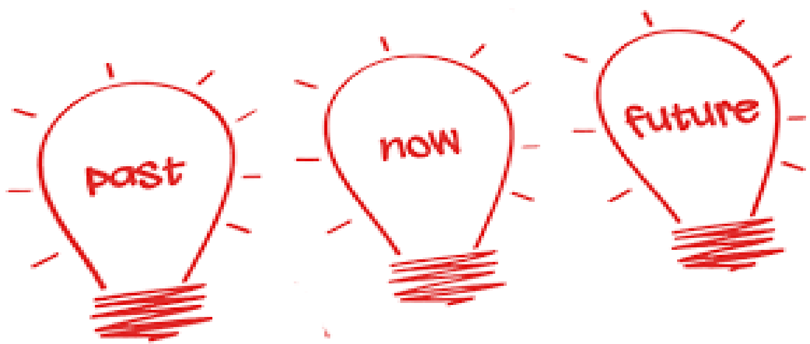
FORECASTING



WHY YOU NEED TO KNOW?

- Every organization has a need to forecast the demand for the goods or services it provides.
- The success of the forecasting effort will play a major role in determining the general success of the organization.
- Example: A retail clothing store must forecast the demand for the shirts it sells by shirt size.

PLANNING	FORECASTING
• process of determining how to deal with the future. • Forecasts are used as inputs for the planning process	• process of predicting what the future will be like. • 2 broad category of forecasting: ▫ Qualitative Forecasting ▫ Quantitative Forecasting

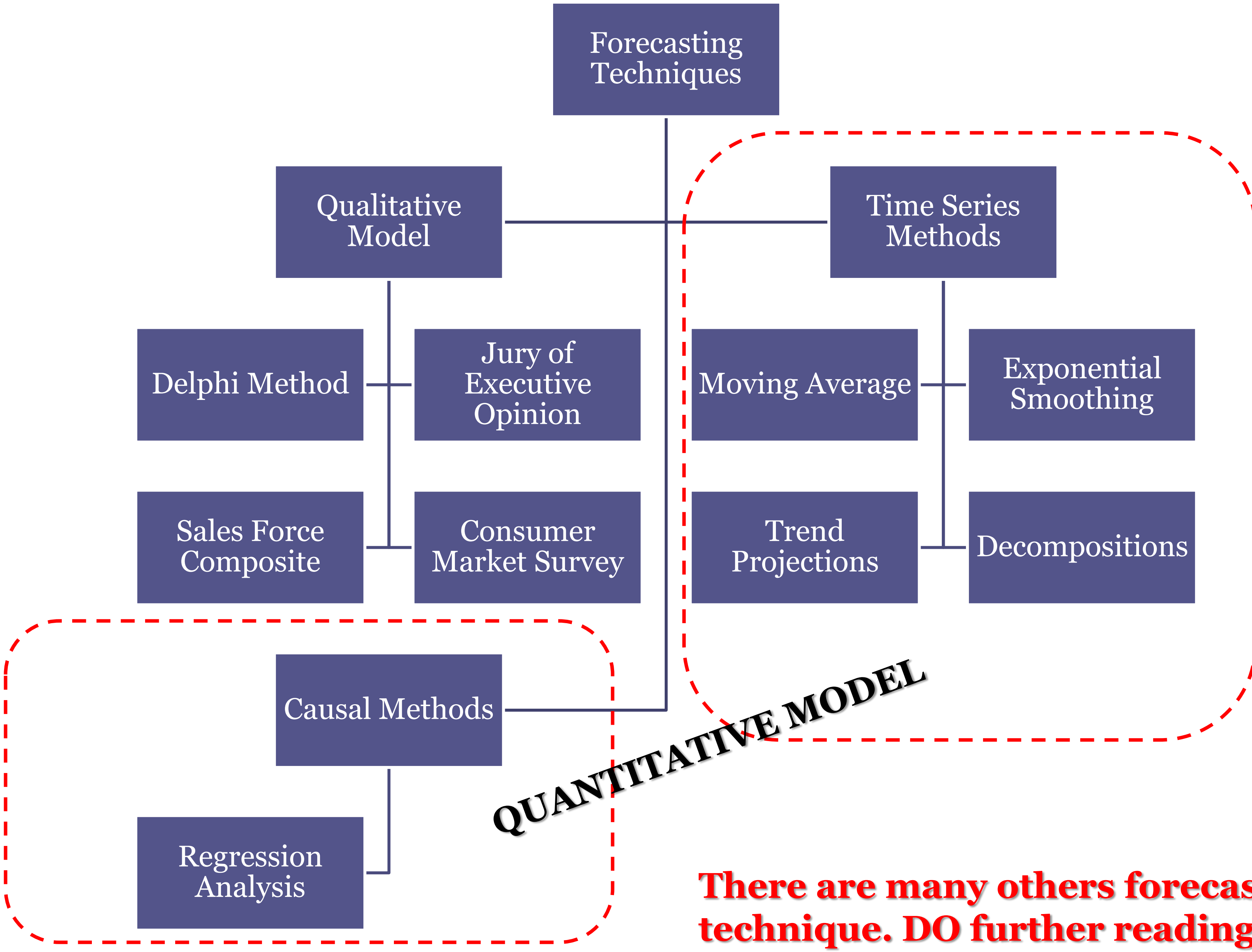
FORECASTING CATEGORIES

QUALITATIVE FORECASTING

- Are based on judgments, opinions, intuition, emotions, or personal experiences.
- They are subjective in nature. They do not rely on any rigorous mathematical computations.
- Useful when subjective factor are very important or when quantitative data are difficult to obtain.

QUANTITATIVE FORECASTING

- Are based on mathematical (quantitative) models.
- They are objective in nature.
- They rely heavily on mathematical computations.



There are many others forecasting technique. DO further reading!

QUALITATIVE FORECASTING

- Delphi Method: allow experts to make forecast
  - 3 different type of participants in the Delphi process:
    - Decision Makers – making the actual process
    - Staff personnel – assist decision makers (prepare, distribute, collect and summarize questionnaire and result)
    - Respondents – provides inputs to the decision makers before the forecast is made

- Executive Opinion: Takes the opinions of a small group of high level managers (often the combination with statistical method), and results in a group estimate of demand.

QUALITATIVE FORECASTING

- Sales Force Composite: Approach in which each salesperson estimates sales in his or her region.
  - These forecast are reviewed to ensure that they are realistic and are then combines at different levels to reach an overall forecast.

- Consumer Market Survey: Approach that uses interviews and surveys to judge preferences of customer and to assess demand.

