

THEORY & OBJECTIVE

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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

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

Where,

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

S_t, S_{t-1}, \dots, 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 $2 = \frac{60+50+40+50}{4} = 50$

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,

α is known as the smoothing constant.

The size of α 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, α , 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

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

[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:

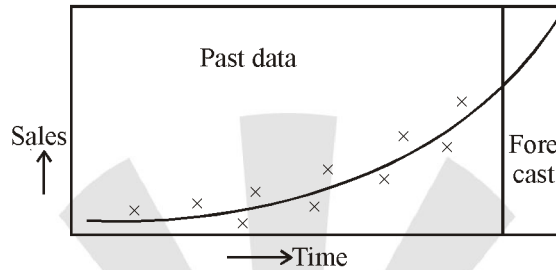
Regression analysis is also known as method of curve fitting. On this method the data on the past sales is plotted against time, and the best curve called the 'Trend line' or 'Regression line' or 'Trend curve'. The forecast is obtained by extrapolating this trend line or curve.

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

$$F_{\text{Oct}} = F_{\text{Sep}} + \alpha (D_{\text{Sep}} - F_{\text{Sep}})$$

$$\alpha = 0.2 \quad F_{\text{Sep}} = 81.67 \quad D_{\text{Sep}} = 75$$

$$F_{\text{Oct}} = 81.67 + 0.2 (75 - 81.67)$$

$$F_{\text{Oct}} = 80.33 \approx 81$$

Forecast for the month of October using moving average

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

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

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 8th month.
- (ii) Compute a weighted three month moving average for the 8th 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 until orders are received before they begin to determine what production facilities, process, equipment, manpower, or materials are required and in what quantities. Most successful organizations 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:

<i>Month</i>	<i>Forecast units</i>	<i>Demand units</i>
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 \pm 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

$$(ii) \text{ Tracking signal} = \frac{\text{Cumulative deviation}}{MAD} = \frac{\sum(x_t - F_t)}{MAD}$$

Where,

MAD = Mean Absolute deviation

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

Month	Forecast	Demand	($x_t - F_t$)	MAD		T.S. = $\frac{\sum(x_t - f_t)}{MAD}$
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

$$\text{Mean square error (MSE)} = \frac{\sum |x_t - F_t|^2}{n} = \frac{4742}{12} = 395.167$$

$$\text{Upper limit} = 3 \times \sqrt{MSE} = 3 \times \sqrt{395.167} = 59.636$$

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:

$$\begin{aligned}F_{\text{may}} &= \alpha \times D_{\text{April}} + (1 - \alpha) F_{\text{April}} \\ &= 0.2 \times 200 + (1 - 0.2) \times 100 = 120\end{aligned}$$

$$\begin{aligned}F_{\text{June}} &= \alpha \times D_{\text{May}} + (1 - \alpha) F_{\text{may}} \\ &= 0.2 \times 50 + (1 - .2) \times 120 = 106\end{aligned}$$

$$\begin{aligned}F_{\text{july}} &= \alpha \times D_{\text{june}} + (1 - \alpha) \times F_{\text{june}} \\ &= 0.2 \times 150 + 0.8 \times 106 = 114.8 = 115\end{aligned}$$

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 an equation $F = 6.9 + 2.9t$ where F is the forecast for period t . The sum of absolute deviation for the five data is?

Solution: Sum of absolute deviation

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



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PRACTICE SHEET

1. Which one of the following forecasting techniques is not suited for making forecasts for planning production schedules in the short range?
 - (a) Moving average
 - (b) Exponential moving average
 - (c) Regression analysis
 - (d) Delphi

2. When using a simple moving average to forecast demand, one would.
 - (a) Give equal weight to all demand data
 - (b) Assign more weight to the recent demand data
 - (c) Include new demand data in the average without discarding the earlier data
 - (d) Include new demand data in the average after discarding some of the earlier demand data

3. In a forecasting model, at the end of period 13, the forecasted value for period 14 is 75. Actual value in the periods 14 to 16 are constant at 100. If the assumed simple exponential smoothing parameter is 0.5, then the MSE at the end of period 16 is:

(a) 820.31	(b) 273.44
(c) 43.75	(d) 14.58

4. The most commonly used criteria for measuring forecast error is:
 - (a) Mean absolute deviation
 - (b) Mean absolute percentage error
 - (c) Mean standard error
 - (d) Mean square error

5. In a time series forecasting model, the demand for five time periods was 10, 13, 15, 18 and 22. A linear regression fit resulted in an equation $F = 6.9 + 2.9 t$ where F is the forecast for period t . The sum of absolute deviations for the five data is:

(a) 2.2	(b) 0.2
(c) -1.2	(d) 24.3

6. **Assertion (A):** Time series analysis technique of sales-forecasting can be applied to only medium and short-range forecasting.

Reason (R): Qualitative information about the market is necessary for long-range forecasting.

