Ch :- 2 Operations Planning

2.1 Demand Forecasting.

* Demand → requirement & desire of consumers
+
willingness and abilities to pay for the same.

* Forecasting → process of making predictions
+
about future happenings / requirements based on available information.

Q] Why demand forecasting?

1] To Plan → Facilities
→ Manpower
→ Funds
→ RM / Inventory
→ Machines
→ Process Strategy

2] Timely Forecast → Competitive Advantage.
No timely forecast → out of the competition.

3] Forecasting → effect → its efficiency & effectiveness accuracy.

Q] What are the sources of information?

- Market Report → Points of Sales Data
- Industry Report
- Sales force opinion
- Expert's views
- Field survey
- Structured customer survey

Structured

Q] Range of forecasting

Short	Medium	Long
few weeks	3-6 m	1 yr & more
6-8 m	1-2 years	generally 5 years
eg) Mobile phones	eg) Consumer durable products, Medicines.	10-15 years.
→ Inventory		
→ workloads < men / M/c		
→ Transport	→ Budget	→ Capital Exp
→ WC	→ Dividend Policy	→ Cash flows
→ setup, prodⁿ runs	→ Capacity Adj	→ Future manpower
→ sales quote	→ Schedule of Operations	→ Material Req.
→ overtime.	→ Maintenance exp.	→ R & D
→more useful in Prodⁿ planning.		

Q] Steps in Forecasting.

1] Objective → Why? Purpose? trend? Production? Customer Preference?

2] Period → Short, Medium, Long

3] Methods → depends upon period information

4] Gather Info → Primary OR Secondary

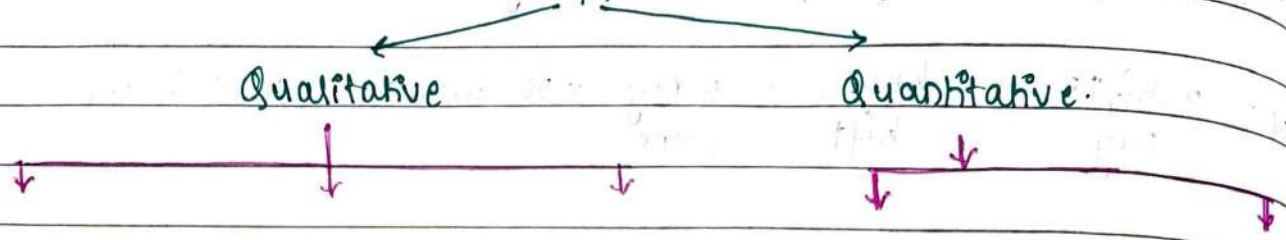
Primary → data we get from records of firm itself

Secondary → from outside means published data, magazines etc.

5] make the forecast.

* Forecasting Methods (How to forecast demand?)

Two Approaches



Delphi method → An iterative group process which employs group of experts, staff, respondents to obtain forecast.

Sales force composite → Group comprising members from sales force of Co. are asked to estimate the likely demand in respective sales zones

Consumer Panel Survey → Group of consumers are asked about their purchase plans to ascertain future demand forecast.

* Causal / Regression Analysis :-

Forecast of a dependent variable is made with the help of its variability nature with an independent variable.

Follows simple regression eqⁿ = $Y = a + bx$

a = y axis intercept of the regression line.
b = slope of the regression line.
x = the independent variable.
Y = the forecast value of dependent variable.

$$b = \frac{\Sigma XY - n \times \bar{X} \times \bar{Y}}{\Sigma X^2 - n \bar{X}^2}$$

$$a = \bar{Y} - b\bar{X}$$

$\bar{Y}, \bar{X}$ are mean of respective variables.
n = no. of data items in x and Y series.

* Methods of forecasting by forming Trend equation.

• Trend :-

→ long term upward or downward movement in the data mainly due to seasonal variations in the time duration.

→ Trend component may be linear or may be non-linear.

