FORECASTING

Forecasting can be termed as prediction of future sale or demand of a perticular project. It is a projection based upon past data and the art of human judgement.

Need or benifits of forecasting :-

i) It helps in determining the volume of production and production rate

ii) It forms the basis for production budget, material budget, labour budget etc;.

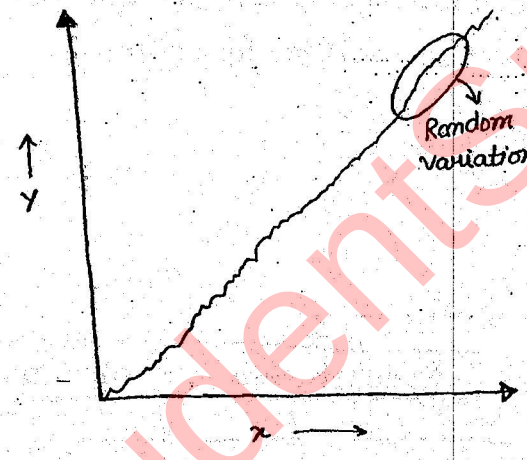
iii) It suggest the need for plant expansion.

iv) It is essential for product design and development.

v) It helps in determining the extent of marketting, advertising, distribution required.

Types of demand variation :-

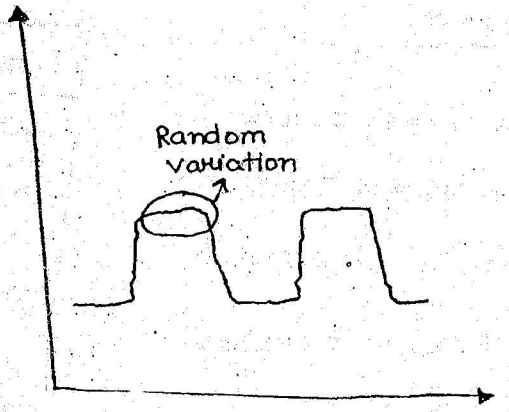
1) Trend Variation (T) :-



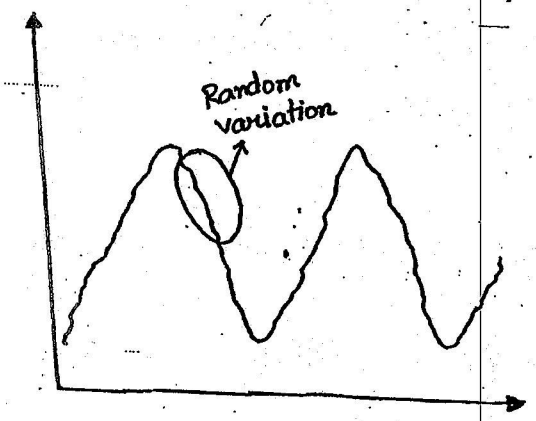
It shows the long term, upward or downward movement in the demand pattern of a perticular product.

2) Seasonal Variation (S) :-

It shows the short term regular variation related to a perticular time of a day or day of a week.

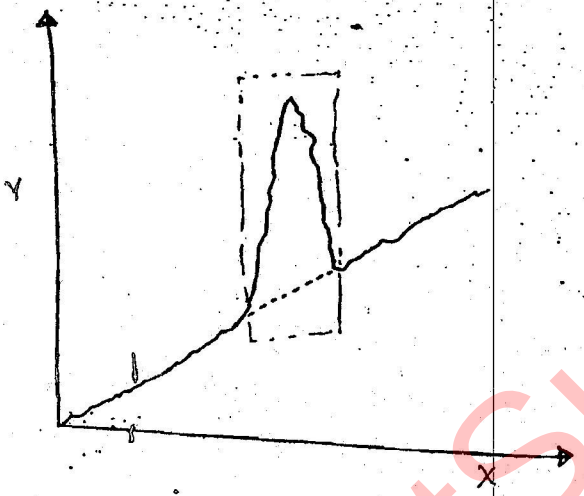


3) Cyclic Variation (c) :-



It shows the long term wave like demand variation normally for a year or more

4) Irregular Variation (I) :-



These are caused due to unusual circumstances which are not reflective of normal behaviour. They may be due to govt. policy change, price hike, strike, shut down etc.,. These are always neglected while forecasting.