 - (a) Both A and R are individually true and R is the correct explanation of A
 - (b) Both A and R are individually true but R is **not** the correct explanation of A
 - (c) A is true but R is false
 - (d) A is false but R is true

7. Given T = Underlying trend, C = Cyclic variations within the trend, S = Seasonal variation within the trend and R = Residual, remaining or random variation, as per the time series analysis of sales forecasting, the demand will be a function of:

(a) T and C	(b) R and S
(c) T, C and S	(d) T, C, S and R

8. Which one of the following methods can be used for forecasting the sales potential of a new product?
 - (a) Time series analysis
 - (b) Jury of executive opinion method
 - (c) Sales force composite method
 - (d) Direct survey method

9. Match List-I with List-II and select the correct answer using the codes given below the lists:

<p style="text-align: center;">List-I</p> <p>A. Decision making under complete certainty</p> <p>B. Decision making under risk</p> <p>C. Decision making under complete uncertainty</p> <p>D. Decision making based on expert opinion</p>	<p style="text-align: center;">List-II</p> <p>1. Delphi approach</p> <p>2. Maximax criterion</p> <p>3. Transportation mode</p> <p>4. Decision tree</p>
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Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	4	3	2	1
(c)	3	4	2	1
(d)	4	3	1	2

10. Match List-I (Methods) with List-II (Problems) and select the correct answer using the codes given below the lists:

List-I

- A. Moving average
- B. Line balancing
- C. Economic batch size
- D. Johnson algorithm

List-II

- 1. Assembly
- 2. Purchase
- 3. Forecasting
- 4. Sequencing

Codes: **A** **B** **C** **D**

- (a) 1 3 2 4
- (b) 1 3 4 2
- (c) 3 1 4 2
- (d) 3 1 2 4

11. A company intends to use exponential smoothing technique for making a forecast for one of its products. The previous year's forecast has been 78 units and the actual demand for the corresponding period turned out to be 73 units. If the value of the smoothening constant \pm is 0.2, the forecast for the next period will be:

- (a) 73 units
- (b) 75 units
- (c) 77 units
- (d) 78 units

12. For sales forecasting, pooling of expert opinions is made use of in.

- (a) Statistical correlation
- (b) Delphi technique
- (c) Moving average method
- (d) Exponential smoothing

13. To meet short range changes in demand of a product, which of the following strategies can be considered?

- 1. Overtime
- 2. Subcontracting
- 3. Building up inventory
- 4. New investments

Select the correct answer from the codes given below:

- (a) 1, 2 and 3
- (b) 1, 3 and 4
- (c) 2 and 3
- (d) 1 and 2



ANSWER SHEET

1. *Ans. (d)*

Moving, average, Exponential moving average is used for short range. Regression is used for short and medium range. Delphi is used for long range forecasting.

2. *Ans. (d)*

3. *Ans. (b)*

Period	14.0	15.00	16.000
X_t	100.0	100.00	100.000
F_t	75.0	87.50	93.750
$(X_t - F_t)$	25.0	12.50	6.250
$\alpha(X_t - F_t)$	12.5	6.25	3.125
F_{t+1}	87.5	93.75	96.875
$(X_t - F_t)^2$	625	156.25	39.0625

$$\Sigma(X_t - F_t)^2 = 820.31$$

$$\text{Mean squared error, MSE} = \frac{820.31}{3} = 273.44$$

4. *Ans. (d)*

5. *Ans. (a)*

Sum of absolute deviation

$$\begin{aligned} &= (D_1 - F_1) + (D_2 - F_2) + (D_3 - F_3) + (D_4 - F_4) \\ &\quad + (D_5 - F_5) \\ &= (10 - 6.9 - 2.9 \times 1) + (13 - 6.9 - 2.9 \times 2) \\ &\quad + (15 - 6.9 - 2.9 \times 3) + \dots \end{aligned}$$

6. *Ans. (b)*

7. *Ans. (c)*

Sales forecasting should not be influenced by the random variations in demand.

8. *Ans. (d)*

9. *Ans. (c)*

10. *Ans. (d)*

11. *Ans. (c)*

New forecast

$$\begin{aligned} &= \text{Old forecast} + \alpha(\text{actual demand} - \text{old forecast}) \\ &= 78 + 0.2(73 - 78) = 77 \end{aligned}$$

12. *Ans. (b)*

13. *Ans. (b)*



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ROUTING, SCHEDULING, ETC.

THEORY

2.1 | ROUTING

Includes the planning of what work shall be done on the material to produce the product or part, where and by whom the work shall be done. It also includes the determination of path that the work shall follow and the necessary sequence of operations which must be done on the material to make the product.

