1. FORECASTING

SUPPLY CHAIN MANAGEMENT:

Supplier	Manufacturer	Warehouse	Distributer	Retailer	Consumer

Procurement of raw materials is done by supplier. Bi-Directional links are **Product, Money, Information.**

TOP LINE: Total Revenue.	**BOTTOM LINE:** Total Profit.

BOTTLENECK PROCESS: Critical operation takes Maximum time.

LEAD TIME: Time consumer should wait after placing order to get delivery of the order.

CANNIBALIZATION: Enter into market Share of other product should not go down by introducing your new product.
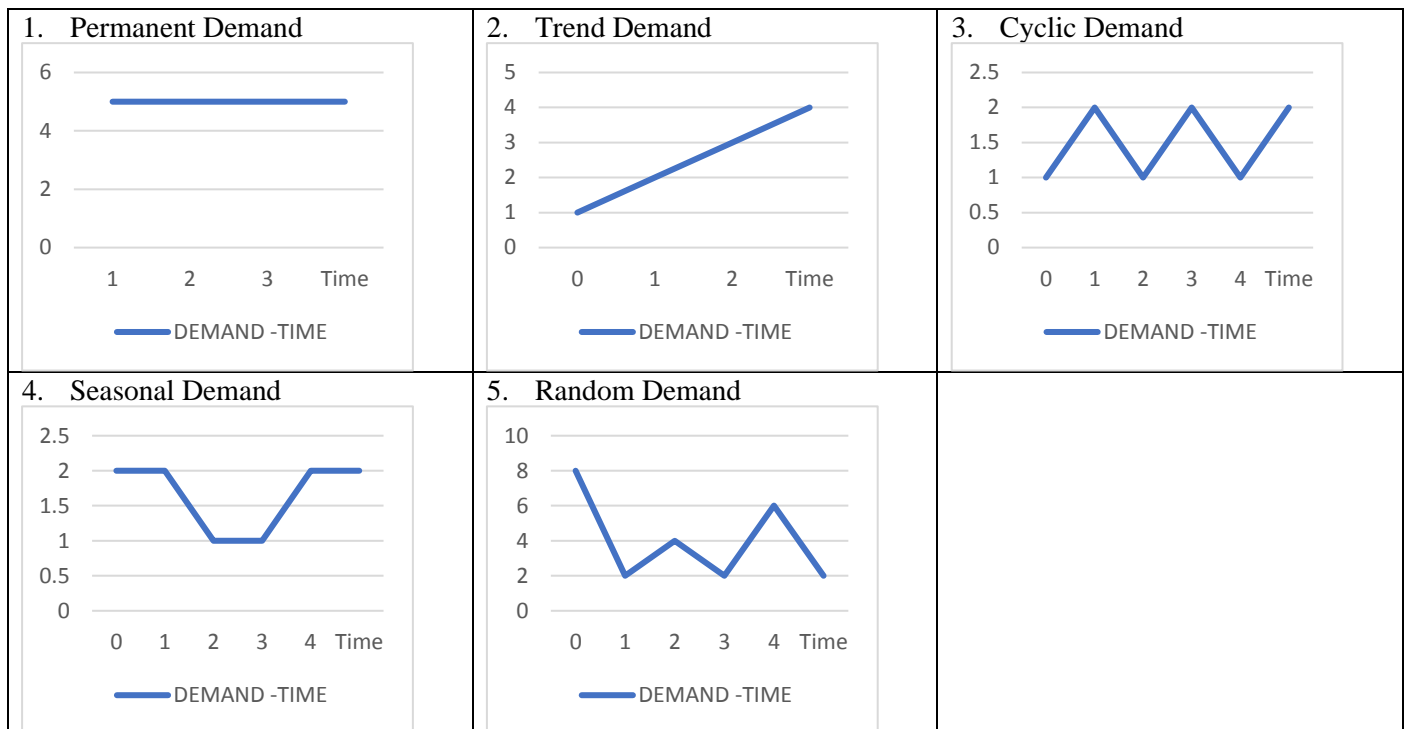
FORECASTING:

- Forecasting estimates the level of demand in future. It becomes the basis for production planning and control (PPC) As well as material requirement planning (MRP-I).
- In rough sense, it can be said as forward casting of previous data.