New product / Long term

- Forecast
  - Qualitative or Subjective
    - Judgemental
      - opinion survey
      - Market Trial
      - Market research
      - Delphi technique
  - Quantitative or objective
    - Time Series
      - Past Average
      - Simple Moving Average (SMA)
      - Weighted moving Average (WMA)
      - Exponential Smoothing
    - Causal / Econometric
      - Corelation
      - Regression

1) Judgemental :-

This method is based upon art of human judgement i.e. how well a human being can predict the demand of the product in future. This method does not require past data or sales figure.

opinion survey : In this method opinions are collected from the customer, retailer and distributor regarding the demand of a product. These informations are used while forecasting.

Market trial : It is applicable for new product and in that case product is introduced b/w the limited population in the form of free sample. The response from the limited population is used to project the demand response from bigger population. It is used for low cost consumable like toothpaste, chocolate, cosmetic items etc,.

Market research : In this method work of survey is assigned to external marketting agencies and the purpose of research is to collect information regarding the demand of a product. The detail of various factor which influence the demand like customer income, occupation, location, quantity, quality etc,. are related to get the forecast.

Delphi Technique : In this method a pannel of expert are asked sequential question in which the respons to one question is used to produce the next question. It is a step-by-step procedure in which information available to some expert is made available to other and the final forecast is obtained by the common opinion of all the expert.

Quantitative

Time series method

In this method past data are arranged in chronological order as dependent variable and time as independent variable. Based upon these past data we need to project the demand in future.

i) Past average :- In this method forecast is given by average or mean of actual demand data for the previous period.

ii) Simple Moving Average (Rolling Average) :

n = no. of period for SMA

1^{st} forecast = $(n+1)^{th}$

if $n = 3$

1^{st} forecast $\rightarrow 4^{th}$

This method uses past data and calculate a rolling average for a constant period. Fresh average 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 is termed as moving avg. method.

iii) Weighted Moving Average :-

This method gives unequal weight to each dumand data in such a manner the sumation of all weight is always equal to 1. The most recent data is given the highest weight and the weight assigned to oldest data will be the least.

Year	Demand	Forecast
2009	320	
2010	370	
2011	450	
2012	430	
2013	470	

$$SMA\ (n=4),\ F_{2013} = \frac{430 + 450 + 370 + 320}{4}$$

$$SMA\ (n=4) = \underline{0.25} \times 430 + \underline{0.25} \times 450 + \underline{0.25} \times 370 + \underline{0.25} \times 320$$

$$WMA\ (n=4) = \underline{0.4} \times 430 + \underline{0.3} \times 450 + \underline{0.2} \times 370 + \underline{0.1} \times 320$$

Sum of digit method –

n = no. of period for WMA

i) Find the sum of n natural number

$$\Sigma n = \frac{n(n+1)}{2}$$

ii) Arrange them in decreasing order of weight as –

$$\frac{n}{\Sigma n},\ \frac{(n-1)}{\Sigma n},\ \frac{(n-2)}{\Sigma n} \ \ldots\ \frac{1}{\Sigma n}$$

eg – $n = 4$

$\Sigma n = 10 \rightarrow \frac{4}{10}, \frac{3}{10}, \frac{2}{10}, \frac{1}{10}$

$n = 5$

$\Sigma n = 15 \rightarrow \frac{5}{15}, \frac{4}{15}, \frac{3}{15}, \frac{2}{15}, \frac{1}{15}$

Q - For the given data generate the forecast for each of the time period for SMA for $n = 3$ and WMA for $n = 4$ period. Also find the forecast for 9th, 10th and 11th period.

Period	Demand	SMA ($n=3$)	WMA ($n=4$)
1	360		
2	440		
3	490		
4	540	430	
5	680	490	487
6	760	570	576
7	840	660	665
8	1010	760	754
9		870	876
10		870	876
11		870	876

Exponential Smoothing

This method requires only the current demand and the forecasted value of for the current period to give the next forecast. This method is modified form of ~~wet~~ WMA which gives weight to all the previous data but in exponentially decreasing order. The most recent data is given the highest weight and the weight assigned to older data decreases exponentially.