QUANTITATIVE FORECASTING

Time Series Model

- Time series models look at past patterns of data and attempt to predict the future based upon the underlying patterns contained within those data.

Associative /Causal Model

- Associative models (often called causal models) assume that the variable being forecasted is related to other variables in the environment.

FORECASTING MODELING

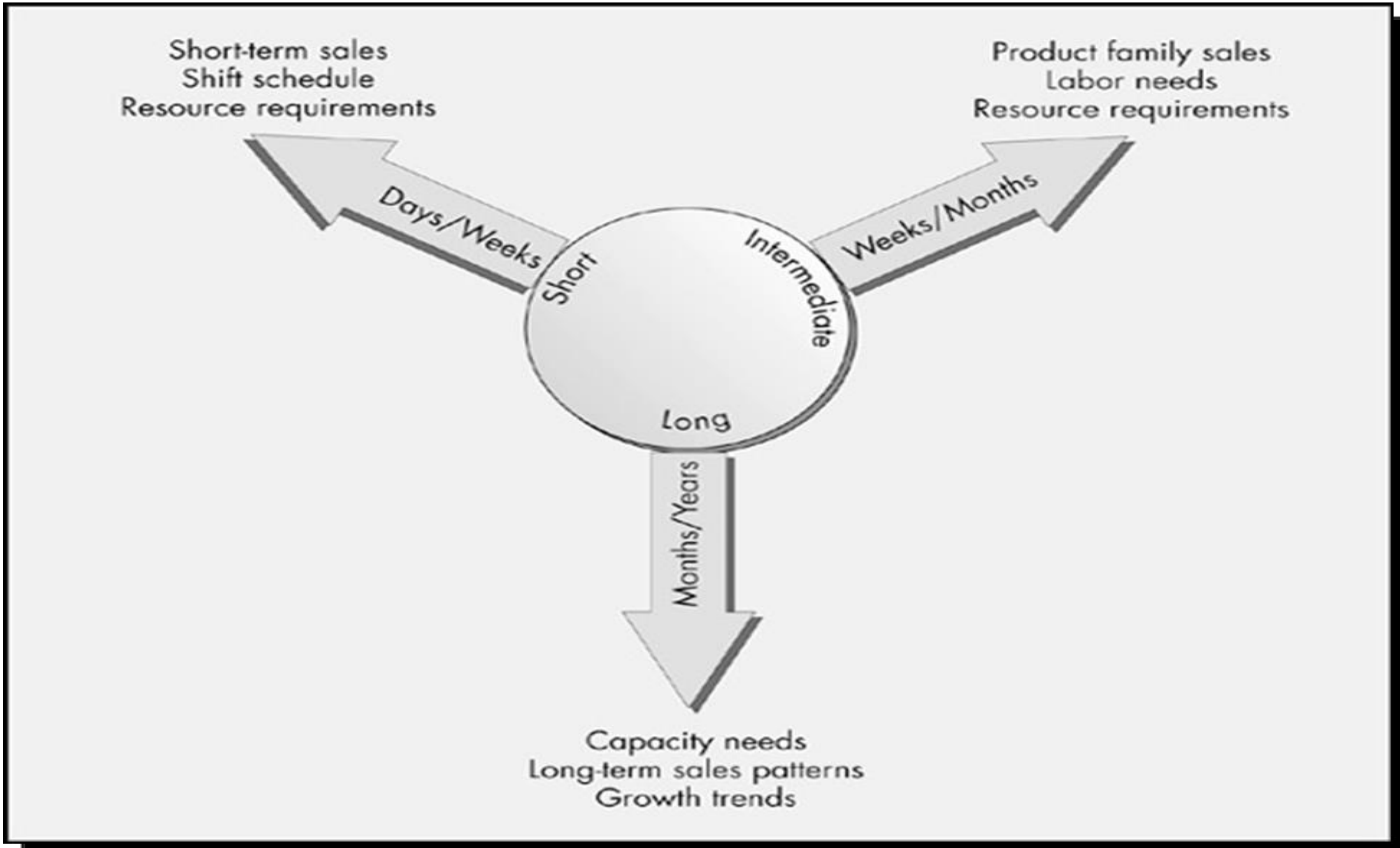
Forecasting model-building process consists of:

- Model Specification – the process of selecting the forecasting technique to be used in a particular situation
- Model Building – the process of estimating the specified model's parameters to achieve adequate fit of the historical data
- Model Diagnosis – The process of determining how well a model fits past data and how well the model's assumptions appear to be satisfied.

FORECASTING MODELING

- An important consideration when you are developing a forecasting model is to use the simplest available model that will meet your forecasting needs.
- Forecasting techniques are generally dependent on the **forecasting horizon**.
  - Forecasting Horizon: The number of future periods covered by a forecast. It is sometimes referred to as forecast lead time.
  - Divided into 4 categories:
    i. Immediate term—less than one month
    ii. Short term—one to three months
    iii. Medium term—three months to two years
    iv. Long term—two years or more

FORECAST HORIZON: Example of Operation Planning



8 STEPS IN FORECASTING

1. Determine the use of the forecast – what objective are we trying to obtain
2. Select the items or quantities that are to be forecasted
3. Determine the time horizon of the forecast- short term? medium term? or long term?
4. Select the forecasting model or models
5. Gather the data needed to make the forecast
6. Validate the forecasting model
7. Make the forecast
8. Implement the results.

MEASURES OF FORECAST ACCURACY

Purpose:

- To see how well one model works or
- To compare that model with other models

How?:

- Forecast value are compared with the actual or observed values ➔ FORECAST ERROR

Forecast error = actual value – forecast value

Measurements:

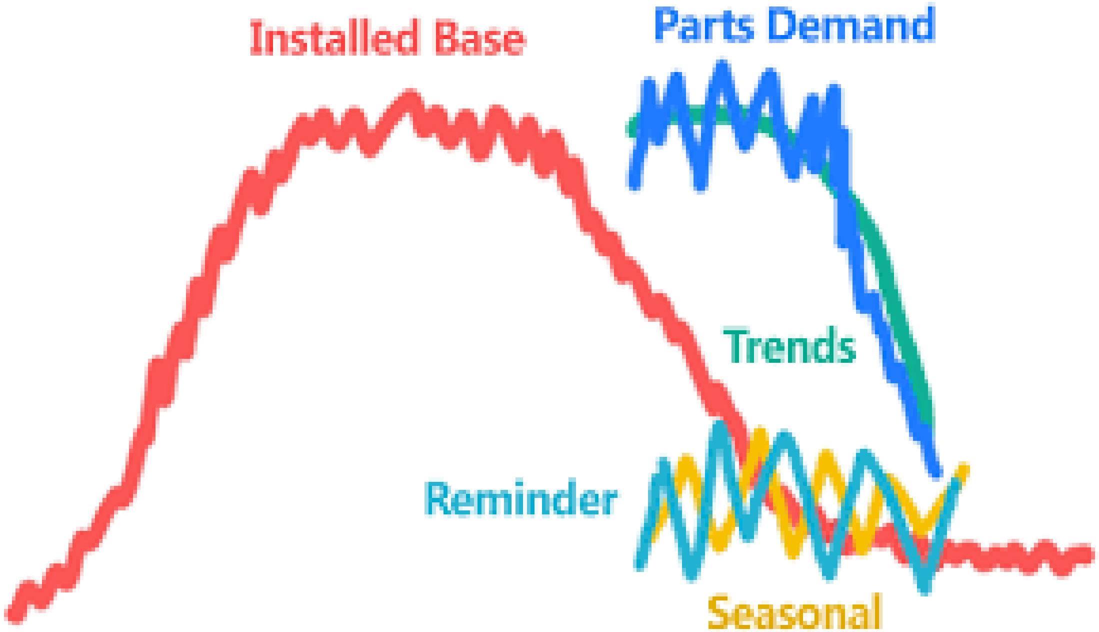
- Mean Absolute Deviation (MAD) - average distance between each data value and the mean.
- Mean Squared Error (MSE) – average of the squared error
- Mean Absolute Percent Error (MAPE)- average of the absolute values of the errors expressed in percentage
- Bias – average errors which tells whether the forecast tends to be too high or too low by how much. Bias may be +ve or –ve.

CAUSAL FORECASTING METHOD

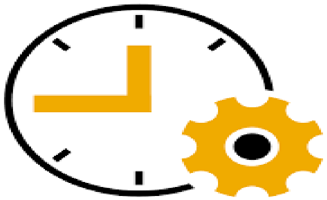
CAUSAL METHOD

- This method consider several variables that are related to the variable being predicted
- When the related variable is identified, a statistical model is build and used to forecast the variable of interest
- Most frequent causal method: Regression analysis
- Example: Prediction for sales of product might be related to firm's advertising budget, the price charged, competitors prices, promotional strategies and even economy and unemployment rate.

TIME-SERIES FORECASTING MODEL



TIME-SERIES



- Time series: based on a sequence of evenly spaced (weekly, monthly, quarterly…) data points.

- Forecasting time series: implies that future value are predicted only from past values and other variables (no matter how potentially it is) are ignored.

- Analyzing time series: breaking down the past data into components and then projecting them forward.

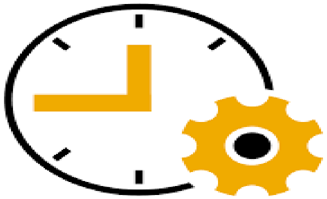
COMPONENT OF A TIME-SERIES

- Components of time series:
  - Trend (T) components
  - Seasonality (S) components
  - Cycles (C) components
  - Random Variation (R) components

to identify the time series component: time-series plot

- All time-series data exhibit one or more of the time-series component.

COMPONENT OF A TIME-SERIES



- 2 general forms of time-series model in statistics:
  1. Multiplicative Model : assume that demand is the product of the four components.

