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Empirical Comparisons and Evaluation of Univariate Time series Models for Forecasting Sales of Internet Browsing Tickets in a Typical Nigerian University

Daramola G.O

Computer Resource Centre, Federal University of Technology, Akure, Nigeria

Abstract: ***The purpose of this research paper is to carry out comparative analysis and evaluation of some univariate time series forecasting methods and their application for forecasting sales of internet browsing ticket. Applying weekly data spreading over October2014 to November 2015 on the amount of money generated from the sales of internet browsing ticket in the Federal University of Technology, Akure, Nigeria. The forecasting performance of various forecasting methods were measured through the use of the following forecast accuracy criteria: Mean Absolute Percentage Error (MAPE), Mean Forecast Error (MFE), Mean Absolute Error (MAE), Mean Square Error (MSE) and Root Mean Square Error (RMSE). The forecasting methods analyzed included; naïve method, moving average, double moving average and exponential smoothing. Among these methods, the moving average method performed better than other competing methods in the sales of Internet Browsing ticket. The moving average method produced the most accurate forecasting based on the data obtained in the ranking table, therefore, as a matter of policy implication, the moving average method is therefore recommended for use in the process of forecasting of sales of internet browsing ticket in Nigeria's Higher Educational Institutions where internet browsing tickets are sold***.

Keywords: Sales, Forecasting, Exponential Smoothing, Moving Average, Accuracy, time series

1. Introduction

A time series is simply a set of observations measured at successive point in time. The observations are usually taken at regular intervals; days, months, years etc. Common examples of time series are the Gross Domestic Product, unemployment rate etc. Time series analysis is thus a procedure that can be used to analyze historical information, build models and predict trends.

Forecasting is a technique for estimating many future aspects of a business organization operations while sales forecasting is the process of estimating future sales. Accurate sales forecasts enable business organizations to make informed business decisions and predict short-term and long-term performance. Business organizations can base their forecasts on past sales data, industry-wide comparisons, and economic trends. Sales forecasting, therefore, gives insight into howbusiness organizations should manage its cash flow and resources. In addition to helping an organization to allocate its internal resources effectively, predictive sales data is important for businesses when planning to acquire investment capital.

2. Literature Survey

Time series forecasting is a very active research topic in the domain of science and engineering. Over the years, various time series forecasting models have been developed in literature and there has been a great deal of deliberations on their applications and performance in sales forecasting. Several time series forecasting techniques such as naive model, moving average, double moving average, exponential smoothing, semi average etc. have being applied to forecasting in previous research works. For example, Pradeep and Rajesh (2013), in their research work, identified the most appropriate forecast method for sales of salted butter milk in Chhattisgarh, India based on accuracy and simplicity. In the study, the accuracy of the forecasting methods were measured using Mean Forecast Error (MFE), Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Root Mean Square Error (RMSE). The result showed that Naive Method obtained the best accuracy, and was selected as the most appropriate forecasting method for forecasting sales of salted butter milk in Chhattisgarh.

Fildes (1989), in his own research work, studied a specific area of time series forecasting and described observations from forecasting competitions and compared the result with the expected result obtained from statistical theory. Markridakis (1989) examined the implications of forecast accuracy and proposed guidelines for implementation. Bunn and Wright(1991) carried out a judgmental and statistical study on the quality of judgment in forecasting and the possible structure available for facilitating interaction with existing statistical models. Cacatto et al. (2012) discussed the various forecasting methods that have been used by food industries in Brazil and how these forecasting methods were utilized.

Moreso, Ryu and Sanchez (2003) analyzed forecasting methods for institutional food service facility by identifying the most appropriate forecasting method for forecasting meal count for an institutional food service facility. The naive model 1,2 and 3, moving average method, double moving average method, exponential smoothing method, double exponential smoothing method, Winter method, Holt's method, simple linear regression and multiple linear regression methods were used. The accuracy of the

forecasting methods was measured using mean absolute deviation, mean squared error, mean percentage error, mean absolute percentage error method, root mean squared error and Theil's U-statistic. The result of the study showed that multiple regressions was themost accurate forecasting method but naïve method 2 was selected as the most appropriate method because of its simplicity and high level of accuracy.