General form →

$$F_t = \alpha D_{t-1} + \alpha(1-\alpha) D_{t-2} + \alpha(1-\alpha)^2 D_{t-3} + \alpha(1-\alpha)^3 D_{t-4} + \ldots\ldots\infty$$

$$F_t = \alpha D_{t-1} + (1-\alpha)\left[\alpha D_{t-2} + \alpha(1-\alpha) D_{t-3} + \alpha(1-\alpha)^2 D_{t-4} \ldots\right]$$

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

or

$$\boxed{F_t = F_{t-1} + \alpha\left(D_{t-1} - F_{t-1}\right)}$$

Error = $e_i = \Delta i = D_i - F_i$

$$F_t = F_{t-1} + \alpha e_{t-1}$$

where, $\alpha \rightarrow$ smoothing const and is equivalent to 'n' period of simple moving average and is given by -

$$\alpha = \frac{2}{n+1}$$

$\alpha \rightarrow 0.1$ to 0.2 generally preferred more

Note :- If for the initial period forecasted value is not given then

i) take the actual demand of first period equal to forecast i.e. take $D_1 = F_1$ and proceed.

ii) take the average of actual demand data as the forecast of first period and proceed.

Q→ The sale of car in a showroom in 4 consecutive month is 70, 68, 82 and 95 respectively with smoothing const of 0.4. Find the forecast for the next month.

Month	Sale	Forecast	Error	
1	70	70	0	F_4
2	68	70	-2	
3	82	69.2	12.8	
4	95	74.32	20.68	

$F_2 = F_1 + \alpha (D_1 - F_1)$

$F_2 = 70$

$F_3 = 70 + \alpha(-2)$

$\rightarrow 70 - 0.8$

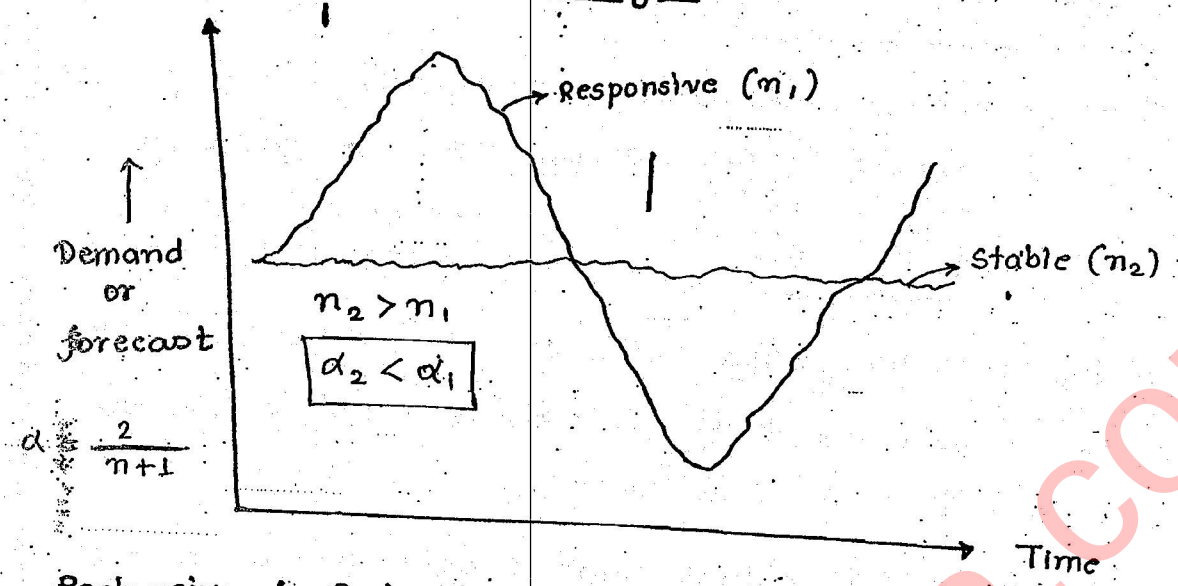
$F_4 = 82 + 0.4(12.8)$

$= 82 + 5.12$

$= 87.12$

$F_5 = 82.59$

Responsiveness and Stability



Responsive : Responsiveness indicates that forecast are fluctuating or swinging pattern. It is preferred for new product and for that no. of period is kept small.

