# Chap 1: Time Series

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# Chap 1: Time Series

Outline:

- Introduction to forecasting
- Forecasting time horizons
- Important of forecasting
- Forecasting methods
- Forecasting process
- Time series
- Components of time series
- Stationary time series models

# Introduction to Forecasting

- Forecasting is a prediction of some future event or events based on past values of the variables (historical data).
- Forecasting is an important problem in many fields including government, environmental sciences, medicine, politics, business, industry and finance.
- Forecasting can be classified as short-term, medium-term and long-term.
  i. Short-term –forecasting events only a few time periods up to 1 year (days, weeks, months)
  ii. Medium-term-forecasts extend from one to two years
  iii. Long-term-forecasts extend beyond that by many years.

# Forecasting Time Horizons

1. *Short-range forecast* is used for planning purchasing, job scheduling, workforce levels, job assignments, and product-ion levels.

2. *Medium-range forecast* is useful in sales planning, production planning /budgeting, cash budgeting, and analysis of various operating plans.

3. *Long-range forecast* is used in planning for new products, capital expenditures, facility location or expansion, and research and development.

# Important of Forecasting

1. Business -Forecasts used to determine services to be offered, locations at which products are to be produced, staffing requirements, control inventories and plan capacity.
2. Marketing-Forecasting is important for advertising expenditures, new promotion, pricing polices and determine whether goals are being met and make adjustments.
3. Economics-Forecasting such as gross domestic product, unemployment, population growth, inflation, job growth, production and consumption are important instrumental for business organization, financial instrument and governments in the strategic planning decisions and budgeting plans.
4. Demography-Forecasts of gender, age, race, births, deaths and migration patterns of populations are important for governments for planning policy and social service actions such as spending for health care, housing, retirement programs and antipoverty programs.

# Important of Forecasting

- Forecasts are seldom perfect. Outside factors we cannot predict or control often impact the forecast.
- Most forecasting techniques assume that what happens in the future is a function of what has happened in the past.
- When forecasting is inadequate, the resulting shortages can mean undependable delivery, loss of customers, and loss of market share.
- When forecasting is in excess, costs can skyrocket.

# Forecasting Methods

**There are two types of forecasting methods**

1. Qualitative Forecasting method- called judgmental methods
   - there is little or no historical data.
   - subjective in nature and require judgment based on experts opinion.
   - Delphi Method widely used for this technique
   - involve using the experiences, judgments and opinions of one or several experts in the field.

2. Quantitative Forecasting method
   - use of historical data
   - most this technique involve the use of time series data.
   - this technique formally discover a pattern of the historical data to identify a formal model and then use the method to extrapolate the pattern into the future.
   - there are several types of forecasting models in general use such as regression, smoothing models, moving average models and others.

# Forecasting Process

There are six forecasting process

1. Problem definition-understand how the forecast will be used in meeting the user expectation.
2. Data collection-obtaining the relevant history data or information.
3. Data analysis –to selection of the forecasting model usually begin with graphical display of time series data.
4. Model selection and fitting-choosing one or more forecasting models, estimating the unknown parameters model and fitting the models to the data.
5. Model validation-an evaluation of the forecasting model whether the forecasting model is adequate.
6. Forecasting-involves getting the adequate model and use this model to forecast.

# Time Series

- A time series is a set of observations collected from a process with equally spaced periods of time.
- Time series is dynamic, it does change over time.
- When working with time series data, the data is usually plotted so the researcher can view the pattern data.
- A time series plot of a variable is a plots each observation against the time at which it was measured. Time is marked on the horizontal scale, and the variable of interest is marked on the vertical scale. Connecting sequential data points by lines helps emphasize changes over time.
- Time series plots can reveal pattern such as random, trends, level shifts, cycle, seasonal, unusual observation or a combination of patterns.

