

Operational Forecasting

Forecasting

- **Predict the next number in the pattern:**

a) 3.7, 3.7, 3.7, 3.7, 3.7, ?

b) 2.5, 4.5, 6.5, 8.5, 10.5, ?

c) 5.0, 7.5, 6.0, 4.5, 7.0, 9.5, 8.0, 6.5, ?

Forecasting

- **Predict the next number in the pattern:**

a) 3.7, 3.7, 3.7, 3.7, 3.7, 3.7

b) 2.5, 4.5, 6.5, 8.5, 10.5, 12.5

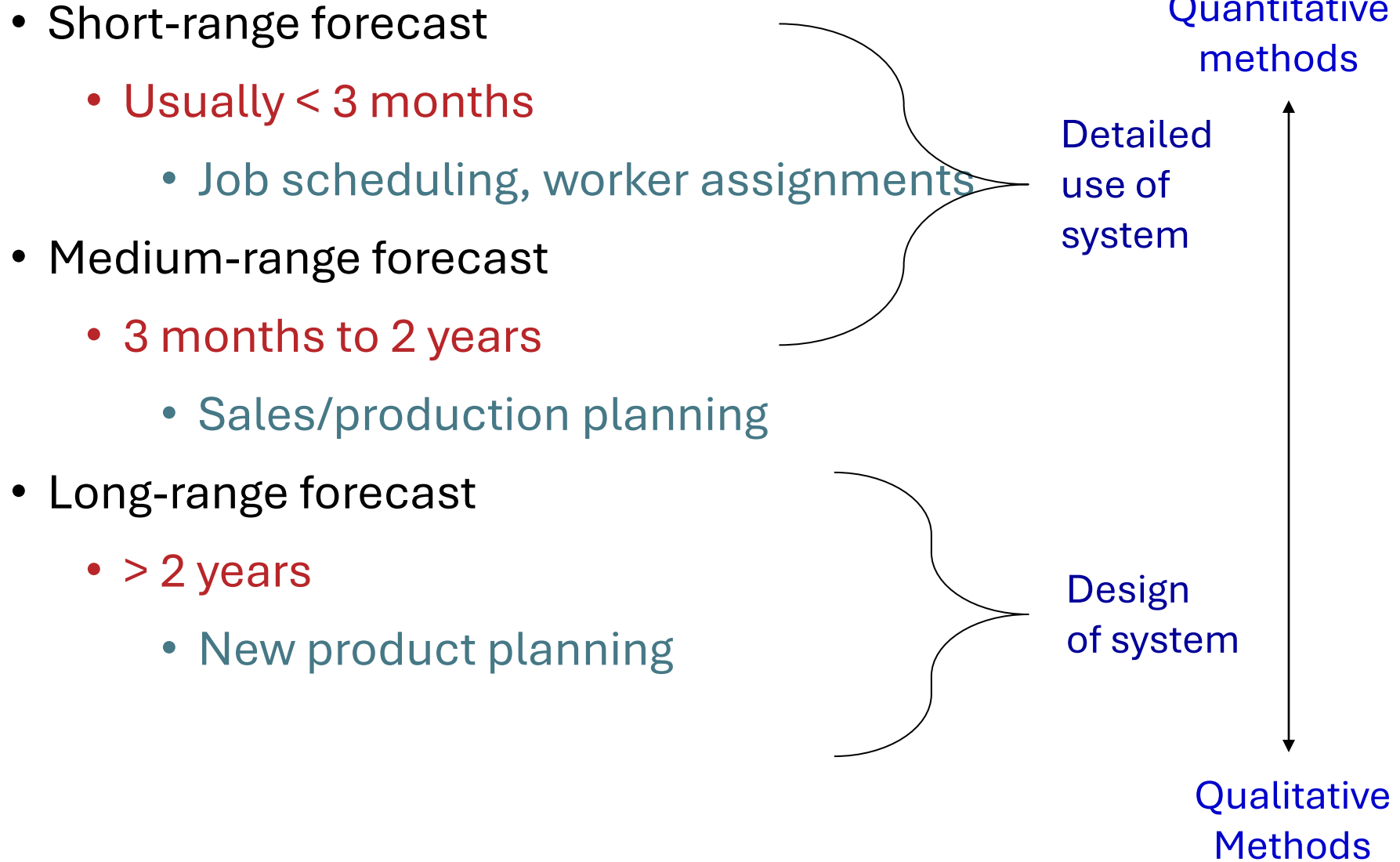
c) 5.0, 7.5, 6.0, 4.5, 7.0, 9.5, 8.0, 6.5, 9.0

- Forecasts rarely perfect because of randomness
- Forecasts more accurate for groups vs. individuals.