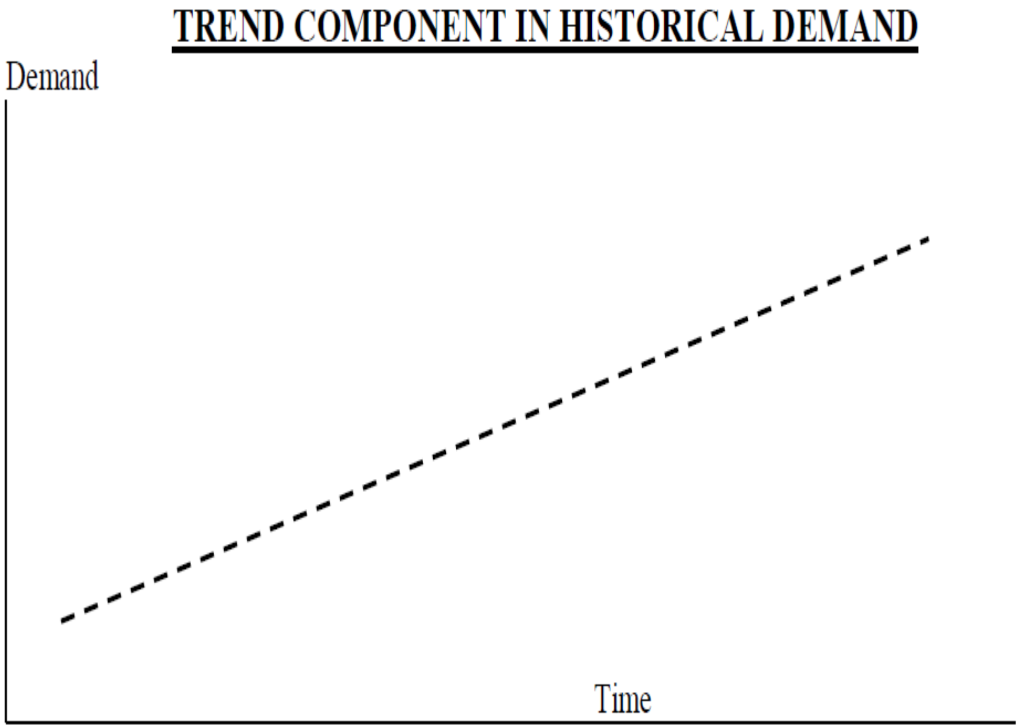
     demand = T x S x C x R

  2. Additive Model: assume that demand is the add of the four components

     demand = T + S + C + R

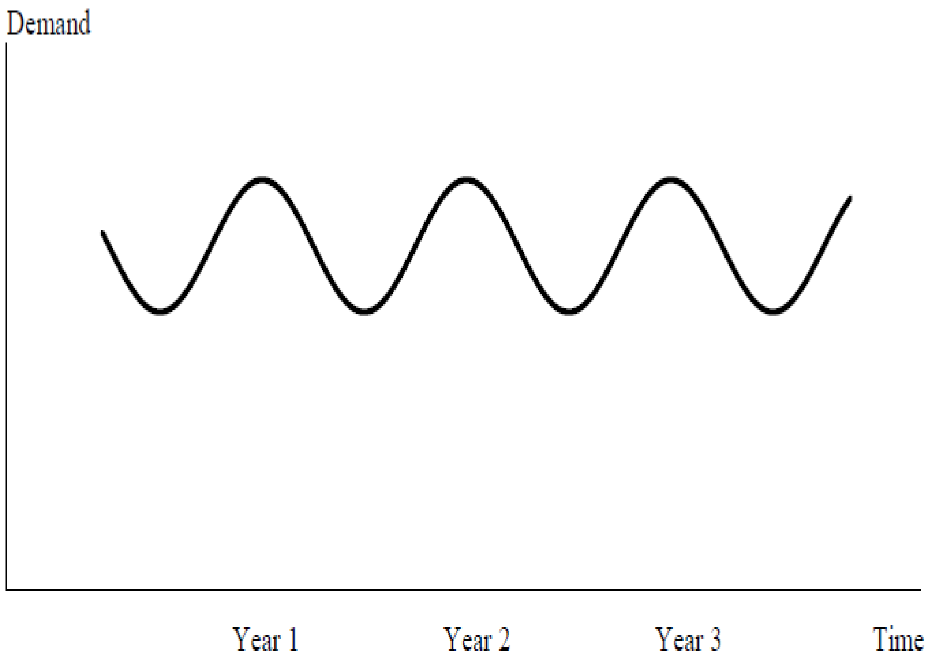
TIME-SERIES COMPONENTS

1. TREND COMPONENTS



- Data exhibit a steady growth or decline over time.
- Trend can be classified as **linear** or nonlinear

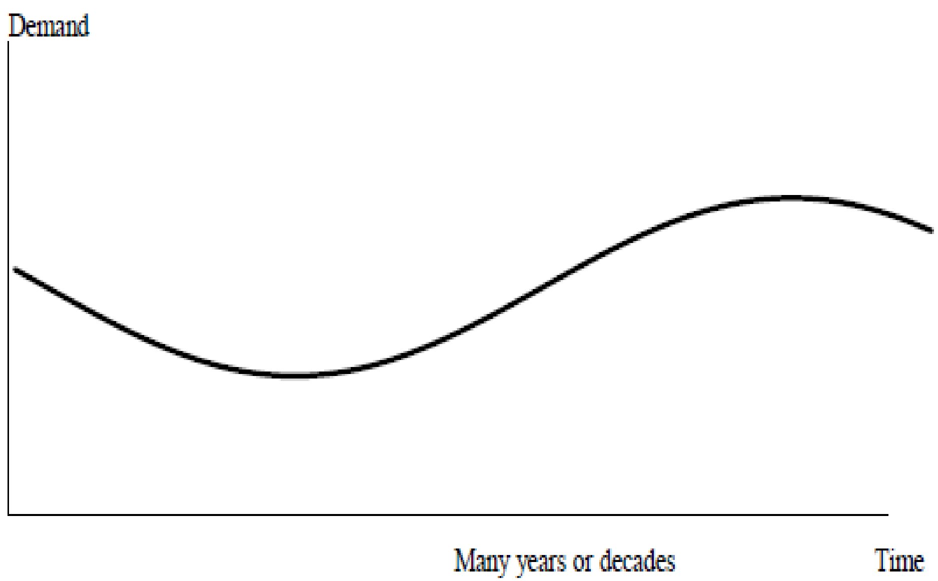
2. SEASONAL COMPONENTS



Pattern of demand fluctuation above or below the trend line that occurs every year

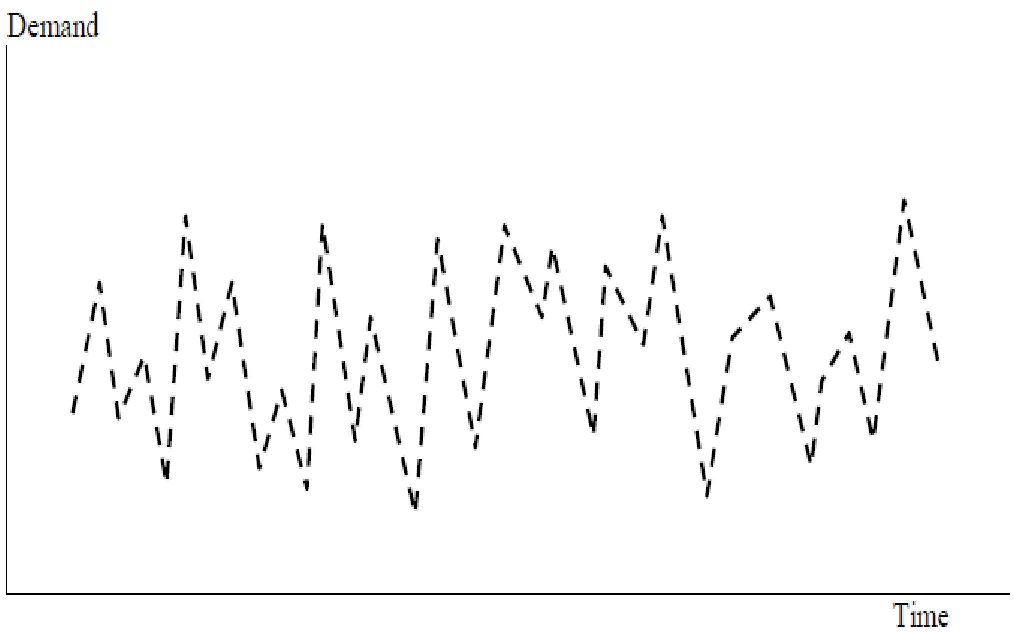
- Data exhibit upward and downward swings in a short to intermediate time frame (most notably during a year).
- Example: for a retail toy store, sales increase in the months leading into Christmas and then substantially decrease after Christmas.
- Can be observed over shorter time periods, example pattern of customers arriving at the bank during any hour may be "seasonal" within a day