→ Linear trend is fairly common and measured by forming the equation $F_t = a + bt$.

F_t = forecast for period t, a = value of F_t at $t = 0$ i.e. y axis intercept ; b = slope of the linear trend eqn shown above , t = specified no of time periods from $t = 0$.

→ $$b = \frac{\Sigma tY - n \times \bar{t} \times \bar{Y}}{\Sigma t^2 - n\bar{t}^2} = \frac{n\Sigma tY - \Sigma t \times \Sigma Y}{n\Sigma t^2 - (\Sigma t)^2}$$

$$a = \bar{Y} - b\bar{t}$$

$\bar{t}, \bar{Y}$ are mean of respective variables
n = no. of data items in t and Y series
Very similar to causal method.

* Method of forecasting by averaging

- simple moving average method
- weighted moving average method.

1] Forecast by simple moving average method is done by:

$$F_t = MA_n = \frac{\sum_{t=1}^{n} A_{t-i}}{n}$$

where F_t = Forecast for period t,
MA_n = n period moving average,
A_{t-i} = Actual demand in period t-i
n = no. of period (data points) in the time series.

2] Forecast by weighted moving average method is done by

$$F_t = WMA_n = \sum_{i=1}^{n} W_{t-i} \times A_{t-i}$$

where F_t = Forecast for period t,
WMA_n = n period weighted moving average
A_{t-i} = Actual demand in period t-i
w_t = weight assigned to product t-i &
n = no. of period (data points) in the time series.

eg)

Year	1	2	3	4	5
Sales	10	20	35	42	58

Find out 3Y-MA against 3 year 3 if the weights are 1, 2, 1.

→

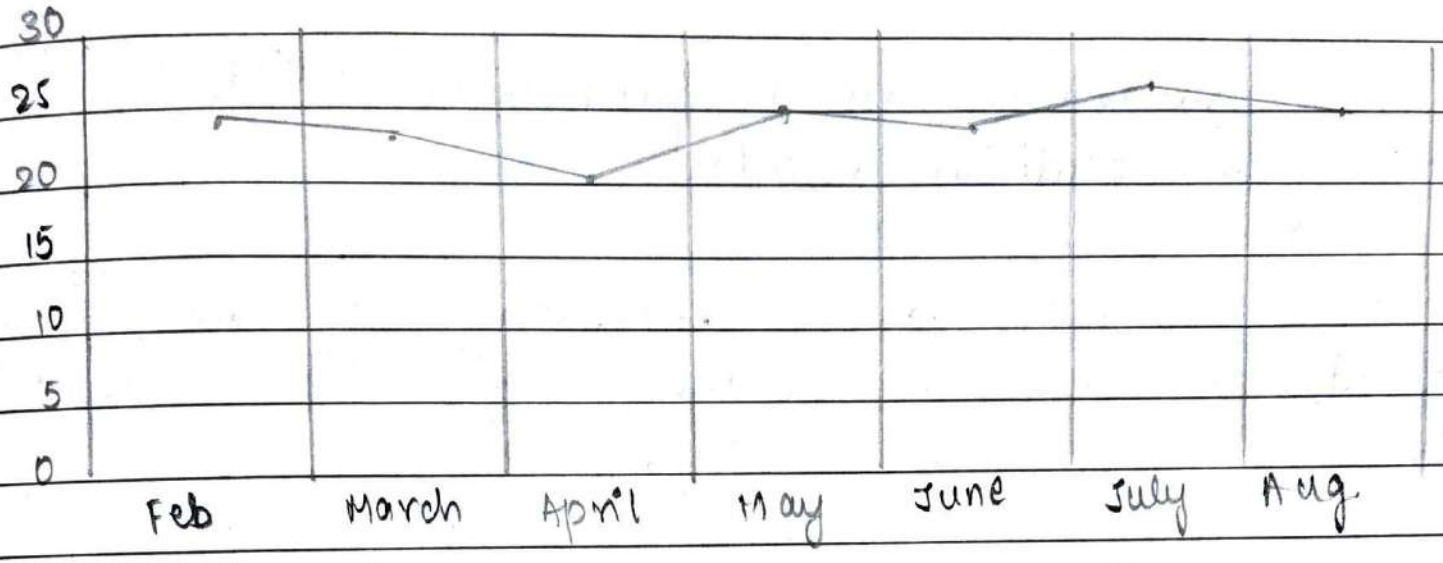
Sales	w	weighted sales
20	1	20
35	2	70
42	1	42
		132