Stability : Stability means that the forecast patter is flat, smooth or has less fluctuation. It is preferred for old existing product and for that no. of period is kept large.

$$\alpha = \frac{2}{n+1} \quad , \quad F_t = F_{t-1} + \alpha (D_{t-1} - F_{t-1})$$

i) if $\alpha = 0$, $n \longrightarrow \infty$ (limit of stability)

$$F_t = F_{t-1}$$

ii) if $\alpha = 1$, $n \longrightarrow 1$ (limit of Responsiveness)

$$F_t = D_{t-1}$$

$0 \longleftarrow \alpha \longrightarrow 1$

stable resp.

Forecast Error :-

When we study error for long duration it becomes helpful to find particular pattern or trend which may regulate our future prediction. The most commonly used method to find forecast error are -

i) Mean Absolute Deviation (MAD)

$$MAD = \frac{\sum_{i=1}^{n} |D_i - F_i|}{n}$$

SNO	D_i	F_i	error
1	250	240	+10
2	240	270	-30
3	270	250	+20

It indicate average magnitude of error made in every period without considering sign i.e in absolute term.

ii) Mean Forecast Error (MFE) or Bias

$$\text{MFE or (Bias)} = \frac{\sum_{i=1}^{n} (D_i - F_i)}{n}$$

It measures the forecast error with regard to direction and shows any tendency of over or under forecast. Positive Bias indicates underestimated forecasting and Negative Bias indicated over estimated forecasting.

Running Sum Forecast Error (RSFE) $= \sum_{i=1}^{n} (D_i - F_i)$

$$\text{Bias} = \frac{RSFE}{n}$$

iii) Mean Square Error (MSE)

$$MSE = \frac{\sum_{i=1}^{n} (D_i - F_i)^2}{n}$$

S.D → $\sigma = \sqrt{MSE}$

MSE is used to compute std. deviation for forecast error which is utilised to plot control chart for forecast error.

iv) Mean Absolute Percentage Error (MAPE) :-

$$MAPE = \frac{\sum_{i=1}^{n} \left| \frac{D_i - F_i}{D_i} \times 100 \right|}{n}$$

It is the average of percentage error compared to actual demand and it is used to put error in prospective because there is difference between 40 out of 1000 or 40 out of 1000.

v) Tracking Signal (T.S) :-

$$T.S = \frac{RSFE}{MAD}$$

It is the term used to represent how well the forecast is predicting the actual value. The value of 0 would be ideal but ±4 or ±5 is the acceptable range.

MSE > MAD > Bias > MAPE > T.S

Q- The demand for luxury car has been shown below. Expert forecasted sale of 100 car for the month of january with smoothing const of 0.2. Find the forecast for the month of june. Also find MAD, MSE, MAPE, Bias and T.S.

Month	Demand	Forecast	Error	$(e_i)^2$	$\frac{e_i}{D_i} \times 100$
Jan	140	100	40	1600	28.57
Feb	180	108	72	5184	40
March	90	122.4	-32.4	1049.76	36
April	60	115.92	-55.92	3127.04	93.2
May	130	104.73	25.27	638.52	19.43
June		109.78	$\Sigma e_i = 48.95$ $\Sigma \lvert e_i \rvert = 225.5$	Σe_i^2 $= 11599.37$	217.20

i) MAD $= \frac{225.5}{5} = 45.11$

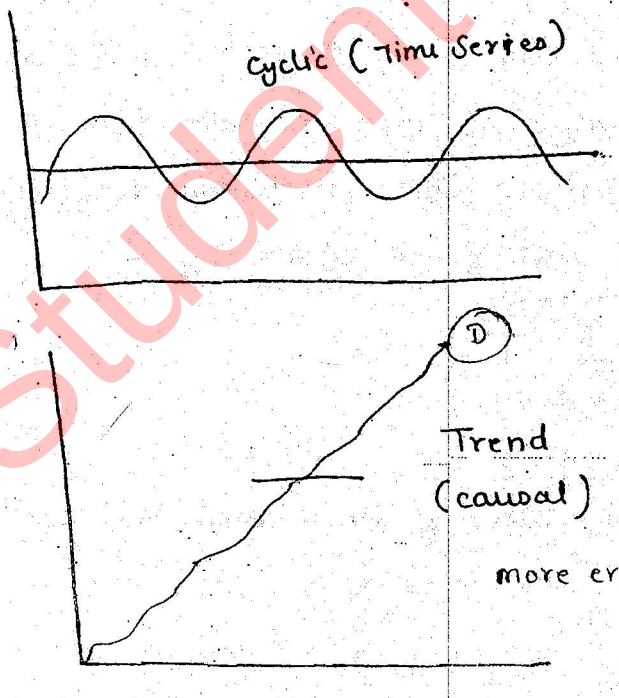
ii) MSE $= \frac{11599.37}{5} = 2319.87$