3. CYCLICAL COMPONENTS



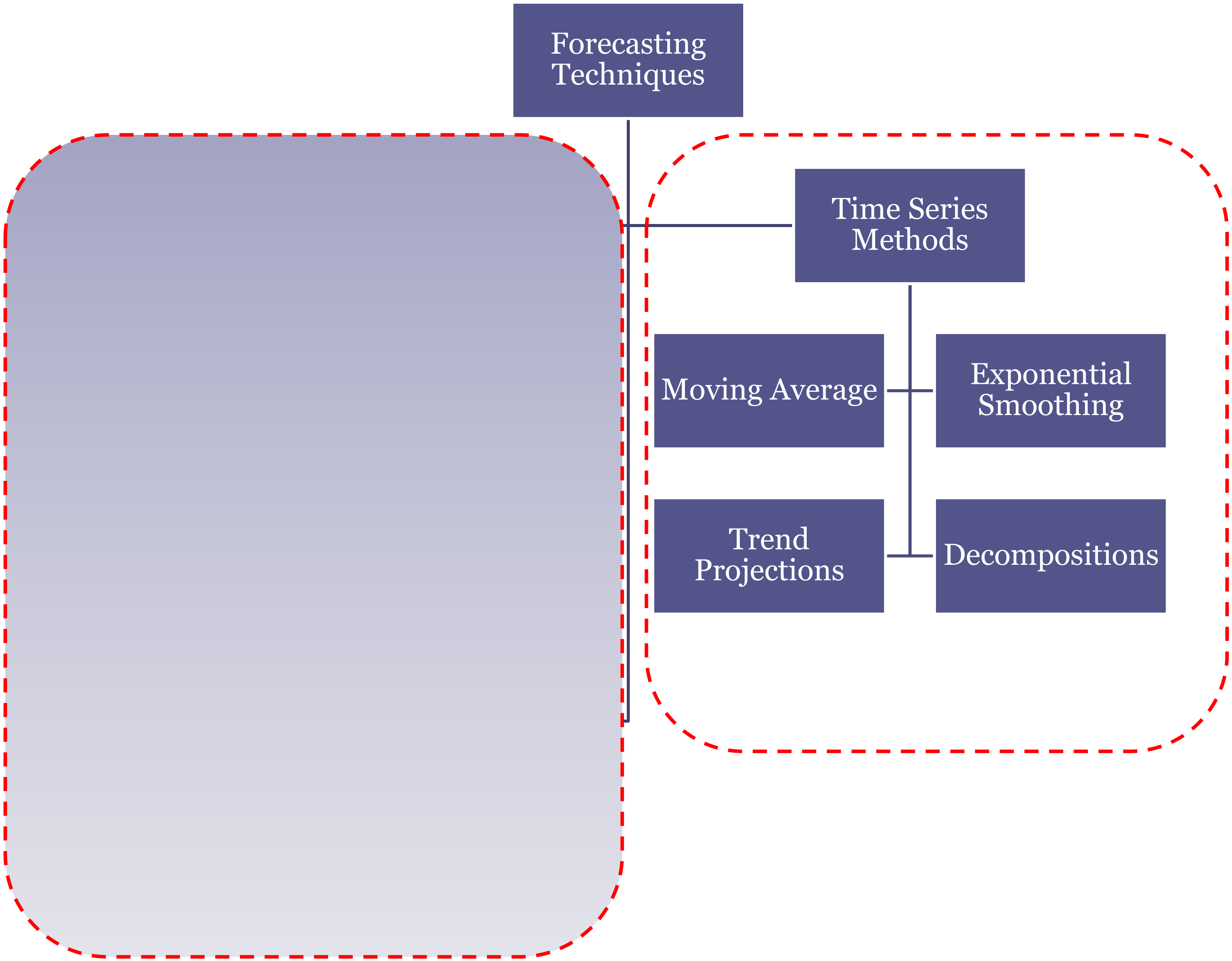
- Data exhibit upward and downward swings in over a very long time frame.
- The cycles vary in length and magnitude.
- Example: Economic measures such as the unemployment rate, gross national product, stock market indexes, and personal saving rates tend to cycle.

3. RANDOM COMPONENTS



- Erratic and unpredictable variation in the data over time with no discernable pattern.
- Is often referred to as "noise" in the data.
- A time series with no identifiable pattern is completely random and contains only noise.

TIME-SERIES FORECASTING METHOD


Forecasting Techniques
Time Series Methods
Moving Average
Exponential Smoothing
Trend Projections
Decompositions

TREND-BASED FORECASTING TECHNIQUES

- The technique are used to identify the presence of a trend and to model that trend.
- Once the trend model has been defined, it is used to provide forecast for future time periods.

Problem: Linear Trend Forecasting

The Taft Ice Cream is a family-operated company selling gourmet ice cream to resort areas. The annual sales data for the 10 year period (2003 – 2012)can be find in the file called **Taft**. Taft owners are considering expanding their ice cream manufacturing facilities. As part of the bank's financing requirements, the managers are asked to supply a forecast of future sales.

Step 1: Model Specification

Plot the time-series data. From the plot, the sales have exhibited a linear growth pattern. A possible forecasting tool is a linear trend (a straight-line) model.

$$y_t = \beta_0 + \beta_1 t + \varepsilon_t$$

where:

y_t = Value of the trend at time t

β_0 = y intercept of the trend line

β_1 = Slope of the trend line

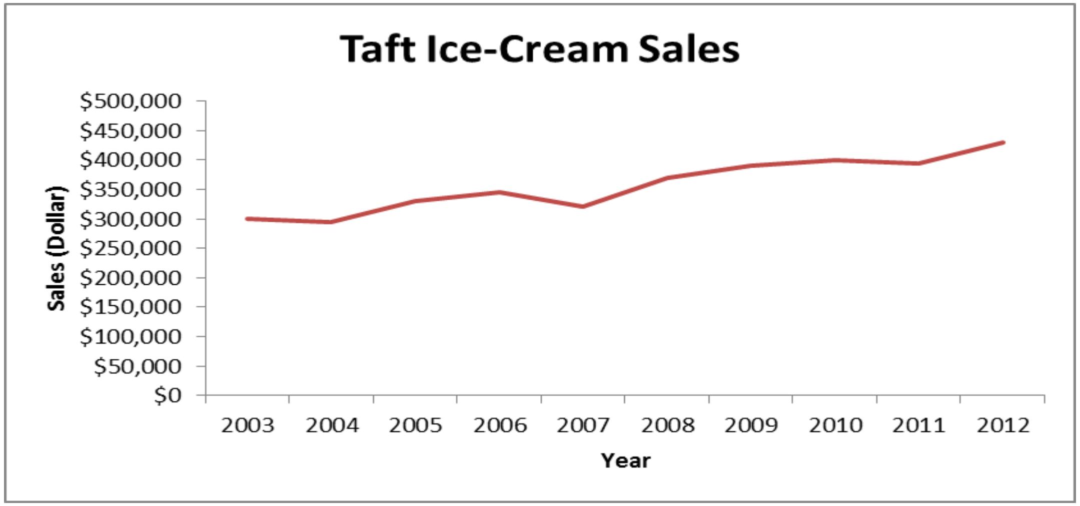
t = Time period ($t = 1, 2, \ldots$)