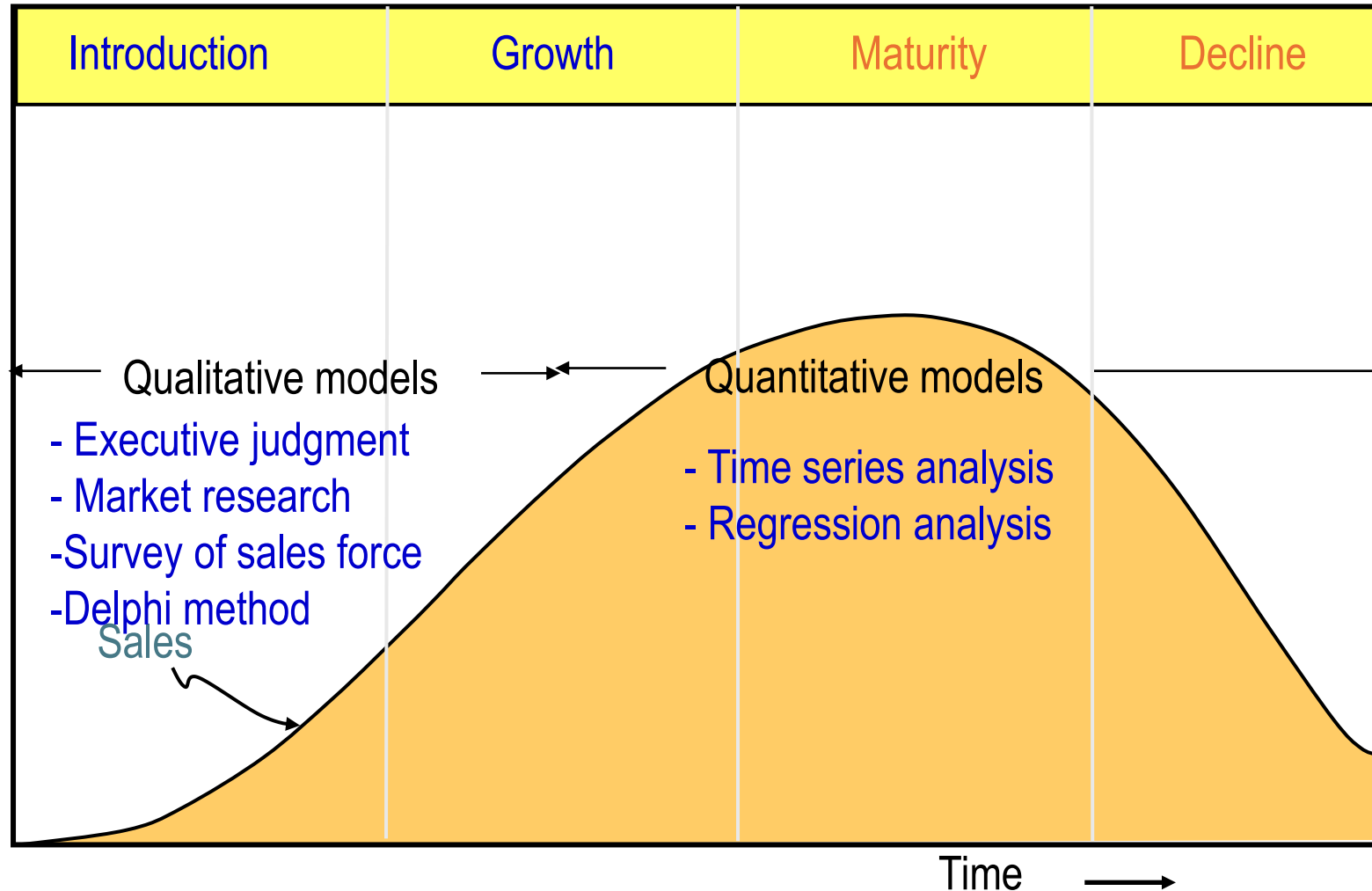
What is Forecasting?

- Process of predicting a future event based on **historical data**
- **Educated Guessing**
- Underlying basis of all business decisions
 - Production
 - Inventory
 - Personnel
 - Facilities
 - ----

Types of Forecasts by Time Horizon



Forecasting Life Cycle (FLC)