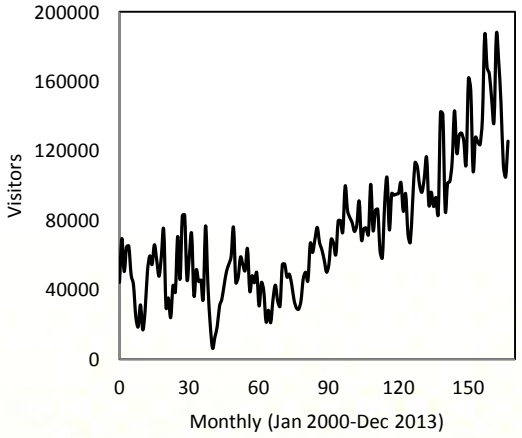
# Time Series

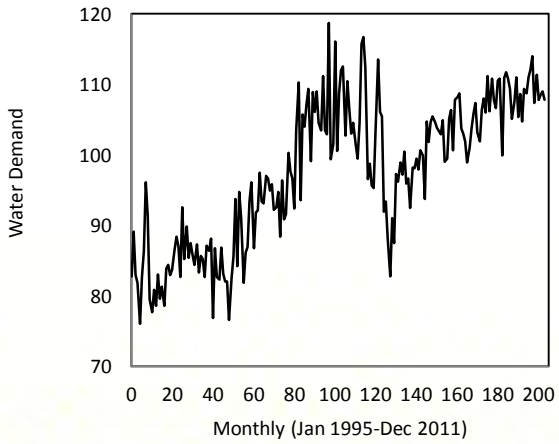
- A time series containing records of a single variable is termed as univariate. If records containing more than variable called multivariate.

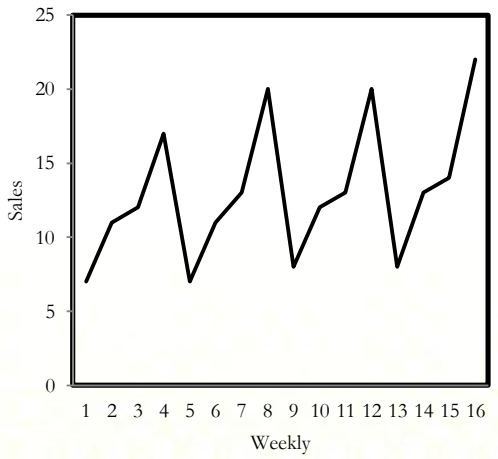
- Time series can be discrete and continuous.
  i. Discrete time series-observations measured at discrete points of time. Example exchange rates between two different country, the number of car in a country, production of a company and so on.
  ii. Continuous time series-observations are measured at every time. For example flow of a river, temperature reading, concentration of a chemical process.

# Time Series

- Usually time series are recorded at equally spaced time intervals such as hourly, daily, weekly, monthly or yearly time separations.
- Continuous time series can be transformed to a discrete by merging data together over a specified time interval.
- Example time series-Daily data on sales, Monthly salary, Daily Customers, Weekly unemployment rates, Monthly water demand, Daily stream flow, and so on.



# Components of Time Series

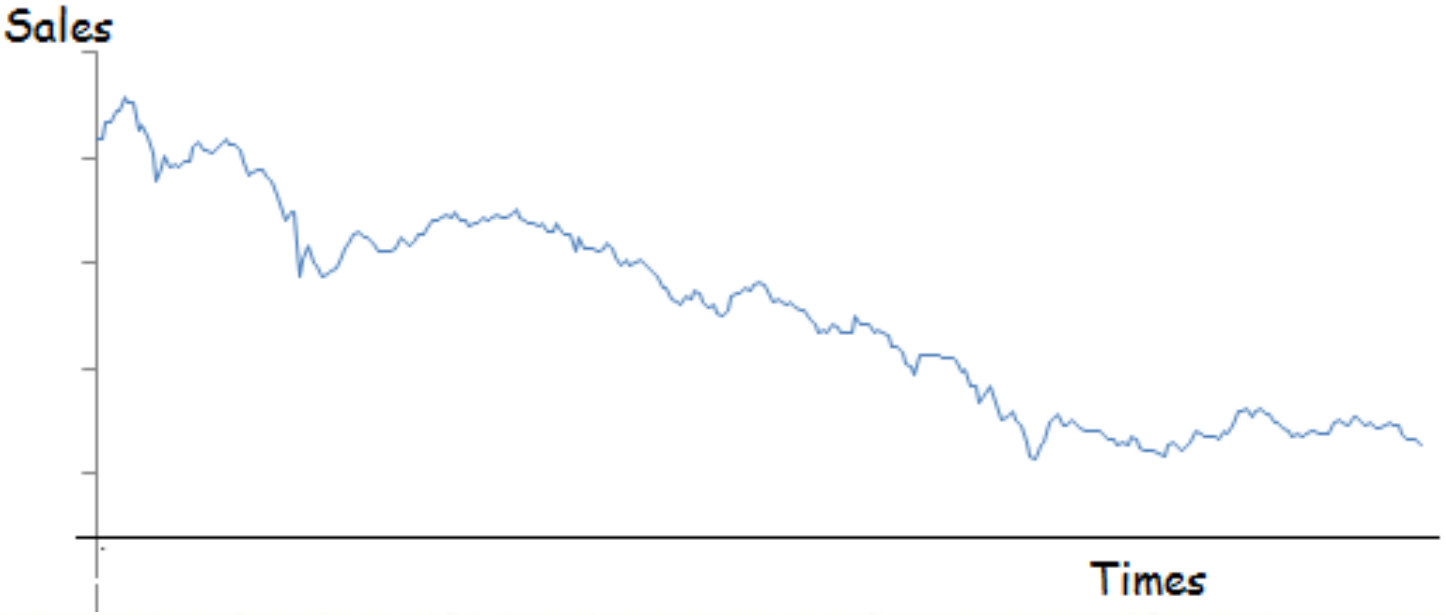
- The purpose of analyzing time series data is to expose and summarize its components before to a model-building process.
- An important step in selecting the correct time-series model is to identify the components in time series through various graphical.
- Once these components or combination of components have been identified, the methods that best fitted these patterns can be evaluated.
- A time series can consist of four components
  i. trend component
  ii. Cycle component
  iii. Seasonal component
  iv. Irregular or random component

