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ENGINEERS ACADEMY

# RRB - JE

# MECHANICAL

## Railway Recruitment Board

## Volume - 6

## Industrial Engineering

SIERRA INNOVATIONS

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# FORECASTING

## THEORY

## 1.1 FORECASTING

Forecasting means estimation of type, quantity and quality of future works e.g. sales etc. It is a calculated economic analysis.

### *1.1.1 Basic Elements of Forecasting*

- Trends
- Cycles
- Seasonal Variations
- Irregular Variations

## 1.2 SALES FORECASTING TECHNIQUES

- Historic Estimation
- Sales Force Estimation
- Trend Line (or Time-series Analysis) Technique
- Market Survey
- Delphi Method
- Judge Mental Techniques
- Prior Knowledge
- Forecasting by Past Average
- Forecasting from Last Period's Sales
- Forecasting by Moving Average
- Forecasting by Weighted Moving Average
- Forecasting by Exponential Smoothing
- Correlation Analysis
- Linear Regression Analysis.

### 1.2.1 Average Method

Forecast sales for next period = Average sales for previous period

$$F_{t+1} = \frac{S_t + S_{t-1} + ..... + S_1}{t}$$

Where, $F_{t+1}$ = Forecast sales for next period

$S_t, S_{t-1}, ...., S_1$ are sales of t number of periods.

***Example***:

| Period No. | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Sales | 7 | 5 | 9 | 8 | 5 | 8 |

Forecast sales for Period No

$$F_6 + 1 = \frac{7+5+9+8+5+8}{6} = 7$$

### 1.2.2 Forecast by Moving Average

In this method the forecast is neither influenced by very old data nor does it solely reflect the figures of the previous period.

***Example:***

| Year | Period | Sales | Four-period average forecasting |
|---|---|---|---|
| 1987 | 1 | 50 | |
| | 2 | 60 | |
| | 3 | 50 | |
| | 4 | 40 | |
| 1988 | 1 | 50 | Forecast for 1988 period 1 $= \frac{50+60+50+40}{4} = 50$ |
| | 2 | 55 | Forecast for 1988 period 2 $= \frac{60+50+40+50}{40} = 50$ |

### 1.2.3 Weighted Moving Average

A weighted moving Average allows any weights to be placed on each element, providing of course, that the sum of all weights equals one.

***Example***:

| Period | Sales |
|---|---|
| Month-1 | 100 |
| Month-2 | 90 |
| Month-3 | 105 |
| Month-4 | 95 |
| Month-5 | 110 |

Forecast (weights 40%, 30%, 20%, 10% of most recent month)

Forecast for month-5 would be:

$$F_5 = 0.4 \times 95 + 0.3 \times 105 + 0.2 \times 90 + 0.1 \times 100 = 97.5$$

Forecast for month-6 would be:

$$F_6 = 0.4 \times 110 + 0.3 \times 95 + 0.2 \times 105 + 0.1 \times 90 = 102.5$$

### 1.2.4 Exponential Smoothing

*New forecast = α (latest sales figure) + (1 – α ) (old forecast) [VIMP]*

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

Where, $\alpha$ is known as the smoothing constant.

The size of $\alpha$ should be chosen in the light of the stability or variability of actual sales, and is normally from 0.1 to 0.3.

The smoothing constant, $\alpha$ , that gives the equivalent of an N-period moving average can be calculated as follows, $\alpha = \frac{2}{N+1}$

For e.g. if we wish to adopt an exponential smoothing technique equivalent to a nine period moving average then, $\alpha = \frac{2}{9+1} = 0.2$

Basically, exponential smoothing is an average method and is useful for forecasting one period ahead. In this approach, the most recent past period demand is weighted most heavily. In a continuing manner the weights assigned to successively past period demands decrease according to exponential law.

### 1.2.5 Generalized Equation

$$F_t = \alpha.\ (1 - \alpha)^0\ d_{t-1} + \alpha.\ (1 - \alpha)^1\ d_{t-2} + \alpha.\ (1 - \alpha)^2\ d_{t-3} + \ldots.. + \alpha\ (1 - \alpha)^{k-1}\ d_{t-k} + (1 - \alpha)^k\ F_{t-k}$$

[Where k is the number of past periods]

It can be seen from above equation that the weights associated with each demand of equation are not equal but rather the successively older demand weights decrease by factor $(1 - \alpha)$. In other words, the successive terms $\alpha\ (1- \alpha)^0$, $\alpha\ (1- \alpha)^1$, $\alpha\ (1- \alpha)^2$, $\alpha\ (1- \alpha)^3$ decreases exponentially.

This means that the more recent demands are more heavily weighted than the remote demands.

**Exponential smoothing method of Demand Forecasting:**

- Demand for the most recent data is given more weightage.
- This method requires only the current demand and forecast demand.
- This method assigns weight to all the previous data.