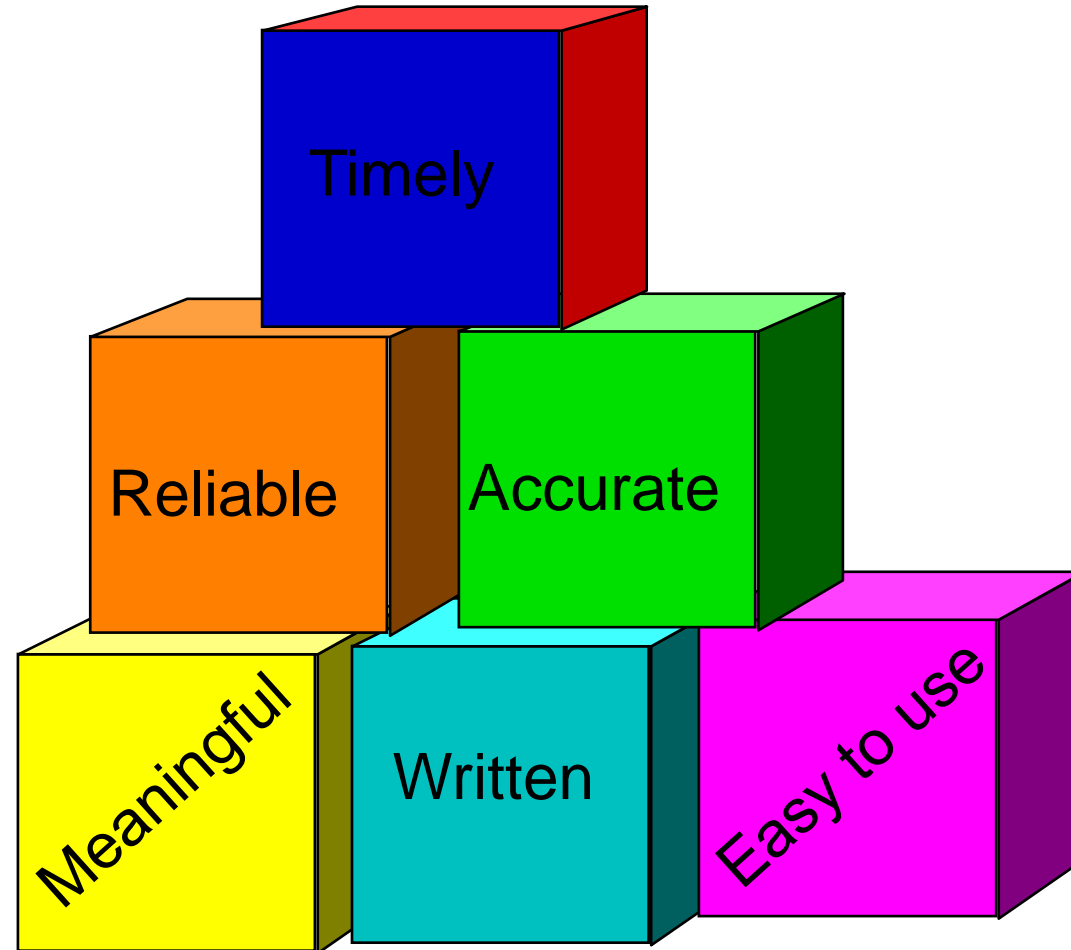
Decisions that Need Forecasts

- Which markets to pursue?
- What products to produce?
- How many people to hire?
- How many units to purchase?
- How many units to produce?
- And so on.....
- **Forecast:** A statement about the future
 - Not necessarily numerical