# Trend Component

- Trends represent a persistent upward or downward movement of the data over a long period of time.
- Trend is usually due to change in population, technology, demographics, consumer preferences etc.
- Trend may be long term or more dynamic and of relatively short duration that persists usually for more than one year.
- If a time series does not contain any trend component, its called stationary.

# Trend Component

- Overall Upward or Downward Movement
- Data Taken Over a Period of Years

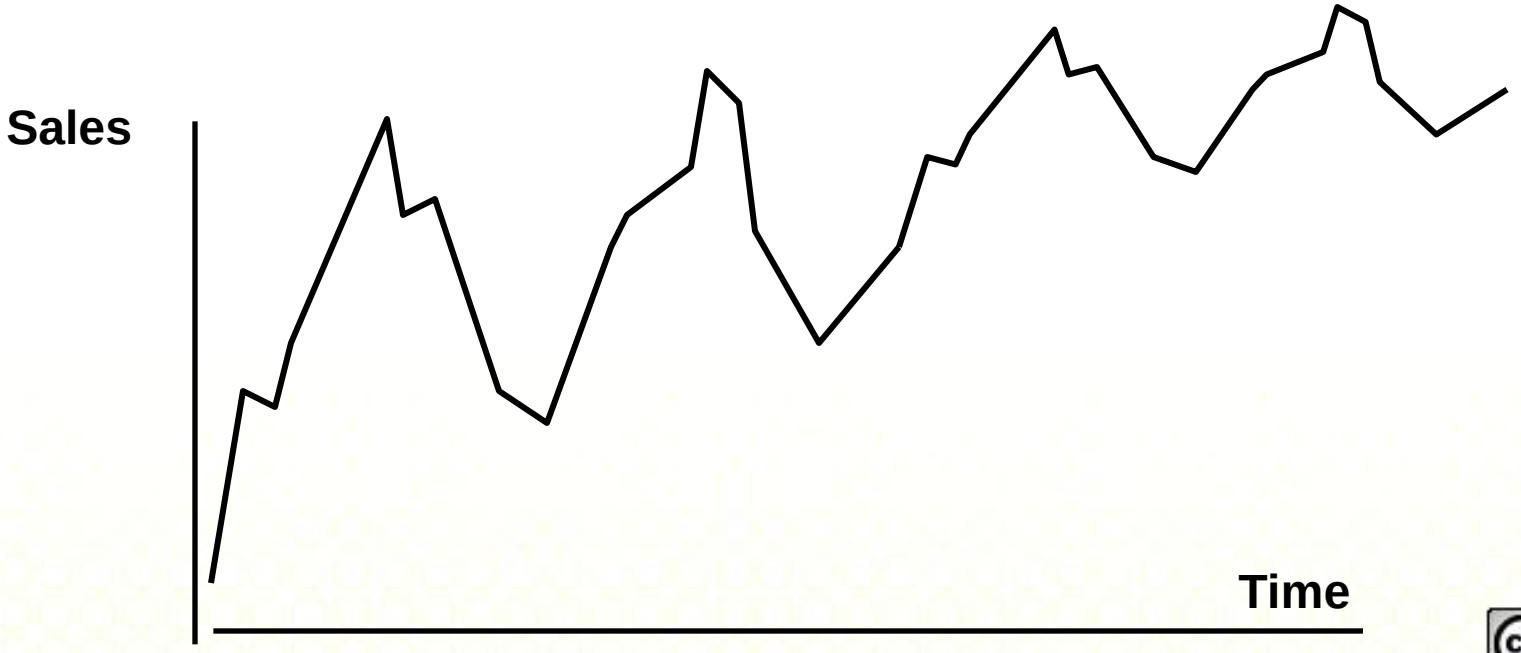


# Cyclical Component

- It represents repeating up and down movements in the data pattern that occurs over a duration of 2 to 10 years or longer but not periodic in nature (not constant).
- Cyclical component is usually due to interactions of factors influencing economy and represents by multiyear cyclical movements in the economy.