3. Data Collection

The sales data used in this study was obtained on weekly basis and it is shown in table 1 below. The data shows the weekly sales of internet browsing ticket obtained from October 2014 to November 2015. Fig1 shows the time plot of the sales data in table1. The time plot showcase the original sales figure plotted against time. The time plot shown in fig1 reveals how the sales data changes over time.

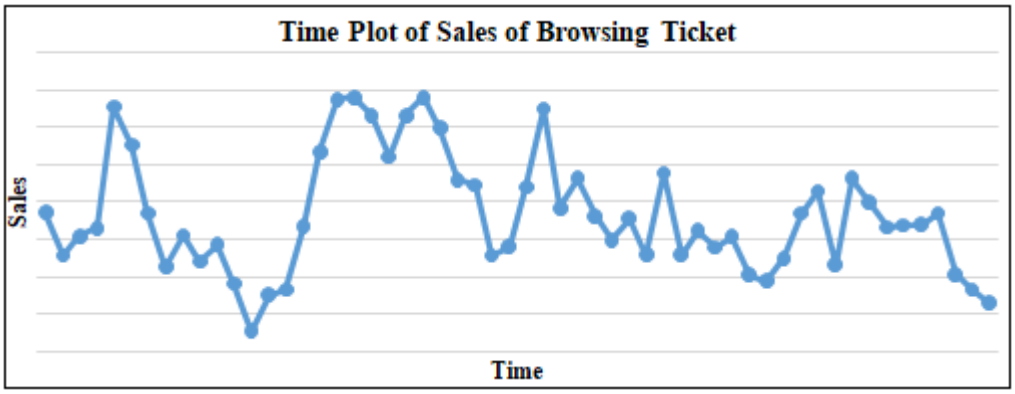

Figure 1: Time Plot of Sales of Internet Browsing Ticket

4. Methodology

This study considered different forecasting methods using sales data obtained from October 2014 to November, 2015. The forecast methods used in the analysis included the naive method, moving average, double moving average and exponential smoothing, the most suitable forecasting method was determined based on accuracy. Accuracy measures such as Mean Forecast Error¸ Mean Absolute Error (MAE), Mean Square Error (MSE), Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) are the indicators used in this work.

5. Forecasting Methods

Forecasting method is the category of forecasting that is applied. There are a number of forecasting methods but the naive method, moving Average Method, Double MovingAverage Method and the exponential smoothing method were employed in this work.

5.1 Naive Method

The very simplest forecasting method is to use the most recent observation. This is called a naïve forecast and it is obtained with minimal amount of effort and data manipulation. They are based on most recent information available (Shim, 2000). The naïve method uses data from the previous week to forecast the current week (one week lag);

Week	Sales	Week	Sales
1	74,900	29	88,400
2	52,150	30	130400
3	62,500	31	77500
4	66,500	32	93050
5	131,250	33	72900
6	110,850	34	60150
7	74,300	35	71550
8	45,800	36	52200
9	62,700	37	95900
10	48,900	38	52400
11	57,600	39	65100
12	37,100	40	56400
13	11,600	41	62150
14	31,300	42	41600
15	33,950	43	38750
16	67,400	44	50600
17	107,300	45	74350
18	135,150	46	86300
19	135,950	47	47050
20	126,350	48	93100
21	104,400	49	80250
22	126,800	50	66900
23	136,300	51	68200
24	119,700	52	68450
25	92,350	53	74300
26	89,350	54	42000
27	52,050	55	33600
28	56,600	56	26750

$F_{t+1} = Y_t$

Where:

F_{t+1} = the forecast value for the next period

Y_t = the actual value at the next period

$F_{t+1} = Y_t$ (1)

Where:

F_{t+1} = the forecast value for the next period

Y_t = the actual value at the next period

5.2 Moving Average Method

The method of obtaining a time series trend involves calculating a set of averages, each one corresponding to a trend (t) value for a time point of the series. These are known as moving averages, since each average is calculated by moving from one overlapping set of values to the next.