ε_t = Model error at time t

Step 2: Model Fitting

The linear trend model are:

The linear regression procedure can be used to compute the least Square trend model.



```
> taftforcast=lm(`Sales `~t,data = Taft)
> summary(taftforcast)

Call:
lm(formula = `Sales ` ~ t, data = Taft)

Residuals:
   Min     1Q Median     3Q    Max 
-30212  -7311   6485   8727  10636 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   277333       9915  27.972 2.88e-09 ***
t              14576       1598   9.122 1.68e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 14510 on 8 degrees of freedom
Multiple R-squared:  0.9123,	Adjusted R-squared:  0.9013 
F-statistic: 83.21 on 1 and 8 DF,  p-value: 1.678e-05
```

The least square trend model for the Taft Company is:

$$\hat{y}_t = 277{,}333 + 14{,}576(t)$$

For a forecast, we use F_t as the forecast value at time period *t*. Thus,

$$F_t = 277{,}333 + 14{,}576(t)$$

Step 3: Model Diagnosis

The R-squared = 0.9123 shows that for these 10 years of data, the linear trend model explains more than 91% of the variation in sales. The p-value for the regression slope coefficient to four decimal places is 0.0000. This means that time (t) can be used to explain a significant portion of the variation in sales.

Although these results are a good sign, the model diagnosis step requires further analysis. (see next slide: Comparing the forecast value to the Actual Data)

COMPARING FORECAST VALUE WITH ACTUAL DATA VALUE

- The slope of the trend line (for Taft Ice-cream): $F_t = 277{,}333 + 14{,}576(t)$

  experienced an average increase in sales per year over the 10-year period

- When substitute when t = 1, we get: $F_t = 277{,}333 + 14{,}576(1) = 291{,}909$ forecast value

- Forecast error (residual) = actual value – forecast value
  - For year 1, the forecast error is:

    $300,000 - $291,909 = $8.091

COMPARING FORECAST VALUE WITH ACTUAL DATA VALUE

	A	B	C	D	E	F	G
1	obs	actual value	predicted	residual	squared residual	absolute residual	
2	1	$300,000	$291,909	$8,091	$65,464,281	$8,091	
3	2	$295,000	$306,485	-$11,485	$131,905,225	$11,485	
4	3	$330,000	$321,061	$8,939	$79,905,721	$8,939	
5	4	$345,000	$335,637	$9,363	$87,665,769	$9,363	
6	5	$320,000	$350,213	-$30,213	$912,825,369	$30,213	
7	6	$370,000	$364,789	$5,211	$27,154,521	$5,211	
8	7	$390,000	$379,365	$10,635	$113,103,225	$10,635	
9	8	$400,000	$393,941	$6,059	$36,711,481	$6,059	
10	9	$395,000	$408,517	-$13,517	$182,709,289	$13,517	
11	10	$430,000	$423,093	$6,907	$47,706,649	$6,907	
12				MSE (10 df)	$1,685,151,530	$110,420	
13				MSE (8 df)	$210,643,941.25	$11,042	MAD

These error measures are particularly helpful when comparing two or more forecasting techniques.

MOVING AVERAGE FORECASTING TECHNIQUES

- Useful when if we can assume that market demands will stay fairly steady over time.
  - It is also called as stationary time series :
    - It is indicate stable processes without observable trends
    - It has the form: $D_t = \mu + \varepsilon_t$
      where μ is a constant and ε_t is a random variable with mean 0 and variance σ^2
    - Two common methods for forecasting stationary series are moving averages and exponential smoothing.

- $$moving\ average = \frac{\sum demand\ in\ previous\ n\ periods}{n}$$

  where n is the number of periods in the moving average (example: four-period moving average, five-period moving average..)

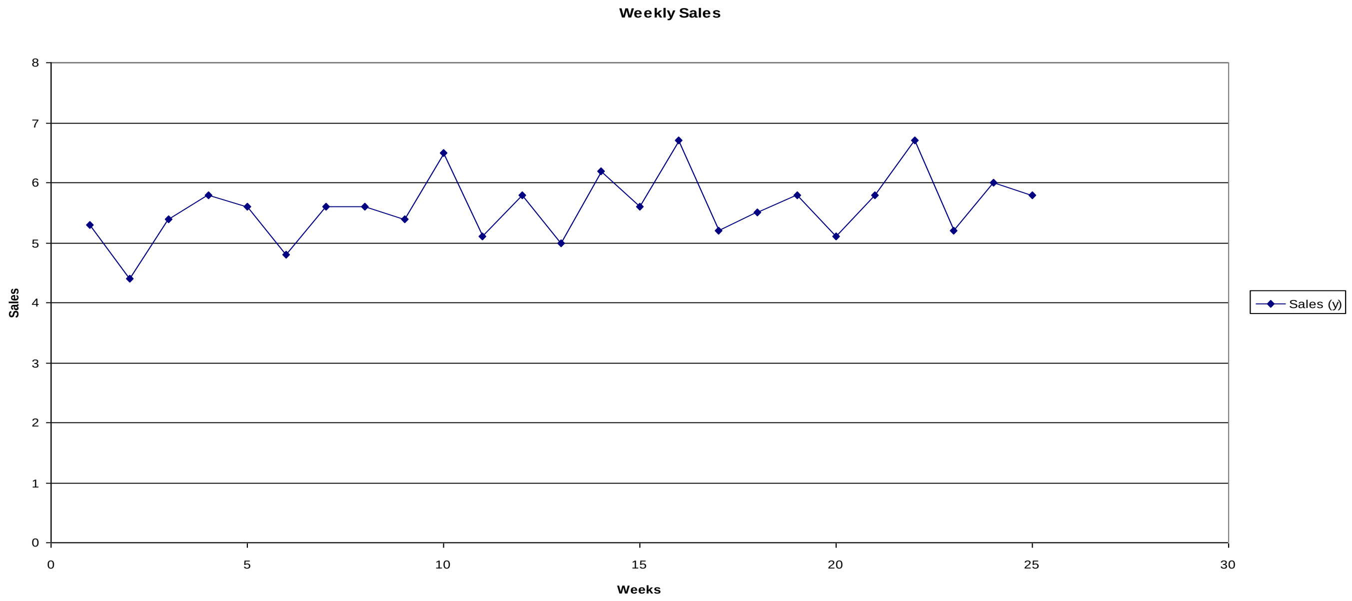
Example 1: Wallace Garden Supply

Table 1 indicate the Wallace Garden Supply Shed Sales. Calculate the forecast value based on 3-month moving average. Identify the RMSE value

MONTH	SALES	3-month MA	Forecast Error
January	10		
February	12		
March	13		
April	16	(10+12+13)/3= 11.66	(16-11.66) =
May	19	(12+13+16)/3= 13.66	
June	23	(13+16+19)/3= 16.00	
July	26	(16+19+23)/3= 19.33	
August	30	(19+23+26)/3= 22.66	
September	28	(23+26+30)/3= 26.33	
October	18	(26+30+28)/3= 28.00	
November	16	(30+28+18)/3= 25.33	
December	14	(18+16+14)/3= 20.66	

Example 2:
The weekly sales figures (in millions of dollars) presented in the following table are used by a major department store to determine the need for temporary sales personnel.