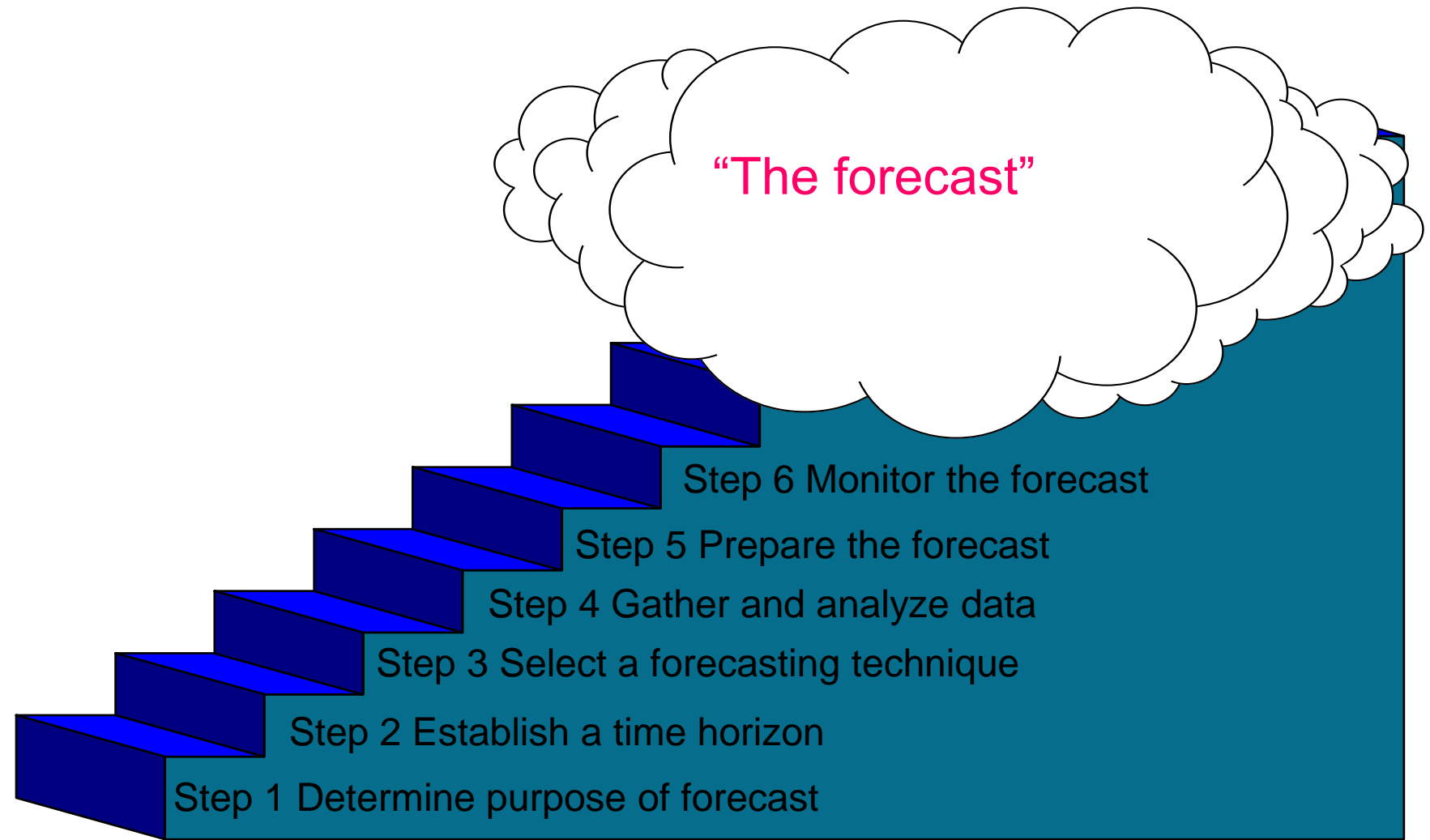
7 R

Right product
Right Quantity
Right Place
Right time
Right Price
Right condition
Right consumer