**Regression Analysis:**

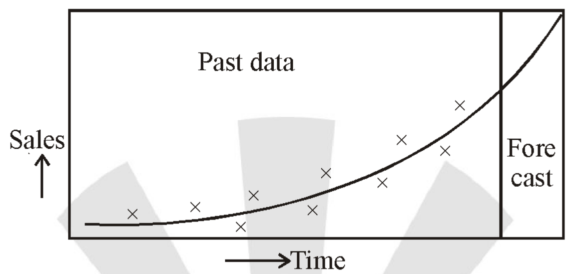
Regression analysis is also known as method of curve fitting. On this method the data on the past sales is plotted against time, and the best curve called the 'Trend line' or 'Regression line' or 'Trend curve'. The forecast is obtained by extrapolating this trend line or curve.

For linear regression

$$y = a + bx$$

$$a = \frac{\sum y - b\sum x}{n}$$

$$b = \frac{n\sum xy - (\sum x)(\sum y)}{n\sum x^2 - (\sum x)^2}$$




$$\text{Standard error} = \sqrt{\frac{\sum(x - y_1)^2}{(n-2)}}$$

***Example*:** What are moving average and exponential smoothing models for forecasting? A dealership for Honda city cars sells a particular model of the car in various months of the year. Using the moving average method, find the exponential smoothing forecast for the month of October 2010. Take exponential smoothing constant as 0.2:

| | | |
|---|---|---|
| Jan. | 2010 | 80 cars |
| Feb. | 2010 | 65 cars |
| March | 2010 | 90 cars |
| April | 2010 | 70 cars |
| May | 2010 | 80 cars |
| June | 2010 | 100 cars |
| July | 2010 | 85 cars |
| Aug. | 2010 | 65 cars |
| Sept. | 2010 | 75 cars |

***Solution:*** (i) ***Moving average model for forecasting:*** Refer theory part of this book.

(ii) ***Exponential smoothing model for forecasting:*** Refer theory part of this book

| *Months* | *Sells cars* | *Forecast demand (n = 3)* |
|---|---|---|
| Jan. | 80 | |
| Feb. | 65 | |
| March | 90 | |
| April | 70 | (80 + 65 + 90)/3 =78.33 |
| May | 80 | (65 + 90 + 70)/3 = 75 |

| | | |
|---|---|---|
| June | 100 | (90 + 70 + 80)/3 = 80 |
| July | 85 | (70 + 80 100)/3 = 83.33 |
| Aug. | 60 | (80 + 100 + 85)/3 = 88.33 |
| Sep. | 75 | (100 + 85 + 60)/3 = 81.67 |

***Forecast of oct. by exponential smoothing method***

$$F_{oct} = F_{sep} + \alpha (D_{sep} - F_{sep.})$$

$$\alpha = 0.2 \ F_{sep} = 81.67 \ D_{spt.} = 75$$

$$F_{oct} = 81.67 + 0.2 (75 - 81.67)$$

$$F_{Oct} = 80.33 \simeq 81$$

***Forecast for the month of October using moving average***

$$F_{oct} = \frac{D_{July} + D_{Aug} + D_{Sep}}{3}$$

$$= \frac{75 + 60 + 80}{3} = 71.67$$

***Example:*** Explain the need for sales forecasting. How are forecasting methods classified?

The past data about the load on a machine centre is as given below:

| *Month* | *Load, Machine-Hours* |
|---|---|
| 1 | 585 |
| 2 | 611 |
| 3 | 656 |
| 4 | 748 |
| 5 | 863 |
| 6 | 914 |
| 7 | 964 |

(i) If a five month moving average is used to forecast the next month's demand, compute the forecast of the load on the centre in the $8^{th}$ month.

(ii) Compute a weighted three month moving average for the $8^{th}$ month, where the weights are 0.5 for the latest month, 0.3 and 0.2 for the other months, respectively.

***Solution:*** Most organizations are not in a position to wait unit orders are received before they begin to determine what production facilities, process, equipment, manpower, or materials are required and in what quantities. Most successful organization anticipate the future and for their products and translate that information into factor inputs required to satisfy expected demand. Forecasting provides a blue print for managerial planning. Forecasting is the estimation of the future on the basis of the past.

In many organizations, sales forecasts are used to establish production levels, facilitate scheduling, set inventory levels, determine man power loading, make purchasing decisions, establish sales conditions (pricing and advertising) and aid financial planning (cash budgeting and capital budgeting).

A good forecast should have the following attributes. It should be accurate, simple, easy, economical, quick and upto date. Following are the basic steps involved in a systematic demand forecast.

(i) State objectives

(ii) Select method

(iii) Identify variables

(iv) Arrange data

(v) Develop relationship

(vi) Prepare forecast and interpret

(vii) Forecast in specific units.

(i) Forecast for 8th month on the basis of five month moving average

$$= (964 + 914 + 863 + 748 + 656)/5 = 829$$

(ii) Forecast for 8th month on the basis of weighted average

$$= 0.5 \times 964 + 0.3 \times 914 + 0.2 \times 863 = 928.8$$

***Example:*** **(i)** List common time-series forecasting models. Explain simple exponential smoothing method of forecasting demand. What are its limitations?