Steps of Forecasting in industries:

- Identify the problem.
- Collect the relevant information.
- Preform a preliminary analysis.
- Choose the forecasting Model.
- Data Analysis.
- Verify Model Performance.

TIME HORIZON		
Short Range (<1yr)	**Medium Range (1-3 yr)**	**Long Range (>3 yr)**
E.g. Labour requirements, Training.	E.g. Facility Expansion.	E.g. New product line development.

TYPES OF DEMANDS:

1. Permanent Demand
2. Trend Demand
3. Cyclic Demand
4. Seasonal Demand
5. Random Demand

TYPES OF FORECASTING BASED ON THE AVAILABILITY OF DATA	
Qualitative Forecasting	**Quantitative Forecasting**
Data is not available	Data is available

QUALITATIVE FORECASTING			
This is also called subjective forecasting. This method is used where past data is not available or is difficult to obtain the past data. Here, the Forecasting value depends upon the consensus of a group of experts.			
Group Averaging	**Group Consensus**	**Delphi Method**	**Market Survey**

GROUP AVERAGING:

- This method involves averaging of individual forecast obtained by different experts working independently.
- In this method, there is no communication among the experts.

GROUP CONSENSUS: This method involves assembling the expert at one place, sharing their individual opinions and finally coming up with common ideas.

DELPHI METHOD:
- This method combines the advantages of group averaging and group consensus and expert panel is chosen and is asked to give their individual forecast among with supporting documents. The co-ordinating agency collects the individual forecast and shares result with all experts without revelling the identity of other experts.
- This process is repeated until the final forecast is obtained.
- It's widely used for medium to long term forecasting.

Drawbacks:
- It's a time-consuming process.
- Getting a panel of experts itself is difficult.

MARKET SURVEY: Feedback or Pamphlet Distribution. In order to get consumer choices.

QUANTITATIVE FORECASTING					
The Forecasting is done based on the past data.					
Time series Forecasting			Casual Method		
Simple Moving Average Method	Weighted Moving Average Method	Simple Exponential Smoothing Method	Correlation Method	Linear Regression	Least Square Method

1. SIMPLE MOVING AVERAGE METHOD:
- This method uses past data and calculates a rolling average for a constant period. Fresh averaging is computed at the end of each period by adding the actual demand data for the most recent period and deleting the data for older period.
- In this method, data changes from period to period, therefore it's termed as moving average method.
- In Simple moving average method, the forecast for the next period is given as the simple average of previous 'n' periods.

$$\left(Demand\ of\ i^{th}\ period\right)_{SMA\ (n\ point)} = \left(\sum_{i=1}^{i}(Demand)_{n-i}\right)\Big/n$$

2. WEIGHTED MOVING AVERAGE METHOD OR RAINFALL FORECAST METHOD:
- Here, Weights are assigned to previous 'n' periods.

Note: If Weights are not given, then it can be calculated by sum of digit method.

$$\left(Demand\ of\ i^{th}\ period\right)_{WMA\ (n\ point)} = \left(\sum_{i=1}^{i}(Demand*Weight)_{n-i}\right)\Big/\sum_{i=1}^{i}(Weight)_{n-i}$$

Sum of Digits Method: i[th] Weight = i / Sum of Series
Sum of 'n' number series starting from zero = n (n+1)/ 2

3. SIMPLE EXPONENTIAL SMOOTHING METHOD:
- This method requires only the current demand and the forecast value for the current period to get the next forecast.
- This method is modified form of weighted moving average which gives weight to all previous data but it exponentially decreases order (The most recent data is give the highest weight)

Note: If for the initial period, forecast value is not given then,
- Take the actual demand for the first period equal to the first period forecast. OR
- Take average of the actual demand data as the forecast of the first period.

Limitation: This method doesn't include trend effect.