Elements of a Good Forecast

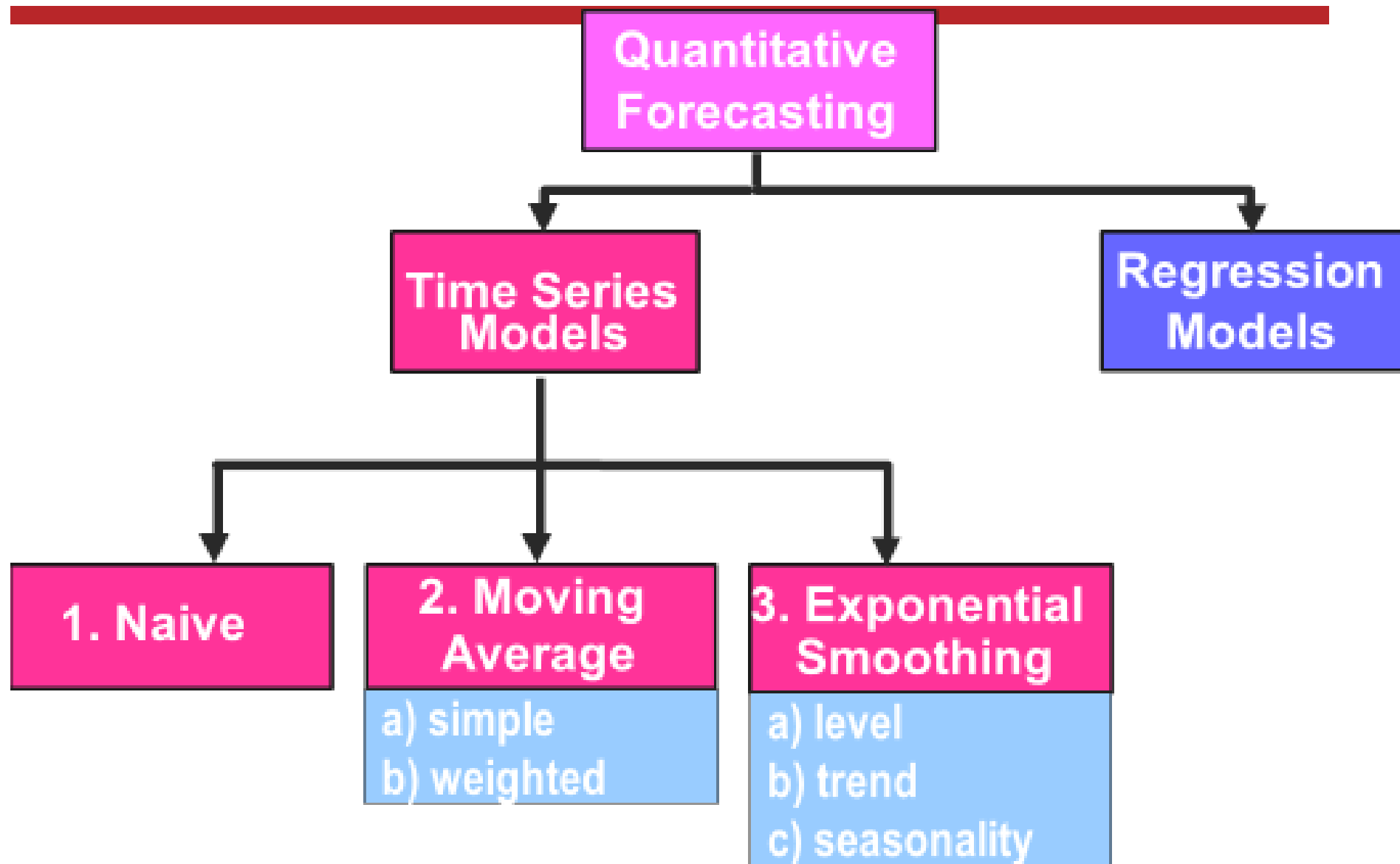


Steps in the Forecasting Process



Types of Forecasts

- Judgmental - Subjective analysis of subjective inputs
- Associative models – Analyzes historical data to reveal relationships between (easily or in advance) observable quantities and forecast quantities. Uses this relationship to make predictions.
- Time series – Objective analysis historical data assuming the future will be like the past



Forecasting Steps

- What needs to be forecast?
 - Level of detail, units of analysis & time horizon required
- What data is available to evaluate?
 - Identify needed data & whether it's available
- Select and test the forecasting model
 - Cost, ease of use & accuracy
- Generate the forecast
- Monitor forecast accuracy over time

Methods of Forecasting the Level

- Naïve Forecasting
- Simple Mean
- Moving Average
- Weighted Moving Average
- Exponential Smoothing

Associative Forecasting

- Based on identification of related variables that can be used to predict values of the variable of interest.
 - Sales of mountain bikes in an area may be related to the percentage of the young population living in that area.
 - Ice cream sales can be related to temperature
 - Home depot bases sales forecasts on mortgage refinancing rates, smaller rates imply higher sales.
 - Changes in Federal Reserve Board's interest rate leads to certain business activities
 - House sales
 - Industrial investments
 - Increase in energy cost leads to price increases in products and services

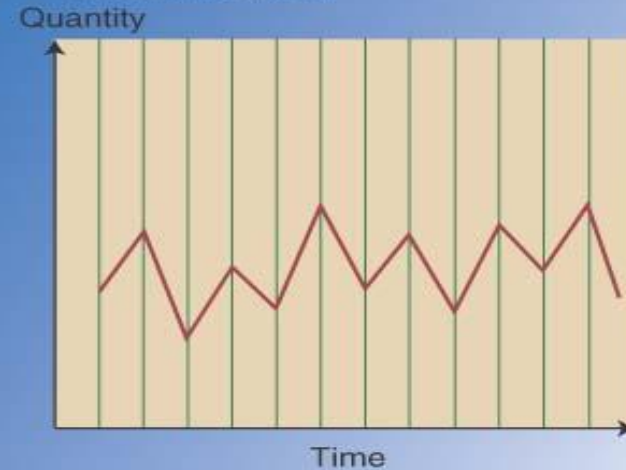
Associative Forecasting

- Find an association between the predictor and the predicted
- Predictor variables - used to predict values of variable interest, sometimes called independent variables
- Predicted variable = Dependent variable
- Regression - technique for fitting a line to a set of points
- Linear regression is the most widely used form of regression
 - The objective is to obtain an equation of a straight line that minimizes the sum of squared vertical deviations of data points from the line.