$= \frac{132}{4} = 33$

Eg:- Monthly sales of ABC Co. for a seven month period are as follows:-

Month	Feb	March	April	May	June	July	Aug
Sales (000 units)	24	23	20	25	23	27	25

Plot the data.



Q. Time Series? (to make forecast, data of actual demand for historical previous periods are taken).

→ 4 components → Trend
→ Seasonality
→ Cyclical
→ Irregular (I) or Random

2 Models

Additive → T + S + C + I

Multiplicative → TSCI

1) Trend → long period of time → up / down, no change trend = 0. stable data

2) Seasonality → Rhym, Regular & Periodic.
→ less than 1 year. Eg :- Consumer → season

3) Cyclical → Business cycle → Prosperity, Recession, Peak, Dep.

4) Irregular (I) or Random → Random, Uncontrollable, Unpredictable.

Forecast is made by forming trend equation or by average method.

* In time series analysis seasonality (S) refers to — regular annual variation.

Eg:- Rush hour rate of UBER cab booking, holiday influenced demand like puja shopping etc.

→ Seasonality in time series is expressed in terms of the amount that actual demand values deviate from the average value of the series.

→ If trend is present, seasonality is expressed in terms of the trend values.

→ In additive model :-
seasonality is expressed as a quantity which is added to or subtracted from the series average in order to incorporate seasonality.

→ In multiplicative model :-
Seasonality is expressed as a percentage of the average (or trend) which is then used to multiply the values of a series to incorporate seasonality.

In practice, businesses use multiplicative model much more than additive model.

Seasonality expressed as a percentage of the average (or trend) is termed Seasonal relative (Seasonal Index)

Eg :- If seasonality relative to christmas month is 1.60 and a trader has monthly average of 300 units of sales then in December the trader could expect a sales demand around 480 (i.e. 300 × 1.6)

* Seasonal Relatives are used for forecasting in 2 ways.

To deseasonalise the forecast
↓
by dividing forecast data by respective seasonal relative.
↓
eg) christmas month's total demand forecast / Seasonal relative of christmas month = Actual forecast resulted by following trend pattern of the underlying product / service.

To seasonalise a forecast
↓
by multiplying the forecast data by respective seasonal relative.
↓
eg) christmas month's demand forecast as per trend pattern of the underlying product * Seasonal relative of christmas month = christmas month's total demand resulted from trend and seasonality.

Seasonal Relatives can be found by

- Simple Average
- Centered Moving Average.

* Imp Notes :

Time Series

↓

2 Models.

- Additive Model → T + C + S + I
- Multiplicative Model → T C S I

→ linear equation = $yt = a + bx$

→ quadratic equation = $yt = a + bt + ct^2$
(Also known as Parabolic form)

→ $yt = ab^t$ → exponential form.

* Regression Analysis / Trend Analysis.

Direct Method

$\Sigma x = 0$

(x is not given)

[Sales/Prodn = y]

Odd

$y = a + bx$

$a = \frac{\Sigma y}{n}$

$b = \frac{\Sigma xy}{\Sigma x^2}$

x = next year time dev.

year, x, y, x^2, Σxy

(bich = 0, pehle = -1, -2, -3
neeche = +1, +2, +3)

Even

$y = a + bx$

$a = \frac{\Sigma y}{n}$

$b = \frac{\Sigma xy}{\Sigma x^2}$

x = alt. year

year; x, y, x^2, Σxy

bich 2 saal = -1 +1

pehle alt -3, -5 ...

neeche alt +3, +5 ...

