Production Planning & Control BMM4823

Forecasting- Part 2

by

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Chapter Description

- Aims
  - To understand types of forecasting methods.
  - To apply quantitative, causal and time series methods for future forecasting demand.

- Expected Outcomes
  - Able to differentiate between qualitative and quantitative forecasting methods
  - Able to determine future demand by using these forecasting methods
  - Able to determine the influence factors for the future demand

- References
  - Heizer, J and Render,B. 2011. Principles of Operations Management, 8th Edition, Pearson Prentice Hall, Inc.

Introduction

What is Quantitative forecasting?

This method is depending on the historical data. It was assumed that the future demand will be influence by previous data.

- 5 methods of quantitative will be covered in this topic;
- Naïve
- Simple moving average
- Weighted moving average
- Exponential smoothing
- Seasonal
- Regression

Naive

Next month demand is the same as demand in most recent month

E.g.

June sales = 500 units

Therefore; July also will be 500 units.

Fast decision but not good and inaccurate.

Moving average

- A simple calculation
- Series of arithmetic means
- A good estimation by using an average
- Less data used more responsive compared to more data

$$\text{Moving average} = \frac{\sum \text{Last demand in } n \text{ periods}}{n}$$

Moving Average

You are manager in Sangat Murah Accessories shop. You want to forecast the Samsung Note 5 cover sales for month of April to June by using a **3-months moving average**.

Month	Sales (x 1000)	Forecast
January	4	
February	6	
March	7	
April	9	$\frac{4+6+7}{3} = 5.67$
May	11	$\frac{6+7+9}{3} = 7.33$
June		$\frac{7+9+11}{3} = 9$

Therefore, the expected demand of that product in June will be 9000 units.

Weighted Moving Average

- Giving weight to each data
- Trend might be in the data
- Less weight to the older data
- Weights based on experience and intuition
- E.g. If 3 months weighted moving average, 1 for January, 1.5 for February and 2.0 for March.

Weighted Moving Average (WMA)

Formula for WMA ;

$$\text{Weighted Moving Average} = \sum \frac{(weight\ of\ period\ n) x\ (demand\ in\ period\ n)}{weights}$$

How to chose the weight ?

Weight is considered arbitrary. Trial and error is used to determine the best weight.

Weighted Moving Average (WMA)

Suppose same example as in E.g. 1. You want to forecast Samsung Note 5 cover sales for months April to June using a 3-months weighted moving average. Use the weight of 1,2 and 3.

Month	Sales (x1000)	Forecast (WMA)
Jan	4	
Feb	6	
Mar	7	
April	9	$\frac{4(1)+6(2)+7(3)}{1+2+3}$ = 6.17
May	11	$\frac{6(1)+7(2)+9(3)}{1+2+3}$ = 7.83
June		$\frac{7(1)+9(2)+11(3)}{1+2+3}$ = 9.67

Exponential Smoothing

$$F_t = F_{t-1} + \alpha\,(A_{t-1} - F_{t-1});$$

Where

F_t = Forecast for period t

F_{t-1} = Forecast for the previous period

α = Smoothing constant, between 0 and 1

A_{t-1} = Actual demand or sales from previous period

Exponential Smoothing

In January, a car dealer predicted February demand for Proton Preve is 142. However, the actual February demand was 153 cars.

