**Mathematics for Forecasting**

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ABSTRACT

This chapter defines the meaning of forecasting. This chapter highlights the role and importance of forecasting in current business environment. Forecasting allows the organizations to plan their activities as per the resources available. The chapter mainly highlights the quantitative techniques of forecasting which are more accurate than qualitative techniques. These techniques are back up with the numerical examples to have more clarity on the concepts mentioned in the chapter.

**Keywords**— Forecasting; quantitative techniques; qualitative techniques

**INTRODUCTION**

Forecasting is the Process of predicting the future values and trends. It allows organizations to be more proactive than receptive. The process of forecasting affects every area or department of organization in numerous ways. A major purpose of forecasting is to give us choice of alternative plan, design, and backup resources so that strategic decisions can be taken for the growth of an organization. It tries to find out how much the service or the products the customers will buy. To forecast different products or service, it involves different tools, techniques and methods which may be quantitative or qualitative in nature. Organization may use forecasting to make decisions regarding price, or should the company enter a new market zone or not. Predicting how much of a product the customer will purchase is the essential to demand management. Forecasting is dedicated to short term production scheduling, thus helping logistics to coordinates product demand with production input availability and timing in order to meet customer delight.

**Reasons why company uses forecasting techniques are listed below.**

Increasing the delight of customer.

Taking steps to decrease stock outs.

Decreasing the levels of Buffer stock which organization may need.

Proper Scheduling operations efficiency.

Decreasing service or product cost of obsolescence.

To Manage the policy of pricing as well as promotion in a optimum way

Improving logistics and other activities of the firm.

**Methodology**

The author has adopted the methodology of exploratory research which has proved a vital role in understanding the concept of forecasting and applications of Mathematical techniques in the business and Management. The approach undertaken was analytical in nature so that the result of application is understood in an appropriate way.

**Data Analysis and Findings of Quantitative Techniques of Forecasting**

A statistical technique projection about the future which uses numerical facts is known as the quantitative method.

**Graphical Method**

It is the method which include the plotting of graph from the given information which signifies that the given

information can be seen in a visual manner. The patterns of the graph and the trends are very easy to locate

thus, demand can be extrapolated so that it can be used for the future purposes.

**Modelling using Econometrics**

 It signifies the different sets of equations which are intended to use for a specific purpose by solving those

simultaneously. This can be studied using independent and dependent variables which may be related among

themselves.

**Method of Moving Average**

Method of Moving average uses the mean of the recent years/month/week parameter. The mean may be

calculated by two, three, four, five etc. period which are taken into consideration. It uses the arithmetic mean

to find the forecasted value for the next year. A three yearly or monthly moving average uses the average of

the last three years or months. Every time a new year of factual data is made available, it replaces the oldest

time year’s data.

Example of method of moving average:

**Table 1: 3 Yearly Average**

|  |  |  |
| --- | --- | --- |
| Year(s) | Demand (Units) | **3 yearly moving average** |
| 1 | 120 | - |
| 2 | 90 | - |
| 3 | 150 | - |
| 4 | 180 | 120 |
| 5 | 210 | 140 |
| 6 | ? | 180 |

Thus, the forecasting value for the 4th year is calculated as follows: The forecasting value of 4th year = (120+90+150)/3 = 120 units. Similarly, we can calculate the other values for 5th and 6th year.

**Analysis of Exponential Smoothing:**

This is some other time collection forecasting method the place the forecast for the subsequent length is calculated as 'weighted average method' of all preceding values. It is based totally on the precept that the latest values are the most vital for predicting the future value. Also, it presumes that values prior to the cutting-edge fee are additionally applicable however in a declining significance as we go again in time. the equation is given as follows:

 Y1t+1= ayt + (1 - a) Y1t ----(1)