Time Series Patterns

(a) Level or Horizontal Pattern:

Data follows a horizontal pattern around the mean



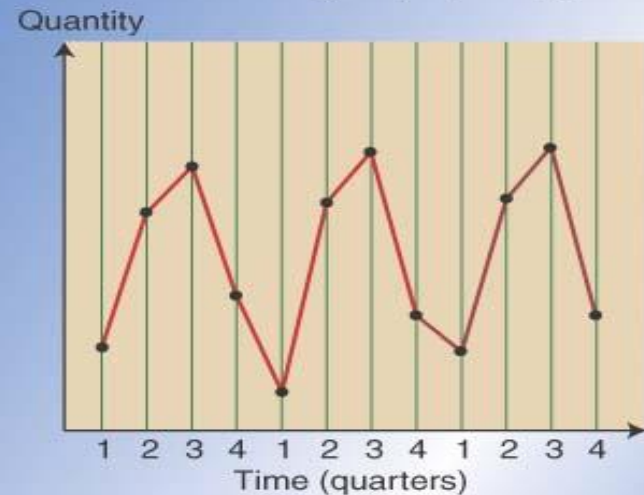
(b) Trend Pattern:

Data is progressively increasing (shown) or decreasing



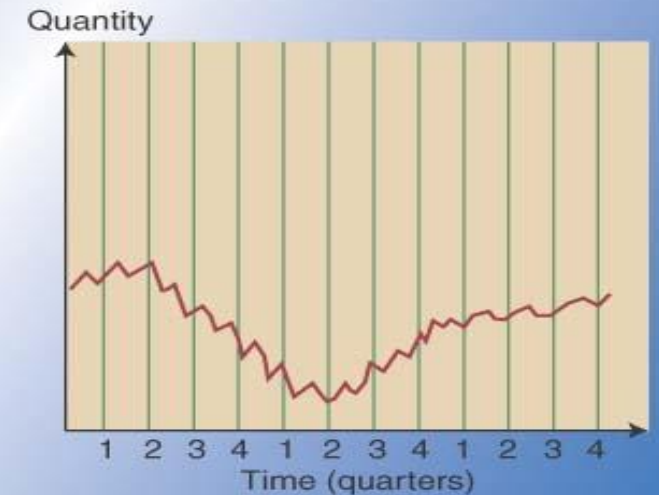
(c) Seasonal Pattern:

Data exhibits a regularly repeating pattern



(d) Cycle:

Data increases or decreases over time



Moving Average

Next period's forecast = simple average of the last N periods

$$F_{t+1} = \frac{A_t + A_{t-1} + \dots + A_{t-N+1}}{N}$$

The Effect of the Parameter N

- A smaller N makes the forecast more
responsive
- A larger N makes the forecast more
stable

Weighted Moving Average

$$F_{t+1} = C_1 A_t + C_2 A_{t-1} + \dots + C_N A_{t-N+1}$$

where

$$C_1 + C_2 + \dots + C_N = 1$$

Double Moving Average

$$\text{Forecast} = 2MA_{1,t} - MA_{2,t} + \frac{2}{m-1} [MA_{1,t} - MA_{2,t}]$$

Example

Computing a Simple Moving Average

The Heartland Produce Company sells and delivers food produce to restaurants and catering services within a 100-mile radius of its warehouse. The food supply business is competitive, and the ability to deliver orders promptly is a factor in getting new customers and keeping old ones. The manager of the company wants to be certain enough drivers and vehicles are available to deliver orders promptly and they have adequate inventory in stock. Therefore, the manager wants to be able to forecast the number of orders that will occur during the next month (i.e., to forecast the demand for deliveries).

From records of delivery orders, management has accumulated the following data for the past 10 months, from which it wants to compute three- and five-month moving averages.

Month	Orders	Month	Orders
January	120	June	50
February	90	July	75
March	100	August	130
April	75	September	110
May	110	October	90

Solution

- Assume a 3 or 5-month moving average

For November (3-month MA)= recent three period/3

$$= (90+110+130)/3 = 110 \text{ orders}$$

$$5\text{-month MA} = (90+110+130+75+50)/5 = 91 \text{ orders}$$

Refer, example 13.2, 50% oct data, 33% sept. data, and 17% August data.