$F_{t+1} = \alpha D_t + (1-\alpha)F_t$ $\alpha = \dfrac{2}{n+1}$	α = Smoothing Constant, $0 \le \alpha \le 1$ F_t, D_t = Current Forecast and Demand, F_{t+1} = Next Period Forecast,	n = No. of demand points. $D_t - F_t$ = Error
CASE I: $\alpha = 0 \Leftrightarrow n = \infty \Leftrightarrow F_{t+1} = F_t$ **Stable Type of Demand.**	**CASE II:** $\alpha = 1 \Leftrightarrow n = 1 \Leftrightarrow F_{t+1} = D_t$ **New Product Development OR Responsive OR unstable demand.**	

Halt's Model => Double Exponential Smoothing Method => Level & Trend Effect.
Winter's Model => Triple Exponential Smoothing Method => Level, Trend & Seasonality Effect

4. CO-RELATION METHOD:

- It indicates the degree of closeness between the two variables and it's value ranges from -1 to 1.
- It's an indicator of the extent to which knowledge of one variable becomes useful for the prediction.

$y = a + bx_1 + cx_2$ x_1, x_2 = Independent Variable, y = Dependent Variable, a = y-intercept or initial level of demand, b = Slope or Trend Effect γ = Co-relation Coefficient. $-1 \le \gamma \le 1$	1. $\gamma = -1$ **Negative Correlation.**	2. $\gamma = 1$ **Strong Correlation.**	3. $\gamma = 0$ **No Correlation.** **Independent variables.**

5. LINEAR REGRESSION:

$y = a + bx$ a **and** b **find by solving 2 Equations.**	$\sum y_i = na + b \sum x_i$
	$\sum x_i y_i = a \sum x_i + b \sum x_i^2$

Types of regression process, 1) Linear Regression, 2) Logistic regression (Certain option is the result E.g. 0 or 1).

6. CASUAL METHOD:

In this method, forecaster tries to establish cause and effect relation between demand and forecast of product or any other factor on which demand is dependent.

7. LEAST SQUARE METHOD:

When the independent variable x is linear and uniform and it's in such a form that it can be modified such that $\sum x = 0$, then the calculation becomes very simple and the method is called Least Square Method.

$y = a + bx$ a **and** b **find by solving 2 Equations.**	$\sum y_i = na$
	$\sum x_i y_i = b \sum x_i^2$

FORECASTING ERRORS		
Mean Absolute Deviation: $MAD = \dfrac{\sum_{i=1}^{N}\lvert D_i - F_i \rvert}{N}$	**Mean Error or Bias:** $ME = \dfrac{\sum_{i=1}^{N}(D_i - F_i)}{N}$ CASE I: Under Estimation: D > F (ME or Bias > 0) CASE II: Over Estimation: D < F (ME or Bias < 0) **Running Sum Forecast Error:** $RSFE = \sum_{i=1}^{N}(D_i - F_i)$	**Mean Absolute Percentage Error:** $MAPE = \dfrac{100}{N}\sum_{i=1}^{N}\left\lvert\dfrac{D_i - F_i}{D_i}\right\rvert$
Mean Square Error: $MSE = \dfrac{\sum_{i=1}^{N}(D_i - F_i)^2}{N}$ Variance = MSE Std. Deviation $(\sigma) = \sqrt{MSE}$		**Tracking Signal:** $(TS) = \dfrac{RSFE}{MAD}$ Range/ limit of TS = $\pm 3\sqrt{MSE}$
Error Preference: MSE > MAD > BIAS > MAPE > TS		

1. **Mean Absolute Deviation:** It indicates the average magnitude of error without considering sign.
2. **Mean Error or Bias:**
- It measures the forecast error with regard to direction and shows any tendency of over or under forecast.
3. **Mean Square Error:** It's used compute the standard deviation for forecast error which is utilized to ploat the control chart.
4. **Mean Absolute Percentage Error:** It's used for forecasting seasonal product.
5. **Tracking Signal:**
- TS monitors the performance of the forecasting model and automatically indicates whether the model needs to be revised or not.
- If Signal goes beyond limits model need to be revised.