Indirect Method

$\Sigma x \neq 0$

(x is given)

$y = a + bx$

$\Sigma y = na + b\Sigma x$ - (1)

$\Sigma xy = a\Sigma x + b\Sigma x^2$ - (2)

(First we add Σ)
(Second me add x).

Direct – Odd

Q.1 Computation of Trend Values.

Years	Time deviation from 2018 (x)	Sales in (000 units)	Squares of time dev. (x^2)	xy.
2015	-3	80	9	-240
2016	-2	90	4	-180
2017	-1	92	1	-92
base year → 2018	0	83	0	0
2019	+1	94	1	94
2020	+2	99	4	198
2021	+3	92	9	276.
n = 7	$\Sigma x = 0$	$\Sigma y = 630$	$\Sigma x^2 = 28$	$\Sigma xy = 56$.

Regression equation of y on x.

$y = a + bx$.

To find values of a & b.

$$a = \frac{\Sigma y}{n} = \frac{630}{7} = 90$$

$$b = \frac{\Sigma xy}{\Sigma x^2} = \frac{56}{28} = 2.$$

Hence, regression eqn = $y = 90 + 2x$.

Demand for next 3 years.

2022 = 90 + 2(4) = 98 units.

2023 = 90 + 2(5) = 100 units

2024 = 90 + 2(6) = 102 units

Direct - Even.

Q.2 Computation of Trend Value of Sales.

Years	Time deviation (x)	Sales (y) in lakhs.	x^2	xy.
2016	-5	100	25	-500
2017	-3	110	9	-330
2018	-1	115	1	-115
2019	+1	120	1	+120
2020	+3	135	9	+405
2021	+5	140	25	+700
n=6	$\Sigma x = 0$	$\Sigma y = 720$	$\Sigma x^2 = 70$	$\Sigma xy = 280$

Regression equation of y on x.

$y = a + bx$.

To find values of a & b.

$$a = \frac{\Sigma y}{n} = \frac{720}{6} = 120$$

$$b = \frac{\Sigma xy}{\Sigma x^2} = \frac{280}{70} = 4.$$

Hence, regression eqn comes to $y = 120 + 4x$.

Demand for next 5 years.

2022 = 120 + 4 (7) = ₹ 148 lakhs

2023 = 120 + 4 (9) = ₹ 156 lakhs

2024 = 120 + 4 (11) = ₹ 164 lakhs

2025 = 120 + 4 (13) = ₹ 172 lakhs

2026 = 120 + 4 (15) = ₹ 180 lakhs.

Indirect

Q.3 Computation of Trend Values.

Population (In lakhs)	Sales of CTV (In thousands)	squares of population	Prodⁿ of population and Sales of col. TV.
X	Y	X^2	XY
5	9	25	45
7	13	49	91
8	11	64	88
11	15	121	165
14	19	196	266.
$\Sigma X = 45$	$\Sigma Y = 67$	$\Sigma X^2 = 455$	$\Sigma XY = 655$.

Regression eqⁿ of Y on X.

$Y = a + bx$.

To find values of a and b, 2 eqⁿ are to be solved.

$\Sigma Y = na + b\Sigma x$ — (1)

$\Sigma XY = a\Sigma X + b\Sigma x^2$ — (2).

By putting values we get:-

$67 = 5a + 45b$ — (1)

$655 = 45a + 455b$. — (2).

Multiplying eqⁿ (1) by 9.

$603 = 45a + 405b$. — (3).

Subtracting eqⁿ (3) from eqⁿ (2).

~~$603 = 45a + 405$~~ $655 = 45a + 455b$

$603 = 45a + 405b$

(−) (−)

$52 = 50b$.