The number of values in each set is always the same and is known as the period of the moving average. The procedure involves computing the average of observations and then using the computed average as the predictor for the next period. The moving average method depends on the number of terms selected for constructing the average. It is represented using the following equation.

$$F_{t+1}=\frac{Y_t+Y_{t-1}+Y_{t-2}+\cdots+Y_{t-n+1}}{n} \quad (2)$$

Table 1: Sales of Internet Browsing Ticket

Where:
n = Number of terms in the moving average
Y_t= the exact value at period t
F_{t+1} = Forecast value for the next period

5.3 Double Moving Average Method

The use of double moving average method for forecasting times series data was recommended by Hanke and Reitsch (1998). Forecasting with a double moving average requires determining two averages. The first moving average is computed and a second moving average is calculated using the following five equations.

$$M_t = F_{t+1} = \frac{Y_t+Y_{t-1}+Y_{t-2}+\cdots+Y_{t-n+1}}{n} \quad (3)$$

$$M_t = (M_t + M_{t-1} + M_{t-2} + \ldots + M_{t-n+1})/n \quad (4)$$

$$At = 2M_t - M_t' \quad (5)$$

$$B_t = \frac{2}{n-1}(M_t - M_t') \quad (6)$$

$$F_{t+p} = A_t + B_t\, p \quad (7)$$

Where:
n = the number of period in the double moving average
Y_t = the actual series value at time period t
P = the number of period ahead to be forecast

5.4 Exponential Smoothing Method

Exponential smoothing has been a popular forecast method for over half a century. It is commonly accepted that the method dates back to 1944 when R.G Brown used it to model the trajectories of bombs fired at submarines in World War II (Gardner, 2006). However Brown's work did not appear in print until 1959. (Brown, 1959). At this time, the method was also being used independently to model series containing seasonal components.(Holt, 1957 and Winters, 1960)

Algorithm for univariate exponential method was initiated by Hyndman et al (2008) and was first introduced to literature by Athanasopoulos et al (2008). The algorithm provides a means of forecasting time series data by selecting from an extensive range of innovations state space models, which have been shown to generate optimal forecasts for all exponential smoothing methods.The Exponential Smoothing technique uses weighted moving average of past data as the basis for the forecast. The basic Exponential Smoothing formular can be shown as follows:
New Forecast = Last Periods Forecasts + α(Last Period's actual value – Last Periods Forecast)
It can be represented mathematically as follows:

$$F_t = F_{t-1} + \alpha\,(A_{t-1} - F_{t-1}) \quad (8)$$

Where:
F_t = New Forecast Value
F_{t-1} = Previous Forecast Value
α = Smoothing Constant ($0 \leq \alpha \leq 1$)
A_{t-1}= Previous Period's actual value.
The accuracy of exponential smoothing method strongly depended on the optimal value of α. The preferred values for α in this study are 0.2 and 0.7

6. Measuring Forecasting Error (MFE)

According to (Hanke&Reitsch, 1998) the forecast error is the difference between an actual value and its forecast value. i.e. Forecast Error = Actual Value – Forecast Value. Accuracy is the criterion that determines the best forecasting method because there is no consensus among researcher as to which measure is best for determining the most appropriate forecasting method (Levine et al., 1999). Accuracy is thus the most important concern in evaluating the superiority of a forecast. The overall goal of the forecast is to minimize error. The most common indicators used to evaluate accuracy of a forecast are: Mean Forecast Error (MFE), Mean Absolute Error (MAE), Mean Square Error (MSE), Root Mean Square Error (RMSE)

6.1 Mean Square Error (MSE)

According to Jarrett (1991) Mean Square Error is a technique for evaluating exponential smoothing and other methods. It is represented by the following equation;

$$MSE = \frac{1}{n}\sum_{t=1}^{n}(Y_t - F_t)^2 \quad (9)$$

Where:
Y_t= the actual value in time period t
F_t = the forecast value in time period t
n = the number of periods

6.2 Root Mean Square Error (RMSE)

According to Jarrett (1991) Root Mean Square Error is the square root of MSE. This measures error in term of units that are equal to the original value. It is represented by the following equation.