Where,

 Y1t+1=Represents the new demand to be forecasted

 Y1t=It represent the old demand which is based on weighted mean

 yt=Previous actual value

 a = Smoothing value or constant, such that 0 < a < 1

 If the value of a is not given it is assumed to be 0.2

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| Demand (Units) | 213 | 201 | 198 | 207 | 220 | 232 | ? |

 With the help of exponential smoothing analysis,

 t + 1 = 7 ( as we need to forecast for the 7th Year)

 Thus, t = 6

 Putting the values in the above formula we have,

 Y17=ay6+ (1 - a) Y16 ------- (2)

 = 0.2 232 + (1 - 0.2) 212

 = 46.4 + 0.8 ` 212

 = 46.4 + 169.6

 = 216 units

 Calculation of Y16= = 212 units

**Regression Analysis:** Regression means 'to regress', which indicates that one has to collect the past data. The meaning of regression analysis in statistics is the collection of the past data which can be analyze for the strategies of organization. The typical model is represented by the following equation.

 Y1 = a1 + b1x + c -------------(3)

###### Where,

 Y1 = dependent variable

 x = independent variable

 c = un-explanatory terms

 The above equation becomes simple regression if c = 0

 Thus, we have;

 Y1 = a1 + b1x; r2 -------------(4)

###### Where,

 r2= represents the power of the given model. It represents if the given model is bad or good.

 The Significance of the given equation Y1=a1 + b1x; r2 ------------(5)

 ⏺ If b sign is positive, that indicates that y1 is directly proportional to x

 ⏺ If b has negative sign, then y1 is indirectly related to x

 ⏺ r2has value between 1 and 0 ( 0 < r2< 1 )

 For example

 If r2= 0.8 = 80% which means that 80% of fluctuations in Y1 is reflected by x and the 20% may be due to c

**Note:**

 ⏺ If 0.8 ≤ r2 model is a good

 ⏺ If 0.6 ≤ r2 < 0.8 model is said to be average.

 ⏺ If r2≤ 0.6 model is said to be poor.

 **Analysis of Multiple regression:** The multiple regression model is represented by

 **Y1 = a1 + b1x1 + b2x2 + ……….bn-1 xn-1 --------------(6)**

###### Where,

 a1 = represents constant

 b1, b2……bn-1= represents co-efficients of regression

 x1, x2……xn-1= represents independent variables

 Y = dependent variable.

Find 3 and 5 period moving average? Hence Forecast value for 11th period

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Demand (Units) | 110 | 120 | 135 | 142 | 154 | 160 | 173 | 180 | 190 | 210 | ? |

 **Table: 2 Solution**

|  |  |  |  |
| --- | --- | --- | --- |
| Period | Demand (limits) | 3 period average | 5 period average |
| 1 | 110 | – | – |
| 2 | 120 | – | – |
| 3 | 135 | – | – |
| 4 | 142 | 121.67 | – |
| 5 | 154 | 132.33 | – |
| 6 | 160 | 143.67 | 132.2 |
| 7 | 173 | 152 | 142.2 |
| 8 | 180 | 162.33 | 152.8 |
| 9 | 190 | 171 | 161.8 |
| 10 | 210 | 181 | 171.4 |
| 11 | ? | 193.33 | 182.6 |

 ∴ As 3 period moving average forecasted value for 11th period is 193.33 units and as per 5 period moving average forecasted value is 182.60 units.

For the following data calculate 3 and 5 monthly moving averages:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Month | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Demand(units) | 220 | 228 | 217 | 219 | 258 | 241 | 239 | 244 | 256 | 260 | 265 |

**Solution:**

**Table 3 : Calculation of Forecasted Demand**

|  |  |  |  |
| --- | --- | --- | --- |
| **Month** | **Demand Y** | **3 – monthly****Moving Average** | **5 – monthly****Moving Average** |
| 1 | 220 |  |  |
| 2 | 228 |  |  |
| 3 | 217 |  |  |
| 4 | 219 | 221.67 |  |
| 5 | 258 | 221.33 |  |
| 6 | 241 | 231.33 | 228.40 |
| 7 | 239 | 239.33 | 232.60 |
| 8 | 244 | 246.00 | 234.80 |
| 9 | 256 | 241.33 | 240.20 |
| 10 | 260 | 246.33 | 247.60 |
| 11 | 265 | 253.33 | 248.00 |
| 12 |  | 260.33 | 252.80 |