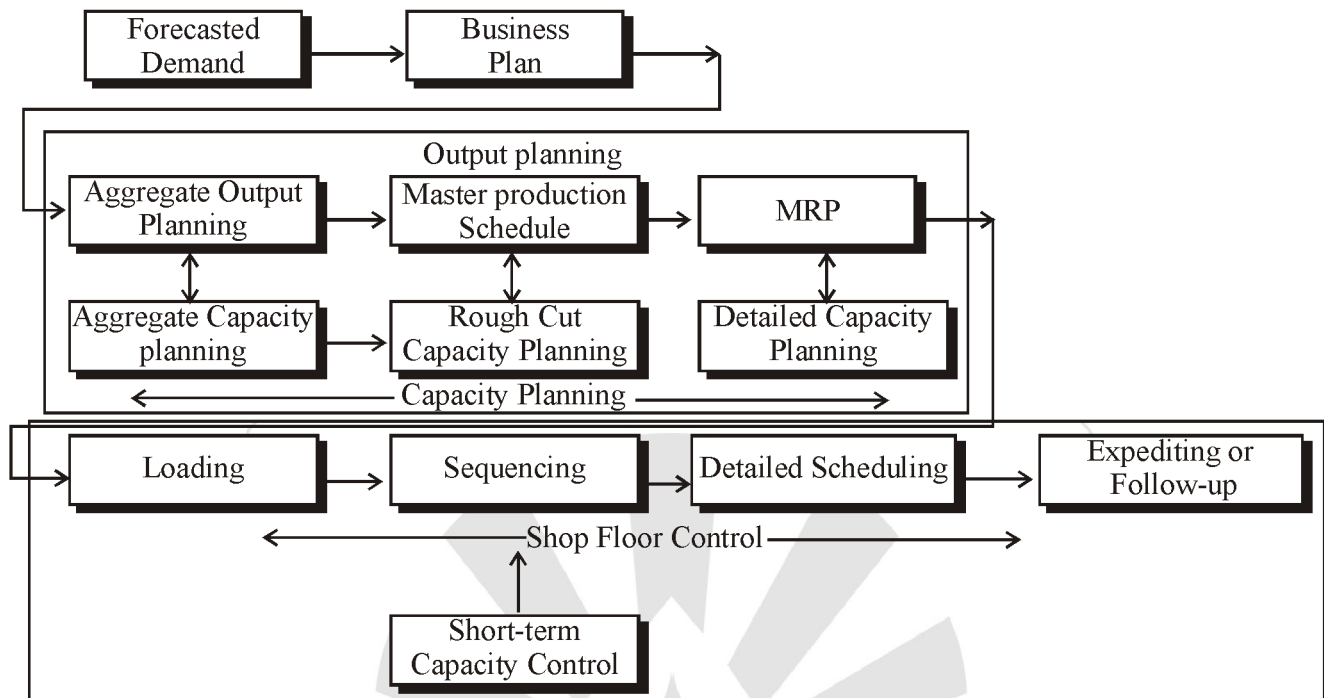
2.1.1 Routing Procedure Consist of the Following Steps

The finished product is analysed thoroughly from the manufacturing stand point, including the determination of components if it is an assembly product. Such an analysis must include:

- The following activities are to be performed in a particular sequence for routing a product.
- Analysis of the product and breaking it down into components.
- Taking makes or buys decisions.
- Determination of operations and processing time requirement.
- Determination of the lot size.
- Material or parts needed.
- Whether the parts are to be manufactured, are to be found in stores (either as raw materials or worked materials), or whether they are to be purchased.
- Quantity of materials needed for each part and for the entire order.

2.2 | SCHEDULING

Scheduling is used to allocate resources over time to accomplish specific tasks. It should take account of technical requirement of task, available capacity and forecasted demand. Forecasted demand determines plan for the output, which tells us when products are needed. The output-plan should be translated into operations, timing and schedule on the shop-floor. This involves loading, sequencing, detailed scheduling, expediting and input/output control.



The Planning and Scheduling Function

2.3 | SEQUENCING

When number of jobs are waiting in queue before an operational facility (such as, a milling machine), there is a need to decide the sequence of processing all the waiting jobs. Sequencing is basically an order in which the jobs, waiting before an operational facility, are processed. For this, priority rule, processing time, etc. are needed.

The decision regarding order in which jobs-in-waiting are processed on an operational facility or work-centre is called as sequencing.

2.4 | DETAILED SCHEDULING

Once the priority rule of job sequencing is known, we can sequence the jobs in a particular order. This order would determine which job is done first, then which the next one is and so on. However, sequencing does not tell us the day and time at which a particular job is to be done. This aspect is covered in detailed scheduling. In this, estimates are prepared regarding setup and processing time at which a job is due to start and finish. Detailed

2.5 | LOADING

The customer order for each job has certain job contents, which need to be performed on various work centers of facilities. During each planning period, jobs orders are assigned on facilities. This ultimately determines the work-load or jobs to be performed in a planned period.

The assignment of specific jobs to each operational facility during a planning period is known as loading.