- A cycle is measured from peak to peak or trough to trough.
- Cycle is one of the most difficult components to forecast because of its longer time frame.

# Cyclical Component

- Upward or Downward Swings the trend line
- May Vary in Length
- Usually Lasts 2 - 10 Years
- Cycles are seldom regular, and often appear in combination with other components

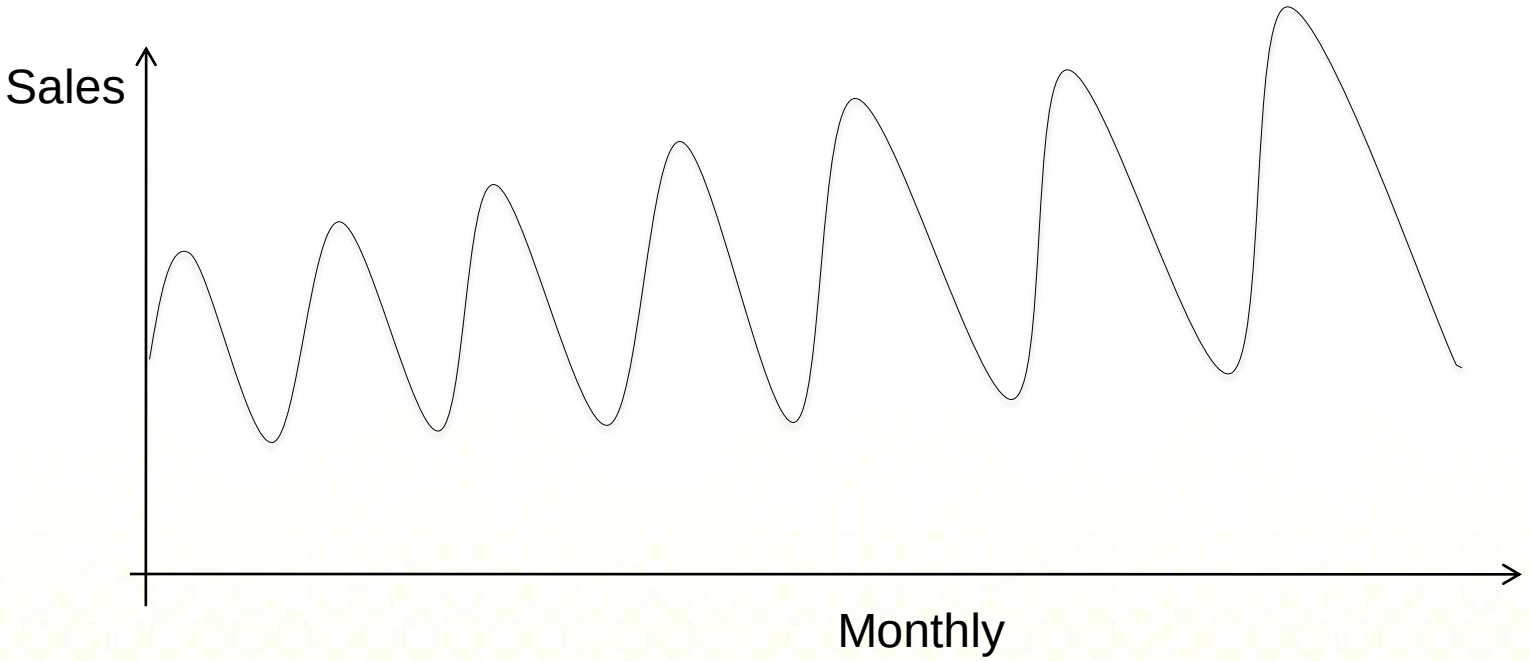


# Seasonal Component

- Seasonality is the component time series represents that repeats on a regular pattern of up and down fluctuations occur within one year, and then is repeated on a yearly basis.
- Seasonal component is usually influenced by seasonal factor such as weather or customs.
- The pattern duration can be as short as an hour, or even less.