3. Find the forecasts by 4–yearly and 5-yearly moving averages, from the following data of sales (‘000’)

 Year 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

 Sales(`) 48 53 55 56 58 63 68 60 61 68 58 63 70 76 83 88

 **Table 4: Solution of 4 and 5 yearly moving average**

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Sales** | **4 – Yearly****Moving Average** | **5 – Yearly****Moving Average** |
| 2000 | 48 |  |  |
| 2001 | 53 |  |  |
| 2002 | 55 |  |  |
| 2003 | 56 |  |  |
| 2004 | 58 | 53.00 |  |
| 2005 | 63 | 55.50 | 54.00 |
| 2006 | 68 | 58.00 | 57.00 |
| 2007 | 60 | 61.25 | 60.00 |
| 2008 | 61 | 62.25 | 61.00 |
| 2009 | 68 | 63.00 | 62.00 |
| 2010 | 58 | 64.25 | 64.00 |
| 2011 | 63 | 61.75 | 63.00 |
| 2012 | 70 | 62.50 | 62.00 |
| 2013 | 76 | 64.75 | 64.00 |
| 2014 | 83 | 66.75 | 67.00 |
| 2015 | 88 | 73.00 | 70.00 |
| 2016 |  | 79.25 | 76.00 |

4. Find the “forecast” for year 7th using weighted “Three years” Moving Average.

**Table 5: Solution weighted 3 yearly moving average**

|  |  |  |  |
| --- | --- | --- | --- |
| Year **(`)** | Sales (1000 `) | Weighted | Weighted moving Averages |
| 1 | 10 | 2 | - |
| 2 | 15 | 3 | - |
| 3 | 12 | 4 | - |
| 4 | 14 | 5 | [2(10)+3(15)+4(12)] / 2+3+4 = 12.56 |
| 5 | 16 | 6 | [3(15)+4(12)+5(14)] / 3+4+5 =13.58 |
| 6 | 18 | 7 | [4(12)+5(14)+6(16)] / 4+5+6 =14.27 |

 Thus for 7th year for casted value = = 16.22

5. Calculate weighted 5 period moving average for the following data. Also find forecasted value for 10th period.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Demand (Units) | 10 | 15 | 5 | 25 | 40 | 30 | 50 | 45 | 60 |

**Solution**

|  |  |  |
| --- | --- | --- |
| Period | Demand (Units) | 5-period moving weighted average |
| 1 | 10 | – |
| 2 | 15 | – |
| 3 | 5 | – |
| 4 | 25 | – |
| 5 | 40 | – |
| 6 | 30 |  = 23.67 |
| 7 | 50 |  = 27.34 |
| 8 | 45 |  = 36.34 |
| 9 | 60 |  = 41.34 |
| 10 | ? |  = 48.67 |

Find weighted 3 and 5 monthly averages

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Monthly  | 1 | 2 | 3 | 4 | 5 | 6 |
| NAV (Cr) | 12 | 15 | 21 | 30 | 33 | 36 |

# Weightage are considered in order of increasing order, 3(2)13

# Hint: 3(2)13 means weights start from 3 till 13 with difference of 2 in weights.

For the following data find 5 period and 3 period average, Also, Forecast demand for the 11th year.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Demand in units  | 110 | 120 | 135 | 142 | 154 | 160 | 173 | 180 | 190 | 210 | ? |

##### CONCLUSION

The chapter has given a depth of understanding the concept of forecasting and different quantitative techniques of forecasting with applications. The readers will have a concrete idea where of how to apply the quantitative techniques and which is appropriate to be applicable.

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