iii) MAPE $= \frac{217.2}{5} = 43.44$

iv) Bias $= \frac{48.95}{5} = 9.78$

v) TS $= \frac{48.95}{45.11} = 1.085$

Causal or Econometric



Data

SNo	D (cyclic)	D (Trend)
1	60	70
2	90	80
3	140	110
4	180	160
5	150	220
6	100	250
7		
8		
9		
10		

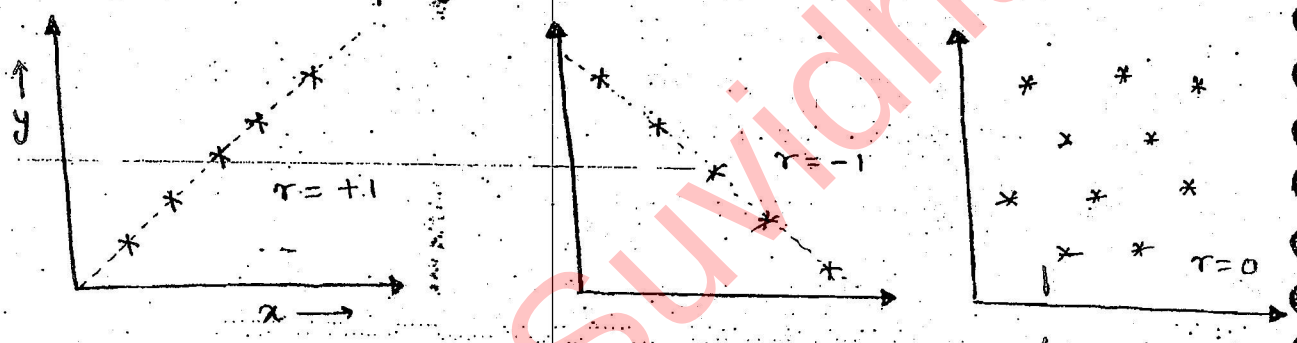
In this method forecaster tries to establish cause and effect relation b/w the demand of the product and any other variable on which demand is dependent.

Corelation Analysis :-

$r \longrightarrow +1$ to -1

for x and y

$r = +0.52$	$r = -0.63$
$x \uparrow$ 100	$x \uparrow$ 100
$y \uparrow$ 52	$y \downarrow$ 63



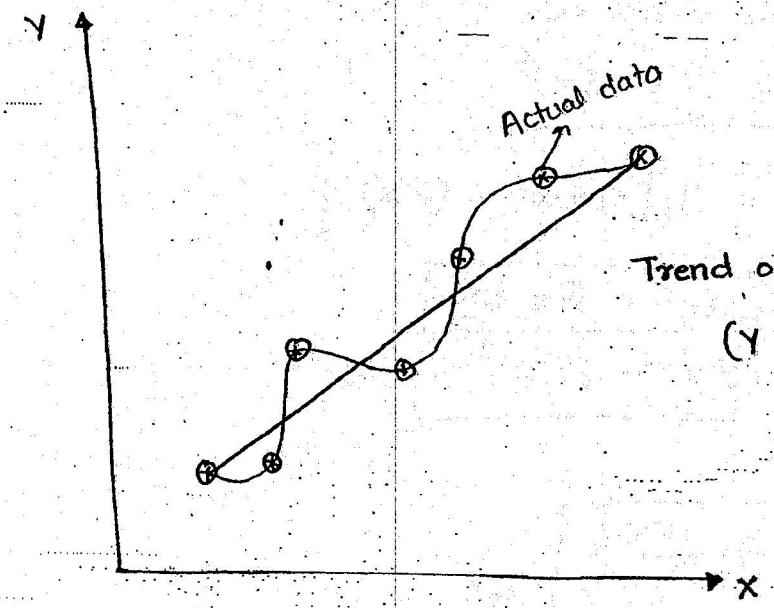
It indicate the degree of closeness b/w the two variable and its value ranges from +1 to -1. It is an indicator of the extent to which knowledge of one variable become useful for the prediction of other. The corelation coefficient b/w the two variable b/w x and y is given by -