# Seasonal Component

- Upward or Downward Swings
- Regular Patterns recur during months, weeks or days.
- Exhibits a short term (less than one year) calendar repetitive behavior

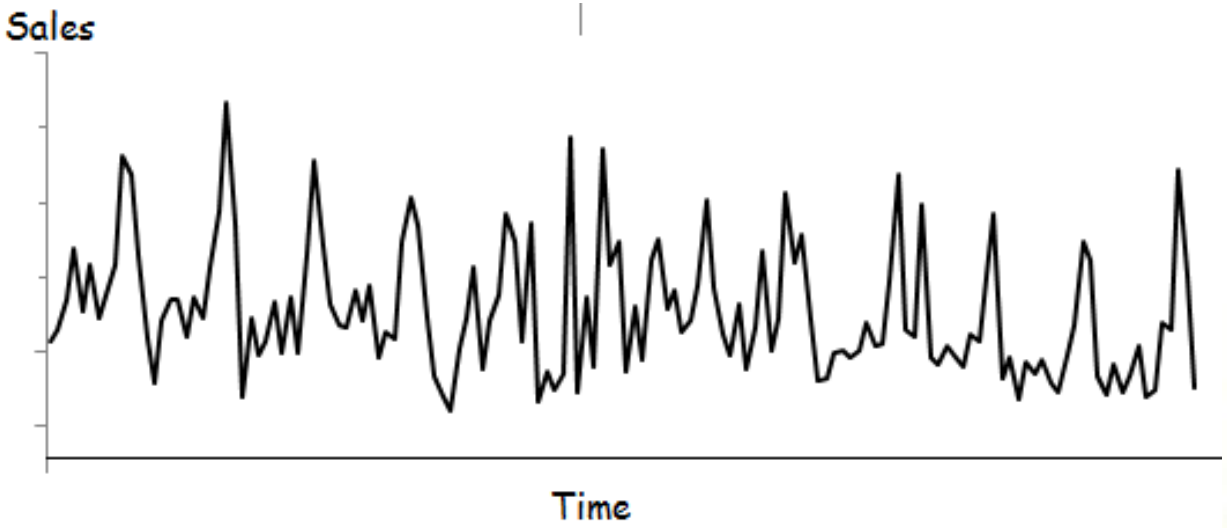


# Random or Irregular Component

- It represents erratic, nonsystematic, random, 'Residual' Fluctuations or definable pattern.
- It is caused by the influence of "outside" events on the data such as nature flood, drought, tsunami, accidents, war and so on.
- The pattern duration is usually occur in short duration and non-repeating.
- Random variation comprises the irregular unpredictable changes in the time series.

# Random or Irregular Component

- Caused by unusual or rare events
- Does not any systematic variation
- The greatest difficulty for forecaster because they are generally unexplainable.



# Stationary Time Series Models: The Naïve Model

- Idea "what happened last period will happen again this time
- The simplest time series forecasting model
- Provides a baseline to measure other models

$$F_t = Y_{t-1}$$

or

$$F_t = Y_{t-4} \text{ : Quarterly data}$$

$$F_t = Y_{t-12} \text{ : Monthly data}$$

# Stationary Time Series Models: Moving Averages

The Moving Average Method (MA) is the average of the last *n* observations of the time series.

$$F_{t+1} = \frac{\sum_{t=0}^{n-1} y_t}{n} = \frac{y_t + y_{t-1} + \ldots + y_{t-n+1}}{n}$$

MA for $n = 3$, MA(3) is

$$F_{t+1} = \frac{\sum_{t=0}^{2} y_t}{3} = \frac{y_t + y_{t-1} + y_{t-2}}{3}$$

# Measures of Forecast Error

- Bias, MAE, MSE and MAPE – typically used for time series
- Bias - The arithmetic sum of the errors

$$Bias = \sum_{t=1}^{n} \frac{y_t - F_t}{n}$$

- MAE- Mean Absolute Error

$$MAE = \sum_{t=1}^{n} \frac{|y_t - F_t|}{n}$$

- MSE-Mean Square Error

$$MSE = \sum_{t=1}^{n} \frac{(y_t - F_t)^2}{n}$$

- MAPE – Mean Absolute Percentage Error

$$MAPE = \frac{100}{n} \sum_{t=1}^{n} \left| \frac{y_t - F_t}{y_t} \right|$$

# Example: Naïve and Moving Average Model

Monthly sales data for certain product were collected over 10-month period, as given below.