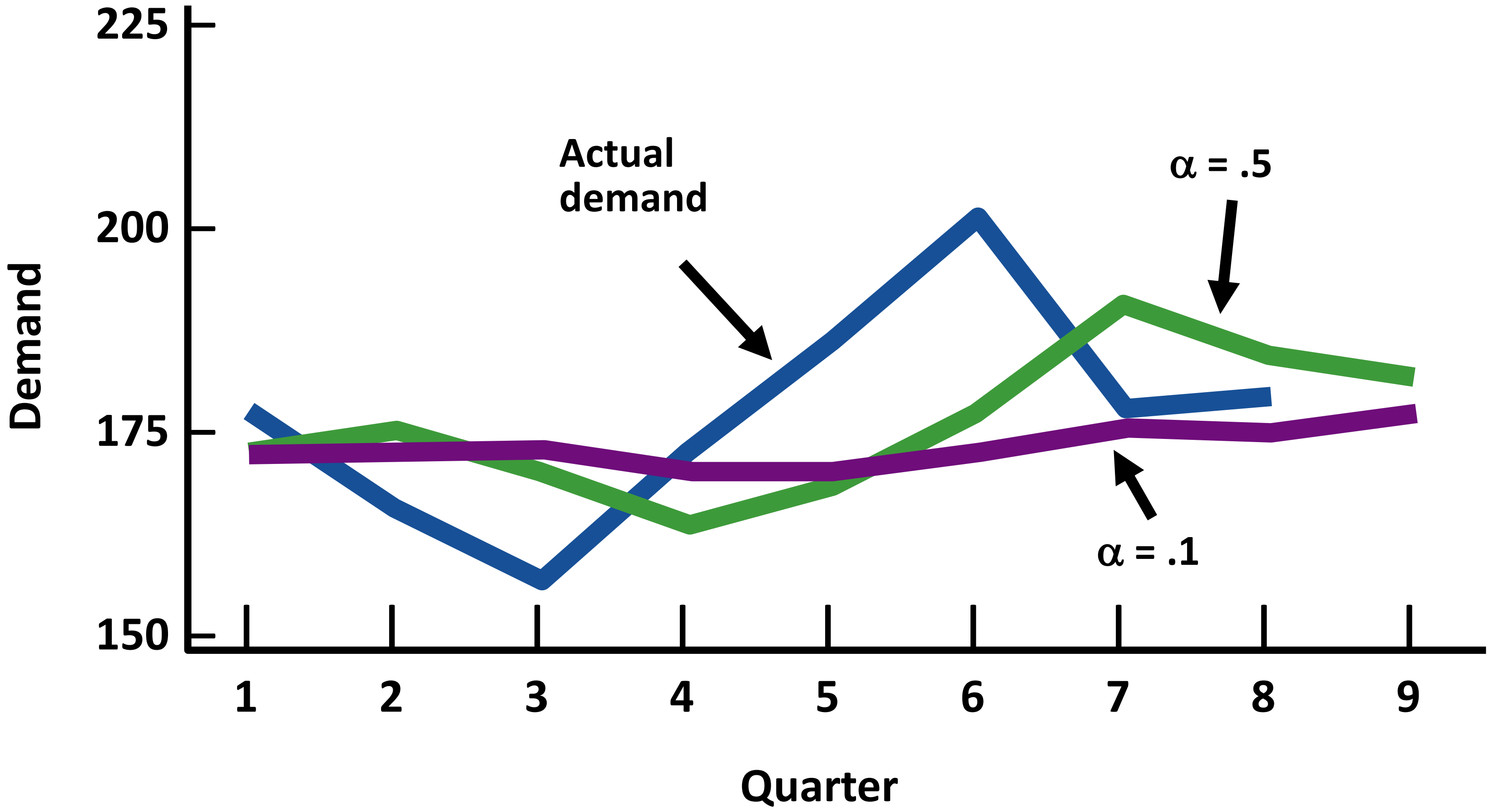
By using a smoothing constant of $\alpha = 0.20$, the dealer wants to forecast month of March demand by using the exponential smoothing model.

Exponential Smoothing

Predicted demand = 142 Preve cars
Actual demand = 153
Smoothing constant α = 0.20

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

New forecast = 142 + .2(153 – 142)
= 144.2
= 144



Source : Heizer 2011

Selection of α

Which α should be chosen?

- **High values of α for an average which is likely to change.**
- **Low values of α for an average which is stable.**

Exponential Smooting

The chosen α should give a minimum error in forecasting

Forecast error = Actual demand - Forecast value

$= A_t - F_t$

Exponential Smoothing

Table 1 shows the demand of drinking water from Always One Sdn. Bhd.

Month	Cartons
January	100
February	80
March	110
April	115
May	105
June	110
July	125
August	120

Use the exponential smoothing method to forecast for January to August. The initial forecast for January was 105 units $\alpha = 0.2$

Exponential Smoothing

Answer of exponential smoothing

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

F_2 = 105 + 0.2(100-105)
= 105 – 1
= 104

F_3 = 104 + 0.2(80 -104)
= 104 + 0.2(-24)
= 104 -4.8
= 99.2

F_4 = 99.2 + 0.2(110 -99.2)
= 99.2 + 2.16
= 101.4

F_5 = 101.4 +0.2(115-101.4)
= 101.4 + 2.72
= 104.1

F_6 = 104.1 + 0.2(105-104.1)
= 104.1 + 0.18
= 104.28
= 104.3

F_7 = 104.3 + 0.2(110-104.3)
= 104.3 + 1.1
= 105.4

Montl
Januar
Februa
March
April
May
June
July
Augus

Exponential Smoothing

$F_8 = 105.4 + 0.2(125-105.4)$
$= 105.4 + 3.92$
$= 109.3$

Forecasting Error

Mean Absolute Deviation (MAD)

$$\text{MAD} = \frac{\sum |\text{Actual - Forecast}|}{n}$$

Mean Squared Error (MSE)

$$\text{MSE} = \frac{\sum (\text{Forecast Errors})^2}{n}$$

Mean Absolute Percent Error

$$\sum \frac{\textbf{(Forecast error)x 100}}{\textbf{Actual}}$$

Forecast error

Example:

The Sales Manager of Always One, want to know how accurate the forecasting method using exponential smoothing. Two values of α are to be examined: $\alpha = .10$ and $\alpha = .50$ He estimates that the demand of drinking water in the first month was 175 cartons.

Forecast Error

Month	Demand (cartons)
January	180
February	160
March	150
April	170
May	190
June	200
July	180
August	85

Solution

Month	Demand (cartons)	σ = 0.10	σ = 0.50
January	180		
February	160	175.50	177.50
March	150	173.95	175.75
April	170	171.56	173.18
May	190	171.40	172.86
June	200	173.26	174.57
July	180	175.93	177.11
August	85	176.34	177.40

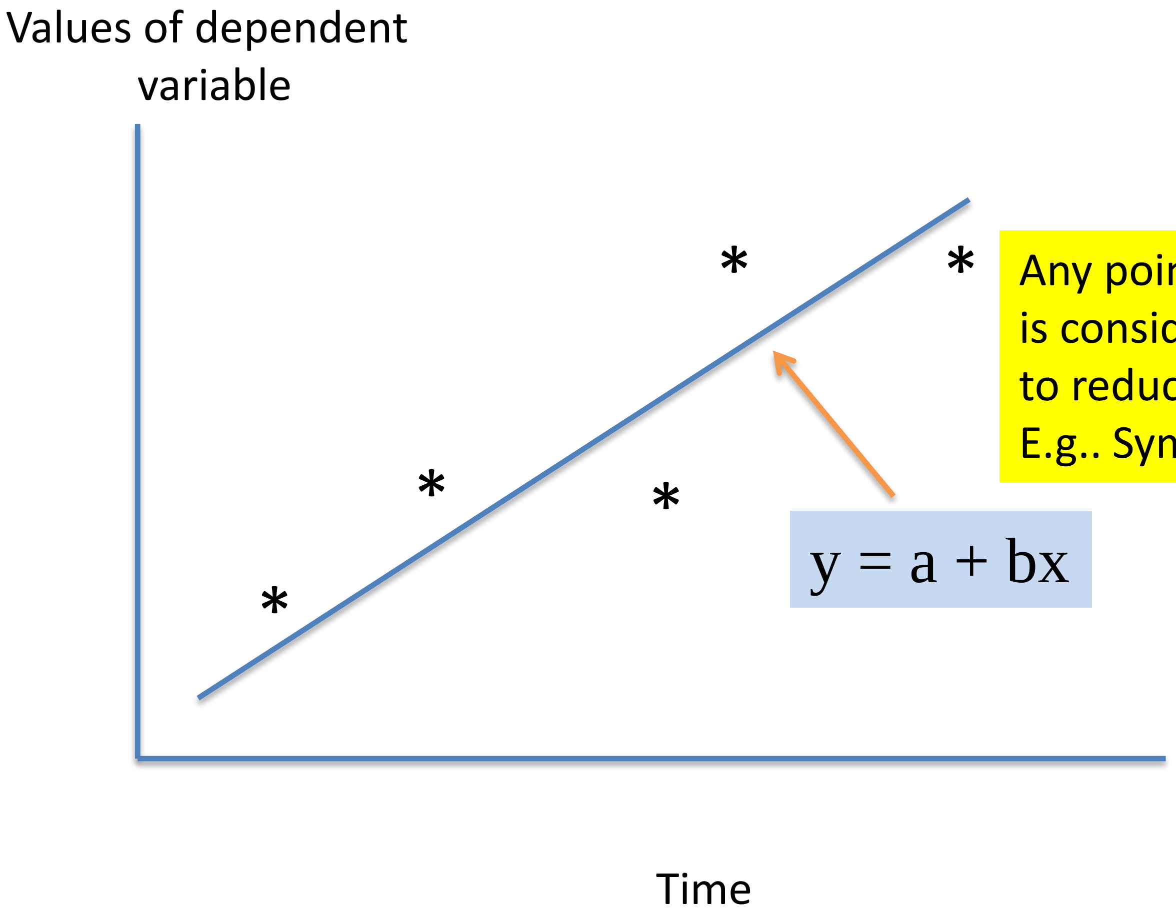
Least Square Methods

The least squares technique used for trend projection

$$\hat{y} = a + bx$$

where $\hat{y}$ = dependent variable; computed from the formula
a = y-axis intercept
b = slope of the regression line
x = the independent variable