Then, 3 month WMA,

$$(0.5*90+0.33*110+0.17*130)=103.4 \text{ orders}$$

Compute for Dec, Jan, Feb, and March

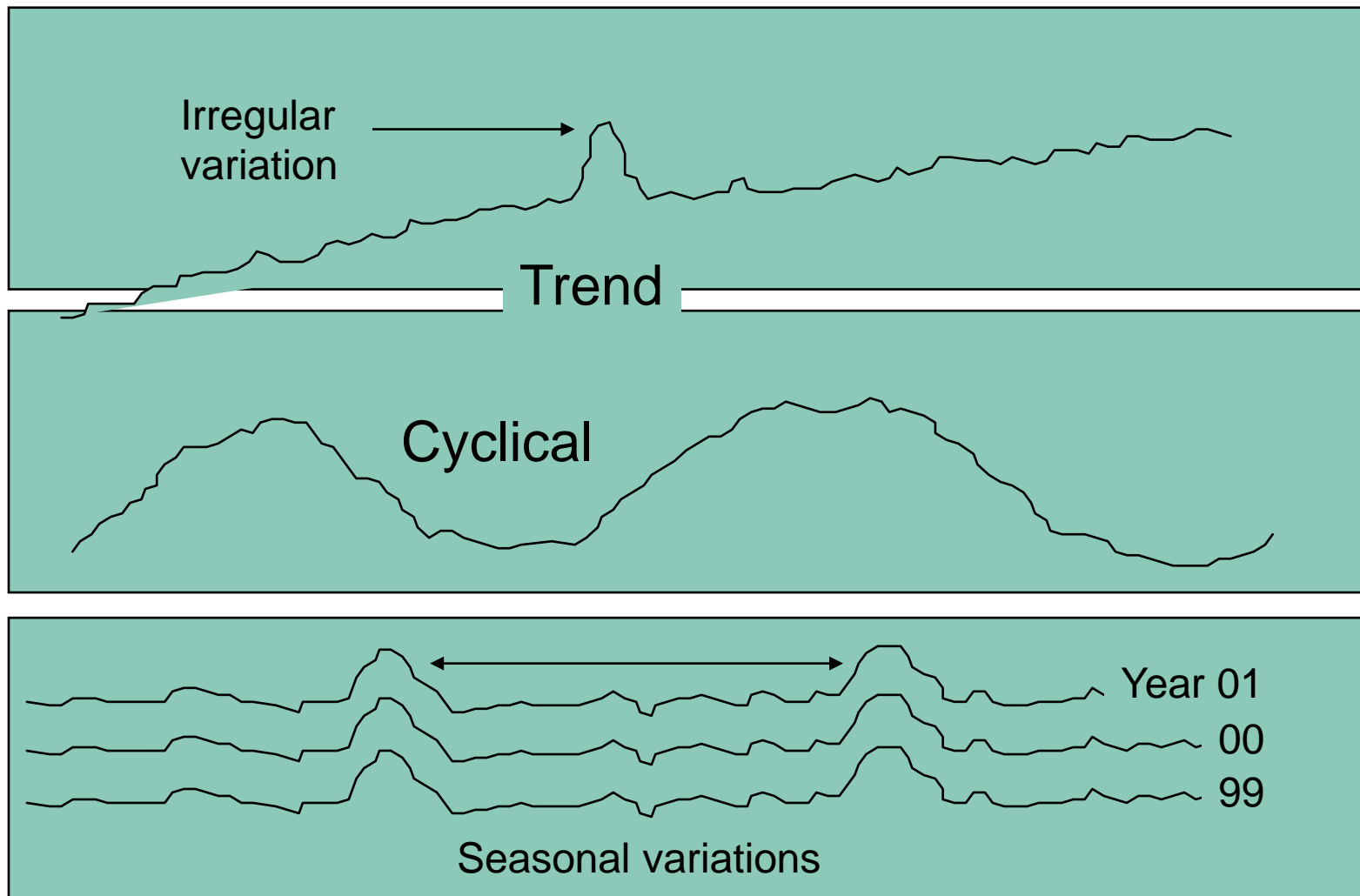
Time series

- **Time-ordered sequence of observations taken at regular intervals over a period of time**
- **Future values of the series can be estimated from past values.**

Types of Variations in Time Series Data

- Trend - long-term movement in data
- Seasonality - short-term regular variations in data
- Cycles – wavelike variations of long-term
- Irregular variations - caused by unusual circumstances
- Random variations - caused by chance

Forecast Variations



Exponential Smoothing (Page 538/Ch13)

Forecast error:=Actual – Forecast = $A(t-1)-F(t-1)$

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

Forecast today=Forecast yesterday+(alpha)*(Forecast error yesterday)

Each new forecast is equal to the previous forecast plus a percentage of the previous error.

Today's forecast

Depends on yesterday's (time-wise dependence, strong memory)