**(ii)** The monthly forecast and demand values of a firm are given below:

| *Month* | *Forecast units* | *Demand units* |
|---|---|---|
| Jan | 100 | 97 |
| Feb | 100 | 93 |
| Mar | 100 | 110 |
| Apr | 100 | 98 |
| May | 102 | 130 |
| Jun | 104 | 133 |
| Jul | 106 | 129 |
| Aug | 108 | 138 |
| Sep | 110 | 136 |
| Oct | 112 | 124 |
| Nov | 114 | 139 |
| Dec | 116 | 125 |

Calculate Tracking Signal for each month. Comment on the forecast model.

***Solution:*** **(i)** Component of time series models

**(1)** Trend (T)

**(2)** Cyclic variation (C)

**(3)** Seasonal variation (S)

**(4)** Random variation (R)

***Exponential Smoothing***

This is similar to the weighted average method. The recent data is given more weightage and the weightages for the earlier periods are successfully being reduced. Let $x_t$ is the actual (historical) data of demand during the period t. Let ± is the weightage given for the period t and $F_t$ is the forecast for the time t then forecast for the time (t + 1) will be given as

**(ii)** Tracking signal $= \dfrac{\text{Cumulative deviation}}{MAD}$

$$= \frac{\Sigma(x_t - F_t)}{MAD}$$

Where, $MAD$ = Mean Absolute deviation

$$= \frac{\text{Sum of absolute deviations}}{\text{Total number of datas}} = \frac{\Sigma(x_t - F_t)}{n}$$

| Month | Forecast | Demand | $(x_t - F_t)$ | MAD | | T.S. $= \dfrac{\sum(x_t - f_t)}{MAD}$ |
|---|---|---|---|---|---|---|
| January | 100 | 97 | -3 | 3 | -3 | -1 |
| February | 100 | 93 | -7 | 5 | -10 | -2 |
| March | 100 | 110 | 10 | 6.67 | 0 | 0 |
| April | 100 | 98 | -2 | 5.5 | -2 | -0.3636 |
| May | 102 | 130 | 28 | 10 | 26 | 2.6 |
| June | 104 | 133 | 29 | 13.167 | 55 | 4.177 |
| July | 106 | 129 | 23 | 14.571 | 78 | 5.353 |
| August | 108 | 138 | 30 | 16.5 | 108 | 6.545 |
| September | 110 | 136 | 26 | 17.55 | 134 | 7.635 |
| October | 112 | 124 | 12 | 17 | 146 | 8.588 |
| November | 114 | 139 | 25 | 17.727 | 171 | 9.646 |
| December | 116 | 125 | 9 | 17 | 180 | 10.588 |

Mean square error (MSE) $= \dfrac{\Sigma|x_t - F_t|^2}{n} = \dfrac{4742}{12}$

$= 395.167$

Upper limit $= 3 \times \sqrt{MSE} = 3 \times \sqrt{395.167}$

$= 59.636$

Since upper limit of T.S < 59.636 hence model should not be revised.

***Example:*** Demand for a certain item has been as shown below:

The forecast for April was 100 units with a smoothing constant of 0.20 and using first order exponential smoothing what is the July forecast? What do you think about a 0.20 smoothing constant?

| *Time* | *Actual Demand* |
|---|---|
| April | 200 |
| May | 50 |
| June | 150 |

***Solution:*** Using exponential smoothing average:

$$F_{may} = \alpha \times D_{April} + (1 - \alpha)\ F_{April}$$
$$= 0.2 \times 200 + (1 - 0.2) \times 100 = 120$$
$$F_{June} = \alpha \times D_{May} + (1 - \alpha)F_{may}$$
$$= 0.2 \times 50 + (1 - .2) \times 120 = 106$$
$$F_{july} = \alpha \times D_{june} + (1 - \alpha) \times F_{june}$$
$$= 0.2 \times 150 + 0.8 \times 106 = 114.8 = 115$$

***Example:*** In a time series forecasting model, the demand for five time periods was 10, 13, 15 18 and 22. A linear regression fit results in as equation F = 6.9 + 2.9 t where F is the forecast for period t. The sum of absolute deviation for the five data is?

***Solution:*** Sum of absolute deviation

$$= |D_1 - F_1| + |D_2 - F_2| + |D_3 - F_3| + |D_4 - F_4| + |D_5 - F_5|$$
$$= |10 - 6.9 - 2.9 \times 1| + |13 - 6.9 - 2.9 \times 2| + |15 - 6.9 - 2.9 \times 3|$$
$$+ |18 - 6.9 - 2.9 - 2.9 \times 4| + |22 - 6.9 - 2.9 \times 5|$$
$$= 0.2 + 0.3 + 0.6 + 0.5 + 0.6 = 2.2$$

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