$b = \frac{52}{50} = \boxed{1.04}$

By putting value of b in eqn (1).

$$67 = 5a + 45b$$
$$67 = 5a + 45(1.04)$$
$$67 = 5a + 46.8$$
$$20.2 = 5a$$
$$a = \frac{20.2}{5}$$

$$\boxed{a = 4.04}$$

Now, putting the values of a & b in regression eqn.

$$y = a + bx$$
$$y = 4.04 + 1.04(x)$$

When x = 10 lakhs.

$$y = 4.04 + 1.04(10)$$
$$= 4.04 + 10.4$$
$$= 14.44 \text{ thousand CTV sets.}$$

When y = 20 lakhs.

$$y = 4.04 + 1.04(20)$$
$$= 4.04 + 20.8$$
$$= 24.84 \text{ thousand CTV sets.}$$

Hence expected demand for CTV for two towns will be 14.44 thousand and 24.84 thousand.

Indirect.

Q.4 Computation of trend value.

Population (in lakhs) (X)	No. of scooters demanded (Y)	Squares of population (X^2)	Product. [XY]
4	4400	16	17,600
6	6600	36	39,600
7	5700	49	39,900
10	8000	100	80,000
13	10,300	169	1,33,900
$\Sigma X = 40$	$\Sigma Y = 35,000$	$\Sigma X^2 = 370$	$\Sigma XY = 3,11,000$.

Regression eqn of Y on X.

$Y = a + bx$

To ~~solve~~ find values of a & b, we need to solve 2 eqn.

$\Sigma Y = na + b\Sigma X$ — (1).

$\Sigma XY = a\Sigma x + b\Sigma x^2$ — (2).

$35,000 = 5a + 40b$ — (1)

$3,11,000 = 40a + 370b$ — (2)

Multiplying eqn (1) with 8, we get.

$2,80,000 = 40a + 320b$ — (3).

By subtracting, we get.

$3,11,000 = 40a + 370b$

$2,80,000 = 40a + 320b$

$31,000 = 50b$

$b = \frac{31,000}{50}$

$b = 620$.

By substituting the value of b in eqn (1).

$$35,000 = 5a + 40(620)$$
$$35,000 = 5a + 24,800$$
$$35,000 - 24,800 = 5a$$
$$5a = 10,200$$
$$a = \frac{10,200}{5}$$
$$= 2040.$$

Regression eqn = $\boxed{y = 2040 + 620x}$

∴ Demand for scooters with a population of 16 lakhs =

$$= y = 2040 + 620(16)$$
$$= 2040 + 9920$$
$$= \underline{11,960}$$

* Moving Average ← 3 years
4 years
5 years.

3 years

Eg.

Years	Sales	3 years M.T (Moving Total)	3 yrs M.A. (÷3) (Moving Avg)
1	200		
2	220 →	660	220
3	240 →	720	240
4	260 →	780	260
5	280 →	840	280
6	300 →	900	300
7	320 →	960	320
8	340 →	1020.	340.
9	360.		

4 years

Years	Sales	4 yrs M.T (Not ~~Centred~~ centred)	4 yrs M.T (Centred)	4 yrs MA (÷8)
1	200			
2	220	→ 920		
3	240	→ 1000	→ 1920	240
4	260	→ 1080	→ 2080	260
5	280	→ 1160	→ 2240	280
6	300	→ 1240	→ 2400	300
7	320	→ 1320.	→ 2560	320.
8	340			
9	360.			

5 years → Same as 3 years Moving Avg.
(Consider 5 figures & divide by 5)

* 4 Yearly Moving Avg.

Year	Sales	4 Years Total (not centred)	4 Yearly Avg	4 Yr MA centred
1	200			
2	220	920	230	
3	240	1000	250	240
4	260	1080	270	260
5	280	1160	290	280
6	300	1240	310	300
7	320	1320	330	320
8	340			
9	360			

* 5 Years Moving Avg.

Year	Sales	5 Yrs Total	5 Yrs Avg.
1	200		
2	220		
3	240	1200	240
4	260	1300	260
5	280	1400	280
6	300	1500	300
7	320	1600	320
8	340		
9	360		