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(Y_t - F_t)^2} \quad (10)$$

Where:
Y_t= the actual value in time period t
F_t = the forecast value in time period t
n = the number of periods

6.3 Mean Forecast Error

Mean Forecast Error (MFE) is the mean of the deviation of the forecast demands from the actual demands. It is represented by the following equation.

$$MFE = \frac{\sum_{t=1}^{n}(Y_t - F_t)}{n} \quad (11)$$

Where:
Y_t= the actual value in time period t
F_t = the forecast value in time period t
n = the number of periods

6.4 Mean Absolute Error

A renowned method for measuring overall forecast error is the Mean Absolute Error (MAE). Heizer and Render (2001) stated that this value is computed by dividing the sum of the absolute values of the individual forecast error by the sample size (the number of forecast periods). It is represented by the following equation.

$$MAE = \frac{\sum_{t=1}^{n} |(Y_t - F_t)|}{n} \quad (12)$$

Where:
Y_t= the actual value in time period t
F_t = the forecast value in time period t
n = the number of periods

7. Results and Discussion

The accuracy of the forecasting methods was measured using Mean Forecast Error (MFE), Mean Absolute Deviation (MAD), Mean Square Error (MSE) and Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE). The smaller the forecast error, the more accurate the forecasting method.

Table 2: Summary of Forecast Accuracy

S/n	Method	MFE	MAE	MAPE	MSE	RMSE
1	Naive method	-0.875	20.126	32.900	617.309	24.846
2	Moving Average (n=3)	-0.569	13.844	23.134	302.522	17.393
3	Double Moving Average (n=3)	-2.320	26.501	42.995	1045.475	32.334
4	Exponential Smoothing (α=0.2)	-2.078	23.587	42.246	834.232	28.883
5	Exponential Smoothing (α=0.7)	-1.156	19.539	32.868	610.388	24.706

Table 2 shows the summary of the forecast accuracy for each of the forecasting methods while table 3 shows the overall ranking of the forecasting methods for the sales data.

Table 3: Overall Ranking of Forecasting method for sales data

S/n	Method	MFE	MAE	MAPE	MSE	RMSE	Total Ranking	Overall Ranking
1	Naïve method	2	3	3	3	3	14	3
2	Moving Average (n=3)	1	1	1	1	1	5	1
3	Double Moving Average (n = 3)	5	5	5	5	5	25	5
4	Exponential Smoothing (α=0.2)	4	4	4	4	4	20	4
5	Exponential Smoothing (α=0.7)	3	2	2	2	2	11	2

The result showed that the Moving Average (n=3) was ranked first because it produced the most accurate forecasting based on the data obtained in table 3. i.e It produced the smallest error i.e (MFE=-0.569, MAE=13.844, MAPE=23.134, MSE=302.522, RMSE=17.393) thus making it more efficient than others

The Exponential Smoothing (α=0.7) was ranked second, it produced the second smallest error i.e (MFE=-1.156, MAE=19.539, MAPE= 32.868, MSE=610.388, RMSE=24.706) as shown in the ranking table 3.

The Naive Method was ranked third because it produced the third smallest error i.e (MFE=-0.875, MAE=20.126, MAPE= 32.900, MSE=617.309, RMSE =24.846) as shown in the ranking table 3.

The Exponential Smoothing (α=0.2) was ranked fourth, it produced the fourth smallest error i.e (MFE= -2.078, MAE=23.587, MAPE= 42.246, MSE=834.232, RMSE=28.883) as shown in the ranking table 3.

The double moving average (n=3) was ranked fifth, it produced the fifth smallest error i.e (MFE=-2.320, MAE=26.501, MAPE= 42.995, MSE=1045.475, RMSE= 32.334) as shown in the ranking table 3.

8. Conclusion and Recommendation

This research work uses Naive method, moving Average Method, Double Moving AverageMethod and the exponential smoothing method of forecasting onsales data and identified the most appropriate forecasting method based on accuracy and simplicity. The result showed that the Moving Average (n=3) was ranked first and was therefore selected as the most appropriate forecasting method for the sales data obtained in this study. The moving average method is therefore recommended for use in forecasting sales of Internet Browsing tickets in higher educational institutions in Nigeria. Effective forecasting of sales with the moving average method will thus help higher educational institutions to:

1) Predict achievable sales revenue
2) Efficiently allocate resources
3) Plan for future increase in bandwidth size.

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Author Profile

Daramola Gbenga holds a B.Sc degree in Computer Engineering from ObafemiAwolowo University, Ile-Ife, Nigeria in 2001. He obtained a Master Degree in Computer Science and Statistics in 2011 and 2017 respectively from Federal University of Technology, Akure, Nigeria. He currently runs a PHD Programme in the Department of Statistics, Federal University of Technology, Akure. His research focus is Optimal Design of Experiments. He has published a few articles in some reputable journals. He currently work in the Computer Resource Centre of the Federal University of Technology, Akure, Nigeria.