$$r = \frac{\Sigma (x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma (x - \bar{x})^2 \; \Sigma (y - \bar{y})^2}}$$

where, $\bar{x}$ and $\bar{y}$ are the avg. value of individual x & y value

* ES → conv

Linear Regression :-



It is a mathematical technique of obtaining the line of best fit between dependant variable which is usually the demand of the product and any variable on which ~~dep~~ demand is dependent. In regression analysis the relation b/w some ind. variable x and dep. variable y can be represented by a straight line.

$$y = a + bx \quad - (1)$$

where, a is the intercept on y-axis

b is the slope on line.

Let n is the period of data given -

Taking Σ on both side of eq (1) -

$$\Sigma y = an + b\Sigma x \quad - (2)$$

Multiplying eq (1) by x

$$xy = ax + bx^2$$

Taking Σ on both side.

$$\Sigma xy = a\Sigma x + b\Sigma x^2 \quad - (3)$$

eq (3) x n - eq (2) x Σx

$$n \cdot \Sigma xy = an\Sigma x + bn\Sigma x^2$$

$$-\Sigma x \Sigma y = -an\Sigma x + b(\Sigma x)^2$$

$$n\Sigma xy - \Sigma x\Sigma y = b\left[n\Sigma x^2 - (\Sigma x)^2\right]$$

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

from eq (2) -

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

$\boxed{Y = a + bx}$ → trend line

Y → Dependent

x → Independent

Special Case –

Least Square Method :- When the independent variable x_i is linear and uniform and it is in such a form that it can be modified to make $\Sigma x = 0$, then the calc. become very simple and the method is called Least Square method.

$$\Sigma x = 0$$

$$\boxed{b = \frac{\Sigma xy}{\Sigma x^2}} \qquad \boxed{a = \frac{\Sigma y}{n}}$$

i) n = odd

Year	Demand	x
2010		-2
2011		-1
2012		0
2013		+1
2014		+2

2) n = even

Year	Demand	x	x^2
2010		-2.5	-5
2011		-1.5	-3
2012		-0.5	-1
2013		+0.5	+1
2014		+1.5	+3
2015		+2.5	+5

2 gapping

Q → A car manufacturer has recently held road side car exhibition. The no. of sales man employed at each exhibition and the no. of car booked is as given below - Fit a linear regression eqn and estimate the no. of car booked if 10 salesman are employed in an exhibition.

No of salesman	No. of car booked	xy	x^2
5	132	660	25
8	160	1280	64
6	148	888	36
8	156	1248	64
9	168	1512	81
3	102	306	9
5	142	710	25
4	98	392	16
6	152	912	36
6	142	852	36
60	1400	8760	392

$$b = \frac{10 \times 8760 - 60 \times 1400}{10 \times 392 - (60)^2} = 11.25$$

$a = 72.5$

or $\Sigma Y = an + b\Sigma x$

$1400 = 10a + 60b$ — (2)

at $x = 10$

$\Sigma xy = a\Sigma x + b\Sigma x^2$

$8760 = 60a + 392b$ — (3)

$y = 185$

Q - The sale of an automobile comp. is as given below. Forecast the demand for next two year using 'Least Square method.

Year	Sales	x	xy	x^2
2006	30	-9	-270	81
7	33	-7	-231	49
8	37	-5	-185	25
9	39	-3	-117	9
10	42	-1	-42	1
11	46	+1	46	1
12	48	+3	144	9
13	50	+5	250	25
14	55	+7	385	49
15	58	+9	522	81
	438		502	330

$$b = \frac{502}{330} = 1.52$$

$$a = \frac{438}{10} = 43.8$$

$$\boxed{Y = 43.8 + 1.52x}$$

for 2016 -

$x = 11$

$y = 43.8 + 1.52 \times 11 = 60.52$ cr

for 2017 -

$x = 13$

$y = 43.8 + 1.52 \times 13 = 63.56$ cr