredictable situations where there is no trend with the data overtime.

Formula: LEARN

$$\text{New Forecast} = \text{Old Forecast} + k(\text{Old Actual} - \text{Old Forecast})$$

Where $0 < k < 1$

New Forecast (For Month of Interest)

Old Forecast (For Previous Month)

Old Actual (For Previous Month)

Example 1: The table below shows sales over an eight week period. Predict the weekly sales using exponential smoothing with $k = 0.3$.

Week No.	Actual Sales	Predicted Sales
1	4500	X
2	4000	
3	3800	
4	4600	
5	4600	
6	4200	
7	3600	
8	4100	

Note:

1. No predicted sales can be calculated for the first week, since there is no previous week's sales figure to use in the formula.
2. Predicted sales for the second week will always be equal to the actual sales for the first week, since the old forecast for the 1st week does not exist.
3. Predicted sales for the third week will be calculated by using the formula.

Example 2: The table below shows sales over a twelve month period. Predict the monthly sales using exponential smoothing with $k = 0.3$.

Month	Sales	Predicted Monthly Sales
Jan	49	X
Feb	46	
Mar	45	
Apr	42	
May	38	
Jun	40	
Jul	45	
Aug	40	
Sept	38	
Oct	28	
Nov	30	
Dec	32	

Note:

1. No predicted sales can be calculated for January, since there is no previous month's sales figure to use in the formula.
2. Predicted sales for February will always be equal to the actual sales for January, since the old forecast for January does not exist.
3. Predicted sales for March will be calculated by using the formula.

Time Series Analysis: involves studying both the **long term trend + the seasonal variations**. The long term trend examines the data for the tendency to rise / to fall / to remain constant. Seasonal variations are short term fluctuations.

Example:

A publican examining his business would use the LONG TERM TREND to decide if his profits were generally increasing and would identify as a SEASONAL VARIATION the differences between Saturday night sales and Monday night sales in his business.

Note:

It is important in Time Series Analysis to separate the different sources of variation – the long term variations from the seasonal (short term) variations.

3. Seasonally Adjusted Forecasts

Remember the aim of the regression line is to explain the relationship between the independent and dependent variables given a set of data. It is used to find the general trend between the variables, however it does not explain short - term variations in the data.

Using time series data, it is useful to know the seasonal variations, which take place in the data when making future predictions. Such predictions are called *seasonally adjusted forecasts* (predictions).

Method: To Make Seasonally Adjusted Forecasts

X = Independent Variable = Time Y = Dependent Variable. E.g. Sales

Given: Set of ***quarterly*** data values over a certain number of years.
The equation of the regression line.

1. Use the given regression line equation, to predict values of the dependent variable for each quarter over the given time period.
2. Calculate the % variation of the actual data values from their corresponding predicted values.

Formula: % Variation = $\left(\frac{\text{Actual Value}}{\text{Predicted Value}} \right) \times \frac{100}{1}$
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3. Calculate the average variation over the given time period for each quarter.
ie. Find the average variation between actual and predicted values for the 1st quarter, for the 2nd quarter for so many years etc.
4. Seasonally Adjusted Forecast for any Quarter =
(Predicted Value from the Regression Line) × Average % Variation for that Quarter

Example 1:

Below is tabulated the sales of a particular item for each quarter over a 3 year period.

Year	Jan – Mar	Apr – Jun	Jul – Sept	Oct – Dec
2003	125	320	620	290
2004	210	420	750	310
2005	230	390	770	480

Given the regression line plotting sales with time is given by **$Y = 287 + 18.4X$** . Determine the seasonally adjusted forecasts for the first four quarters in the above table.

Example 2:

Below is tabulated the sales of a particular item for each quarter over a 3 year period.

Year	Jan – Mar	Apr – Jun	Jul – Sept	Oct – Dec
2003	200	320	620	290
2004	210	420	750	310
2005	230	390	770	480

- (i) Given the regression line plotting sales with time is given by $Y = 282.9 + 20.5X$. Determine the seasonally adjusted forecasts for each quarter in the above table.
- (ii) Determine the seasonally adjusted forecasts for each quarter in 2006.