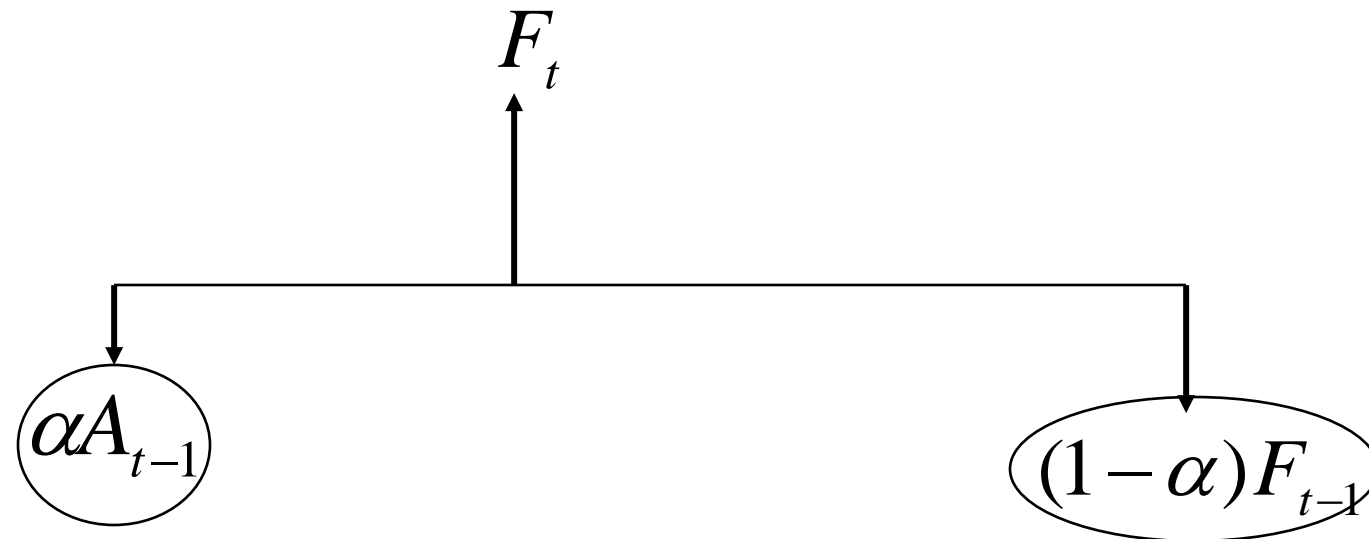
Therefore, we should give more weight to the more recent time periods when forecasting.

- Alpha = smoothing constant = percentage of the forecast error.

Exponential Smoothing as an Weighted Average

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

Idea--The most recent observations might have the highest predictive value along with the most recent forecast errors. Let us balance them:



Example of Exponential Smoothing

Forecasts made in a period and the period has the same color

Period	Actual	Forecast with	Error with	Forecast with	Error with
1	42	Alpha=0.1	Alpha=0.1	Alpha=0.4	Alpha=0.4
2	40	42	-2.00	42	-2
3	43	41.8	1.20	41.2	1.8
4	40	41.92	-1.92	41.92	-1.92
5	41	41.73	-0.73	41.15	-0.15
6	39	41.66	-2.66	41.09	-2.09
7	46	41.39	4.61	40.25	5.75
8	44	41.85	2.15	42.55	1.45
9	45	42.07	2.93	43.13	1.87
10	38	42.36	-4.36	43.88	-5.88
11	40	41.92	-1.92	41.53	-1.53
12		41.73		40.92	

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

HiTek Computer Services repairs and services personal computers at its store, and it makes local service calls. It primarily uses part-time State University students as technicians. The company has had steady growth since it started. It purchases generic computer parts in volume at a discount from a variety of sources whenever they see a good deal. Thus, they need a good forecast of demand for repairs so that they will know how many computer component parts to purchase and stock, and how many technicians to hire.

The company has accumulated the demand data shown in the accompanying table for repair and service calls for the past 12 months, from which it wants to consider exponential smoothing forecasts using smoothing constants (α) equal to 0.30 and 0.50.

Demand for Repair and Service Calls

Period	Month	Demand	Period	Month	Demand
1	January	37	7	July	43
2	February	40	8	August	47
3	March	41	9	September	56
4	April	37	10	October	52
5	May	45	11	November	55
6	June	50	12	December	54

Forecast Accuracy

- Forecasts are rarely perfect
- Need to know how much we should rely on our chosen forecasting method
- Measuring **forecast error**:

$$E_t = A_t - F_t$$

- Note that over-forecasts = negative errors and under-forecasts = positive errors

Forecast Accuracy

- Error - difference between actual value and predicted value
- Mean absolute deviation (MAD)
 - Average absolute error (weights all errors evenly)
- Mean squared error (MSE)
 - Average of squared error (weights errors according to their squared values)
 - MAPE (Mean absolute percentage error)
- Tracking signal
 - Ratio of cumulative error and MAD

<https://statxo.com/wp-content/uploads/2018/11/Case-Study-Demand-Forecasting.pdf>

MAD & MSE

Forecast error = Actual – Forecast

$$MAD = \frac{\sum_{t=1}^n |A_t - F_t|}{n}$$

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

$$Tracking\ Signal = \frac{\sum_{t=1}^n A_t - F_t}{MAD}$$

Estimate of (forecast error) standard deviation = $s = \sqrt{MSE}$

Statistics says : MSE is the unbiased estimator for the variance of forecast error.

Use for MAD & MSE

- Compare the accuracy of alternative
 - forecasting methods using MAD and MSE.
 - parameter (such as alpha) values used in forecastingby using MAD and MSE
- Determine which method yields the lowest MAD or MSE for a given set of data.