Period (t)	Sales (y)
1	5.3
2	4.4
3	5.4
4	5.8
5	5.6
6	4.8
7	5.6
8	5.6
9	5.4
10	6.5
11	5.1
12	5.8
13	5
14	6.2
15	5.6
16	6.7
17	5.2
18	5.5
19	5.8
20	5.1
21	5.8
22	6.7
23	5.2
24	6
25	5.8

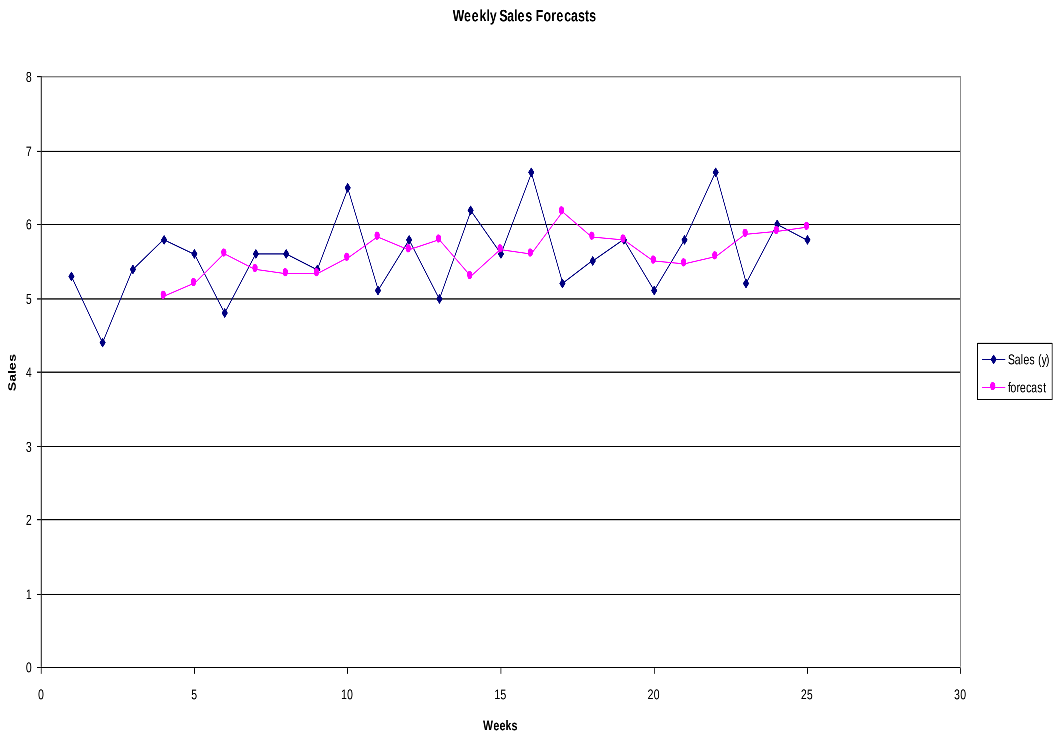


Use a three-week moving average (k=3) for the department store sales to forecast for the week 24 and 26.

$$\hat{y}_{24} = \frac{(y_{23} + y_{22} + y_{21})}{3} = \frac{5.2 + 6.7 + 5.8}{3} = 5.9$$

The forecast error is $e_{24} = y_{24} - \hat{y}_{24} = 6 - 5.9 = .1$

Period (t)	Sales (y)	forecast
1	5.3	
2	4.4	
3	5.4	
4	5.8	5.033333
5	5.6	5.2
6	4.8	5.6
7	5.6	5.4
8	5.6	5.333333
9	5.4	5.333333
10	6.5	5.533333
11	5.1	5.833333
12	5.8	5.666667
13	5	5.8
14	6.2	5.3
15	5.6	5.666667
16	6.7	5.6
17	5.2	6.166667
18	5.5	5.833333
19	5.8	5.8
20	5.1	5.5
21	5.8	5.466667
22	6.7	5.566667
23	5.2	5.866667
24	6	5.9
25	5.8	5.966667
		5.666667