**Sales (In RM '000)**

| Month | Sales |
|---|---|
| January | 10 |
| February | 11 |
| March | 11 |
| April | 12 |
| May | 13 |
| June | 11 |
| July | 9 |
| August | 12 |
| September | 11 |
| October | 10 |


The plot of these data suggests that there is no trend or seasonal pattern.

# Example: Naïve and Moving Average Model

Naïve model is $F_t = Y_{t-1}$

Moving Average for n=3, MA(3) is

$$F_{t+1} = \frac{y_t + y_{t-1} + y_{t-2}}{3}$$

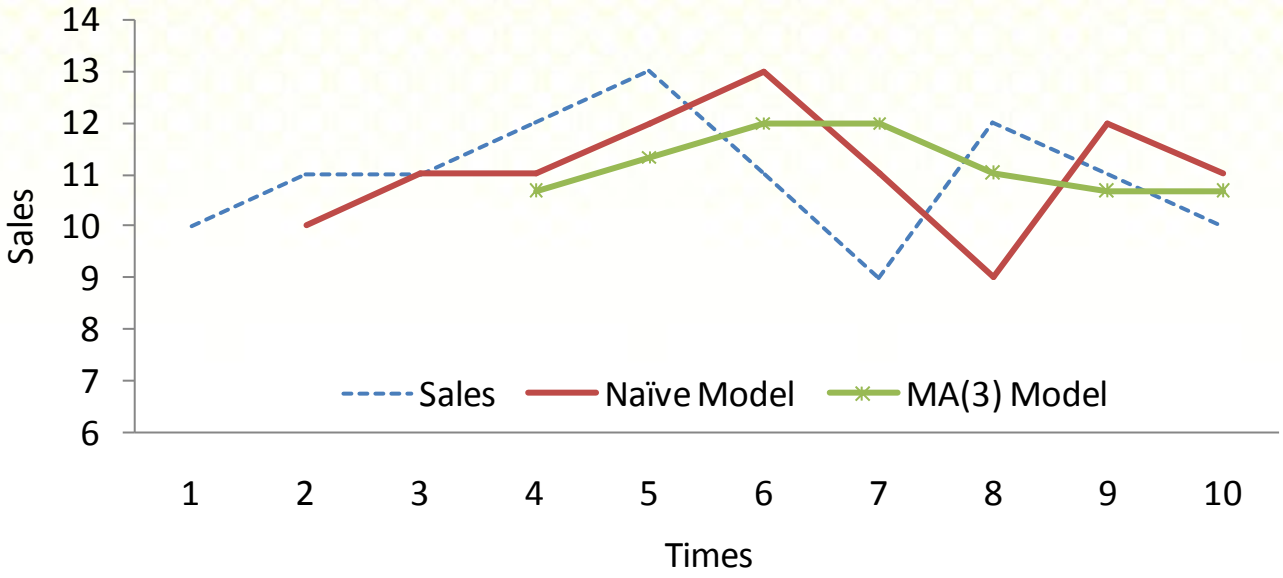
Start at $t = 3$ $F_4 = \frac{11+11+10}{3} = 10.67$

Start at $t = 4$ $F_5 = \frac{12+11+11}{3} = 11.33$

The remaining forecasts in Table were calculated in the same manner.

| Monthly | Sales | Naïve Model | MA(3) Model |
|---|---|---|---|
| 1 | 10 | - | - |
| 2 | 11 | 10 | - |
| 3 | 11 | 11 | - |
| 4 | 12 | 11 | 10.67 |
| 5 | 13 | 12 | 11.33 |
| 6 | 11 | 13 | 12.00 |
| 7 | 9 | 11 | 12.00 |
| 8 | 12 | 9 | 11.00 |
| 9 | 11 | 12 | 10.67 |
| 10 | 10 | 11 | 10.67 |

# Comparison Naïve and MA(3) Models




| | MAE | MSE | MAPE |
|---|---|---|---|
| Naïve | 1.333 | 2.444 | 0.122 |
| MA(3) | 1.286 | 2.302 | 0.121 |

MA(3) more better than Naïve model in fitting sales data