Least square methods



Any points deviate from trend line is considered errors. This method try to reduce an error.
E.g.. Symbol (*) as in the graph

Equations to calculate the regression variables

$$\hat{y} = a + bx$$

$$b = \frac{\Sigma xy - n\bar{x}\bar{y}}{\Sigma x^2 - n\bar{x}^2}$$

$$a = \bar{y} - b\bar{x}$$

The determination of regression variables

$$\hat{y} = a + bx$$

$$b = \frac{\Sigma xy - n\bar{x}\bar{y}}{\Sigma x^2 - n\bar{x}^2}$$

$$a = \bar{y} - b\bar{x}$$

The demand for electric power at Waja Steel over the period of 6 years is analysed (in megawatts). Yaman, the production manager wants to forecast 2018 demand by fitting a straight line trend.

From the above information;

Megawatt value is considered dependent variable - (y)
Time is considered independent variable - (x)
Therefore, each year should be converted to value of 1, 2, 3, ….

Example

Year	Time Period (*x*)	Electrical Power Demand (y)
2011	1	74
2012	2	79
2013	3	80
2014	4	90
2015	5	105
2016	6	142
2017	7	122

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

$$a = \bar{y} - b\bar{x}$$

Year	Time period (x)	Demand Watts (y)	x	xy
2011	1	70	1	70
2012	2	75	4	150
2013	3	80	9	240
2014	4	90	16	360
2015	5	110	25	550
2016	6	150	36	900
2017	7	120	49	840
2018	8	?		
Total	28	695	140	3110
Average	4	99.3		

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} = \frac{3{,}110 - 7(4)(99.3)}{140 - (7)(4^2)}$$

$$= \frac{329.6}{28}$$

$$= 11.77$$

$a = \bar{y} - b\bar{x}$

$= 99.3 - 11.77(4)$

$= 52.22$

In this case the projection for 2018 is **146.62 Megawatts.**

Therefore;

Y= 52.22 + 11.8x

Least Square Methods

1. **Should plot the data to find a relationship between independent and dependent variable.**
2. **Should predict a reasonable period, not too far from historical data.**
3. **Any deviations from trend line are assumed to be random.**

Associative forecasting

Used when changes in one or more independent variables. Can be used to predict the changes in the dependent variable

Most common technique is linear regression analysis

We apply this technique just as we did in the time series

Associative forecasting

The sales of smart phones were depending on

i) Promotional strategies
ii) Allocation budget for advertising
iii) Price from competitors
iv) Economy – national and global

Associative forecasting

Forecasting the effect based on the least squares technique

$$\hat{y} = a + bx$$

where $\hat{y}$ = computed value of the variable to be predicted (dependent variable)

a = y-axis intercept

b = slope of the regression line

x = the independent variable though to predict the value of the dependent variable

Associative forecasting - Example

Always One Enterprise would like to estimate the advertising cost in order to increase their sales. Table below shows the past advertising cost and sales for that period. Find the model for this data.

Advertising x(RM 1000)	Sales x(RM100000)
2.0	1
3.0	3
2.5	4
2.0	2
2.0	1
3.5	7

Associative forecasting- check

Data	Advertising x(RM 1000) *x*	Sales x(RM10000) Y	x^2	xy
1	2.0	2	4	4
2	3.0	4	9	12
3	2.5	3	6.25	7.5
4	2.0	2	4	4
5	2.0	2	4	4
6	3.5	5	12.25	17.5
Total	15.0	18	39.5	49
Average	2.5	3		

Associative forecasting

From the calculation;

$\bar{x}$ = 2.5

$\bar{y}$ = 3.0

Then substitute into a formula

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} = \frac{49 - 6(2.5)(3.0)}{39.5 - (6)(2.5^2)}$$

= 2

$a = \bar{y} - b\bar{x}$

= 3.0 - (2)(2.5)

= -2

Therefore , the model is y = 2x -2

Let say we are allocating RM4000 for advertising in next year, the expected sales will be RM60000.

Summary

- Use qualitative forecasting for new product which no historical data
- Use quantitative forecasting for existing product based on historical data
- Chosen α is depending on underlying average
- Time series forecasting affected due to environment, political or economy changes