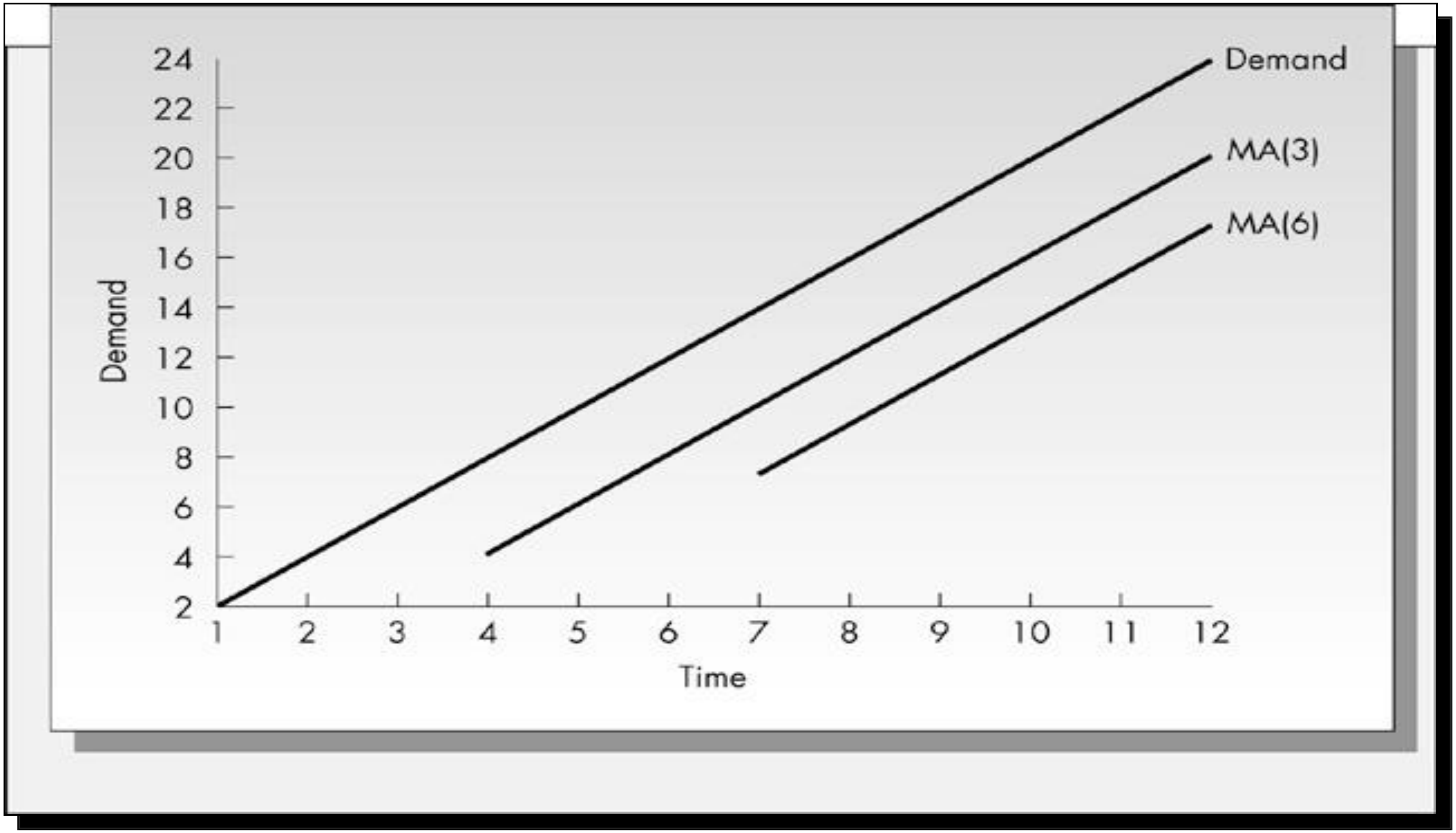


RMSE = 0.63

SUMMARY OF MOVING AVERAGE

- *Advantages of Moving Average Method*
  - Easily understood
  - Easily computed
  - Provides stable forecasts
- *Disadvantages of Moving Average Method*
  - Requires saving lots of past data points: at least the N periods used in the moving average computation
  - Lags behind a trend
  - Ignores complex relationships in data

MOVING AVERAGE: LAG TREND



WEIGHTED MOVING AVERAGE

- When there is a trend or pattern, weight can be used to place more emphasis on recent values
- This may make the techniques more responsive to changes because later periods may be more heavily weighted.
- Assigning weight – requires some experience and a bit of luck! (it is arbitrary: there is no set of formula)
    - However, several different sets of weight can be tried and the one with lowest MAD should be used

- $weighted\ moving\ average = \dfrac{\sum(weight\ for\ period\ n)(demand\ in\ period\ n)}{\sum weights}$

- Look example 1: Wallace Garden supply decides to forecast storage shed sales by weighting the past three months as follows:

Weights Applied	Period
3	Last Month
2	Two Month Ago
1	Three Month Ago

$$\frac{(3) \times \text{Sales last month} + (2) \times \text{Sales two month ago} + (1) \times \text{Sales three month ago}}{6}$$

6 → Sum of the weight

Example 1: Wallace Garden Supply
Weighted Moving Average

MONTH	SALES	3-month MA	Forecast Error
January	10		
February	12		
March	13		
April	16	[(3x13)+(2x12)+(1x10)] /6 =	(16-forecast value) =
May	19	[(3x16) + (2x13)+(1x12)]/6 =	(19-forecast value) =
June	23		
July	26		
August	30		
September	28		
October	18		
November	16		
December	14		

LIMITATIONS OF MOVING AVERAGE

1. Increasing the size of *n* (the number of periods average) does smooth out fluctuation better, BUT it makes the method less sensitive to real changes in the data.

2. Cannot pick up trends very well. Because they are averages, they will always stay within past levels and will not predict a change to either a higher or a lower level.

3. It requires extensive record keeping of past data when *n* is large

EXPONENTIAL SMOOTHING FORECASTING TECHNIQUES

- Limitations of trend projection forecast:
  - it gives as much weight to the earliest data in the time series as it does to the data that are close to the period for which the forecast is required.
  - Trend approach does not provide an opportunity for the model to “learn” or “adjust” to changes in the time series.

- Exponential Smoothing or Smoothing Model:
  - Widely used to overcome these problems and to provide forecasts in situations in which there is no pronounced trend in the data.
  - These models attempt to “smooth out” the random or irregular component in the time series by an averaging process.
  - Although it is a type of MA technique, it involves little record keeping of the past data.

- The basic exponential smoothing formula:

New forecast = last period's forecast + α(last period's actual demand – last period's forecast)

where α is a weight (or smoothing constant) that has a value between 0 and 1.

- In mathematical form:

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

where

F_t= new forecast (for time period t)

F_{t-1}= previous forecast (for time period t-1)

α = smoothing constant ($0 \leq \alpha \leq 1$)

A_{t-1}= previous period's actual demand

- Example: In January, a demand for car is 142 if a certain car model for February was predicted by a dealer. Actual February demand was 153 autos. Using a smoothing constant of (α = 0.20), we can forecast the March demand using the exponential smoothing model.

Using the formula:
New forecast (for March demand) = 142 + 0.2(153 -142) = 144.2
Thus, the demand forecast for the cars in March is 144.

Suppose the actual demand for the cars in March is 136. A forecast for the demand in April with constant of (α = 0.20), is
New forecast (for April demand) = 144.2 + 0.2(136 -144.2) = 142.6 or 143 autos

SELECTING THE SMOOTHING CONSTANT

- The appropriate value of smoothing constant (α) can make a difference between an accurate forecast and an inaccurate forecast.

- The objective is to obtain the most accurate forecast.
- Several values of the smoothing constant may be tried and the one with lowest MAD could be selected.

MORE TIME - SERIES FORECASTING!!!

Further Reading is Essential:
Neural Network Forecasting
Machine Learning Forecasting
Other statistical Forecasting (Box-Jenkins, ARMA, ARIMA etc)
Adaptive Forecasting – Intelligently forecast